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A REGIONAL APPROACH TO MONITORING SALMONID ABUNANCE TRENDS: A PILOT PROJECT FOR THE APPLICATION OF THE CALIFORNIA COASTAL SALMONID MONITORING PLAN IN COASTAL MENDOCINO COUNTY

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Coastal Mendocino County Salmonid Monitoring Project

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This report documents the first year results of a three-year pilot, funded by the Fisheries Restoration Grants Program, to evaluate salmonid monitoring methodologies for California's Coastal Monitoring Plan (CSMP). We considered five coastal Mendocino County streams as a hypothetical region of California to evaluate the use of life cycle monitoring streams (LCS) and regional spawning surveys (SGS) for monitoring salmonids at a regional scale. The primary purpose of this study was to assess: 1) if the field sampling protocols provided statistically valid and accurate estimates, 2) the logistical problems encountered, and 3) the level of resources needed for regional LCS and SGS monitoring. We examined escapement estimation methods, calibration of SGS data from LCS data, regional sampling rates, and produced annual abundance estimates and evaluated regional trends. To estimate LCS escapement and calibrate potential bias in SGS estimates we used live fish capture-recapture methods. Fish were captured and tagged at the Pudding Creek fish ladder, the Noyo River Egg Collecting Station (ECS), and a floating board resistance weir in Caspar Creek. Recaptures were visual observations of fish during SGS in these streams. For regional SGS escapement estimates two sampling designs were used: 1) SGS conducted in three streams at 33% sampling and resulting stream estimates summed with LCS estimates to calculate regional escapement (33% sum of streams), and 2) SGS conducted in a Generalized Random Tessellation Sampling (GRTS) frame draw at 10%. All habitat in each LCS was surveyed providing a systematic sample of 37 (48%) additional reaches to examine regional sampling rate. To estimate SGS escapement we used carcass capture-recapture, live fish counts, redd counts, redd area measurements, and spawner: redd ratios developed in the LCS. Smolt abundance was estimated from downstream trapping in Caspar and Pudding creeks and in the Little and South Fork Noyo rivers. Available smolt abundance data from 2001 to 2004 and adult return data from 2000 through 2005-06 were used to estimate smolt to adult survival. The LCS capture-recapture methods produced reliable coho escapement estimates for Pudding Creek and the South Fork Noyo River and provided information for reducing bias in SGS estimates. The coho and steelhead capture-recapture estimates for the other LCS streams had large confidence bounds due to the low numbers of marked and recaptured fish. It took approximately 1110 person hours in the field and 120 laboratory hours to estimate escapement for one LCS. Carcass capture-recapture was not reliable because too few carcasses were observed. Regional SGS escapement was best estimated using spawner: redd ratios developed at LCS streams. The 10% and 48% GRTS escapement estimates overlapped the 33% sum of stream estimates but the variance was higher at 10%. Redd area escapement estimates were not different from capture-recapture estimates for steelhead, but were for coho due to difficulties counting coho redds experienced during 2005-06. It took approximately 3330 person hours to estimate SGS escapement for 37 reaches surveyed eight times. We recommend annual evaluation of the relationship between redd counts; redd based escapement estimates, and capture-recapture estimates to determine the best method for estimating abundance from SGS data. For regional monitoring the annual GRTS sample draw should be increased to ≥ 24 reaches to evaluate sampling rates between 10% and 30% and account for access issues.

INTRODUCTION

Accurate estimates of escapement are essential for effective management and conservation of salmonids (Busby et al. 1996, McElhany et al. 2000). In coastal Northern California Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutc*h) and steelhead (*O. mykiss*) are listed species under the U. S. Endangered Species Act (Federal Register 1999, 2000, 2005). Coastal coho salmon are also listed under the California State ESA as threatened in coastal Northern California (CDFG 2003). Delisting criteria will presumably depend on whether important populations have reached abundance thresholds, one of the four key components of the Viable Salmonid Population (VSP) concept (Busby et al. 1996). The Steelhead Restoration and Management Plan for California (McEwan and Jackson 1996) states that an important management objective for north coast steelhead is "maintaining and increasing population abundance" and recommends population monitoring of naturally produced stocks. The Recovery Strategy for California coho Salmon (CDFG 2004) states that population monitoring will be necessary to determine if recovery goals and quantatative recovery targets have been met.

The Action Plan for monitoring California's coastal salmonids (Boydstun and McDonald 2005) describes a sampling scheme to monitor four components of the VSP: Abundance, Population Growth Rate, Population Spatial Structure, and Diversity (McElhany et al. 2000). This plan follows a sampling scheme similar to the Oregon Plan (Stevens 2002, Firman and Jacobs 2000) where metrics of adult and juvenile population status and data on habitat conditions are collected in a rotating panel design (Overton and McDonald 1998) to monitor regional salmonid populations. Boydstun and McDonald (2005) propose using spawning ground surveys for regional monitoring of California's coastal salmonids where adult escapement is estimated from redd surveys and live fish and carcass counts in a Generalized Random Tessellation Sampling (GRTS) rotating panel design that samples 10% of all available spawning habitat. These extensive regional Spawning Ground Surveys (SGS) are considered first stage sampling. To calibrate the SGS escapement estimates from the first stage sampling, they propose the use of escapement estimates from Life Cycle Monitoring Streams (LCS) as second stage sampling using known numbers of returning adults, or estimated numbers considered as true. Under the Action Plan LCS are locations where complete freshwater life history and habitat conditions are monitored. Boydstun and McDonald (2005) suggest that the first stage sampling (e.g. the SGS) could utilize 1) redd counts, where either the total numbers of redds are a sufficient measure of adult population status or redd counts are converted to adult numbers using an estimated number of fish per redd based on second stage sampling in the LCS (e.g. 2.5 fish per redd) or using redd areas, 2) repeated live fish counts with the Area Under the Curve (AUC), or 3) salmon carcass capture-recapture techniques (Boydstun 1987). According to the Action Plan, LCS must be located in watersheds where it is possible to accurately estimate numbers of spawning adults and their corresponding smolt production with high confidence in the estimates. Additionally the Action Plan states that the California Department of Fish and Game will need to determine which of the above methods should be used after a few years of field experience and data analysis.

This report documents results from the first year of a three-year pilot project for evaluating salmonid abundance monitoring methodologies for California's Coastal Salmonid Monitoring Plan (CSMP). This study is a cooperative effort between the Department of Fish and Game and Campbell Timberlands Management with oversight from NOAA Fisheries, Southwest Fisheries Science Center. The primary purpose of this pilot study was to assess three aspects of the CSMP: 1) Do the fields sampling protocols provide statistically valid and acceptably accurate estimates and are they suitable for a CSMP? 2) What were the logistical problems and challenges encountered? 3) What are the resources needed for regional and LCS monitoring? The secondary purpose of this pilot study was to produce annual abundance estimates and evaluate trend detection methods.

This first year of study was funded by the Fisheries Restoration Grants Program (FRGP) grant number P0410527 for Fiscal Year 2004/2005 and covers field and laboratory work conducted from March 2005 through December 2007. Laboratory work during this period consisted of developing both a sampling frame and sample draw, acquiring necessary field gear, defining data collection and storage procedures, setting up grant contracts, and preparation of this report. Field activities in fall 2005 and winter/spring 2006 included determining study reaches, building and setting weirs and traps, and collecting data on adult escapement and smolt abundance (spring 2006 and 2007). The second year of study, field year 2006-2007, funded by FRGP grant number P0510544 for the period of 1 June 2006 through 1 September 2008 will collect adult escapement data during winter 2006-2007 and smolt abundance during spring 2008 and will include laboratory activities associated with data collection and storage procedures, setting up grant contracts, and report preparation. The third year of study, field year 2007-2008 funded by FRGP grant number P0610540 for period of 1 June 2007 trough 30 September 2009, will collect adult escapement data during winter 2007-2008 and smolt abundance during spring 2009 and will include laboratory activities associated with data collection and storage procedures, setting up grant contracts, and report preparation.

For this study, we considered five coastal Mendocino County streams (Figure 1) as a hypothetical region of coastal California to evaluate the logistics, feasibility, and reliability of data from LCS and regional SGS for monitoring salmonids. Two of these five streams and a sub basin of the Noyo River were treated as LCS, where three different types of adult capture structures were tested: 1) a flashboard dam and fish ladder on Pudding Creek, 2) the Noyo River Egg Collecting Station (ECS) on the South Fork Noyo River, and 3) a floating board resistance weir in Caspar Creek. Fish were marked and released at each of these structures. Recaptures were live fish observations made during spawning ground surveys in all the spawning habitats in these streams. A screw trap in Pudding Creek and fyke traps in the South Fork Noyo River and Caspar Creek were operated to estimate smolt abundance. Data collection, management, and analysis are discussed in relation to long term monitoring under the California Plan and recommendations are provided to improve monitoring of California's coastal salmonids.

MATERIALS AND METHODS

Study Area

The intensively monitored LCS (Figure 1) were selected for a variety of reasons. Caspar Creek was chosen due to the history of monitoring and restoration activities in this basin; because it is a California Department of Forestry (CDF) experimental watershed; and there are many years of adult escapement, juvenile rearing, and downstream trapping data. The South Fork of Caspar Creek is gauged and many water quality parameters are collected and reported in real time (www.fsfed.us/psw/topics/water/caspar). The South Fork Noyo was selected because the Noyo River has a stream gage; there is a long history of coho data relating to the Noyo ECS; known numbers of coho salmon can be marked and released above the ECS; because there are over six years data on coho escapement, redd counts, and smolt abundance above the ECS (2000-2005, Appendix 1); because there is a history of CDFG management activities in this watershed; Chinook and coho salmon and steelhead are found in this stream; and the entire watershed is owned by CDF. Pudding Creek was selected because there is a weir and fish ladder where fish can be marked and released; this ladder was operated as an egg collecting station in the 1950's and 1960's potentially providing historic data for comparison; there are six consecutive years adult escapement estimates in this stream (2000-2005, Appendix 1) and fish were marked and released at this site in 2003-04 and 2004-05 with recaptures made during spawning surveys; and the stream and watershed are similar in size to Caspar Creek.

The regionally monitored basins (Figures 1-3) were selected for a variety of reasons. Hare Creek supports coho and steelhead, there are four consecutive years' data on adult escapement and smolt abundance (2000-03, Appendix 1), and the entire watershed is within Jackson State Demonstration Forest. The Little River was selected because the entire steam and watershed is located in Van Dame State Park and there are over six years of adult escapement and smolt abundance data for coho and steelhead. The upper and main stem Noyo River was selected because the Noyo River is large and extends considerably further inland than many coastal Mendocino streams, there is a real time stream flow gauge (http://waterdata.usgs.gov/ca/nwis/uv?11468500), Chinook and coho salmon and steelhead are present, there are four consecutive years data on adult escapement and smolt abundance (2000-2003), and access to the stream is established.

LCS Capture-Recapture Experiments

In the three LCS (Caspar and Pudding creeks and the South Fork Noyo River above the ECS), live fish capture-recapture methods where recaptures were from spawning ground survey observations, were used to estimate escapement and calibrate potential bias in spawning escapement estimates for coho and steelhead. We used live fish counts, redd counts and measurements, and carcass capture-recapture data from spawning surveys to estimate escapement following Gallagher and Gallagher (2005) and Gallagher (2005a-b). We then used the results from the LCS streams to correct potential bias in spawning ground escapement estimates for the extensively monitored streams.

To estimate salmonid escapement we marked fish with weekly time specific individually numbered bi-colored floy tags (Glen Szerlong, NOAA Fisheries, Santa Cruz, Personal Communication), and to evaluate tag loss, we marked fish with weekly stream specific operculum punches. Floy tags on carcasses were recovered and all carcasses inspected for operculum punches to estimate tag loss and residence time *(rt)*. We used the Schnabel capture-recapture method to estimate coho and steelhead escapement during 2005-06 (Krebs 1989). Adult coho were captured and marked at a Floating Board Resistance weir (Figure 4), constructed and operated in Caspar Creek 4.9 km from the Pacific Ocean, at a fish ladder on a flashboard dam (Figure 5) in Pudding Creek located 0.25 km from the Pacific Ocean, and known numbers of coho were marked and released above the Noyo River ECS (Figure 6) during 2005-06. Adult steelhead were captured and marked at the ECS, the Pudding Creek fish ladder, and in fyke traps in Caspar Creek and the South Fork Noyo River.

Chinook and coho populations were also estimated by capture-recapture of carcasses during spawning surveys in all streams using with Jolly-Seber method, or the Schnabel or Petersen method when recaptures were less than seven (Krebs 1989). We examined the carcass mark-recapture data for 2005-06 by survey reach to determine if this type of data was useful for producing reach specific escapement estimates.

Spawning Ground Surveys

For the regional SGS escapement estimates two sampling survey designs were used. The first approach used a 33% sampling rate (Gallagher and Gallagher 2005) in extensive watersheds and combined the resulting whole stream estimates with LCS mark/recapture estimates made in intensive watersheds (Caspar Creek, SF Noyo River, and Pudding Creek). The second approach used a 10% sampling rate drawn from the regional sampling frame using a Generalized Random Tessellation Sampling (GRTS) scheme as described in the Action Plan.

To estimate escapement in the intensively and extensively monitored watersheds we used data collected during spawning surveys following Gallagher and Knechtle (2003), Gallagher and Gallagher (2005), and Gallagher at al. (2007). The entire extent of spawning habitat was surveyed in the LCS streams to increase maximize the observation rate of tagged and untagged fish and to provide data for evaluating potential biases in escapement estimates derived from spawning surveys. For the 33% regional stream sampling design Hare Creek, Little River, and the Noyo River were divided into 0.5 to 4.5 km reaches and a third of these were randomly selected for spawning ground surveys (Figure 2). For the 10% regional GRTS sampling design all spawning habitat in the five streams was divided into uniquely identified reaches ranging in length from 0.26 to 3.79 km (Danna McCain, Institute for River Ecosystems, Personal Communication) resulting in a sample frame with 76 reaches. Trent MacDonald (West Inc.) used this sample frame to create a GRTS sample draw, each reach in the sample frame is assigned a GRTS Order number (Table 1). To achieve a 10% sampling rate, 8 reaches are to be sampled each year. To improve the utility of the data set to track population trends, the first three reaches (GRTS Order 1-3) are sampled each year. For each successive year of the study the next five subsequent reaches are added to that year's surveys, e.g. in 2005-06 GRTS Order numbers 1-3 and 5-8 are sampled; in 2006-07GRTS Order numbers 1-3 and 9-13 are sampled; etc. The reaches sampled in 2005-06 are shown in Figure 3.

Surveys were conducted approximately biweekly from early-December 2005 to mid-April 2006 in all selected stream reaches. Due to the need to sample all habitat in the intensively monitored streams and our intent to continue complete sampling in Little River, a systematic sample of 37 (48% sample rate) additional GRTS reaches was available to examine sampling rate at the regional scale. Calculation of 95% confidence intervals for redd counts and redd based escapement estimates followed Brower and Zar (1984) using observer efficiency SE's and treating stream reaches as samples for each stream. Redd density was calculated from the observer efficiency corrected redd counts divided by the reach length (km) for each survey segment.

Escapement Estimates

Redd Area and One Redd Per Female

Redd area and one redd per female estimates were made by multiplying the bias corrected number of redds by the male to female ratio observed in each reach and summing this with the number of redds. Redd area and one redd per female fish density (number per km) was calculated by dividing these estimates by the reach length (km) for each survey segment.

Spawner: Redd Ratios

We evaluated using the number of fish per redd (spawner: redd ratio) to convert bias corrected redd counts into fish numbers. We calculated spawner: redd ratios by dividing capture-recapture estimates for coho and steelhead by the bias corrected redds counts for all available data (Table 2, Appendix 1). These estimates were then used to convert redds counts into fish numbers in each stream such that fish per redd in Pudding Creek was used to estimate fish from redd counts in the South Fork Noyo River and visa versa. We also examined using multiyear and annual multi-stream average coho salmon spawner: redd ratios using data from above the ECS 2001-2006, Caspar Creek 2005-06, and Pudding Creek 2004 - 2006. The numbers of fish per redd were similarly estimated using AUC in all streams for which this data was available. To examine transferability of the data among streams and years we compared predicted escapement from these data to capture-recapture escapement estimates for all streams and years that data was available. Spawner: redd ratios were used to convert redd counts into fish numbers for each reach and these numbers were transformed into density by dividing by reach length.

AUC

Spawning population estimates were derived from live fish observations using the AUC (English et al. 1992, Hilborn et al. 1999). Coho *rt* was estimated from the time between the initial capture of live fish and the recapture of tagged fresh (clear eyes and no fungus assumed recently deceased) carcasses in Caspar Creek 2005-06, Pudding Creek 2003-04 through 2005-06, and in the South Fork Noyo River above the ECS 2001 through 2006 (Table 3). Coho *rt* was also taken from the literature (Beidler and Nickelson 1980). We estimated steelhead *rt* as the time between capture and recapture of tagged fish, and from available past observations in Pudding Creek, the Noyo River (Table 3), and used values from the literature (Gallagher and Gallagher 2005). Residence times were compared among streams and over years using paired t-tests and ANOVA to determine transferability among streams and years.

Observer efficiency (*e*), the ratio of total fish seen to the total present (Korman et al. 2002), was estimated following Gallagher (2005a-b) as the total number of marked fish observed during spawning surveys divided by the total number of marked fish present. We also predicted *e* for each species from weekly estimates of stream flow and water visibility using regression models of Gallagher (2005b). Live fish density for each reach was calculated by dividing AUC estimates by reach length.

Bias in Spawning Ground Survey Escapement Estimates

We used the results of the mark-recapture experiments and SGS escapement estimates from the LCS to identify and quantify potential biases in spawning ground survey escapement estimates. This was similar to the approach used in Oregon where index weir counts are used to correct for biases in redd counts for steelhead population monitoring (Susac and Jacobs 2002). Relationships between redd counts and escapement were used to convert redd counts to fish numbers and 95% confidence bounds were calculated using bootstrap simulation with 1000 iterations.

Regional Escapement

During 2005-06 we field verified all the selected GRTS stream reaches for access and in November 2005, we marked the beginning and ends in the field. Due to concern that GIS measured stream reach lengths might differ from on the ground lengths, 28 of the selected GRTS reaches were measured in the field during spring 2006. Field measured and GIS reach lengths were compared with ANOVA. The resulting linear regression model was used to correct GIS reach lengths (Table 1) and these lengths were used for calculating fish and redd density.

Regional GRTS escapement estimates followed the methods outlined by Boydstun and MacDonald (2005) where redd or fish density is averaged for sample reaches and the result multiplied by the total length of habitat in the sample frame. Due to the low sample size ($n = 8$ and $n = 37$), the 95% confidence intervals for these estimates were calculated using bootstrap with replacement of 1000 iterations (Trent MacDonald, West Inc. Personal Communication). To calculate regional escapement for the regional 33% sum of stream design, the total counts from the intensively monitored LCS streams were combined with estimates from random sampling in the extensively monitored basins following Gallagher and Gallagher (2005).

Smolt Abundance

We used downstream migrant traps to estimate smolt abundance using capture-recapture methodology in the three LCS and in Little River. Traps were placed in the streams in mid-March and checked daily until early-June 2006. Three fyke traps were operated in Caspar Creek. One trap was located about 5.0 km above the Pacific Ocean in the main stem of Caspar Creek. Two other traps were placed above the confluence of the North Fork and South Fork Caspar Creek; one in the South Fork and the other in the North Fork. We deployed two fyke traps above the ECS; one in the South Fork Noyo River and the other in the North Fork South Fork Noyo River. One fyke trap was located in Little River about 2.5 km above the Pacific Ocean. CTM purchased a screw trap (purchased independently of the FRGP Grant # P0410527) and deployed and operated it in Pudding Creek. In late spring, the flows in Pudding Creek were too low to operate the screw trap, so it was replaced with a fyke trap.

In general, we followed the methods of Gallagher (2000, 2003) and Barrineau and Gallagher (2001), except that we used pit tags as the primary mark for fish > 70 mm. One year and older coho and steelhead (> 70 mm FL) were also marked with a maxillary clip to assess tag loss. Traps were checked daily. We measured and weighed all steelhead and coho > 50 mm (FL) to the nearest mm and to the nearest 0.1 g. Captured fish were marked with a site and week specific mark (pit tag or fin clip) and released upstream of the traps. To estimate the number of young-of-the-year salmon passing the trap, we marked batches of 50 fish with Bismarck Brown three days per week. All other species captured were measured to total length and released below the traps. We examined all steelhead and coho >50 mm for marks each day. Those without marks were marked and released at least 100 m above the traps. Recaptured fish were measured, weighed and released at least 100 m below the traps. Measured and marked fish were anesthetized using alka-seltzer (Ross unpublished), except in Pudding Creek where we used MS 222.

To estimate salmonid populations, capture probabilities, and timing for each trap all captures and recaptures by week and size/age class were totaled to create capture-recapture matrices for input to Darr (Bjorkstedt 2003). We ran these matrices in Darr to produce population estimates and capture probabilities for both coho and steelhead at different size classes. For steelhead, we determined the following classes: < 70 mm (YOY), 71-120 mm (Y+), and > 120 mm (Y++). For coho, we determined these classes: < 70 mm (YOY) and > 70 (Y+). We developed age/size classes 1) by examining fork length frequencies from Gallagher (2000), 2) by examining the size age relationships from Shapovalov and Taft (1954), and 3) by our discussion with local fish biologists. Steelhead < 71 mm that were captured before fry were first observed in the spring were assumed to be Y+. We treated coho that were > 50 mm as Y+ until YOY were found that were > 50 mm in spring. Afterwards, fork length frequencies were used to separate year classes.

We used a similar approach to calculate populations for each species and size/age class using a two-trap analysis for Caspar Creek. All fish captured and marked at the two traps above the confluence of the North Fork and South Fork were treated as the marked and released portion in the Darr input matrix; all marked fish recaptured at lower trap were treated as recaptured in the matrix.

