

**Results of the 2000 Steelhead (*Oncorhynchus mykiss*) Fyke Trapping
and Stream Resident Population Estimations and
Predictions for the Noyo River, California with
Comparison to Some Historic Information**



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Cover Photograph: Steelhead juvenile approximately 75 mm captured at the North Spur trap in mid-May 2000.
Note: Freeze brand below dorsal fin.

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Results of the 2000 Steelhead (*Oncorhynchus mykiss*) Fyke Trapping and Stream Resident Population Estimations and Predictions for the Noyo River, California with Comparison to Some Historic Information

Prepared By

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Abstract

Downstream movement fyke trapping and over-summer resident population studies in the Noyo River were conducted during spring and summer 2000 to estimate juvenile and young-of-the-year (YOY) steelhead (*Oncorhynchus mykiss*) and coho (*Oncorhynchus kisutch*) population abundance, size, age, survival, migration timing, and distribution. Information was collected on all species found in the river and a simple population model was developed to predict YOY steelhead populations based on adult female estimates from spawning surveys. Juvenile habitat quality from historic stream surveys was compared to habitat use during 2000. Six traps were placed in the Noyo River above North Spur in April and checked daily until 1 August 2000. All steelhead and most coho > 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. Population estimates were computed using a maximum-likelihood 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 four times between May and August 2000. All steelhead and coho > 50 mm were marked with site and time specific freeze brands and released. Fish < 50 mm were counted and released. Population estimates were computed using the Jolly-Seber method for each reach and expanded to estimate stream resident populations. Steelhead populations were estimated by summing the trap and stream estimates. Steelhead YOY populations were predicted using the number and size of females estimated from spawning surveys and a length/fecundity relationship to estimate the number of eggs in each stream reach. An estimate of 80% survival from egg to fry was used to calculate the number of fry expected in each stream reach and stream specific estimated probability of survival from Jolly-Seber population estimates was used to predict the number of YOY present in August. Migrating steelhead population estimates ranged from 41,821 (95% CI = 6,126) for the summation of individual traps to 61,977 (95% CI = 13,241) for the two trap method. Coho population estimates ranged from 976 (95% CI = 1,407) for the two trap method to 3,812 (95% CI = 1,814) for the summation of individual traps. The summation of individual traps and the two trap population estimates were not significantly different ($t = 0.11$, $p = 0.91$, $n = 5$). Capture probabilities were significantly higher for coho ($t = -2.59$, $p = 0.027$, $n = 5$). Coho and steelhead catch and capture probabilities were significantly positively correlated with stream flow and negatively correlated with water temperature. Rearing steelhead populations ranged from 0.65 to 3.22/m. On average 19.6% of the estimated steelhead YOY population and 70.8% of the year plus population did not migrate during the study. Survival of YOY steelhead ranged from 0.34 to 1.0. Survival estimates for year plus steelhead were > 1.0 due to low recapture numbers. Year plus steelhead and coho migrated earlier in the year while YOY steelhead moved throughout the study period. Estimated and predicted YOY steelhead populations were not significantly different adding confidence to the population model and spawning survey estimates of adult females. Current juvenile habitat use was slightly higher than historic information in the upper Noyo River. The steelhead population model developed for the Noyo River during 2000 may be applicable to other rivers. Downstream movement and resident population monitoring should continue in the Noyo River to follow populations through successive life stages which may allow for detection of population bottle necks and point towards solutions if they exist.

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Introduction

Many populations of salmonids in California are considered at risk of extinction and are listed or are proposed for listing under the Federal Endangered Species Act (ESA) (Higgins et al. 1992, Nehlsen et al. 1991, Federal Register 1996, Huntington et al. 1996, Federal Register 2000). In response to the 1996 proposed ESA listing of steelhead (*Oncorhynchus mykiss*), the State of California Department of Fish and Game (CDFG) entered a Memorandum of Agreement (MOA) with the National Marine Fisheries Service (NMFS) in 1998 to provide improved conservation and management of North Coast steelhead (Federal Register 2000). The MOA, in part, commits CDFG to develop and implement a program directed at monitoring, evaluating, and adaptive management of North Coast (Northern California Evolutionary Significant Unit-ESU) steelhead. Since 1998 CDFG has taken significant steps to implement and expand their steelhead monitoring program (Federal Register 2000) including implementation of SB 271, changes in harvest regulations and hatchery practices, and development of the North Coast Steelhead Research and Monitoring Program (S-RAMP). The implementation of S-RAMP began in July 1999. However, in June 2000 NMFS formally listed northern California ESU steelhead as Threatened Species under the ESA (Federal Register 2000). The listing, by in large, is due to the failure of the California Board of Forestry to change timber harvest regulations.

Little current 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 populations (McEwan and Jackson 1996). The Eel River is the only stream in the northern California ESU for which recent estimates of winter-run steelhead exist (CDFG 1998). 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 its 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 estimates of juvenile abundance combined with estimates of adult abundance and studies of the relationship between juvenile and adult abundance (Prager et al. 1999). Including information on life stage-specific survival may help assess population bottlenecks.

Existing young-of-the-year (YOY) and juvenile steelhead emigration information for coastal Mendocino County is limited to eight local rivers and streams and was generally collected to monitor coho emigration and rearing or examine enhancement programs. Harris and Hendrix (2000) describe emigration trapping for Caspar, Hare, and Wages creeks and the Little and South Fork Noyo rivers. Trapping has occurred annually since 1987 on Caspar Creek and Little River and since 1998 for Wages and Hare creeks and the South Fork Noyo River. Two traps have been operated in the South Fork Noyo River since 1998. One is located in the South Fork above the Egg Collecting Station (ECS) and the other is on the North Fork South Fork just above the confluence (Harris and Hendrix 2000). These traps were generally operated from mid-March through June. During 1997-98 the South Fork trap was operated from October through June to examine juvenile migration during the fall and winter (Harris 1998). Before 2000 out-migrant data was only reported as total captured (Harris 1997, 1998, 1999a). In 2000, a mark-recapture program was used to estimate the population of coho and steelhead moving past traps (Harris and Hendrix 2000). Maahs (1995) conducted out-migration trapping on the Little North Fork Noyo River, Salmon Creek, and the South Fork Ten Mile to determine the number of fish going to the ocean. These traps were operated from late-April to June. Maahs (1996) conducted out-migration trapping on the Little North Fork Noyo and the South Fork Ten Mile rivers from early-March to mid-June 1996 to determine the number of fish going to the ocean, examine production associated with a propagation effort on the Ten Mile River, and assist with a study examining habitat factors potentially limiting coho production (Manning 1998). Maahs (1997) conducted out-migration trapping in the South Fork Ten Mile River from March to May 1997 to enumerate coho and steelhead emigrants and examine trap mortality due to sculpin predation.

Existing over-summer resident assessment is limited to five stations on three coastal Mendocino County streams which have been electro-fished annually since 1986 (Harris 1999b). Caspar Creek and Little River

have two electro-fishing stations and Pudding Creek has one station. The purpose of these surveys was to determine the abundance, distribution, and trends in residing coho and steelhead populations. Steelhead were found in all streams and Harris (1999b) states that steelhead populations were 10% of the 1988 estimate in 1999.

In general, the above studies report estimates of fish numbers without error estimates. Krebs (1989) states that a basic rule of descriptive statistics is to never report an ecological estimate without some measure of the possible error. There are numerous methods to estimate emigration and over-summer populations of salmonids. Manning (1998) used the Peterson mark-recapture method to estimate emigration and a modified Hankin and Reeves (1988) approach to estimate over-summer populations in the Little North Fork Noyo River. The Peterson method assumes, among other things, that the population is closed (i.e. no migration or emigration) which is clearly not the case for smelting salmonids. Darroch (1961) introduced a maximum-likelihood estimate for stratified populations, similar to the Jolly-Seber method (Krebs 1989), where stratification attempts to overcome problems with other methodologies due to non-random mixing and variable catchability (Dempson and Stansbury 1991). The Darroch (1961) method was used by (Dempson and Stansbury 1991) to estimate Atlantic salmon smolt populations using a two trap stratified mark-recapture design. They had a 20% recapture rate and population confidence levels of < 8%. Thedinga et al. (1994) used a two trap mark-recapture program to estimate salmonid smolt populations in Alaska using trap efficiencies and shot term survival estimates to determine population sizes and calculated variance in population levels using bootstrap techniques. A software program using the Darroch (1961) method for estimating emigrating populations and trap efficiencies in small populations is under development (Darr, E. Bjorksted Pers. Comm.). Over summer populations can be estimated, including estimates of error, using a variety of methods including removal, mark-recapture, and stratified snorkeling combined 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 2000 fyke trapping and over-summer population surveys in the Noyo River was to quantitatively estimate juvenile and YOY steelhead populations, abundance, size, age, survival, migration timing and distribution, and evaluate the utility and efficiency of trapping and electro-fishing for this purpose. In addition, information was collected to estimate similar parameters for coho populations in the Noyo River. Information was collected on all species found in the river during these studies. A simple population model was developed to predict YOY steelhead populations from adult female estimates from spawning surveys.

Study Area

The Noyo River watershed (Fig. 1) is a forested, coastal watershed in Mendocino County, California, which drains approximately 260 km² 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 the ability of trapping and electro-fishing to produce these metrics. The Noyo River was chosen because, 1) a significant proportion of the watershed is in Jackson State Demonstration Forest, 2) the remainder of the watershed is primarily owned by two timber companies, 3) CDFG operates the Noyo River ECS on the South Fork Noyo River, 4) CDFG has conducted coho studies on the South Fork Noyo since 1986, and 5) CDFG has implemented many different types of habitat improvement projects in the South Fork Noyo River for many years. In addition, the Noyo River watershed is subject to several recent changes in management including no harvest of wild adult steelhead, no artificial propagation of steelhead, and different land uses due to different landowner ownership.

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 land owners in the basin include the Mendocino Redwood Company (the upper watershed) and The Campbell Group (along the main stem).

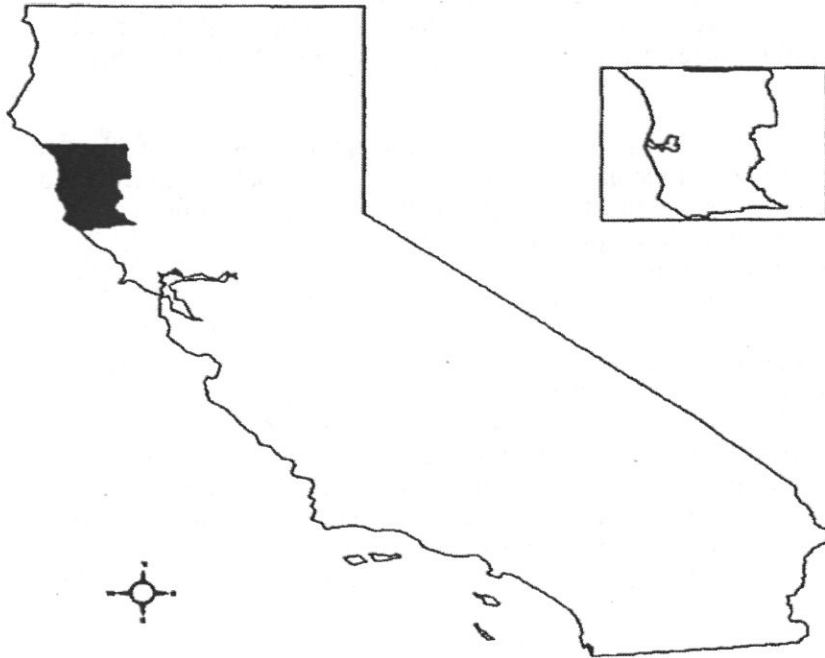


Fig. 1 Location of the Noyo River watershed and Mendocino County in California.

Study Sites

Fyke Trapping

Six fyke net trapping sites were selected in the upper Noyo River to enumerate steelhead and other species populations, determine some population variables, and test trapping methods during 2000 (Fig. 2). Trap sites were selected based on access, ability to properly set the traps, and located close to the confluence of the stream of interest. Traps were placed in Hayworth Creek (HWC), the mainstem Noyo above Redwood Creek (MSN), in the North Fork Noyo River above the confluence of Hayworth Creek (NFN), in the Noyo River at North Spur below the North Fork confluence (NRS), in Olds Creek (OLD), and in Redwood Creek (RWC) (Fig. 2). Two traps were operated by CDFG (Harris and Hendrix, 2000) in the South Fork Noyo River during 2000. One trap was located in the South Fork above the ECS the other was located in the North Fork South Fork (Fig. 2).

Resident Population Estimates

To examine differences in fish size, age, and condition between trap catches and instream residents and determine delayed emigration above and below traps, estimate survival, and estimate stream resident populations 100 m sections of stream above and below each trap were electro-fished periodically during spring and summer 2000. Each 100 m section began 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 downstream section of the MSN/RWC site was a 100 m section in the Noyo River below the confluence of these two streams. The upstream section for NRS was in the Noyo River above the NFN confluence. At OLD two downstream sections were shocked. One in OLD the other was in the Noyo River below the OLD confluence.

Methods and Materials

Fyke Trapping

In general the methods employed by Harris and Hendrix (2000) were followed for this study. The top of a 3.05 x 1.22 x 1.19 m fyke net (5 mm mesh) was set in the head of a riffle with the downstream end connected to a 3.05 m long 20 cm diameter pipe with a 3 mm mesh live car set in the riffle tail. Each trap had one to four 2.44 x 1.22 m (6 mm mesh) weir panels set diagonally into the mouth of the net to funnel fish into the traps. Wood panels and boulder walls were placed along the weir panels during periods of low flow to increase water velocity into the traps. Debris screens were set above the opening of each trap and a 0.5 to 1 m section of stream on one side of the trap weir was left unblocked to allow adult fish to bypass the traps.

Traps were set in HWC, NFN, MSN, and RWC on 5 April 2000. The OLD and NRS traps were put in place on 17 April 2000. All traps were checked daily through 1 August 2000. The trap checking procedures differed from Harris and Hendrix (2000) in that 30 fish of each species and size class were measured to fork length each day. 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 Gallagher (1999) and released upstream of the traps. Fish of each species and size more than the 30 measured were counted each day. Due to confusion about ESA section 10 permitting, coho were not consistently marked throughout the trapping period. 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 some recaptured steelhead. All mortalities were recorded by species and size class. Water and air temperatures and general weather information were recorded daily for each trap.

Mark Retention and Survival

To estimate mark retention and survival 17 steelhead > 50 mm were collected from a section of the Noyo River below the MSN trap on 17 May 2000 by electro-fishing, freeze branded, and held for 10 days in a live car. The live car was placed in an area of 1/2 high flow and 1/2 low flow behind a stump to allow food into the cage and also give fish a low velocity area in which to rest.

Stream Flow and Temperature

Water temperature was measured daily while processing fish at each trap site. Continuous digital temperature recorders were placed at the trap sites on 5 May. Temperature recorders were set to record water temperature every hour. Daily water temperatures prior to 5 May were combined with daily average water temperature for analysis.

