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ANNUAL REPORT
JUVENILE SALMONID ABUNDANCE ESTIMATION IN THE UPPER NOYO RIVER, CALIFORNIA SPRING 2003
PROJECT 2a2

By

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ABSTRACT

Modified fyke/pipe trapping and April-June resident population studies in the upper Noyo River were conducted during spring and summer 2003 to estimate juvenile and young-of-the-year (YOY) steelhead (*Oncorhynchus mykiss*) and Chinook (*O. tshawytscha*) and coho salmon (*O. kisutch*) population abundance, size, age, survival, migration timing, and distribution. Information was collected on all species captured and data was compared to results from 2000, 2001, and 2002. Six traps were placed in the Noyo River in late-March 2003 and checked daily until 22 June 2003. All steelhead, coho, and chinook salmon >50 mm were marked with weekly and trap-specific freeze brands. Fish < 50 mm fork length were counted. Marked fish were released above traps and recaptured fish were released below the traps. Modified fyke/pipe population estimates were computed using a maximum-likely-hood estimate for stratified populations. Populations were estimated by summing all trap estimates and using a two-trap mark-recapture method. One hundred meter reaches above and below each trap site were electro-fished a minimum of four times between April and July. All steelhead and coho >50 mm were marked with site and time specific freeze brands and released. Fish < 50 mm were counted and released. Resident population estimates were computed using the Jolly-Seber method for each reach and expanded to estimate stream resident populations. Steelhead and coho populations were estimated for traps and stream reaches and survival estimates were made. Steelhead trap population estimates were different among years. Coho YOY trap population estimates were and Y+ were not significantly different among years. Rearing density estimates for stream segments were not different between years. Steelhead and coho survival estimates were not different from estimates reported in the literature. Downstream movement and resident population monitoring could continue in the upper Noyo River to follow cohorts through successive life stages, although the 2003 results suggest the use of trapping for long term monitoring should be approached cautiously.

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[1]Anadromous Fisheries Resource Assessment and Monitoring Program Report No. FB-14-Draft, September 11. Philip K. Bairrington, Senior Biologist Supervisor, California Department of Fish and Game, 50 Ericson Ct. Arcata, CA 95521.

This report should be cited as: Gallagher, S. P. 2004. Juvenile salmonid (*Oncorhynchus kisutch*, O. *mykiss*, and *O. tshawytscha*) abundance estimation in the upper Noyo River, California spring 2003. California Department of Fish and Game, 50 Ericson Ct. Arcata, CA 95521. Draft 14 September 2011. 32 pp.

INTRODUCTION

Coho (*Oncorhynchus kisutch*), Chinook (*O. tshawytscha*), and steelhead (*O. mykiss*) are listed as Threatened under the Endangered Species Act in coastal Northern California (Federal Register 1997, 1999, 2000). Little information exists for the majority of steelhead stocks in California and basic life history, biological, and abundance trend information is needed to understand the nature and character of these populations (McEwan and Jackson 1996). Four key parameters for assessing viable salmonid populations are abundance, population growth rate, population spatial structure, and diversity (McElhany et al. 2000). Juvenile abundance, due to the relative ease of data collection, is the most common measure of salmonid abundance in California (Prager et al. 1999). This type of work is rated very desirable and of high cost by Prager et al. (1999). The NMFS recommends continued estimation of juvenile abundance combined with estimates of adult abundance and studies relating juvenile and adult abundance (Prager et al 1999). Information on life stage-specific survival may help assess population bottlenecks. There is a need for a reliable technique for long term monitoring of chinook, coho, and steelhead populations in coastal Northern California.

The Anadromous Fisheries Resource Assessment and Monitoring Program (formerly the Steelhead Research and Monitoring Program: S-RAMP) began conducting studies directed at evaluating techniques for long term monitoring of freshwater life history phases of steelhead in the Noyo River, California in 2000. Because juvenile Chinook and coho are found in the river at the same time as steelhead, testing of methodologies for population assessment also included these species. This report summarizes four years of study of trapping and electro-fishing as techniques to evaluate young-of-the-year (YOY) and juvenile salmonid abundance in the Noyo River.

Existing young-of-the-year (YOY) and juvenile coho and steelhead emigration information for coastal Mendocino County is summarized by Gallagher (2000, 2002a, 2002b, 2003a) and Harris and Knechtle (2002, 2003). Earlier monitoring programs were limited to eight local streams and generally collected data to monitor coho emigration and rearing or examine enhancement programs (Maahs 1995, 1996, 1997, Harris and Hendrix 2000). Gallagher (2000 and 2001, 2002b) summarized existing over-summer resident assessments for coastal Mendocino County Streams. In general, data summarized by Gallagher (2001, 2002b) and reported by Harris and Knechtle (2002), for trapping results prior to 2000, report estimates of fish numbers without error estimates. Krebs (1989) states that a basic rule of descriptive statistics is that one never report an ecological estimate without some measure of the possible error. Since 1999, salmonid trapping programs in coastal Mendocino County have improved (Gallagher 2003a, Harris and Knechtle 2003) by including mark-recapture and data analysis with a maximum-likelihood estimate for stratified populations (Darroch 1961). Over summer resident populations can be estimated, including estimates of error, using a variety of methods including removal, mark-recapture, and stratified snorkeling calibrated with electro-fishing (Hankin and Reeves 1988). Assumptions involved with these methods are outlined in Brower and Zar (1984), Krebs (1989), and Hankin and Reeves (1988), respectively.

The purpose of the fyke/pipe trapping and April-June resident population surveys in the Noyo River was to quantitatively estimate juvenile and YOY salmonid population abundance, size at age, survival, migration timing and distribution, and continue to evaluate the utility and efficiency of trapping and electro-fishing as long-term monitoring tools. Information was collected on all species captured in the river during these studies. Estimates of YOY, one year (Y+), and two year and older (Y++) steelhead were compared to YOY and Y+ estimates from Gallagher (2000, 2002a, 2003a) to examine cohort survival. Estimates of one year old (Y+) coho were compared to YOY estimates from Gallagher (2002a, 2003a) to examine cohort survival.

STUDY AREA

The Noyo River watershed (Figure 1) is a forested, coastal watershed in Mendocino County, California, which 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. The Noyo River was selected to conduct a pilot YOY and juvenile steelhead mark-recapture program to estimate various population parameters and test the ability of trapping and electro-fishing to produce these metrics in 1999 (Gallagher 2000).

The Noyo River watershed is unique in Mendocino County because approximately 19% of the basin is owned and managed by the California Department of Forestry and Fire Protection (CDF) as a demonstration forest (the South Fork). Other major landowners in the basin include the Mendocino Redwood Company (the upper watershed) and The Campbell Group (along the main stem).

Fyke Trapping Study Sites

Six fyke net trapping sites were selected in the Noyo River to enumerate Chinook, coho, and steelhead populations, determine population parameters, and further evaluate trapping methods during 2003 (Figure 2). Trap sites were selected based on access, ability to install the traps, and were located close to the confluence of the stream of interest. Traps were placed in Hayworth Creek (HWC) at rkm 43.6, in the main stem Noyo above Redwood Creek (MSN) at rkm 51.1, in the North Fork Noyo River above the confluence of Hayworth Creek (NFN) at rkm 43.6, in the Noyo River at Northspur below the North Fork confluence (NRS) at rkm 37.6, in Olds Creek (OLD) at rkm 49.5, and in Redwood Creek (RWC) at rkm 51.1 (Figure 2). Two traps were operated by CDFG (Harris and Knechtle 2003) in the South Fork Noyo River during 2003. One trap was located in the South Fork above the Noyo Egg Collecting Station (ECS) the other was located in the North Fork South Fork (Figure 2). Traps were also operated in Caspar, Hare, and Wages creeks and Little River (Harris and Knechtle 2003).

Resident Population Study Sites

To estimate survival and stream resident populations, 100 m reaches above and below each trap were electro-fished periodically during spring 2003. Each 100 m section was located 100 m above or below each trap. The downstream section for the HWC/NFN site was a 100 m section in the North Fork below the confluence of the two streams. The upstream section for NRS was in the mainstem Noyo River above the NFN confluence. One downstream section was electro-shocked (below OLD trap site) in the Noyo River below the confluence with Olds Creek because the trap was located at the mouth of Olds Creek.