Summer Rearing

We conducted a pilot over-summer rearing abundance survey in late-summer 2006, which followed methods of Neillands (2005). First, Pudding Creek was stratified into four reaches based on stream size, gradient, and tributary input. Then, each of these four reaches was divided into 0.5 km segments and one segment from each reach was randomly selected. Following that, each 0.5 km reach was habitat typed and habitat units were selected for conducting salmonid abundance dive counts. Finally, we selected a subset of the dive units for multiple pass dive counts and another for electro-fishing calibration following Hankin and Moore (unpublished). We analyzed the data for each reach and determined average reach estimates. We calculated the total population estimates for each species and size class by multiplying average density by the total length of habitat in Pudding Creek.

Survival

We estimated smolt to adult survival for three streams over four years from smolt abundance data from 2001 to 2004 (Harris 2001, 2002, 2003, 2004) and adult return data from 2000 through 2004-05 (Gallagher 2005b, Appendix 1) and 2005-06. We calculated spawner recruit (spawner/spawner) ratios from data from Gallagher (2005b, Appendix 1) combined with our 2005-06 results.

Trends in coho Salmon Abundance

Trends in coho and steelhead abundance over seven years and three complete life cycles of coho (2000 to 2003 and 2003 to 2006) were examined following Gallagher and Knechtle (2004) and Gallagher (2005b). Trent MacDonald used this data to develop a statistical package for detecting trends in coho salmon abundance from regionally collected data (see MacDonald et al. 2007 for discussion of trend detection methods). To determine if the slope of adult abundance versus year from 2000 to 2006 for each stream differed from zero or from one another, we graphically examined and statistically tested them. Coho and steelhead redd counts and redd densities versus year were similarly examined for trends.

Effort

The spawning survey protocols of Gallagher et al. (2007) and Gallagher and Knechtle (2004) include instructions for recording information on total drive time drive to and from each site and total time to survey each reach. We used this information and estimates of driving distance, mileage rate, and staff time costs to estimate costs per survey reach for regional monitoring. We used similar effort estimates to determine costs for monitoring adult escapement at the LCS.

Data Analysis

Analysis and calculation of the redd data and AUC escapement followed Gallagher and Gallagher (2005) and Gallagher (2005b). An ANOVA or the Kruskal-Wallis ANOVA on ranks when Standard Kurtosis p-values were < 0.05 were used to test if estimates *rt* and *e* were different among streams or over years. Relationships between capture-recapture, releases above the Noyo River ECS, and AUC escapement estimates and redd counts were examined with correlation. Repeated measures ANOVA, treating years or streams as samples, was used to test for differences in survival estimates among streams and over years. Bland-Altman analysis (Glantz 1997) was used to determine if redd counts, escapement based on redd counts, and AUC escapement estimates and capture-recapture escapement estimates were equally reliable metrics for monitoring escapement. We compared population estimates with ANOVA or the Kruskal-Wallis ANOVA on ranks when Standard Kurtosis p-values were < 0.05. Statistical significance was accepted at $p < 0.05$, although, endangered species management often accepts statistical significance at the < 0.10 level (Pete Adams, NOAA Fisheries Santa Cruz, Personal Communication).

RESULTS

High stream flows limited spawning surveys during 2005-06, particularly during late-December (Figure 7). Noyo River peak flows ≥ 284 m^3/s have only been recorded 15 times over the last 54 years, two of these events were in late-December 2005. Also, we could not survey a large portion of the upper Noyo River until late-December due to access issues.

LCS Capture-Recapture Experiments

Because the Caspar Creek weir failed in late-December 2005, we only captured and tagged eight coho salmon there. Thus, the live coho capture-recapture had large 95% confidence bounds (Table 4). On the spawning grounds over nine weeks, we observed 28 coho salmon, of which only one was tagged. The use of weed mat and chain link fence greatly reduced scour around the hard parts of the weir. At the ECS 78 coho were captured and marked over eight weeks. On spawning ground surveys above the ECS, we observed 24 coho salmon, 10 of which were marked. The live coho capture-recapture escapement estimate above the ECS was 0.48-0.62 of the point estimate (Table 4). Uncertainty in the live coho capture-recapture estimate for Pudding Creek was within 20% of the point estimate (Table 4). At the Pudding Creek dam and fish ladder, we captured 349 coho salmon, tagged 345, and recaptured 11 of these (fish that went back over the dam and then back up the ladder) fish over 6 weeks. During nine weeks of spawning ground surveys, we observed 106 live coho salmon of which 77 were marked. The capture-recapture estimate using live fish marked at the Pudding Creek fish ladder and carcass recaptures on the spawning grounds was 801–1083–1605. This estimate overlapped the live fish estimate but the uncertainty was 0.44 to 0.67 of the point estimate (Table 4).

The probability of a coho recaptured at the Pudding Creek fish ladder losing both a floy tag and an operculum punch was zero, floy tag loss probability was zero, and operculum punch loss probability was 0.006. The probability of a coho carcass on the spawning grounds loosing a floy tag or an operculum punch was 0.79, the probability of losing a floy tag was 0.56, and the probability of losing and operculum punch was 0.28. We did not estimate tag loss for steelhead or for coho in Caspar Creek and the South Fork Noyo River because few tagged carcasses were observed.

Coho carcass capture-recapture estimates were lower than live fish estimates and only the Caspar Creek estimates overlapped (Table 4). Because few coho carcasses were observed, we could not make carcass capture-recapture estimates for Little River, the Noyo River, or the South Fork Noyo River. We did not produce capture-recapture estimates for Chinook salmon because too few carcasses were marked and none were recaptured.

One male coho (42 cm fork length) marked at the ECS was recaptured in Caspar Creek five days later and a female coho (43 cm fork length) marked at Pudding Creek was observed in the ECS 30 days after being tagged. Stray rate based on this data was 0.013 for ECS marked fish and 0.003 for Pudding Creek marked fish.

Uncertainty associated with the Caspar Creek live steelhead capture-recapture estimate ranged from 0.14-0.89 of the point estimate (Table 5). Because the hybrid Floating Board Resistance weir failed no steelhead were captured in it. However, six steelhead were captured and marked and three were recaptured in fyke traps in Caspar Creek. We did not generate a capture-recapture estimate for steelhead above the ECS because no marked steelhead were observed there. However, we were able to use capture-recapture to estimate escapement for the entire Noyo River (Table 5), but the uncertainty in this estimate was large because only one tagged steelhead was observed during spawning ground surveys. Eight steelhead were captured and tagged at the ECS over 21 weeks and one in a fyke trap on the South Fork Noyo. During spawning ground, surveys one tagged and 51 untagged steelhead were observed in the Noyo River. The Pudding Creek steelhead capture-recapture estimate had large confidence bounds. Over 12 weeks a total of 26 steelhead were captured in the Pudding Creek fish ladder, 17 of these were marked and one was recaptured. Three steelhead were observed during spawning surveys on Pudding Creek, one of which was marked.

Spawning Ground Surveys

Coho redd count observer efficiency was similar among the intensively and extensively monitored streams (Table 6). The total number of coho redds in each stream ranged from seven to 184 and was lowest in Little River (Table 6, Appendix 2). Coho redd density ranged from 1.51 to 5.52/km in the five study streams. Steelhead redd count observer efficiency varied among streams and was lower than that estimated for coho redd counts (Table 7, Appendix 2). The total number of steelhead redds in each stream ranged from 34 to 326. Steelhead redd density ranged from 1.11 to 7.6/km. Chinook salmon redds were only observed in the Noyo River. We surveyed 12 of 23 GRTS reaches known to be used by Chinook during 2005-06. Chinook redd count observer efficiency was 0.33. In the Noyo River we estimated 6 – 13 – 27 Chinook redds and a redd density of 0.19/km (SE = 0.10).

Escapement Estimates

Redd Area and One Redd Per Female

Coho redd area escapement estimates were lower than the live fish capture-recapture estimates in the LCS streams (Table 6). Coho escapement based on the assumption of one redd per female only overlapped the live fish capture-recapture estimates in Caspar Creek (Tables 4 and 6). Coho redd area escapement estimates did not overlap estimates based on one redd per female, fish per redd, or the AUC. Steelhead redd area escapement estimates overlapped the capture-recapture estimates in Caspar and Pudding creeks and the Noyo River (Tables 5 and 7). Steelhead redd area escapement estimates overlapped the fish per redd and AUC estimates (Tables 5 and 7). Chinook salmon escapement based on one redd per female was 2-13-27 in the Noyo River during 2005-06.

Spawner: Redd Ratios

Coho spawner: redd ratios varied among the three LCS streams (Table 2). The number of fish per redd above the ECS over six years (2000 to 2005-06) was not significantly different from the number of fish per redd in Pudding Creek during 2004 through 2005-06 ($T = 19.0$, $p = 0.38$, n = 6:3, Table 2). However, these data were not normally distributed (K-S Dist. = 0.34 $p = 0.03$) and the 2005-06 estimates in Pudding Creek and above the ECS were much higher than pervious years estimates. To account for annual differences in stream flow, visibility, and the number of fish per redd, we used the 2005-06 three stream average number of coho per redd of 3.32 - 8.02 - 11.40 to expand redd counts to escapement estimates for all streams during 2005-06 (Table 4). Escapement estimates based on the 2005-06 three stream average spawner: redd ratio overlapped the capture-recapture estimates (Table 4).

Steelhead spawner: redd ratios varied between the two LCS streams where capture-recapture estimates were made (Table 2). Like the coho estimates, the number of steelhead per redd in the Noyo River (2000 to 2003 and 2006) was not significantly different from the number of fish per redd in Pudding Creek during 2004 through 2005-06 ($t = 1.16$, $df = 6$, $p = 0.29$, ß = 0.08). However, unlike the coho estimates, the 2005-06 estimates in the Noyo River and Pudding Creek were lower than the previous years estimates (Table 2). To account for annual differences in stream flow, visibility, and numbers of fish per redd we used the 2005-06 two stream average steelhead per spawner: redd ratio (0.14 – 0.64 – 1.29) to expand redd counts to escapement for all streams during 2005-06 (Table 5). Steelhead escapement estimates based on these variables overlapped the capture-recapture estimates (Table 5).

AUC

Based on overlap with coho live fish capture-recapture estimates the most reliable coho AUC escapement estimates resulted from using the 2005-06 three stream average *rt* and *e* calculated as the total observed marked divided by the total marked (Table 4, Appendix 3). Coho residence time was significantly different between Pudding Creek and the South Fork Noyo River over the last four years (ANOVA F = 3.22, df = 183, p = 0.005, ß = 0.77, Table 3). Examined individually coho *rt* was different between the South Fork Noyo River in 2002-03 and the South Fork Noyo River and Pudding Creek in 2003-04 (Tukey's q > 4.32, p < 0.04). Thus the use of the 2005-06 three stream average *rt* of 15.03 - 21.73 – 28.42 days seamed reasonable. Live fish observer efficiency was the same as predicted from stream flow in Pudding Creek (Appendix 3), but it was higher in Caspar Creek and above the ECS (0.22 and 0.18, respectively).

Based on overlap with live fish capture-recapture estimates the most reliable steelhead AUC escapement estimates were calculated using the 2000-05 average *rt* and *e* estimated as the total observed marked divided by the total marked in each stream (Appendix 3). Steelhead *rt* was significantly different among streams and years (ANOVA F = 3.71, df = 34, p = 0.006, ß = 0.82, Table 3). Steelhead *rt* was significantly different between the main stem Noyo River, its' tributaries, and Pudding Creek (Tukey's q > 4.32, p < 0.04). We observed too few tagged steelhead in any of the LCS streams to estimate *rt* for 2005-06. Thus, we used the multi-year multi-stream average residence time of 11.33 – 15.43 – 19.54 days. Because we did not observe tagged steelhead during spawning surveys in Caspar Creek, we predicted *e* by using the relationship between observation ability and water visibility presented by Gallagher and Gallagher (2005).

The Chinook AUC escapement (without estimates of *e*) for the Noyo River during 2005-06 was 8-32-73. The Chinook salmon female: male ratio in the Noyo River was 1.00:1.00.

Bias in Spawning Ground Survey Escapement Estimates

Combining the 2005-06 coho escapement estimates with data from Gallagher (2005a-b) (Appendix 1) and treating years as samples, spawning survey based escapement estimates (redd area, one redd per female, fish per redd, and AUC) were not significantly different than releases above the ECS (ANOVA F = 2.09, df = 29, p = 0.21, ß = 0.16). Redd counts and releases above the ECS were significantly correlated (r = 0.86, p = 0.03, n = 6). Treating years as samples for Pudding Creek 2003-04 to 2005-06, capture-recapture escapement estimates were not significantly different than estimates based on redd area, one redd per female, fish per redd, AUC or carcass capture-recapture (ANOVA F = 2.38, df = 17, p = 0.11, ß = 0.30). Redd counts and coho live fish capture-recapture estimates were not significantly correlated over three years in Pudding Creek (r = 0.99, p = 0.07, n = 3).

Bland-Altman analysis (Glantz 1997) suggests that coho escapement based on spawner: redd ratios were equally reliable to capture-recapture estimates. The two variables showed high correlation (r = 0.84), the mean difference and standard deviation between the measures was low, the data for the difference between the measures and the mean of the two were within two standard deviations, and the mean and the difference between the two measures were not significantly correlated ($r = 0.58$, $p = 0.60$). Coho AUC and live fish capture-recapture, redd counts, redd area, and one female per redd escapement estimates were not equally reliable measures of escapement.

Treating years and rivers as samples (Noyo River 2000-2003 and 2005-06, Pudding Creek 2003 to 2005-06, and Caspar Creek 2005-06, Appendix 1) steelhead capture-recapture, redd area, one redd per female, fish per redd, and AUC escapement estimates were significantly different (ANOVA $F = 4.55$, $df = 35$, $p = 0.01$, $ß = 0.71$). When examined individually, only redd area and AUC escapement estimates were significantly different (Tukey's $q = 5.20$, $p = 0.006$). Redd counts and live fish capture-recapture estimates were significantly correlated ($r = 0.86$, $p = 0.003$, $n = 9$). Bland-Altman analysis suggests that steelhead capture-recapture, spawner: redd ratio, and redd area escapement estimates were equally reliable. However, AUC and capture-recapture escapement estimates were shown to be not equally reliable.

Regional Escapement

Reach lengths measured in the field and estimated from GIS layers in ArcView© were not significantly different ($W = 74.0$, $p = 0.3$, Table 1) and were significantly positively correlated ($r = 0.87$, $p < 0.001$, $n = 27$). We used these data to develop to a statistically significant ($r^2 = 0.76$, $p < 0.01$) predictive model for correcting GIS measured reach lengths (Equation 1) and used it to correct GIS measured reach lengths for GRTS frame.

Equation 1: Measured stream length (km) = 0.233 + (0.915 * GIS length).

The total number of coho and steelhead redds estimated by the regional 33% sum of stream design were similar to the 10% and 48% GRTS estimates (Table 8). The statistical uncertainty was greater at 10% GRTS sampling rate than at 48%. The variance associated with mean coho redd density did not substantially decrease after 30 reaches (Figure 8). The variance associated with mean steelhead redd density did not substantially decrease after 32 reaches (Figure 9). The average coho and steelhead redd densities at 10% and 48 % GRTS sampling were similar, but had higher variance at 10% (Tables 8-9). Coho GRTS redd density was within the bounds estimated for all five streams (Table 6). The GRTS steelhead redd density estimate was within the bounds estimated for four of the five streams (Tables 7 and 9). The total number of Chinook salmon redds in the Noyo River was within the range estimated from 5% and 20%GRTS sampling (Table 10). Chinook salmon redd density calculated at 5% was similar to the 20% estimate, but had higher variance.

Coho redd area and one redd per female escapement from the regional 33% sum of streams design were within the range estimated by 10% and 48% GRTS sampling (Table 8). The confidence bounds for these estimates were tightest using the summation of streams and the highest for the 10% GRTS expansions. The redd area and one redd per female GRTS sampling estimates were within 25% of the sum of stream estimates, except for the one fish per redd estimate from 10% GRTS (Table 8). Steelhead redd area escapement from the regional 33% sum of streams were within the range estimated by 10% and 48% GRTS sampling (Table 9). Steelhead redd area escapement estimates from 10% and 48% GRTS sampling were < 25% of the regional 33% sum of stream estimates.

Coho and steelhead spawner: redd ratio escapement estimates from the regional 33% sum of streams were within the range estimated by 10% and 48% GRTS sampling (Tables 8-9). The coho and steelhead GRTS estimates at 48% and steelhead GRTS estimates at 10% were < 25% of the regional 33% sum of stream estimates. The variance about the cumulative average coho and steelhead redd area, one redd per female, and fish per redd density followed the redd density pattern and it did not substantially decrease after 32 reaches (Figures 8 and 9).

The coho and steelhead AUC 33% sum of streams and the GRTS sampling estimates overlapped (Tables 8-9). The variance was lowest for sum of streams and highest for 10% GRTS sampling. However, the 33% sum of streams and the GRTS sampling AUC estimates differed by > 25%. The variance associated with mean coho and steelhead AUC density did not substantially decrease after about 8 reaches (Figures 10 and 11).

The Chinook salmon one redd per female and the AUC escapement estimates for stream specific sampling in the Noyo River overlapped the 5% and 20% GRTS estimates. We did not estimate escapement by redd area or fish per redd for Chinook because there were no capture-recapture estimates for comparisons. It was not possible to make Chinook or coho carcass capture-recapture escapement estimates at the regional level using 33% sum of streams or GRTS sampling because too few carcasses were observed.

Smolt Abundance

Coho smolt abundance estimates were highest in Pudding Creek and lowest in the North Fork South Fork Noyo River in spring 2006 (Table 11). We PIT tagged 963 coho in Caspar Creek, 971 in the South Fork Noyo River, and 5898 in Pudding Creek. A large number of two year old (Figure 12) coho smolts were observed in Pudding Creek but not in the other study streams. Capture probability for all traps ranged from 0.09 to 0.63 and was lowest for the two-trap method in Caspar Creek.

Steelhead year old smolt abundance estimates were highest for the two-trap method in Caspar Creek and lowest in the South Fork Noyo River in spring 2006 (Table 12). A total of 306 steelhead were PIT tagged in Caspar Creek, 232 in the South Fork Noyo River, and 426 in Pudding Creek. We observed the largest numbers of two-year-old steelhead smolts in Pudding Creek and the lowest in Little River. Capture probability for year old smolts ranged from 0.01 to 0.72 and was lowest for the two-trap method in Caspar Creek. Capture probability for two year and older steelhead smolts ranged from 0.02 to 0.55.

The percentage of salmonid smolts recaptured multiple times or in more than one trap was generally low (Appendix 4). The time between capture and recapture ranged from a few days to over one month. The proportion of fish showing delayed migration was lower for steelhead than for coho, but overall it was rather low.

Summer Rearing

Steelhead young-of-the-year (YOY) summer rearing density in Pudding Creek ranged from 0.08 fish/m^2 to 0.40 fish/m^2 and was highest in the upper reach (Table 13). However, we estimated there was more YOY steelhead in the lower part of the stream than in the upper reach. Steelhead year old (Y+) and two year and older (Y++) density was highest in the upper reach of Pudding Creek, but we estimated higher overall populations in the lower reach.

Similar to our findings for steelhead, YOY coho summer rearing density was higher in the upper reach than in the lower reaches (Table 13). However, our population estimates suggest there were more YOY coho in the lower reach than in the upper reaches. Coho Y+ summer rearing density and population estimates were similar among all four reaches (Table 13). During electro-fishing in the lower Pudding Creek reach we recaptured seven Y+ coho salmon that were PIT tagged during downstream trapping and from this estimated there were approximately 811 PIT tagged coho in this reach. This suggests that 19.5% of coho salmon PIT tagged in the downstream trap did not go to the ocean during spring 2006. However, it should be noted that this is based on seven individuals captured in two small electro-fishing reaches that occurred in approximately 7 km of stream channel.

We estimated there were about twice as many YOY coho than steelhead YOY in Pudding Creek during summer 2006 (Table 14). There were three times as many rearing Y+ steelhead than coho in Pudding Creek during summer 2006 (Table 14).

Survival

Coho smolt to adult survival was similar among streams over four years and ranged from 0.01 to 0.16 (Table 15). Treating years as samples smolt to adult survival was not significantly different among streams (ANOVA $F = 3.56$, $df = 13$, $p = 0.08$). However, the power of this test was low ($ß = 0.39$).

Recruits per spawner ratios were greater than 1.00 for all returns except the 2002-03 to 2005-06 cohort (Table 15). Treating years as samples recruits per spawner estimates were not significantly different among streams (ANOVA $F = 0.43$, $df = 15$, $p = 0.81$). The power of this test was low ($ß = 0.05$). When the streams were treated as samples, recruits per spawner estimates were not significantly different over four years (ANOVA $F = 3.03$, $df = 15$, $p = 0.10$). However, the power of this test was low ($ß = 0.32$).

Trends in coho Salmon Abundance

There were no significant trends in coho escapement over three life cycles in three streams ($t = 1.56$, $df = 4$, $p = 0.15$, Figure 13a). In Pudding Creek and the Noyo River there appeared to be a drop in adult coho escapement over two life cycles (Figure 13a). There were no significant trends in coho escapement over seven years (T = 51 (6, 6), p = 0.06, Figure 13b). The slopes of the regressions of escapement versus year for Little River, the Noyo River above the ECS, Caspar and Pudding creeks over seven years was significantly positive (T = 26, (4,4), p = 0.03). There was no trend in coho redd density and redd counts in all the study steams over seven years (T > 45, p > 0.06, Figures 14a-b, 15 a-b). The slopes of the regressions of redd counts and redd density versus year for Little River, the Noyo River above the ECS, Caspar and Pudding creeks over seven years was significantly positive (T >22, p = 0.03, Figures 14a-b, 15a-b).

The slopes of steelhead AUC escapement versus year was not significantly different than zero in the study streams over five years (T = 39, (6, 6), p = 1.00, Appendix 1). The slope of steelhead redd counts versus years in the study streams over six years was not significantly different than zero (t = 0.31, df = 5, p = 0.76, ß = 0.05, Figure 14c). The slope of steelhead redd density versus years in the study streams over six years was not significantly different than zero (T = 45, p = 0.39, Figure 15 a, c).

