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

By

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ABSTRACT

This pilot study treated five coastal Mendocino County streams as a microcosm of the entire coast of California to evaluate the logistics, feasibility, and reliability of Life Cycle Monitoring Streams (LCS) and regional spawning surveys for status and trend monitoring of salmonids throughout coastal California. We examined field logistics, sampling rates, different escapement estimation methodologies for LCS and spawning ground surveys, and calibration of spawning ground survey data from results of LCS experiments. Three streams were selected as LCS's to estimate adult escapement and smolt abundance. Additionally, four other basins, in conjunction with the three LCS's, were surveyed in a Generalized Random Tessellation Sampling (GRTS) design at a 10% sampling rate to collect adult escapement data. We surveyed all habitat in the LCS streams producing a systematic sample of 37 (48%) additional reaches available to examine the regional sampling rate. To develop escapement estimates for comparison to regional estimates, all five streams were also sampled at 33%. For our estimates of escapement, and to calibrate the potential bias in spawning ground escapement estimates for coho and steelhead in the three LCS streams, we used live fish capture-recapture methods. To estimate escapement for the LCS, for individual streams, and for the GRTS sampling at 10% and 48%, we used live fish counts, redd counts, redd areas, and carcass capture-recapture data from spawning ground surveys. Redd counts were converted to escapement using spawner: redd ratios developed in the LCS streams. Smolt abundance was estimated from downstream migrant traps operated during spring 2006 in Caspar and Pudding creeks and in the Little and South Fork Noyo rivers. We conducted a pilot summer rearing population study in Pudding Creek during summer 2006. Smolt abundance data from 2001 to 2004 and adult return data from 2000 through 2005-06 were used to estimate smolt to adult survival for three streams over four years. These data were also used to examine trends in adult abundance and spawner recruit (spawner/spawner) ratios. For estimating annual escapement and providing information for reducing bias in spawning ground based escapement estimates for regional sampling, we found that the live fish capture-recapture method using weekly stream specific bi-colored floy tags and different shape operculum punches at the LCS streams was useful. The results of this study suggest that carcass capture-recapture was not reliable for monitoring because too few carcasses were marked and recovered in any GRTS reach. To estimate coastal salmonids escapement, conversion of redd counts from GRTS sampling to escapement estimates using annual spawner: redd ratios developed at LCS streams was reliable. Escapement estimates from annual spawner: redd conversions of redd counts were not different than capture-recapture estimates and were transferable among streams. The 10% and 48% GRTS escapement estimates overlapped the sum of stream estimates but the variance was higher at 10%. Redd area escapement estimates were not different than capture-recapture estimates for steelhead, but were different for coho due to difficulties counting coho redds experienced during 2005-06. The AUC escapement estimates were not significantly different from capture-recapture estimates and produced reasonable estimates at 10% and 48% GRTS sampling. Due to the need for annual estimates of residence time and observer efficiency the AUC methodology may prove too cumbersome for regional monitoring of coastal salmonids. Coho smolt to adult survival was similar to that reported by other researchers. Coho adult to adult survival was higher than reported by other researchers. There were no trends in adult coho escapement over three generations or over seven years. We recommend using annual LCS spawner: redd ratios to convert redd counts to escapement for regional spawning ground surveys in a GRTS scheme with a sample rate of 10%. The initial annual GRTS sample draw and field data collection should be 15% of the total annual GRTS frame to account for access issues both prior to and during the field season.

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 as threatened species under the U. S. Endangered Species Act (Federal Register 1997, 1999, 2000). 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 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 Memorandum of Understanding between CDFG and NOAA Fisheries (MOU, 1998) states, among many listed objectives, that "extensive resource monitoring is required to evaluate and conserve North Coast steelhead." This study was directed, in part, at furthering the goals of the Steelhead Restoration and Management Plan (McEwan and Jackson 1996), the activities outlined in the MOU, and the coho recovery plan (CDFG 2003).

The action plan for coast-wide monitoring of California Salmonids (Boydstun and McDonald 2005) outlines a sampling scheme to monitor the four components of the Viable Salmonid Populations concept (VSP): Abundance, Population Growth Rate, Population Spatial Structure, and Diversity (McElhany et al. 2000). Under this concept populations at risk of extinction must reach VSP population health goals for each of these parameters to be considered recovered. The California Plan follows a sampling scheme similar to that of the Oregon Plan (Stevens 2002, Firman and Jacobs 2000) where metrics of adult and juvenile populations status and data on habitat conditions are collected in a rotating panel design (Overton and McDonald 1998) intended to monitor salmonid population status and trends at the regional or evolutionarily significant unit (ESU) scale.

Boydstun and McDonald (2005) propose the use of annual spawning ground surveys for long term regional monitoring of California coastal salmonids. In these surveys, adult population sizes are estimated annually in a rotating panel design that samples 10% of all spawning habitat which use one or a combination of commonly used techniques including live fish or redd counts and salmon carcass counting (first stage sampling). They further propose the use of second stage sampling (life cycle monitoring stations), where known estimates of returning adults from total counts or capture-recapture experiments are used to calibrate spawning ground escapement estimates from the first stage sampling. Boydstun and McDonald (2005) suggest that the first stage sampling could utilize 1) redd surveys, where either the total numbers of redds are a sufficient measure of adult population status or redd counts are converted to adult numbers using estimates of the number of fish per redd (from second stage sampling or by assigning a constant such as 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). Boydstun and McDonald (2005) wrote 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.

The purpose of this pilot study was to treat five streams in coastal Mendocino County as a microcosm of the entire coast of California proposed for monitoring under the California Plan (Boydstun and MacDonald 2005) to evaluate the logistics, feasibility, and reliability of Life Cycle Monitoring Streams (LCS) and Regional Spawning Ground Surveys for long term status and trend monitoring of salmonids throughout coastal California. Specifically, we examined the following parameters: 1) field logistics, 2) sampling rates, 3) different escapement estimation methodologies for LCS and spawning ground surveys, and 4) calibration of spawning ground survey data from results of LCS experiments. For this regional approach, two basins and one sub basin were selected for intensive life history monitoring (adult escapement and smolt abundance). In addition, four other basins, in conjunction with the three intensively monitored watersheds were extensively monitored (e.g. the regional sampling approach for adult escapement) in a rotating panel design at a 10% sampling rate to collect data on adult escapement. Due to the need to sample all habitat in the intensively monitored streams and our intent to continue complete sampling in one stream, a systematic sample of 37 (48% sample rate) additional reaches was used to examine sampling rate at the regional scale (Trent MacDonald, West Inc., Personal Communication). Furthermore, all five streams were sampled at 33% to develop escapement estimates for comparison to regional estimates. A small scale sampling frame and a Generalized Random Tessellation Sampling (GRTS) draw, tied to the approach in the California Plan, was developed for this study. This study was a cooperative effort between the DFG and Campbell Timberlands Management.

In the three life cycle monitoring streams (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, 2005b) for the LCS, for individual streams, and for the regional estimates at 10% and 48% sampling. We then used the results from the LCS streams to correct potential bias in spawning ground escapement estimates for the extensively monitored streams. In the spring of 2006, downstream migrant traps were operated to estimate smolt abundance in Caspar Creek, Pudding Creek, Little River, and South Fork Noyo River. A pilot summer rearing population study was also conducted during summer 2006 in Pudding Creek following Neillands (2005). To estimate smolt to adult survival for the three streams over four years, we used smolt abundance data from 2001 to 2004 (Harris 2001, 2002, 2003, 2004) and adult return data from 2000 through 2004-05 (Gallagher 2005b) and 2005-06. Trends in adult abundance and spawner recruit (spawner/spawner) ratios were examined with data from Gallagher (2005b, Appendix A) combined with the 2005-06 results. 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.

We found that live fish capture-recapture method using weekly stream specific bi-colored floy tags and different shape operculum punches was useful for estimating annual escapement and for providing information for reducing bias in spawning ground based escapement estimates for regional sampling at the LCS streams. Boydstun and MacDonald (2005) suggested carcass capture-recapture as one potential methodology for estimating escapement for LCS and regionally. The results of this study suggest that this methodology may not to be reliable for long term monitoring because few carcasses were marked and recovered in any GRTS reach. Consequently, we could not generate carcass capture-recapture escapement estimates for Chinook salmon in the Noyo River or for coho in three of five streams. We found that the conversion of redd counts to escapement estimates using annual spawner: redd ratios developed at LCS streams appears reliable for long term monitoring of coastal salmonids at the regional level using redd counts in a rotating panel design. Escapement estimates from annual spawner: redd conversions of redd counts were not different than capture-recapture estimates and appear to be transferable among streams. We found that the 10% GRTS sampling rate may be too small for the current study area. However, at the Coastal California scale it will likely result in an annual GRTS sample of > 30 reaches which appears sufficient for encompassing the range of variation in redd density observed in this study. The 10% and 48% GRTS escapement estimates overlapped the sum of stream estimates but the variance was higher at 10%. Redd area escapement estimates were not different than capture-recapture estimates for steelhead. However, they were different for coho due to our difficulties counting coho redds during 2005-06. Boydstun and MacDonald (2005) acknowledge that in some years stream flows will limit salmonid monitoring activities. The 2005-06 season appears to have been one of these anticipated seasons.

The AUC produced reasonable escapement estimates for LCS streams and regionally. However, the AUC method is sensitive to the time between surveys and estimates of residence time (*rt*) and observer efficiency (*e*) (English et al. 1992, Hilborn et al. 1999). Both *rt* and *e* require independent capture-recapture experiments for their estimation - experiments which are usually capable of producing escapement estimates without the AUC (Gallagher and Gallagher 2005). Observer efficiency and residence time should be estimated annually for each stream and estimated throughout each season (English et al. 1992, Manske and Schwarz 2000) due to the sensitivity of the AUC method to these variables (Hilborn et al. 1999). The AUC can produce vastly different results depending on which estimates of *rt* and *e* are used. Since these variables are difficult and perhaps expensive to generate, this method of estimating escapement may prove too cumbersome for long term regional monitoring of coastal salmonids (Gallagher 2005b).

The use of a screw trap increased the sampling period for downstream smolt trapping, which produced reasonable abundance estimates. The use of screw traps in other coastal streams should be investigated for use with LCS's.

Coho smolt to adult survival over four return cycles was similar to that reported by other researchers. Coho adult to adult survival was higher than that reported by other researchers. We found no trends in adult coho escapement over three generations or over seven years. The slopes of adult returns versus year for coho were not significantly different than zero. However, seven years data and only three adult coho generations may be an insufficient time series for detecting trends in abundance.

We recommend using annual LCS spawner: redd ratios to convert redd counts to escapement for regional spawning ground surveys in a GRTS scheme with a sample rate of 10%. The initial annual GRTS sample draw and field data collection should be 15% of the total annual GRTS frame to account for access issues both prior to and during the field season.

MATERIALS AND METHODS

Study Area and Data Collection

The intensively monitored basins (LCS) were selected for a variety of reasons (Figure 1). Caspar Creek was chosen due to the history of monitoring and restoration activities in this basin; because it is a CDF experimental watershed; various restoration actions have been implemented in this stream; 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 to estimate abundance, sex ratios, observer efficiency for the AUC; because there are over six years data on coho escapement, redd counts, and smolt abundance above the ECS (2000-2005, Appendix A); 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 California Department of Forestry. 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 A) 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 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 A), 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 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.

The Mendocino Coast study area (Figure 1) is within the Big-Navarro-Garcia hydrologic unit (1598 sq. mi.) and the Mendocino Unit of the CCC Coho ESU.

Caspar Creek (Figure 2) drains approximately 23 km^2 east of the town of Caspar and flows into the Pacific Ocean south of the town of Caspar. The majority of the watershed is owned and managed as an experimental forest by the California Department of Forestry (CDF).

Hare Creek (Figure 3) drains approximately 24 km^2 immediately south of Fort Bragg and flows into the Pacific Ocean south of Fort Bragg. Most of the watershed in owned and managed as an experimental forest by CDF.

Little River (Figure 4) drains approximately 13 km^2 immediately east of the town of Little River. The Little River flows through Van Damme State Park and into the Pacific Ocean north of the town of Little River. The Little River watershed is owned and managed by the California Department of Parks and Recreation.

Noyo River (Figure 5) drains approximately 260 km^2 immediately west of Willits. The Noyo River flows through the coast range and into the Pacific Ocean at Fort Bragg. Approximately 19% of the Noyo River, the South Fork, is owned and managed by the CDF. Other landowners in the basin are Mendocino Redwood Company (the upper watershed) and Hawthorne Timber Company (the main stem).

Pudding Creek (Figure 6) is a tributary to the Pacific Ocean near the town of Ft. Bragg in Mendocino County, California. It has a drainage area of approximately 48 km^2. Most of the Pudding Creek watershed is owned and managed by Hawthorne Timber Company.

Adult Escapement

Life Cycle Monitoring Streams

Capture-Recapture

To quantitatively estimate salmonid escapement in the intensively monitored basins, we used capture-recapture of live fish where fish were captured and marked in traps on their way to spawning areas, and recaptures were made during spawning surveys and in fyke nets (primarily for steelhead returning to the ocean). We marked fish with weekly time specific individually numbered bi-colored floy tags, and to evaluate tag loss, we marked fish with weekly stream specific operculum punches (Figure 7). 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 escapement in Caspar and Pudding creeks and in the South Fork Noyo River above the ECS during 2005-06 (Krebs 1989). Adult coho were captured and marked with brightly colored individually numbered floy tags and operculum punches at a Floating Board Resistance weir (Figure 8), constructed and operated in Caspar Creek 4.9 km from the Pacific Ocean. Adult coho were captured and marked with brightly colored floy tags and operculum punches at a fish ladder on a flashboard dam (Figure 9) in Pudding Creek located 0.25 km from the Pacific Ocean. Known numbers of coho were marked with bi-colored floy tags and released above the Noyo River ECS (Figure 10) during 2005-06. Marked fish were recaptured visually during spawning surveys. Following the recommendation of Gallagher (2005a) and Glen Szerlong (NOAA Fisheries, Santa Cruz, Personal Communication), floy tag colors and operculum punch shapes were changed weekly. Floy tags on coho carcasses were recovered and all carcasses inspected for operculum punches to estimate tag loss and residence time *(rt)*.

Steelhead escapement in Caspar and Pudding creeks and the in the Noyo River was estimated using the Schnabel capture-recapture method during 2005-06 (Krebs 1989). Adult steelhead were captured and marked with brightly colored individually numbered floy tags and operculum punches at the ECS, the Pudding Creek fish ladder, and in fyke traps in Caspar Creek and the South Fork Noyo River (see Smolt Abundance below). Steelhead recaptures were made during spawning surveys and in down stream fyke traps. Following the recommendation of Gallagher (2005a) and Glen Szerlong (NOAA Fisheries, Santa Cruz, Personal Communication) floy tag colors and operculum punch shapes were changed weekly.

Chinook and coho populations were also estimated by capture and recapture of carcasses (Figure 11) during spawning surveys in all streams following Gallagher and Gallagher (2005) with Jolly-Seber method, or the Schnabel or Petersen method when recaptures were less than seven (Krebs 1989). Carcass mark-recapture data for 2005-06 was examined by survey reach to determine the appropriateness of the data for producing reach specific capture-recapture estimates. Data from freshly dead floy tagged carcasses was used to estimate *rt*.

Spawning Ground Surveys

Redd counts

To estimate escapement in the intensively monitored watersheds we used data collected during spawning surveys following Gallagher and Gallagher (2005) and Gallagher (2005b). In order to increase numbers for the recapture matrices, and to provide sufficient data for evaluating potential biases in escapement estimates derived from spawning surveys, the entire extent of spawning habitat was surveyed approximately biweekly during 2005-06 in the LCS streams. From early-December 2005 to mid-April 2006, we surveyed all available spawning habitat approximately bi-weekly. High flows limited the number of surveys early in the field season. Field methods, reduction of bias in redd counts, escapement estimation from redd data, and examination of the relationship between redd counts and capture-recapture escapement estimates followed Gallagher and Gallagher (2005), Gallagher and Knechtle (2003), and Gallagher at al. (In

Press). Redd density was calculated from the observer efficiency corrected redd counts divided by the reach length (km) for each survey segment.

Redd area and one redd per female

Escapement estimates based on redd data followed Gallagher and Gallagher (2005) and were made by expanding total redd counts by the male to female ratio, and by a method which assumes the number of redds a female makes is related to redd size (redd area method). Redd area estimates followed Gallagher and Gallagher (2005). Escapement estimates assuming one redd per female were made by multiplying the observer efficiency corrected number of redds by the male to female ratio observed in each river and then 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.

Fish per redd

The number of fish per redd (spawner: redd ratio) is a conversion factor to convert bias corrected redd counts into fish numbers. We calculated the number of fish per redd by dividing the capture-recapture estimates for coho and steelhead by the corrected estimate of the number of redds of each species in Caspar and Pudding creeks and in the South Fork Noyo River for all available data - years (Table 1). These estimates were then used to convert redds counts to fish numbers in each stream such that fish per redd in Pudding Creek was used to estimate fish in the South Fork Noyo River and visa versa. To convert redd counts to fish numbers and compare these data to capture-recapture estimates, we used the average number of coho per redd from 2001-2006 above the ECS, Caspar Creek during 2005-06, and Pudding Creek 2004 - 2006. The number of fish per redd were compared among streams and years to examine transferability of the data.

We converted steelhead redd counts to fish numbers and compared these data to capture-recapture estimates using the number of fish per redd from the Noyo River 2000-2003 and 2005-06, Caspar Creek 2005-06, and Pudding Creek 2004 - 2006 (Table 1). The numbers of fish per redd were similarly estimated using AUC in all streams for which this data was available. We compared predicted escapement from these data to capture-recapture escapement estimates for all streams and year's that data was available.

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 2) and taken from the literature (Beidler and Nickelson 1980). Residence times were compared among steams and over years using paired t-tests and ANOVA. The

AUC escapement estimates were calculated with various combinations of *rt* and *e* and compared to capture-recapture escapement estimates for the LCS streams.

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 2), and taken from the literature (Gallagher and Gallagher 2005). Residence times were compared among streams and over years using paired t-tests and ANOVA. The AUC escapement estimates were calculated with various combinations of *rt* and *e* and compared to capture-recapture escapement estimates.

Due to the amount of data available for analysis from the floy tagging of fish, observer efficiency (*e*), the ratio of total fish seen to the total present (Korman et al. 2002), was estimated various ways. Following Gallagher and Gallagher (2005) the total number of fish of each species observed during spawning surveys was divided by the capture - recapture estimates for each season. Thus confidence intervals for AUC and capture-recapture estimates were interrelated for the calculated estimates. Observer efficiency was also estimated from the total marked fish and the total observed marked during spawning surveys for the entire season. We predicted the weekly estimates of *e* for each species from weekly estimates of stream flow and water visibility using regression models from past studies (Gallagher 2005b). Escapement 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 and spawning survey based escapement estimates to identify and quantify potential biases in escapement estimates. This is based on spawning surveys and redd counts similar to the approach used in Oregon, where index weir counts are used to correct for biases in redd counts for population monitoring of steelhead (Susac and Jacobs 2002). We also used data from the mark-recapture program for calculating area-under-the-curve (AUC) escapement estimates (see Hilborn et al. 1999 for a discussion of the AUC). The differences we found among streams in residence time and observer efficiency data from the mark-recapture experiments was examined to determine if these data were transferable among streams. To determine transferability, we examined estimates of the number of fish per redd among streams. Relationships between redd counts and escapement were then used to convert redd counts to fish numbers. 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.

Individual Stream Estimates

Redd counts

Field methods, reduction of bias in redd counts, escapement estimation from redd data, and examination of the relationship between redd counts and AUC escapement estimates followed Gallagher and Gallagher (2005), Gallagher and Knechtle (2003), and Gallagher at al. (In Press). Redd density was calculated from the observer efficiency corrected redd counts divided by the reach length (km) for each survey segment.

Escapement

To quantitatively estimate salmonid escapement in the extensively monitored basins (Hare Creek and the Little and Noyo rivers) we used the area-under-the-curve (AUC) and methods based on redd counts following Gallagher and Gallagher (2005) and Gallagher (2005b) as described above for LCS streams. For individual streams 33% of the total spawning habitat was randomly selected, sampled, and escapement estimates were generated by expanding stream reach average densities by the total length of habitat in each stream (Gallagher and Gallagher 2005). These estimates were combined with population estimates for the intensively monitored streams as the total escapement for the "microcosm" regional estimate and compared to those created by sampling the frame developed as part of the pilot program for the California Plan (see regional monitoring below).

Regional Estimates

Sample frame

Regional escapement estimates followed the methods outlined by Boydstun and MacDonald (2005). A sampling frame was developed by dividing the total extent of spawning habitat in the five study streams into uniquely identified reaches, which ranged in length from 0.26 to 3.79 km in length (Danna McCain, Institute for River Ecosystems, Personal Communication) resulting in 76 unique reaches. A Generalized Random Tessellation Sample (GRTS) sampling scheme for this sampling frame was developed by Trent MacDonald (Table 3). Following Boydstun and MacDonald (2005) a 10% sample draw selected eight reaches for sampling to estimate regional spawning escapement. 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.

For this pilot study, a three year rotating panel for the 76 reaches was created to capture both annual abundance and trends (Table 3). In this sampling scheme the first 8 GRTS reaches (expanded to 9 reaches in 2006-07 for evenness in effort) were selected for sampling during the first year of study. The first three will be sampled every year, the second three reaches will be sampled every other year, and the following three will be sampled every third year. Carrying this sequence through all 76 reaches created a three year rotating panel for the pilot study area (Trent MacDonald, West Inc., Personal Communication).

During 2005-06 we field verified all the selected GRTS stream reaches for access, and in November 2005, we marked the beginning and end points 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 3) and these lengths were used for calculating density.

Redd counts

Field methods, reduction of bias in redd counts, escapement estimation from redd data, and examination of the relationship between redd counts and AUC escapement estimates followed Gallagher and Gallagher (2005), Gallagher and Knechtle (2003), and Gallagher at al. (In Press). Redd density was calculated from the observer efficiency corrected redd counts divided by the reach length (km) for each survey segment.