METHODS AND MATERIALS

Fyke Trapping

The methods developed by Gallagher (2000, 2002a, 2003a) and Barrineau and Gallagher (2001) were followed for this study. Traps were set in HWC, MSN, NFN, NRS, OLD, and RWC in late-March 2003, were operated for a few days and blown out by high flows, reset in early-April and again destroyed by high flows, and reset in mid-April. All traps were checked daily through 22 June 2003. Trap checking procedures followed procedures outlined by Barrineau and Gallagher (2001). All steelhead and coho > 50 mm fork length were measured to the nearest mm, weighed to the nearest 0.1 g, marked with a site and week specific brand following the methods of Everest and Edmundson (1967) and Gallagher (1999) and released upstream of the traps. Thirty 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. All steelhead and coho >50 mm were examined for marks each day. Those without marks were marked and released a minimum of 100 m above the traps. Recaptured fish were measured, weighed and released a minimum of 100 m below the traps. Measured and branded fish were anesthetized using alka-seltzer (Ross unpublished). Scale and tissue samples were taken from a small sample of coho and Chinook salmon and steelhead each day. Mortalities were recorded by species and size class each day.

Resident Population Field Sampling

To examine delayed emigration above and below traps, estimate survival, and estimate stream resident populations, 100 m sections above and below each trap were electro-fished periodically during spring and summer 2003. In general, one person operated an electro-fisher (Smith-Root model 12-B set at I-5 and 300 volts) accompanied by two persons with dip nets. All crew members wore polarized glasses to help increase detection of fish. All steelhead and Chinook and coho salmon > 50 mm fork length were measured to the nearest mm, weighed to the nearest 0.1 g, marked with a site and date specific freeze brand, and released as near as possible to the place where they had been captured. All fish <50 mm were counted. Fish were continuously monitored during and after capture to detect signs of stress. Water temperature in holding buckets was monitored and replaced often during warm days or when catches were high. Sampling occurred bi-weekly beginning in late-April.

Data Analysis

To estimate steelhead populations, capture probabilities, and timing for each trap, I totaled all captures and recaptures by week and size/age class to create capture-recapture matrices for input to Darr (Bjorkstedt 2000). These matrices were than ran in Darr to produce population estimates and capture probabilities for steelhead 51-70 mm (YOY), 71-120 mm (Y+), and > 120 mm (Y++). Age/size classes were developed by examining fork length frequencies from Gallagher (2000), examination of size age relationships from Shapovalov and Taft (1954), and discussion with local fish biologists. Steelhead < 71 mm captured before fry were first observed in the spring were assumed to be Y+. Coho salmon were treated as Y+ until YOY were found > 50 mm in spring, after which fork length frequencies were used to separate year classes. I also totaled all other species caught by week. Total species and numbers observed throughout the trapping period were used to calculate species diversity for each trap. Species diversity was calculated as H' using the Brillouin index because trapping is a selective and nonrandom collection method (Brower and Zar 1984).

To estimate steelhead YOY populations, fish < 70 mm captured in late-spring were assumed to be YOY. I calculated weekly totals of steelhead and coho <50 mm from the daily catch data, multiplied this by weekly capture probabilities from Darr for each trap, and estimated standard deviations (SD) using the percentage of SD from total estimates multiplied by these estimates. The YOY trap population estimates were combined with steelhead < 50 mm estimates to calculate the total YOY population for each trap. In cases where too few YOY, Y+, or Y++ steelhead were marked and recaptured to make separate population estimates, I used the percentage of each life stage captured in a trap over the season multiplied by the Darr population estimate for all fish > 50 mm to get population estimates. Standard deviations were estimated by multiplying the proportion of each age class present by the confidence estimate for fish >50mm from Darr. The total population above NRS was assumed to be the sum of all traps (all traps combined).

A similar approach was used to calculate populations for each species and size/age class using a two-trap method for NRS. All fish captured and marked at the five traps above NRS were treated as the marked and released portion in the Darr input matrix and all marked fish recaptured at NRS were treated as recaptured in the matrix. These matrices were run in Darr to estimate parameters as above. The total population moving past the traps above NRS was calculated by summing the estimates from the five traps above NRS as it was assumed that the NRS population estimate represents fish moving past NRS.

Steelhead population and survival estimates in electro-fishing reaches were computed using the Jolly-Seber method in the program Jolly (Krebs 1989). In cases where enough (generally > 7 recaptures) steelhead of each size class were marked and recaptured, population estimates were made separately for YOY (51-70 mm), Y + steelhead (71-120 mm), and Y++ (>120 mm). In cases where to few steelhead of one age class (based on fork length size at sample time) were marked and recaptured, total population estimates were made and multiplied by the percentage of fish in each size class. Total counts of fish < 50 mm were multiplied by the proportion of marked fish from the Jolly-Seber estimates for all life stages combined. The procedure described above was used to estimate 95% confidence intervals for YOY steelhead < 50 mm. All electro-fishing reaches were measured and population estimates for each section were divided by the actual length of stream sampled to produce estimates of the number of fish/m. Stream resident populations were estimated by multiplying the number of fish/m for each age class by the total length of stream in which redds were observed (Gallagher 2001, 2002b, 2003b).

YOY populations were estimated for each stream reach by summing the individual trap and stream reach population estimates. To estimate the total population of steelhead Y+ and Y++, trap estimates and stream resident population estimates by stream reach were summed. To estimate the total population with the two-trap method, the trap population estimates and the stream resident estimates were summed. The below NRS population estimate was not included in this analysis. Bootstrap confidence levels were the sum of the individual confidence levels. Y+ and Y++ populations were estimated as above.

Coho Y+ and steelhead Y+ and Y++ population estimates from electro-fishing and trapping were combined to estimate the total number of each species present above NRS during 2003. Steelhead Y+ and Y++ trap population estimates were multiplied by two because Gallagher (2002a) found that approximately 50% of the estimated populations moved past the NRS trap between November 2000 and February 2001, before traps were put in place during 2000 and 2002. Coho Y+ trap population estimates were multiplied by 1.03 because Gallagher (2002a) found that approximately 3% of the estimated populations moved past the NRS trap between November 2000 and February 2001, before traps were put in place during 2000 and 2002. These data were compared to YOY and Y+ estimates from 2000, 2001, and 2002 (Gallagher 2000, 2002a, 2003a) to estimate survival.

Populations were compared using ANOVA, repeated measured ANOVA, t-tests, paired t-tests or the Kruskal-Wallis one way ANOVA and Mann-Whitney U-tests when standard kurtosis p-values were < 0.05. Statistical significance was accepted at the 0.05 probability level.

RESULTS

Fyke Trapping-Steelhead

Steelhead trap captures and population estimates differed and between size/age class and among trap sites during 2003 (Table 1). Standard deviations (SD) associated with steelhead 51-70 mm, 71-120 mm, > 120 mm and all > 50 mm were large and ranged from 0.26 to 0.97 of the population estimate (Figure 3, Table 1). There is no clear pattern in trap population estimates among traps sites and age/size class over four years (Figure 3). Treating each year as a sample, YOY population estimates were significantly different over four years (ANOVA $f = 7.04$, $p = 0.004$, $\beta = 0.90$). Tukey's pair-wise comparison showed that YOY steelhead trap population estimates were different between 2000-2003 and 2000-2001 (q = 5.88 and 5.19, p = 0.004 and 0.01, respectively). Treating each year as a sample, Y+ population estimates were significantly different over four years (ANOVA f = 3.48, p = 0.04). However, the power of this test was low (β = 0.431). Tukey's pair-wise comparison showed that Y+ steelhead trap population estimates were only significantly different between 2000 and 2003 (q = 4.42, p = 0.03). Steelhead Y++ trap population estimates were significantly different over four years (ANOVA f = 3.64, p = 0.04). However, the power of this test was low (β = 0.51). Tukey's pair-wise comparison showed that Y++ steelhead trap population estimates were only significantly different between 2002 and 2003 (q = 4.45, p = 0.03).