Staff gauges were attached to fence posts and placed in areas of relatively level stream flow at each trap site on 25 April. Gauge heights were recorded while checking the traps each day. Stream flows at each site were measured 4 times between 25 April and 10 October. Stream flows and staff gauge heights were used to create a stream flow rating curve for each site following the methods outlined by Bovee (1996). To determine stream flows at each site prior to 25 April the percentage of flow at each site on 25 April was calculated relative to the total stream flow from USGS gauge # 11468500 located about 1 km below the South Fork confluence. The percentage of flow from each stream was multiplied by daily stream flows at USGS gauge # 11468500 to estimate the stream flow for each creek prior to 25 April 2000. Stream flows for each site after 25 April were estimated using stage-discharge regressions used to develop the rating curves for each site.

Resident Population Estimates

To examine differences in fish size, age, and condition between trap catches and instream residents and determine 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 2000. In general one person operated the electro-fisher (Smith-Root model 12-B set at 1-5 and 300 volts) accompanied by two persons with dip nets. All crew members used polarized glasses to help increase detection of fish. 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 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 was intended to occur bi-weekly beginning in late-May. Logistics and time constraints made it possible to sample each site four times between June and August.

Historic and Current Comparisons

Information on steelhead and coho rearing habitat, condition, and density was gleaned from stream habitat surveys conducted throughout the Noyo River by CDFG during 1957, 1959, and 1967 (Appendix A). These surveys were generally conducted during the summer months and only contain comments on steelhead and coho rearing habitat and condition. Surveys during 1967 present fish density and estimates of stream production. From general statements in these reports a stream rearing habitat rating (Table 1) was developed for each stream or stream segment which had been surveyed each year.

Table 1. Juvenile rearing habitat use and habitat descriptions from 1957 and 1959 stream surveys and the number of fish per meter from 1967 and 2000 population estimates used to compare habitat over these years.

Habitat Descriptors 1957-67	Fish/ Linear Meter	Rating
No Data	-	0
Excellent, Very Abundant, Very Numerous	>3.69	1
Important, Good, Good Potential	2.47-3.69	2
Common, Fairly Abundant, Fairly Numerous, Fair	1.24-2.46	3
Minor, Not Abundant, Not Numerous, Not Good,	<1.23	4
Questionable, Scarce, Unimportant, Value Doubtful		
None, None Spotted	0	5

The number of steelhead/m of stream from electro-fishing during 2000 was used to develop a rating system of rearing habitat use from the 2000 electro-fishing similar to that for the historic information (Table 1). The difference between the highest and lowest number of steelhead/m observed was divided into four classifications of habitat use. This data was compared graphically with the historic data to examine trends.

Data Analysis

To estimate steelhead and coho > 50 mm populations, capture probabilities, and timing for each trap I initially totaled all captures and recaptures by week to create capture-recapture matrices for input to Darr (E. Bjorkstedt, Pers. Comm.). These matrices were then ran in Darr to produce population estimates and capture probabilities. I calculated weekly totals of steelhead and coho < 50 mm from the daily catch data. 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 potentially a selective and nonrandom collection method (Brower and Zar 1984).

To estimate steelhead YOY populations I examined weekly fork length frequencies (Appendix B) to estimate the separation point in fish size between YOY and older fish. In general, steelhead < 70 mm were assumed to be young of the year (D. Wright Pers. Comm, Appendix B). I then examined weekly captures and recaptures and split out YOY sized fish to develop Darr input matrices by size/age. These matrices were ran in Darr to estimate year plus steelhead populations, capture probabilities, and timing for each trap. Similarly, I developed and ran matrices for each trap for marked and recaptured YOY size fish. The YOY trap population estimates were combined with the total count of steelhead < 50 mm to estimate the total YOY population for each trap. In cases (RWC) where too few YOY or year plus steelhead were marked and recaptured to make separate population estimates I used the percentage of YOY > 50 mm plus the total YOY count to get a total population estimate. Confidence intervals for steelhead < 50 mm were estimated by multiplying the proportion of the confidence estimate divided by the population estimate for YOY > 50mm from the Darr analysis. 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 class using a two trap method. 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 captured and recaptured at NRS were treated as captured and 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.

Relationships between average weekly temperature and stream flow and weekly capture probabilities were examined using Spearman rank correlation. Relationships between daily trap catches and daily stream flow and temperature were examined using Spearman rank correlation.

Condition factor for trap captured and resident fish were calculated following methods outline in Moore (1997). Differences between trap and resident fork lengths and condition factors were compared using Mann-Whitney U-tests. Differences between the one and two trap population estimation methods were examined with t-tests.

Steelhead population and survival estimates at all electro-fishing sites were estimated using the Jolly-Seber method in the program Jolly (Krebs 1989). In cases where enough YOY > 50 mm were marked and recaptured population estimates were made separately for YOY (51-70 mm) and year plus steelhead (> 70 mm). In cases where too 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 between 51-70 mm. This was added to counts of steelhead < 50 mm to estimate total YOY and year plus populations in each 100 m reach. 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 2000). Population estimates in the Noyo River between OLD and NRS used the average density of the below OLD and above NRS multiplied by the stream distance represented by the two.

Young of the Year Population Estimation and Prediction

YOY populations were estimated for each stream reach by summing the individual trap and stream reach population estimates. To estimate the total population all trap estimates were pooled with stream resident population estimates by stream reach. The total YOY population was the sum of the individual trap and stream combinations. To estimate the total population with the two trap, the all trap population estimates were pooled with the stream estimates. The below NRS population estimate was not included in this analysis. Confidence levels were the sum of the individual confidence levels.

To calculate the predicted number of YOY the number of adults in each stream segment above each trap, the proportion of female to males, and the average size of a female steelhead during 2000 estimated by Gallagher (2000) was used to estimate the size and number of females in each reach. Length/fecundity relationship developed by Shapovalov and Taft (1954) was used to estimate the number of eggs per female and the total expected number of eggs in each stream reach. The data presented in Shapovalov and Taft (1954, Fig. 27) was reanalyzed to produce confidence estimates around their regression. This resulted in an estimate of the 95% confidence level of 9.67 eggs/cm of female size. This relationship was used to estimate the 95% confidence level for total egg production in each stream. An estimate of 80% survival from egg to fry (20% mortality in a non-silted stream) from Shapovalov and Taft (1954) was used to calculate the number of fry expected in each stream reach. The estimated probability of survival from Jolly-Seber estimates based the electro-fishing this season (Table 2) was used to estimate the number of YOY present in August. In two cases (OLD, RWC) the number of marked-recaptured fish was such that the survival estimates were not reliable. For these creeks the average survival (0.623) from all other sites was used.

Predicted and estimated population estimates were compared using Mann-Whitney U-tests or t-tests when standard kurtosis p-values were > 0.05. Statistical significance was accepted at the 0.05 probability level.

Table 2. Probability of survival from Jolly-Seber mark-recapture electro-fishing population estimates in the Noyo River during 2000.

Stream	Segment	<70mm			>70mm		
		Probability of Survival			Probability of Survival		
		Low 95%	Estimate	High 95%	Low 95%	Estimate	High 95%
Hayworth Cr.	Above Confluence	0.372	0.689	1.255	0.91	3.09	10.71
Mainstem Noyo	Above Redwood Cr.	0.155	0.34	0.76	0.155	0.34	8.76
Mainstem Noyo	Northspur to Olds Cr.	0.4	1	2.59	0.708	2.09	5.3
Mainstem Noyo	Olds Cr. to Redwood Cr.	0.247	0.589	1.402	0.199	0.479	1.136
North Pork Noyo	Above Hayworth Cr	0.245	0.791	2.655	0.47	1.69	6.41
North Fork Noyo	Northspur to Hayworth Cr.	0.182	0.442	1.066	0.589	0.97	1.443
Olds Cr.	Above Confluence	0.81	2.48	6.96	0.625	1.45	2.68
Redwood Cr.	Above Confluence	1.45	9.48	655.1	2.3	15.5	103.3

Results

Fyke Trapping

The total number of steelhead captured by size class for each trap, the total in all traps, and for the two trap estimate are shown in Table 3. Darr input matrices summarizing weekly captures are shown in Appendix C. Population estimates and 95 % confidence intervals for steelhead 51-70 mm, > 70 mm and all > 50 mm are shown in Table 3. Larger streams or streams with larger drainage areas had higher estimated populations. Confidence levels ranged from 22 to 71 % of the estimated population for steelhead between 51-70 mm and averaged 18.3%. The average confidence level for steelhead > 70 mm was 33.3% of the estimated population and ranged from 12 to 100%. Generally those traps with higher numbers of recaptures had lower confidence bounds. The NRS site (Fig. 2) is below the other five sites and captured fish were produced above and below these sites. Capture probability for steelhead > 50 mm ranged from 0.05 to 0.18 with an average of 0.13 (Table 3). Capture probabilities for steelhead 51-70 mm ranged from 0.03 to 0.14 with an average of 0.10. Capture probabilities for steelhead > 70 mm ranged from 0.13 to 0.19 with an average of 0.16. Treating the different size classes as individual samples the one and two trap estimates are not significantly different (Fig. 3, Table 3, $t = 0.11, p = 0.91, n = 4$). Population estimates for the two trap method were higher while the total count of steelhead < 50 mm was lower (Fig. 3, Table 3). The average of individual trap capture probabilities for each size class was higher than for the two trap method (Table 3). Confidence levels from the two trap method were lower for fish > 70 and all fish > 50 estimates than for individual traps combined. A total of 154,823 (95% CI including the % estimate for < 50 mm = 59,004) YOY and 18,862 (95% CI = 3,259) year plus steelhead were estimated in the Noyo River above North Spur by totaling all traps. A total of 116,775 (95% CI including the % estimate for < 50 mm = 39,295) YOY and 24,484 (95% CI = 2,231) year plus steelhead were estimated in the Noyo River above North Spur by the two trap method (Fig. 3, Table 3).

Weekly trap captures, population estimates, capture probability for marked size steelhead YOY (generally 51-70 mm, Appendix B) for individual traps are shown in Fig. 4. Weekly capture probabilities ranged from 0.01 to 0.45 for YOY steelhead. Weekly trap captures, population estimates, capture probability for marked size year plus steelhead (generally > 70mm, Appendix B) for individual traps are shown in Fig. 5. Weekly capture probabilities ranged from 0.02 to 1.0 for year plus steelhead. Weekly trap captures, population estimates, and capture probability from the two trap estimation for marked size YOY and year plus steelhead are shown in Fig. 6. Weekly captures and population estimates were generally higher for year plus steelhead early in the year while marked YOY population estimates were higher later in the season. The percentage of each size/age class (YOY are < 50 mm and 51-70 mm, Appendix B) captured for each trap are shown in Fig. 7. Fry (< 50 mm) and year plus steelhead were captured early in the year while YOY 51-70 mm were captured later in the year (Fig. 7).

The total number of coho captured by size class for each trap, totals for all traps, and for the two trap estimate are shown in Table 4. Population estimates and 95 % confidence intervals for coho > 50 mm are shown in Table 4. No migrating coho were captured in Olds Creek. Hayworth Creek and the MSN had the highest individual coho population estimates (Table 4). Capture probabilities for coho ranged from 0.17 to 0.83. The average individual trap capture probability was 0.40. Capture probability was significantly higher for coho than for steelhead (Tables 3-4, $t = -2.59, p = 0.027$). The total coho population > 50 mm was estimated as 3812 (95% CI = 1814) by combining individual trap estimates and 976 (95%CI = 1407) for the two trap method (Table 4, Fig. 8). Contrary to steelhead estimates the combined one trap estimate was much higher than the two trap estimate (Fig. 8, Table 4). Including coho in comparison of the one and two trap estimates and treating each size class as a sample, there was no significant difference between the estimates (Figs. 3 and 8, $t = 0.11, p = 0.91, n = 5$).

Table 3. Number of juvenile steelhead captured, population estimates (N), and capture probability for six fyke traps, the total of all traps, and the total for the two trap mark-recapture method by size class in the Noyo River during 2000. Numbers in parentheses are 95% CIs. Asterisk indicates total count only.

Stream Site	< 50mm*			51-70mm			>70mm			Total >50mm		
	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability	Total Captured	N	Capture Probability	Total Captured	N	
Hayworth Creek	15438	7532	0.14	220	2230	0.16	766	7410				
Mainstem Noyo	18637	2321 (2935)	0.09	531	7016 (1792)	0.13	730	10315 (2234)				
North Fork Noyo	19045	1187	0.13	701	3002	0.18	836	4401				
Noyo at North Spur	61222	10119 (3701)	0.1	968	5960 (696)	0.15	1450	16431 (3807)				
Olds Creek	11115	1315 (942)	0.05	73	654 (148)	0.19	128	1870 (858)				
Redwood Creek	6892	nd	nd	34	nd	nd	39	1394 (1372)				
Total 1 Estimates	132349	22474 (4861)	-	2527	18862 (3259)	-	3949	41821 (6162)				
Two Trap Estimate	71127	45648 (13250)	0.03	1608	24484 (2231)	0.07	2546	61977 (13241)				

Table 4. Number of coho captured, population estimates (N), and capture probabilities for six traps, the total of all traps, and the two trap mark-recapture method in the Noyo River during 2000. Numbers in parentheses are 95% CI's. Asterisk indicates total count only.

Stream Site	<50mm	Total>50mm		
		Total Captured	N	Capture Probability
Hayworth Creek	11	169	224 (40)	0.13
Mainstem Noyo	2	118	2051 (1399)	0.27
North Fork Noyo	0	8	16 (11)	0.5
Noyo at North Spur	70	610	1263 (3238)	0.37
Olds Creek	0	0	-	-
Redwood Creek	0	43	251 (235)	0.17
Total 1 Estimates	13	948	3812 (1814)	
Two Trap Estimates	13	338	976 (1407)	0.24

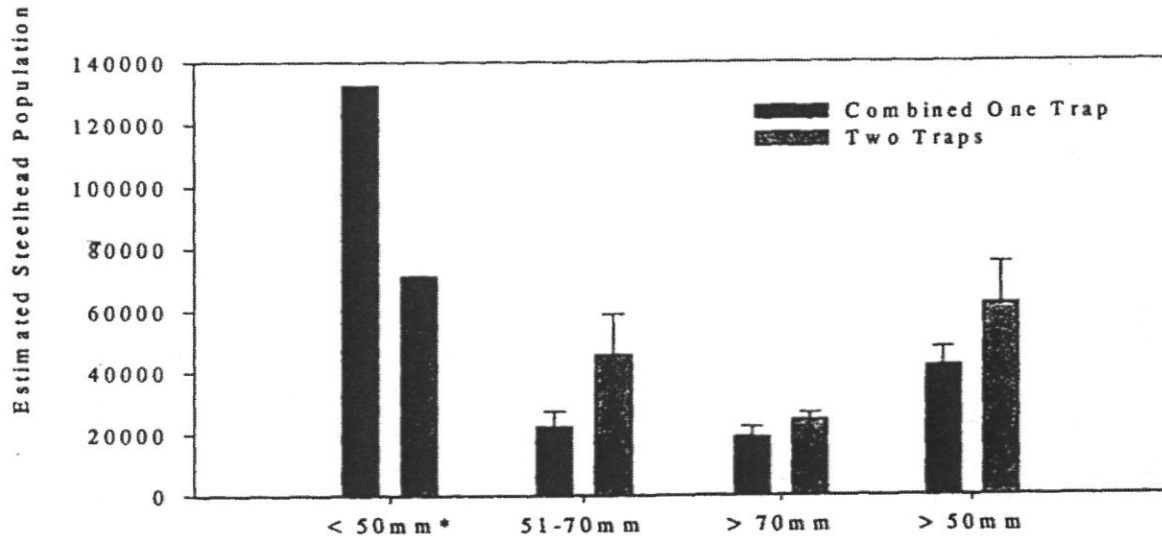


Fig. 3. Estimated steelhead population estimates from the total of six individual traps and the two trap mark-recapture method. Thin bars are 95% confidence levels. * Total count only.