Escapement

Spanwner abundance in each reach was estimated from live fish counts and redd data following Gallagher and Gallagher (2005) and Gallagher (2005b) as described above for LCS streams. These reach abundance data were converted to density estimates and expanded to regional escapement estimates following Boydstun and MacDonald (2005). Standard error and 95% confidence bounds were calculated using bootstrap simulation (Trent MacDonald, West Inc., Personal Communication).

Smolt Abundance

The purpose of the smolt trapping was to acquire capture-recapture data by age class and species in a format for use in the Darr model (Bjorkstedt 2003) to produce estimates of smolt abundance. The data were the total number of unmarked fish, the total number of fish marked and released, and the total number of recaptured marked fish of each species and size class by day and week for each trap. To create weekly sums for input into Darr, we compiled total capture, mark, recapture, and mortalities data. We checked the traps daily and recorded information on other captured species. In general, we used the methods developed by Gallagher (2000, 2003) and Barrineau and Gallagher (2001), except that we used pit tags as the primary mark. We weighed and measured all steelhead and coho > 50 mm (FL) the nearest mm and to the nearest 0.1 g. They were marked with a site and week specific mark (pit tag or fin clip) and released upstream of the traps. Twenty fish of each species and size/age class were measured; all others were counted each day. 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. Scale and tissue samples were taken from a small sample of coho and steelhead each day. Mortalities were recorded by species and size class each day.

To estimate smolt abundance using pit tag capture-recapture methodology during spring 2006, we tagged one year and older coho and steelhead (> 70 mm FL) with individual numbered pit tags and gave them a maxillary clip to assess tag loss. We gave year old (based on fork length at time of capture) coho and steelhead (< 70 mm) a weekly specific fin clip. 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.

To estimate smolt abundance using pit tags and capture-recapture methodology, three fyke traps (Figure 12) were operated in Caspar Creek in spring 2006. One trap was located about 5.0 km upstream of the Pacific Ocean (main stem) and two other traps were placed above the confluence of the North Fork and South Fork of Caspar Creek. One trap was in the South Fork just above the confluence and the other in the North Fork. We deployed two fyke traps above the ECS. One was in the South Fork Noyo River and the other in the North Fork South Fork Noyo River. CTM purchased a screw trap (purchased independently of the FRGP Grant # 054), and deployed and operated it in Pudding Creek during spring 2006 (Figure 13). In late spring, the flows in Pudding Creek were too low to operate the screw trap, so it was replaced with a fyke trap.

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 also summed all other species caught by week.

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. We ran the matrices in Darr to estimate the above noted parameters.

Summer Rearing

We conducted a pilot over-summer rearing abundance survey was 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 (Figure 14). 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 A) and 2005-06. We calculated spawner recruit (spawner/spawner) ratios from data from Gallagher (2005b, Appendix A) 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). We compared the slopes of adult abundance versus year for all seven years with paired t-tests treating each stream as a sample. 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.

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. Statistical significance was accepted at $p < 0.05$.

RESULTS

Stream flows and rainfall limited spawning surveys during 2005-06, particularly during late-December and early-January (Figure 15). Peak flows on the Noyo River have only been annually recorded ≥ 284 m^3/s 15 times over the last 54 years. During late-December 2005, the Noyo River reached 284 m^3/s twice (Figure 15). Steelhead and coho were first captured at Pudding Creek in December 2005, and steelhead captures continued through March (Figure 16).

Adult Escapement

Life Cycle Monitoring Streams

Capture-Recapture

The uncertainty associated with the live coho capture-recapture escapement estimates in the LCS streams was lowest for Pudding Creek and highest for Caspar Creek (Table 4). The hybrid Floating Board Resistance weir (Figure 17) was damaged by high flows in December 2005, and consequently we only captured and tagged eight coho. However, the use of weed mat and chain link fencing greatly reduced scour around the hard parts of the weir. Due to the weir damage, we only observed one of the marked coho during spawning surveys on Caspar Creek. 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 the marked fish captured this season in different streams was 0.013 for fish marked at the ECS and 0.003 for fish marked at Pudding Creek.

Coho carcass capture-recapture estimates were lower than live fish estimates, and only the Caspar Creek estimates overlapped (Table 4). We did not generate coho carcass capture-recapture estimates for Little River, the Noyo River, or the South Fork Noyo River due to the lack of observed carcasses.

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. The Schnabel capture-recapture estimate using live fish marked at the fish ladder and combined operculum and floy tag (one, the other, or both) carcass recaptures on the spawning grounds of 801–1083–1605 was higher, had larger uncertainty, but overlapped the live fish capture-recapture estimate (Table 4). We could not estimate tag loss for coho in Caspar Creek or the South Fork Noyo River because too few tagged carcasses were observed.

The uncertainty associated with the live steelhead capture-recapture escapement estimates in the LCS streams was lower in Caspar Creek than in Pudding Creek (Table 5). We could not generate capture-recapture escapement estimates for steelhead above the ECS, because no marked steelhead were observed during spawning surveys in streams above the ECS. However, an escapement estimate for the entire Noyo River was calculated from one observed steelhead tagged in the upper Noyo at the ECS (Table 5).

Spawning Ground Surveys

Redd counts

Observer efficiency in coho redd counts was similar among the LCS streams (Table 6). The total number of coho redds in these streams ranged from 26 (SE = 2) to 107 (SE = 9) and was lowest above the ECS (Figure 18, Table 6).

Observer efficiency in steelhead redd counts in the LCS streams ranged from 0.72 (SE = 0.14) to 0.44 (SE = 0.11) and was lowest above the ECS (Table 7). In these streams, the total number of steelhead redds ranged from 42 (SE = 5) to 59 (SE = 2) and was lowest in Caspar Creek (Figure 19, Table 7).

Redd area and one redd per female

In the three LCS streams, coho redd area escapement estimates were lower than the live fish capture-recapture estimates (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). Steelhead escapement estimates based on redd areas overlapped the capture-recapture estimates in Caspar and Pudding creeks (Tables 5 and 7).

Fish per redd

The number of coho per redd based on capture-recapture of live fish and bias corrected redd counts varied among the three LCS streams (Table 5). The number of fish per redd above the ECS over six years (2000 to 2005-06) was not significantly different than the number of fish per redd in Pudding Creek during 2004 through 2005-06 ($T = 19.0$, $p = 0.38$, n = 6:3, Table 1). However, these data were not distributed normally (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 (Table 1). To account for annual differences in stream flow, visibility, and the number of fish per redd, we used the three stream average number of coho per redd during 2005-06 of 8.02 ± 2.41 (SE) 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 number of fish per redd overlapped the capture-recapture estimates (Table 4).

For steelhead, we also found that the number of fish per redd based on capture-recapture of live fish and bias corrected redd counts varied among the two LCS streams where capture-recapture estimates were made (Table 5). Like the coho estimates, the number of steelhead per redd in the Noyo River (2000 to 2003 and 2006) was not significantly different than the number of fish per redd in Pudding Creek during 2004 through 2005-06 ($t = 1.16$, $df = 6$, $p = 0.29$, $ß = 0.08$, Table 1). However, unlike the coho estimates, the 2005-06 estimates in the Noyo River and Pudding Creek were lower than the previous years estimates (Table 1). To account for annual differences in stream flow and visibility and differences in the number of fish per redd, we used the two stream average number of steelhead salmon per redd during 2005-06 of 0.65 ± 0.41 (SE) to expand redd counts to escapement estimates for all streams during 2005-06 (Table 5). The escapement estimates based on the 2005-06 two stream average number of fish per redd overlapped the capture-recapture estimates (Table 5).

AUC

We produced the most reliable coho AUC escapement estimates for the three LCS streams, based on overlap with live fish capture-recapture estimates, by using the three stream average 2005-06 *rt* and *e*, which were based on the total observed marked divided by the total marked in each stream (Table 4). 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 2). When we examined coho *rt* individually, it was only 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). To account for annual differences in stream flow and visibility in 2005-06, we used the average *rt* among the three LCS streams of 15.03 - 21.73 – 28.42 days to convert the trapezoidal approximation into fish numbers. We obtained the most reliable estimates of *e* for the three LCS streams by dividing the total observed marked fish by the total marked fish in each stream (Table 4). This method of calculating observer efficiency for the AUC was the same as predicted from stream flow (Gallagher and Gallagher 2005) in Pudding Creek (Table 4), but it was higher in Caspar Creek and above the ECS (0.22 and 0.18, respectively).

We produced the most reliable steelhead AUC escapement estimates for the three LCS streams, based on overlap with live fish capture-recapture estimates, by using the average 2000-05 *rt* and *e*, which are based on the total observed marked divided by the total marked in each stream (Table 5). Steelhead *rt* was significantly different among streams and years (ANOVA F = 3.71, df = 34, p = 0.006, ß = 0.82, Table 2). Examined individually, steelhead *rt* was significantly different between Noyo River main stem observations and those in tributaries and Pudding Creek (Tukey's q > 4.32, p < 0.04). We observed too few tagged steelhead in any of the LCS streams during 2005-06 to estimate *rt* this year. Because *rt* was not different among tributaries and in Pudding Creek over the last few years (Table 2), we used the multi-year multi-stream average of 11.33 – 15.43 – 19.54 days to convert the trapezoidal approximation into fish numbers for 2005-06. Steelhead *e*, calculated as the total observed marked divided by the total marked in each stream, was different between Pudding Creek and the South Fork Noyo River. It was also different from that predicted from water visibility (Gallagher and Gallagher 2005) in Pudding Creek and the South Fork Noyo River (0.33 ± 0.01 and 0.32 ± 0.01, respectively). Because we did not observe tagged steelhead in Caspar Creek, we predicted *e* by using the relationship between observation ability and water visibility presented by Gallagher and Gallagher (2005).

Bias in spawning ground survey escapement estimates

The uncertainty in Coho escapement estimates based on redd area did not overlap the capture-recapture estimates for the three LCS streams (Tables 4 and 6). Only in Caspar Creek did escapement estimates assuming one redd per female overlap the capture-recapture estimates. However, the 95% confidence bounds for the Caspar Creek capture-recapture estimate were large. The carcass capture-recapture escapement estimates overlapped estimates based on redd area and one redd per female for Caspar and Pudding creeks. Escapement estimates based on the three stream average number of fish per redd 2005-06 overlapped the capture-recapture estimates in all three streams. The estimated number of fish per redd in Caspar Creek was similar to the estimate based on releases above the ECS. However, the associated uncertainty was greater (Table 4). The associated uncertainty in the AUC and capture-recapture escapement estimates overlapped in all three LCS streams.

When the 2005-06 coho escapement estimates were combined with data from Gallagher (2005) (Appendix A) and years treated (2000 – 2005-06) 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 ($r = 0.86$, $p = 0.03$, $n = 6$). When treating years as samples in 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 escapement (ANOVA $F = 2.38$, $df = 17$, $p = 0.11$, $ß = 0.30$). Additionally in Pudding Creek, we found that redd counts and coho live fish capture-recapture estimates were not significantly correlated over three years in ($r = 0.99$, $p = 0.07$, $n = 3$).

Bland-Altman analysis (Glantz 1997) suggests that coho escapement based on fish per redd conversions from redd counts 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 ($r = 0.58$, $p = 0.60$). Because the three stream 2005-06 average of the number of coho per redd produced escapement estimates similar to the capture-recapture estimates, it appears that this conversion factor was transferable among streams. However, the fish per redd estimate in Caspar Creek may only overlap the capture-recapture estimate due to the large confidence bounds of the latter. In Table 4 the statistical uncertainty in capture-recapture estimates are 95% confidence limits, whereas the uncertainty in the fish per redd estimates are standard errors (for consistency with Gallagher 2005a).

The coho AUC escapement estimates and the capture-recapture escapement estimates appear to be equally reliable measures of escapement. Both values were highly correlated ($r = 1.00$), the mean difference and standard deviation between the measures was low, and the data for the difference between the measures and the mean of the two were within two standard deviations. However, the mean and the difference between the two measures were also significantly correlated ($r = 1.00$, $p < 0.001$).

Bland-Altman analysis (Glantz 1997) suggests that coho redd counts, redd area escapement, and escapement based on the assumption of one fish per redd were not equally reliable estimates of escapement compared to capture-recapture methods. None of the escapement estimates were correlated ($r > 0.84$, $p > 0.12$), the mean difference and standard deviation between the measures were high, and the mean and the difference between the two measures were significantly correlated ($r > 0.98$, $p < 0.055$). However, all data for the difference between the measures and the mean of the two were within two standard deviations.

Steelhead escapement estimates based on redd area overlapped capture-recapture estimates for Caspar and Pudding creeks (Tables 5 and 7). We did not produce capture-recapture estimates for the South Fork Noyo River above the ECS because tagged fish were not observed during spawning surveys in these streams. However, we did generate a capture-recapture estimate for the entire Noyo River. Because the confidence bounds were large, the capture-recapture and redd area escapement estimates overlapped for the Noyo River (Tables 5 and 7). For Caspar and Pudding creeks, and the Noyo River, the AUC and the capture recapture escapement estimates overlapped (Tables 5 and 7). Escapement estimates based on the two stream average number of steelhead per redd during 2005-06 overlapped capture-recapture estimates.

For steelhead, when we treated years and rivers as samples (Noyo River 2000-2003 and 2005-06, Pudding Creek 2003 to 2005-06, and Caspar Creek 2005-06, Appendix A), we found capture-recapture escapement estimates, 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 also significantly correlated ($r = 0.86$, $p = 0.003$, $n = 9$).

Bland-Altman analysis (Glantz 1997) suggests that steelhead escapement based on fish per redd conversions of redd counts and capture-recapture estimates were equally reliable. The two variables showed high correlation ($r = 0.96$), 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 ($r = -0.48$, $p = 0.72$, $n = 3$). The AUC steelhead escapement estimates and capture-recapture escapement estimates may not be equally reliable measures of escapement. Both values were correlated ($r = 0.73$), the mean difference and standard deviation between the measures was high, the mean and the difference between the two measures were not significantly correlated ($r = -0.42$, $p = 0.72$, $n = 3$), and data for the difference between the measures and the mean of the two were within two standard deviations. Redd area and capture-recapture escapement estimates for steelhead may be equally reliable. The Bland-Altman analysis showed that both measures were correlated ($r = 0.98$), the mean difference and standard deviation between the measures was medium, the mean and the difference between the two measures were not significantly correlated ($r = 0.98$, $p = 0.11$, $n = 3$), and data for the difference between the measures and the mean of the two were within two standard deviations.

Individual Stream Estimates

Redd counts

Observer efficiency in coho redd counts was similar among the extensively monitored streams (Table 4). The total number of coho redds in these streams ranged from 7 (SE = 1) to 184 (SE = 12) and was lowest in Little River (Figure 18, Table 4).

In steelhead redd counts, observer efficiency ranged from 0.20 (SE = 0.17) to 1.00 (SE = 0.00) in the extensively monitored streams and was lowest in Little River (Table 7). The total number of steelhead redds in these streams ranged from 34 (SE = 2) to 326 (SE = 49) and was highest in the Noyo River (Figure 19, Table 7).

Chinook salmon redds were only observed in the Noyo River. Observer efficiency for Chinook redds in the Noyo River during 2005-06 was 0.33. The estimated number of Chinook redds in the Noyo River was 6 – 13 – 27. We surveyed twelve of the 23 GRTS reaches known to be used by spawning Chinook during 2005-06. Chinook spawning habitat comprises an estimated total of 66.6 km for in the Noyo River. Redd density for Chinook was 0.19/km (SE = 0.10). We could not survey a large portion of the upper Noyo River until late-December due to access issues.

Escapement

The coho escapement estimates based on spawning survey sampling 33% of each of the extensively monitored streams varied depending on the estimation method (Tables 4 and 6). Uncertainty in the estimates was highest for the AUC method and lowest for the redd area method. We used the 2005-06 three stream average coho *rt* and *e* predicted from stream flow to calculate AUC escapement estimates for the extensively monitored streams following Gallagher and Gallagher (2005). We could only generate carcass capture-recapture estimates for Hare Creek because too few carcasses were tagged and recovered in the other streams. Based on the noted results of bias in spawning survey escapement estimates, we found that the estimates from conversion of redd counts into fish numbers from estimates of fish per redd in the LCS streams appear to be the most reliable. In general, these estimates were higher than those of other methods and only overlap AUC estimates in Little River. Stream flows during the 2005-06 season were quite high and limited spawning surveys early in the season (Figures 15 and 16).

The steelhead escapement estimates based on spawning survey sampling 33% of each of the extensively monitored streams varied depending on the estimation method (Tables 5 and 7). The estimates from conversion of redd counts into fish numbers from estimates of fish per redd in the LCS streams appear to be the most reliable, based on the results of bias in spawning survey escapement estimates. Uncertainty in the estimates was highest for the AUC method and lowest for the redd area method. All methods of estimating escapement produced results that overlap the capture-recapture estimate in the Noyo River. However, the 95% confidence interval for the capture-recapture estimate in the Noyo River was quite large due to few recaptures. The steelhead AUC escapement estimates for the extensively monitored streams used the 2000-05 average *rt* and *e* predicted from water visibility.

Chinook salmon escapement based on one redd per female was 2-13-27 in the Noyo River during 2005-06. We did not produce capture-recapture estimates for Chinook salmon in 2005-06, because too few carcasses were marked and none were recaptured. 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. Chinook were not observed in any of the other study streams during 2005-06.

Regional Estimates

Sample frame

Reach lengths measured in the field and estimated from GIS layers in Arc View were not significantly different (W = 74.0, p = 0.3, Table 3) 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).

Equation 1:

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

We used this equation to correct GIS lengths for estimating abundance for the regional sampling frame (Table 3) resulting in a total of 172.5 km of coho and steelhead spawning habitat in the five streams. We estimate a total of 23 Chinook salmon spawning reaches (66.6 km) in the Noyo River.

Redd counts

When we estimated the total number of coho redds in the five streams by adding the LCS estimates and the 33% sampling of the extensively monitored streams, it was within the range estimated by expanding the GRTS reach density estimates with the sampling rates of 10% and 48% (Table 8). The statistical uncertainty was greater at the 10% GRTS sampling rate than at 48%. The variance associated with the mean coho redd density did not substantially decrease after about 30 reaches (Figure 20). When we calculated the coho redd density for 8 reaches (10%) (1.48-3.52-6.14), it was similar to the calculated average of 37 reaches (1.63-2.65-3.76) but had higher variance. It was within the bounds estimated for the five streams (Table 6).

When we estimated the total number of steelhead redds in the five streams by adding the LCS estimates and the 33% sampling of the extensively monitored streams, it was within the range estimated by expanding the GRTS reach density estimates with the sampling rates of 10% and 48% (Table 9). The statistical uncertainty was greater at the 10% GRTS sampling rate than at 48%. The variance associated with the mean steelhead redd density did not substantially decrease after 32 reaches (Figure 21). When the steelhead redd density was calculated for 8 reaches (10%) (1.00-2.92-4.15), it was similar to the calculated average of the 37 reaches, but it had higher variance (2.76-4.17-5.95). It was within the bounds estimated for four of the five streams (Table 7). Steelhead redd density was higher than coho density during 2005-06.

The total number of Chinook salmon redds in the Noyo River was within the range estimated by expanding the GRTS reach density estimates with the sampling rates of 10% and 48% (Table 10). When the Chinook salmon redd density was calculated for 8 reaches (10%) (0.00-0.26-0.77) it was similar to, but had higher variance than, that calculated from the average of 23 reaches (0.00-0.17-0.43). It was within the bounds estimated for the entire Noyo River (Table 10).

Escapement

When the coho redd area escapement was estimated by adding LCS estimates and 33% sampling of the extensively monitored streams, it was within the range estimated by expanding GRTS reach estimates with sampling rates of 10% and 48% (Table 8). When we produced individual stream escapement estimates by redd area summation, they did not overlap summation estimates based on one redd per female, fish per redd, or the AUC. They mostly overlapped the estimates derived from the 10% and 48% GRTS sampling. When estimates of coho escapement were based on one redd per female, fish per redd, and AUC for the sum of individual steams, they overlapped the 10% and 48% GRTS expansion estimates. Similar to the redd area estimates, these estimates had the tightest confidence bounds for the summation of streams, and they had the highest with the 10% GRTS expansions. The point estimates the for 10% and 48% GRTS expansions were less than the sum of the LCS streams (1120 fish) for all redd area estimates and the one fish per redd estimate at 48%. When all GRTS reaches were expanded, they were within 25% of the sum of stream estimates - except for the one fish per redd estimate from 10% GRTS and the AUC at 48% (Table 8).

The variance about the mean cumulative average density of coho based on redd area, one redd per female, and fish per redd followed the redd density pattern (Figure 20), and it did not substantially decrease after 32 reaches. The variance associated with the mean coho AUC density did not substantially decrease after about 8 reaches (Figure 22). This suggests the 10% sampling rate was reasonable for AUC.

Steelhead escapement estimates based on redd area, fish per redd, and AUC for the sum of individual steams overlapped the 10% and 48% GRTS expansion estimates (Tables 5, 7, and 9). These estimates had the tightest confidence bounds for the summation of streams, and the highest with the 10% GRTS expansions. When we calculated the point estimates for the 10% and 48% GRTS expansions, they were less than the sum of the LCS streams (268 fish) for fish per redd estimate at 10%. However, the 95% confidence values overlapped. Only the steelhead escapement estimates based on redd area and fish per redd at 48% GRTS expansions were within 25% of the sum of stream estimates (Table 9).

When the variance about the mean cumulative average steelhead density was calculated based on redd area or fish per redd, it followed the redd density pattern (Figure 21) and did not substantially decrease after 32 reaches. The variance associated with the mean steelhead AUC density did not substantially decrease after about 8 reaches (Figure 23). This suggests a 10% sampling rate was reasonable for the AUC. However, the expanded AUC for the steelhead GRTS estimates had the largest range in their 95% confidence bounds.

The Chinook salmon escapement estimate calculated at one redd per female and the AUC escapement estimate for stream specific sampling in the Noyo River overlapped the 5% and 20% GRTS reach density expansion 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 also not possible to make Chinook or coho carcass capture-recapture escapement estimates at the regional level using the GRTS sampling (at either 10% or 48%) because too few carcasses were captured, marked, and recaptured in individual GRTS reaches.