Effort

We surveyed each LCS and regional spawning reach approximately eight times between 1 December 2005 and 30 March 2006 (range 3-10). It took on average 12.6 person hours (range 5.8 to 18.6) to prepare for, drive to and from, and survey one reach (for safety each survey requires two people). The average driving distance per reach was 45.3 km (range 16 to 150 km). Survey time and thus costs increased with increasing numbers of reaches (Table 16). It took between 400 and 495 person hours to operate the adult capture facilities used in this study (Table 17). Construction and deployment of the hybrid Floating Board Resistance weir took about 220 person hours. We spent over 200 person hours entering and checking data. We spent approximately 660 person hours developing and refining our database, working on data queries, and working on developing handheld computer data collection. It took approximately 3020 person hours to operate the downstream traps and over 400 person hours to enter and check the data, prepare data summaries, and run data matrices in Darr. We spent approximately 21,000$ on PIT tags and associated equipment. Data analysis and report preparation took about 450 person hours.

DISCUSSION

LCS Capture-Recapture Experiments

The LCS live fish capture-recapture methodology developed for this study produced generally reliable coho salmon escapement estimates for Pudding Creek and the South Fork Noyo River and provided information for reducing bias in regional spawning escapement estimates. Despite the poor survey conditions during 2005-06, we were able to observe enough coho salmon to produce reasonable escapement estimates. Krebs (1989) states that population estimates for management should have an accuracy of ± 25% and preliminary surveys should be ± 50%. Uncertainty in the live coho capture-recapture estimate for Pudding Creek was < 20% of the point estimate (Table 4). Above the ECS, uncertainty was 0.48-0.62 of the point estimate. Tag loss on live fish was minimal and thus did not influence population estimates.

The flashboard dam and fish ladder at Pudding Creek worked reasonably well for capturing and tagging coho salmon and steelhead. Improvements we made to the facility increased our efficiency in processing fish and reduced fall back of tagged fish. High flows during 2005-06 allowed coho to circumnavigate the fish ladder and < 27% of the coho observed in Pudding Creek were untagged. The ECS was less effective at capturing coho salmon during high flow events, as > 58% of the fish observed above this structure were untagged. During high flows, fish can swim over the ECS apron. Because we were inexperienced with trap operations during peak events, the structure was flooded and filled with debris twice during 2005-06. After each flood event, we were then required to wait over a week to clean the ECS facility, during which time fish were not captured. However, we gained valuable operational experience during 2005-06 that should help increase our future capture efficiency.

The coho and steelhead capture-recapture estimates for the other LCS streams (Tables 4-5) had large confidence bounds due to the low numbers of marked and recaptured fish. Reflecting the small sample size, the respective 95% confidence intervals ranged from 0.03 to 0.89 of the point estimates. The same peak hydrologic events that hindered our trapping and tagging operations also limited our ability to conduct spawning ground surveys. The 2005-06 water year was the first since 1999-2000 where high flows limited surveys so severely. High flows were seen throughout the region. In December 2005, Russian River flows were the highest on record since the early 1950's. Boydstun and MacDonald (2005) acknowledge that stream flows will limit salmonid monitoring activities in some years. The 2005-06 season was one of these anticipated seasons.

In Caspar Creek, our Floating Board Resistance weir failed due to high flows and the resulting heavy debris load that collapsed the supporting tripods. Because we installed weed matt and chain link fence on the stream channel below the weir, the damage was not a result of scour, a common problem with temporary weirs in coastal streams. The use of this material greatly reduced scour and should improve temporary weir functions in coastal streams. For the 2006-07 season, we believe the improvements made to the Caspar Creek weir should increase capture probability and consequently improve escapement estimates. There are improvements to the other LCS trapping stations that may be made as well. For example, the number of steelhead captured and tagged in Pudding Creek during spring 2007 might be increased by the use of fyke traps. At the ECS, adding light to the entrance might increase steelhead captures, as it appears they are averse to dark places.

We were only able to produce coho carcass capture-recapture estimates for two of the three LCS streams (Table 4). These estimates had wide confidence bounds, which were > 25% of the point estimates and only overlapped the live fish estimate in Caspar Creek. We observed few to no coho and Chinook salmon carcasses in the streams surveyed during 2005-06. High flows between surveys can bury, wash away, or otherwise decrease the chance of finding carcasses and Cederholm et al. (1989) found that the occurrence of buried carcasses was greatly underestimated. As stated above, high stream flows limited our survey abilities this year. In earlier studies in these streams, Gallagher (2005a-b) found that carcass capture-recapture escapement underestimated known releases of coho above the ECS and recommended against using this technique for population monitoring. We found that carcass capture-recapture was not reliable for monitoring populations in coastal streams.

Spawning Ground Surveys

Our results suggest that redd counts were reasonable indices of salmonid escapement. Similar to previous work in this area (Gallagher 2005a-b) redd counts were significantly correlated with capture-recapture estimates and steelhead redd counts and capture-recapture estimates appeared to be equally reliable. However, during 2005-06 we found that coho redd counts were lower than would be expected based on the number of females estimated by capture-recapture experiments and that they were not equally reliable to these estimates. Contrary to this Gallagher (2005b) found that coho redd counts were as reliable as live fish capture-recapture. This suggests that redds were missed due to high flows during spawning surveys in 2005-06. The high stream flows during 2005-06 likely scoured or otherwise obscured redds between surveys.

Escapement Estimates

Redd Area and One Redd Per Female

The Redd area method was reliable for estimating steelhead escapement. Because survey conditions were better later in the season steelhead redd area escapement estimates were similar to capture-recapture and AUC estimates. The steelhead redd area 95% confidence estimates were < 25% of the point estimates in five of six streams. Gallagher and Gallagher (2005) found that steelhead and coho redd area and capture-recapture escapement estimates were not different and recommended using redd areas for estimating escapement. Although coho redd area and one redd per female 95% confidence estimates were generally < 25% of the point estimates they were lower than capture-recapture estimates. Therefore, we concluded that they were unreliable this season as a result of high stream flows.

Spawner: Redd Ratios

Converting bias corrected coho and steelhead redd counts to fish numbers using the 2005-06 three stream mean spawner: redd ratios produced escapement estimates that were as reliable as the capture-recapture estimates. Gallagher (2005a-b) found similar results and that spawner: redd ratios were transferable among streams. However, due to the variance in the spawner: redd ratios, resulting from poor survey conditions and possibly small sample size, the 95% confidence estimates were > 25% of the fish per redd point estimates. The 2005-06 coho ratios were much higher than previous year's estimates. Consequently the multiyear average spawner: redd ratio (Table 2) did not produce escapement estimates that overlapped the capture-recapture estimates. Dunham et al. (2001) found considerable annual variation in bull trout spawner: redd ratios in Idaho, which they attributed to life history variation, or bias in redd counts. Al-Chockachy et al. (2005) attributed variation in bull trout spawner: redd ratios to differences in contributions from different life history forms. During 2005-06 variation in coho and steelhead spawner: redd ratios was mostly likely due to poor survey conditions.

The number of steelhead per redd in coastal Mendocino County was not different than reported by Susac and Jocobs (2002) for coastal Oregon rivers. They found annual variation in steelhead spawner: redd ratios similar to our results. The spawner: redd ratios resulting from this study and those of Susac and Jocobs (2002) were somewhat lower than 1.2 female steelhead per redd reported by Duffy (2005). Our escapement estimates using the multiyear average steelhead spawner: redd ratios (Table 2) were similar to capture-recapture estimates, which suggests that conditions for steelhead redd counts were favorable during the later part of the 2005-06 season. Converting bias corrected redd counts with spawner: redd ratios may be reliable for long term monitoring, yet further evaluation of this technique is warranted.

AUC

The AUC method is sensitive to the time between surveys and estimates of *rt* and *e* (Hilborn et al. 1999) which should be estimated annually for each stream (English et al. 1992, Manske and Schwarz 2000). The 2005-06 estimates of *rt* and *e* were generated from capture-recapture experiments in the LCS streams. The AUC estimates using these variables were not different than capture-recapture estimates and were similar to those developed from redd counts and spawner: redd ratios. This suggests the use of these values was reasonable. Although the AUC 95% confidence bounds were > 25% of the point estimates for all streams, the capture-recapture and AUC estimates for Pudding Creek and the ECS were < 25% of their respective point estimates. Because the AUC and capture-recapture data are interrelated improving capture-recapture estimates at LCS streams will improve AUC estimates.

Lestelle and Weller (2002) found that AUC escapement estimates were more reliable than redd count estimates at high spawner abundance and that redd counts were better at low spawner abundance. Live coho may be more readily detected than redds during surveys conducted when conditions are marginal. Therefore, live fish observations may have utility for producing escapement estimates during water years such as encountered in late-December 2005 and early-January 2006. The use of LCS streams to estimate *rt* and *e*, to develop multiyear average values, and to refine predictive relationships between *e* and stream flow/visibility may improve AUC escapement estimation.

Bias in spawning ground survey escapement estimates

Coho AUC, redd area, and one female per redd escapement estimates did not produce estimates similar to capture-recapture methods during 2005-06. Gallagher and Gallagher

(2005) found no difference between ACU, redd area, and one redd per female escapement estimates and recommended using redd areas. Gallagher (2005a) found redd area and one redd per female escapement estimates equally reliable to capture-recapture and AUC escapement estimates. Treating years as samples, redd area and one redd per female estimates were not significantly different. However, they were substantially lower than capture-recapture and AUC during 2005-06. This is most likely due to undercounting of redds due to high stream flows.

Steelhead redd area, spawner: redd ratios, and capture-recapture escapement estimates were equally reliable and transferable among streams. Gallagher (2005a, 2005b) found similar results with annual spawner: redd ratios and states that they were transferable among streams. Gallagher and Gallagher (2005) found that steelhead capture-recapture, AUC, and redd area escapement estimates were not different and recommended using redd areas. In this study as in previous studies (Gallagher and Gallagher 2005, Gallagher 2005a-b) redd counts and escapement estimates were significantly correlated, consequently redd counts themselves might serve as useful annual indices of escapement.

Converting bias corrected coho redd counts to fish numbers using annual average spawner: redd ratios produced escapement estimates that were equally reliable as capture-recapture estimates and were transferable among streams. Gallagher (2005b) suggests using multiyear average spawner: redd ratios to convert redd counts into escapement estimates. When we used the 2002-03 through 2005-06 average coho per redd (Table 2) to convert redd counts to escapement it underestimated escapement relative to capture-recapture estimates. This is due to the noted difficulties counting coho redds during 2005-06. Therefore, we now believe that annual spawner: redd ratios from LCS streams should be used to convert redd counts into escapement estimates. The spawner: redd ratios developed in this study appear useful for regional monitoring of coastal salmonids. However, we recommend annual evaluation of the relationship between redd counts, redd based escapement estimates, and capture-recapture estimates to determine the best method for estimating abundance from spawning ground survey data.

Regional Escapement

The stream reach lengths from GIS were very similar to field measured lengths and, since the mean difference between measured and GIS based reach lengths was less than 30 m, using uncorrected GIS stream lengths for future monitoring seems reasonable. Carcass capture-recapture did not work for producing individual reach densities for the GRTS sampling escapement estimates at the regional scale.

Boydstun and MacDonald (2005) state that the most important feature of GRTS sampling is that it produces a randomized sample of units such that any contiguous subset of units constitutes a spatially balanced group of units. They further suggest that a sampling rate of 10% should be used for regional monitoring. We selected the first eight reaches in Table 1 for GRTS sampling of our hypothetical region during 2005-06. We also used a systematic sample of 37 reaches (48%) to evaluate sampling rate. The performance curves for redd density (Figures 8-9) indicate that sampling eight reaches was insufficient for encompassing the variation in redd density for regional sampling. However, redd were likely undercounted due to high stream flows during 2005-06 as stated above. With better survey conditions eight out of 76 reaches might prove sufficient. The bootstrap population estimates also support the idea that eight reaches were insufficient during 2005-06 (Tables 8-10). Krebs (1989) states that population estimates should be accurate to ± 25% for management purposes. Jacobs and Nickelson (2005) had confidence levels within 28% for coast wide monitoring of coho in Oregon. In our study the GRTS population estimates at 10% and 48% sampling rates were within 25% of the "true" sum of streams estimates (Tables 8-10). The GRTS redd density estimates generally overlapped the individual stream values (Table 6-10) at 10% and 48% sampling and variance about the mean redd density did not substantially decrease after about 32 reaches (Figures 8-9). Boydstun and MacDonald (2005) state that > 30 GRTS samples are necessary for use of the normal approximation to estimate 95% confidence bounds for regional population estimates. Based on these results it seems likely that a sample draw of > 30 GRTS reaches will be necessary for monitoring all streams supporting coastal salmonids in California. We found that the variance about the mean redd densities were less with the 48% sampling as were the 95% confidence bounds about the population estimates (Tables 8-10), furthering the notion that > 30 reaches should be sampled at the regional level (e.g. the entire coast of California).

The GRTS and the sum of streams population estimates overlapped each other when examined by the estimation method. The variance was less at 48% sampling than at 10%. Although the performance curves for AUC density suggest that 10% sampling was reasonable the variance for these estimates was greater than that of redd based estimates. Coho GRTS redd area and one female per redd escapement estimates were less than the sum of streams AUC and fish per redd estimates as a result of difficulties counting redds due to high stream flows during 2005-06. The AUC and fish per redd escapement estimates from GRTS sampling overlapped one another but Bland-Altman analysis suggest both were not equally reliable measures of abundance. Our results suggest that the use of GRTS sampling of > 30 reaches and the use of spawner: redd ratios to expand redd counts to population estimates will likely produce reasonable escapement estimates for monitoring California's coastal salmonids as described by Boydstun and MacDonald (2005). With another years data these relationships should improve. We recommend further evaluation of the use of LCS data to convert reach specific SGS data into regional estimates.

Smolt Abundance

The use of a screw trap in Pudding Creek allowed sampling of smolt abundance in higher stream flows than could be sampled with fyke traps. Due to the success of the screw trap in Pudding Creek we plan on purchasing and deploying another screw trap on the South Fork Noyo River during spring 2007. Pit tags provided individual marking and data on multiple recaptures. Only a small proportion of fish were captured multiple times or showed delayed migration and they did not have a substantial effect on abundance estimates. Because the PIT tags provide unique individual marks we were able to account for these multiple recaptures when developing input matrices for Darr and thus reduced this potential source of error in the estimates. In 2008-09, pit tagged smolts returning as adults should provide useful information on ocean survival.

In Pudding Creek we captured a large proportion of coho salmon > 120mm, our established cut off between age one and age two coho salmon. Based on fork length frequencies we assumed these fish were age two (Figure 12). Bell (2001) states that age-two coho smolts had not been documented in California prior to his discovery of them using PIT tags in Prairie Creek, Humboldt County. He states that 28% of fish captured during the second year of the study were age two. In Pudding Creek during 2006 about 22.5% of the smolts were two year olds. Our over-summer data suggests that about 20% of the year old coho tagged in spring 2006 remained in Pudding Creek an additional year. The maximum size two year old coho smolt reported by Bell (2001) was about 110 mm. Because many of the fish we captured in Pudding Creek were > 110 mm, they may be more than two years old. According to ODFW (1996) coho smolts remain in streams for two or three years in British Columbia, the coldest part of their range. Water temperatures in Pudding Creek are similar to those of the other coastal streams we studied and we did not observe coho > 120mm in any other streams during 2006. Fish this size have not been captured during summer electro-fishing survey conducted in this stream since 1989 (Scott Harris, CDFG, Personal Communication). Nor have they been observed by CTM electro-fishing surveys conducted in many local streams since 1993. The large coho in Pudding Creek may be a result of the dam. After observing dam operations for two hydrologic seasons, it seems that some late-season smolts may not be able to migrate past the structure in summer. However, our trapping operations indicate downstream migration may still occur during this period. These two events seemingly present a scenario that delays migration, forcing the delayed fish to reside in the stream for an addition year. At this point, however, the implication of delayed migration due to dam operation is conjecture. Determining possible causes for these larger presumably older coho in Pudding Creek will require further research and monitoring.

Summer Rearing

Summer rearing density estimates for steelhead and coho were similar to those reported recently for the Noyo River (Gallagher 2003). Coho salmon summer rearing densities were similar to those reported by Ebersole et al. (2006) in coastal Oregon. Summer rearing population estimates for Pudding Creek in 2006 combined with smolt abundance data for 2007 will likely be useful for estimating over winter survival. Our YOY coho summer rearing population estimate was considerably less than estimated for a similar sized stream in Oregon during 2002 (Ebersole et al. 2006). The over summer rearing population estimate was similar to calculated summer rearing numbers using the 2005-06 female escapement estimate and assuming 3000 eggs per female (Shapovalov and Taft 1954) and an egg to summer survival rate of 0.025 (14112 – 17016 – 21312). This suggests that using reach expanded electro-fishing calibrated dive counts to estimate summer rearing abundance was reasonable. The percentage of over summering one year old coho was similar to that reported by Bell (2001) in Prairie Creek, Humboldt County.

Survival

Smolt to adult survival over four smolt to adult return cycles was similar to that reported by Bradford (1999), Logerwell et al. (2003), and Shapovolov and Taft (1954). Coho adult to adult survival was much higher than the average value of 0.13 reported by Shapovalov and Taft (1954). For the South Fork Noyo River this might be a result of the fact that the 1999-2000, 2000-2001, and 2002-2003 data were total counts of releases above the ECS whereas the later year's data were capture-recapture estimates. The 2002-03 adult escapement consisted of a large proportion of hatchery fish released in spring 2001 and this could affect both the adult and smolt survival estimates. Coho smolt to adult survival is influenced by ocean conditions that were generally favorable from 1999 to 2004. Ocean productivity was poor during the time of salmonid ocean entry in 2005 (Kudela et al. 2006) and adult to adult and smolt to adult survival during this period was likely negatively influenced by these conditions.

Trends in coho Salmon Abundance

In Caspar Creek, the number of coho and steelhead currently returning to spawn appears to be the same as during the early 1960's. During the 1960-61 season Kabel and German (1967) counted coho and steelhead entering Caspar Creek at a mill pond fish ladder, which was removed in summer 1961. Although not clearly stated in their report, assuming that all fish entering the stream were counted at this ladder, there were a total of 322 coho and 92 steelhead in Caspar Creek in 1960-61. Following a strict three year life cycle the offspring of the 1961 coho reproduction would be encountered 13 generations later in 2001-02 and 14 generations later in 2004-05. In 2001-02 Gallagher (2003) produced an AUC estimate of 381 (range 305-565) coho for Caspar Creek and in 2004-05 the carcass based escapement estimate was 197 (95% CI = 129-411).

We did not find significant trends in coho escapement over seven years in four streams, similar to the findings of Gallagher and Knechtle (2004). This may be a result of the length of the limited seven-year time series. Because coho generally have a rigid three-year life cycle, we might not observe trends with only seven years data. Trend detection may be more appropriate with more year's data and annual estimates examined by three-year cohorts which include potential covariates such as mean December to January stream flow, an index of the Pacific decadal oscillation or ocean survival, annual precipitation, March to June stream flow two years previous, and perhaps other values. Larsen et al. (2004) found that trend detection increased markedly with increased time series and Shea and Mangel (2001) state that statistical uncertainty in trend detection for modeled coho populations increased with shorter time series. There is increasing evidence that Pacific salmonid populations follow a decadal cycle in abundance that is related to large scale climate (Smith and Ward 2000, Smith et al. 2000). If salmonid population abundance fluctuates on decadal or longer periods, the five-year dataset examined could be too short to detect these long-term trends. However, Bradford et al. (2000) suggest their results, and others they cite, argue against the idea that regional climate variation affect coho freshwater survival. Nonetheless, the merit of this exercise was the exploration of potential methods using annual escapement estimates for trend detection. These data may also prove useful for population viability analyses (Legault 2005) such as done by Chilcote (2001) for steelhead in Oregon.

OTHER GRANT P0410527 TASKS

We finalized the study design, helped create the sample frame, and had the GRTS sample draw made.

Constructed and operated a hybrid floating board resistance weir in Caspar Creek during 2005-06 and constructed an improved floating board resistance weir for 2006-07.

Purchased, learned, programmed, and tested handheld data loggers for use in field data collection. This included refinement of the database and coordination and collaboration with Seth Ricker and others.

We tested methods and designs for a second trap on Pudding Creek to capture smolts below the fish ladder at the dam.

We redesigned our database and improved data management and analysis.

We provided outreach in the form of a newspaper article (Cover story in the Fort Bragg Advocate News 23 March 2006).

Scale collection and genetic tissue collection and archiving and scale reading.

We acquired and used of bootstrap data analysis software to produce 95% CI's.

Created GIS layers of redd locations.

Appendix 5 lists other Grant P0410527 related tasks completed for conducting this study.

RECOMMENDATIONS

This study should be continued through at least 2010 to gather data on multiple generations of salmonids and increase the data set for trend detection. After 2010, or sooner, these streams should be included in a larger coast-wide monitoring effort. In Caspar Creek we should rebuild the floating panel resistance board weir to improve captures of coho and steelhead and continue evaluation of the utility of this type of temporary weir for LCS monitoring. Increase capture and marking of steelhead by better operation of the Pudding Creek flashboard dam and the Noyo ECS. Bootstrap simulations should be used to calculate 95% confidence bounds for regional population estimates. To improve predictive models for observer efficiency capture-recapture data, stream flow, and water visibility data should be collected. The transferability of residence time, observer efficiency, and spawner: redd data should continue to be evaluated. The use of handheld Palm Pilots should be continued and refinements made to improve data collection by adding quality controls for data input. Coordination with other collecting this type of data should continue and a standardized data base should be constructed for use at the regional level for both LCS streams and regional GRTS sampling. Access agreements with landowners should be established prior to November 1st each season. A screw trap should be used in the South Fork Noyo River to estimate smolt abundance and evaluate the use of this methodology for use in other LCS streams.

We recommend annual evaluation of the relationship between redd counts, redd based escapement estimates, and capture-recapture estimates to determine the best method for estimating abundance from spawning ground survey data. The initial annual GRTS sample draw and field data collection should be increased to include GRTS reaches 1-24 to evaluate the sampling rate at 10%, 15%, 20%, 25%, and 30% for regional monitoring and to account for access issues both prior to and during the field season. Capture-recapture at LCS streams should use weekly specific colored floy tags and operculum punches with recaptures made during spawning ground surveys. Smolt abundance should be estimated annually at LCS streams using downstream migrant traps and PIT tag capture-recapture.