Capture probability for steelhead > 50 mm ranged from 0.04 to 0.14 (Table 1). Capture probabilities for steelhead > 50 mm were not significantly different over four years (ANOVA f=0.05, p =0.98). Capture probabilities for steelhead 51-70 mm ranged from 0.02 to 0.15. Capture probabilities for steelhead 51-70 mm over four years were not significantly different (Tukey's q < 4.26, p > 0.05). Capture probabilities for steelhead between 71-120 mm ranged from 0.05 to 0.25. Capture probabilities for steelhead between 71-120 mm were not different between 2001, 2002, and 2003 (ANOVA f =0.67, p = 0.54). The power of this test was low (β = 0.05). Capture probability for steelhead > 120 mm ranged from 0.24 to 0.33. Capture probabilities for steelhead > 120 mm were not estimated due to low numbers of recaptures during 2003. Population estimates for the one and two-trap methods overlapped (Table 1). However, trap capture probabilities were lower with the two trap method than for individual traps in 2003.

Fyke Trapping-Coho Salmon

The total number of coho salmon captured and trap population estimates by size/age class ranged from 25 to 61,776 (Table 2 and Figure 4). The SD for trap populations estimates were large and ranged from 0.30 to 0.95 of the estimates (Table 2, Figure 4). Treating each year as a sample, YOY population estimates were significantly different over four years (ANOVA f = 4.59, p = 0.02). However, the power of this test was low (β = 0.67). When examined by year the 2002 population estimates were significantly higher than 2000 (q = 4.55, p < 0.05) and 2001 (q = 4.50, P < 0.05) population estimates. Treating each year as a sample, Y+ population estimates were not significantly different over three years (ANOVA H = 2.47, p = 0.29). The power of this test was low (β = 0.41). The summed trap estimates were within the range of the two-trap estimates for Y+ coho salmon (Table 2).

Capture probabilities for coho YOY was 0.28 at the only trap for which it was possible to calculate (Table 2). Capture probabilities for coho Y+ ranged from 0.04 to 0.21. Treating each year as a sample, there was no difference in Y+ capture probability between 2001, 2002, and 2003 (ANOVA f=0.38, p = 0.69). The power of this test (β = 0.05) was low. Treating each year as a sample, there was no difference between capture probabilities for coho > 50 mm (ANOVA f = 2.35, p = 0.11). However, the power of this test was low (β = 0.28).

Fyke Trapping-Chinook Salmon

Between 13,012 and 24,212 YOY Chinook salmon were estimated to have passed North Spur in 2003 (Table 3), about half the number estimated to pass this point during 2002. Chinook salmon capture probability ranged from 0.23 to 0.36 and was higher than that of steelhead (Table 1) and coho (Table 2) and similar to that estimated for 2002.

Fyke Trapping-Other Species

Seven species of fish were captured in fyke traps in the Noyo River during 2003 (Table 4). Juvenile Pacific lamprey were captured at all traps except OLD. One frog species, two of salamander, three of newts, two snake, and one turtle species were captured throughout the trapping season. Species diversity at each trap site ranged from 0.09 to 0.58 and was highest for the RWC trap (Table 4). Species diversity was significantly different for trapping results between 2000, 2001, 2002, and 2003 (ANOVA $f = 9.32$, $p = 0.001$). When examined individually, species diversity was significantly higher in 2003 than in 2000 (Tukey's $q = 7.05$, $p < 0.01$) and not different between other years.

Resident Population Estimates

The estimated number of steelhead/m and 95% confidence levels for 100 m stream reaches electro-fished in the upper Noyo River during 2003 and the length of stream these segments represent are shown in Table 5. Total resident populations were expanded for the entire stream for 2000, 2001, 2002, and 2003 (Figure 5). Rearing population estimates by survey reach for 2000, 2001, 2002, and 2003 are shown in Figure 7. Treating each year as a sample YOY rearing density was not significantly different over four years (ANOVA $f = 0.73$, $p = 0.63$). Treating each year as a sample Y+ rearing densities were not significantly different over four years (ANOVA $f = 0.57$, $p = 0.75$), and Y++ rearing densities were not significantly different over four years (ANOVA $H = 11.57$, $p = 0.11$). Resident population estimates for the Noyo River below NRS and the South Fork Noyo River were not made.

The estimated number of coho salmon/m and 95% confidence levels for 100 m stream reaches electro-fished in the Noyo River during 2003 and the length of stream these segments represent are shown in Table 6. Total coho salmon resident populations were expanded for the entire stream for 2000, 2001, 2002, and 2003 (Figure 6). Treating each year as a sample YOY rearing densities were not significantly different between 2001, 2002, and 2003 (ANOVA $f = 1.20$, $p = 0.37$, Figure 8). However, the power of this test was low ($\beta = 0.08$).

Survival Estimates

The probability of survival for coho and steelhead from one marking period to the next from Jolly-Seber mark-recapture electro-fishing in the upper Noyo River during 2003 is shown in Table 7. Average survival estimates based on the sum of trap and electro-fishing population estimates for steelhead YOY to Y+, YOY to Y++, and Y+ to Y++ are shown in Table 8. Coho salmon YOY to Y+ survival (2001 to 2002) is shown in Table 8. Coho salmon YOY to adult and Y+ to adult survival is listed in Table 8.

DISCUSSION

Fyke Trapping

There was no clear trend in trap population estimates for steelhead or Chinook and coho salmon in the Noyo River over four years. However, the confidence levels associated with the population estimates were large. Steelhead trapping results in coastal Mendocino County are variable within and among rivers and between years in streams studied by Harris and Knechtle (2003). There are no clear trends in Y+ steelhead captures over 14 years of migration trapping for Caspar Creek and Little River. Similarly, there are no apparent trends in four years of trapping for the South Fork and North Fork South Fork Noyo, Hare Creek, and Wages Creek (Harris and Knechtle 2003). Maahs (1997) compared results of trapping of Y+ steelhead in three tributaries to the South Fork Ten Mile River between 1995, 1996, and 1997. He found two of three streams had fewer out migrants in 1997, while the third stream was relatively constant.

The YOY steelhead population estimates for 2000 were significantly higher than 2001 and 2003. Traps were operated until late-August 2000, which allowed more YOY to be captured, marked, and recaptured, whereas during 2001 and 2003 traps were removed in mid-June. Capture probabilities were not different among years. Stream flows likely differed somewhat over four years and were significantly associated with capture probabilities (Gallagher 2002a). Thus trapping duration, rather than stream flow, probably resulted in differences in YOY population estimates. Adult populations were not significantly different over four years in the Noyo River (Gallagher and Gallagher In Press), suggesting that seeding differences were not responsible for differences in YOY population estimates.

The Y+ steelhead population estimates were significantly higher in 2000 than in 2003 and Y++ population estimates were significantly higher in 2002 than in 2003. These differences likely result from differences in trapping duration. Capture probabilities were not significantly different among years. In 2000 traps were installed in early-March and operated until August. During 2002 traps were installed in early-March and operated until late-June. During 2003, due to high stream flows, traps were not placed until late-April and were removed in late-June. Gallagher (2002a) found that approximately 50% of the estimated steelhead Y+ and Y++ population moved past a trap between November and February 2001. Gallagher (2003) found that about 60% of steelhead Y+ and 90% of steelhead Y++ were captured before week 16 (mid-April). Traps were not operated during the winter and trapping did not begin until late-April during 2003. It is unknown how many fish moved past the traps during the winter and spring 2003, nor during previous years. Because stream flow and trapping duration and timing of operation appear to strongly affect trapping results it may be unrealistic to use downstream trapping for monitoring trends in population abundance.