Smolt Abundance

The coho smolt abundance estimates were highest in Pudding Creek and lowest in the North Fork South Fork Noyo River in Spring 2006 (Table 11). In addition to the large number of year old coho smolts, a large number of two year old (see fork length below) coho smolts were observed in Pudding Creek. Capture probability ranged from 0.09 to 0.63 and was lowest for the two-trap method in Caspar Creek. Capture probability for assumed one and two year-old smolts in Pudding Creek was similar. Standard errors were within < 15% of the coho population point estimates.

The steelhead year old smolt abundance estimates were highest in for the two trap estimation in Caspar Creek and lowest in the South Fork Noyo River in Spring 2006 (Table 12). 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. Capture probability for assumed one and two year or older smolts in Pudding Creek differed. Standard errors were generally within < 15% of the steelhead one year old population point estimates. Standard errors were generally > 25% of the steelhead two year and older population point estimates.

The percentage of salmonid smolts that were recaptured multiple times or in more than one trap were generally low (Table 13). 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 generally rather low.

In Pudding Creek, fork length frequencies showed a large component of coho that we assumed to be two year old coho smolts (Figure 24). Fish of this size were not observed in the other streams examined in this study.

Summer Rearing

Steelhead young-of-the-year (YOY) summer rearing density in Pudding ranged from 0.08 fish/m^2 to 0.40 fish/m^2 and was highest in the upper reach (Table 14). However, we estimated there were 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 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 14). 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 14). We recaptured seven Y+ coho salmon that were PIT tagged during downstream trapping in two summer rearing electro-fishing units in the lower reach of Pudding Creek and estimated there were approximately 811 PIT tagged coho in the lower reach. This suggests that 19.5% of coho salmon PIT tagged in the downstream trap did not immigrate to the ocean during spring of 2006.

We estimated there were about twice as many YOY coho than steelhead YOY in Pudding Creek during summer 2006 (Table 15). There were three times as many rearing Y+ steelhead than coho in Pudding Creek during summer 2006 (Table 15).

Survival

Coho smolt to adult survival was similar among streams over four years and ranged from 0.01 to 0.16 (Table 16). When we treated 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 ($ß = 0.39$). The estimate of smolt to adult survival was lowest for the 2004 smolt to 2006 adults.

Recruits per spawner ratios were greater than 1.00 for all returns - except the 2002-03 to 2005-06 cohort (Table 16). When years were treated 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

We found no significant trends in coho escapement over three life cycles in three of the study streams (t = 1.56, d.f. = 4, p = 0.15, Figure 25a). In Pudding Creek and the Noyo River, there appears to be a drop in adult coho escapement over two life cycles (Figure 25a). We also found no significant trend in coho escapement over seven years (T = 51 (6, 6), p = 0.06, Figure 25b). 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, Figure 25b). There was no trend in Coho redd density and redd counts in the study steams over seven years (T > 45, p > 0.06, Figures 26a-b, 27 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 26a-b, 27a-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 A). The slope of steelhead redd counts versus years in the study streams over six years was not significantly different than zero (t = 0.31, d.f. = 5, p = 0.76, ß = 0.05, Figure 26c). 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 27a, c).

DISCUSSION

Adult Escapement

Life Cycle Monitoring Streams

Capture-Recapture

We found the live fish capture-recapture methodology at the LCS streams useful for estimating annual escapement and for providing information for reducing bias in spawning based escapement estimates for regional sampling. The coho population estimate for Caspar Creek based on live fish capture-recapture had large confidence bounds as few fish were marked because the hybrid floating board resistance weir failed during high flows in December 2005. The part of the hybrid weir that failed was the fence panels from an Alaskan temporary weir (Figure 17). The failure was caused by the high debris load which collapsed the supporting tripods. These types of structures commonly fail this way. (Mark Zuspan, Personal Communication). Heavy scour was limited at the floating board rail, the live box, and the tripods supporting the weir fence because we installed weed matt and chain link fence. This material greatly reduced scour, which we expect will increase the utility of temporary weirs in coastal streams.

We improved capture-recapture escapement estimates at the LCS streams and estimated of tag loss by the use of weekly specific colored floy tags and different shaped operculum punches. Tag loss on live fish was minimal suggesting the assumption of capture-recapture experiments, that organisms don't loose their marks, was not violated. It also indicates that capture-recapture estimates using this methodology will be useful for long term monitoring at LCS streams under the California Plan approach (Boydstun and

MacDonald 2005). However, floy tag and operculum punch loss on carcasses was high, which suggests that capture-recapture programs using floy or operculum punch recaptures on carcasses at LCS streams should be used with caution. The assumption that organisms don't loose their marks was violated using this approach. Although the floy and operculum mark recaptures on carcasses produced escapement estimates similar to the live fish capture-recapture estimates the confidence bounds were much larger (Table 4).

The coho and steelhead capture-recapture estimates for Caspar Creek (Tables 4-5) had large confidence bounds due to the low number of marked and recaptured fish. These estimates may be improved by increasing the number of captured and tagged fish. In response to this problem we made improvements to the Caspar Creek Floating Board Resistance weir (Figure 28) for the 2006-07 season that should increase captures of salmon and improve escapement estimates. The experience we gained during 2005-06 for the operation of the Pudding Creek flashboard dam should help us increase steelhead captures at this structure. The number of steelhead captured and tagged in Pudding Creek during spring 2007 might be increased by the use of a fyke trap. However, stream flows may limit this approach. Steelhead capture at the ECS might be improved by adding tines at the bottom of the apron to keep fish from getting on the apron and force them into the ECS. Steelhead are averse to dark places, so keeping the lights on in the fish ladder might increase steelhead captures. Generally, the entrance to the ECS is dark because the lights are operated by a generator that does not operate consistently. It will require solar panels, a small hydropower system, or a connection to the grid to provide electricity to the ECS.

Carcass population estimates require unique individual marks, a short duration between surveys, and a complete river survey to increase the chance of recapturing marked fish. High flows between surveys can bury, wash away, or otherwise decrease the chance of finding carcasses. Cederholm et al. (1989) found that the distance carcasses drifted was directly related to freshets and that the occurrence of buried carcasses was greatly underestimated. Our surveys were limited by high flows during the period that Chinook and Coho carcasses were expected to occur during 2005-06 (Figures 15 and 16). Gallagher (2005a, 2005b) found that escapement based on carcass capture-recapture experiments were not reliable because they tended to underestimate known releases of coho above the ECS and therefore recommends against using this technique for monitoring. Carcass capture-recapture did not work for producing individual reach escapement estimates required for the GRTS sampling escapement estimates at the regional scale. However, the carcass's encountered during spawning surveys provided useful information on residence time and scales, otoliths, and tissue samples recovered from them.

Spawning Ground Surveys

Redd counts

We found that observer efficiency in Chinook and coho and steelhead redd counts were similar to previous year's estimates (Gallagher 2005a, Gallagher 2005b, Gallagher and Gallagher 2005). When we treated years as samples, redd counts were significantly correlated with capture-recapture escapement estimates. Gallagher (2005b) found that redd counts and capture-recapture escapement estimates were equally reliable. However, during 2005-06 we found that 1) coho redd counts were lower than in previous years, 2) they were lower than would be expected based on the number of females generated by capture-recapture estimates, and 3) the capture-recapture escapement estimates were slightly lower than previous year's estimates (Appendix A). The low redd counts subsequently caused spawner: redd ratios to be much higher than estimated for previous years (Table 1). This suggests that redds were missed or not counted during spawning surveys. High flows in late-December and early-January (Figures 15-16) limited spawning surveys and probably flattened or obscured redds made during this period. Redds may also have been scored during this period. The 2005-06 water year was the first since 1999-2000 where high flows limited surveys this severely. Russian River flows during December 2005 were the highest on record since the early 1950's. Boydstun and MacDonald (2005) acknowledge that some year's stream flows will limit salmonid monitoring activities.

Redd area and one redd per female

Coho redd area and one female per redd escapement estimates were lower than capture-recapture estimates for the same reasons described for redd counts. However, steelhead redd area escapement estimates were similar to AUC and capture-recapture estimates because flows and survey conditions were better later in the season. Gallagher (2005b) also found that redd counts and capture-recapture escapement estimates were equally reliable.

Fish per redd

We found that converting bias corrected coho redd counts to fish numbers using the annual average of number of fish per redd from the 2005-06 three stream average produced escapement estimates that were equally reliable as capture-recapture estimates. Gallagher (2005a, 2005b) found similar results with annual estimates: that spawner: redd ratios were transferable among streams. Treating years as samples (Table 1) spawner: redd ratios were not significantly different. The 2005-06 coho ratios, however, were much higher than previous years estimates due to limitations of spawning surveys as described for redd counts. Using the annual three stream average spawner: redd ratio provided some measure of the associated statistical uncertainty for converting redd counts to fish numbers. Due to the noted difficulties experienced early in the season, coho redd counts were lower than would be expected from female escapement based on the capture-recapture experiments. Consequently the multiyear average spawner: redd ratios 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. The 2005-06 coho spawner: redd ratios were much higher than estimates from previous years (Table 1) suggesting that bias in redd counts (undercounting) was the source of this difference. Boydstun and MacDonald (2005) acknowledge that some year's stream flows will limit salmonid monitoring activities. The 2005-06 season appears to have been one of these anticipated seasons.

Converting bias corrected steelhead redd counts to fish numbers using annual (2005-06) three stream average spawner: redd ratio produced escapement estimates that were equally reliable as capture-recapture estimates. Gallagher (2005b) found similar results with annual estimates and found that spawner: redd ratios were transferable among streams. Treating years as samples (Table 1) spawner: redd ratios were not significantly different. Using the annual three stream average spawner: redd ratio provided some measure of the associated statistical uncertainty for converting redd counts to fish numbers. The number of steelhead per redd in coastal Mendocino County were 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. 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 1) were similar to capture-recapture estimates, which suggests that survey conditions for redd counts were favorable for steelhead spawning surveys during the later part of the 2005-06 season. Converting bias corrected steelhead redd counts with spawner: redd ratios appears reliable for long term monitoring.

AUC

The AUC method is sensitive to the time between surveys and estimates of *rt* and *e* (English et al. 1992, Hilborn et al. 1999), both of which require independent capture-recapture experiments for their estimation which are usually capable of producing escapement estimates without the AUC (Gallagher and Gallagher 2005). The 2005-06 estimates of *rt* and *e* were generated from capture-recapture experiments in the LCS streams. Storms and high flow/high turbidity limited surveys during some periods. However, the AUC estimates, using the three stream 2005-06 average *rt* and *e*, which was calculated as the total observed number of marked fish divided by the total number of released marked fish in the LCS streams, were not significantly different than "true" escapement estimates of steelhead and coho.

The AUC escapement estimates were also similar to those developed from redd counts and spawner: redd ratios. This suggests the use of these values was reasonable. However, the overlap of the capture-recapture and AUC escapement estimates may be due to the interrelatedness of the data. The AUC can produce vastly different results depending on which estimates of *rt* and *e* are used, and since these variables are difficult and perhaps expensive to generate, this method of estimating escapement may prove too cumbersome for long term regional monitoring of coastal salmonids (Gallagher 2005b). Lestelle and Weller (2002) found that AUC escapement estimates were more reliable than redd count estimates at high spawner abundance, and, conversely, the redd counts were better at low spawner abundance. Live coho may be more readily detected than their redds during spawning surveys conducted when survey conditions are marginal (e.g. poor water visibility). 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 further develop multiyear average *rt* values and, additionally, refining stream flow/visibility *e* predictive relationships (Gallagher and Gallagher 2005) may improve estimation of these values and subsequently improve AUC escapement estimations.

The 2002-03 ECS coho residence time estimates were significantly lower than estimates from other streams and years. This is likely due to difference in water years and because the 2002-03 marked and recovered fish were fish that were captured and marked later in the season. Except for 2002-03 in the South Fork Noyo River coho residence time was not significantly different among streams or over years (Table 2). Our estimates of *rt* were much higher than the estimate of 11.8 days presented by Beidler and Nickelson (1980) for coastal Oregon coho. Observer efficiency and residence time should be estimated annually for each stream and estimated throughout each season (English et al. 1992, Manske and Schwarz 2000) because the AUC method is very sensitive to these variables (Hilborn et al. 1999).

Observer efficiency for coho varied among the LCS streams during 2005-06 and was lower than predicted from stream flow for two of three streams (Table 4). This is probably due to low numbers of captured and tagged fish in Caspar Creek and the periodicity of surveys in the South Fork Noyo River above the ECS during 2005-06. Pudding Creek coho observer efficiency was the same as predicted from stream flow and was similar to estimates generated during 2003-04 and 2005-06 in both Pudding Creek and the South Fork Noyo River. The estimated observer efficiency values for coho at LCS streams may not be transferable to streams where they were not estimated. Continued investigation of these variables may improve predictive models for their estimation.

Steelhead residence time was only different between estimates made for main stem Noyo River and the other smaller creeks and tributaries. This is likely due to the fact that steelhead move a great deal within streams (Sean Hayes, NOAA Fisheries Santa Cruz, Personal Communication), and those main stem observations were made for fish both on their way to and returning from spawning in tributaries. Main stem estimates of steelhead *rt* should be used for data from larger rivers and tributary estimates should be used for data for tributaries and smaller streams.

For steelhead, observer efficiency differed between the Noyo River, Pudding Creek, and the values estimated from water visibility using models from Gallagher and Gallagher (2005). Steelhead observer efficiency values for use in the AUC, which are estimated at LCS streams, may not be transferable to streams where they were not estimated. Continued investigation of these variables may improve predictive models for their estimation.

Bias in spawning ground survey escapement estimates

Converting bias corrected coho redd counts to fish numbers using annual (2005-06) three stream average spawner: redd ratio produced escapement estimates that were equally reliable as capture-recapture estimates and AUC escapement estimates and were transferable among streams. Gallagher (2005a, 2005b) found similar results with annual estimates and found that spawner: redd ratios were transferable among streams. The use of the three stream 2005-06 average number of coho per redd provided a measure of statistical uncertainty in the estimates. 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 of coho per redd (Table 1) 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 the use of spawner: redd ratios from LCS streams to convert redd counts into escapement estimates should use annual estimates. This is because they include differences in stream flow and visibility that are encountered during the season for which they are used, and thus they potentially reduce inter-annual differences when annual estimates are outside the range of multiyear averages. Further evaluation of the relationship between redd counts and escapement should improve conversions of redd counts to escapement estimates. The spawner: redd ratios developed in this study appear useful for regional monitoring of coastal salmonids.

Coho escapement estimates based on redd area and the assumption of one female per redd did not produce estimates similar to AUC or capture-recapture methods during 2005-06. 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.

To estimate steelhead escapement the following methods were equally reliable and transferable among streams: redd area, conversion of bias corrected redd counts to escapement using spawner: redd ratios, AUC, and capture-recapture. Gallagher (2005a, 2005b) found similar results with annual spawner: redd ratios and found that they were transferable among streams. Redd counts and escapement estimates were significantly correlated, consequently redd counts might serve equally well as annual indices of escapement. As previously noted, the AUC requires estimates of rt and e which in many cases are potentially difficult to obtain and interpret. However, redd counts and their conversion into escapement using spawner: redd ratios or redd areas provide escapement estimates that are not reliant on these values. The spawner: redd ratios developed in this study appear useful for regional monitoring of coastal salmonids.

Regional Estimates

Sample frame

The stream reaches estimated with GIS were very similar to field measured reaches. The relationship between map based and field measured stream lengths should be used to correct stream lengths developed electronically for the sample frame. 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.

Redd counts and escapement

Boydstun and MacDonald (2005) state that the most important feature of the 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 3 for GRTS sampling of our region during 2005-06. We also had a systematic sample of 37 reaches (48%) to evaluate sampling rate. The performance curves for redd density (Figures 20-21) indicate that sampling eight reaches was insufficient for encompassing the variation in redd density for regional sampling. However, see discussion of redd undercounting in relation to high stream flows during 2005-06 above. With better survey conditions eight out of 76 reaches might prove sufficient. The idea that eight reaches was insufficient is also evident in the bootstrap population estimates (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 6-7, 8-10) at 10% and 48% sampling. The variance about the mean redd density did not substantially decrease after about 32 reaches (Figures 20-21). This is also evident in the bootstrap population estimates (Tables 8-10). Boydstun and MacDonald (2005) state that > 30 samples are necessary for use of the normal approximation to estimate 95% confidence bounds for regional population estimates. It seems likely that a sample draw of > 30 reaches would result for a GRTS sample necessary for monitoring all streams supporting coastal salmonids in California. 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), which furthers 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%. The performance curves for AUC density suggest that 10% sampling was reasonable. The variance for the AUC 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 and Bland-Altman analysis suggest both were equally reliable measures of abundance. The use of GRTS sampling of > 30 reaches and the use of AUC and 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.

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 this pilot project, we plan on purchasing and deploying a screw trap on the Noyo River during spring 2007. Pit tags provided individual marking and data on multiple recaptures. In 2008-09, pit tagged smolts returning as adults will likely provide useful information on ocean survival. The small proportion of fish that were captured multiple times or had delayed migration did not have a great affect on abundance estimates. We were able to account for these multiple recaptures when developing input matrices for input into Darr and thus reduce this potential source of error in the estimates because pit tags provide unique individual marks.

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). Our 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. This approach should be useful in providing data for estimating over summer and over winter survival for Life Cycle Monitoring of coastal salmonids.

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 spring 2001 and this could affect both the adult and smolt survival estimates. Coho smolt to adult survival is influenced by ocean conditions which were generally favorable from 1999 to 2004. Ocean productivity was poor during the time of salmonid ocean entry in 2005 Kudela et al. (2006) thus adult to adult and smolt to adult survival during this period was likely influenced by these conditions.

Trends in Coho Salmon Abundance

In Caspar Creek, the number of coho and steelhead currently returning to spawn is the same as it was 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 late-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) estimated using the AUC that there were 381 (range 305-565) coho in 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, which is similar to the findings of Gallagher and Knechtle (2004). This may be a result of the length of the limited seven year time series. Coho generally have a rigid three year life cycle, so 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 which is related to large scale climate (Smith and Ward 2000, Smith et al. 2000). If salmonid population abundance fluctuates on decadal or longer time frames, the five years data 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 effects of climate affect freshwater survival in coho. 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 TASKS

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 use during 2006-07.

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

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

Redesigned our data base and improved data management and analysis.

Outreach in the form of a newspaper article.

Genetic tissue collection and archiving.

Scale collection, archiving, mounting and reading.

Acquisition and use of bootstrap data analysis software.

Consultation with statisticians.

Acquisition and use of screw trap in Pudding Creek.

Modifications to Pudding Creek fish ladder and tagging station and improvement to access road for screw trap on Pudding Creek.

Created GIS layers of redd locations.

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

RECOMMENDATIONS

This study should continue through at least 2010 to gather data on multiple generations of salmonids to better the data set for trend detection. In Caspar Creek, we should rebuild the floating panel resistance board weir to improve captures of coho and steelhead, and to continue evaluation of the utility of this type of temporary weir for use as LCS and regional monitoring of salmonids. Increase capture and marking of steelhead by better operation of the Pudding Creek flashboard dam and by making improvement to the Noyo ECS. Increase the GRTS draw to the first nine reaches to even sampling. Include GRTS reaches 10-24 in the over sample to evaluate the sampling rate at 10%, 15%, 20%, 25%, and 30% for regional monitoring. Bootstrap simulations should be used to calculate 95% confidence bounds for regional population estimates. Arc View reach lengths should be corrected with the predictive model developed in this study. Capture-recapture at LCS streams should use weekly specific colored floy tags and operculum punches and the data combined with reach specific stream flow and water visibility estimates to improve residence time estimates and predictive models for observer efficiency. The transferability of these data should continue to be evaluated. The use of handheld data loggers should be continued and refinements made to improve data collection and quality controls improved 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. Annual estimates of spawner: redd ratios from LCS streams should be used to convert bias corrected redd counts into escapement estimates for data from GRTS reach samples. Results from capture-recapture escapement estimates and spawning surveys should be used to reduce bias in spawning survey based escapement estimates and relationships between these data should continue to be evaluated. 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 using annual LCS spawner: redd ratios to convert redd counts to escapement for regional spawning ground surveys in a GRTS scheme with a sample rate of 10%. The initial annual GRTS sample draw and field data collection should be 15% of the total annual GRTS frame 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 Bjorksted, and 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 us access to streams on their property.

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PERSONAL COMMUNICATIONS

Sean Hayes, NOAA Fisheries Santa Cruz, August 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. Caspar Creek watershed showing weir and trap locations.