Weekly trap captures, population estimates, capture probability for coho > 50 mm for each trap are shown in Fig. 9. Weekly capture probabilities ranged from 0.10 to 0.8 for coho (Fig. 9.) Weekly trap captures, population estimates, capture probability from the two trap estimation for coho > 50 mm are shown in Fig. 10. Weekly trap capture probabilities from the two trap estimation ranged from 0.18 to 0.44. Coho were generally captured during late-winter and early spring. The percentage of each size/age class (YOY are assumed to range from < 50 mm to around 90 mm) captured for each trap are shown in Fig. 11. Coho were most frequently captured early in the year (Fig. 11). Larger, assumed to be one year old coho, were not caught after week 22.

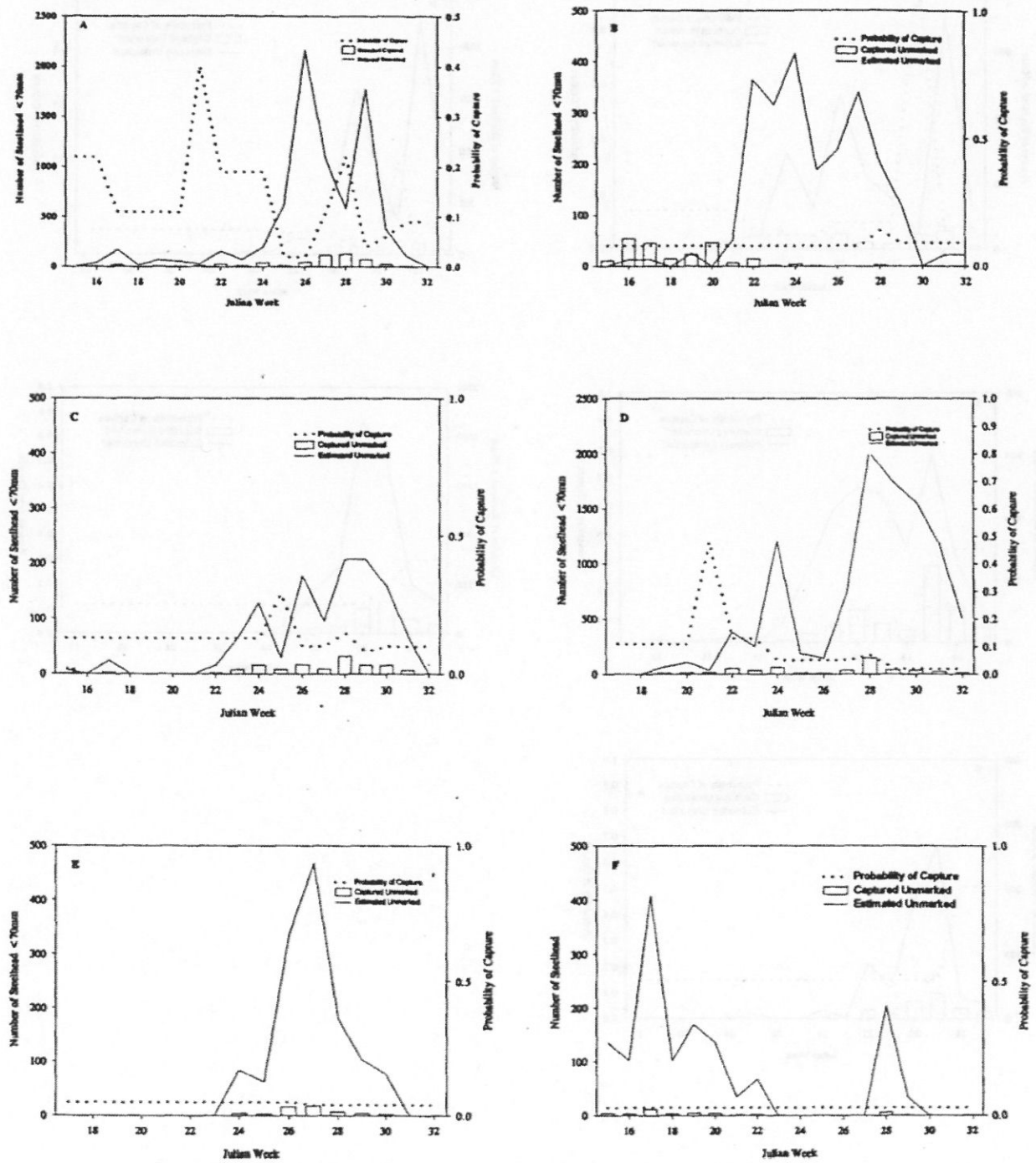


Fig. 4. Weekly population estimates, total captures, and probability of capture for marked size steelhead YOY (generally 51-70 mm, see Appendix B). A. HWC. B. MSN. C. NFN. D. NRS. E. OLD. E.RWC (>50 mm)

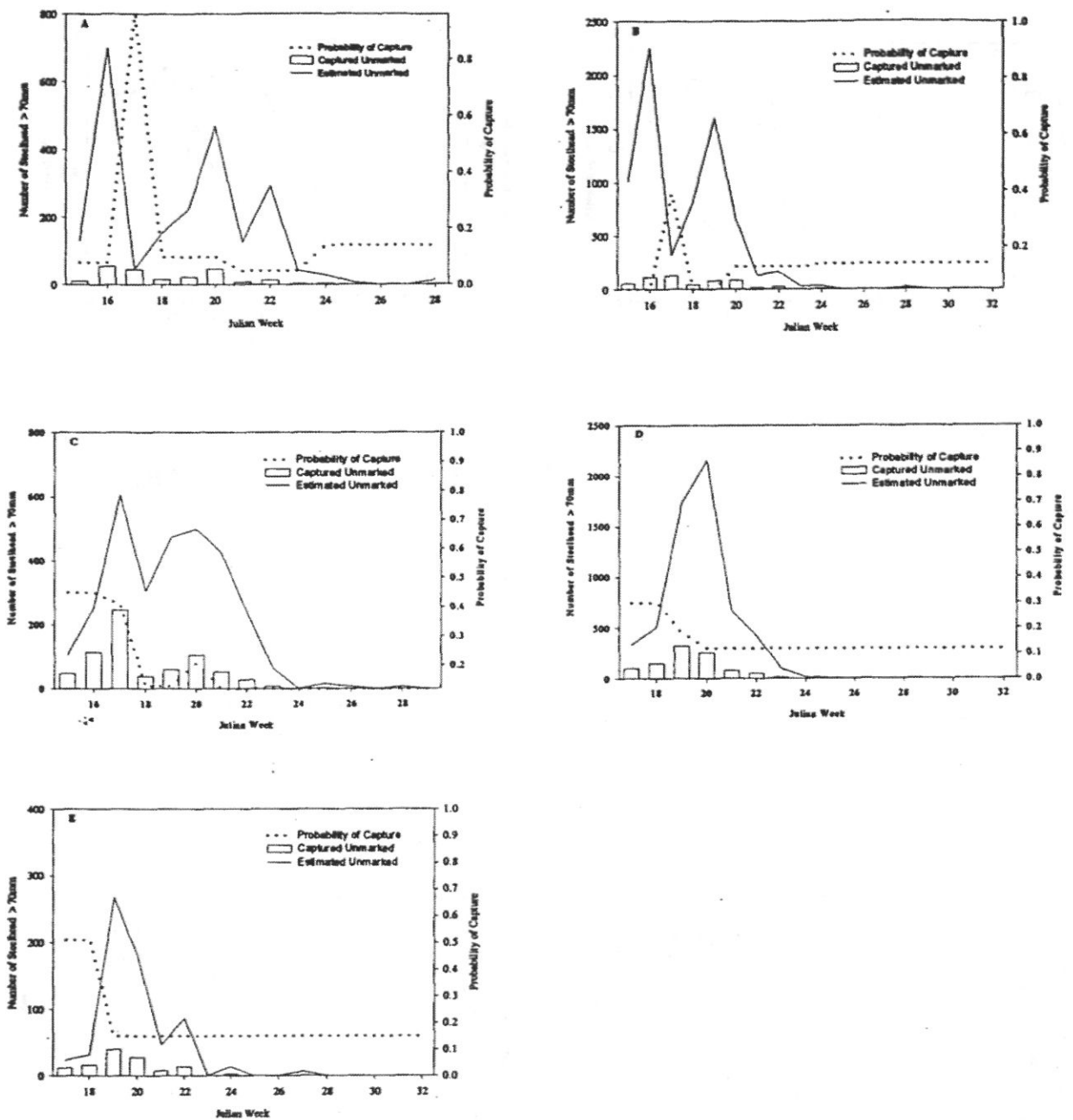


Fig. 5. Weekly population estimates, total captures, and probability of capture for year plus steelhead (generally > 70 mm, see Appendix A). A. HWC. B. MSN. C. NFN. D. NRS. E. OLD.

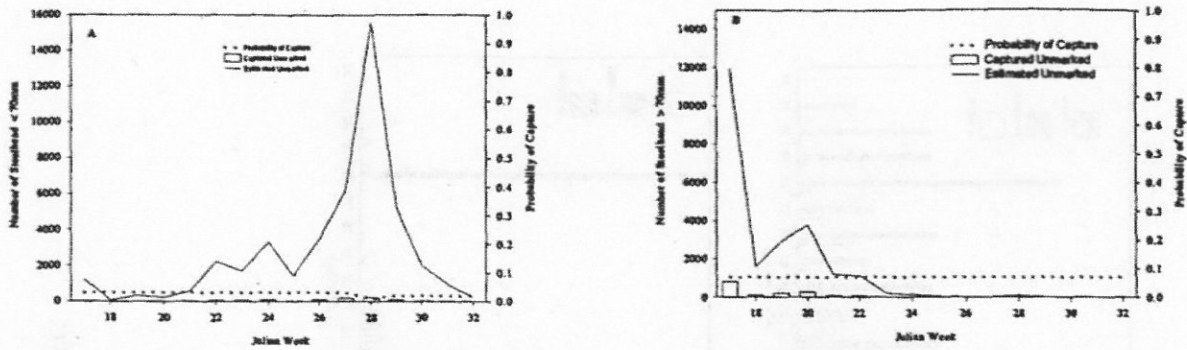


Fig. 6. Weekly trap captures, population estimates, capture probability from the two trap mark-recapture estimation of YOY and year plus steelhead. A). Steelhead. B). Coho.

Six species of fish were captured in fyke traps in the Noyo River during 2000 (Tables 3-5). Non-salmonid species captures are shown by week in Fig. 12. Pacific Lamprey > 250 mm were considered adults and were captured between week 16 and 28. No adult lamprey, sculpin or three spine stickleback were captured at the NFN trap (Fig. 12 C, Table 5). Pacific lamprey < 120 mm, assumed to be ammocoetes, were captured throughout the trapping period in the NFN trap (Fig. 12). No adult or juvenile lamprey or three spine stickleback were captured at the OLD trap (Fig. 12 E, Table 5) suggesting lamprey do not inhabit this creek. One California roach (*Hesperoleucas semmetricus*, not listed in Table 5) was captured at the North Spur trap on 16 May 2000. No California roach were captured at any other traps or during extensive electro-fishing this year. Three species of frogs, three species of salamander, three species of newts, three species of snakes, one species of skink, and one species of turtle were capture throughout the trapping season. Species diversity at each trap site ranged from 0.016 to 0.11 and was highest for the RWC trap (Table 5).

Mark Retention and Survival

All 17 steelhead > 50 mm captured, branded and held in a live car in the river retained their brands and survived for 10 days until released. One of these fish was recaptured in subsequent electro-fishing nine weeks later. On average 72% of fish captured in fyke traps and released above the traps were recaptured in the traps within seven days (Table 6). Of the fish captured and marked in the fyke traps and recaptured above the traps during electro-fishing nine percent were found more than 84 days after initial capture (Table 6). One of two fish captured and marked in the fyke traps was captured after 63 days below the traps while electro-fishing (Table 6). Twenty seven percent of fish captured and marked in the five upper fyke traps were recaptured within seven days, 33.1 % were recaptured within 7-14 days, and 0.8% were recaptured after 49 days in the downstream trap suggesting a travel time between seven and 49 days (Table 7) for about 7 km. Steelhead captured and marked during electro-fishing above the traps were recaptured between seven and 63 days post marking (Table 8). Steelhead captured and marked during electro-fishing below the traps were recaptured between seven and 84 days post marking (Table 8). This suggests mark retention was 100% for 10 days or less and at least some marks were clearly visible after 84 days. Only one fish captured and branded above the traps by electro-fishing was captured in the traps. This fish was recaptured in the trap one day after electro-fishing and was felt to be in poor condition. This suggests that mortality from branding was low and that fish captured during electro-fishing were not migrating.

Trap mortality for steelhead < 50 mm ranged from 0.57 to 1.0 % and averaged 0.76%. Trap mortality for steelhead > 50 mm ranged from 0 to 0.02% and averaged 0.0037%. No trap caught and branded fish were found dead in the traps. The number of trap mortalities generally increased as total captures increased.

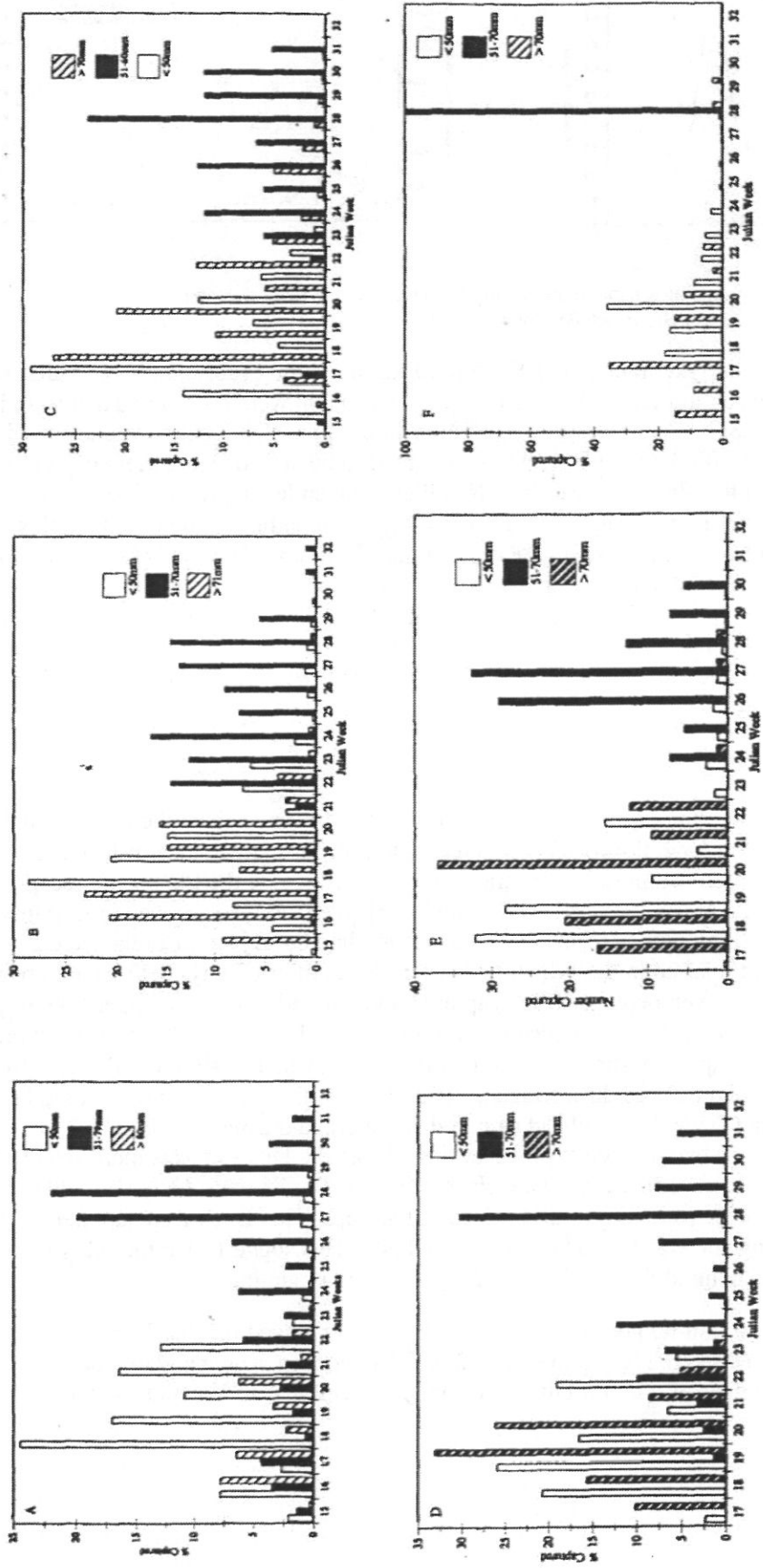


Fig. 7. Percentage of steelhead captured by week and size class in the Noyo River during 2000. A. HWC. B. MSN. C. NFN. D. NRS. E. OLD. F. RWC.