Capture probabilities were not significantly different over four years. Probability of capture was higher for older age classes suggesting that older age fish are actively moving. Maahs (1995) had a recapture rate of 74% for year plus steelhead trapping in the Little North Fork Noyo River that he attributed to stream size and trap design. Trapping methods and trap design were similar to that described by Maahs (1995) in the Noyo during 2002. During 1996, trap efficiencies were approximately 36% and during 1997 were about 42% for streams monitored by Maahs (1996, 1997). Harris and Knechtle (2002) report 2002 year plus steelhead capture probabilities for the North Fork South Fork and the South Fork Noyo River at 20 and 33%, respectively. Trap capture probabilities for the upper Noyo River during 2002 were generally lower than those reported recently for other local streams. Ward and Slaney (1988) report box trap efficiencies of 90% for Y+ steelhead on the Keogh River in British Columbia. Thedinga et al (1994) found that screw trap efficiencies varied among salmonid species and was lowest for steelhead at 3%. Fyke net trap efficiencies in the Noyo during 2003 were better than those reported for screw traps and lower than box traps and other local fyke traps. While this may be a result of trap type and design it may also be a result of marking loss or misidentification. Gallagher (1999, 2000) found freeze brands to remain readable on salmon for between 14 and 60 day and Everest and Edmonson (1967) found brands to remain for over 2 months.

Dempson and Stansbury (1991) used a two-trap approach to estimate Atlantic salmon smolt populations in Newfoundland. Their reported confidence limits were within 8% of the population estimates. Similar to 2002 (Gallagher 2003a) the two trap approach on the Noyo River during 2003 had lower estimated capture probabilities and larger confidence intervals for YOY, Y+, and Y++ steelhead than that calculated by summing the results from individual traps. This is opposite to trapping results in the Noyo River during 2000 and 2001(Gallagher 2000, 2002a). The differences in population estimates from summing all individual traps and the two-trap method do not appear to be significantly different. Using a single trap at NRS may be sufficient to monitor salmonid movement in the Noyo River. This would reduce field effort considerably, but would not allow following cohorts and estimation of survival over time in individual tributaries.

The trap population estimates for coho salmon did not show any clear patterns over four years and the statistical confidence bounds were large. YOY coho salmon population estimates from trapping during 2002 were higher than during 2000 and 2001, but not different in 2003. This could be because populations were actually higher, or due to stream flows, differences in trap placement and design, differences in survival, or different marking techniques. Coho salmon Y+ population estimates were not different over four years.

More Chinook YOY were captured and population estimates were higher in 2002 than in 2003. This is most likely due to differences in the time of trap placement and the duration of trapping. There were more Chinook salmon adults in the Noyo River in 2003 than during 2002 (Gallagher and Gallagher In Press). Chinook YOY were captured in large numbers beginning the first day of trap operation in 2003 suggesting they were moving prior to traps being set in the river. Chinook salmon were not captured in Olds Creek or the North Fork Noyo River above Hayworth Creek. Chinook, but not coho, were captured in Hayworth Creek.

Resident Population Estimates

The purpose of the electro-fishing mark recapture in the Noyo River during 2003 was, in part, to estimate rearing populations. Harris (1999) presents summer juvenile steelhead densities for three local creeks from 1986 to 1999 that ranged from 0.01 to 1.3/m^2. Burns (1971) found summer juvenile steelhead densities in Caspar Creek to range between 0.03 to 0.55/m^2 in 1967, 1968, and 1969. The average density observed in the Noyo River during 2003 was similar to previously reported densities. There was no clear pattern or significant difference in YOY, Y+, or Y++ rearing density over four years. Suggesting, at the level of intensity employed on the Noyo River, either densities over four years were the same or that electro-fishing 2% of the Noyo River above NRS is insufficient for trend detection. Anadromous fish densities in the Little North Fork Noyo have been similar over the last few years (D. Wright Personal Communication) and were not different than those presented by Burns (1971). Suggesting that population levels in the Noyo River have been stable for over 30 years, as measured by summer rearing density. Switching to removal type population estimation methodology might allow more sampling intensity at a similar cost while increasing the power of results. However, Peterson et al. (2004) found that removal estimates are biased and as such should only be used as population indices.

Survival

Juvenile steelhead survival estimates derived from Jolly-Seber mark-recapture and calculated from population estimates in the Noyo River are similar to those reported in the literature. Shapovalov and Taft (1954) found that steelhead survival from egg to smolt was 3% and ranged from zero for YOY to almost 18% for Y++. Burns (1971) found that steelhead YOY mortality in Caspar Creek averaged 73% from June to October and that year plus fish averaged 44% mortality over this period. The YOY survival based on mark-recapture estimates in the upper Noyo River was similar to estimates from Burns (1971) and Gallagher (2000, 2002a). Bustard and Narver (1975) estimate YOY to Y + steelhead survival at 6%, ranging from 5-13% in Carnation Creek (an unlogged stream) in British Columbia. Survival rates may be lower than estimated herein because fish < 70 mm were captured in the traps until the traps were removed from the streams whereas Y+ and Y++ size fish were not. Therefore, steelhead < 70 mm appear to be moving downstream through July and this may affect population estimates and thus survival estimates. Also a large proportion of fish may have been missed by not trapping in winter and early spring. The average YOY to Y++ survival estimates are similar to the findings of Burns (1971). Age/size relationships that include scale analysis may better define age class separations by fork length and improve population and survival estimates of YOY, Y+, and Y++ steelhead. Trapping throughout the year and using techniques such as the modified Hankin and Reeves (1988) approach to estimate rearing populations might produce better survival estimates. This was the fourth year of following the 2000 cohort.

Coho salmon over-winter survival (YOY to Y+) in the upper Noyo River was similar to estimates reported in the literature. Shapovalov and Taft (1954) found that coho salmon survival from egg to smolt was 1.35%. Bustard and Narver (1975) found coho salmon survival to average 35% in British Columbia and ranged from 61-74% in an unlogged stream. Elliot and Hubart (1978) report survival of 26% in SE Alaska. Quinn and Peterson (1996) found coho survival to be 57% in Washington. Manning (1998) reports over-winter survival rates in coastal Northern California of 31% in the Little North Fork Noyo River, 18% in the South Fork Little River (Humboldt County), and 22% in Little Lost Man Creek. Johnson and Solazzi (1995 as cited in Manning 1998) report survival of 11-23% for Oregon streams. Barber (2002) estimated coho over-winter survival in Little River (Mendocino County, California) over a period of years from 1987 to 1999 to range from 19 to 33%. If the survival range of 61-74% for an unlogged stream (Bustard and Narver 1975) is assumed to be the high end for over-winter survival (not accounting for potential latitudinal differences, Braaten and Guy 2002), the estimated survival in the Noyo River is below this range. This suggests that there may be some stream specific limiting factors. Barber (2002) suggested that her (assumed to be) low over-winter survival estimates could be due to insufficient over-wintering habitat. Bell et al (2001) found coho using off channel habitats had increased over-winter survival. Investigation of habitat conditions in the Noyo River and developing relationships between habitat and fish abundance may further understanding of habitat related survival for coho and steelhead.

RECOMMENDATIONS

Downstream movement and resident populations monitoring could be continued in the upper Noyo River to follow YOY, Y+, and Y++ populations through successive life stages. This may allow the detection of habitat-induced population bottlenecks. Coordination with other programs in other rivers has improved the standardization of methods for enumeration of YOY and juvenile salmonids. This may allow for large scale comparisons and monitoring of population trends. Age-length relationships should be developed for juvenile steelhead by scale and/or otolith reading in the Noyo River and this information should be used to track year classes and potentially improve population and survival estimates.

Trapping should begin as early in the year as possible after high flows in January, February, or March. Running traps earlier and longer may increase the likelihood of capturing larger and assumed to be older steelhead. Modifying traps to increase their efficiency should also be done. Because all traps in the Noyo River showed similar capture trends over three years it is possible that the Noyo River basin is behaving as, and is representative of, an independent population as defined by McElhany et al. (2000). It is important to note that, although the power of the tests was low, there were some significant differences in population estimates over four years. These differences were, for the most part, due to limitations in trapping duration due to high spring flows, a major drawback to the use of trapping for long term monitoring. Over four years density information based on summer electro-fishing showed no clear pattern or trend. Summer electro-fishing for long term monitoring may lack sufficient power and should be considered cautiously.

However, due to:

1). The inability to operate traps throughout the winter and spring: 50% of the total 2001 steelhead population estimate at Northspur moved prior to early-March and traps could not be deployed until late-April 2003.

2). The fact that year-to-year climate and therefore stream flows are extremely variable.