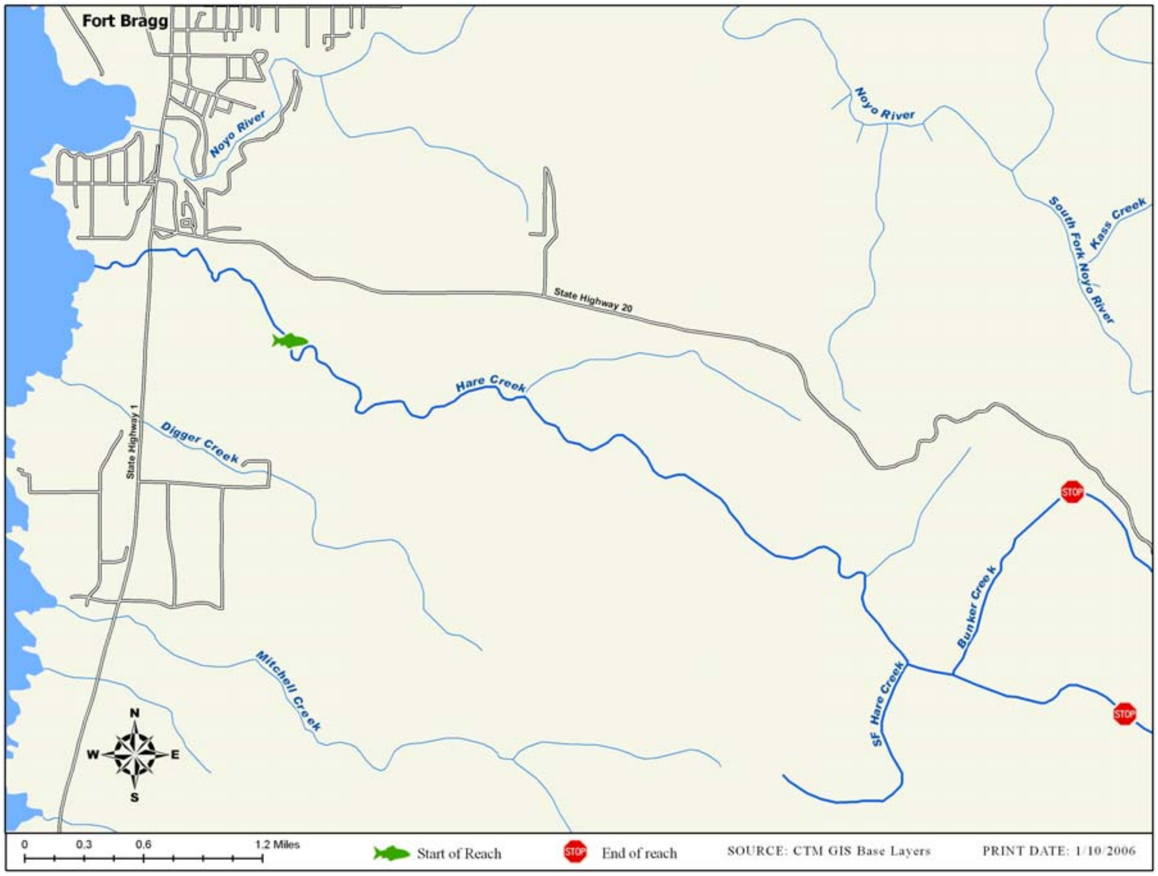


Figure 3. Hare Creek.

Figure 4. Little River.

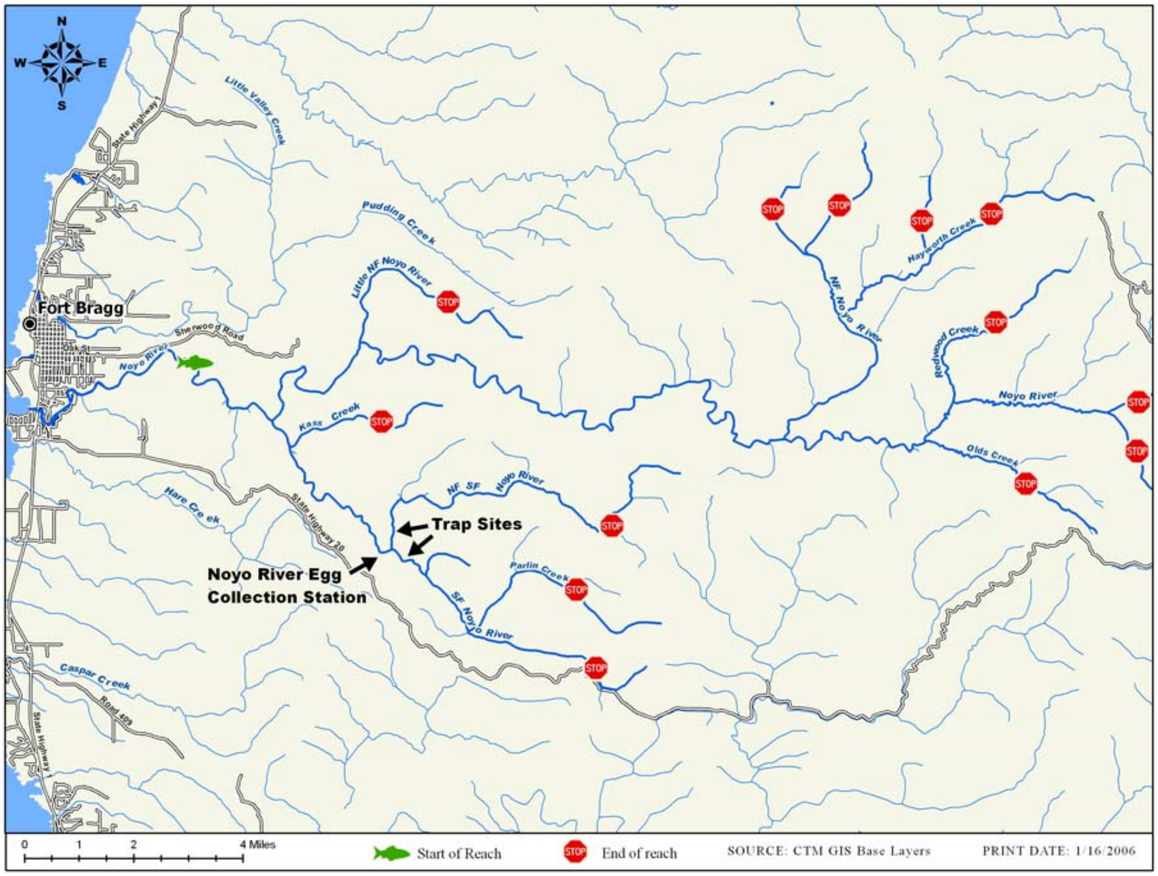


Figure 5. Noyo River.

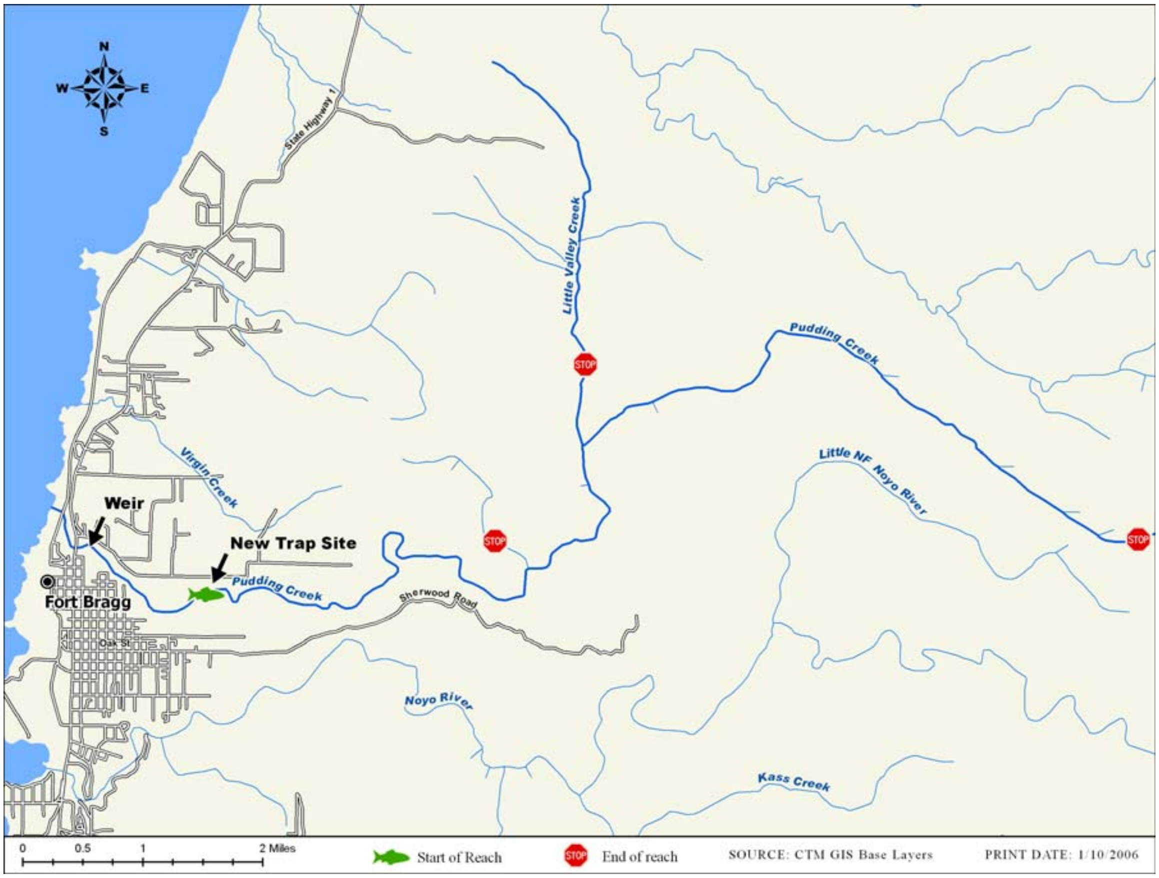


Figure 6. Pudding Creek.

Figure 7. Female steelhead with a floy tag and an operculum punch.

Figure 8. 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.

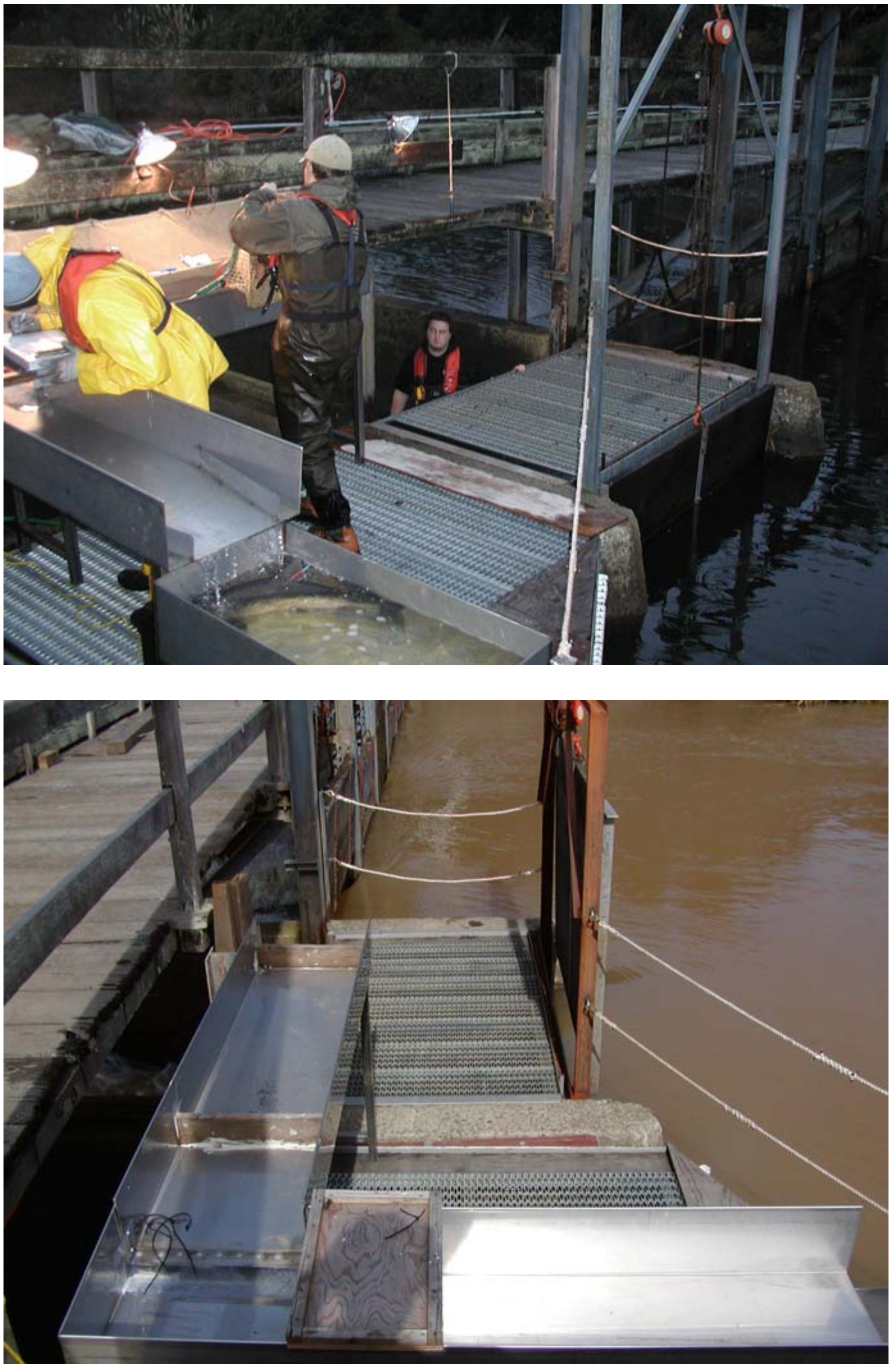


Figure 9. Pudding Creek fish ladder trap and flashboard dam.

Figure 10. South Fork Noyo River Egg Collecting Station.

Figure 11. Numbered metal carcass tag on a recently deceased Chinook salmon.

Figure 12. Fyke-pipe trap on the Noyo River.

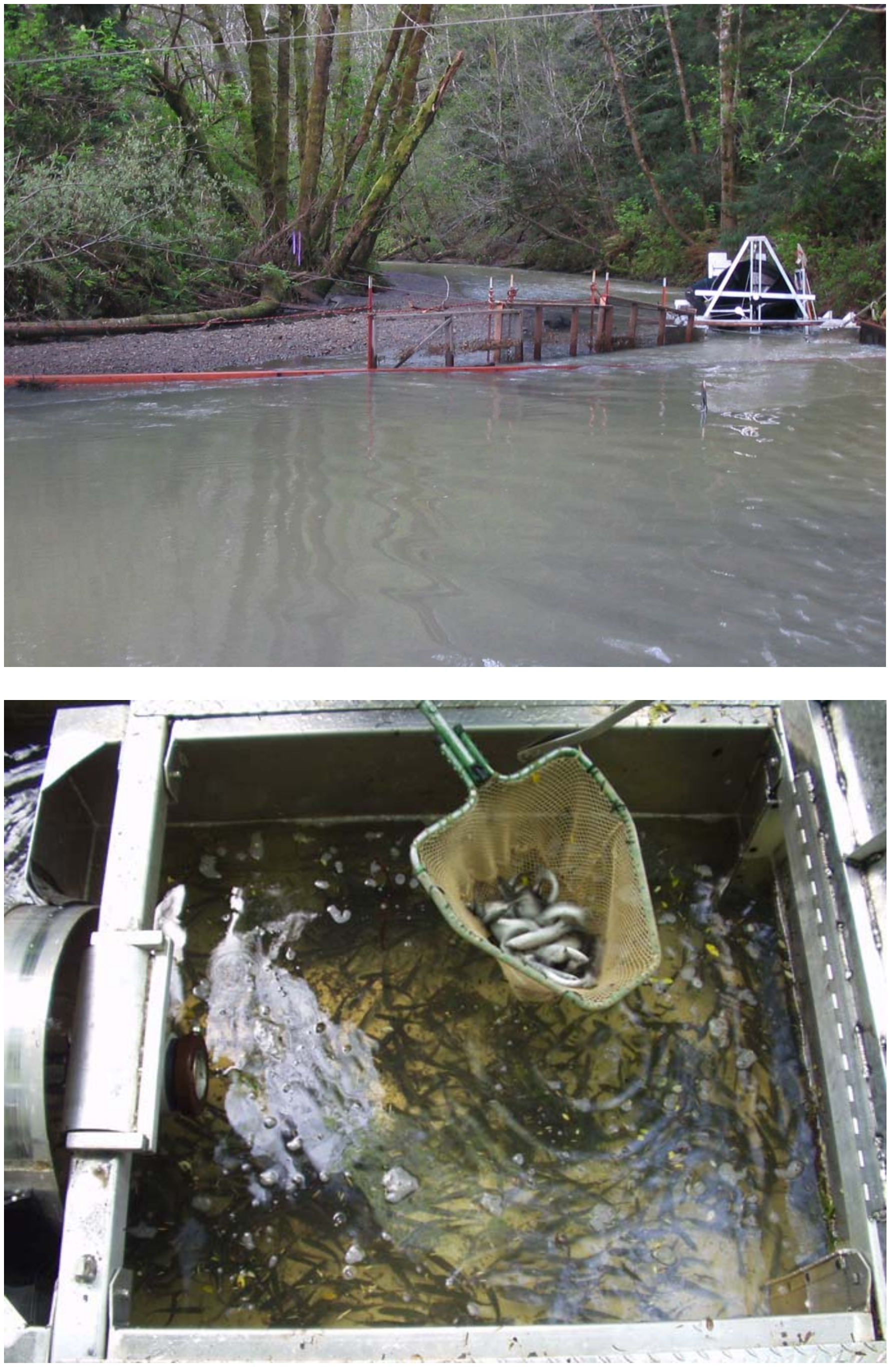


Figure 13. A). Screw trap on Pudding Creek. B). Live car full of fish.

Pudding Creek Dive Survey Sample Reaches

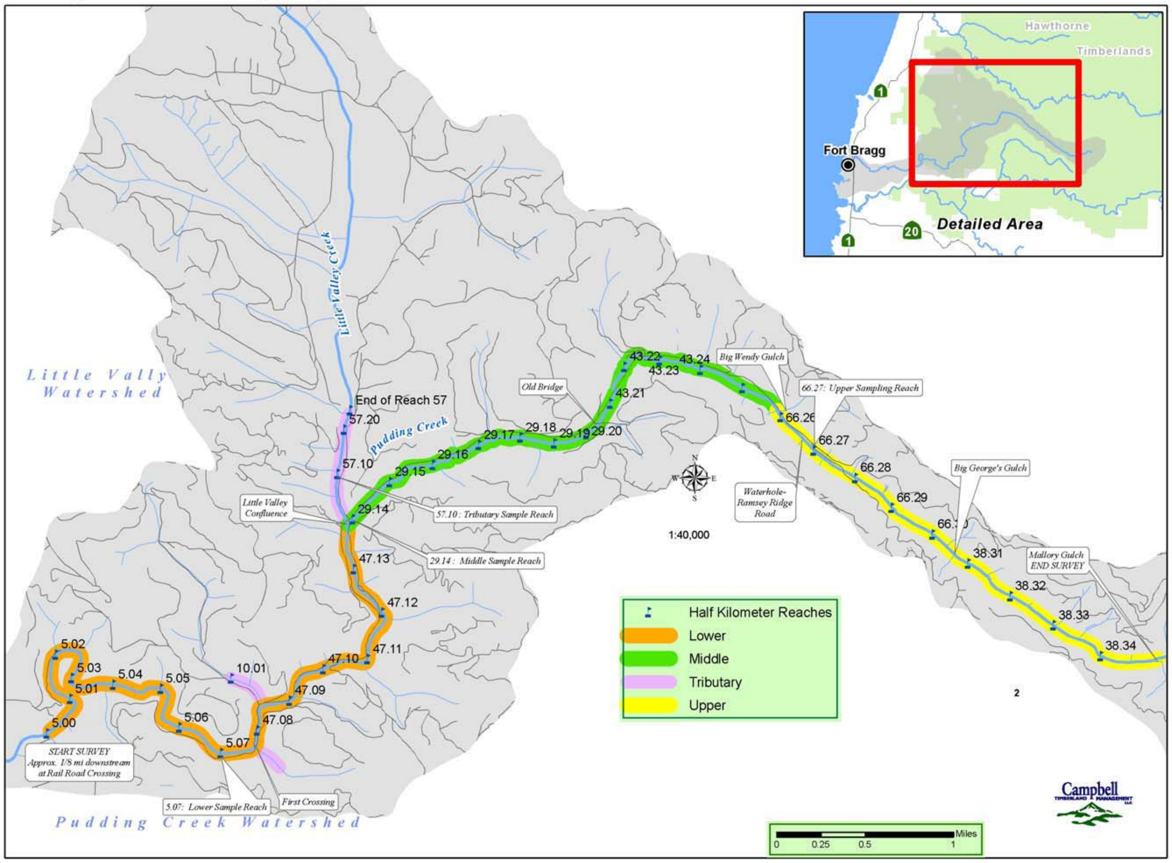


Figure 14. Pudding Creek summer rearing study reaches.

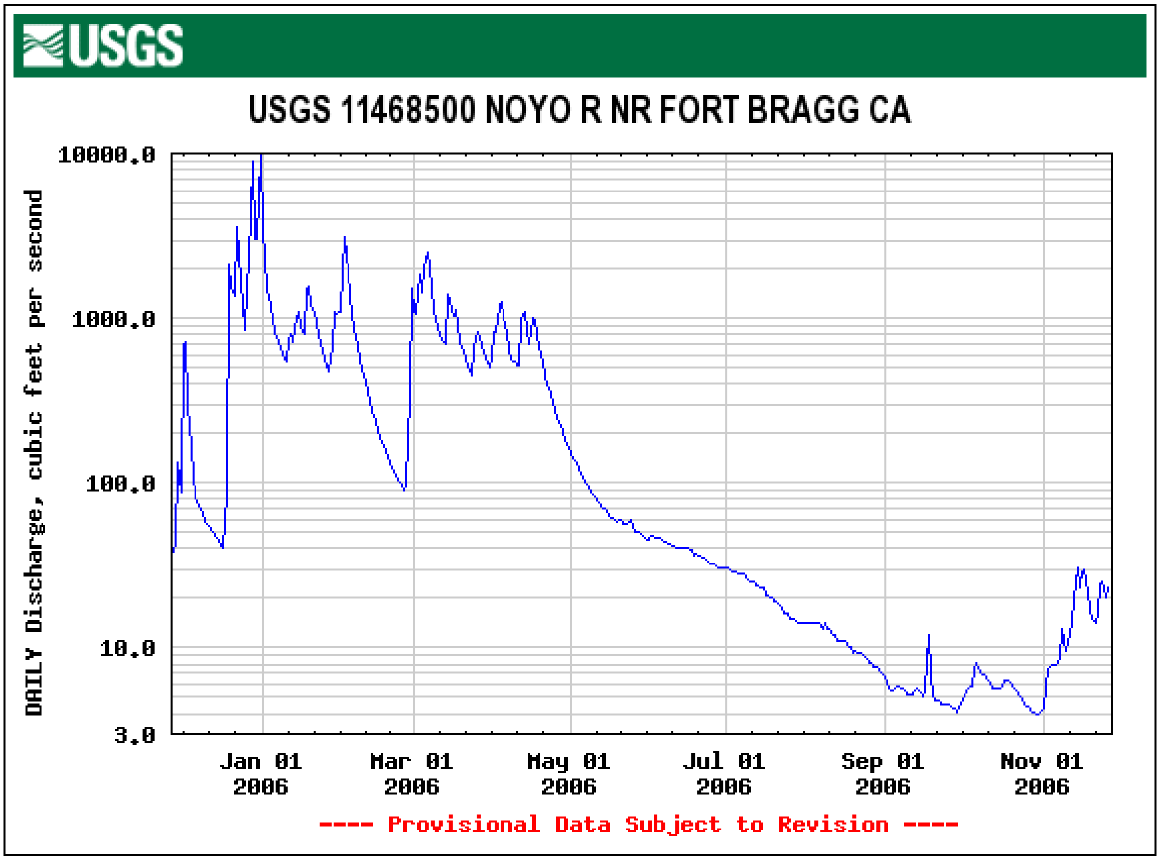


Figure 15. Noyo River stream flows during 2005-06. From USGS gauge number 114685400 available at http://waterdata.usgs.gov/ca/nwis/uv?11468500.