ACKNOWLEDGEMENTS

Pete Adams, Eric Bjorkstedt, Glen Szerlong, and Tommy Williams (NOAA Fisheries Santa Cruz), Barry Collins, Scott Harris, George Neillands, Morgan Knechtle, Seth Ricker (CDFG), Danna McCain (HSU), and Steven Levesque (CTM) helped develop this study. Personnel from the California Department of Fish and Game's Anadromous Fisheries Resource Assessment and Monitoring Program and the Central Coast Salmon and Steelhead Resource Assessment Program, Campbell Timberlands Management, and NOAA Fisheries Santa Cruz helped with collecting the data for this study. Thanks to the Mendocino Redwood Company for granting access to streams on their property. We thank Berry Collins and Gordon Reeves for providing critical comments on earlier drafts of this report.

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PERSONAL COMMUNICATIONS

Pete Adams, NOAA Fisheries Santa Cruz, January, 2007.

Sean Hayes, NOAA Fisheries Santa Cruz, August 2006.

Scott Harris, CDFG, Willits, CA December 2006.

Trent MacDonald, West Inc., Laramie Wyoming, November 2006.

Dana McCain, Institute for River Ecosystems, Arcata, CA August 2005.

Glen Szerlong, NOAA Fisheries Santa Cruz, August 2004.

Mark Zuspan, CDFG, Arcata, CA December 2006.

Figure 1. Study area in northern California.

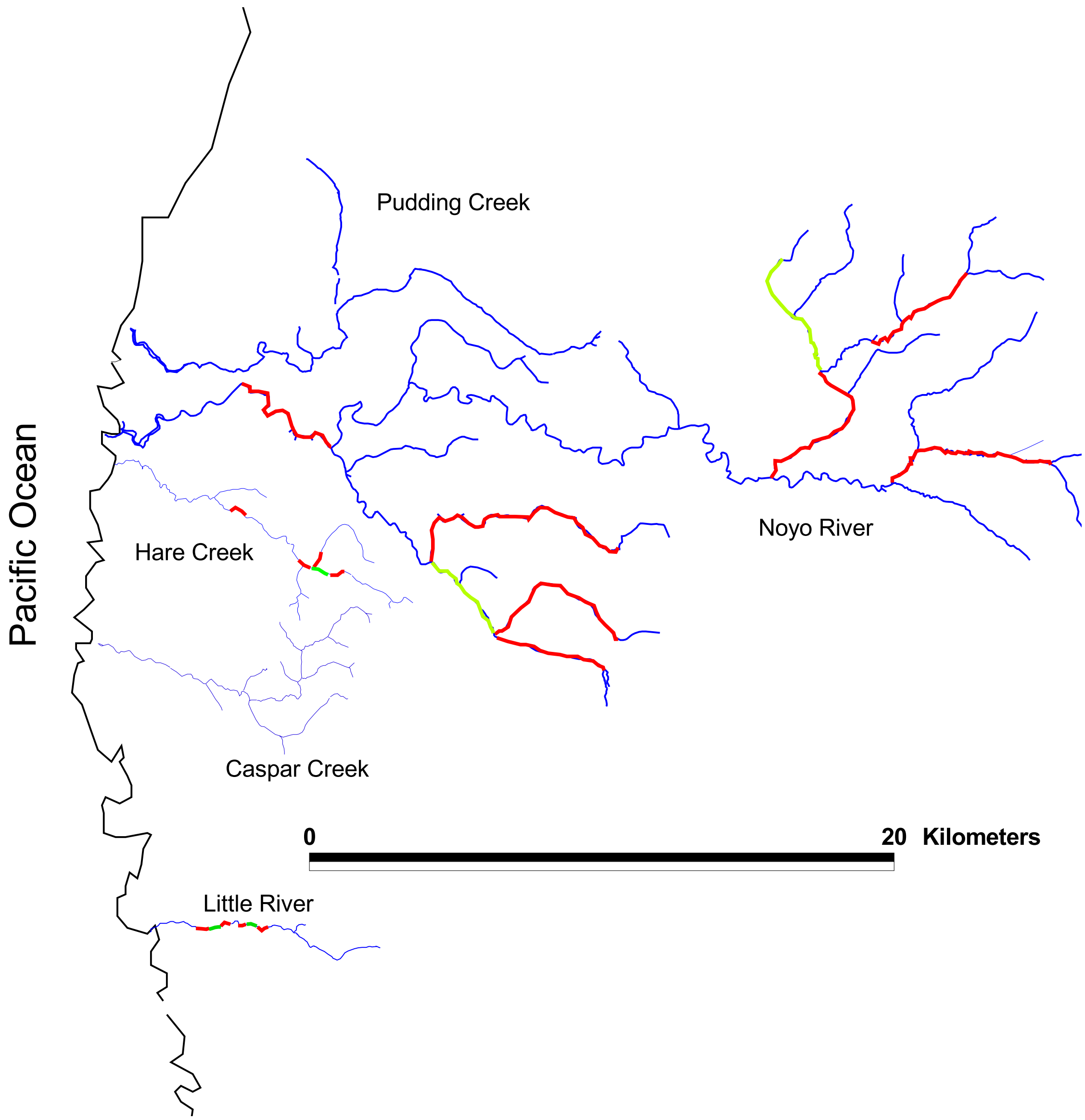


Figure 2. Spawning ground surveys for the 33% sampling rate in the extensively monitored streams during 2005-06. Green and red indicate surveyed segments.

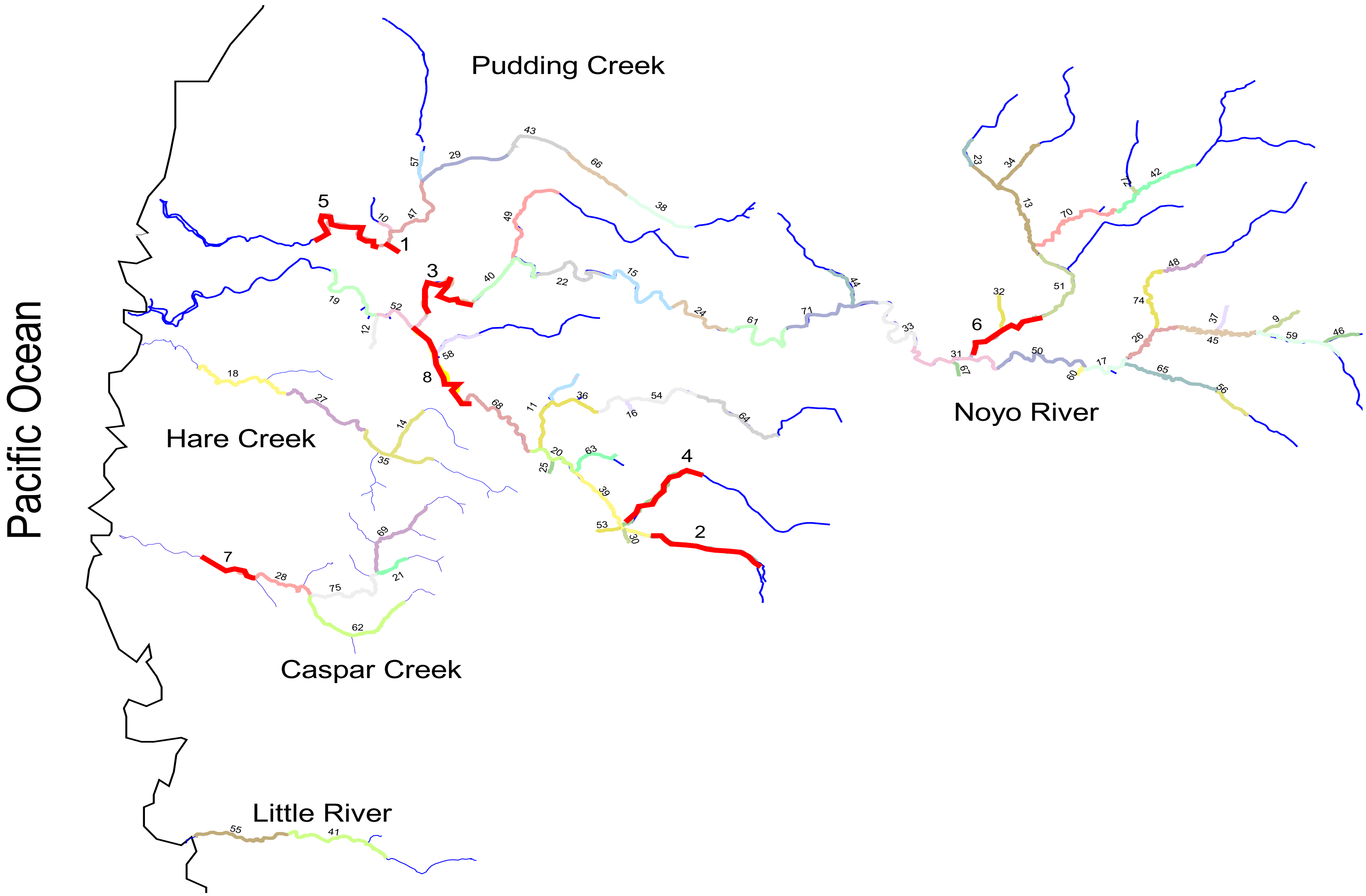


Figure 3. Mendocino coast pilot study regional sampling frame. Reaches 1-8 in red indicate the sampling reaches selected from the GRTS draw at the 10% sampling rate.

Figure 4. Caspar Creek hybrid floating resistance board weir. Note that there is 2.5 m of floating panel and 9.5 m of Alaskan weir fence.

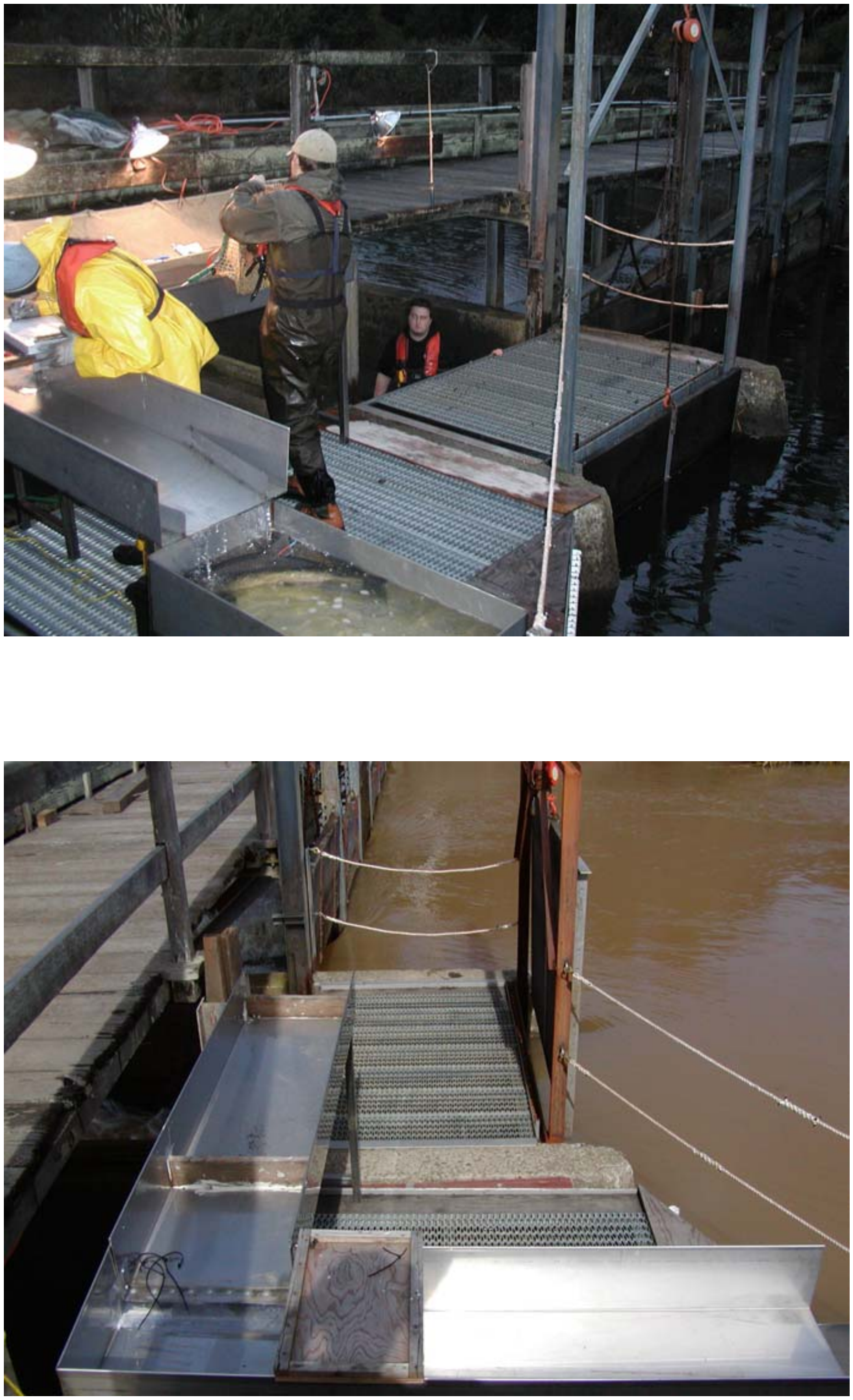


Figure 5. Pudding Creek fish ladder trap and flashboard dam. Stainless steel chute with water pump, fish holding tanks, grated walkways, lights, and safety lines are among the many improvements made to this structure as part of this study.

Figure 6. South Fork Noyo River Egg Collecting Station.

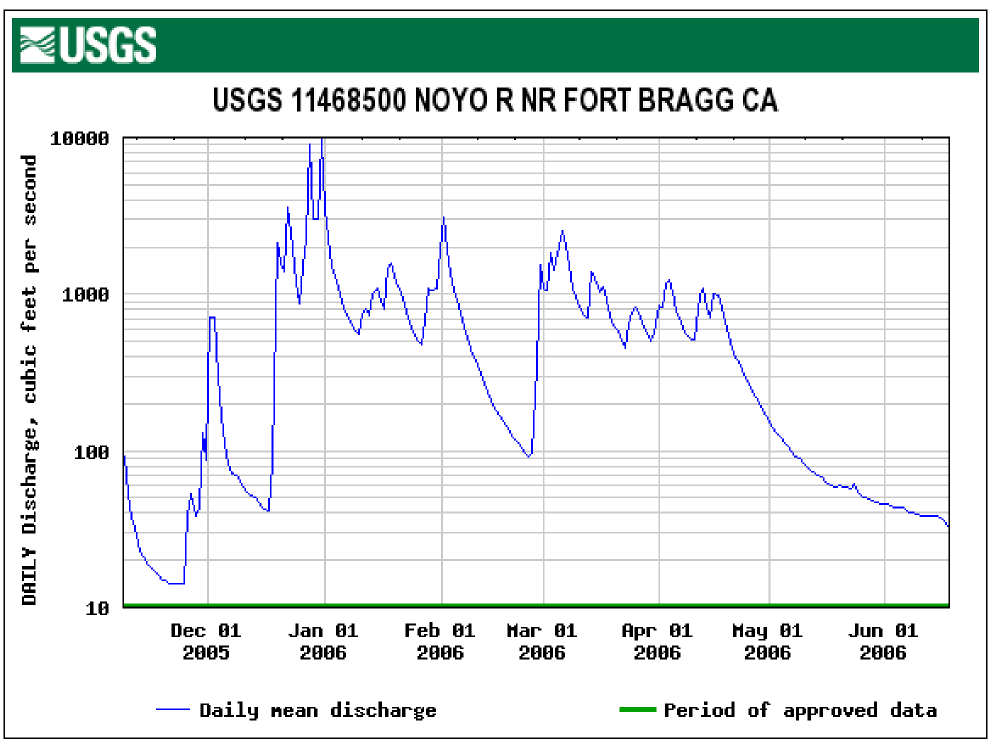


Figure 7. Noyo River stream flows during 2005-06. From USGS gauge 114685400 available at http://waterdata.usgs.gov/ca/nwis/uv?11468500.

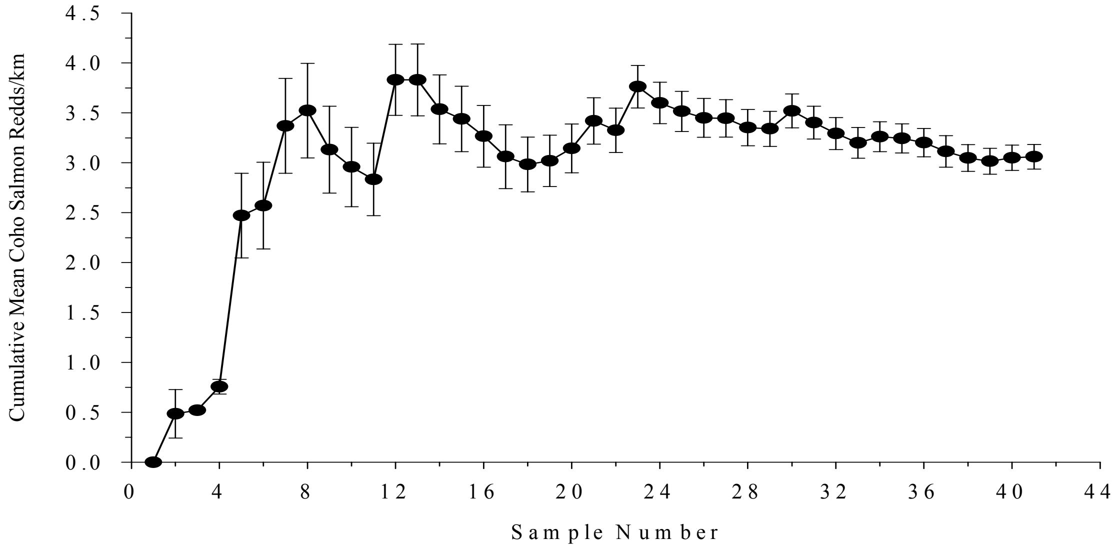


Figure 8. Cumulative average coho salmon redd density for 45 GRTS reaches (converted to sample number for presentation) sampled during 2005-06.

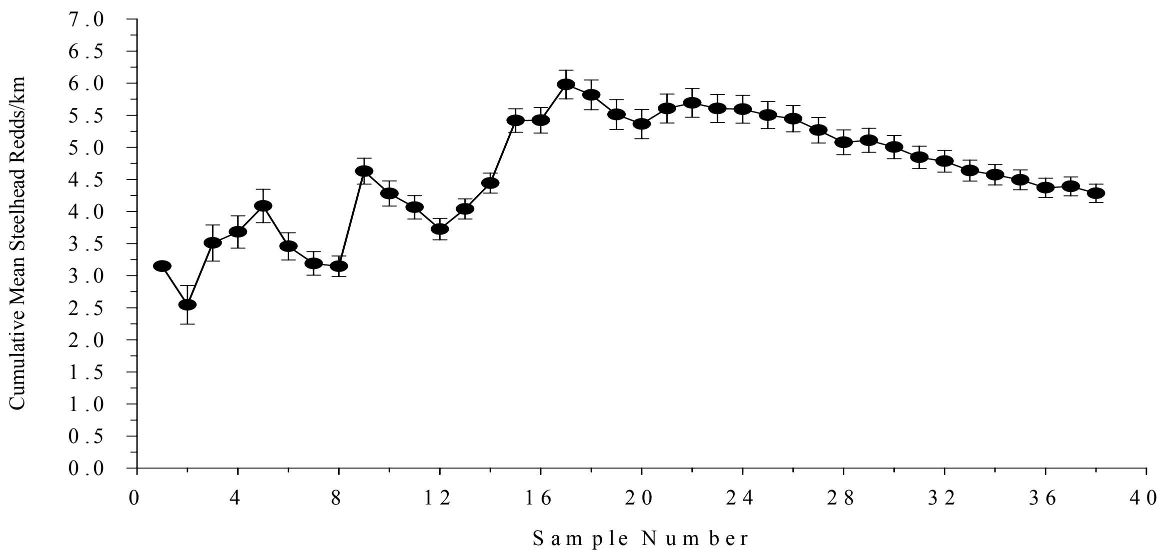


Figure 9. Cumulative average steelhead redd density for all 40 GRTS reaches (converted to sample number for presentation) sampled during 2005-06.

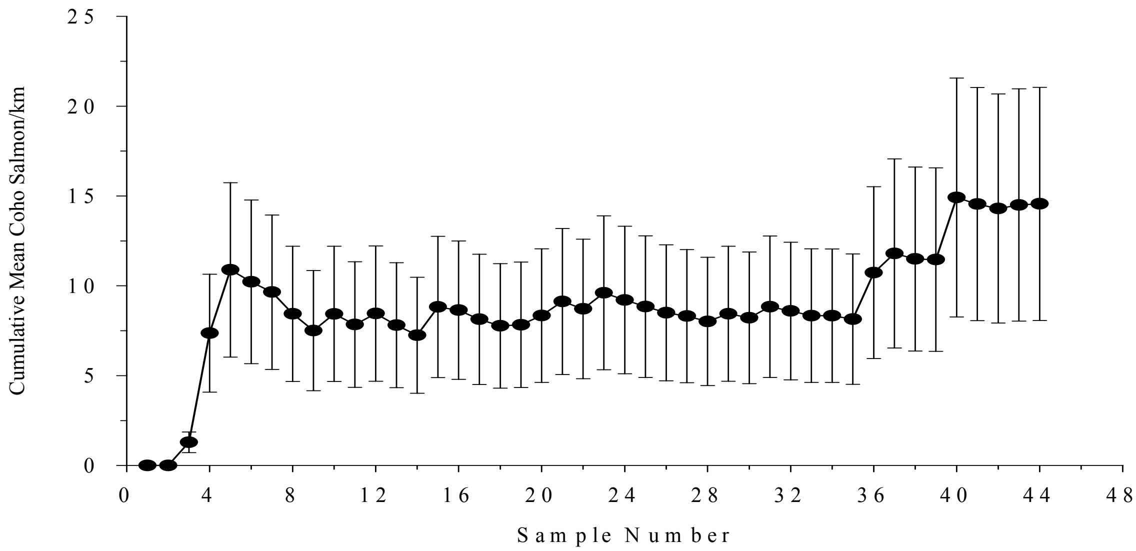


Figure 10. Cumulative average coho salmon AUC density for all 45 GRTS reaches (converted to sample number for presentation) sampled during 2005-06.