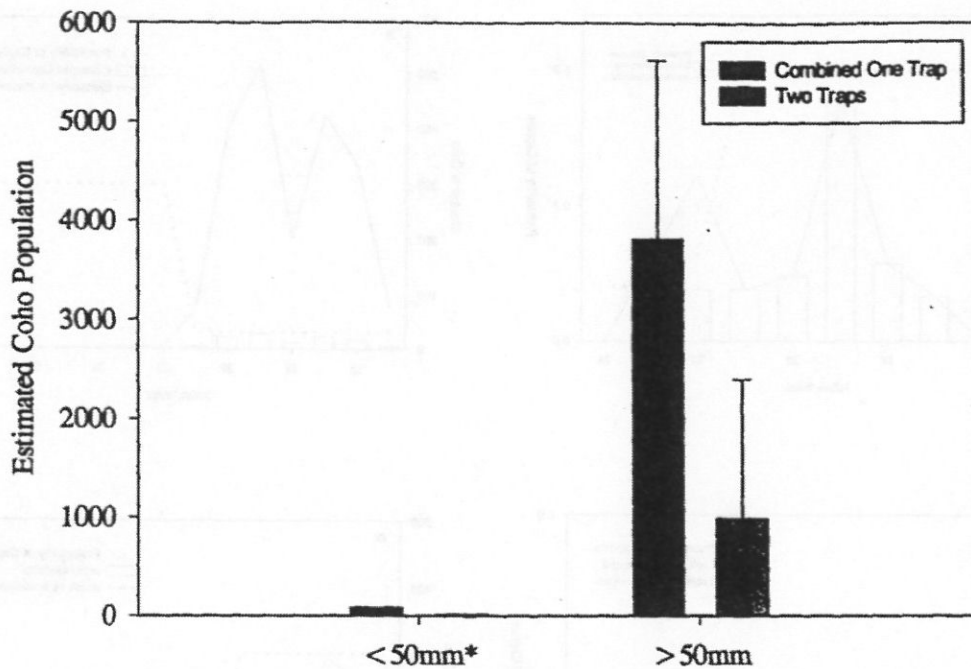


Fig. 8. Coho population estimates from the sum of all traps and the two trap mark-recapture estimation. * < 50 mm coho count only.

The probability of survival from one marking period to the next from Jolly-Seber mark-recapture electrofishing in the Noyo River during 2000 is shown in Table 2. Survival for marked sized YOY steelhead (assumed to be 51-70 mm from fork length frequencies, Appendix B) averaged 0.64 and ranged from 0.34 to 1.0 for stream reaches for which recaptures were sufficient to produce population estimates. Probability of survival estimates for year plus steelhead (assumed to be greater than 70 mm from fork length frequencies, Appendix B) were greater than 1.0 for three out of six cases where recaptures were sufficient to produce population estimates. This is likely a result of poor population estimates due to low numbers of marked and recaptured fish.

Stream Flow and Temperature

Daily average stream discharge and temperature for five fyke net trap sites are shown in Fig. 13. No stage discharge relationship was established for RWC and therefore it was not possible to determine daily stream flow from gauge for this site. Stream flow ranged between 0.01 and 0.50 m³/s at the MSN and NFN sites. Stream flow at the HWC site ranged from 0.02 to 1.1 m³/s. Stream flow at the OLD site ranged from 0.01 to 0.11 m³/s. The NRS site, being below the other streams, had the highest discharge and ranged from 0.15 to 1.7 m³/s. Water temperature at HWC, NFN, and OLD ranged from 8-18 C (Fig. 13.). At the NRS site water temperature ranged from 9-19 C. Water temperature at the MSN site ranged from 8-20 C.

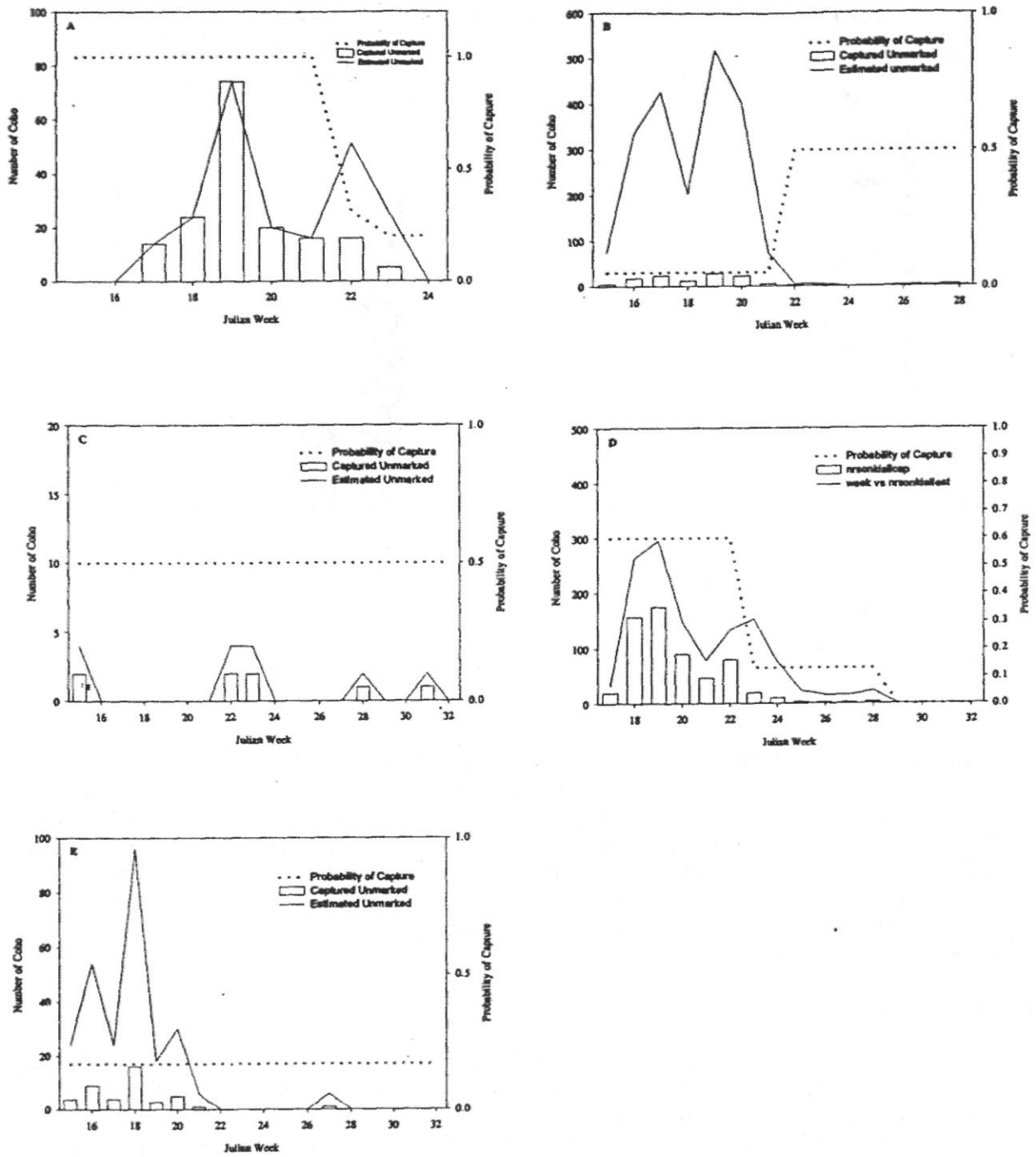


Fig. 9. Weekly population estimates, total captures, and probability of capture for coho > 50 mm. A. HWC. B. MSN. C. NFN. D. NRS. E. RWC.

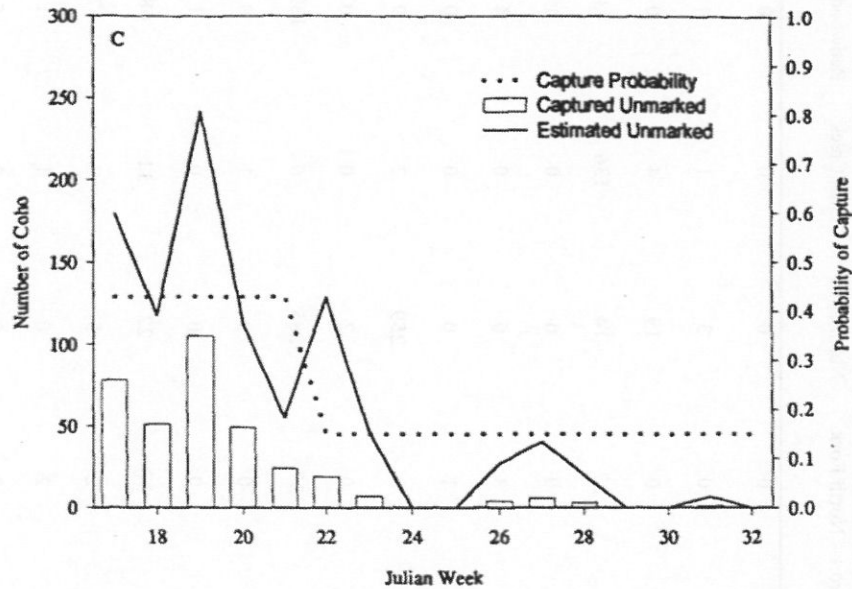


Fig. 10. Weekly trap captures, population estimates, capture probability from the two trap mark-recapture estimation for coho > 50 mm.

Steelhead total catches at each trap site were significantly positively correlated with stream flow and significantly negatively correlated with water temperature (Table 9). The pattern for steelhead < 50 mm was the same (Table 9). Steelhead catch for fish between 51-70 mm were significantly positively correlated with discharge at only two sites and significantly negatively correlated with temperature at one site (Table 9). Steelhead > 70 mm (assumed to be year plus) were significantly positively correlated with stream flow and significantly negatively correlated with water temperature (Table 9). Total coho daily captures followed the same pattern at the two sites where captures were sufficient for this analysis (NFN and NRS). Recaptures were only sufficient to examine daily capture versus stream flow and water temperature at the NRS site. For all size classes daily catches were significantly positively correlated with stream flow and significantly negatively correlated with water temperature (Table 9).

Weekly trap steelhead and coho capture probabilities and weekly average stream discharge and weekly average water temperature correlation coefficients and p-values are shown in Table 10. In three of five cases stream discharges were significantly positively correlated with steelhead > 50 mm capture probabilities. In three of five cases water temperatures were significantly negatively correlated with steelhead > 50 mm capture probabilities. In two of five cases stream discharges were significantly positively correlated with steelhead 51-70 mm capture probabilities. In two of five cases water temperatures were significantly negatively correlated with steelhead 51-70 mm capture probabilities. In four of five cases stream discharges were significantly positively correlated with steelhead > 70 mm capture probabilities. In three of five cases water temperatures were significantly negatively correlated with steelhead > 70 mm capture probabilities. In the two instances where coho captures were sufficiently high to estimate capture probabilities they were significantly positively correlated with stream discharge and significantly negatively correlated with water temperature (Table 10).

Table 5. Total non-salmonid species captured and total species diversity (H') for each fyke net trap in the Noyo River during 2000. Note: species diversity includes salmonid species.

Species	Common Name	Abbreviation	Total Captured						
			Hayworth Creek	Mainstem Noyo	North Fork	North Spur	Olds Creek	Redwood Creek	
<i>Ascaphus truei</i>	Tailed frog	Astr	1	0	0	0	0	0	0
<i>Clemmys marmorata</i>	Western pond turtle	Clma	0	13	0	3	1	4	4
<i>Cottos alueticus</i>	Coast sculpin	Coal	8	0	0	19	4	0	0
<i>Dicamptodon enstatatus</i>	Pacific giant salamander	Dien	3	18	27	14	136	43	43
<i>Diadophis punctiatus</i>	Ringneck snake	Dipu	0	0	0	0	0	1	1
<i>Ensatina sp.</i>	Esdatina sp.	Ensp	1	0	3	0	0	4	4
<i>Eumeces skiltonianus</i>	Western skink	Eusk	0	0	1	0	0	0	0
<i>Gasterosteus aculeatus</i>	Three spine stickleback	Gaac	0	26	0	259	2	9	9
<i>Hyla sp.</i>	Tree frog	Hysp	1	0	0	2	0	0	0
<i>Lampetra tridentata</i>	Pacific lamprey	Latr	64	223	37	285	0	132	132
<i>Lampropeltis sp.</i>	King snake	Lasp	0	0	0	0	1	0	0
<i>Plethodon elongatus</i>	Del Norte salamander	Plel	0	0	0	0	0	1	1
<i>Rana boylei</i>	Foothill yellow-leg frog	Rabo	13	62	37	22	11	68	68
<i>Taricha granulosa</i>	Rough-skinned newt	Tagr	3	23	2	5	2	17	17
<i>Taricha rivularis</i>	Red-bellied newt	Tari	2	0	2	0	1	1	1
<i>Taricha torosa</i>	California Newt	Tato	1	3	3	0	3	5	5
<i>Thamnophis sp.</i>	Garter snake	Thsp	0	3	10	1	3	0	0
Species Diversity H*			0.0169	0.0662	0.0217	0.0534	0.0369	0.1124	0.1124

Table 6. Percentage of trap branded fish recaptured by week in each trap and those recaptured above and below the traps during electro-fishing surveys.