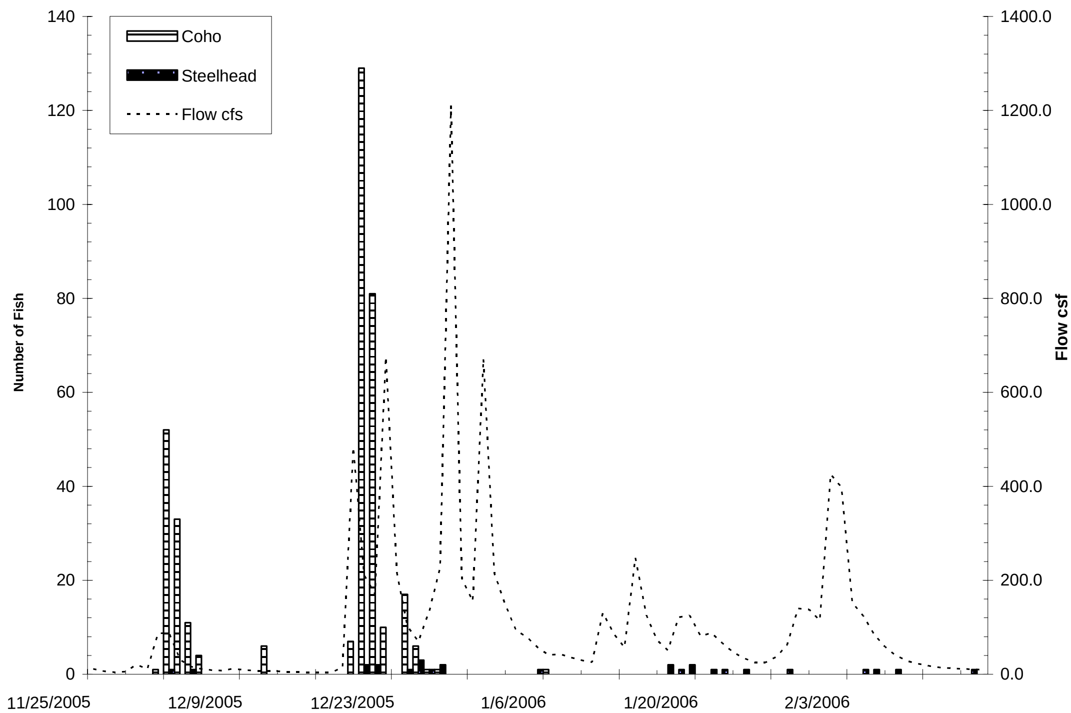
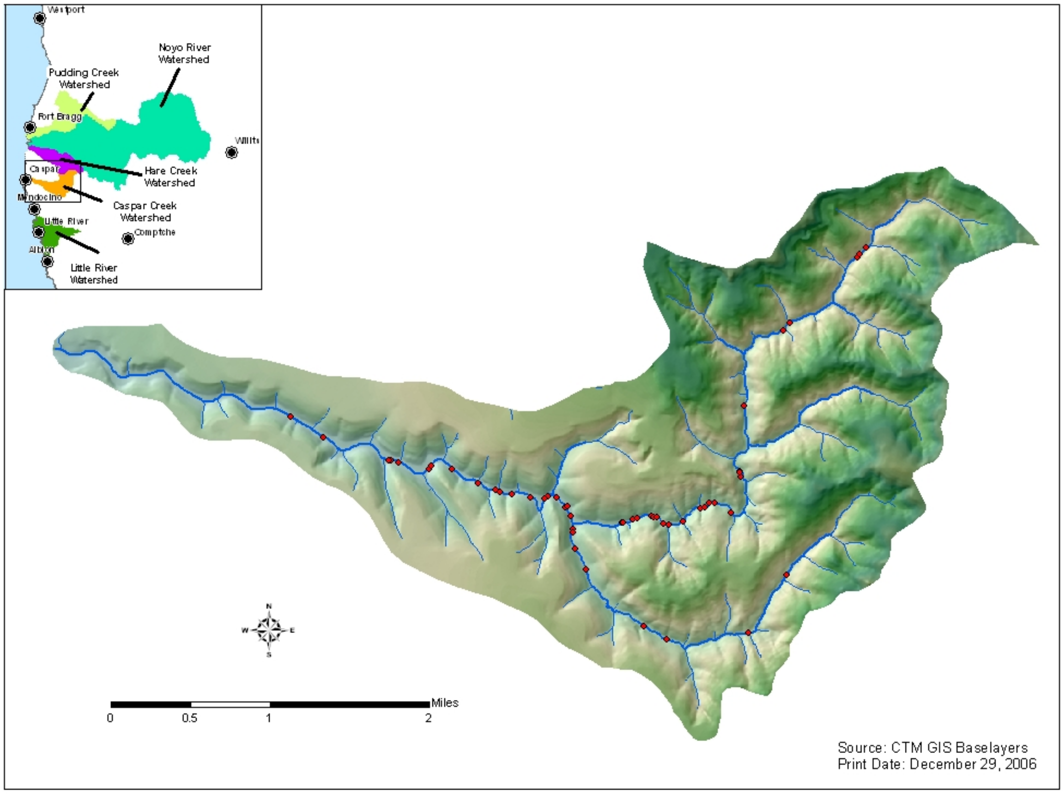


Figure 16. Pudding Creek stream flows and salmonid capture timing.

Figure 17. Caspar Creek hybrid Floating Board Resistance Weir after high December 2005 flows. Note that person in this photograph is able to stand below the weir indicating scour did not occur even though the stage was about one meter above the top of the weir two days prior to taking this picture.

Caspar Creek Coho Salmon Redd Distribution 2005-2006



Hare Creek Coho Salmon Redd Distribution 2005-2006

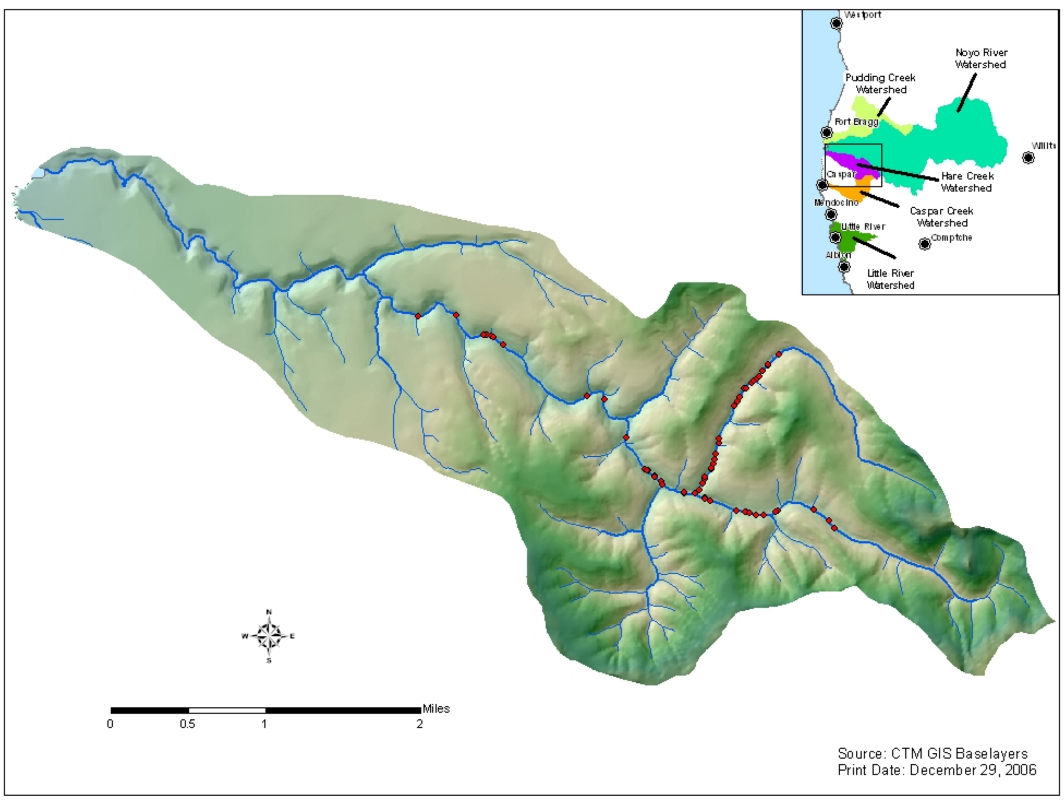
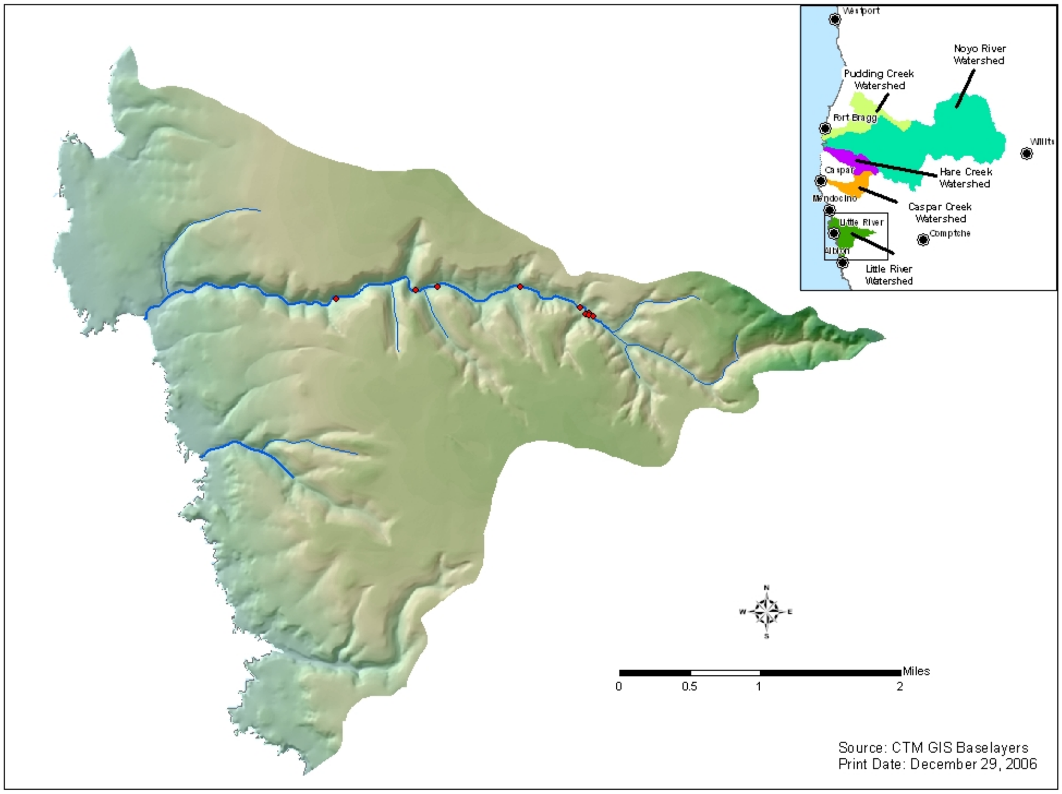


Figure 18. Coho salmon redd locations in five study streams during 2005-06. A). Caspar Creek. B). Hare Creek.

Little River Coho Salmon Redd Distribution 2005-2006



Noyo River Coho Salmon Redd Distribution 2005-2006

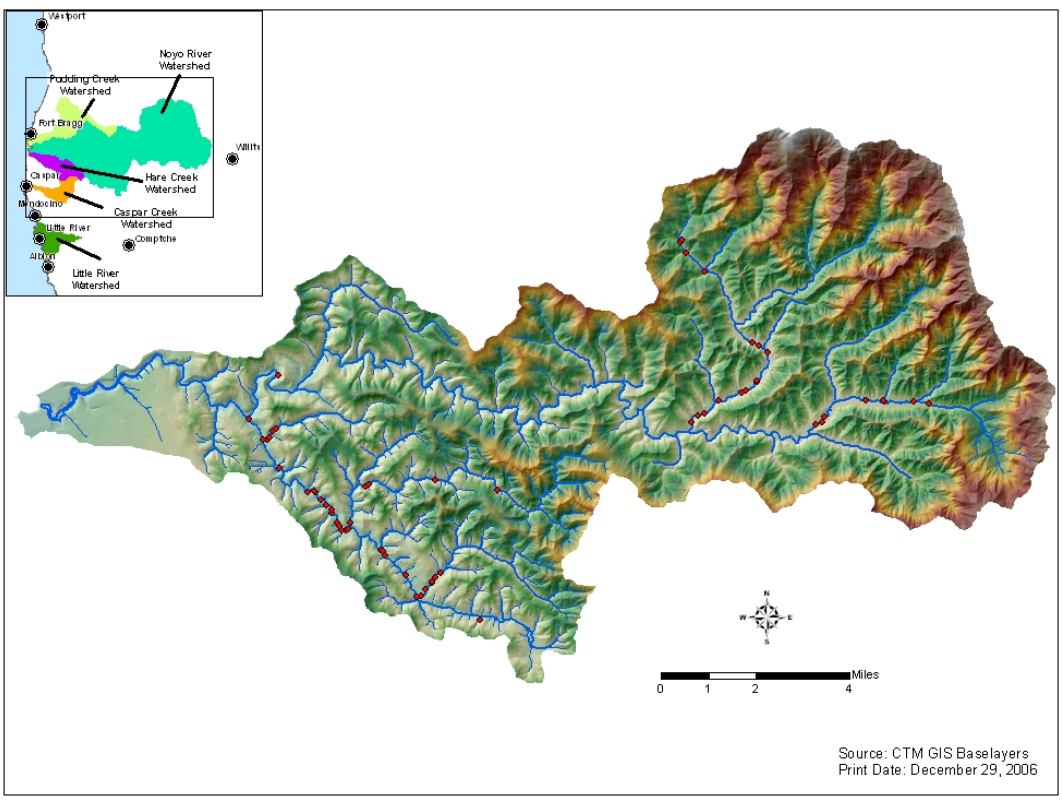


Figure 18 (continued). Coho salmon redd locations in five study streams during 2005-06. C). Little River. D). Noyo River.

Pudding Creek Coho Salmon Redd Distribution 2005-2006

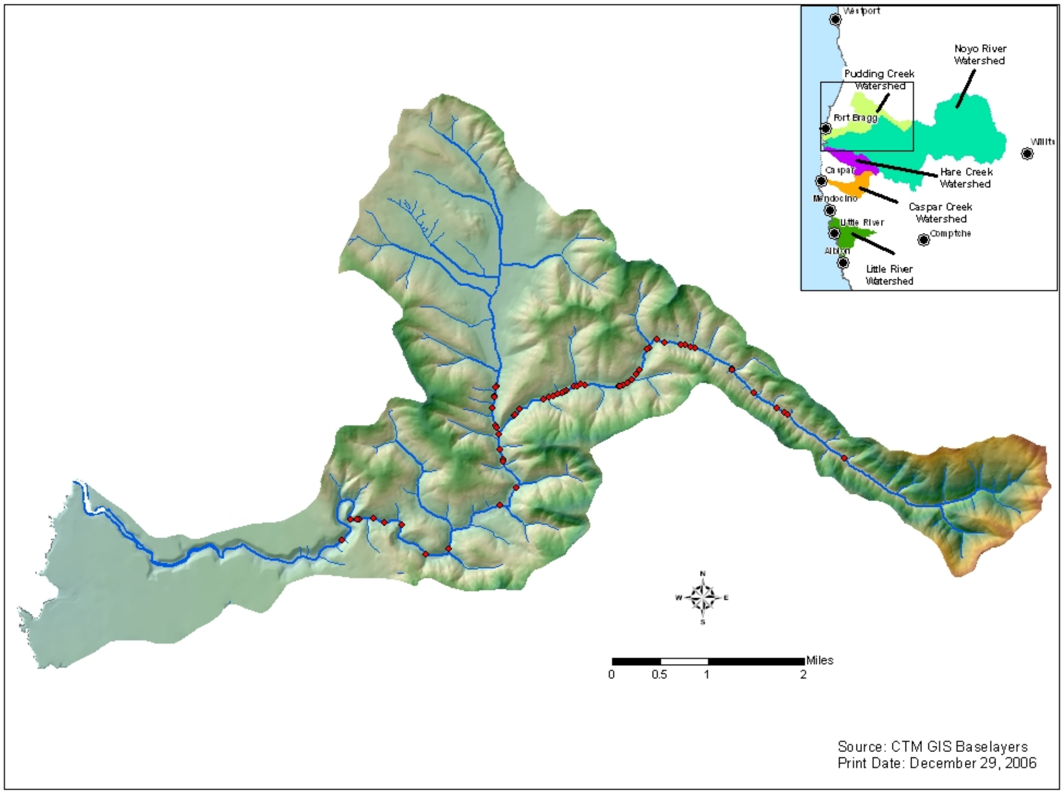
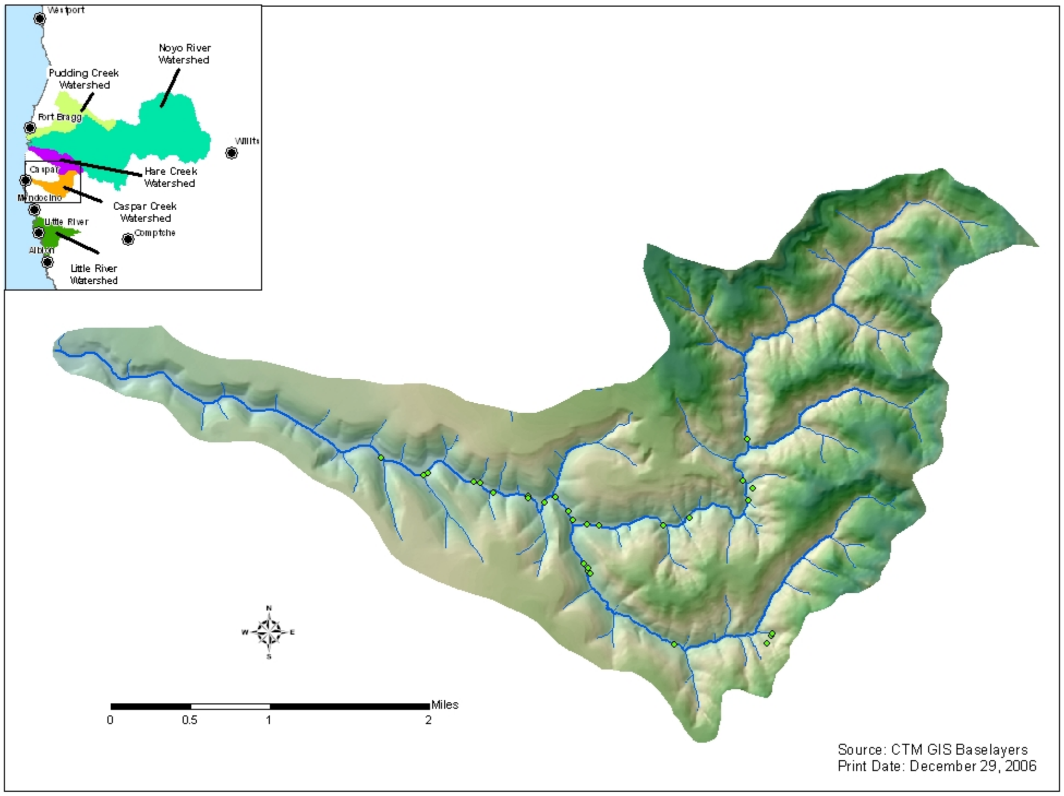


Figure 18 (continued). Coho salmon redd locations in five study streams during 2005-06.
E). Pudding Creek

