ANADROMOUS SALMONID RESOURCES OF MENDOCINO COUNTY COASTAL AND INLAND RIVERS

1990-91 through 1991-92

An Evaluation of Rehabilitation Efforts

Based on Carcass Recovery and

Spawning Activity

FINAL REPORT

August 1994

Salmon Trollers Marketing Association

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This work was funded by the California Department of Fish and Game, Inland Fisheries Division, Fisheries Restoration Program. Contract Number FG-9364

ABSTRACT

Spawning surveys were conducted for three years in Mendocino County streams. The results from the last two years of surveys are reported here. Surveys were conducted in seven watersheds in 1991-1992 and in ten watersheds in 1990-1991. These surveys were conducted as a means of evaluating the effectiveness of restoration efforts to restore salmon populations. The populations of chinook and coho salmon were estimated by several methods including marking and recapture of carcasses, live fish count expansions, and from redd counts. A new model was developed to estimate spawning numbers which incorporated estimates of the average daily retention rate of carcasses. The reliability of estimates are assessed in two streams where known numbers of fish were released. In both areas, carcass and live-based estimates were well below the actual number of fish released; 8-15 percent for carcass-based estimates and 21-42 percent for live-based estimates. Redd counts were used to produce a range in spawning estimates which are believed to encompass the actual populations. It was estimated that coho salmon could be expected to produce between 1 and 4 redds per female and chinook salmon between 1 to 1.8 redds per female.

The lower end of the population estimates below are developed from carcass estimates unless the minimum redd-based estimate was higher. The upper range is developed from redd counts with an exception where counts were made at counting stations contributed partial counts. The largest population of coho salmon was found in the South Fork Noyo where the run is enhanced through artificial production. This run is estimated to have been between 414 and 1006 in 1991-1992 and between 225 and 399 in 1990-91. The remainder of coho runs surveyed were supported by natural production only. The Hollowtree Creek coho run was about 120 fish in 1991-92 and between 44 and 76 in 1990-91. Caspar Creek had between 55 and 196 in 1991-1992 and between 8 and 28 in 1990-1991. Little River had between 14 and 32 in 1991-1992 and only a single pair in 1990-91. The Pudding Creek coho run was between 28 and 102 in 1991-92 and in 1990-91 between 11 and 74. The Ten Mile coho run was between 14 and 42 and its chinook run between 51 and 154 in 1991-92. The chinook run in Hollowtree Creek was between 290 and 420 in 1991-92 and between 24 and 53 in 1990-91. The 1991-92 chinook run was composed of 5, 5, 51, 35 and 3 percent age 2, 3, 4, 5 and 6 year old fish, respectively. Returns from hatchery released chinook composed 10 percent of the age four Hollowtree fish.

Restoration activities were related to salmon production in several ways. Of five streams into which coho were reintroduced by the CA. Dept. of Fish and Game planting of yearling coho, only one had spawning activity believed to be returning coho adults from plants although low flow conditions may have prevented coho from entering planted streams. Introductions of chinook salmon into the Ten Mile River have resulted in natural chinook production. Habitat restoration activities could not be linked to improved coho or chinook salmon production in Mendocino County streams although other factors such as changes in ocean survival rates may mask benefits. In some areas, low water conditions are believed to have negatively impacted the number of fish that spawned.

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INTRODUCTION

Rivers of cool, clear water once tumbled down river valleys, propelled through deep dark pools embraced by an abundance of moss covered logs and surrounded by lush stands of giant conifers and water loving alders. These were the conditions that great abundances of salmon once met on their return from the sea. These were the conditions in which they evolved; the conditions they encountered as they emerged from the gravel of their birth and to which they returned to spawn, digging their redds perhaps, down into the exact spot from which their life began.

As conditions in the streams have deteriorated so too have the numbers of salmon declined. With river systems and salmon runs now only remnants of what they once were, those who wish to see rivers alive with spawning fish try, as best they can, to restore these runs of salmon; to try and recreate again this once mighty resource. In this endeavor we have, through the expenditure of many millions of dollars, funded stream enhancement work, reared and released into the wild millions of artificially produced young fish, passed laws to limit degradation to natural environment and restricted the take of salmon. While we continue these efforts, we do it with strong desire and commitment and with the presumption that what we are doing is beneficial; that the natural production of salmon in our streams will increase from our efforts.

The streams of Mendocino County have undergone extensive restoration activities during the last 30 years. There have been many artificial propagation programs and our fisheries have been heavily curtailed, while at the same time, little to nothing has been done to monitor the population levels of salmon and steelhead in Mendocino County. In this study, it was hoped, that through a spawning survey one could assess the extent to which salmon were using streams for spawning. This would tell us whether salmon runs were present in these "restored streams" and give us an indication as to the magnitude of these runs. Streams initially selected for surveys were those that significant restoration work and/or artificial propagation had occurred. In addition, California Department of Fish and Game requested that several streams be included in surveys as part of an effort to establish index areas for monitoring purposes.