Trap	Total Captured	Time between capture and recapture (Days)												
		<7	7-14	14-21	21-28	28-35	35-42	42-49	49-56	56-63	63-70	70-77	77-84	84-91
Hayworth Creek	76	81.6	11.8	5.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mainstem Noyo	60	61.7	28.3	3.3	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Fork Noyo	166	67.5	24.7	4.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Spur	100	85.0	10.0	4.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Olds Creek	21	38.1	57.2	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Redwood Creek	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average		72.3	22.0	3.6	1.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Traps	9	0.0	9.0	9.1	9.1	18.2	18.2	9.1	0.0	0.0	0.0	9.1	9.1	9.1
Below Traps	2	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0

Table 7. Percentage of fish marked and released in five traps above NRS and recaptured at NRS by week.

Trap	Total Captured	Time between capture and recapture (Days)												
		<7	7-14	14-21	21-28	28-35	35-42	42-49	49-56	56-63	63-70	70-77	77-84	84-91
Hayworth Creek	31	19.4	45.2	12.9	12.9	3.2	0.0	3.2	3.2	0.0	0.0	0.0	0.0	0.0
Mainstem Noyo	31	25.8	32.3	6.5	22.6	6.5	3.2	3.2	0.0	0.0	0.0	0.0	0.0	0.0
North Fork Noyo	48	29.2	27.1	25.0	12.5	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Olds Creek	12	58.3	41.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Redwood Creek	11	18.2	18.2	18.2	18.2	9.1	9.1	9.1	0.0	0.0	0.0	0.0	0.0	0.0
Average		27.8	33.1	15.0	14.3	5.3	1.5	2.3	0.8	0.0	0.0	0.0	0.0	0.0

Table 8. Percentage of fish marked and released during electro-fishing recaptured above and below traps by electro-fishing by week in the Noyo River during 2000.

Trap	Total Captured	Time between capture and recapture (Days)												
		<7	7-14	14-21	21-28	28-35	35-42	42-49	49-56	56-63	63-70	70-77	77-84	84-91
Above Traps	140	0	7.14	15.71	22.86	15	13.57	5.71	8.57	5	6.43	0	0	0
Below Traps	127	0	15.75	40.49	19.69	11.81	3.15	2.36	5.51	0.79	0.79	1.57	0	2.36

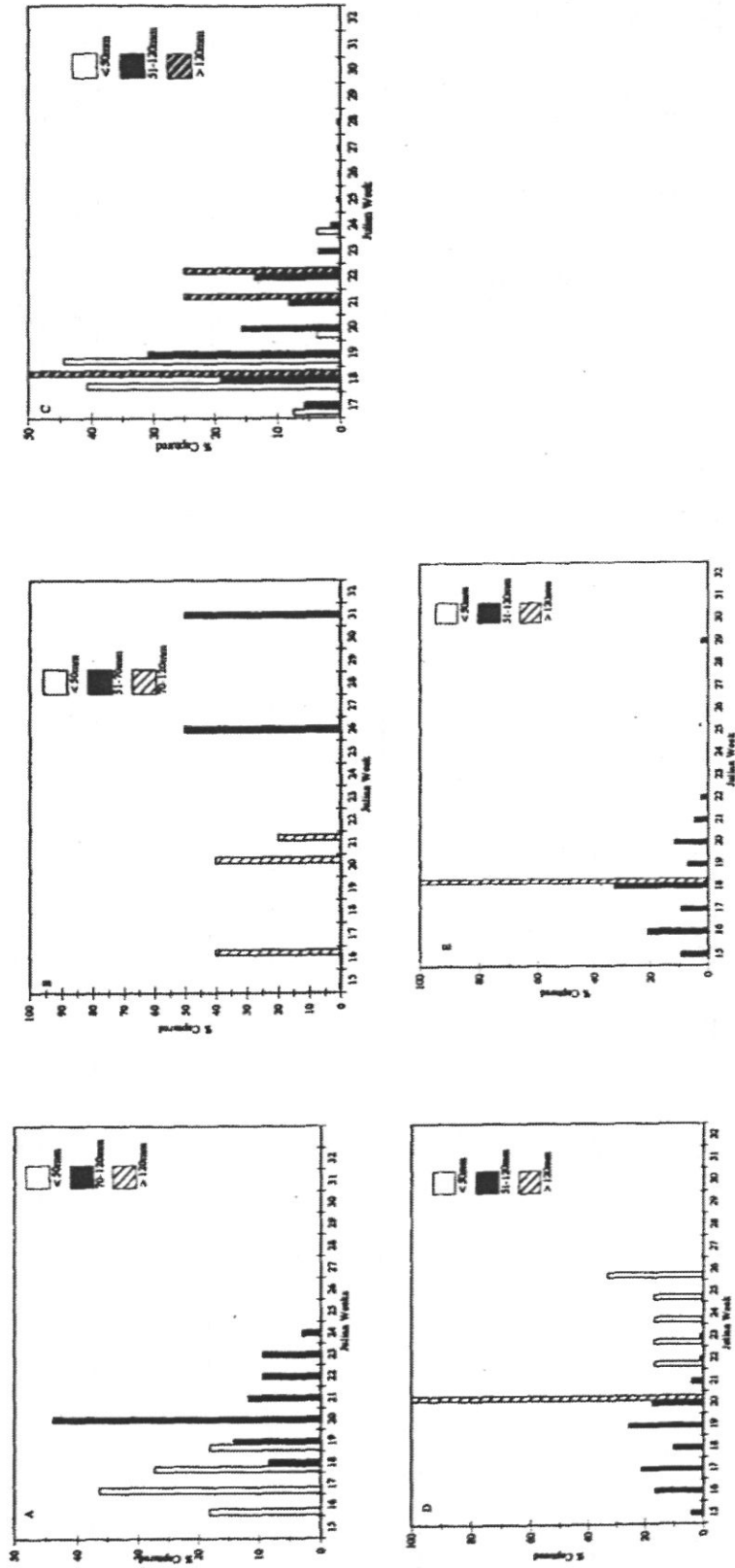


Fig. 11. Percentage of coho captured by week and size class in the Noyo River during 2000. A. HWC. B. MSN. C. NFN. D. NRS. E. RWC.

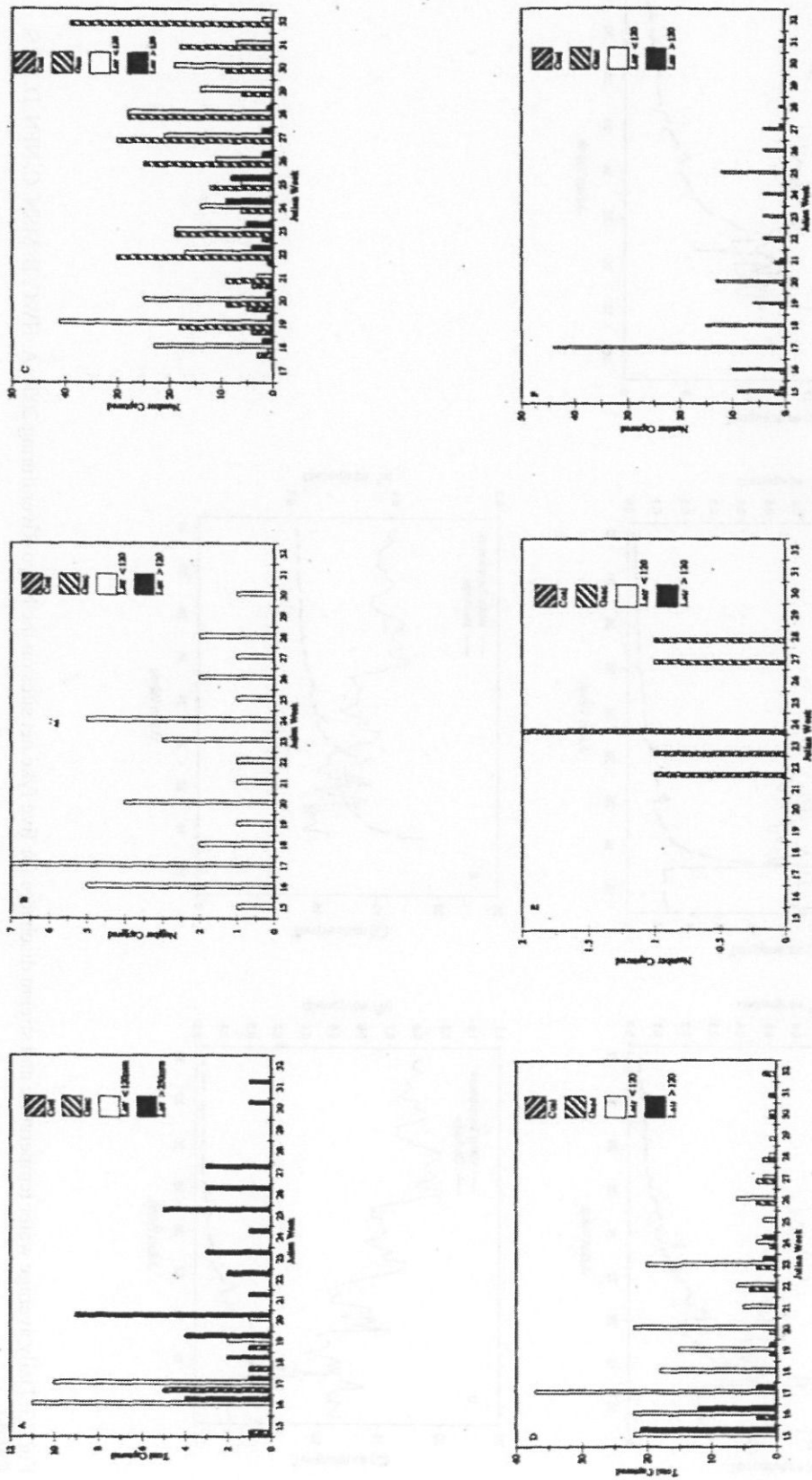


Fig. 12. Non-salmonid fish species captured in six fyke net traps on the Noyo River during 2000. A. HWC, B. MSN, C. NFN, D. NRS, E. OLD, P. RWC. Abbreviations are the same as in Table 5.

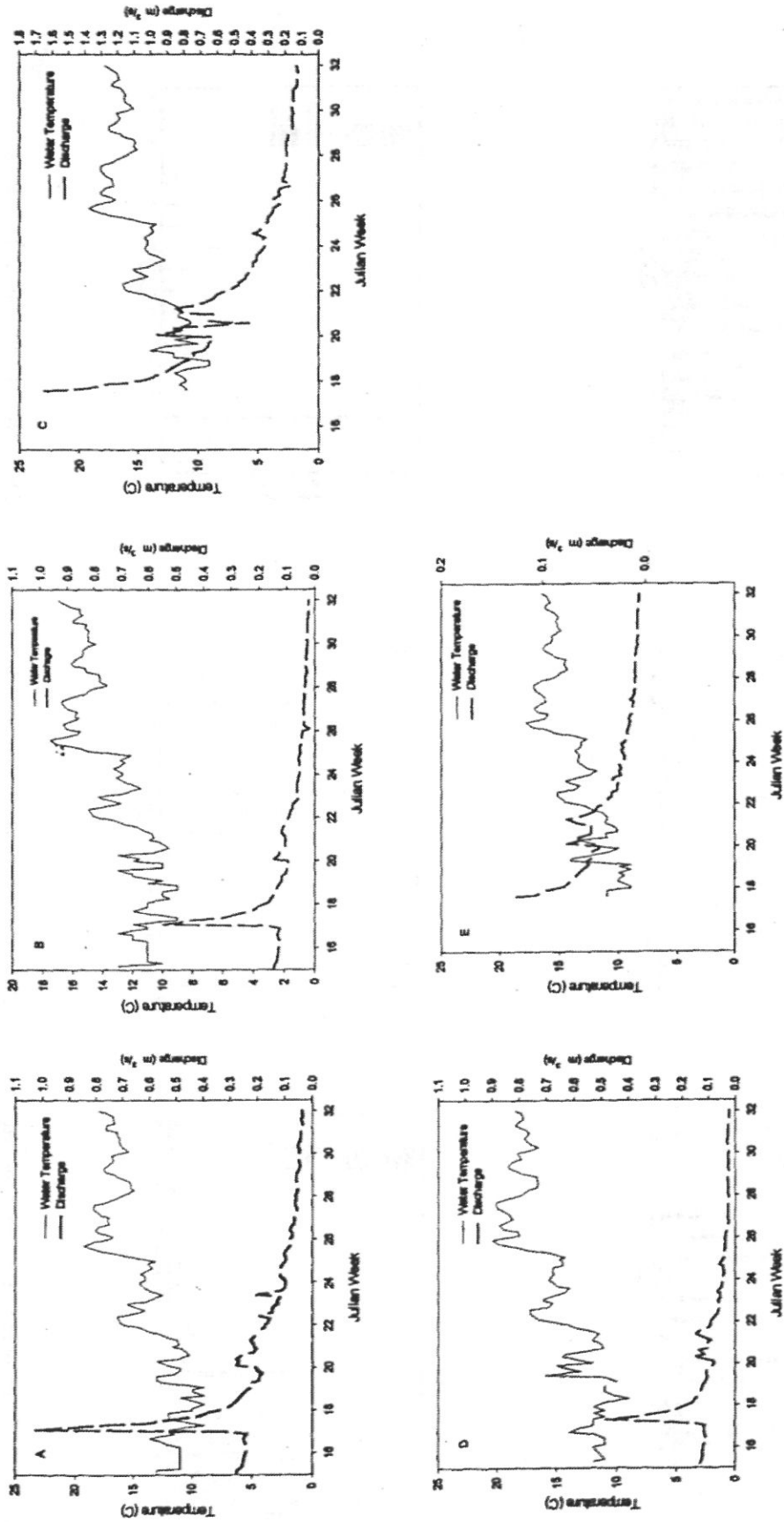


Fig. 13. Daily average water temperature and stream discharge for five fyke net sites on the Noyo River during 2000. A. HWC. B. MSN. C. NFN. D. NRS. E.RWC.

Table 9a. Results of correlation comparisons between daily steelhead fyke net captures and daily stream discharge and daily water temperatures for five trap sites on the Noyo River during 2000. n = 188 Days for HWC, MSN, and NFN and 106 days for NRS and OLD.

Trap	Variable	Daily Captures		
		Total	<50mm	>70mm
Hayworth Cr.	Discharge	r = 0.742, p < 0.001	r = 0.779, p < 0.001	r = 0.779, p < 0.001
	Temperature	r = -0.657, p < 0.001	r = -0.684, p < 0.001	r = -0.623, p < 0.001
Mainstem Noyo	Discharge	r = 0.462, p < 0.001	r = 0.441, p < 0.001	r = 0.788, p < 0.001
	Temperature	r = -0.556, p < 0.001	r = -0.547, p < 0.001	r = -0.503, p < 0.001
North Fork	Discharge	r = 0.342, p < 0.001	r = 0.293, p = 0.002	r = -0.505, p < 0.001
	Temperature	r = -0.430, p < 0.001	r = -0.413, p < 0.001	r = 0.813, p < 0.001
North Spur	Discharge	r = 0.664, p < 0.001	r = 0.659, p < 0.001	r = 0.812, p < 0.001
	Temperature	r = -0.591, p < 0.001	r = -0.587, p < 0.001	r = -0.647, p < 0.001
Olds Cr.	Discharge	r = 0.262, p = 0.008	r = 0.322, p = 0.001	r = 0.528, p < 0.001
	Temperature	r = -0.253, p = 0.01	r = -0.433, p < 0.001	r = -0.421, p < 0.001

Table 9b. Results of correlation comparisons between daily coho fyke net captures and daily stream discharge and daily water temperatures for five trap sites on the Noyo River during 2000. n = 118 Days for HWC, MSN, and NFN and 106 days for NRS and OLD.