Caspar Creek Steelhead Redd Distribution 2005-2006



Hare Creek Steelhead Redd Distribution 2005-2006

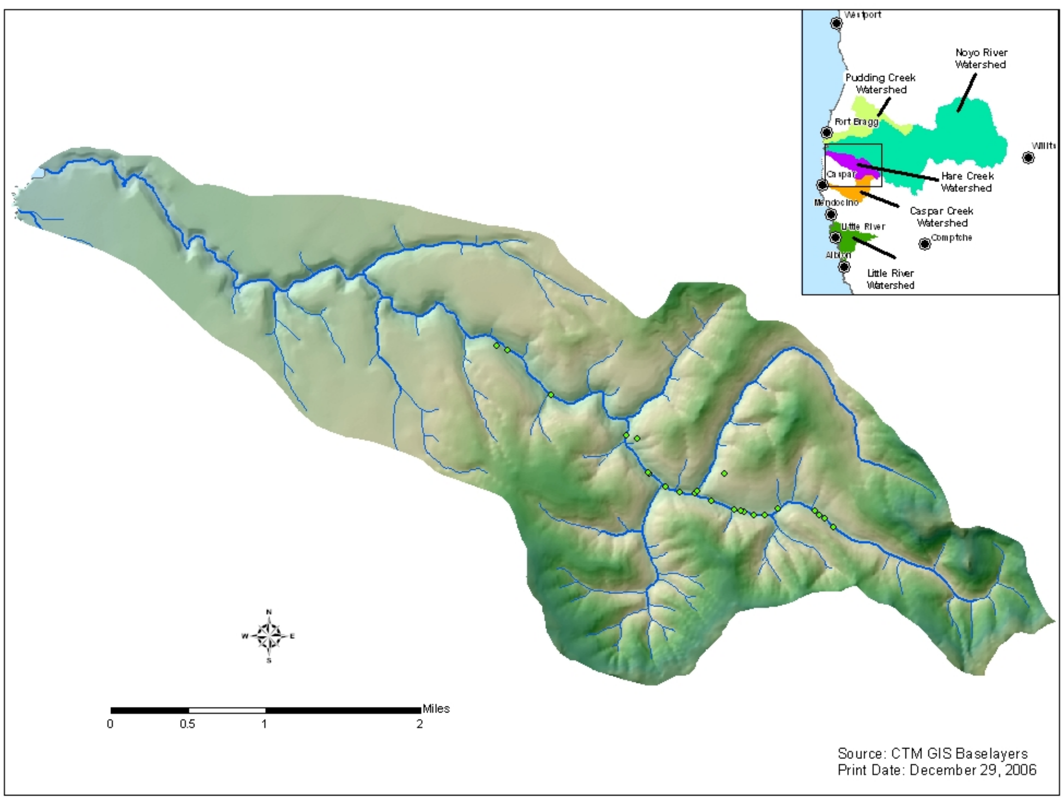
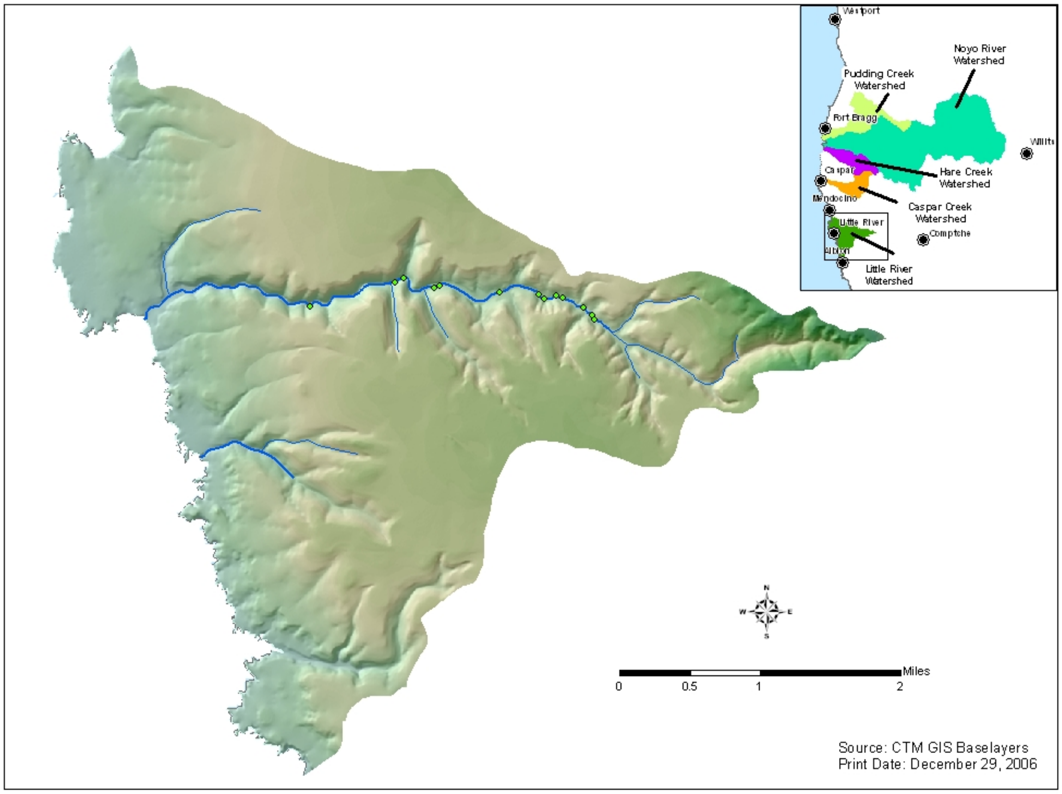


Figure 19. Steelhead redd locations in five study streams during 2005-06. A). Caspar Creek. B). Hare Creek.

Little River Steelhead Redd Distribution 2005-2006



Noyo River Steelhead Redd Distribution 2005-2006

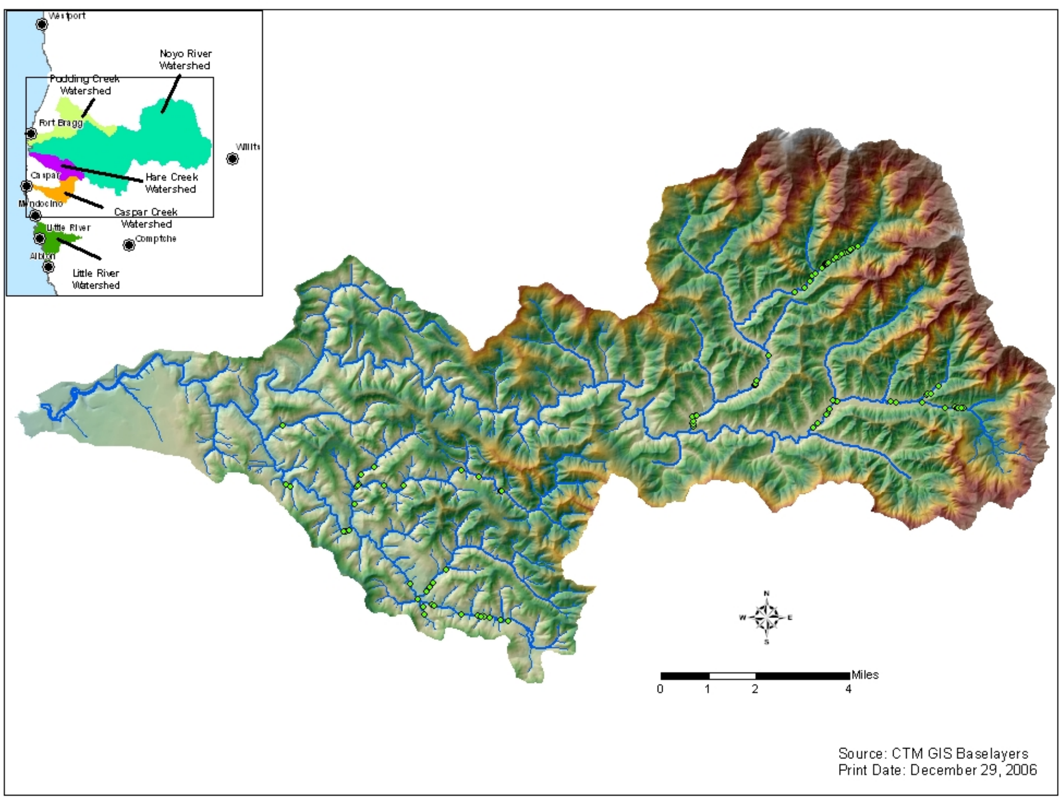


Figure 19 (continued). Steelhead redd locations in five study streams during 2005-06. C). Little River. D). Noyo River.

Pudding Creek Steelhead Redd Distribution 2005-2006

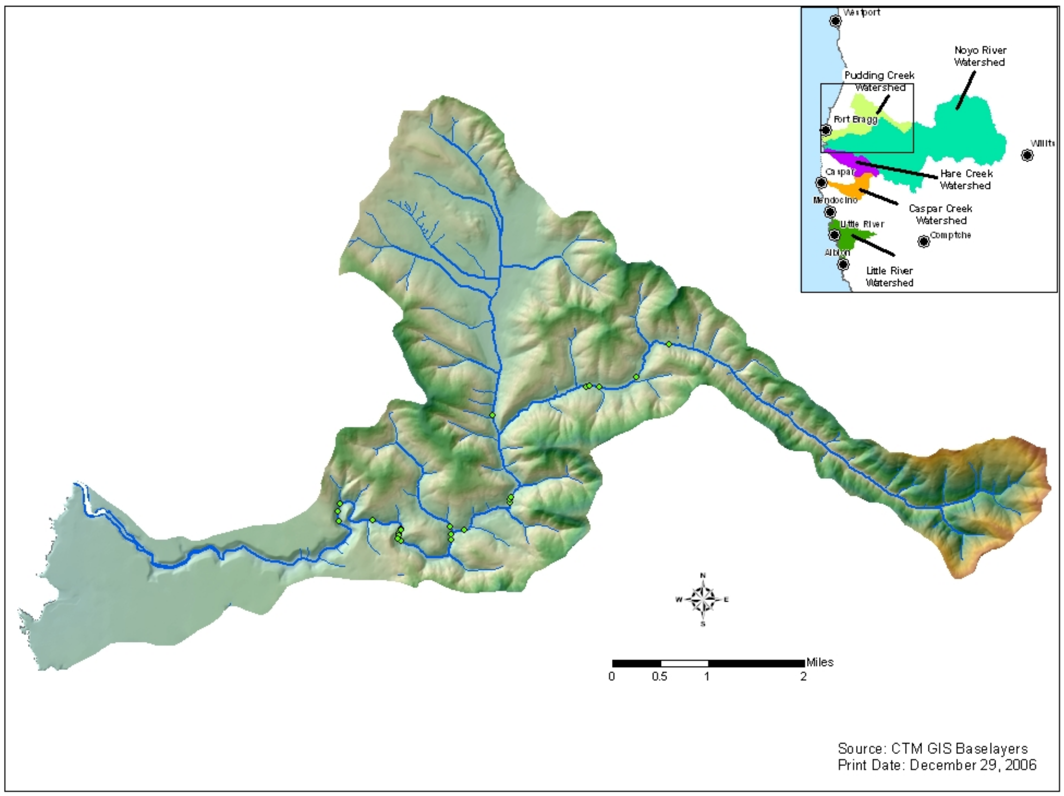


Figure 19 (continued). Steelhead redd locations in five study streams during 2005-06. E). Pudding Creek

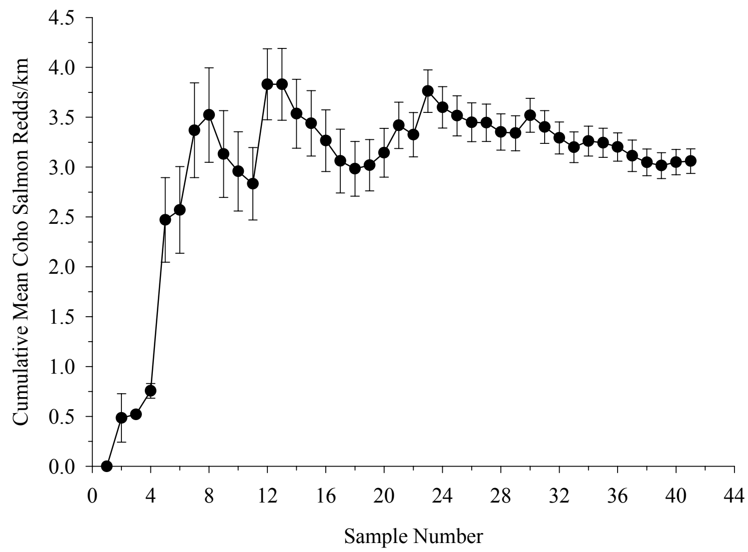


Figure 20. Cumulative average coho salmon redd density.

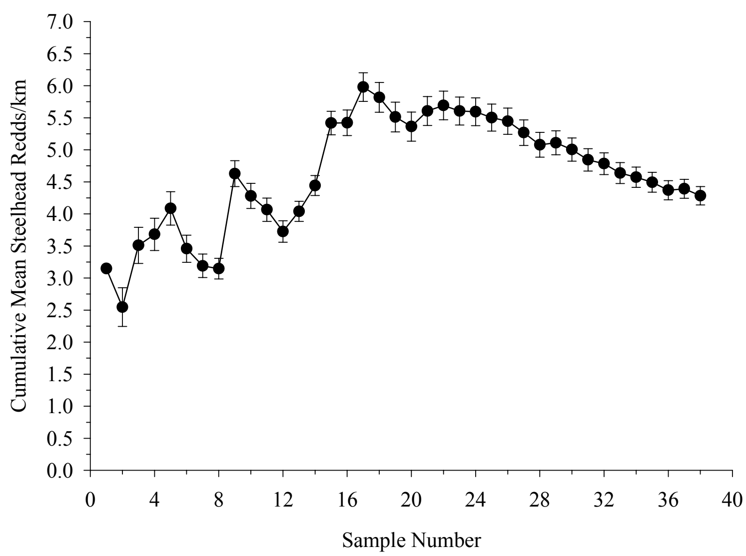


Figure 21. Cumulative average steelhead redd density.

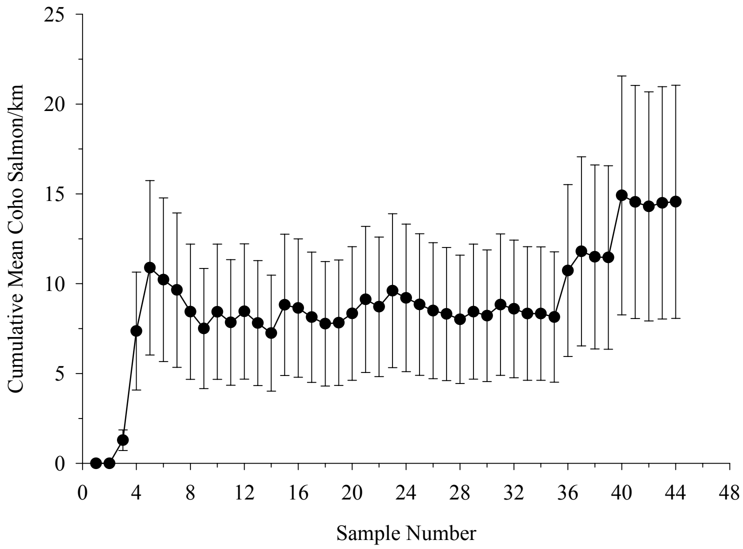


Figure 22. Cumulative average coho salmon AUC density.

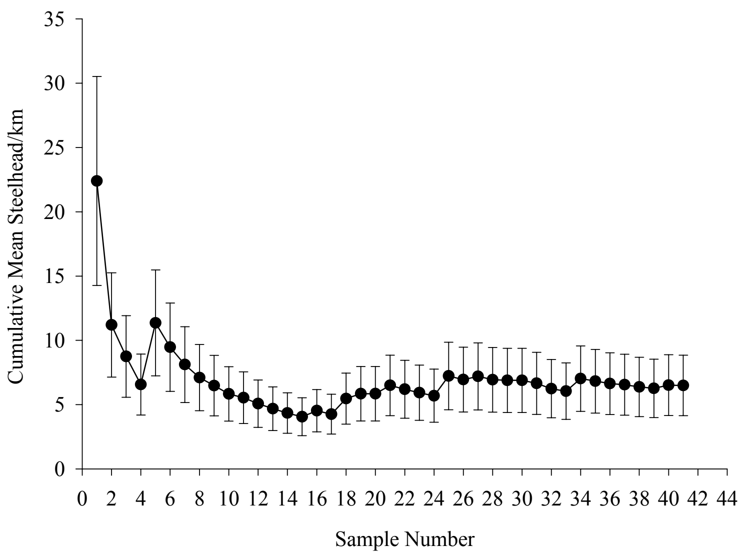


Figure 23. Cumulative average steelhead AUC density.

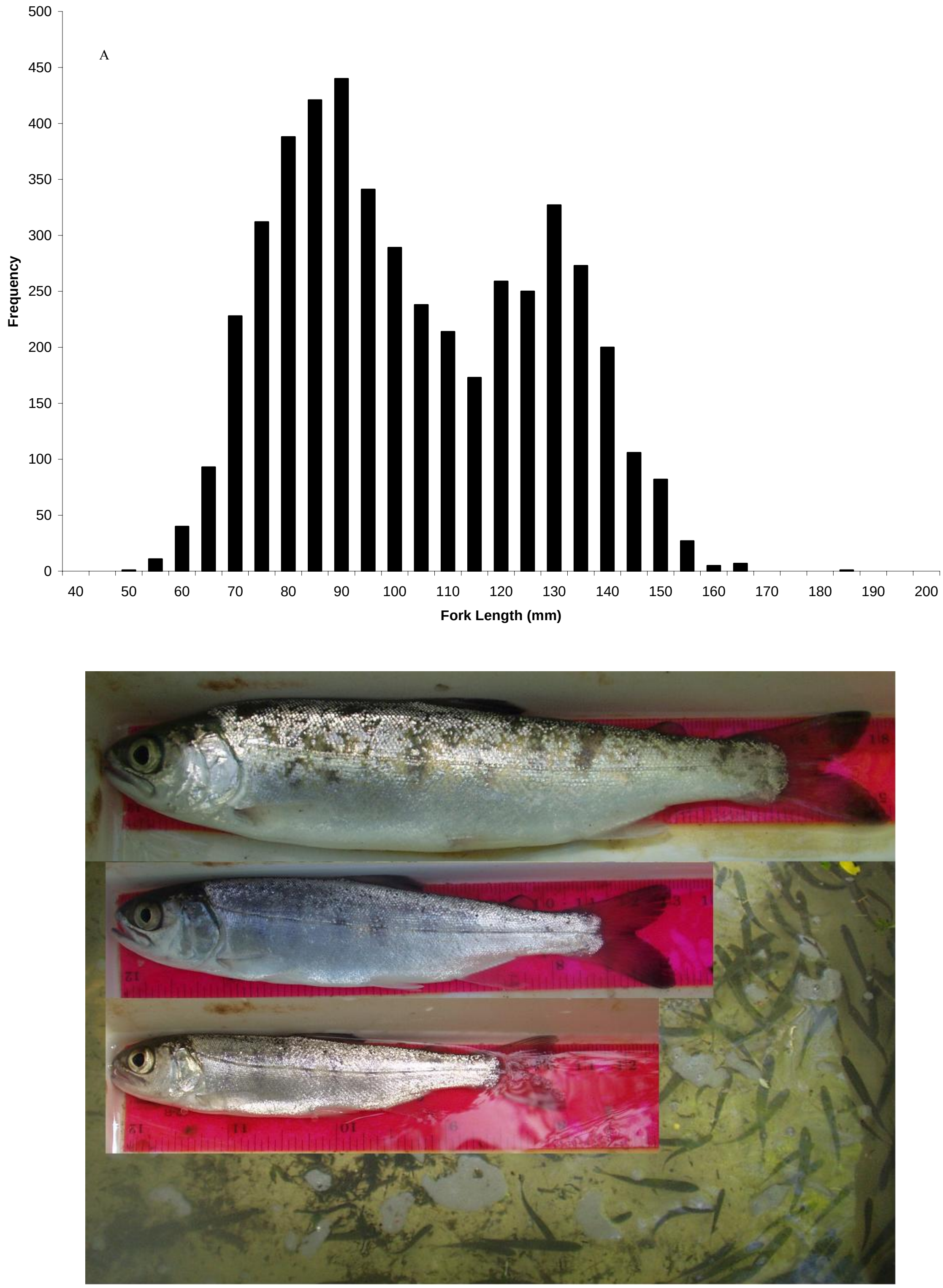


Figure 24. Coho salmon fork length frequencies from Pudding Creek trapping during spring 2006.

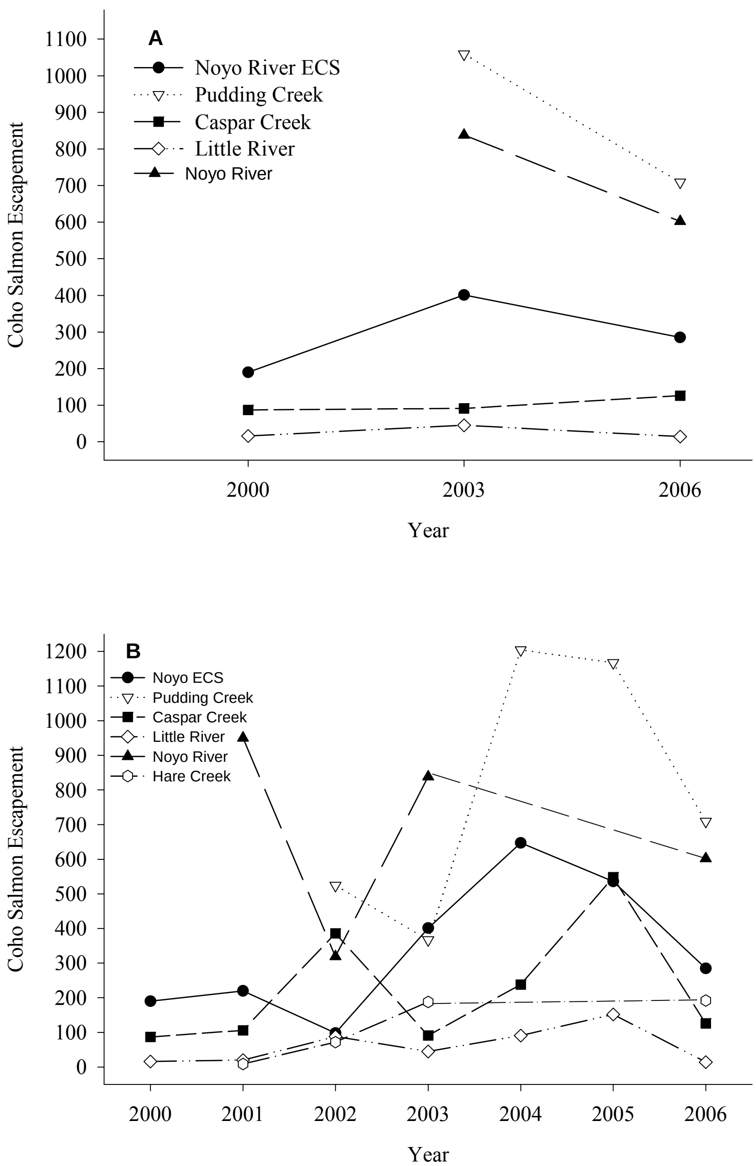


Figure 25. Coho salmon abundance trends. A). Three year adult returns. B). All years data.