3). Differences between yearly climate make consistency in the year-to-year timing and duration of trapping difficult.

4). The idea that stream flows affect the number of fish moving, the timing of movement, the number of fish captured in traps, and that generally captures are significantly associated with stream flow and water temperature.

5). The idea that even though traps appear to show a similar lack of trend over four years, some population estimates were significantly different due to difficulties operating traps in high water.

6). Five years of trapping data on the South Fork and North Fork South Fork Noyo River show no significant trends in fish captures, although there may not be any trends.

Thus:

Trapping as a long-term monitoring tool should be approached cautiously.

Considering the above it is likely that management decisions based on inferences of change over time from trapping population estimates may be susceptible to type I and type II errors. On the other hand, continued monitoring using multiple traps and electro-fishing may allow continued examination of coho, Chinook, and steelhead cohorts over successive years, may help define the variability in steelhead life histories in the upper Noyo River, and hopefully improve management prescriptions.

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The Mendocino Redwood Company granted access to company property on the upper Noyo River. Thanks to the Mendocino Redwood Company for allowing us access to the river and the use of their roads. Charles Bellow ungraciously disallowed access to the North Fork and roads to the upper North Fork. Matt Coleman, Craig Comen, John

Henderson, Natalie Lohi, George Neillands, Alan Palacios, Andy Polowsky, and Chris Sjezk helped conduct this study.

PERSONAL COMMUNICATIONS

Dave Wright. November 2003. Campbell Timberland Management, Fort Bragg, CA 95437

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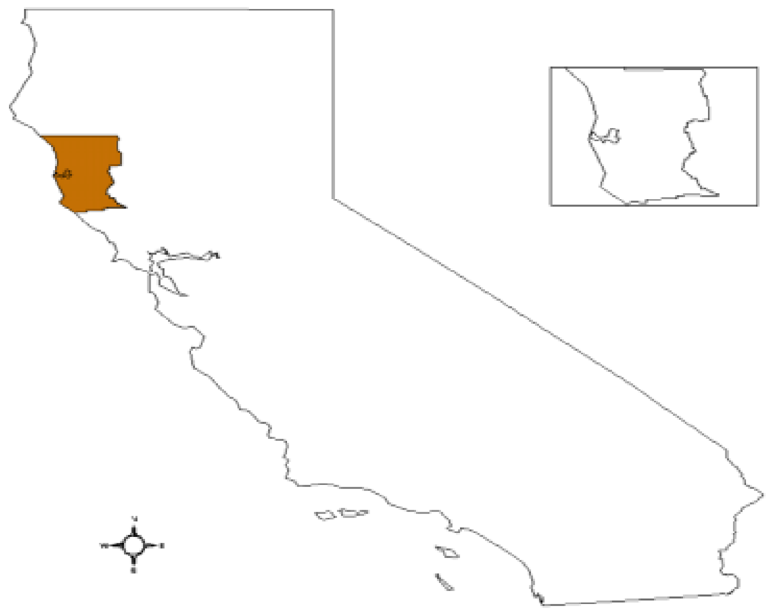

Figure 1. Location of the Noyo River watershed in Mendocino County, California.

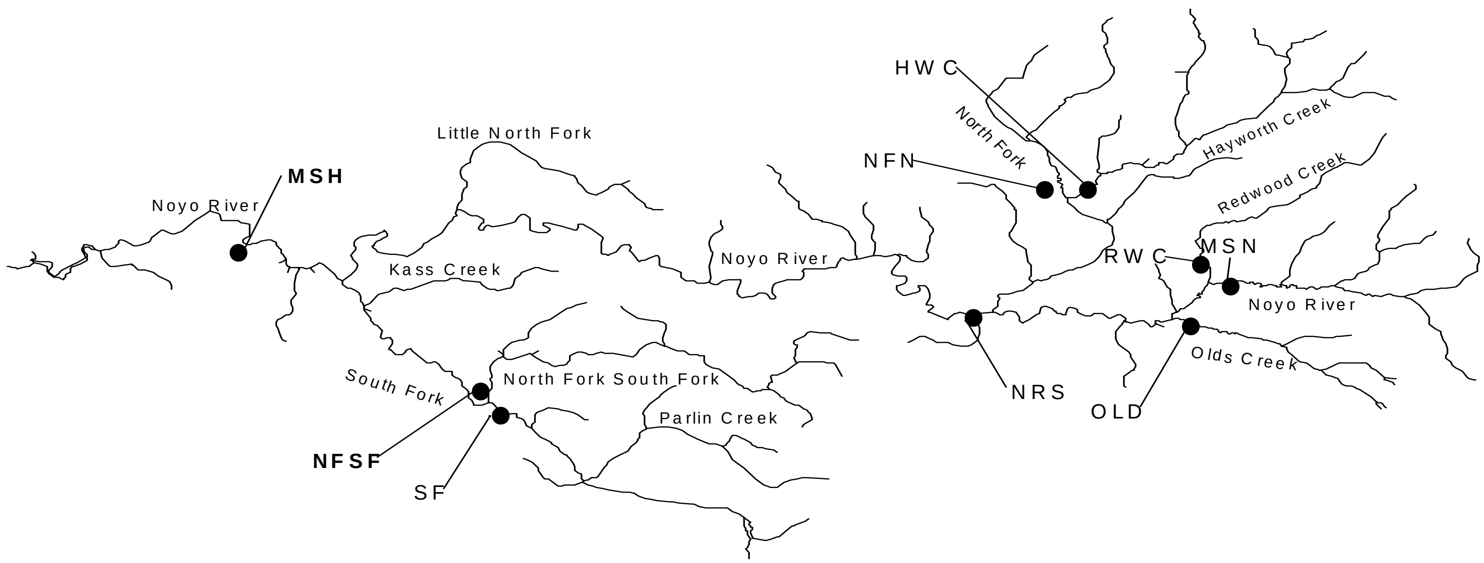

Figure 2. Location of fyke traps in the upper Noyo River during 2003. Circles indicate traps operated for this study. HWC is Hayworth Creek. MSN is the Noyo below Redwood Creek. NFN is the North Fork. NRS is Northspur. OLD is Olds Creek. RWC is Redwood Creek. SF is the South Fork. NFSF is the North Fork of the South Fork (SF and NFSF data not reported herein). The Madsen Hole site (MSH) was not operated in 2003.