Trap	Variable	Daily Captures		
		<50mm	51-70 mm	>70mm
Coho				
	Total			
Hayworth Cr.	Discharge	-	-	-
	Temperature	-	-	-
Mainstem Noyo	Discharge	r = 0.306, p<0.00	-	-
	Temperature	r = -0.413, p<0.0	-	-
North Fork	Discharge	-	-	-
	Temperature	-	-	-
North Spur	Discharge	r = 0.619, p<0.00	r = 0.383, p = 0.00	r = 0.697, p<0.00
	Temperature	r = -0.657, p<0.0	r = -0.473, p = 0.0	r = -0.441, p<0.0
Olds Cr.	Discharge	-	-	-
	Temperature	-	-	-

Table 10. Results of correlation comparisons between weekly capture probability and weekly average stream discharge and water temperatures for five trap sites on the Noyo River during 2000. n = 17 weeks for HWC, MSN, and NFN and 15 weeks for NRS and OLD.

Trap	Variable	Steelhead			Coho		
		Total > 50 mm	51-70 mm	>70mm	Total > 50 mm		
Hayworth Cr.	Discharge	r = 0.137, p = 0.58	r = 0.224, p = 0.37	r = 0.782, p = 0.01	-		
	Water Temperature	r = -0.189, p = 0.45	r = -0.449, p = 0.06	r = -0.138, p = 0.64	-		
Mainstem Noyo	Discharge	r = 0.253, p = 0.31	r = -0.315, p = 0.06	r = 0.415, p = 0.09	r = -0.767, p < 0.01		
	Water Temperature	r = -0.095, p = 0.71	r = 0.285, p = 0.25	r = 0.175, p = 0.48	r = 0.868, p < 0.01		
North Fork	Discharge	r = 0.716, p < 0.01	r = 0.086, p = 0.73	r = 0.683, p = 0.01	-		
	Water Temperature	r = -0.626, p = 0.01	r = -0.04, p = 0.88	r = -0.595, p = 0.02	-		
North Spur	Discharge	r = 0.920, p < 0.01	r = 0.426, p = 0.10	r = .830, p < 0.01	r = 0.781, p = 0.01		
	Water Temperature	r = -0.916, p < 0.01	r = -0.449, p = 0.08	r = -0.588, p = 0.01	r = -0.782, p = 0.01		
Olds Cr.	Discharge	r = 0.804, p < 0.01	r = 0.636, p = 0.01	r = 0.760, p < 0.01	-		
	Water Temperature	r = -0.736, p < 0.01	r = -0.669, p = 0.01	r = -0.608, p = 0.01	-		

Resident Population Estimates

The estimated number of steelhead/m and 95% confidence levels for 100 m stream reaches electro-fished in the Noyo River during 2000 and the length of stream these segments represent are shown in Table 11. Steelhead < 50 mm were not marked so these numbers are based on total catch without confidence bounds. Recaptures at the RWC and OLD sites were low and therefore the confidence bounds were wide. Steelhead 51-70 mm (assumed to be YOY based on fork length frequencies, Appendix B) densities averaged 0.45/m and ranged from 0.24 to 1.36/m (excluding the RWC site). Steelhead > 70mm (assumed to be year plus based on length frequencies, Appendix B) densities averaged 0.95/m and ranged from 0.15 to 2.78/m (Table 11, excluding the RWC site). Total resident populations were estimated by multiplying the estimated number of fish/m by the length of stream each segment represented (Fig. 14). Adding these estimates to their respective trap estimates and dividing the result by the resident population estimate gave an estimate of the proportion of YOY remaining in the stream above the traps. A similar procedure was used to estimate the percentage of year plus steelhead remaining in the stream above the traps. The average percent YOY residing, excluding RWC due to problems with population estimates, as of 1 August 2000 was 19.6% and ranged from 8.9 to 29.4 % (n = 5, S.E. = 3.5%). The highest percent rearing was in the NFN while the lowest was at NRS. Thus, on average, 80.4% of the YOY produced above the traps moved below the traps by 1 August 2000. The average percent year plus steelhead residing was 64.7 (S.E. = 9.5%) and ranged from 37.3 to 80.1 near four of the traps. It is unknown what percentage of the year plus population moved to the ocean rather than downstream to rear.

Steelhead fork lengths were significantly different between trap captured fish and fish captured electro-fishing above the traps for the weeks when electro-fishing was conducted in all but two cases (Table 12). Steelhead were significantly larger in the streams than in the traps. Condition factor of steelhead captured electro-fishing were significantly higher than fish captured in the traps in nine out of 12 cases (Table 13). These data support the idea that later in the season, when flows are lower and temperatures higher, larger steelhead are not migrating.

Historic and Current Comparisons

The main stem Noyo River was never surveyed by CDFG and juvenile salmonid habitat quality or abundance assessed (Appendix A). Habitat quality ratings from 2000 are not presented here (numbers/m are shown in Table 11). Historic and current juvenile salmonid habitat use ratings are shown in Fig. 15. The 1957 and 1959 habitat use evaluations were based on visual surveys whereas during 1967 and 2000 habitat use was based on population estimates. The NFN was similar between 1957 and 1959 but increased in habitat quality since 1967 (Fig. 15a). Hayworth Creek was rated lower in 1957 than in 1967 and 2000. Gulches in the Noyo River were not surveyed in 2000 (Fig. 15b). Two of the three gulches surveyed in 1957 and 1959 increased in habitat quality. No other gulches were surveyed more than once. One creek increased in habitat use between 1957 and 1959. Two of three creeks surveyed between 1957 and 1959 increased in habitat quality and the other remained stable (Fig. 15c). Olds Creek increased between the historic surveys and the 2000 survey. Redwood Creek increased between 1957 and 1967 but was rated the same in 1967 and 2000. Streams and stream reaches in the South Fork were not surveyed during 2000. One of four reaches in the South Fork increased while the other three decreased in habitat quality between 1957 and 1959. Kass Creek decreased in juvenile habitat quality between 1957 and 1967 (Fig. 15d).

Young of the Year Population Estimation and Prediction

The estimated and predicted YOY steelhead populations for the Noyo River by stream reach and the total above NRS are shown in Fig. 16. Treating the stream reaches as samples there was no significant difference between estimated and predicted YOY steelhead populations in the Noyo River during 2000 (Fig. 16: T = 72, n = 8:8, p = 0.72). Removing the total trap estimated and predicted populations (all traps combined and

Table 11. Estimated number and 95% confidence levels of steelhead/m in eight reaches in the Noyo River during 2000.

Stream	Segment	Length (km)	Estimated Number per Meter						
			<50n		51-70mm			>70mm	
			Low 95	Estimate	High 95	Low 95	Estimate	High 95	
Hayworth Cr.	Above Conflu	6.6	0.189	0.561	0.805	1.952	0.458	1.234	6.03
Mainstem Noyo	Above Redwo	4.85	1.023	0.19	0.242	0.55	0.121	0.155	0.35
Mainstem Noyo	Northspur to 0	5.02	0.328	0.487	1.002	3.929	0.124	0.325	1.79
Mainstem Noyo	Olds Cr. to Red	1.6	0.506	0.708	1.362	2.323	0.282	0.499	1.61
North Fork	Above Haywo	4.85	0.645	0.43	1.092	5.779	0.365	1.022	5.42
North Fork	Northspur to Ha	6.19	0.526	0.486	0.752	2.86	0.182	2.78	0.6
Olds Cr.	Above Conflu	1.72	0.387	0.296	0.862	5.839	0.201	0.651	4.38
Redwood Cr.	Above Conflu	3.71	0.616	1.031	5.43	75.11	0.599	3.008	43.54

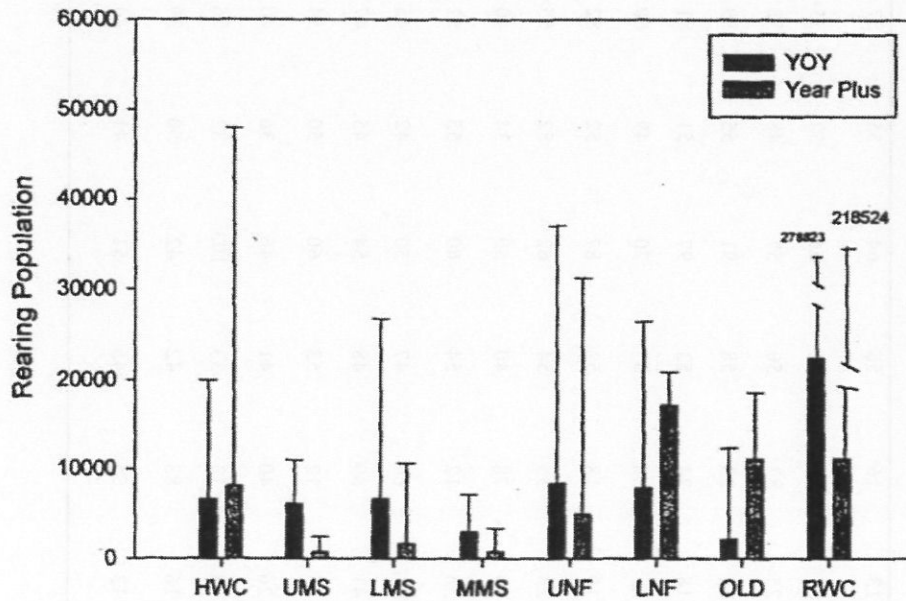


Fig. 14. Estimated numbers of residing steelhead in eight stream reaches in the upper Noyo River during 2000. Thin lines are 95% confidence levels. Reach abbreviations are the same as Fig. 2 except UMS is the Noyo River above RWC, LMS is Noyo River between NRS and OLD, MMS is the Noyo River between OLD and RWC, UNF is NFN above HWC, and LNF is NFN below HWC.

Table 12. Results of fork lengths comparisons between fyke trap captured steelhead and steelhead captured electro-fishing above traps during spring 2000 on the Noyo River.

Stream	Week	Fork Length						t-value	P-value		
		N		Median		25%					
		Trap	E-fish	Trap	E-fish	Trap	E-fish				
Hayworth Cr.	25	13	16	56	64	55	57	65	114	157	0.105
	29	81	36	54	66	52	55	57	106	2987	<0.01
	31	25	82	50	57	48	52	52	68	762	<0.01
Mainstem Noyo	23	29	23	58	91	55	89	63	100	919	<0.01
	26	18	24	53	97	51	81	54	110	177	<0.01
	30	2	58	67	70	49	60	85	103	37	0.33
North Fork Noyo	25	10	18	52	87	52	82	60	94	92	0.01
	28	28	35	54	62	52	55	55	85	621	<0.01
	30	59	78	40	50	34	40	45	58	3070	<0.01
Noyo at Northspur	27	36	12	54	60	55	52	58	80	413	0.01
	29	147	66	47	50	42	45	51	57	8368	0.02
	32	41	69	48	54	45	47	52	61	1675	<0.01
Olds Cr.	27	25	12	53	60	50	54	54	106	326	0.01
	30	26	40	41	46	36	40	47	53	654	0.01
	26	48	13	33	103	32	76	35	134	714	<0.01
Redwood Cr.	30	16	83	42	42	50	39	46	61	333	<0.01
	31	13	55	45	51	41	44	47	65	261	0.01

Table 13. Comparison of steelhead condition factors between trap captured fish and those collected during electro-fishing above traps on the Noyo River during spring 2000. N is sample size.

Stream	Week		Condition Factor						t-value	p-value	
	Trap	E-fish	Median			75%					
			Trap	E-fish	Trap	E-fish	Trap	E-fish			
Hayworth Cr.	25	14	16	0.96	1.18	0.9	1.05	1.02	1.24	152	0.07
	29	73	34	1.02	1.19	0.97	1.12	1.08	1.28	2741	<0.001
	31	10	63	0.97	1.13	0.95	1.01	1.14	1.21	259	0.08
Mainstem Noyo	23	29	23	0.98	1.18	-	-	-	-	-5.51	<0.001
	26	15	24	1.01	1.17	0.96	1.12	1.12	1.22	183	<0.001
North Fork Noyo	25	10	18	1.03	1.22	-	-	-	-	-3.27	0.03
	28	28	32	1	1.18	-	-	-	-	-6.45	<0.001
	30	7	29	0.99	1.07	-	-	-	-	-1.09	0.28
Noyo at Northspu	27	36	16	1.01	1.12	0.95	1.05	1.1	1.22	559	0.007
	29	36	29	1.09	1.18	1.02	1.1	1.22	1.22	1103	0.055
	32	11	29	1.02	1.08	0.93	1.03	1.06	1.14	160	0.049
Olds Cr.	27	17	10	1.04	1.19	-	-	-	-	-4.66	<0.001