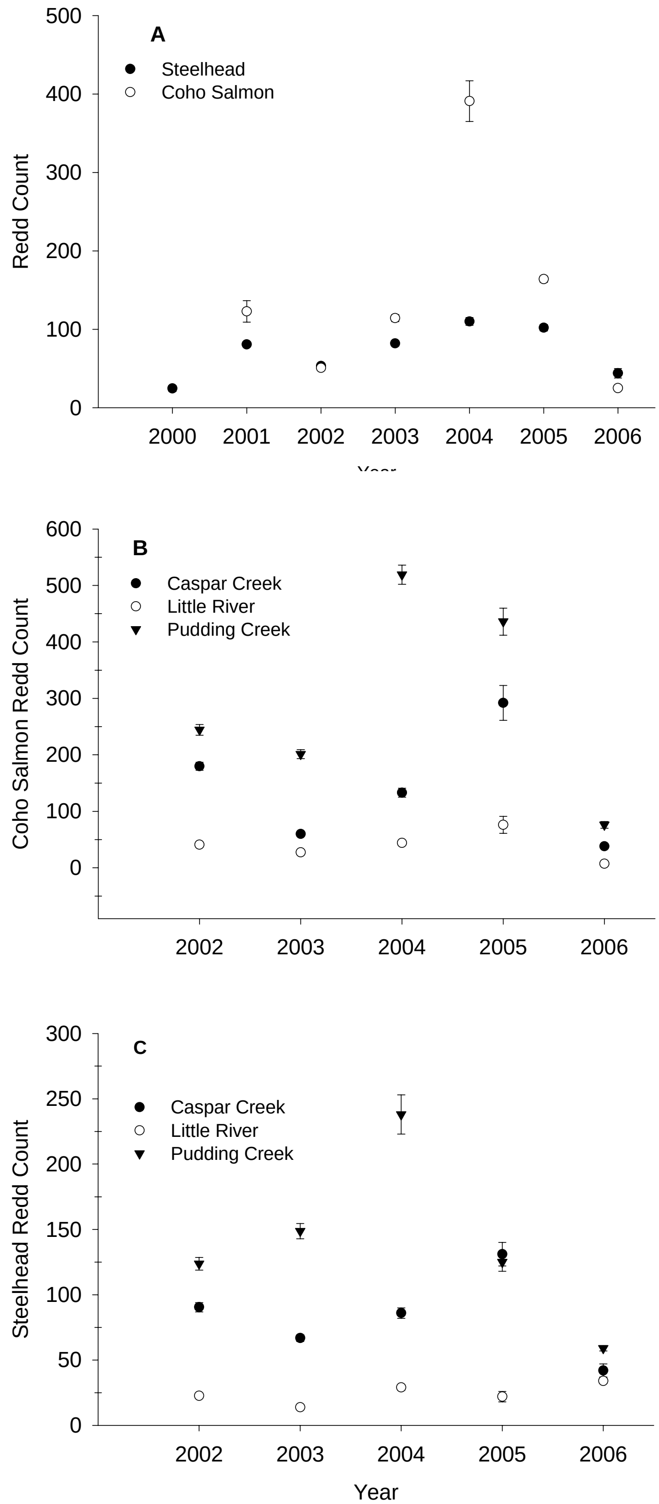


Figure 26. Coho and steelhead redd counts versus year. A). Above the South Fork Noyo River ECS. B). Coho salmon redds in Caspar and Pudding creeks and Little River. C). Steelhead redds in Caspar and Pudding creeks and Little River.

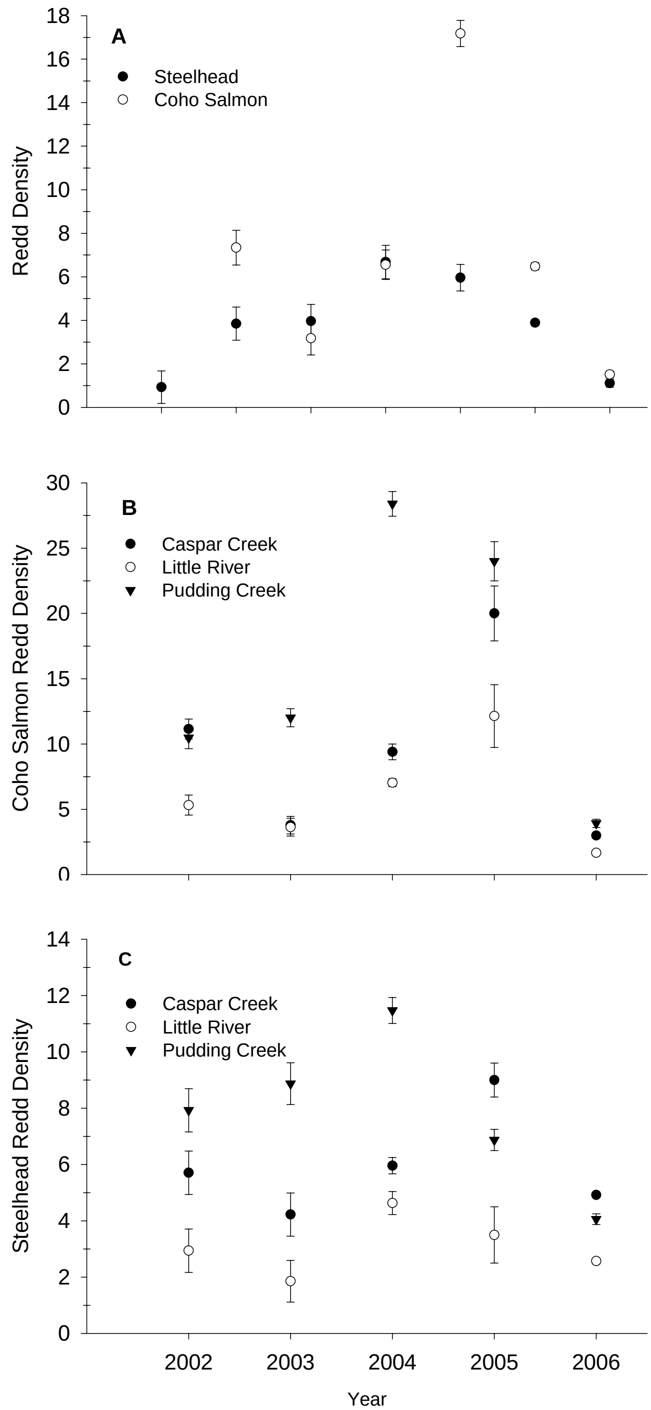


Figure 27. Redd densities versus year. A). Above the South Fork Noyo River ECS. B). Coho salmon redd densities in Caspar and Pudding creeks and Little River. C). Steelhead redd densities in Caspar and Pudding creeks and Little River.

Figure 28. Floating Board Resistance Weir redesigned and set in Caspar Creek for 2006-07.

Table 1. Coho salmon and steelhead fish per redd estimates for some coastal Mendocino County streams 2000 to 2006. 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 2. 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	Steelhead Residence Time		
		Point Estimate	Low 95% CI	High 95% CI			Point Estimate	Low 95% CI	High 95% CI
2002-03	South Fork Noyo River	12.20	8.98	15.42	1999-2000	Noyo River Tributaries	12.13	6.99	17.26
2003-04	South Fork Noyo River	28.09	25.97	30.22	1999-2000	Noyo River Main Stem	38.00	24.76	51.24
2004-05	South Fork Noyo River	26.81	21.14	32.48	2000-01	Noyo River Tributaries	16.67	6.55	26.78
2005-06	South Fork Noyo River	18.25	19.14	37.39	2001-02	Noyo River Tributaries	15.00	na	na
2003-04	Pudding Creek	32.63	28.99	36.27	2002-03	Noyo River Tributaries	13.25	2.40	24.10
2004-05	Pudding Creek	21.10	11.33	30.87	2002-03	Noyo River Main Stem	28.00	na	na
2005-06	Pudding Creek	25.00	14.38	35.62	2004-05	South Fork Noyo River	10.00	0.00	27.24
2005-06	Caspar Creek	16.00	na	na	2005-06	Noyo River Main Stem	48.00	na	na
					2003-04	Pudding Creek	9.37	3.00	15.75
					2004-05	Pudding Creek	28.33	22.43	34.24

Table 3. 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 Pannel	Sample Year
1	0.25	0.47	1237350394485	Pudding Creek	Every Year	Every Year
2	3.11	3.08	1237256394246	South Fork Noyo River	Every Year	Every Year
3	3.44	3.38	1238090394278	Noyo River	Every Year	Every Year
4	3.09	3.06	1236581393696	South Fork Noyo River	Every Two Years	2005-06
5	3.75	3.67	1238079394591	Pudding Creek	Every Two Years	2005-06
6	2.59	2.60	1235507394210	Noyo River	Every Two Years	2005-06
7	1.75	0.69	1238153393619	Caspar Creek	Every Three Years	2005-06
8	3.14	3.11	1237256394246	South Fork Noyo River	Every Three Years	2005-06
9	1.32	1.44	1234595394310	Noyo River	Every Three Years	2005-06
10	0.50	0.69	1237342394522	Pudding Creek	Every Two Years	2006-07
11	3.15	3.11	1236844393908	South Fork Noyo River	Every Two Years	2006-07
12	1.16	1.29	1237376394280	Noyo River	Every Two Years	2006-07
13	3.89	3.79	1235507394210	Noyo River	Every Three Years	2006-07
14	1.72	1.80	1237311393877	Hare Creek	Every Three Years	2006-07
15	3.32	3.27	1238090394278	Noyo River	Every Three Years	2006-07
16	0.46	0.65	1236580394057	South Fork Noyo River	Every Two Years	2006-07
17	1.73	1.82	1238090394278	Noyo River	Every Two Years	2006-07
18	3.32	3.27	1238116394173	Hare Creek	Every Two Years	2006-07
19	2.81	2.80	1238090394278	Noyo River	Every Three Years	2007-08
20	1.75	1.84	1237256394246	South Fork Noyo River	Every Three Years	2007-08
21	1.07	1.21	1237338393537	Noyo River	Every Three Years	2007-08
22	2.76	2.75	1238090394278	Noyo River	Every Two Years	2007-08
23	1.04	1.19	1235524394765	Noyo River	Every Two Years	2007-08
24	2.22	2.26	1238090394278	Noyo River	Every Two Years	2007-08
25	0.46	0.65	1236805393879	South Fork Noyo River	Every Three Years	2007-08
26	2.28	2.32	1238090394278	Noyo River	Every Three Years	2007-08
27	2.97	2.95	1238116394173	Noyo River	Every Three Years	2007-08
28	2.07	2.13	1238153393619	Caspar Creek	Every Two Years	2008-09
29	2.61	2.62	1238079394591	Pudding Creek	Every Two Years	2008-09
30	0.50	0.69	1236571393687	South Fork Noyo River	Every Two Years	2008-09
31	3.31	3.26	1238090394278	Noyo River	Every Three Years	2008-09
32	1.18	1.32	1235402394298	Noyo River	Every Three Years	2008-09
33	3.29	3.24	1238090394278	Noyo River	Every Three Years	2008-09
34	2.00	2.06	1235430394703	Noyo River	Every Two Years	2008-09
35	2.46	2.48	1238116394173	Hare Creek	Every Two Years	2008-09
36	1.30	1.42	1236813394045	South Fork Noyo River	Every Two Years	2008-09
37	0.88	1.04	1234732394311	Noyo River	Every Three Years	2009-10
38	2.17	2.22	1238079394591	Pudding Creek	Every Three Years	2009-10
39	3.21	3.17	1237256394246	South Fork Noyo River	Every Three Years	2009-10
40	2.82	2.81	1238090394278	Noyo River	Every Two Years	2009-10
41	3.28	3.23	1237900392738	Little River	Every Two Years	2009-10
42	2.99	2.97	1235321394542	Noyo River	Every Two Years	2009-10
43	2.18	2.22	1238079394591	Pudding Creek	Every Three Years	2009-10
44	1.55	1.65	1235883394348	Noyo River	Every Three Years	2009-10
45	3.24	3.19	1238090394278	Noyo River	Every Three Years	2009-10
46	1.07	1.21	1234399394284	Noyo River	Every Two Years	2001-11
47	3.02	2.99	1238079394591	Pudding Creek	Every Two Years	2001-11
48	1.50	1.60	1234927394310	Noyo River	Every Two Years	2001-11
49	3.22	3.18	1236955394453	Noyo River	Every Three Years	2001-11
50	3.32	3.27	1238090394278	Noyo River	Every Three Years	2001-11
51	3.24	3.19	1235507394210	Noyo River	Every Three Years	2001-11
52	1.89	1.97	1238090394278	Noyo River	Every Two Years	2001-11
53	0.70	0.87	1236578393689	South Fork Noyo River	Every Two Years	2001-11
54	3.30	3.25	1236844393908	South Fork Noyo River	Every Two Years	2001-11
55	2.88	2.86	1237900392738	Little River	Every Three Years	2011-12
56	1.20	1.33	1235025394204	Noyo River	Every Three Years	2011-12
57	1.00	1.15	1237253394670	Pudding Creek	Every Three Years	2011-12
58	1.56	1.66	1237193394176	South Fork Noyo River	Every Two Years	2011-12
59	2.71	2.72	1238090394278	Noyo River	Every Two Years	2011-12
60	0.48	0.67	1235144394194	Noyo River	Every Two Years	2011-12
61	3.02	3.00	1238090394278	Noyo River	Every Three Years	2011-12
62	3.88	3.78	1237544393465	Caspar Creek	Every Three Years	2011-12
63	1.60	1.70	1236730393844	South Fork Noyo River	Every Three Years	2011-12
64	2.92	2.91	1236844393908	South Fork Noyo River	Every Two Years	2112-13
65	3.09	3.06	1235025394204	Noyo River	Every Two Years	2112-13
66	2.16	2.21	1238079394591	Pudding Creek	Every Two Years	2112-13
67	0.54	0.73	1235562394199	Noyo River	Every Three Years	2112-13
68	3.28	3.24	1237256394246	South Fork Noyo River	Every Three Years	2112-13
69	2.96	2.94	1238153393619	Noyo River	Every Three Years	2112-13
70	3.30	3.26	1235321394542	Noyo River	Every Two Years	2112-13
71	3.10	3.07	1238090394278	Noyo River	Every Two Years	2112-13
72	0.29	0.50	1235008394700	Noyo River	Every Two Years	2112-13
73	0.03	0.26	1236741394119	Noyo River	Every Three Years	2112-13
74	2.53	2.55	1234927394310	Noyo River	Every Three Years	2113-14
75	2.82	2.81	1238153393619	Caspar Creek	Every Three Years	2113-14
76	nd	3.66	nd	Caspar Creek	Every Two Years	2113-14*

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

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.

Stream Name	Number Live	Female:Male	Escapement				AUC Variables		Fish/Redd	Fish/km[1]
			Mark-Recapture		Fish Per Redd *	AUC **	Trapezoidal Area	Observer Efficiency		
			Carcass	Live Fish						
Caspar Creek	39	1.10:1.00	22-36-82	48-126-4961	305 ± 92	155 - 203 - 293	617.5	0.14^	3.32	9.84
Hare Creek~	39	1.38:1.00	10-21-78	nd	882 ± 265	35 - 142 - 331	617.4 ± 428	0.21 ± 0.01	nd	52.80
Little River	4	na	na	nd	56 ± 17	54 ± 15	69.5	0.21 ± 0.01	nd	9.33
Pudding Creek	82	0.68:1.00	77-148-540	588-709-888	610 ± 183	433 - 566 - 818	1721.5	0.21 ± 0.01^	9.33 ± 1.5	36.54
South Fork Noyo	52	0.44:1.00	nd	178-285-588 (78)	200 ± 60	230 - 302 - 436 -	917.5	0.07^	11.4 ± 1.08 (3.12 ± 0.42)	10.82 2.96
Noyo~	11	na	nd	nd	1476 ± 443	593 ± 342	2285.1 ± 2902	0.18^	nd	13.52

* Average fish per redd 2005-06 avg cas sf and pc 8.01 ± 2.41 (se)
^ Data from total observed marked / total marked. Noyo includes recaptures below ECS.
** 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
1 From fish per redd estimates or live fish capture-reacpture
AUC oe pc total obs marked/total marked = 0.21
AUC os cas total obs marked/total marked = .14
AUC oe sf total obs marked/total marked =0.07

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	Female:Male	Esacpement Estimate			AUC Variables		Fish/Redd	Fish/km
			Mark-Recapture	Fish Per Redd *	AUC **	Trapezoidal Area	Observer Efficiency		
Caspar Creek	8	1.50:1.00	4-6-28	19 ± 2	18 - 22 - 30	110.5	0.32	0.09	2.14
Hare Creek~	3	na	nd	31 ± 12	15 - 19 - 26	96	0.32	nd	4.86
Little River	1	na	nd	22 ± 1	1	3	0.32	nd	3.63
Pudding Creek	2	2.20:1.00	28-76-280	43 ± 3	26 - 33 - 46	31	0.06^	1.29 ± 0.72	3.91
South Fork Noyo	11	0.60:1.00	nd	52 ± 5	104 - 131 - 179 -	223	0.11	nd	1.96
Noyo~	52	na	70-186-7294	209± 31	219 - 278 - 379	2268.9	0.11^	0.57 ± 0.10	1.70

* Average fish per redd 2005-06 avg cas sf and pc 0-0.64-1.99
^ Data from total observed marked / total marked
** 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	Redd Observer Efficiency	Number of Redds		Escapement Estimate		Redds/km
		Raw	O. E.	Redd Area	1 Redd/Female	
Caspar Creek	0.72 ± 0.12	27	38 ± 3	29 ± 3	73 ± 5	2.99 ± 0.20
Hare Creek*	0.85 ± 0.06	76	110 ± 5	64 ± 4	192 ± 9	5.52 ± 0.24
Little River	0.75 ± 0.12	4	7 ± 0.7	6 ± 1	14 ± 1	1.67 ± 0.11
Noyo River*	0.62 ± 0.10	123	184 ± 12	285 ± 6	602 ± 39	1.63 ± 0.11
Pudding Creek	0.66 ± 0.11	49	76 ± 6	107 ± 9	188 ± 15	3.92 ± 0.32
South Fork Noyo	0.70 ± 0.09	20	25 ± 3	26 ± 2	82 ± 10	1.51 ± 0.16

* Total estimates from reach density expansions

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

Stream Name	Redd Observer Efficiency	Number of Redds		Redd Area	Redds/km
		Raw	O. E.		
Caspar Creek	0.69 ± 0.15	32	42 ± 5	25 ± 2	4.92 ± 0.05
Hare Creek*	1.00 ± 0.00	80	80 ± 0	65 ± 4	7.6 ± 0.00
Little River	0.20 ± 0.17	14	34 ± 2	10± 2	2.57 ± 0.10
Noyo River*	0.43 ± 0.11	278	326 ± 49	88 ± 5	2.98 ± 0.45
Pudding Creek	0.72 ± 0.14	53	59 ± 2	37 ± 3	4.06 ± 0.19
South Fork Noyo	0.44 ± 0.11	37	44 ± 6	82 ± 4	1.11 ± 0.18

* Total estimates from reach density expansions

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 *	-	485 ± 27	491 ± 23	899 - 1069 - 1219	3329 ± 1000	1558 ± 750
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 - 31501	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*	-	541 ± 58	190 - 225 - 260	218 - 324 - 430	278 - 353 - 481
10% GRTS Sample (n = 8)	1.00 - 2.92 - 4.15	172 - 504 -716	72 - 504 - 716	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 deviations.

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	23927 (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 deviations.

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 (860)	0.1	184	2704 (700)	0.37

Table 13. Time between capture and recapture and multiple capture histories for steelhead and coho salmon in downstream traps during spring 2006. Data are percentage of recaptured fish observed. Numbers in parentheses are total recaptures.

Trap Location	Coho Salmon > 70 mm									Steelhead 70 - 120 mm									Steelhead > 120								
North Fork Caspar Creek *	**Time between Capture and reccapture (88)**									**Time between Capture and reccapture (33)**									**Time between Capture and reccapture (23)**								
All fish were marked at NFC 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	7.2	7.2	0.93	0	0	0	0	0	0	36	1.5	0	0	1.5	0	0	0	0	53	3.3	3.3	0	0	0	0	0	0
Recaptured at Main stem	2	0.4	0.23	0.23	0	0.23	0	0	0.23	1.5	1.5	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured NFC/ then at Mainstem	0.4	0.7	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3
Recaptured NFC/ then at SFC	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0
Recaptured twice at NFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	3.3	0	0	0	0	0	0	0
Recaptured three times at NFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0
Recaptured at SFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0
Recaptured at SFC/ then at Mainstem	0	0.23	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 at Mainstem twice	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	0

South Fork Caspar Creek	**Time between Capture and reccapture (229)**									**Time between Capture and reccapture (20)**									**Time between Capture and reccapture (5)**								
All fish were marked at SFC 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	25.4	16.7	1.4	0.23	0.4	0	0	0	0	16.6	3	1.5	1.5	1.5	3	0	0	0	10	0	3.3	0	0	0	3.3	0	0
Recaptured at Main stem	1.1	0.93	0.23	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 SFC/ then at Mainstem	3.9	0.93	0	0.23	0	0	0.23	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured SFC/ then at NFC	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured twice at SFC	0.4	0	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured three times at SFC	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	0
Recaptured at NFC	0.23	0.23	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 at NFC/ then at Mainstem	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	0
Recaptured at Mainstem twice	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Mainstem Caspar Creek	**Time between Capture and reccapture (112)**									**Time between Capture and reccapture (13)**									**Time between Capture and reccapture (2)**								
All fish were marked at MSC 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	14.4	9.7	0.4	0.4	0.23	0.4	0	0	0	13.6	1.5	3	0	0	1.5	0	0	0	3.3	0	0	0	0	3.3	0	0	0
Recaptured at Main stem	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	0
Recaptured NFC/ then at Mainstem	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	0
Recaptured NFC/ then at SFC	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	0
Recaptured twice at MSC	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	0
Recaptured three times at MSC	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	0
Recaptured at SFC	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	0
Recaptured at SFC/ then at Mainstem	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	0
Recaptured at Mainstem twice	0	0.23	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

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

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

Table 14. 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 15. Pudding Creek summer rearing population estimates.