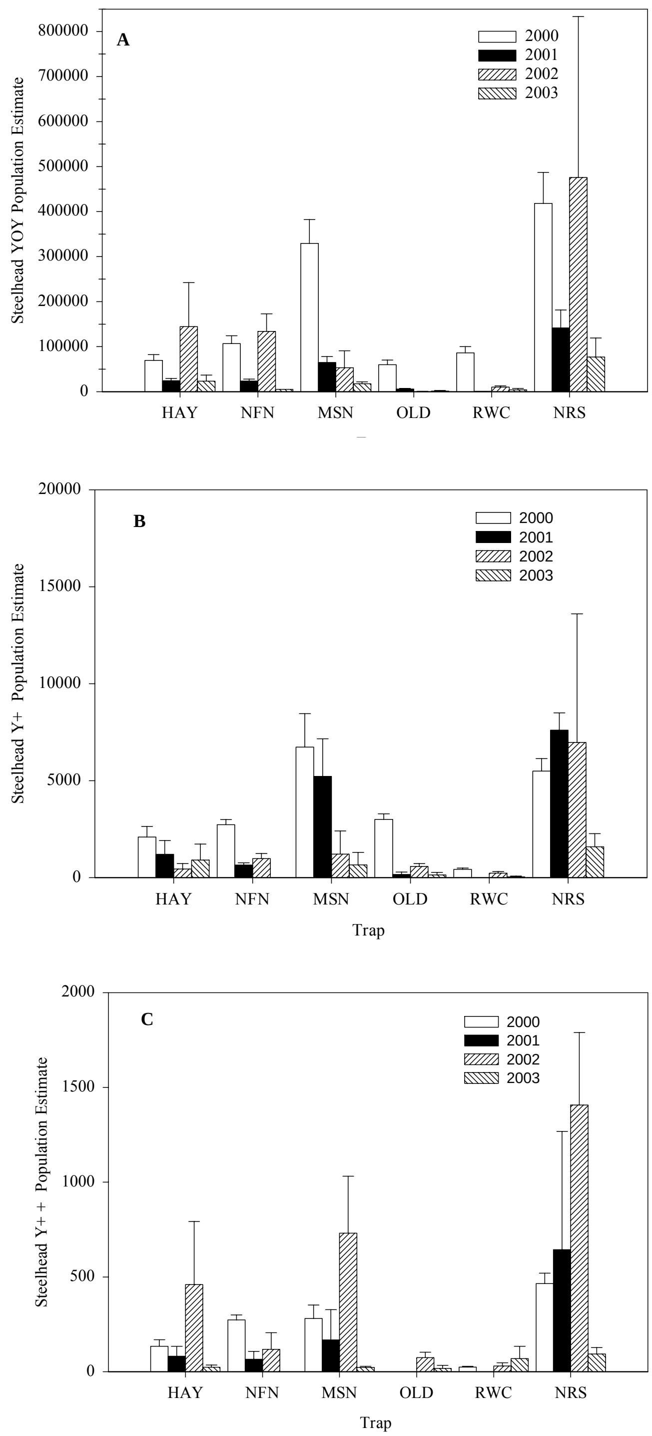

Figure 3. Trap population estimates for YOY (A), Y+ (B), and Y++ (C) steelhead in the Noyo River 2000, 2001, 2002, and 2003. Thin lines are standard deviations. Abbreviations are the same as in Figure 2. Note: scales are different.

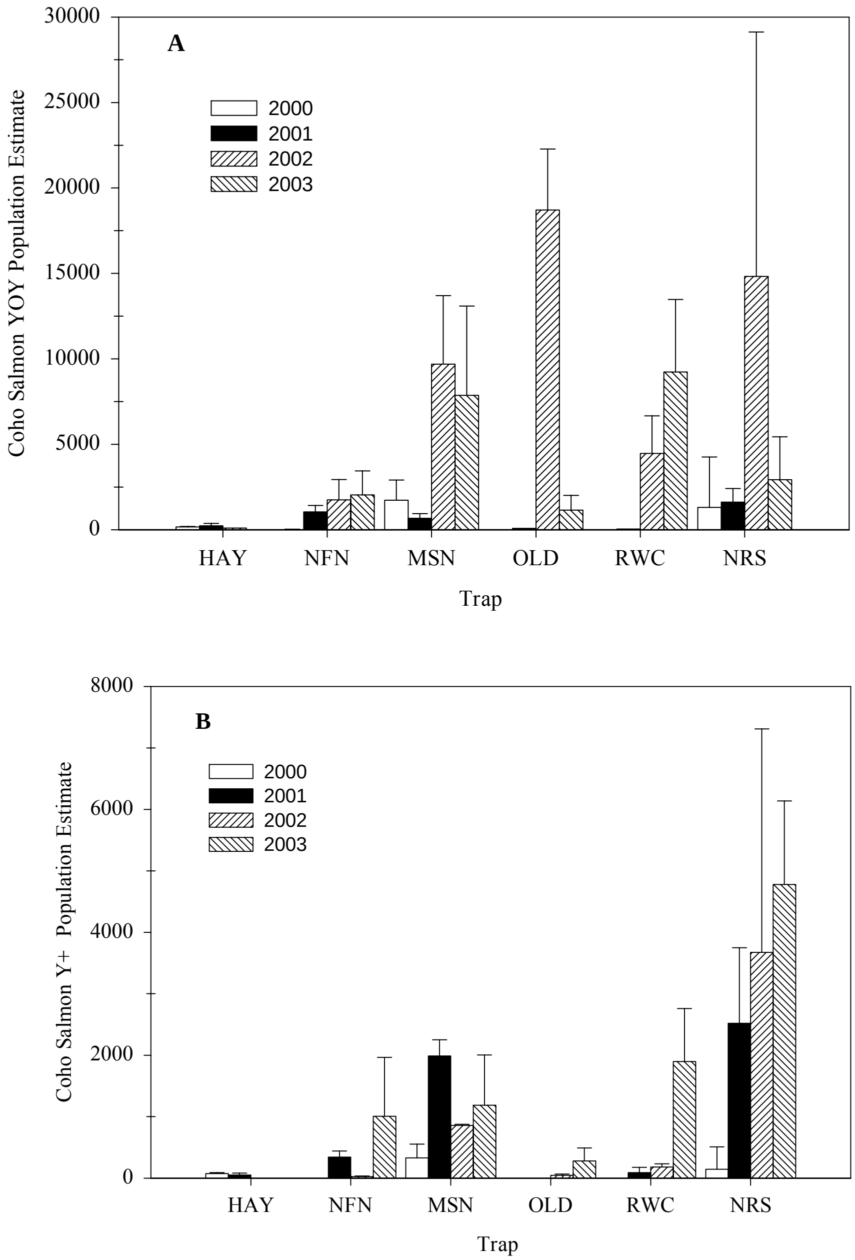

Figure 4. Coho salmon trap population estimates YOY (A) and Y+ (B) in the upper Noyo River 2000, 2001, 2002, and 2003. Thin lines are standard deviations. Abbreviations are the same as in Figure 2. Note: Scales are different.

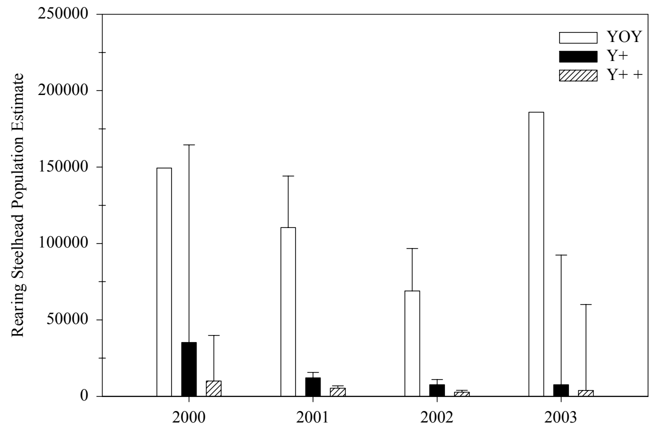

Figure 5. Young- of-the-Year, Y+, and Y++ rearing steelhead populations in the upper Noyo River during 2000, 2001, 2002, and 2003. Thin Lines are 95% confidence limits.

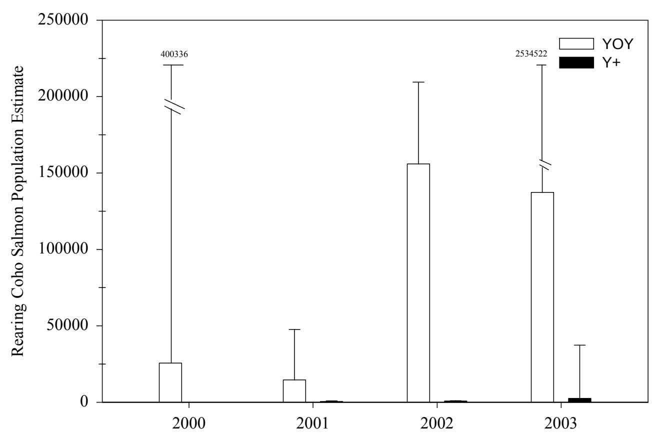

Figure 6. Young- of-the-Year and Y+ rearing coho populations in the upper Noyo River during 2000, 2001, 2002, and 2003. Thin Lines are 95% confidence limits.