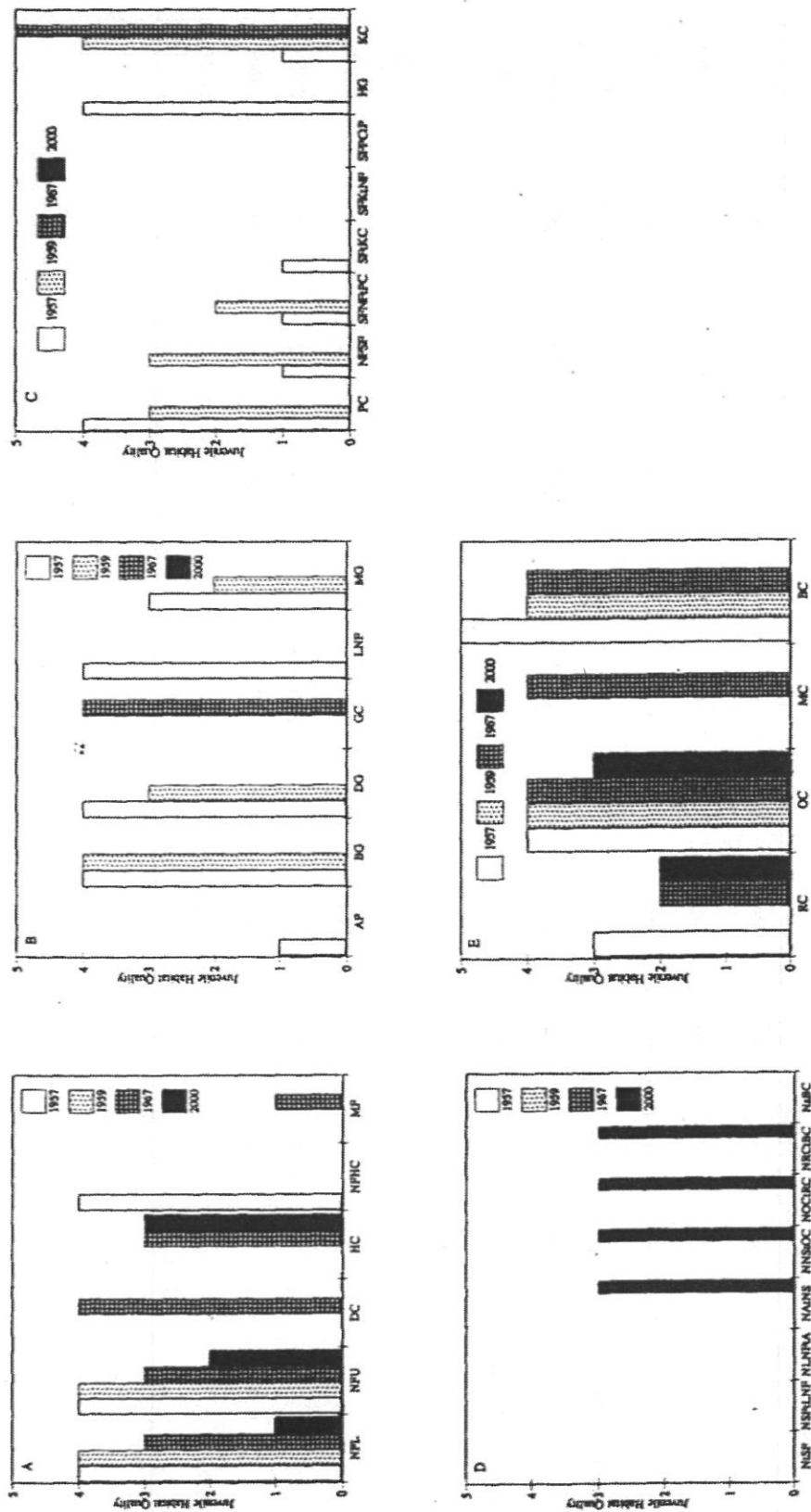


Fig. 15. Juvenile habitat quality and use from historic and current surveys on the Noyo River. Abbreviations are the same as in Figs. 2 and 14. A). NFN. NPL is lower North Fork, NFU is upper North Fork, DC is Dewarren Cr., HC is HWC, NFHC is North Fork HWC, and MP is the Middle Fork. B). Gulches and the Little North Fork (LNF). AG is Alpine Gulch, BG is Brandon Gulch, DG is Duffy Gulch, GC is Gulch C, and MG is Marble Gulch. C). South Fork (SF) Noyo River. PC is Parlin Cr., SFNFPC is SF from North Fork South Fork (NF) to PC., KC is Kass Cr., SFKNF is SF from KC to NF., SFPCTP is SF from PC to Maguire Pond, and HG is Hayshed Gulch. D). Noyo River (N) below NRS. Abbreviations are as above. E). Creeks in the Noyo River. RC is RWC, OC is OLD, MC is McMullen Cr., and BC is Burbeck Cr.

the two trap method) from the analysis there was no significant difference between the YOY population estimates ($T = 43, n = 6:6, p = 0.59$). The large error associated with the all traps combined population estimate and the two trap population estimate in Fig. 16 result from large confidence range associated with the RWC population estimates which results from errors in both the downstream migration trapping and electro-fishing where too few recaptures were made to make reliable population estimates (Tables 3 and 11, Fig 16).

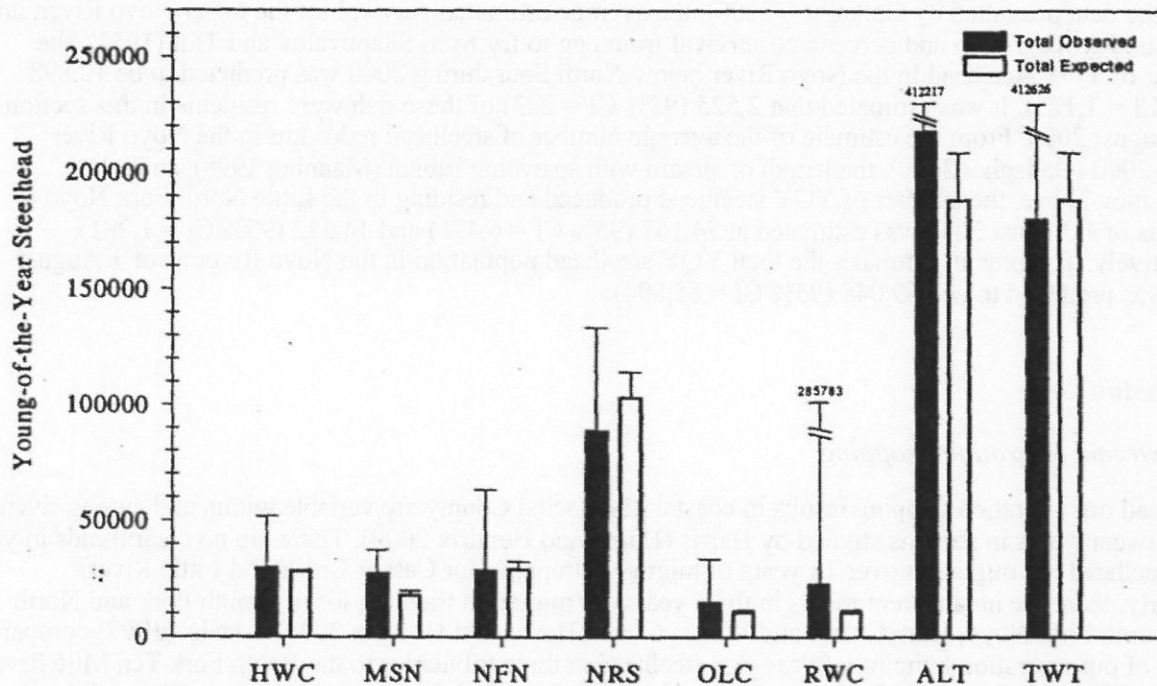


Fig. 16. The estimated and predicted YOY steelhead populations for the Noyo River by stream reach and the total above NRS. Abbreviations are the same as Figs. 2 and 14 except that ALT is the sum of all individual traps and stream reach estimates and TWT is the sum of the two trap mark-recapture population estimate and stream reach estimates. Thin lines are 95% confidence estimates.

By week 32 the predicted number of fry surviving from the production of one 57 cm female was estimated to be 1,307 (95% CI = 551). The difference between two stream segments (HWC, NFN) predicted versus estimated YOY were within the predicted production of one female. The OLD segment difference between the predicted and estimated YOY was within three females production. The NRS and RWC predicted versus estimated YOY were within the predicted production of 10 and 9 females, respectively. The sum of all traps and the two trap predicted versus estimated YOY were within the predicted production of 21 and six females, respectively.

The YOY trap counts presented by Harris and Hendrix (2000) for the South Fork and the North Fork South Fork Noyo River and the average estimated percent residency from the upper Noyo River during 2000, was used to estimate the number of YOY steelhead above these traps. From estimates of adult female steelhead (Gallagher 2000), the average survival estimated for the upper Noyo River, and the fecundity regression and percentage survival from egg to fry from Shapovalov and Taft (1954), the predicted number of YOY for the South Fork and the North Fork South Fork Noyo River during 2000 was calculated. The YOY steelhead population estimated

for the South Fork and the North Fork South Fork was 10,596 (high 95% CI = 12,028) and 6,565 (high 95% CI = 7,266), respectively. The YOY steelhead population predicted for the South Fork and the North Fork South Fork was 38,697 (95% CI = 3,657) and 9,673 (95% CI = 844), respectively. The South Fork estimated versus predicted YOY steelhead populations differed by the predicted production of nine females. The North Fork South Fork estimated versus predicted YOY steelhead population estimate differed by the predicted production of less than one female.

From the data presented by Gallagher (2000), the average estimated survival for the upper Noyo River, and the fecundity regression and percentage survival from egg to fry from Shapovalov and Taft (1954), the number of YOY steelhead in the Noyo River below North Spur during 2000 was predicted to be 12,898 (95% CI = 1,125). It was estimated that 2,525 (95% CI = 223) of these fish were residents in this section as of 1 August 2000. From the estimate of the average number of steelhead redds/km in the Noyo River during 2000 (Gallagher 2000), the length of stream with spawning habitat (Manning 1998), and information above, the number of YOY steelhead produced and residing in the Little North Fork Noyo River as of 1 August 2000 was estimated at 74,167 (95% CI = 6,471) and 14,522 (95% CI = 1,281), respectively. Totaling all estimates the total YOY steelhead population in the Noyo River as of 1 August 2000 was predicted to be 259,048 (95% CI = 85,894).

Discussion

Downstream Migration Trapping

Steelhead out migration trapping results in coastal Mendocino County are variable within and among rivers and between years in streams studied by Harris (Harris and Hendrix 2000). There are no clear trends in year plus steelhead out migration over 13 years of migration trapping for Caspar Creek and Little River. Similarly, there are no apparent trends in three years out migration trapping for the South Fork and North Fork South Fork Noyo, Hare Creek, and Wages Creek (Harris and Hendrix 2000). Maahs (1997) compared results of out-migration trapping of year plus 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. Maahs (1995, 1996, 1997) used mark-recapture to estimate trap efficiencies in order to expand trap counts for days in which traps were not in operation. Trapping results for coastal Mendocino County to date are not comparable with results from the Noyo 2000 work because of the variability in trap counts over time and among streams, because each stream is unique, and due to the lack of reported error estimates. It might be possible to standardize trap counts by drainage area for comparison.

Trap capture probabilities ranged from 7 to 19% for year plus steelhead in the Noyo during 2000. Maahs (1995) had a recapture rate of 74% for year plus steelhead trapping in the Little North Fork Noyo River which was attributed to stream size and trap design. Trapping methods and trap design were similar to that described by Maahs (1995) in the Noyo during 2000. During 1996, trap efficiencies were approximately 36% and during 1997 were about 42% for streams monitored by Maahs (1996, 1997). Harris and Hendrix (2000) report year plus steelhead capture probabilities for the North Fork South Fork and the South Fork Noyo River at 30 and 18%, respectively. Trap capture probabilities for the upper Noyo River during 2000 were lower than those reported recently for other local streams. Ward and Slaney (1988) report box trap efficiencies of 90% for year plus 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 2000 were better than those reported for screw traps and lower than box traps and other local fyke traps. Trap efficiencies may be improved by better trap placement. Putting traps into the river earlier in the year, modifying trap design, or using box traps may improve capture probabilities and resulting population estimates.

Population estimates from traps in each stream in the Noyo River during 2000 were larger for larger

streams. Confidence levels ranged between 4.1 and 100% of the population estimates. Generally, those streams with low capture probabilities had large confidence intervals which probably resulted from poor trap placement and/or low flows. The streams with larger populations of steelhead moving downstream had more redds/km (Gallagher 2000). 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. The two trap approach on the Noyo River during 2000 had lower estimated capture probabilities and tighter confidence intervals for year plus steelhead, while YOY steelhead and the total marked population confidence intervals were larger with the two trap method than that calculated by summing the results from individual traps. These differences are much less when the two traps with low numbers of recaptures are not included suggesting better trap placement may improve population confidence intervals. The differences in population estimates from summing all individual traps and the two trap method were not significantly different. The confidence limits for year plus steelhead were 4.1 % of the population estimate using the two trap method versus 18.3% arrived at by totaling all the trap estimates. The NRS trap population estimate is 20% of the two trap population estimate. Only using one trap at NRS to estimate the number of YOY and year plus steelhead in the Noyo River above North Spur may not be appropriate. The two trap count of YOY steelhead < 50 mm is much lower than the estimate obtained by summing the individual trap counts. This is likely a result of mortality between the upper and lower traps and that some fish rear in the reaches between the traps. Thedinga et al. (1994) estimated steelhead mortality between traps located 17 km apart on the Situk River in Alaska at 10%.

Coho were not consistently marked throughout the study period due to ESA permit concerns. Coho capture probabilities were much higher and confidence limits were also much higher than for steelhead. The wide confidence intervals were a result of the low number of marked and recaptured fish. Coho may be more susceptible to fyke traps than steelhead due to differences in their life histories. If coho exhibit a strict juvenile life history, spending only one year in fresh water (Harris 1998), then they may be expected to be captured in downstream traps more readily due to their drive to move to the ocean. Steelhead, on the other hand, have a more variable life cycle and the drive to move downstream to the ocean during anyone year may not be as strong. Thus if they encounter an obstacle they might just as well remain in the stream longer than negotiate to get to the sea. Hams and Hendrix (2000) report capture probabilities for coho in the South Fork and North Fork South Fork of 0.27 and 0.38, respectively. Coho capture probabilities were higher in the upper Noyo during 2000. Maahs (1997) reports trap efficiency for coho in the Ten Mile River to range from 24 to 58%. Maahs (1995) had recapture rates of 90% for coho in the Little North Fork Noyo River. Manning (1998) reports trap capture efficiencies for coho in the Little North Fork Noyo River of 77% for 1995 and 91 % for 1996. Coho capture probabilities were generally within this range for the upper Noyo during 2000. Coho population estimates exhibit a similar pattern to steelhead where larger streams have larger populations. Coho were not found in Olds Creek and have not been observed there during presence/absence surveys (A. Nadig, Pers. Comm.). The summed individual trap and two trap population estimates were not significantly different. However, these two estimates show the opposite pattern observed for steelhead where the two trap estimate was the higher number.

Mark Retention and Survival

Gallagher (1999) found that chinook salmon (*Oncorhynchus tshawytscha*) retained freeze brands for 49 days and that mortality associated with branding was low. Everest and Edmundson (1967) found that freeze brands last at least two months and that the duration of the brand increases with the duration of freeze brand contact. Some brands on steelhead in the Noyo River were observed after more than 80 days. Brand contact time was generally about three seconds. It appears that freeze branding is a relatively inexpensive and effective method to mark steelhead > 50 mm. Continued sampling of electro-fishing reaches and winter-spring 2000/2001 fyke trapping will allow continued evaluation of mark retention.

Steelhead travel time between the up stream traps and the NRS trap ranged from less than seven to more than 49 days. The majority of marked and recaptured steelhead were captured within one week of first capture. Thedinga et al. (1994) states that 90% of marked and released steelhead in the Situk River, Alaska were captured within 6 days of release and that some fish traveled as much as 33 km/day. Because of weekly marking stratification it was not possible to determine maximum travel time for steelhead smolts in the Noyo River during 2000. However, delayed travel above and below traps in weekly intervals was examined. Some fish marked in the traps were found by electro-fishing above the traps more than 80 days since their original capture. One fish marked at RWC was found in the MSN trap a few days later, indicating this fish moved upstream. Observations such as this further complicate population estimates. A marking program which utilizes few marks would not detect delays of this magnitude. A program which individually marked fish would detect delays and travel time with high resolution but might be quite time consuming and logistically difficult. Locating another trap lower in the watershed would add to our understanding of movement patterns and timing.

Fry mortality in the Noyo River during 2000 increased with increasing catch. Maahs (1997) estimated fry mortality due to trapping in the South Fork Ten Mile at 25 % and attributed at least some of this to predation by sculpin. Thedinga et al. (1994) estimated steelhead mortality at about 10% between traps located 17 km apart on the Situk River in Alaska and found handling mortality to be negligible. Mortality associated with trapping in the Noyo River during 2000 was similar to that reported by Thedinga et al. (1994). In trap predation was not examined in this study.