Species	YOY				Y+				Y++			
	Number/km	SE	Population Estimate	SE	Number/km	SE	Population Estimate	SE	Number/km	SE	Population Estimate	SE
Coho	1153	114	23628	2337	76	5	1562	103	-	-	-	-
Steelhead	562	68	11521	1394	216	26	4423	533	75	9	1538	184.5

Table 16. Coho salmon smolt to adult survival and spawner recruit ratios for some coastal Mendocino County streams 2000 to 2006.

Variable	Noyo Ecs			Pudding Creek			Caspar Creek			Little River			Noyo River			Hare Creek		
	Low ^	Point Estimate	High	Low ^	Point Estimate	High	Low ^	Point Estimate	High	Low ^	Point Estimate	High	Low ^	Point Estimate	High	Low ^	Point Estimate	High
1999-2000 Adults	-	190	-	nd	nd	nd	64	87	110	12	16	20	nd	nd	nd	nd	nd	nd
2001 Smolts	2874	4152	5430	nd	nd	nd	4021	3799	4021	261	264	277	21536	26765	31994	1978	2193	2408
2002-2003 Adults	-	401	-	nd	nd	nd	86	91	96	42	45	48	84	487	890	182	188	194
Survival Smolt to Adult (adults/smolts)	0.14	0.10	0.07	nd	nd	nd	0.02	0.02	0.02	0.16	0.17	0.17	0.00	0.02	0.03	0.09	0.09	0.08
Recruits/Spawner (adult03/adult00)	-	2.11	-	nd	nd	nd	1.34	1.05	0.87	3.50	2.81	2.40	nd	nd	nd	nd	nd	nd
2000-2001 Adults	-	220	-	nd	nd	nd	104	106	108	19	20	21	nd	nd	nd	nd	nd	nd
2002 Smolts	6778	7562	8346	nd	nd	nd	2073	2224	2375	1508	1575	1642	nd	nd	nd	nd	nd	nd
2003-2004 Adults	530	647	706	nd	nd	nd	224	238	252	86	91	96	nd	nd	nd	nd	nd	nd
Survival Smolt to Adult (adults/smolts)	0.08	0.09	0.08	nd	nd	nd	0.11	0.11	0.11	0.06	0.06	0.06	nd	nd	nd	nd	nd	nd
Recruits/Spawner (adult04/adult01)	2.41	2.94	3.21	nd	nd	nd	2.15	2.25	2.33	4.53	4.55	4.57	nd	nd	nd	nd	nd	nd
2001-2002 Adults	76	112	148	504	524	544	378	386	394	85	88	91	nd	nd	nd	nd	nd	nd
2003 Smolts	5073	5357	5641	nd	nd	nd	4617	4976	5335	2000	2115	2230	nd	nd	nd	nd	nd	nd
2004-2005 Adults	-	536	-	899	1167	1773	490	548	516	122	152	182	nd	nd	nd	nd	nd	nd
Survival Smolt to Adult (adults/smolts)	0.11	0.10	0.10	nd	nd	nd	0.11	0.11	0.10	0.06	0.07	0.08	nd	nd	nd	nd	nd	nd
Recruits/Spawner (adult05/adult02)	7.05	4.79	3.62	1.78	2.23	3.26	1.30	1.42	1.31	1.44	1.73	2.00	nd	nd	nd	nd	nd	nd
2002-2003 Adults	-	401	-	1025	1059	1093	86	91	96	42	45	48	593	838	1083	182	188	194
2004 Smolts	7632	7975	8409	nd	nd	nd	5062	5753	6444	2120	2202	2284	nd	nd	nd	nd	nd	nd
2005-2006 Adults	178	285	588	588	709	888	48	126	4961	13	14	15	563	602	641	183	192	201
Survival Smolt to Adult (adults/smolts)	0.02	0.04	0.07	nd	nd	nd	0.01	0.02	0.77	0.01	0.01	0.01	nd	nd	nd	nd	nd	nd
Recruits/Spawner (adult06/adult03)	0.44	0.71	1.47	0.57	0.67	0.81	0.56	1.38	51.68	0.31	0.31	0.31	0.95	0.72	0.59	1.01	1.02	1.04

^ Smolt data range are ± one SD, one redd per female are ± one Se, and adult capture-recapture are 95% ci's.
ECS used carcass capture-recapture for 0102, relase data for others except 2004-2006 which used live mark-recaptuer estimates, smolt estimates are sum of nfsf and sf traps, errors are sd (From Harris 2000 to 2005).
Pudding Creek used mark-recapture for 2004-2006 and 1 redd per female for other years.
Caspar used 1 redd per female for all years except 2005-06 which is the live fish capture-recapture live estimate.
Little River used 1 redd per female
Hare Creek used one redd per female
Noyo River used one redd per female excpet for 2003 which is the live fish capture-recapture estimate.

APPENDIX A

Population data for several coastal Mendocino County streams 2000 to 2006.

Table 1a-e Coho salmon data

Year	site	ECS Count	Capture-Recapture			Female to Male Ratic	Carcass Capture-Recapture			Redd Area		1 Redd/Female		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate			Fish Per Redd		
		(Fish released)	Point Estimate	Low 95% ci	High 95% ci		Point Estimate	Low 95% ci	High 95% ci	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% ci	High 95% ci
2000	ecs sf	190	na	-	-	0.35:1.00*	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	ecs sf	220	na	-	-	0.79:1.00	na	na	na	198	13	323	17	116	-	-	1334	1	123	14	5.47	0.62	484.62	177.73	791.51	1.54	nd	nd
2002	ecs sf	98	na	-	-	1.04:1.00	112	76	148	68	3	96	5	64	37	91	507.4	0.54, 0.80 from lit	51	2	2.27	0.09	200.94	73.69	328.19	4.31	nd	nd
2003	ecs sf	401	na	-	-	0.79:1.00	110	94	136	338	13	514	26	319	0	650	867.5	0.4-0.7-1.0	114	4	6.56	0.66	449.16	164.73	733.59	0.86	nd	nd
2004	ecs sf	530	647	530	706	1.00:1.04	133	91	257	480	33	760	50	587	490	684	4722	0.14+-0.02	391	26	17.18	0.59	1540.54	564.98	2516.10	1.65	1.45	1.69
2005	ecs sf	286	536	272	854	1.13:1.00	124	48	710	197	4	309	6	422	-	-	1455	0.23+-0.09	164	4	6.48	0.16	646.16	236.97	1055.35	3.27	1.70	5.08
2006	ecs sf	78	285	178	588	0.44:1.00	na	na	na	26	2	200	60	302	230	436	917.5	0.07	25	2	1.51	0.16	98.50	36.12	160.88	11.40	7.74	21.78

* Total grisel and hatchery. Only fish considered adults was 0.85:1.00. From Jones (2000).
^ Observer bias corrected.
Grand mean fish per redd all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26

Year	Site	Capture-Recapture			Female to Male Ratio	Carcass Capture-Recapture			Redd Area		1 Redd/Female		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate *			Fish Per Redd		
		Point Estimate	Low 95% ci	High 95% ci		Point Estimate	Low 95% ci	High 95% ci	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/kn	SE	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% CI	High 95% CI
2001	Pudding Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	Pudding Creek	na	na	na	1.09:1.00	340	205	1081	489	19	524	20	690	698	692	414	0.20-0.65-1.00	244	10	7.93	0.97	961.36	352.57	1570.15	nd	nd	nd
2003	Pudding Creek	na	na	na	1.25:1.00	93	0	225	314	16	367	8	225	205	245	2582	0.1	184	9	9.48	0.46	724.96	265.87	1184.05	nd	nd	nd
2004	Pudding Creek	1204	1067	1600	1.00:1.04	1441	819	3558	754	23	1059	34	1132	943	1321	9115	0.18-+0.01	519	17	28.39	0.94	2044.86	749.93	3339.79	2.32	2.13	2.99
2005	Pudding Creek	1167	899	1773	0.85:1.00	781	250	4388	657	35	949	43	984	877	1120	8370.5	0.27+-0.07	436	24	24.00	1.54	1717.84	630.00	2805.68	2.68	2.18	3.85
2006	Pudding Creek	709	588	888	0.68:1.00	148	77	540	107	9	188	15	566	433	818	1721.5	0.21+-0.01	76	6	3.92	0.32	299.44	109.82	489.06	9.33	8.40	10.83

* Grand mean all rivers and years 3.94 se 1.104 n = 10 df 9 alpha se = 2.26

Year	Site	Capture-Recapture			Female to Male Ratio	Carcass Capture-Recapture			Redd Area		1 Redd/Female		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate. **			Fish Per Redd		
		Point Estimate	Low 95% ci	High 95% ci		Point Estimate	Low 95% ci	High 95% ci	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% CI	High 95% CI
2000	Caspar Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	87*	23*						43.52*	11.52	3.41					nd	nd	nd
2001	Caspar Creek	nd	nd	nd	nd	nd	nd	nd	nd	31	106	2	25	17	33	295	1	53.00	1.00	4.15	0.08	208.82	76.58	341.06	nd	nd	nd
2002	Caspar Creek	na	na	na	0.91:1.00	95	45	135	352	10	386	8	305	nd	nd	2585.7	1	183.00	4.00	11.15	0.76	721.02	264.43	1177.61	nd	nd	nd
2003	Caspar Creek	na	na	na	1.23:1.00	10	3	17	61	1	91	5	31	20	62	235.75	0.32-0.64-1.00	59.00	2.00	3.78	0.68	232.46	85.25	379.67	nd	nd	nd
2004	Caspar Creek	na	na	na	1.30:1.00	17	6	201	153	9	238	14	93	78	108	749	0.16+-0.02	133.00	8.00	9.40	0.60	524.02	192.18	855.86	nd	nd	nd
2005	Caspar Creek	na	na	na	1.14:1.00	197	123	411	200	35	548	58	121	98	219	1105	0.18+-0.01	292.00	31.00	19.99	2.12	1150.48	421.93	1879.03	nd	nd	nd
2006	Caspar Creek	126	48	4961	1.10:1.00	36	22	82	29	3	73	5	203	155	293	617.5	0.14	38.00	3.00	2.99	0.20	149.72	54.91	244.53	3.32	1.37	121.00

* 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

Year	Site	Capture-Recapture			Female to Male Ratio	Carcass Capture-Recapture			Redd Area		1 Redd/Female		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate **		
		Point Estimate	Low 95% ci	High 95% ci		Point Estimate	Low 95% ci	High 95% ci	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci
2000	Little River				1.00:1.00						16*	4*						8*	2	1.31	0.33			
2001	Little River	nd	nd	nd	nd	nd	nd	nd	19	4	20	0.7	7	4	10	82.6	lit 0.59 0.79	10	1	1.64	0.16	39.40	14.45	64.35
2002	Little River	nd	nd	nd	1.00:1.00	13	7	75	60	2	88	3	56	25	81	660.8	lit 0.59 0.79	41	1.6	6.72	0.26	161.54	59.24	263.84
2003	Little River	nd	nd	nd	1.25:1.00	6	1	11	34	3	45	3	28	5	59	319.5	lit 0.59 0.79	27	1	4.43	0.16	106.38	39.01	173.75
2004	Little River	nd	nd	nd	0.92:1.00	14	9	1495	67	3	91	5	85	53	211	607	0.16+-0.02	44	2	7.03	0.32	173.36	63.58	283.14
2005	Little River	nd	nd	nd	1.00:1.00	60	19	114	116	24	152	30	142	45	270	190.5	0.06-0.12-0.36	76	15	12.14	2.40	299.44	109.82	489.06
2006	Little River	nd	nd	nd	1.00:1.00^	nd	nd	nd	6	1	14	1	54	39	69	69.5	0.21+-.01	7	1	1.67	0.11	27.58	10.11	45.05

^ assume 1:1
* expaneded scott harris 1999-2000 raw count of 32 assume 0.64 oe in redd detection (32*0.36+32)

Year	Site	Capture-Recapture			Female to Male Ratio	Carcass Capture-Recapture			Redd Area		1 Redd/Female		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate **			Fish Per Redd		
		Point Estimate	Low 95% ci	High 95% ci		Point Estimate	Low 95% ci	High 95% ci	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% CI	High 95% CI
2000	Noyo River	na	-	-	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na				nd	nd	nd
2001	Noyo River	nd	nd	nd	1.53:1.00	331	194	468	701	19	950.04	25	593	0	0	6819.5	none	475	123.50	9.30	2.42	1871.50	686.36	3056.64	nd	nd	nd
2002	Noyo River	nd	nd	nd	1.04:1.00	337	266	408	496	20	319	20	208	166	333	1909	0.54-0.80 lit	284	11.00	1.70	0.49	1118.96	410.37	1827.55	nd	nd	nd
2003	Noyo River	487	84	890	0.79:1.00	239	183	346	516	190	838	245	527	433	1044	4979.5	0.40-0.70-1.00	471	137.00	3.84	1.11	1855.74	680.58	3030.90	1.03	0.25	1.46
2004	Noyo River	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-	nd	nd	nd
2005	Noyo River	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-	nd	nd	nd
2006	Noyo River	nd	nd	nd	0.44:1.00^	nd	nd	nd	285	6	602	39	593	251	1185	2285.1+-2902	0.18	184	12.00	1.63	0.11	4.00	265.87	1184.05	nd	nd	nd

^ ecs captures

Year	Site	Capture-Recapture			Female to Male Ratio	Carcass Capture-Recapture			Redd Area		1 Redd/Female		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate **		
		Point Estimate	Low 95% ci	High 95% ci		Point Estimate	Low 95% ci	High 95% ci	Estimate	SE	Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci
2001	Hare Creek	nd	nd	nd	1.00:1.00*	nd	nd	nd	8	1	9	1	nd	nd	nd	nd	nd	4	1.00	0.48	0.12	15.76	5.78	25.74
2002	Hare Creek	nd	nd	nd	1.00:1.00	9	5	78	60	3	72	4	16	11	105	126.5	0.59-0.70-1.0 lit	36	9.36	4.36	1.13	141.84	52.02	231.66
2003	Hare Creek	nd	nd	nd	0.87:1.00	34	19	79	75	7	188	6	51	51	508	581	0.10-1.0	82	20.00	9.93	2.42	323.08	118.49	527.67
2004	Hare Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-
2005	Hare Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	-	-	-
2006	Hare Creek	nd	nd	nd	1.38:1.00	21	10	78	64	4	192	9	142	0	284	617.4+-428	0.21	110	5.00	5.52	0.24	433.40	158.95	707.85

* assume 1:1

Table 2a-e. Steelhead data.

Year	Site	Capture-Recapture			Female to Male Ratio	Redd Area		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate **		
		Point Estimate	Low 95% ci	High 95% ci		Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci
2000	ecs sf	nd	nd	nd	0.75:1.00	26	0.3	nd	nd	nd	nd	nd	22	5	0.93	0.22	18.48	24.42	30.36
2001	ecs sf	nd	nd	nd	1.16:1.00	68	0.5	12	2	22	38	see noyo all	98.6	0.6	3.84	0.92	82.82	109.45	136.07
2002	ecs sf	nd	nd	nd	1.02:1.00	28	0.4	57	18	123	224.5	0.145-0.32-1	46	6	3.96	0.95	38.64	51.06	63.48
2003	ecs sf	nd	nd	nd	1.24:1.00	62	4	37	8	48	73	0.12-0.24-0.75	95	6	6.68	0.40	79.80	105.45	131.10
2004	ecs sf	nd	nd	nd	0.71:1.00	91	3	138	49	227	173.5	0.038+-0.001	110	5	5.96	0.61	92.40	122.10	151.80
2005	ecs sf	nd	nd	nd	1.40:1.00	55	4	21	11	32	24	0.04-+0.005	125	4	2.89	0.12	105.00	138.75	172.50
2006	ecs sf	nd	nd	nd	0.60:1.00	82	4	131	104	179	223	0.11	44	6	1.11	0.18	36.96	48.84	60.72

** Grand mean all data as of 2005-06 no cas 06

Year	Site	Capture-Recapture			Female to Male Ratio	Redd Area		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate **			Fish Per Redd		
		Point Estimate	Low 95% ci	High 95% ci		Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% CI	High 95% CI
2000	Caspar Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	Caspar Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	Caspar Creek	nd	nd	nd	1.00:1.00*	80	3	nd	nd	nd	nd	nd	91.5	5	5.71	1.3704	76.86	101.565	126.27	nd	nd	nd
2003	Caspar Creek	nd	nd	nd	1.00:1.00*	65	5	21	0	25	69.5	0.12-0.24-0.75	64	2	4.22	0.1266	53.76	71.04	88.32	nd	nd	nd
2004	Caspar Creek	nd	nd	nd	0.60:1.00	77	4	117	40	194	147	0.035+-0.001	86	4	5.96	0.29	72.24	95.46	118.68	nd	nd	nd
2005	Caspar Creek	nd	nd	nd	1.00:1.00	100	7	51	26	76	58	0.04+-0.005	131	9	9	0.6	110.04	145.41	180.78	nd	nd	nd
2006	Caspar Creek	6	4	26	1.50:1.00	25	2	22	18	30	110.5	0.32	42	5	4.92	0.05	35.28	46.62	57.96	0.14	0.11	0.55

*Assume 1:1
** Grand mean all data as of 2005-06 no cas 06

Year	Site	Capture-Recapture			Female to Male Ratio	Redd Area		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate **			Fish Per Redd		
		Point Estimate	Low 95% ci	High 95% ci		Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% CI	High 95% CI
2000	Pudding Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	Pudding Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	Pudding Creek	nd	nd	nd	1.00:1.00*	117	4	35	1	69	95.5	0.10-0.22-0.35	123.5	7	7.9268	1.90243	103.74	137.085	170.43	nd	nd	nd
2003	Pudding Creek	nd	nd	nd	1.00:1.00*	125	3	80	25	161	245.5	0.12-0.24-0.75	137	3	8.8704	2.1289	115.08	152.07	189.06	nd	nd	nd
2004	Pudding Creek	265	69	461	0.89:1.00	186	13	541	180	902	682	0.042+-0.008	238	15	11.47	0.46	199.92	264.18	328.44	1.11	0.31	1.82
2005	Pudding Creek	203	122	284	2.25:1.00	100	5	334	167	501	387.5	0.04+-0.005	125	7	6.87	0.38	105	138.75	172.5	1.62	1.03	2.15
2006	Pudding Creek	76	28	280	2.20:1.00	37	3	33	26	46	31	0.06	59	2	4.06	0.19	49.56	65.49	81.42	1.29	0.49	4.59

*Assume 1:1
grand mean all data as of 2005-06 no cas 06

Year	Site	Capture-Recapture			Female to Male Ratio	Redd Area		AUC					Redd Counts^		Redd Density		Fish Per Redd Escapement Estimate **		
		Point Estimate	Low 95% ci	High 95% ci		Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci
2000	Little River	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2001	Little River	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2002	Little River	nd	nd	nd	1.00:1.00*	16	1	nd	nd	nd	nd	nd	22	0.5	3.61	0.08	18.48	24.42	30.36
2003	Little River	nd	nd	nd	1.00:1.00*	10	1	27	9	54	82	0.12-0.24-0.75	14	2	2.30	0.33	11.76	15.54	19.32
2004	Little River	nd	nd	nd	1.00:1.00*	20	2	106	35	177	134	0.042	29	2	4.36	0.41	24.36	32.19	40.02
2005	Little River	nd	nd	nd	1.00:1.00*	20	6	12	6	18	13.5	0.04+-0.005	22	6	3.50	0.60	18.48	24.42	30.36
2006	Little River	nd	nd	nd	1.00:1.00*	10	2	1	0	0	3	0.32	34	2	2.57	0.10	28.56	37.74	46.92

*Assume 1:1
** Grand mean all data as of 2005-06 no cas 06.

Year	Site	Capture-Recapture			Female to Male Ratio	Redd Area		AUC					Redd Counts^		Redd Density		Fish Per Redd Estimates **			Fish Per Redd		
		Point Estimate	Low 95% ci	High 95% ci		Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci	Point Estimate	Low 95% CI	High 95% CI
2000	Noyo River	228	0	456	0.75:1.00	195	31	173	47	393	548.8	0.13-0.25-0.44	167	27	1.52	0.37	140.28	185.37	230.46	1.37	0.00	2.35
2001	Noyo River	334	89	819	1.16:1.00	343	9	222	28	416	1061	0.13-0.25-0.44	449.5	12	2.96	0.71	377.58	498.95	620.31	0.74	0.20	1.77
2002	Noyo River	364	75	653	1.02:1.00	207	13	185	47	417	1501.5	0.12-0.22-0.73	235	10	2.87	0.69	197.40	260.85	324.30	1.55	0.33	2.67
2003	Noyo River	316	31	601	1.23:1.00	342	44	375	1	749	1203.7	0.12-0.24-0.75	530.13	55.35	5.08	0.51	445.31	588.44	731.58	0.60	0.07	1.03
2004	Noyo River	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2005	Noyo River	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2006	Noyo River	186	70	7249	0.60:1.00	88	5	278	219	379	2268.9	0.11	326	49	2.98	0.45	273.84	361.86	449.88	0.57	0.25	19.33

** Fish per redd grand mean al years

Year	Site	Capture-Recapture			Female to Male Ratio	Redd Area		AUC					Redd Counts		Redd Density		Fish Per Redd Estimates **		
		Point Estimate	Low 95% ci	High 95% ci		Estimate	SE	Point Estimate	Low 95% ci	High 95% ci	Trapeziodal Area	Observer Efficiency	Number	SE	Number/km	SE	Point Estimate	Low 95% ci	High 95% ci
2000	Hare Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	redd grand mean a	low 95% ci	high 95%ci
2001	Hare Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd			
2002	Hare Creek	nd	nd	nd	1.00:1.00	64	3	44	7	81	970.2	0.13-0.25-0.44?	89	5.5	10.774818	0.66586	74.76	98.79	122.82
2003	Hare Creek	nd	nd	nd	1.25:1.00	46	5	58	18	116	177	0.12-0.24-0.75	84	9	10.169492	1.08959	70.56	93.24	115.92
2004	Hare Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd			
2005	Hare Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd			
2006	Hare Creek	nd	nd	nd	1.00:1.00*	65	4	19	15	26	96	0.32	80	0	7.6	0	67.2	88.8	110.4

*Assume 1:1
** Grand mean all data 0.84-1.11-1.38

Appendix B.

FRGP # 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.