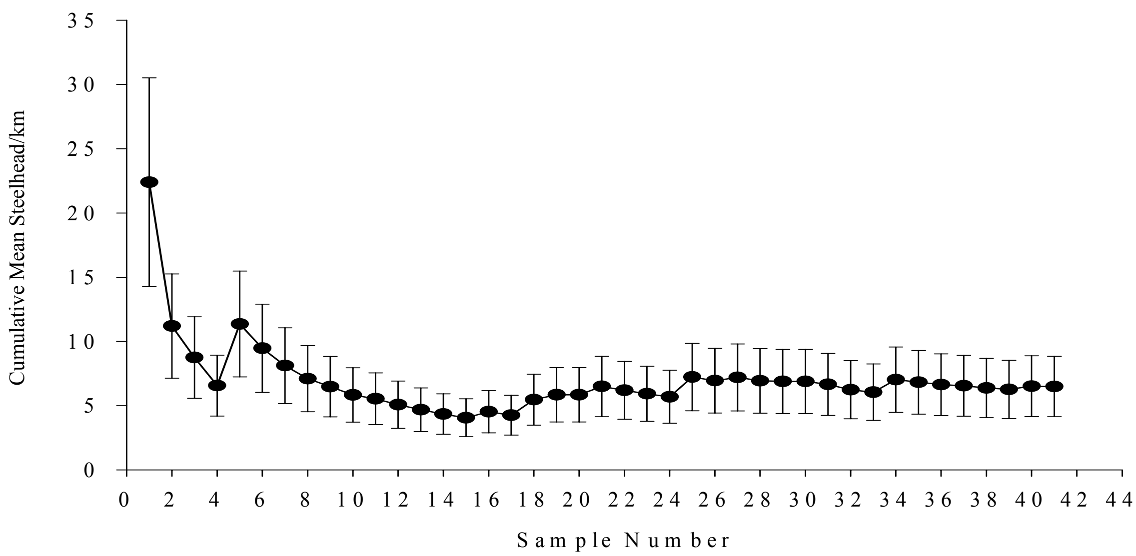


Figure 11. Cumulative average steelhead AUC density for all 40 GRTS reaches (converted to sample number for presentation) sampled during 2005-06.

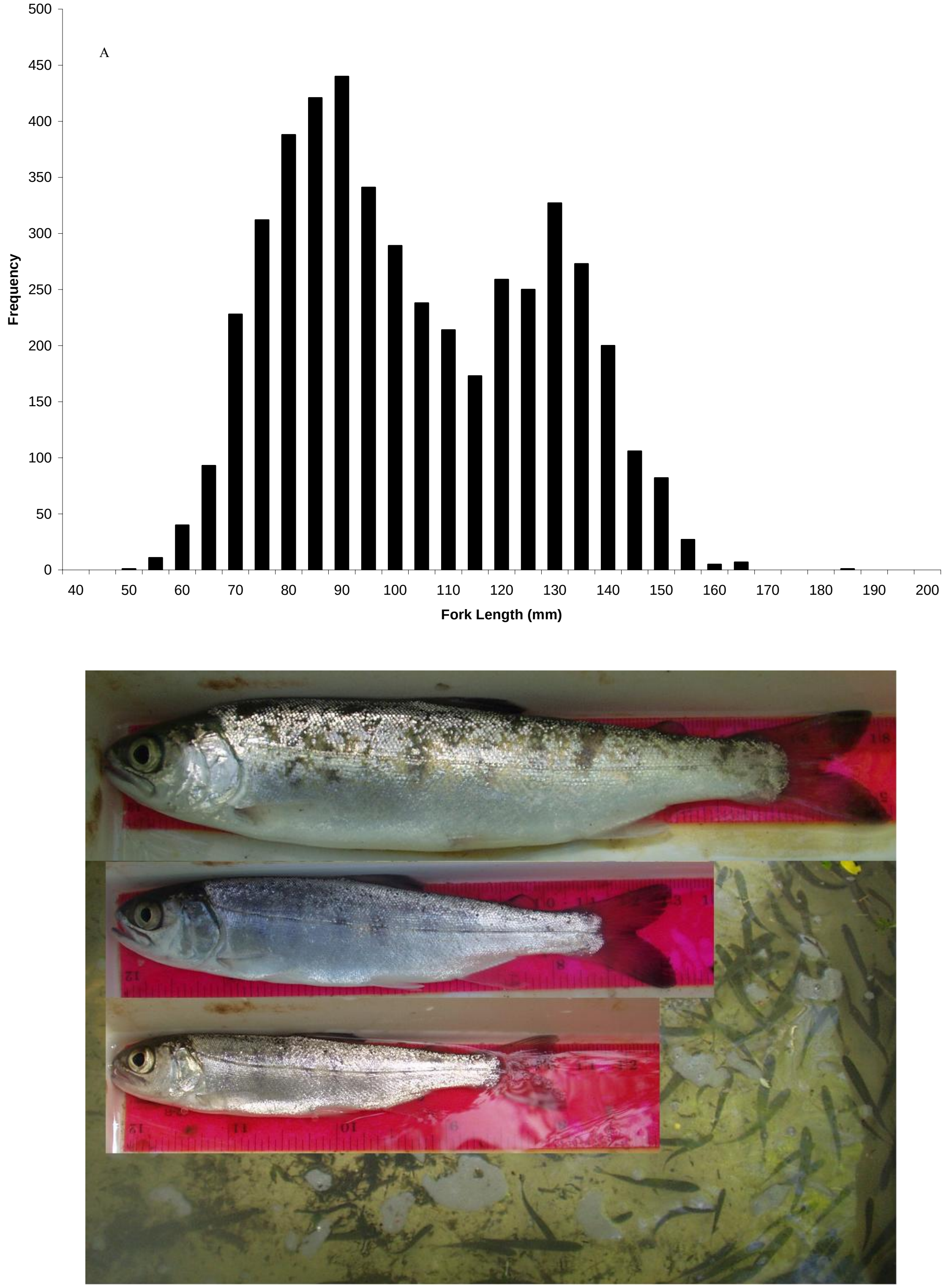


Figure 12. Coho salmon fork length frequencies from Pudding Creek trapping during spring 2006. In panel B upper fish is 175 mm, middle fish is 125mm, and bottom fish is 95mm.

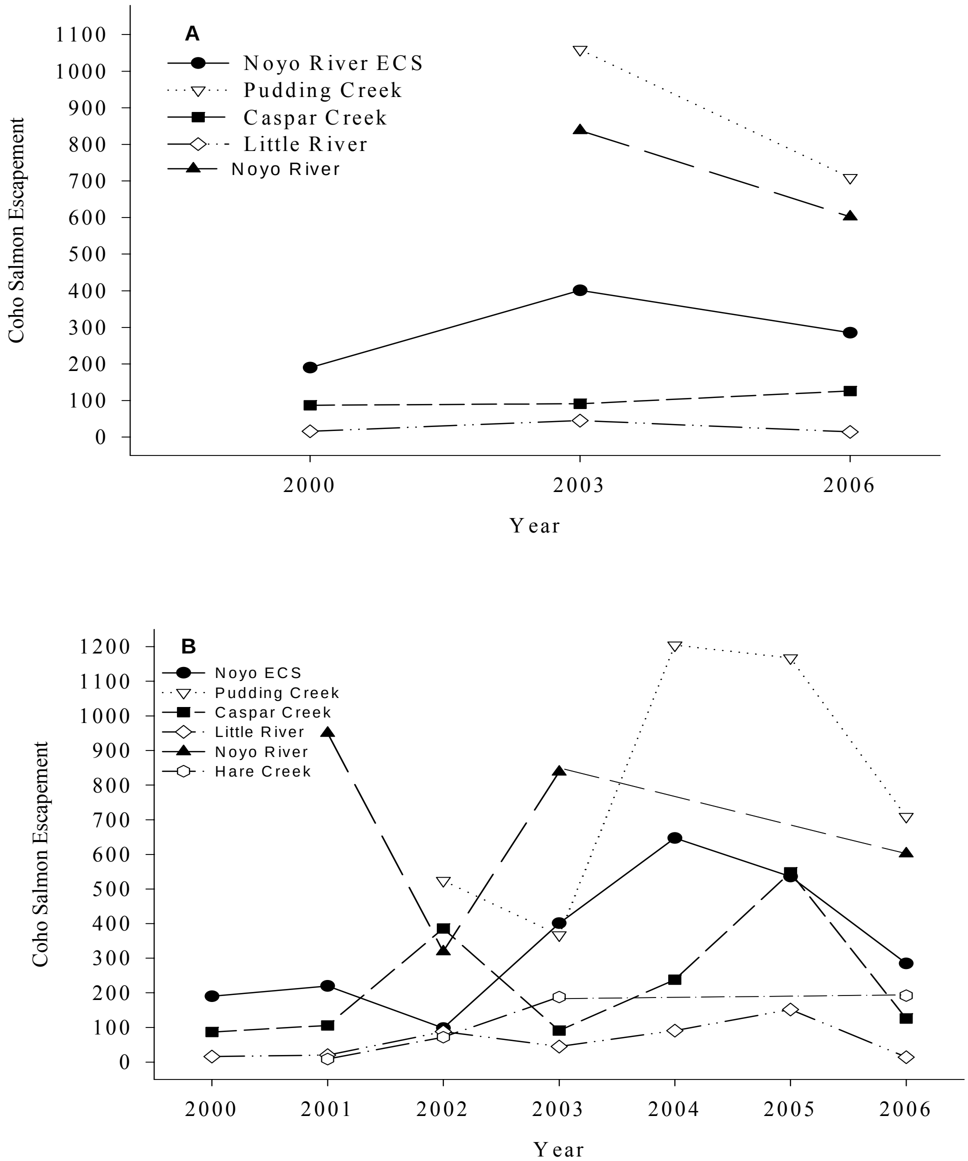


Figure 13. Coho salmon abundance trends. A). Three year adult returns. B). All years data.

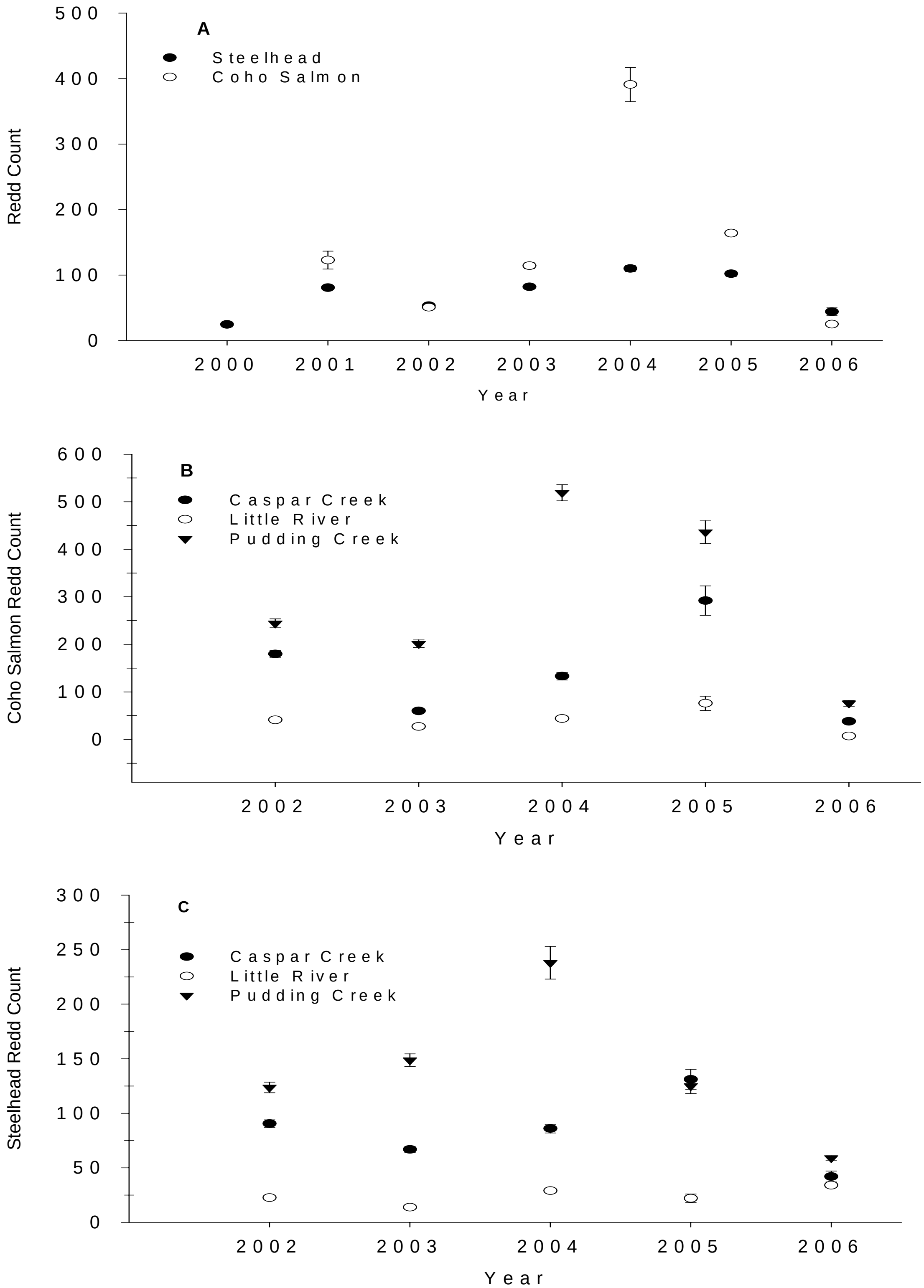


Figure 14. Coho and steelhead redd counts versus year. A). Above the South Fork Noyo River ECS. B). Coho salmon redds in Caspar and Pudding creeks and Little River. C). Steelhead redds in Caspar and Pudding creeks and Little River.

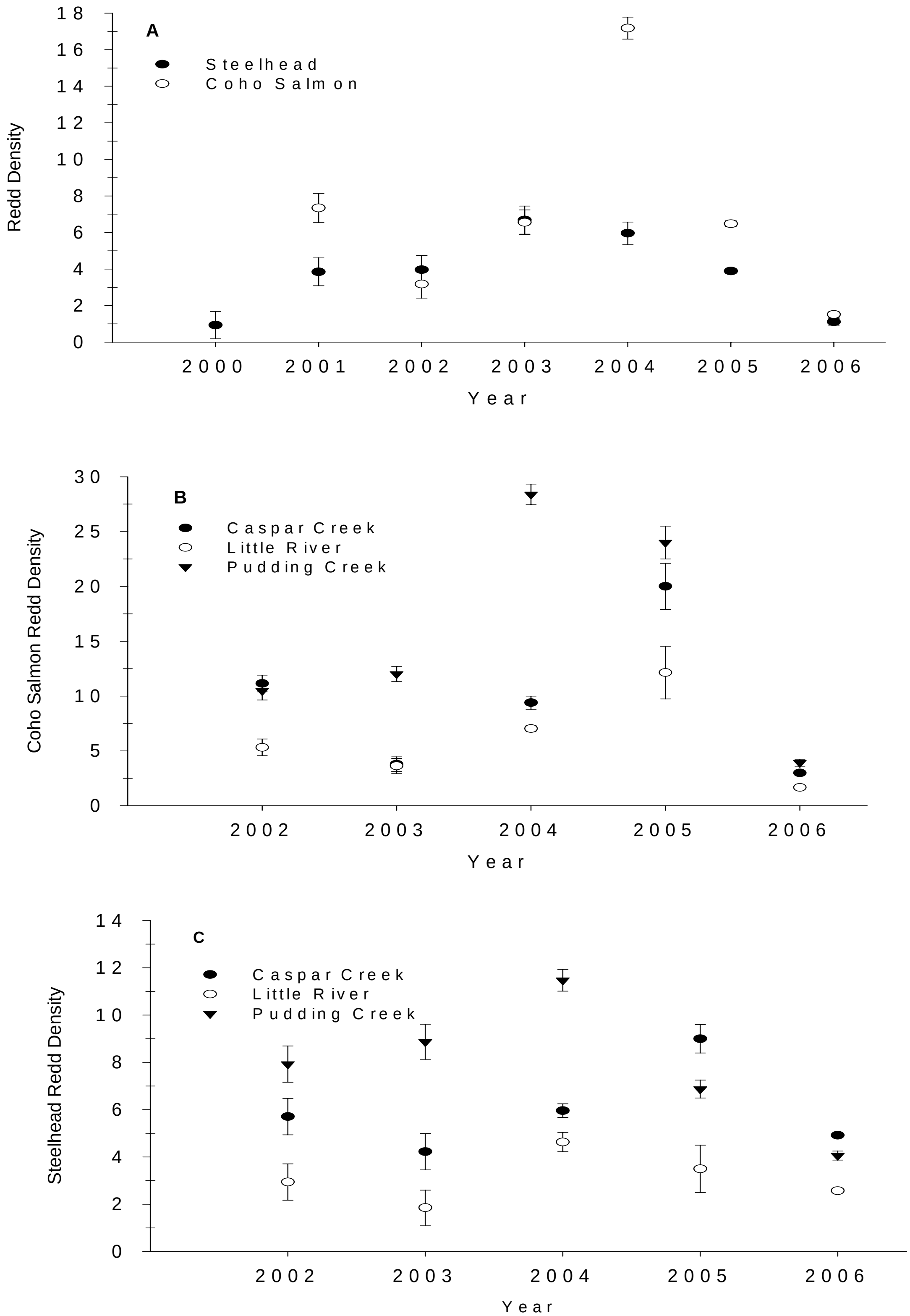


Figure 15. Redd densities (#/km) versus year. A). Above the South Fork Noyo River ECS. B). Coho salmon redd densities in Caspar and Pudding creeks and Little River. C). Steelhead redd densities in Caspar and Pudding creeks and Little River.

Table 1. GRTS order, GIS and predicted reach length, Latitude-Longitude ID, stream name, and rotating panel sampling schedule.

Grts Order	Map Length (km)	Predicted Length (km)	Latitude Logitude ID	Stream Name	Sample Year
1	0.25	0.47	1237350394485	Pudding Creek	Every Year
2	3.11	3.08	1237256394246	South Fork Noyo River	Every Year
3	3.44	3.38	1238090394278	Noyo River	Every Year
4	3.09	3.06	1236581393696	South Fork Noyo River	2005-06
5	3.75	3.67	1238079394591	Pudding Creek	2005-06
6	2.59	2.60	1235507394210	Noyo River	2005-06
7	1.75	0.69	1238153393619	Caspar Creek	2005-06
8	3.14	3.11	1237256394246	South Fork Noyo River	2005-06
9	1.32	1.44	1234595394310	Noyo River	2006-07
10	0.50	0.69	1237342394522	Pudding Creek	2006-07
11	3.15	3.11	1236844393908	South Fork Noyo River	2006-07
12	1.16	1.29	1237376394280	Noyo River	2006-07
13	3.89	3.79	1235507394210	Noyo River	2006-07
14	1.72	1.80	1237311393877	Hare Creek	2007-08
15	3.32	3.27	1238090394278	Noyo River	2007-08
16	0.46	0.65	1236580394057	South Fork Noyo River	2007-08
17	1.73	1.82	1238090394278	Noyo River	2007-08
18	3.32	3.27	1238116394173	Hare Creek	2007-08
19	2.81	2.80	1238090394278	Noyo River	2008-09
20	1.75	1.84	1237256394246	South Fork Noyo River	2008-09
21	1.07	1.21	1237338393537	Noyo River	2008-09
22	2.76	2.75	1238090394278	Noyo River	2008-09
23	1.04	1.19	1235524394765	Noyo River	2008-09
24	2.22	2.26	1238090394278	Noyo River	2009-10
25	0.46	0.65	1236805393879	South Fork Noyo River	2009-10
26	2.28	2.32	1238090394278	Noyo River	2009-10
27	2.97	2.95	1238116394173	Noyo River	2009-10
28	2.07	2.13	1238153393619	Caspar Creek	2009-10
29	2.61	2.62	1238079394591	Pudding Creek	2010-11
30	0.50	0.69	1236571393687	South Fork Noyo River	2010-11
31	3.31	3.26	1238090394278	Noyo River	2010-11
32	1.18	1.32	1235402394298	Noyo River	2010-11
33	3.29	3.24	1238090394278	Noyo River	2010-11
34	2.00	2.06	1235430394703	Noyo River	2011-12
35	2.46	2.48	1238116394173	Hare Creek	2011-12
36	1.30	1.42	1236813394045	South Fork Noyo River	2011-12
37	0.88	1.04	1234732394311	Noyo River	2011-12
38	2.17	2.22	1238079394591	Pudding Creek	2011-12
39	3.21	3.17	1237256394246	South Fork Noyo River	2112-13
40	2.82	2.81	1238090394278	Noyo River	2112-13
41	3.28	3.23	1237900392738	Little River	2112-13
42	2.99	2.97	1235321394542	Noyo River	2112-13
43	2.18	2.22	1238079394591	Pudding Creek	2112-13
44	1.55	1.65	1235883394348	Noyo River	2113-14
45	3.24	3.19	1238090394278	Noyo River	2113-14
46	1.07	1.21	1234399394284	Noyo River	2113-14
47	3.02	2.99	1238079394591	Pudding Creek	2113-14
48	1.50	1.60	1234927394310	Noyo River	2113-14
49	3.22	3.18	1236955394453	Noyo River	2114-15
50	3.32	3.27	1238090394278	Noyo River	2114-15
51	3.24	3.19	1235507394210	Noyo River	2114-15
52	1.89	1.97	1238090394278	Noyo River	2114-15
53	0.70	0.87	1236578393689	South Fork Noyo River	2114-15
54	3.30	3.25	1236844393908	South Fork Noyo River	2115-16
55	2.88	2.86	1237900392738	Little River	2115-16
56	1.20	1.33	1235025394204	Noyo River	2115-16
57	1.00	1.15	1237253394670	Pudding Creek	2115-16
58	1.56	1.66	1237193394176	South Fork Noyo River	2115-16
59	2.71	2.72	1238090394278	Noyo River	2116-17
60	0.48	0.67	1235144394194	Noyo River	2116-17
61	3.02	3.00	1238090394278	Noyo River	2116-17
62	3.88	3.78	1237544393465	Caspar Creek	2116-17
63	1.60	1.70	1236730393844	South Fork Noyo River	2116-17
64	2.92	2.91	1236844393908	South Fork Noyo River	2117-18
65	3.09	3.06	1235025394204	Noyo River	2117-18
66	2.16	2.21	1238079394591	Pudding Creek	2117-18
67	0.54	0.73	1235562394199	Noyo River	2117-18
68	3.28	3.24	1237256394246	South Fork Noyo River	2117-18
69	2.96	2.94	1238153393619	Noyo River	2118-19
70	3.30	3.26	1235321394542	Noyo River	2118-19
71	3.10	3.07	1238090394278	Noyo River	2118-19
72	0.29	0.50	1235008394700	Noyo River	2118-19
73	0.03	0.26	1236741394119	Noyo River	2118-19
74	2.53	2.55	1234927394310	Noyo River	2119-20
75	2.82	2.81	1238153393619	Caspar Creek	2119-20
76	nd	3.66	nd	Caspar Creek	2119-20*

* Start over at lowest ever two years GRTS order number.