Shapovalov and Taft (1954) found that steelhead survival from egg to smolt was 3% and ranged from zero for YOY to almost 18% for three year old fish. Bums (1972) 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 summer survival in the Noyo River averaged 0.64 (64%), thus mortality was 36%. Estimated YOY survival rates may be lower than actually occur because fish < 70 mm were captured in the traps until the traps were removed from the streams whereas year plus size fish were not. Therefore, steelhead < 70 mm appear to be moving downstream through July and this may affect survival estimates. Average year plus summer survival was greater than 1.0. This is likely a result of small sample size, because too few fish were recaptured, and because later in the season streams are smaller making captures more successful. The use of 70 mm as the separation point between YOY and year plus was based on examination of fork length frequencies and is the standard used by others in the region (D. Wright, Pers. Corn). Shapovalov and Taft (1954) state that YOY sizes in July ranged from 43-77mm in Waddell Creek. Age/size relationships that include scale analysis may better define age class separations by fork length and improve population and survival estimates of YOY and year plus populations.

Stream Flow and Temperature

Loch et al (1988) found that downstream movement of juvenile steelhead in Washington was related to decreasing monthly flow and increasing water temperature. Captures and capture probabilities in the Noyo River during 2000 were generally significantly positively associated with stream flow and negatively associated with temperature. This is opposite Loch et al. (1988). Generally, movement of steelhead between 51-70 mm were not significantly associated with stream flow or temperature. These were generally the size of fish found in the traps later in the year. They were considered YOY and may be forced to move later in the year to find new rearing habitat lower in the system. However, Bums (1971) could not find evidence that streams reach carrying capacity in the summer. Movement of YOY and year plus fish within a system, rather than actual emigration to the ocean, has been documented in other areas (Loch et al. 1988). Shapovalov and Taft (1954) state that steelhead may migrate downstream and move back upstream before migrating to the ocean. Everest (1973) found that summer steelhead smolts rear in the mainstem Rouge River in summer and return to tributaries with winter freshets. There maybe other seasonal triggers such as photo-period which stimulate movement. No relationship between moon phase and steelhead captures were observed during this study.

Larger steelhead were captured in traps earlier in the year and the captures and capture probabilities were significantly associated with stream flow and temperature. Shapovalov and Taft (1954) found that most larger and older steelhead migrate between March and May in Waddell Creek and the highest proportion of all migrants is in spring and summer. They also state that migration during January through late-February is light due to high flows. Ward and Slaney (1988) found most steelhead in the Keogh River British Columbia migrated in April and May and found no smolts moving in mid-winter. Therefore if traps were operated throughout the winter the association between flow, temperature, and trap captures might not hold. It is interesting to note that in all cases stream flow and temperature were significantly correlated. Apparently the fyke traps used in the Noyo River during 2000 were more effective when stream temperatures were low and flows were high. It may be that larger steelhead cease moving when temperatures rise and stream flows are low or that they avoid traps altogether. There is the possibility this is an adaptive response to avoid moving lower in the river where temperatures may exceed survival thresholds and sand berms may cut off access to the ocean.

Resident Population Estimates

The purpose of the electro-fishing mark recapture in the Noyo River during 2000 was, in part, to estimate rearing populations and fish densities were reported as the number/m. Harris (1999b) presents summer juvenile steelhead densities for three local creeks from 1986 to 1999 which range from 0.01 to 1.3/m². Bums (1971) found summer juvenile steelhead densities in Caspar Creek to range between 0.03 to 0.55/m² in 1967, 1968, and 1969. The average density observed in the Noyo River during 2000 was 0.23/m² (95% C.I = 0.69/m²) and ranged from 0.08 (95% C.I = 0.17/m²) to 0.86 (95% C.I = 1.2/m²) was similar to previously reported densities. Fish size and condition were expected to be greater in traps as compared to fish in the stream because smoltification changes body form, larger fish were expected to be moving, and trap predation might increase fish weight. Differences in size and condition may be due to the electro-fishing residency study being conducted later in the year when larger fish had already past the traps or they moved before traps were put in.

Historic and Current Comparisons

Juvenile salmonid population estimates for many streams in the Noyo River were not made during 2000 so that comparison to historic information is limited. In general the historic stream surveys (Appendix A) were conducted to identify logjams. Stream surveys in the 1950's only provided qualitative statements on juvenile populations or habitat conditions. Stream surveys conducted during 1967 estimated stream populations or standing crop, estimates of error were not included and the methods used to derive these values are not stated. The pattern in spawning habitat between the upper Noyo and the South Fork (Gallagher 2000) is similar to that for juveniles in that the South Fork had an apparent declining trend between 1957 and 1967. The upper river juvenile habitat and use patterns are also similar to those observed for spawning habitat use (Gallagher 2000) in that habitat quality appears to have increased slightly since 1957.

Young-of-the-Year Population Estimation and Prediction

Juvenile steelhead population estimates and predictions based on adult numbers derived from spawning surveys for the Noyo River during 2000 are not significantly different. The three segments in which the estimated and predicted number of YOY differed the most were the segments in which Gallagher (2000) found the most lamprey spawning and therefore were areas with the most uncertainty in steelhead redd numbers. The RWC site predicted and estimated YOY populations differed greatly due to low trap efficiency, the low number of fish marked and recaptured in the traps, and the low number of fish marked and recaptured while electro-fishing. This error compounded in the total estimate obtained by summing all the individual trap and stream segment estimates. Although the trap efficiencies were lower for the two trap method, the estimated and predicted YOY population differ by the predicted production of six females as compared to the sum of the individual traps which differed by the predicted production of 21 females.

The YOY population estimate and the predicted population for the South Fork Noyo River differed by the predicted production of nine females because YOY caught in traps in the South Fork drainage were not completely enumerated as traps were opened to allow YOY to escape after weekly permit limits were reached (J. Hendrix, Pers. Comm.). Uncertainty in female estimates for this section may also result from confusion with lamprey redds (Gallagher 2000). No steelhead were observed spawning above the ECS prior to the beginning of steelhead spawning surveys in the South Fork Noyo River (S. Harris, Pers. Comm.). Differences between estimated and predicted YOY populations could also have resulted from using average female size observed in the Noyo River during 2000. More intensive spawning surveys could provide more details about the size of fish in each stream. The simple life stage model developed here for the Noyo River seems to provide reasonable estimates of the YOY population and adds confidence to female population estimates based on redd counts. Continued monitoring of juvenile steelhead populations in the Noyo River may allow estimation of life stage specific survival which may help point to fresh water habitat induced bottlenecks if they exist. The YOY populations estimated during 2000 for the Noyo River provide a baseline cohort for long term monitoring. Steelhead YOY were predicted using an estimate of 80% survival from eggs to fry for streams with little silting (Shapovalov and Taft 1954). The lack of significant difference between estimated and predicted YOY steelhead populations in the Noyo River during 2000 suggests that silting may not be a limiting factor in the upper Noyo River. In most cases the estimated YOY populations were greater than predicted based on estimated female populations suggesting that redds were missed during spawning surveys, or that females produced more eggs than expected. Female population estimates were derived from redd counts which had a 16% level of uncertainty (Gallagher 2000). Including this uncertainty in predicted population estimates would likely increase the overlap between estimated and predicted populations. Following the 2000 cohort in the Noyo River over a number of years should help identify habitat induced bottlenecks if they exist. This type of model could be applied to other rivers to either estimate YOY populations or back into estimates of adult populations. More work is necessary to refine this model and monitoring this years cohort through successive years will improve this life history model.

Recommendations for Further Study

Downstream movement and resident populations as well as adult monitoring should be continued in the Noyo River to follow this seasons juvenile and YOY population through successive life stages. This may allow the detection of habitat induced population bottle necks, if they exist, and point towards potential solutions to these problems. Coordination should be encouraged with others working on this river so that similar methods are employed in enumeration of YOY and juvenile salmonids to allow for large scale comparisons and monitoring of population trends. Age-length relationships should be developed for juvenile steelhead in the Noyo River and this information should be used to track year classes and make potentially better population estimates. Fork length frequency analysis coupled with information on age at size from the literature can be used here as well. Further refinement of the Darr method will likely improve the predictive abilities of this mathematical application. Changing marks on a daily basis for one or a series of traps, although potentially logistically very difficult, will add greatly to our understanding of delayed movement in steelhead. This information will also help improve the Darr method (E. Bjorkstedt, Pers. Comm.). This preliminary trapping effort was very time consuming and therefore expensive. Crews of two checked traps daily for four months requiring 13440 person hours. Data analysis and report preparation required approximately 550 person hours. A data base is underdevelopment which should speed data entry, checking, and analysis. Because this was the first season, analysis took many directions, required review of much background material, development of rating curves for staff gauges, and understanding many different software applications. The format for future migration monitoring is now generally developed and should decrease the amount of effort required for analysis and reporting of findings.

Trapping should begin earlier in the year and/or be conducted through an entire year to examine seasonal

movement trends. Running traps earlier and longer may increase the likely hood of capturing larger assumed to be older steelhead. Modifying traps to increase their efficiency should also be done. More traps should be added, specifically placing a trap in the lower watershed would allow estimation of smolt production and travel time. A rotary screw trap could be used for this purpose. Continued monitoring will help better define the variability in steelhead life histories in the Noyo River and hopefully improve management prescriptions.

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References

- Brower, J. E. and J. H. Zar. 1984. *Field and Laboratory Methods for General Ecology*. Wm. C. Brown and Company, U.S.A. 226pp.
- Bovee, K. D. 1996. A comprehensive overview of the instream flow incremental methodology. National Biological Service, Fort Collins, Co.
- Burns, J. W. 1971. The carrying capacity for juvenile salmonids in some Northern California streams. *Calif. Fish and Game* 57:44-57.
- California Department of Fish Game. 1998. Strategic plan for management of Northern California steelhead trout. California Department of Fish Game, Sacramento, California. 234 pp.
- Darroch, J. N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. *Biometrika* 48: 241-260.
- Dempson, J. B. and D. E. Stansbury. 1991. Using partial counting fences and a two-sample stratified design for a mark-recapture estimation of an Atlantic salmon smolt population. *North American Journal of Fisheries Management* 11:27-37.
- Everest, F. H. 1973. Ecology and management of summer steelhead in the Rouge River, Oregon. Oregon State Game Commission, Corvallis, Oregon. 47 pp.
- Everest, F. H. and E. H. Edmundson. 1967. Cold branding for field use in marking juvenile salmonids. *Progressive Fish Culturist* 29:175-176.
- Federal Register. 2000. Endangered and Threatened Species: Threatened Status for one Steelhead Evolutionarily Significant Unit (ESU) in California. Federal Register, Washington D.C. 65: 36704-36094.
- Federal Register. 1996. Proposed Listing Determination for 15 Evolutionarily Significant Units (ESU) of steelhead in Washington, Oregon, Idaho, and California. Federal Register, Washington D.C. 61:41514-41612.

- Gallagher, S. P. 2000. Results of the winter 2000 steelhead (*Oncorhynchus mykiss*) spawning survey on the Noyo River, California with comparison to some historic habitat information. California Department of Fish and Game, Fort Bragg, CA. 28 pp.
- Gallagher, S. P. 1999. Experimental comparisons of fish habitat and fish use between channel rehabilitation sites and the vegetation encroached channel on the Trinity River. U. S. Fish and Wildlife Service, Arcata, California. 71 pp.
- Hankin, D. G. and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45: 1-32.
- Harris, S. 1999a. Annual Performance Report Federal Aid in Sport Fish Restoration Act: Down stream migration of juvenile salmonids . California Department of Fish and Game, California. Grant Number F-51-R-9. 8pp.
- Harris, S. 1999b. Annual Performance Report Federal Aid in Sport Fish Restoration Act: Juvenile salmon and steelhead stock assessment. California Department of Fish and Game, California. 5 pp.
- Harris, S. 1998. Annual Performance Report Federal Aid in Sport Fish Restoration Act: Down stream migration of juvenile salmonids . California Department of Fish and Game, California. Grant Number F-51-R-9. 4pp.
- Harris, S. 1997. Annual Performance Report Federal Aid in Sport Fish Restoration Act: Down stream migration of juvenile salmonids . California Department of Fish and Game, California. Grant Number F-51-R-9. 4pp.
- Harris, S and J. Hendrix. 2000. Annual Performance Report Federal Aid in Sport Fish Restoration Act: Down stream (out) migration of juvenile salmon and steelhead . California Department of Fish and Game, California. Grant Number F-51-R-9. 15pp.
- Higgins, P. 1998. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy for the Redwood Coast Land Conservancy, Gualala. California. 57 pp.
- Huntington, C., W. Nehlsen, and J. Bowers. 1996. A survey of Healthy Native Stocks of Anadromous Salmonids in the Pacific Northwest and California. Fisheries 21:6-14.
- Krebs, C. J. 1989. Ecological Methodology, Hapre & Row, Publishers, Inc, New York, NY. 664 pp.
- Loch, J. J., S. A. Leider, M. W. Chilcote, R. Cooper, and T. H. Johnson. 1988. Difference in yield, emigration-timing, size, and structure of juvenile steelhead from two small western Washington streams. Calif. Fish and Game 74:106-118.
- Maahs, M. 1997. 1997 Outmigrant trapping, coho relocation, and sculpin predation survey of the South Fork Ten Mile River. Prepared for the Humboldt County Resource Conservation District. Salmon Trailers Marketing Association, Inc., Fort Bragg, California. 37 pp.
- Maahs, M. 1996. 1996 South Fork Ten Mile River and Little North Fork Noyo Outmigrant trapping. Prepared for the Humboldt County Resource Conservation District. Salmon Trailers Marketing Association, Inc., Fort Bragg, California. 27 pp.
- Maahs, M. 1996. 1995 Outmigrant studies in five Mendocino County streams. Prepared for the Humboldt County Resource Conservation District. Salmon Trailers Marketing Association, Inc., Fort Bragg, California.

30pp.

Manning, D. J. 1998. Carrying capacity and limiting habitat analysis for coho salmon (*Oncorhynchus kisutch*) in streams of northwestern California. Thesis (MS) Humboldt State University, Arcata, CA. 103pp.

McElhany, P., M. Ruckelshaus, M. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 158p.

McEwan, Dennis and Jackson, and Terry. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game, Sacramento, CA. 256 pp.

Moore, T. L. 1997. Condition and feeding of juvenile chinook salmon in selected intermittent tributaries of the upper Sacramento River. Thesis (MS) California State University Chico, Chico, CA 66 pp.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho and Washington. Fisheries (AFS) 16:4-21.

Prager, M., P. Spencer, T. Williams, S. Kramer, P. Adams, and T. Hablett. 1999. Southwest regional approach to data collection on California Salmonids. Report of a workshop held August 12-13, 1998. Tiburon, California. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz/Tiburon Laboratory Administrative Report SC-99-03.

Shapovalow, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Saimo gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California and recommendations regarding their management. California Department of Fish and Game, California. Bulletin ff 98. 375 pp.

Thedinga, J. F., M. L. Mmphy, S. W. Johnson, J. M. Lorenz, and K. V. Kodki. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River. Alaska to predict glacial flooding. North American Journal of Fisheries Management 14:837-851.

Ward, B. R. and P. A. Slaney. 1988. Life history and smolt-to-adult survival of Keogh River steelhead trout (*Saimo gairdneri*) and the relationship to smolt size. Canadian Journal of Fisheries and Aquatic Sciences 45:1100-1122.

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Eric Bjorkstedt. September 2000. National Marine Fisheries Service, Santa Cruz, CA

Scott Harris. October 2000. California State Department of Fish and Game, Willits, CA

John Hendrix. July 2000. California State Department of Fish and Game, Fort Bragg, CA

Aaron Nadig. December 1999. Mendocino Redwood Company, Fort Bragg, CA

David Wright. August 2000. Campbell Timberland Management, Fort Bragg, CA