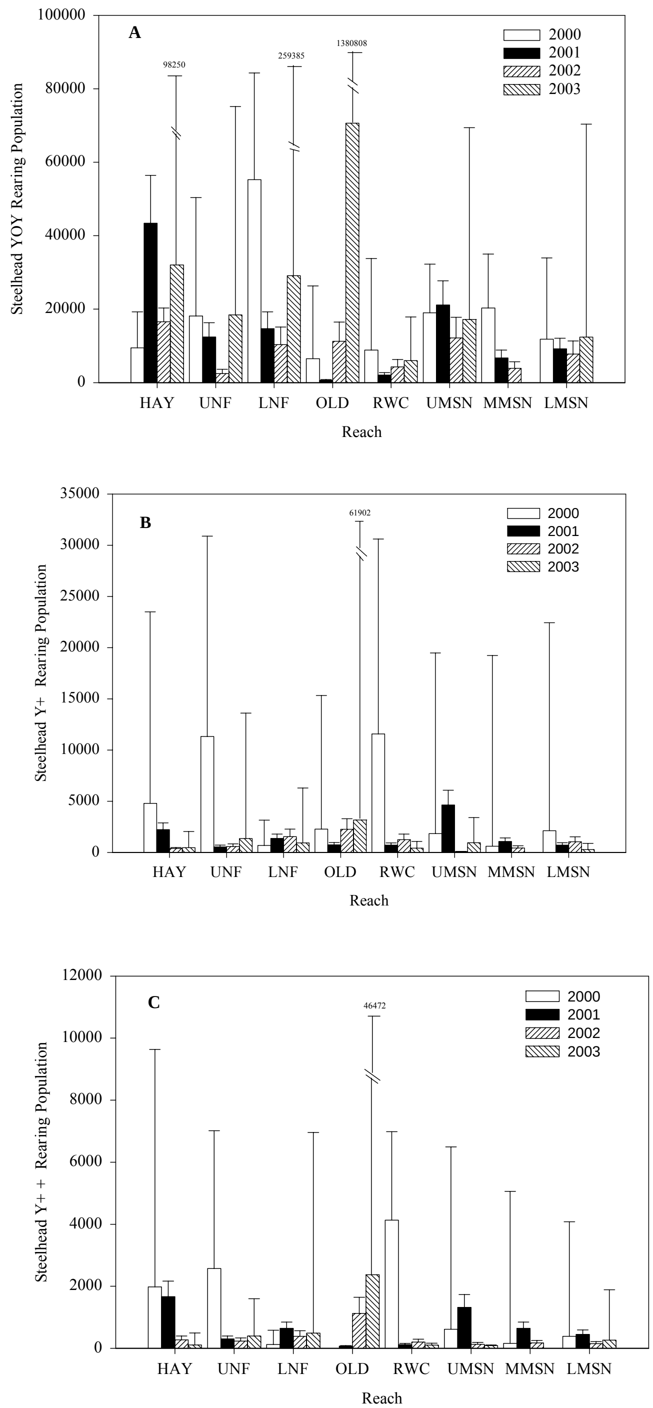

Figure 7. Rearing steelhead populations in eight reaches in the upper Noyo River 2000, 2001, 2002, and 2003. YOY (A), Y+ (B), and Y++ (C). Thin lines are 95% confidence limits. Abbreviations are the same as in Figure 2, except UMSN is the Noyo above RWC, MMSN is the Noyo between RWC and OLD, and LMSN is the Noyo from NRS to OLD.

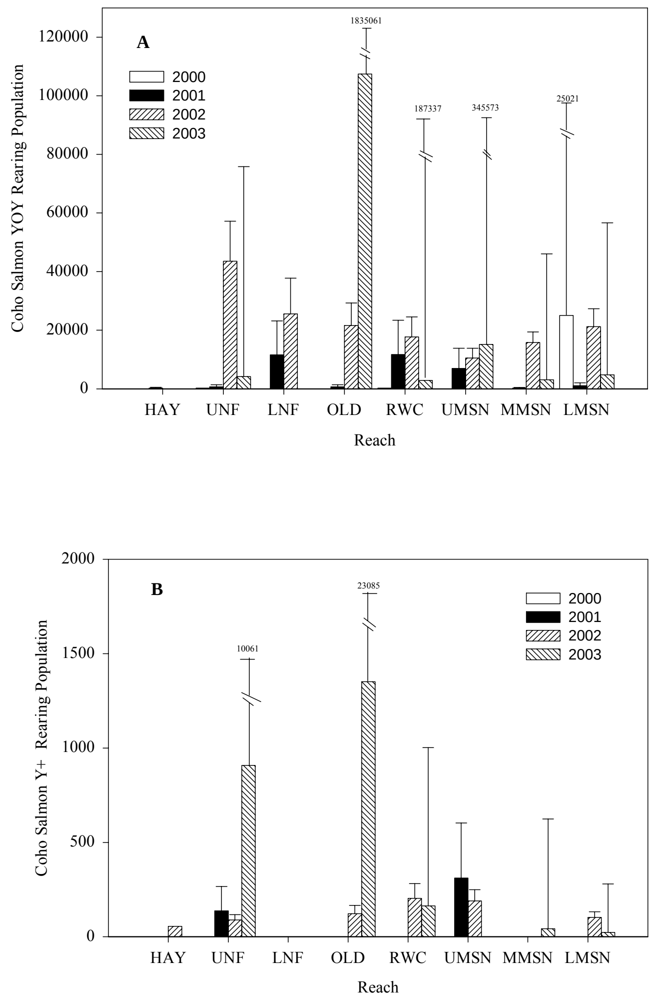

Figure 8. Rearing coho salmon YOY (A) and Y+ (B) populations in the Noyo River 2001 to 2003. Thin lines are 95% confidence limits. Abbreviations are the same as in Figure 2, except UMSN is the Noyo River above RWC, MMSN is the Noyo River between RWC and OLD, and LMSN is the Noyo River from NRS to OLD.

Table 1. Steelhead population estimates from fyke traps in the upper Noyo River during 2003. Numbers in parentheses are standard deviations.

Trap Location	< 50 mm		51-70 mm			71-120 mm			> 120 mm			> 50 mm		
	Total Captured	N	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability
Hayworth Creek	1874	23152 (13589)	3	36 (21)		46	906 (823)	0.25	2	24 (14)		56	1182 (1013)	0.2
Mainstem Noyo	2125	16718 (4045)	135	939 (246)	0.15	30	660 (644)	0.05	3	23 (6)		168	1271 (308)	0.14
North Fork Noyo	5198	- -	8	- -		10	- -		1	- -		19	- -	
Northspur	6287	76142 (41934)	54	630 (347)	0.09	156	1594 (672)	0.1	7	94 33		217	2313 (802)	0.08
Olds Creek	58	1025 (953)	16	283 (263)		8	141 (131)		1	18 (16)		26	486 (454)	0.06
Redwood Creek	448	3894 (3621)	0			5	43 (40)		8	69 (65)		13	104 (97)	0.13
Total Indivdual Traps	15990	120931 (64142)	216	1888 (877)		255	3344 (2310)		22	261 (134)		499	5356 (2674)	
Two Traps Northspur	15990	16630 (11641)	155	8990 (6301)	0.02	107	1320 (515)	0.08	6	94 (33)		282	7015 (2428)	0.04

Table 2. Coho salmon population estimates from fyke traps in the upper Noyo River during 2003. Numbers in parentheses are standard deviations. Asterisks indicate that capture probabilities for fish > 50 mm were used to expand total captures for other size classes.

Trap Location	< 50 mm		51-80 mm			> 80 mm			> 50 mm		
	Total Captured	N	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability
Hayworth Creek	25	-	0	-	-	0	-	-	0	-	-
Mainstem Noyo	1112	7464 (4851)	19	399 (379)	*	48	1008 (956)	*	70	2060 (1950)	0.05
North Fork Noyo	95	1995 (1376)	2	42 (29)	*	56	1185 (818)	*	59	1239 (854)	0.05
Northspur	330	2846 (2447)	12	78 (67)	0.28	374	4778 (1361)	0.08	386	4593 (981)	0.08
Olds Creek	184	1028 (771)	21	119 (89)	*	59	280 (210)	0.21	76	347 (361)	0.3
Redwood Creek	630	8552 (3934)	26	676 (311)	*	89	1896 (856)	0.04	115	1957 (894)	0.05
Total Indivdual Traps	2376	21885 (19588)	80	1314 (4633)	0.28	626	9147 (3738)	0.11	706	10196 (5689)	0.106
Two Traps Northspur	2376	61776 (20386)	40	1040 (1373)	*	280	4532 (5964)	0.07	320	8498 (2777)	0.04

Table 3. Chinook salmon population estimates from fyke traps in the upper Noyo River during 2003. Numbers in parentheses are standard deviations.