Table 2. Coho salmon and steelhead fish per redd estimates for some coastal Mendocino County streams 2000 to 2006 (See Appendix 1 for raw data). Coho salmon fish per redd estimates for the South Fork Noyo River above the ECS 2000 to 2002 are based on release counts. All other estimates are based on live fish capture-recapture experiments.

Year	Site	Number of Steelhead Per Redd			Year	Site	Number of Coho Salmon Per Redd		
		Point Estimate	Low 95% CI	High 95% CI			Point Estimate	Low 95% CI	High 95% CI
2000	Noyo River	1.37	0.00	2.35	2001	South Fork Noyo River ECS	1.54	nd	nd
2001	Noyo River	0.74	0.20	1.77	2002	South Fork Noyo River ECS	4.31	nd	nd
2002	Noyo River	1.55	0.33	2.67	2003	South Fork Noyo River ECS	0.86	nd	nd
2003	Noyo River	0.60	0.07	1.03	2004	South Fork Noyo River ECS	1.65	1.45	1.69
2004	Noyo River	nd	nd	nd	2005	South Fork Noyo River ECS	3.27	1.70	5.08
2005	Noyo River	nd	nd	nd	2006	South Fork Noyo River ECS	11.40	7.74	21.78
2006	Noyo River	0.57	0.25	19.33	2004	Pudding Creek	2.32	2.13	2.99
2006	Caspar Creek	0.14	0.11	0.55	2005	Pudding Creek	2.68	2.18	3.85
2004	Pudding Creek	1.11	0.31	1.82	2006	Pudding Creek	9.33	8.40	10.83
2005	Pudding Creek	1.62	1.03	2.15	2006	Caspar Creek	3.32	1.37	121.00
2006	Pudding Creek	1.29	0.49	4.59					

Table 3. Coho salmon and steelhead residence time (time from capture until death or recapture) estimates for some coastal Mendocino County streams 2000 to 2006. Coho salmon residence time is time between capture and recapture as freshly dead carcasses.

Year	Site		Coho Salmon Residence Time			Year	Site	n	Steelhead Residence Time		
		n	Point Estimate	Low 95% CI	High 95% CI				Point Estimate	Low 95% CI	High 95% CI
2002-03	South Fork Noyo River	5	12.20	8.98	15.42	1999-2000	Noyo River Tributaries	8	12.13	6.99	17.26
2003-04	South Fork Noyo River	119	28.09	25.97	30.22	1999-2000	Noyo River Main Stem	3	38.00	24.76	51.24
2004-05	South Fork Noyo River	21	26.81	21.14	32.48	2000-01	Noyo River Tributaries	3	16.67	6.55	26.78
2005-06	South Fork Noyo River	4	18.25	19.14	37.39	2001-02	Noyo River Tributaries	1	15.00	na	na
2003-04	Pudding Creek	19	32.63	28.99	36.27	2002-03	Noyo River Tributaries	4	13.25	2.40	24.10
2004-05	Pudding Creek	10	21.10	11.33	30.87	2002-03	Noyo River Main Stem	2	28.00	na	na
2005-06	Pudding Creek	6	25.00	14.38	35.62	2004-05	South Fork Noyo River	2	10.00	0.00	27.24
2005-06	Caspar Creek	1	16.00	na	na	2005-06	Noyo River Main Stem	1	48.00	na	na
						2003-04	Pudding Creek	8	9.37	3.00	15.75
						2004-05	Pudding Creek	3	28.33	22.43	34.24

Table 4. Number of live coho salmon observed during spawning surveys, female to male ratio, escapement estimates, estimates of the number of coho salmon per redd, and fish density for several coastal Mendocino County streams during 2005-06. Numbers in parentheses are ECS release counts.

Stream Name	Number Live	Number of Females	Female:Male	Escapement				Fish/km[1]
				Mark-Recapture		Fish Per Redd *	AUC **	
				Carcass	Live Fish			
Caspar Creek	39	7	1.10:1.00	22-36-82	48-126-4961	126 - 305 - 433	155 - 203 - 293	9.84
Hare Creek~	39	20	1.38:1.00	10-21-78	nd	365 - 882 - 1254	35 - 142 - 331	52.80
Little River	4	1	na	na	nd	23 - 56 - 80	39 - 54 - 69	9.33
Pudding Creek	106	42	0.66:1.00	77-148-540	588-709-888	252 - 610 - 866	433 - 566 - 818	36.54
South Fork Noyo	24	11	0.44:1.00	nd	178-285-588 (78)	83 - 200 - 285	230 - 302 - 436	10.82 2.96
Noyo~	11	6	na	nd	nd	578 - 1394 - 1984	489 - 593 - 936	13.52

* Average fish per redd 2005-06 bootstrap 95% c'is 3.32-8.01-11.40.
~ Total estimates from reach density expansions.
1 From fish per redd estimates or live fish capture-reacpture.

Table 5. Number of live steelhead observed during spawning surveys, female to male ratio, escapement estimates, estimates of the number of steelhead per redd, and fish density for several coastal Mendocino County streams during 2005-06.

Stream Name	Number Live	Number of Females	Female:Male	Esacpement Estimate			Fish/km
				Mark-Recapture	Fish Per Redd *	AUC **	
Caspar Creek	8	3	1.50:1.00	4-6-28	6 - 26 - 54	18 - 22 - 30	2.14
Hare Creek~	3	1	na	nd	11 - 53 - 103	15 - 19 - 26	4.86
Little River	1	0	na	nd	5 - 22 - 44	1	3.63
Pudding Creek	2	2	2.20:1.00	28-76-280	8 - 38 - 76	26 - 33 - 46	3.91
South Fork Noyo	11	1	0.60:1.00	nd	6 - 28 - 57	104 - 131 - 179 -	1.96
Noyo~	52	14	na	70-186-7294	46 - 209 - 420	219 - 278 - 379	1.70

* Average fish per redd 2005-06 bootstrap 95%cis 0.14-0.64-1.29.
** AUC rt avg 0506 obs all streams and total obs marked/ total marked each stream (hare, lr, noyo predicted oe)
~ Total estimates from reach density expansions

Table 6. Coho salmon redd data and redd based escapement estimates for several coastal Mendocino County streams 2005-06.

Stream Name	n**	Redd Observer Efficiency	Number of Redds		Escapement Estimate		Redds/km
			Raw	O. E.	Redd Area	1 Redd/Female	
Caspar Creek	5	0.72 ± 0.12	27	30 - 38 - 46	21 - 29 - 37	59 - 73 - 87	2.99 ± 0.20
Hare Creek*	5	0.85 ± 0.06	76	96 - 110 - 124	53 - 64 - 75	167 - 192 - 271	5.52 ± 0.24
Little River	2	0.75 ± 0.12	4	0 - 7 - 16	0 - 6 - 19	1 - 14 - 27	1.67 ± 0.11
Noyo River*	9	0.62 ± 0.10	123	156 - 184 - 212	271 - 285 - 299	512 - 602 - 692	1.63 ± 0.11
Pudding Creek	9	0.66 ± 0.11	49	62 - 76 - 90	86 - 107 - 128	153 - 188 - 223	3.92 ± 0.32
South Fork Noyo	8	0.70 ± 0.09	20	0 - 25 - 84	21 - 26 - 31	58 - 82 - 106	1.51 ± 0.16

* Total estimates from reach density expansions.
** Number of reaches.

Table 7. Steelhead redd data and redd based escapement estimates for several coastal Mendocino County streams 2005-06.

Stream Name	Redd Observer Efficiency	n**	Number of Redds		Redd Area	Redds/km
			Raw	O. E.		
Caspar Creek	0.69 ± 0.15	5	32	22 - 42 - 56	19 - 25 - 31	4.92 ± 0.05
Hare Creek*	1.00 ± 0.00	5	80	80 ± 0	54 - 65 - 76	7.6 ± 0.00
Little River	0.20 ± 0.17	2	14	25 - 34 - 89	0 - 10 - 35	2.57 ± 0.10
Noyo River*	0.43 ± 0.11	9	278	213 - 326 - 439	76 - 88 - 100	2.98 ± 0.45
Pudding Creek	0.72 ± 0.14	9	53	54 - 59 - 64	30 - 37 - 44	4.06 ± 0.19
South Fork Noyo	0.44 ± 0.11	8	37	30 - 44 - 58	73 - 82 - 91	1.11 ± 0.18

* Total estimates from reach density expansions
** Number of Reaches

Table 8. Coho salmon regional population estimates for the sum of five streams and GRTS reach expansions at 10% and 48% sampling rate during 2005-06.

	Redd Density	Redd Count	Redd Area	1 Redd/Female	Fish Per Redd	AUC
Sum of Stream Estimates *	-	344 - 415 - 488	431 - 491 - 588	892 - 1068 -1246	1335 - 3247 - 4617	1151 - 1558 - 5447
10% GRTS Sample (n = 8)	1.48 - 3.51 - 6.14	256 - 605 - 1059	283 - 612 - 992	409 - 1280 - 2382	1933 - 4870 - 8077	383 - 1454 - 2852
48% Stratified GRTS (n = 37)	1.63 - 2.65 - 3.76	281 - 457 - 648	374 - 436 - 895	697 - 1100 - 3151	2235 - 3665 - 5238	1228 - 2672 - 4560

* 33% sampling and total from LCS streams

Table 9. Steelhead regional population estimates for the sum of five streams and GRTS reach expansions at 10% and 48% sampling rate during 2005-06.

	Redd Density	Redd Count	Redd Area	Fish Per Redd	AUC
Sum of Stream Estimates*	-	314 - 541 - 648	179 - 225 - 286	76 - 348 - 697	278 - 353 - 481
10% GRTS Sample (n = 8)	1.00 - 2.92 - 4.15	172 - 504 -716	72 - 244 - 421	109 - 252 - 409	31 - 1225 - 2634
48% Stratified GRTS (n = 37)	2.76 - 4.17 - 5.95	476 - 719 - 1026	214 - 316 - 436	291 - 455 - 650	448 - 1031 - 1742

* 33% sampling and total from LCS streams

Table 10. Chinook salmon regional population estimates for the sum of all Noyo River reaches and GRTS reach expansions at 5% and 20% sampling rate during 2005-06.

	Redd Density	Redd Count	1 Redd/Female	AUC
33% Sampling Noyo *	-	2 - 13 - 27	4 -26 - 59	8 - 32 - 73
5 % GRTS Sample (n = 3)	0 - 0.26 - 0.77	0 - 44 - 133	0 - 34 - 103	0 - 67 - 202
20 % Stratified GRTS (n = 13)	0 - 0.17 - 0.43	0 - 29 - 74	0 - 23 - 57	0 - 21 - 49

* 66.6 km onts spawnin habitat in Noyo River

Table 11. Coho salmon downstream trapping results for traps in several coastal Mendocino County Streams during spring 2006. YOY is young-of-the year. Y+ are one year old fish. Y++ are two year and older fish. ND is no data. Numbers in parentheses are standard errors, double these for 95% CI's.

Trap Location	YOY			Y+			Y++		
	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability
Caspar Mainstem	2966	ND	ND	562	2253 (180)	0.25	ND	ND	ND
Caspar North Fork	5128	23312 (3183)	0.25	268	1163 (200)	0.32	ND	ND	ND
Caspar South Fork	2873	5889 500	0.48	380	926 (131)	0.63	ND	ND	ND
Caspar Two Traps	8001	102967 (15715)	0.09	648	6728 (822)	0.09	ND	ND	ND
Little River	ND	ND	ND	726	1294 (59)	0.58	ND	ND	ND
Noyo NFSF	ND	ND	ND	342	1190 (147)	0.29	ND	ND	ND
Noyo South Fork	ND	ND	ND	931	4790 (463)	0.23	ND	ND	ND
Pudding Creek	4118	33024 (5010)	0.24	4569	19875 (1496)	0.42	1840	5781 (401)	0.47

Table 12. Steelhead downstream trapping results for traps in several coastal Mendocino County Streams during spring 2006. Y+ are one year old fish. Y++ are two year and older fish. ND is no data. Numbers in parentheses are standard errors, double these for 95% CI's.

Trap Location	YOY			Y+			Y++		
	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability
Caspar Mainstem	3143	ND	ND	70	514 (228)	0.72	22	209 (139)	0.1
Caspar North Fork	3666	21764 (2617)	0.14	194	1166 (277)	0.32	45	81 (10)	0.55
Caspar South Fork	261	323 (71)	0.87	137	388 (62)	0.422	12	29 (9)	0.41
Caspar Two Traps	3927	336765 (149724)	0.01	331	18788 (8329)	0.01	48	2304 (2279)	0.02
Little River	ND	ND	ND	193	969 (167)	0.33	11	33 (15)	0.33
Noyo NFSF	ND	ND	ND	190	840 (137)	0.23	15	225 216	0.06
Noyo South Fork	ND	ND	ND	146	713 (132)	0.21	23	176 (94)	0.13
Pudding Creek	1266	21923 (5615)	0.12	261	2660 (660)	0.1	184	2704 (860)	0.37

Table 13. Reach specific data from summer rearing snorkel surveys in Pudding Creek during August 2006. Onmy is steelhead. Onki is coho salmon. YOY is young of the year. Y+ is year old. Y++ is two year and older fish.

	Reach	Population Estimate	SE	Density (fish/m)	Density (fish/m^2)	Biomass
ONMY YOY	1	450	68.97	0.83	0.16	0.48
	2	194	13.08	0.38	0.12	0.38
	3	142	56.26	0.28	0.08	N/A
	4	381	4.10	0.77	0.40	0.67
ONMY Y+	1	173	26.48	0.32	0.06	0.49
	2	74	5.02	0.15	0.05	0.25
	3	55	21.60	0.11	0.03	0.28
	4	146	1.57	0.29	0.15	1.57
ONMY Y++	1	60	9.21	0.11	0.02	0.80
	2	26	1.75	0.05	0.02	0.44
	3	19	7.51	0.04	0.01	0.20
	4	51	0.55	0.10	0.05	1.70
ONKI YOY	1	679	11.50	1.25	0.24	0.87
	2	638	60.96	1.24	0.40	1.01
	3	643	132.17	1.25	0.35	0.82
	4	432	25.82	0.87	0.46	1.25
ONKI Y+	1	45	0.76	0.08	0.02	0.08
	2	42	4.03	0.08	0.03	0.21
	3	42	8.74	0.08	0.02	0.14
	4	29	1.71	0.06	0.03	0.18

Table 14. Pudding Creek summer rearing population estimates.

Species	YOY			Y+			Y++		
	Number/km	SE	Population Estimate	Number/km	SE	Population Estimate	Number/km	SE	Population Estimate
Coho	1153	114	23628	76	5	1562	-	-	-
Steelhead	562	68	11521	216	26	4423	75	9	1538

Table 15 Coho salmon survival and spawner: recruit ratios for several Mendocino County streams 2000 to 2006.

Variable	Noyo Ecs			Pudding Creek			Caspar Creek			Little River			Noyo River			Hare Creek		
	Low ^	Estimate	High	Low ^	Estimate	High	Low ^	Estimate	High	Low ^	Estimate	High	Low ^	Estimate	High	Low ^	Estimate	High
2000 Smolts	2102	2763	3424	nd	nd	nd	2889	3259	3629	917	975	1033	nd	nd	nd	820	1128	1436
2001-2002 Adults	76	112	148	nd	nd	nd	352	386	420	50	88	126	nd	nd	nd	nd	nd	nd
Survival Smolt to Adult	0.04	0.04	0.04	nd	nd	nd	0.12	0.12	0.12	0.05	0.09	0.12	nd	nd	nd	nd	nd	nd
1999-2000 Adults	-	190	-	nd	nd	nd	0	87	186	0	16	67	nd	nd	nd	nd	nd	nd
2001 Smolts	1596	4152	6708	nd	nd	nd	3355	3799	4243	259	264	280	16307	26765	37223	1763	2193	2623
2002-2003 Adults	-	401	-	nd	nd	nd	70	91	112	42	45	48	84	487	890	179	188	197
Survival Smolt to Adult	0.25	0.10	0.06	nd	nd	nd	0.02	0.02	0.03	0.16	0.17	0.17	0.01	0.02	0.02	0.10	0.09	0.08
Recruits/Spawner (03/00)	-	2.11	-	nd	nd	nd	na	1.05	0.60	nd	2.81	0.72	nd	nd	nd	nd	nd	nd
2000-2001 Adults	-	220	-	nd	nd	nd	97	106	115	6	20	33	nd	nd	nd	nd	nd	nd
2002 Smolts	5994	7562	9130	nd	nd	nd	1922	2224	2526	1441	1575	1709	nd	nd	nd	nd	nd	nd
2003-2004 Adults	530	647	706	nd	nd	nd	178	238	298	28	91	154	nd	nd	nd	nd	nd	nd
Survival Smolt to Adult	0.09	0.09	0.08	nd	nd	nd	0.09	0.11	0.12	0.02	0.06	0.09	nd	nd	nd	nd	nd	nd
Recruits/Spawner (04/01)	2.41	2.94	3.21	nd	nd	nd	1.84	2.25	2.59	4.67	4.55	4.67	nd	nd	nd	nd	nd	nd
2001-2002 Adults	76	112	148	438	524	610	352	386	420	50	88	126	nd	nd	nd	nd	nd	nd
2003 Smolts	4789	5357	5925	nd	nd	nd	4258	4976	5694	1885	2115	2345	nd	nd	nd	nd	nd	nd
2004-2005 Adults	-	536	-	899	1167	1773	298	548	798	0	152	535	nd	nd	nd	nd	nd	nd
Survival Smolt to Adult	0.11	0.10	0.09	nd	nd	nd	0.07	0.11	0.14	0.00	0.07	0.23	nd	nd	nd	nd	nd	nd
Recruits/Spawner (05/02)	7.05	4.79	3.62	2.05	2.23	2.91	0.85	1.42	1.90	0.00	1.73	4.25	nd	nd	nd	nd	nd	nd
		686																
2002-2003 Adults	-	401	-	333	367	401	61	91	121	7	45	83	84	487	890	163	188	213
2004 Smolts	7289	7975	8661	nd	nd	nd	4371	5753	7135	2038	2202	2366	nd	nd	nd	nd	nd	nd
2005-2006 Adults	178	285	588	588	709	888	48	126	4961	1	14	27	512	602	692	183	192	201
Survival Smolt to Adult	0.02	0.04	0.07	nd	nd	nd	0.01	0.02	0.70	0.00	0.01	0.01	nd	nd	nd	nd	nd	nd
Recruits/Spawner (06/03)	0.44	0.71	1.47	1.77	1.93	2.21	0.79	1.38	41.00	0.14	0.31	0.33	6.10	1.24	0.78	1.12	1.02	0.94

^ Adult and smolt data ranges are 95% ci's.
ECS adult escapement from carcass capture-recapture 2001-02, live fish mark-recaptue for 2004-2006, and relase counts other years. Smolt estimates are from Harris 2000 to 2005.
Pudding Creek adult escapement from live fish mark-recapture for 2004-2006 and 1 redd per female for other years (95%ci based on redd count SE and n = 3 reaches).
Caspar from live fish capture-recapture for 2005-06 and 1 redd per female for other years (95%ci based on redd count SE and n = 3 reaches).
Little River adult escapement from 1 redd per female (95%ci based on redd count SE and n = 2 reaches).
Hare Creek adult escapement from 1 redd per female (95%ci based on redd count SE and n = 4 reaches 2002-03 and 5 reaches 2005-06).
Noyo River adult escapement from live fish caprure-recapture 2002-03 and1 redd per female for other years (95%ci based on redd count SE and n = 9 reaches).

Table 16. Regional spawning ground survey (extensive) average cost per reach for eight surveys. Costs rounded to nearest dollar.

Number of Reaches	Person Hours [1]	Field Survey Cost [2]	Transportation [3]	Cost/Reach [4]	Cost/Fish [5]	Cost/Coho	Total Cost all Reaches
8	70.35	$1,310	$66	$2,126	$241	$244	$17,008
32	78.81	$1,466	$112	$2,317	$375	$324	$74,144
38	78.58	$1,463	$99	$2,312	$429	$387	$87,856
45	78.31	$1,458	$96	$2,304	$391	$358	$103,680

[1] Two persons per survey and two hours per person per survey for office prep time.
[2] 13.20$/hr plus 0.28% benefits and 13% overhead =18.62/hr.
[3] Federal Milage Rate 0.485$/mi or 0.30/km.
[4] Includes field gear costs estimated at 750$.
[5] Chinook and coho salmon and steelhead. Does not inlcuded data storage, analysis, and reporting costs about 50 person hours/reach.

Table 17. Life cycle monitoring streams (Intensive Monitoring) adult escapement operational costs.

Site	Adult Tagging							Spawning Surveys [4]	Cost/Fish [5]	Cost/Coho
	Person Hours [1]	Field Costs [2]	Transportation [3]	Tagging Equipment	Palm Pilots	Saftey Gear	Total Cost			
Pudding Creek	495	$9,217	$540	$3,747	$750	$500	$14,750	$20,253	$45	$50
Noyo ECS	455	$7,909	$810	$3,747	$750	$500	$13,712	$29,403	$151	$151
Caspar Creek [6]	400	$7,448	$675	$3,747	$750	$500	$12,441	$14,302	$203	$212

[1] Two persons per survey and two hours per person per survey for office prep time.
[2] 13.20$/hr plus 0.28% benefits and 13% overhead =18.62/hr.
[3] Federal Milage Rate 0.485$/mi or 0.30/km.
[4] Based on costs estimates for surveying each stream.
[5] Chinook and coho salmon and steelhead. Does not inlcuded data storage, analysis, and reporting costs about 50 person hours/reach.
[6] Does not include one time start up cost for building a weir of ~10,000$.