Trap Location	< 50 mm		> 50		
	Total Captured	N	Total Captured	N	Capture Probability
Hayworth Creek	1205	4552 (501)	186	509 (54)	0.36
Mainstem Noyo	110		7		
North Fork Noyo	0		0		
Northspur	2370	6430 (579)	558	1521 (132)	0.34
Olds Creek	0		0		
Redwood Creek	678		6		
Total Indivdual Traps	4363	10982 (1080)	757	2030 (186)	
Two Traps Northspur	4363	(23333) (3500)	199	880 (132)	0.23

Table 4. Total species captured and species diversity (H') for each trap in the upper Noyo River during 2003.

Species	Common Name	Total Captured					
		Hayworth Creek	Mainstem Noyo	North Fork	Northspur	Olds Creek	Redwood Creek
Clemmys marmorata	Western Pond Turtle	0	2	0	0	0	2
Cottus alueticus	Coast Sculpin	1	0	0	12	1	0
Cottus asper	Prickly Sculpin	0	0	0	1	0	0
Dicamptodon ensatus	Pacific Giant Salamander	1	1	28	2	11	4
Ensatina sp.	Ensatina	0	0	1	0	1	0
Gasterosteus aculeatus	Three-Spined Stickleback	0	3	0	30	0	2
Lampetra tridentata	Pacific Lamprey	16	103	14	47	0	32
Pituophis melanoleucus	Gopher Snake	0	0	1	0	0	0
Rana boylii	Foothill Yellow-Legged Frog	4	14	10	6	13	48
Taricha granulosa	Rough-Skinned Newt	0	2	0	0	1	2
Taricha rivularis	Red-Bellied Newt	1	0	1	6	0	0
Taricha torosa	California Newt	0	0	1	0	0	0
Thamnophis species	Garter Snake	1	0	1	0	0	0
Oncorhynchus mykiss	Steelhead	1930	2293	5217	6504	84	461
Oncorhynchus kisutch	Coho Salmon	25	1182	154	716	260	745
Oncorhynchus tshawytscha	Chinook Salmon	1714	117	0	2928	0	684
Species Diversity **H'**		***0.33***	***0.4***	***0.09***	***0.39***	***0.35***	***0.58***

Table 5. Estimated number of steelhead per meter and 95% confidence limits in eight reaches in the upper Noyo River during 2003.

Stream	Segment	Length (km)	Estimated Number/m											
			< 50 mm			51-70 mm			71-120 mm			> 120 mm		
			Low 95%	Estimate	High 95%	Low 95%	Estimate	High 95%	Low 95%	Estimate	High 95%	Low 95%	Estimate	High 95%
Hayworth Creek	Above Confulence	5.5	1.54	3.98	22.85	0.11	0.21	0.84	0.05	0.09	0.37	0.01	0.02	0.09
Noyo River	Above Redwood Cr.	4.9	1.45	3.15	12.74	0.16	0.35	1.43	0.09	0.19	0.69	0.02	0.02	0.02
Noyo River	Olds Cr. To Redwood Cr.	1.6	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Noyo River	Northspur to Olds Cr.	5.0	0.87	2.37	13.32	0.04	0.11	0.75	0.03	0.05	0.18	0.02	0.05	0.38
North Fork Noyo	Above Hayworth Cr.	5.0	1.87	3.51	12.16	0.05	0.18	2.89	0.08	0.27	2.72	0.04	0.08	0.32
North Fork Noyo	Northspur to Hayworth Cr.	6.2	1.09	4.40	43.64	0.07	0.29	2.86	0.05	0.15	1.01	0.03	0.08	1.12
Olds Creek	Above Confulence	3.5	0.60	1.88	38.68	0.03	0.14	2.79	0.02	0.09	1.86	0.01	0.07	1.39
Redwood Creek	Above Confulence	5.1	0.81	1.62	7.55	0.02	0.07	0.96	0.04	0.13	0.41	0.02	0.05	0.19

Table 6. Estimated number of coho salmon per meter and 95% confidence limits in eight reaches in the upper Noyo River during 2003.

Stream	Segment	Length (km)	< 80 mm			> 80 mm		
			Low 95%	Estimate	High 95%	Low 95%	Estimate	High 95%
Hayworth Creek	Above Confulence	5.5	0.00	0.00	0.00	0.00	0.00	0.00
Noyo River	Above Redwood Cr.	4.9	0.52	3.09	73.62	0.00	0.00	0.00
Noyo River	Olds Cr. To Redwood Cr.	1.6	0.64	1.91	28.77	0.01	0.02	0.40
Noyo River	Northspur to Olds Cr.	5.0	0.37	0.95	11.33	0.01	0.01	0.05
North Fork Noyo	Above Hayworth Cr.	5.0	0.16	0.83	15.16	0.05	0.18	2.19
North Fork Noyo	Northspur to Hayworth Cr.	6.2	nd	nd	nd	nd	nd	nd
Olds Creek	Above Confulence	3.5	0.82	3.07	55.50	0.01	0.04	0.70
Redwood Creek	Above Confulence	5.1	0.94	2.76	50.04	0.01	0.06	0.68

Table 7. Jolly-Seber based survival estimates for steelhead and coho salmon from electro-fishing reaches in the Noyo River during 2003.

Site	Steelhead								Coho	
	YOY		Y +		Y + +		All		Y+	
	Estimate	95%Ci	Estimate	95%Ci	Estimate	95%Ci	Estimate	95%Ci	Estimate	95%Ci
Hayworth Creek	0.53	0.47	0.66	0.44	-	-	0.44	0.64	-	-
Northfork Above Hayworth Creek	-	-	0.38	0.33	0.61	0.49	1.00	0.27	1.00	0.29
Northfork Below Hayworth Creek	-	-	0.25	0.55	0.67	0.33	0.26	0.63	-	-
Olds Creek	-	-	-	-	0.66	0.33	0.33	0.61	0.73	0.27
Redwood Creek Above Trap	-	-	0.96	0.41	1.00	0.71	1.00	0.71	0.71	0.29
Redwood Creek Below Trap	0.20	0.08	1.00	0.17	0.60	0.40	0.93	0.14	0.66	0.44
Noyo Above Redwood Creeek	-	-	1.00	1.00	0.57	0.37	1.00	1.00	0.23	0.77
Noyo Redwood to Olds Creek	-	-	-	-	-	-	0.33	0.94	-	-
Noyo Northspur to Olds Creek	-	-	0.40	0.60	-	-	0.20	0.50	-	-
Average	0.38	0.53	0.46	0.54	0.47	0.51	0.46	0.56	0.40	0.51
SE	0.14	0.08	0.09	0.08	0.07	0.05	0.06	0.06	0.09	0.06

Note: YOY are fish < 70 mm for steelhead and < 80 mm for coho salmon (i.e. fish born in 2003). Y+ are steelhead between 70 and 120 mm and coho salmon > 80 mm (fish born the previous spring). Y++ steelhead are assumed to be > 120 mm fork length.

Table 8. Steelhead and coho salmon survival estimates from trap and electro-fishing population estimates 2000 to 2003.

Species	Life-Stage	Proportion Surviving Average	n	S.E.	Range
Steelhead	YOY-Y+	0.09	23	0.03	0.003-0.47
Steelhead	YOY-Y+ +	0.06	12	0.03	0.002-0.30
Steelhead	Y+ -Y+ +	0.35	12	0.05	0.14-0.61
Coho Salmon	YOY-Y+	0.12	12	0.04	0.004-0.42
Coho Salmon	YOY-Adult	0.01	2	0.005	0.006-0.017
Coho Salmon	Y+-Adult	0.06	25	0.01	0.002-0.29

Note: YOY are fish < 70 mm for steelhead and < 80 mm for coho salmon (i.e. fish born during 2002). Y+ are steelhead between 70 and 120 mm and coho salmon > 80 mm (fish born in the previous spring). Y++ are steelhead > 120 mm fork length. Data include estimates of from Caspar and Hare Creeks, the Little River, and the South Fork above the ECS and the North Fork South Fork Noyo River from Harris and Knechtle (2003).