APPENDIX 1

Coho salmon and steelhead population data for several coastal Mendocino County streams 2000 to 2006.

Noyo River above the ECS.coho salmon adult escapement data.

Year	ECS Release	Female: Male	Live Fish Capture-Recapture			Carcass Capture-Recapture			AUC		
			Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	190	0.35:1.00*	na	-	-	nd	nd	nd	nd	nd	nd
2001	220	0.79:1.00	na	-	-	na	na	na	116	-	-
2002	98	1.04:1.00	na	-	-	112	76	148	64	37	91
2003	401	0.79:1.00	na	-	-	110	94	136	319	0	650
2004	530	1.00:1.04	647	530	706	133	91	257	587	490	684
2005	286	1.13:1.00	536	272	854	124	48	710	422	-	-
2006	78	0.44:1.00	285	178	588	na	na	na	302	230	436

* Total grisel and hatchery. Only fish considered adults was 0.85:1.00. From Jones (2000).

Noyo River above the ECS coho salmon redd counts, density, and escapement estimates based on redd data (redd area, 1 redd/female, and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		1 Redd/Female		Fish Per Redd Escapement Estimate		
	Number	SE	Number/km	SE	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	123	14	5.47	0.62	198	13	323	17	485	178	792
2002	51	2	2.27	0.09	68	3	96	5	201	74	328
2003	114	4	6.56	0.66	338	13	514	26	449	165	734
2004	391	26	17.18	0.59	480	33	760	50	1541	565	2516
2005	164	4	6.48	0.16	197	4	309	6	646	237	1055
2006	25	3	1.51	0.16	26	2	82	10	200	83	285

^ Observer bias corrected.
** Grand mean all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26. 2005-06 bootstrap 95%cis 3.32-8.01-11.40.

Pudding Creek coho salmon escapement data.

Year	Female: Male	Live Fish Capture-Recapture			Carcass Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci	Point Estim	Low 95% ci	High 95% ci
2001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	1.09:1.00	na	na	na	340	205	1081	690	698	692
2003	1.25:1.00	na	na	na	93	0	225	225	205	245
2004	1.00:1.04	1204	1067	1600	1441	819	3558	1132	943	1321
2005	0.85:1.00	1167	899	1773	781	250	4388	984	877	1120
2006	0.68:1.00	709	588	888	148	77	540	566	433	818

Pudding Creek coho salmon redd counts, density, and escapement estimates based on redd data (redd area, 1 redd/female, and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		1 Redd/Female		Fish Per Redd Escapement Estimate *		
	Number	SE	Number/km	SE	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	244	10	7.93	0.97	489	19	524	20	961	353	1570
2003	184	9	9.48	0.46	314	16	367	8	725	266	1184
2004	519	17	28.39	0.94	754	23	1059	34	2045	750	3340
2005	436	24	24.00	1.54	657	35	949	43	1718	630	2806
2006	76	6	3.92	0.32	107	9	188	15	610	252	866

^ Observer bias corrected.
** Grand mean all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26. 2005-06 bootstrap 95%cis 3.32-8.01-11.40.

Caspar Creek coho salmon escapement estimates.

Year	Female: Male	Live Fish Capture-Recapture			Carcass Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd			
2001	nd	nd	nd	nd	nd	nd	nd	25	17	33
2002	0.91:1.00	na	na	na	95	45	135	305	nd	nd
2003	1.23:1.00	na	na	na	10	3	17	31	20	62
2004	1.30:1.00	na	na	na	17	6	201	93	78	108
2005	1.14:1.00	na	na	na	197	123	411	121	98	219
2006	1.10:1.00	126	48	4961	36	22	82	203	155	293

Caspar Creek coho salmon redd counts, density, and escapement estimates based on redd data (redd area, 1 redd/female, and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		1 Redd/Female		Fish Per Redd Escapement Estimate. **		
	Number	SE	Number/km	SE	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	43.52*	11.52	3.41		nd	nd	87*	23*			
2001	53	1.00	4.15	0.08	nd	31	106	2	209	77	341
2002	183	4.00	11.15	0.76	352	10	386	8	721	264	1178
2003	59	2.00	3.78	0.68	61	1	91	5	232	85	380
2004	133	8.00	9.40	0.60	153	9	238	14	524	192	856
2005	292	31.00	19.99	2.12	200	35	548	58	1150	422	1879
2006	38	3.00	2.99	0.20	29	3	73	5	205	126	433

* Expaneded Harris (1999-2000) raw count of 32 assume 0.64 oe in redd detection (32*0.36+32)
** Grand mean all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26. 2005-06 bootstrap 95%cis 3.32-8.01-11.40.

Little River coho salmon escapement estimates.

Year	Female: Male	Live Fish Capture-Recapture			Carcass Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	1.00:1.00									
2001	nd	nd	nd	nd	nd	nd	nd	7	4	10
2002	1.00:1.00	nd	nd	nd	13	7	75	56	25	81
2003	1.25:1.00	nd	nd	nd	6	1	11	28	5	59
2004	0.92:1.00	nd	nd	nd	14	9	1495	85	53	211
2005	1.00:1.00	nd	nd	nd	60	19	114	142	45	270
2006	1.00:1.00^	nd	nd	nd	nd	nd	nd	54	39	69

Little River coho salmon redd counts, density, and escapement estimates based on redd data (redd area, 1 redd/female, and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		1 Redd/Female		Fish Per Redd Escapement Estimate **		
	Number	SE	Number/km	SE	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	8*	2	1.31	0.33			16*	4*	nd	nd	nd
2001	10	1	1.64	0.16	19	4	20	0.7	39	14	64
2002	41	1.6	6.72	0.26	60	2	88	3	162	59	264
2003	27	1	4.43	0.16	34	3	45	3	106	39	174
2004	44	2	7.03	0.32	67	3	91	5	173	64	283
2005	76	15	12.14	2.40	116	24	152	30	299	110	489
2006	7	1	1.67	0.11	6	1	14	1	56	23	80

* expaneded scott harris 1999-2000 raw count
** Grand mean all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26. 2005-06 bootstrap 95%cis 3.32-8.01-11.40.

Noyo River coho salmon escapement estimates.

Year	Female: Male	Live Fish Capture-Recapture			Carcass Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	na	na	-	-	na	na	na	na	na	na
2001	1.53:1.00	nd	nd	nd	331	194	468	593	0	0
2002	1.04:1.00	nd	nd	nd	337	266	408	208	166	333
2003	0.79:1.00	487	84	890	239	183	346	527	433	1044
2004	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2006	0.44:1.00^	nd	nd	nd	nd	nd	nd	593	489	936

^ ecs captures

Noyo River coho salmon redd counts, density, and escapement estimates based on redd data (redd area, 1 redd/female, and fish/redd).

Year	Redd Counts		Redd Density		Redd Area		1 Redd/Female		Fish Per Redd Escapement Estimate **		
	Number	SE	Number/km	SE	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	na	na	na	na	na	na	na	na	nd	nd	nd
2001	475	123.50	9.30	2.42	701	19	950.04	25	1872	686	2057
2002	284	11.00	1.70	0.49	496	20	319	20	1119	410	1827
2003	471	137.00	3.84	1.11	516	190	838	245	1856	681	3031
2004	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-
2005	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-
2006	184	12.00	1.63	0.11	285	6	602	39	1394	578	1984

** Grand mean all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26. 2005-06 bootstrap 95%cis 3.32-8.01-11.40.

Hare Creek coho salmon escapement estimates.

Year	Female: Male	Capture-Recapture			Carcass Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2001	1.00:1.00*	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	1.00:1.00	nd	nd	nd	9	5	78	16	11	105
2003	0.87:1.00	nd	nd	nd	34	19	79	51	51	508
2004	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2006	1.38:1.00	nd	nd	nd	21	10	78	142	35	331

* assume 1:1

Hare Creek coho salmon redd counts, density, and escapement estimates based on redd data (redd area, 1 redd/female, and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		1 Redd/Female		Fish Per Redd Escapement Estimate **		
	Number	SE	Number/km	SE	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2001	4	1.00	0.48	0.12	8	1	9	1	16	6	26
2002	36	9.36	4.36	1.13	60	3	72	4	142	52	232
2003	82	20.00	9.93	2.42	75	7	188	6	323	118	528
2004	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-
2005	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-
2006	110	5.00	5.52	0.24	64	4	192	9	881	365	1254

** Grand mean all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26. 2005-06 bootstrap 95%cis 3.32-8.01-11.40.

Noyo River above the ECS steelhead escapement data.

Year	Female: Male	Live Fish Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	0.75:1.00	nd	nd	nd	nd	nd	nd
2001	1.16:1.00	nd	nd	nd	12	2	22
2002	1.02:1.00	nd	nd	nd	57	18	123
2003	1.24:1.00	nd	nd	nd	37	8	48
2004	0.71:1.00	nd	nd	nd	138	49	227
2005	1.40:1.00	nd	nd	nd	21	11	32
2006	0.60:1.00	nd	nd	nd	131	104	179

Noyo River above the ECS steelhead redd counts, density, and escapement estimates based on redd data (redd area and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		Fish Per Redd Escapement Estimate **		
	Number	SE	Number/km	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	22	5	0.93	0.22	26	0.3	24	18	30
2001	98.6	0.6	3.84	0.92	68	0.5	109	83	136
2002	46	6	3.96	0.95	28	0.4	51	39	63
2003	95	6	6.68	0.40	62	4	105	80	131
2004	110	5	5.96	0.61	91	3	122	92	152
2005	125	4	2.89	0.12	55	4	139	105	172
2006	44	6	1.11	0.18	82	4	44	30	54

** Grand mean all data 0.84-1.11-1.38. 2005-06 bootstrap 95% cis 0.14-0.64-1.29

Pudding Creek steelhead escapement data.

Year	Female to Male R	Live Fish Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd
2002	1.00:1.00*	nd	nd	nd	35	1	69
2003	1.00:1.00*	nd	nd	nd	80	25	161
2004	0.89:1.00	265	69	461	541	180	902
2005	2.25:1.00	203	122	284	334	167	501
2006	2.20:1.00	76	28	280	33	26	46

*Assume 1:1

Pudding Creek steelhead redd counts, density, and escapement estimates based on redd data (redd area and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		Fish Per Redd Escapement Estimate **		
	Number	SE	Number/km	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	124	7	7.93	1.90	117	4	137	103	170
2003	137	3	8.87	2.13	125	3	152	115	189
2004	238	15	11.47	0.46	186	13	264	200	328
2005	125	7	6.87	0.38	100	5	139	105	172
2006	59	2	4.06	0.19	37	3	37	30	44

** Grand mean all data 0.84-1.11-1.38. 2005-06 bootstrap 95% cis 0.14-0.64-1.29

Caspar Creek steelhead escapement data.

Year	Female: Male	Live Fish Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd
2002	1.00:1.00*	nd	nd	nd	nd	nd	nd
2003	1.00:1.00*	nd	nd	nd	21	0	25
2004	0.60:1.00	nd	nd	nd	117	40	194
2005	1.00:1.00	nd	nd	nd	51	26	76
2006	1.50:1.00	6	4	26	22	18	30

*Assume 1:1

Caspar Creek steelhead redd counts, density, and escapement estimates based on redd data (redd area and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		Fish Per Redd Escapement Estimate **		
	Number	SE	Number/km	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	92	5.00	5.71	1.37	80	3	102	77	126
2003	64	2.00	4.22	0.13	65	5	71	54	88
2004	86	4.00	5.96	0.29	77	4	95	72	119
2005	131	9.00	9.00	0.60	100	7	145	110	181
2006	42	5.00	4.92	0.05	25	2	26	6	54

** Grand mean all data 0.84-1.11-1.38. 2005-06 bootstrap 95% cis 0.14-0.64-1.29

Little River steelhead escapement data.

Year	Female: Male	Live Fish Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd
2002	1.00:1.00*	nd	nd	nd	nd	nd	nd
2003	1.00:1.00*	nd	nd	nd	27	9	54
2004	1.00:1.00*	nd	nd	nd	106	35	177
2005	1.00:1.00*	nd	nd	nd	12	6	18
2006	1.00:1.00*	nd	nd	nd	1	0	0

*Assume 1:1

Little River steelhead redd counts, density, and escapement estimates based on redd data (redd area and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		Fish Per Redd Escapement Estimate **		
	Number	SE	Number/km	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	22	0.5	3.61	0.08	16	1	24	18	30
2003	14	2	2.30	0.33	10	1	16	12	19
2004	29	2	4.36	0.41	20	2	32	24	40
2005	22	6	3.50	0.60	20	6	24	18	30
2006	34	2	2.57	0.10	10	2	34	9	59

** Grand mean all data 0.84-1.11-1.38. 2005-06 bootstrap 95% cis 0.14-0.64-1.29

Noyo River steelhead escapement data.

Year	Female: Male	Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	0.75:1.00	228	0	456	173	47	393
2001	1.16:1.00	334	89	819	222	28	416
2002	1.02:1.00	364	75	653	185	47	417
2003	1.23:1.00	316	31	601	375	1	749
2004	nd	nd	nd	nd	nd	nd	nd
2005	nd	nd	nd	nd	nd	nd	nd
2006	0.60:1.00	186	70	7249	278	219	379

Noyo River steelhead redd counts, density, and escapement estimates based on redd data (redd area and fish/redd).

Year	Redd Counts^		Redd Density		Redd Area		Fish Per Redd Estimates **		
	Number	SE	Number/km	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	167	27	1.52	0.37	195	31	185	140	230
2001	450	12	2.96	0.71	343	9	499	378	620
2002	235	10	2.87	0.69	207	13	261	197	324
2003	530	55	5.08	0.51	342	44	588	445	732
2004	nd	nd	nd	nd	nd	nd	nd	nd	nd
2005	nd	nd	nd	nd	nd	nd	nd	nd	nd
2006	326	49	2.98	0.45	88	5	209	46	420

** Grand mean all data 0.84-1.11-1.38. 2005-06 bootstrap 95% cis 0.14-0.64-1.29

Hare Creek steelhead escapement data.

Year	Female: Male	Capture-Recapture			AUC		
		Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd
2002	1.00:1.00	nd	nd	nd	44	7	81
2003	1.25:1.00	nd	nd	nd	58	18	116
2004	nd	nd	nd	nd	nd	nd	nd
2005	nd	nd	nd	nd	nd	nd	nd
2006	1.00:1.00*	nd	nd	nd	18	22	30

*Assume 1:1

Hare Creek steelhead redd counts, density, and escapement estimates based on redd data (redd area and fish/redd).

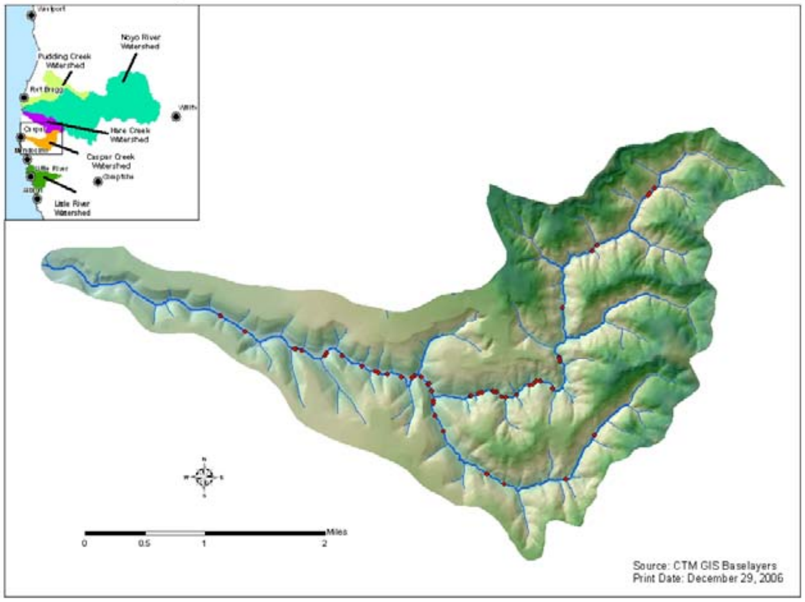
Year	Redd Counts		Redd Density		Redd Area		Fish Per Redd Estimates **		
	Number	SE	Number/km	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci
2000	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	89	5.5	10.77	0.67	64	3	99	75	123
2003	84	9	10.17	1.09	46	5	93	71	116
2004	nd	nd	nd	nd	nd	nd	nd	nd	nd
2005	nd	nd	nd	nd	nd	nd	nd	nd	nd
2006	80	0	7.60	0.00	65	4	52	38	64

** Grand mean all data 0.84-1.11-1.38. 2005-06 bootstrap 95% cis 0.14-0.64-1.29

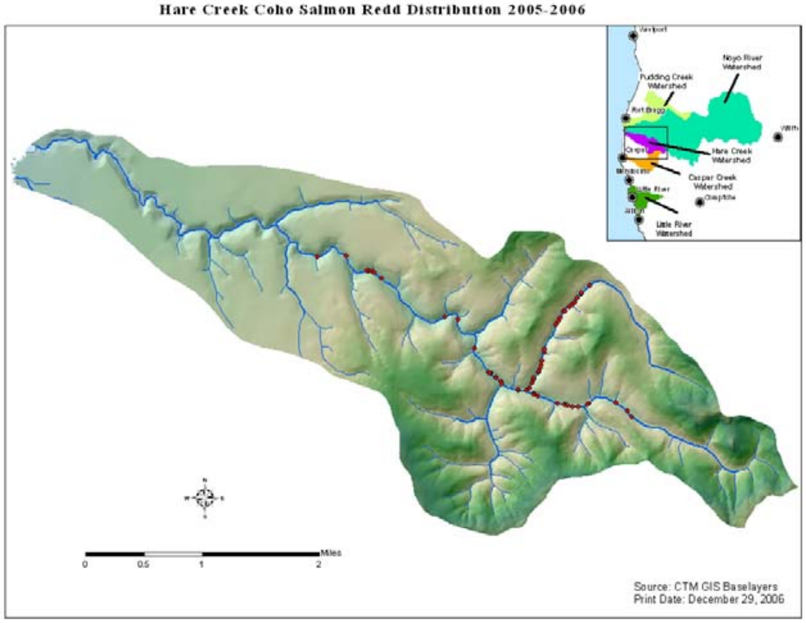
APPENDIX 2

Coho salmon and steelhead redd locations during 2005-06.

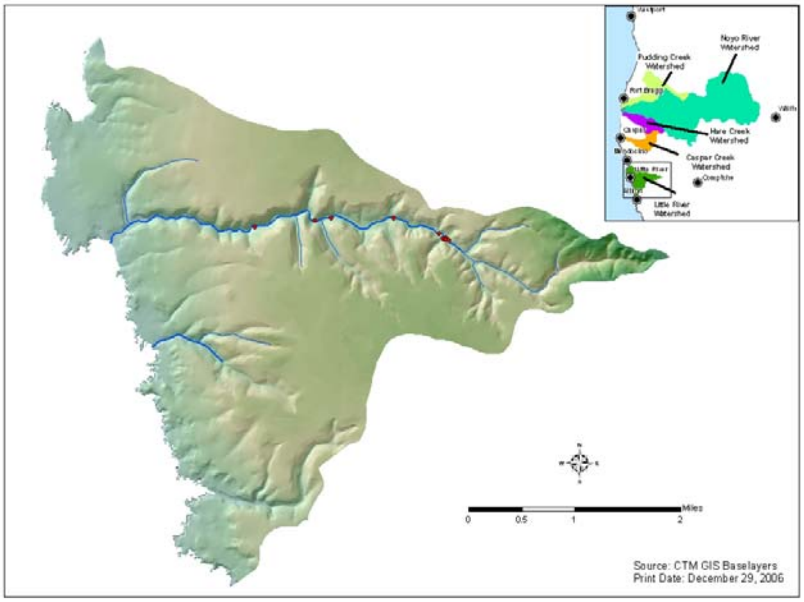
Caspar Creek Coho Salmon Redd Distribution 2005-2006



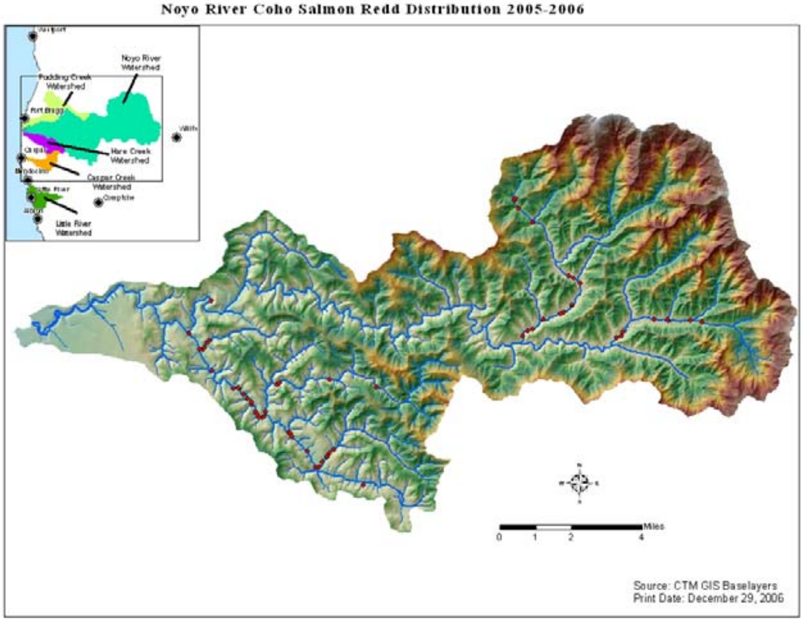
Hare Creek Coho Salmon Redd Distribution 2005-2006



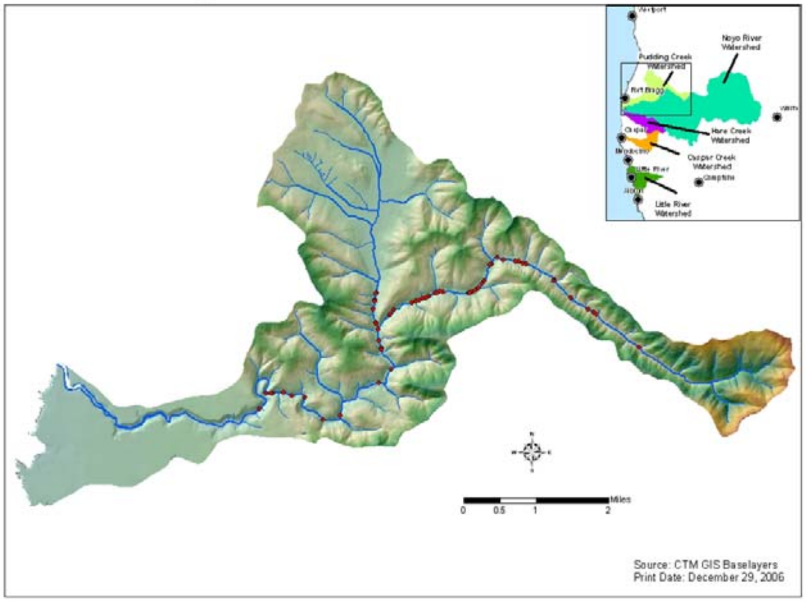
Little River Coho Salmon Redd Distribution 2005-2006



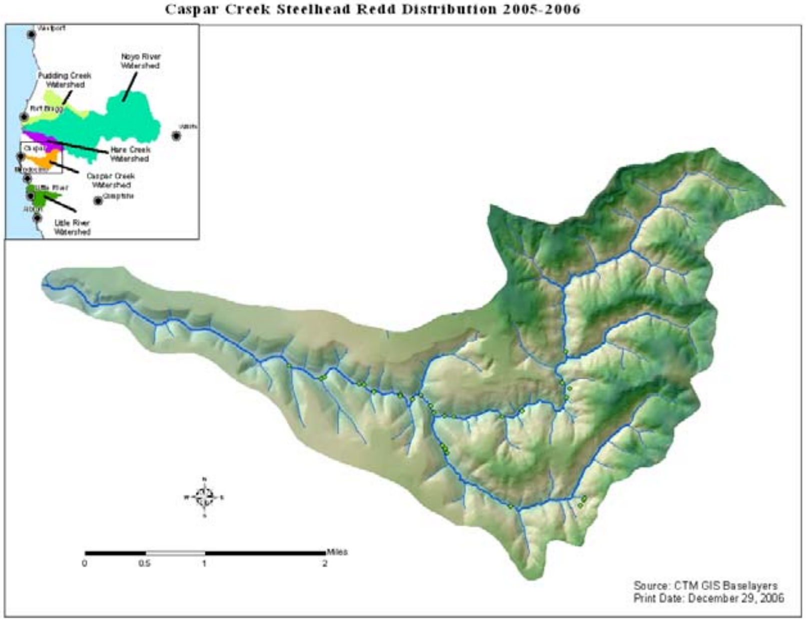
Noyo River Coho Salmon Redd Distribution 2005-2006



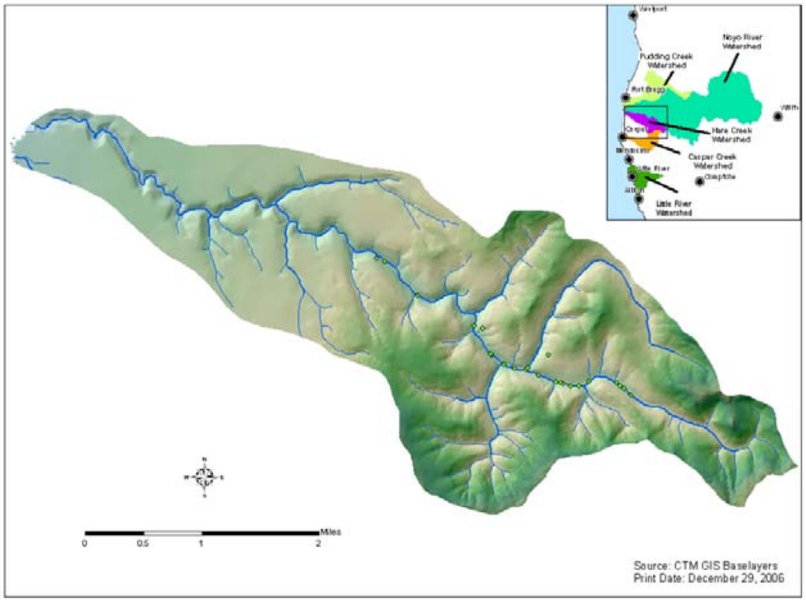
Pudding Creek Coho Salmon Redd Distribution 2005-2006



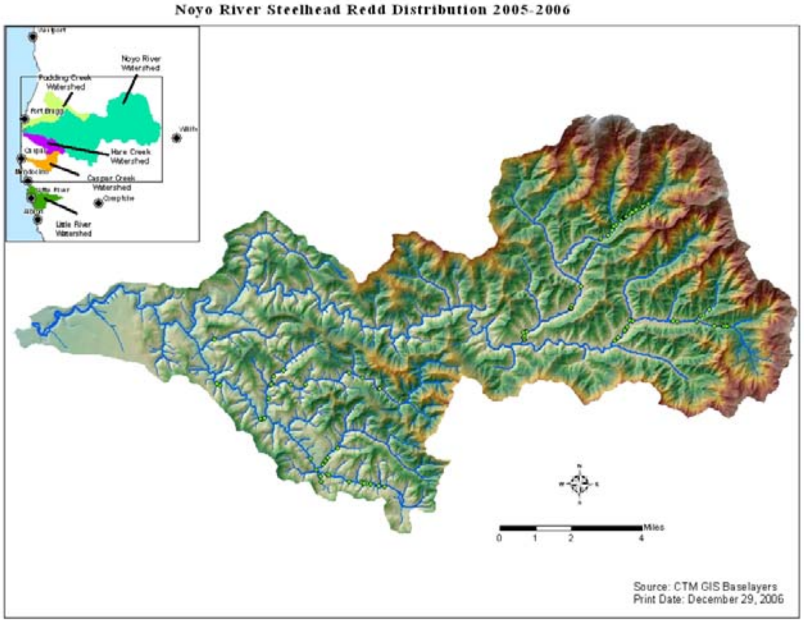
Caspar Creek Steelhead Redd Distribution 2005-2006



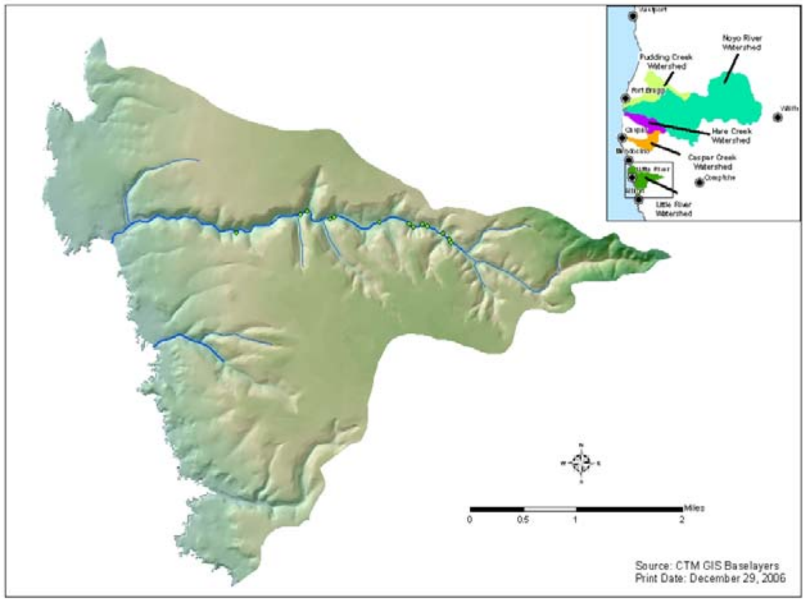
Hare Creek Steelhead Redd Distribution 2005-2006



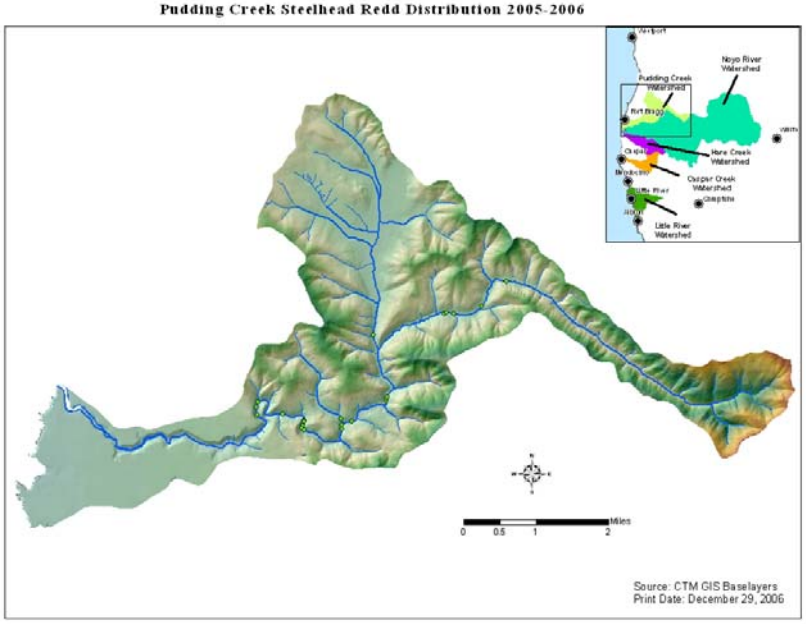
Noyo River Steelhead Redd Distribution 2005-2006



Little River Steelhead Redd Distribution 2005-2006



Pudding Creek Steelhead Redd Distribution 2005-2006



APPENDIX 3

Coho salmon and steelhead AUC variables for several coastal Mendocino County streams during 2005-06.

Stream Name	Steelhead AUC Variables: Trapezoidal Area	Steelhead AUC Variables: Observer Efficiency	Steelhead/Redd	Coho Salmon AUC Variables: Trapezoidal Area	Coho Salmon AUC Variables: Observer Efficiency	Coho/Redd
Caspar Creek	110.5	0.32	0.09	617.5	0.14^	3.32
Hare Creek~	96	0.32	nd	617.4 ± 428	0.21 ± 0.01	nd
Little River	3	0.32	nd	69.5	0.21 ± 0.01	nd
Pudding Creek	31	0.06^	1.29 ± 0.72	1721.5	0.21 ± 0.01^	9.33 ± 1.5
South Fork Noyo	223	0.11	nd	917.5	0.07^	11.4 ± 1.08 (3.12 ± 0.42)
Noyo~	2268.9	0.11^	0.57 ± 0.10	2285.1 ± 2902	0.18^	nd

^ Data from total observed marked / total marked

APPENDIX 4

Multiple captures from downstream migrant traps during spring 2006.

Coho Salmon > 70 mm

Trap Location	<7	7-14	15-21	22-28	29-35	36-42	45-52	53-60	61-68
North Fork Caspar Creek * — All fish were marked at NFC and Then. . .	**Time between Capture and reccapture (88)**								
DARR Recapture results	7.2	7.2	0.93	0	0	0	0	0	0
Recaptured at Main stem	2	0.4	0.23	0.23	0	0.23	0	0	0.23
Recaptured NFC/ then at Mainstem	0.4	0.7	0	0	0	0	0	0	0
Recaptured NFC/ then at SFC	0	0	0	0	0	0	0	0	0
Recaptured twice at NFC	0	0	0	0	0	0	0	0	0
Recaptured three times at NFC	0	0	0	0	0	0	0	0	0
Recaptured at SFC	0	0	0	0	0	0	0	0	0
Recaptured at SFC/ then at Mainstem	0	0.23	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0	0	0	0	0	0
South Fork Caspar Creek — All fish were marked at SFC and Then. . .	**Time between Capture and reccapture (229)**								
DARR Recapture results	25.4	16.7	1.4	0.23	0.4	0	0	0	0
Recaptured at Main stem	1.1	0.93	0.23	0	0	0	0	0	0
Recaptured SFC/ then at Mainstem	3.9	0.93	0	0.23	0	0	0.23	0	0
Recaptured SFC/ then at NFC	0	0	0	0	0	0	0	0	0
Recaptured twice at SFC	0.4	0	0	0	0	0.23	0	0	0
Recaptured three times at SFC	0	0	0	0	0	0	0	0	0
Recaptured at NFC	0.23	0.23	0	0	0	0	0	0	0
Recaptured at NFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0.23	0	0	0	0	0
Mainstem Caspar Creek — All fish were marked at MSC and Then. . .	**Time between Capture and reccapture (112)**								
DARR Recapture results	14.4	9.7	0.4	0.4	0.23	0.4	0	0	0
Recaptured at Main stem	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at SFC	0	0	0	0	0	0	0	0	0
Recaptured twice at MSC	0	0	0	0	0	0	0	0	0
Recaptured three times at MSC	0	0	0	0	0	0	0	0	0
Recaptured at SFC	0	0	0	0	0	0	0	0	0
Recaptured at SFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0.23	0	0	0	0	0	0	0

Steelhead 70 - 120 mm

Trap Location	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68
North Fork Caspar Creek * — All fish were marked at NFC and Then. . .	**Time between Capture and reccapture (33)**								
DARR Recapture results	36	1.5	0	0	1.5	0	0	0	0
Recaptured at Main stem	1.5	1.5	0	1.5	0	0	0	0	0
Recaptured NFC/ then at Mainstem	1.5	0	0	0	0	0	0	0	0
Recaptured NFC/ then at SFC	1.5	0	0	0	0	0	0	0	0
Recaptured twice at NFC	0	0	0	0	0	0	0	0	0
Recaptured three times at NFC	0	0	0	0	0	0	0	0	0
Recaptured at SFC	0	0	0	0	0	0	0	0	0
Recaptured at SFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0	0	0	0	0	0
South Fork Caspar Creek — All fish were marked at SFC and Then. . .	**Time between Capture and reccapture (20)**								
DARR Recapture results	16.6	3	1.5	1.5	1.5	3	0	0	0
Recaptured at Main stem	0	0	0	0	0	0	0	0	0
Recaptured SFC/ then at Mainstem	1.5	0	0	0	0	0	0	0	0
Recaptured SFC/ then at NFC	0	0	1.5	0	0	0	0	0	0
Recaptured twice at SFC	0	0	0	0	0	0	0	0	0
Recaptured three times at SFC	0	0	0	0	0	0	0	0	0
Recaptured at NFC	0	0	0	0	0	0	0	0	0
Recaptured at NFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0	0	0	0	0	0
Mainstem Caspar Creek — All fish were marked at MSC and Then. . .	**Time between Capture and reccapture (13)**								
DARR Recapture results	13.6	1.5	3	0	0	1.5	0	0	0
Recaptured at Main stem	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at SFC	0	0	0	0	0	0	0	0	0
Recaptured twice at MSC	0	0	0	0	0	0	0	0	0
Recaptured three times at MSC	0	0	0	0	0	0	0	0	0
Recaptured at SFC	0	0	0	0	0	0	0	0	0
Recaptured at SFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0	0	0	0	0	0

Steelhead > 120

Trap Location	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68
North Fork Caspar Creek * — All fish were marked at NFC and Then. . .	**Time between Capture and reccapture (23)**								
DARR Recapture results	53	3.3	3.3	0	0	0	0	0	0
Recaptured at Main stem	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at Mainstem	0	0	0	0	0	0	0	0	3.3
Recaptured NFC/ then at SFC	0	0	3.3	0	0	0	0	0	0
Recaptured twice at NFC	3.3	3.3	0	0	0	0	0	0	0
Recaptured three times at NFC	0	3.3	0	0	0	0	0	0	0
Recaptured at SFC	0	3.3	0	0	0	0	0	0	0
Recaptured at SFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0	0	0	0	0	0
South Fork Caspar Creek — All fish were marked at SFC and Then. . .	**Time between Capture and reccapture (5)**								
DARR Recapture results	10	0	3.3	0	0	0	3.3	0	0
Recaptured at Main stem	0	0	0	0	0	0	0	0	0
Recaptured SFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured SFC/ then at NFC	0	0	0	0	0	0	0	0	0
Recaptured twice at SFC	0	0	0	0	0	0	0	0	0
Recaptured three times at SFC	0	0	0	0	0	0	0	0	0
Recaptured at NFC	0	0	0	0	0	0	0	0	0
Recaptured at NFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0	0	0	0	0	0
Mainstem Caspar Creek — All fish were marked at MSC and Then. . .	**Time between Capture and reccapture (2)**								
DARR Recapture results	3.3	0	0	0	0	3.3	0	0	0
Recaptured at Main stem	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at SFC	0	0	0	0	0	0	0	0	0
Recaptured twice at MSC	0	0	0	0	0	0	0	0	0
Recaptured three times at MSC	0	0	0	0	0	0	0	0	0
Recaptured at SFC	0	0	0	0	0	0	0	0	0
Recaptured at SFC/ then at Mainstem	0	0	0	0	0	0	0	0	0
Recaptured at Mainstem twice	0	0	0	0	0	0	0	0	0

* A total of 429 PIT tagged coho were recaptured in all three traps in Caspar Creek.

Multiple captures from downstream migrant traps during spring 2006.

Trap Location	Coho Salmon > 70 mm									Steelhead 70 - 120 mm									Steelhead > 120								
North Fork South Fork Noyo	**Time between Capture and reccapture (78)**									**Time between Capture and reccapture (25)**									**Time between Capture and reccapture (2)**								
All fish were marked at NFSF and Then. . . .	<7	7-14	15-21	22-28	29-35	36-42	45-52	53-60	61-68	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68
DARR Recapture results	74	26	0	1.2	1.2	0	0	0	0	68	28	4	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0
Recaptured twice at NFSF	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0
Recaptured at SF Noyo and not at NFSF	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Fork Noyo	**Time between Capture and reccapture (145)**									**Time between Capture and reccapture (21)**									**Time between Capture and reccapture (3)**								
All fish were marked at SF Noyo and Then. . . .	<7	7-14	15-21	22-28	29-35	36-42	45-52	53-60	61-68	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68
DARR Recapture results	55	33	6.2	4.1	0	0.68	0	0	0	61	14	9.5	0	4.7	0	4.7	0	0	66.6	33.3	0	0	0	0	0	0	0
Recaptured twice at SF Noyo	0	0.68	0	0.68	0	0.68	0	0	0	0	0	0	0	4.7	4.7	0	0	0	0	0	0	0	0	0	0	0	0
Pudding Creek	**Time between Capture and reccapture (1204)**									**Time between Capture and reccapture (21)**									**Time between Capture and reccapture (15)**								
All fish were marked at Pudding Creek and Then. . .	<7	7-14	15-21	22-28	29-35	36-42	45-52	53-60	61-68	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68	<7	7-14	15-21	29-35	36-42	37-44	45-52	53-60	61-68
Recaptured once	82.2	9.7	2.7	0.4	0.08	0.08	0.08	0	0	81	4.8	9.5	0	0	0	0	0	0	80	0	0	13.3	6.7	0	0	0	0
Recaptured twice	1.5	1.2	0.08	0	0.08	0	0	0	0	4.8	4.8	0	0	0	0	4.8	0	0	0	0	0	0	0	0	0	0	0
Recaptured three times	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured Four times	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX 5

FRGP Grant # 054 2005-06 Highlights as of 4/10/2006

I. General Activities:

- Grant received 15 March 2005.
- Contract with Pacific States Marine Fisheries Commission and subcontract to cooperator Campbell Timberlands Management (CTM), hire staff, and prepare for first field season (2005-06) during fall 2005.
- Independent of the grant, CTM funded Dave Wright ¾ time and hired Wendy Hollow as crew leader from 11/1/05 to 5/30/06 for work on Pudding Creek.

II. Evaluation of the Pudding Creek Fish Ladder, Noyo River ECS and a Floating Board Resistance Weir on Caspar Creek for Adult Capture and Marking as Life Cycle Monitoring Stations:

- With statisticians at NOAA Fisheries developed a statistically valid mark-resight design using weekly stratification of bi-colored floy tags for all three streams.
- Consult with Seth Ricker (CDFG) and Dave Gibney (Institute for River Ecosystems, HSU) to develop standardized data base and data collection procedures.
- To reduce stress on fish and improve operational efficiency at the Pudding Creek fish ladder and tagging station CMT contracted fabricator Matt Yeager (independent of the grant) to improve the infrastructure including construction of wet tagging chute and recovery pen, flow reduction gate, and seal block/fish entry gate (cost $19,000).
- Construct, deploy, and operate a floating board resistance weir on Caspar Creek. Use of weed mat and cyclone fence greatly reduces scour, a major problem for use of temporary weirs in coastal streams.

III. Spawning Ground Surveys:

- Develop and implement a statistically valid study design and sampling scheme for estimating escapement in intensively monitored basins, each stream, and regionally following the California Plan.
- Sampling frame created with Dana McCain at IRE used for GRTS sample draw by Trent MacDonald (West Inc,) resulting in 78, two to four km reaches. CA Plan sample of 10% resulted in selection of 8 reaches. Combined, the 33% sampling of each stream and the intensively monitored basins results in a sample rate of 55% for post hoc evaluation of sampling rate at regional level.
- Field identified and surveyed selected reaches December 2005 to present.
- With help from Seth Ricker and Dave Gibney purchased handheld data loggers and developed and tested a data base for spawning ground survey data. Use of this technology reduces costs and data entry errors.

IV. Evaluation of Pudding Creek, South Fork Noyo River and Caspar Creek for Downstream Smolt Trapping as Life Cycle Monitoring Stations:

- Established new trap sites on Pudding and Caspar Creeks.

- Improvements to Pudding Creek trap site and methods including following recommendations of consultant Doug Parkinson (CTM contract 1000$) to purchase and use a 5' rotary screw trap ($17,000) in spring 2006 and repair of access road ($12,000). Solved some operational issues for operation of the screw trap during 2006-07.
- Acquired pit tags associated equipment. Consulted with Seth Ricker and Mike Sparkman to standardize the use of pit tags for smolt abundance and ocean survival (assuming adult monitoring work is done in 2007-08).

V. Complimentary Studies:

- CTM contract with Gordon Reeves at OSU to evaluate CTM monitoring.
- Ongoing collaborative study on fine sediment in salmonid redds and summer riffles CTM and DFG.