In the first year (the 1989-90 spawning season), 82 streams and tributaries were surveyed. An initial report (Nielsen, J.L. et.al. 1990) reported the finding and included an evaluation of various spawning population estimation models. This report presents the results from the last two years of surveys and discusses the overall results from the three year survey in relation to the restoration activities that have occurred in these streams. The streams and their locations are shown on Figure 1.

This study was carried out as an initial investigation as to the state of the salmonid runs in streams where restoration efforts have been conducted. This survey was funded through the California Department of Fish & Game Fisheries Restoration Program; contract number FG9364,

METHODS

Survey methods used are described in detail in Nielsen, et al., (1990). In brief, spawning ground surveys were conducted where salmon carcasses were tagged with colored hog-rings in the lower jaw. The color was alternated weekly to establish mark-recapture data. Counts of redds and live fish were made during each survey;
one change from the initial survey year is that all redds were flagged to prevent recounting on following surveys. In addition, flow and turbidity data were collected. Most streams were surveyed on a weekly basis unless conditions were unsuitable. Ail carcasses were tagged with hog-rings if there were jaws present. Skeletons without jaws were tagged with a hole punch if the tail was present and notes were taken where skeletons of fish were found which could not be tagged. Only jaw-tagged carcasses were used to determine recovery rates. All carcasses that were measurable were measured (fork length) and a scale sample was taken for age determination. Fish carcasses were also examined for adipose fin clips for Coded-Wire-Tag (CWT) recovery. All stream surveyors were experienced-having participated in the initial survey in 1989-90.

The standard area-under-the-curve (AUC) estimates (Beidler and Nickelson, 1980) of spawning population based on carcass and live fish counts are made in this report. This model estimates the population of spawning salmon by dividing the integral of the escapement curve by the average residence time of fish in the survey area. Since counts of live fish include fish that are not always identified to species, the total estimate from live fish counts are apportioned based on the fraction that each species composed within the group identified to species. No estimate of the life span of a spawning fish was estimated in this study so the 11 day average (Beidler & Nickelson, 1980) was used. The AUC procedure for carcasses data is the same as for live fish data only the mean carcass duration was estimated based on tag and recapture data from each streams. None of the streams sampled had sufficient number of tags or tag recoveries to preform the Jolly-Sober estimates or the nonparametric area-under-the-curve model used to estimate populations in some of the streams in the 1989-90 survey (Nielsen, et. al., 1990).

The Jolly-Seber model used for population estimation in two stream areas in the 1989-90 survey report was not used as too few carcasses were tagged to utilize this model. The low numbers of carcasses found in these surveys and the general low number of spawners/carcasses in the smaller coastal streams preclude the use of the Jolly-Seber model in most instances.

A new model was developed based on the observed carcass retention rates found during this study. This model, called here the Carcass Retention (CR) Model, has one basic assumption:

> That carcasses deposited during a survey interval were deposited evenly throughout that interval

One other inherent assumption is that carcasses disappear from spawning areas or become non-taggable at a constant daily rate. While one might expect fresh carcasses to disappear either sooner or later than old or decomposing carcasses, recovery data suggests that their rate of disappearance, or alternatively, their rate of retention, is constant. With this assumption, and the ability to estimate this rate based on the recovery of tagged carcasses, an estimate of the number of spawners can be made.

Carcass Retention Model

This model assumes that there is a constant daily rate of carcass retention, meaning that, for each day after carcass deposition, a constant fraction of those carcasses disappear or become untaggable and that fraction remains constant throughout the spawning period. The model assigns the number of carcasses found during a survey to each day in the interval between surveys by weighing each day by the likelihood that a carcass deposited would still be there when the survey was conducted. For example, if a survey was conducted on a seven-day interval, a carcasses deposited on the first day will have a much lower probability of being found than a carcass deposited the day prior to the survey. The model calculates the new carcasses population in the survey interval as:

$$\text{New Population (survey i)} = \frac{CxDays}{\sum_{i=1}^{Days} D_1^{\,i}}$$

Where: D_1= Daily carcass retention rate
C= Number of carcasses found survey i
Days = # of Days in survey interval

If D_1=0.5, Days=3 and C=90 the new carcass population would be:

$$\frac{90 * 3}{.875} = 308$$

Alternatively, if all fish did not die evenly throughout the period and died the day prior to the survey, the carcass population estimate would have been 360, or, if all died three days before the survey, the new carcass population estimate would have been 720.

It is important to note that the estimates made in this report do not account for carcasses not recovered until a second or third survey after tagging. This did happen and accounting for this does increase the carcass population estimates. The methods used here assume all carcass found in a survey were deposited since the last survey. No accounting for delayed recoveries of carcasses was done in this report since it added a considerable greater amount of calculation and where this was attempted in the key control reaches, the increase in the population estimate did not significantly improve the results to warrant its use. This model has not been gone through a rigorous testing but is presented here to advance a methodology which can be readily utilized in a stream which has low population of fish and carcasses. It is hoped that a more in-depth review of the CR models premise will occur from its use here.

In each stream or stream section, an estimate of "carcass retention" is made unless too little tagging data was collected to make this estimate. The retention curve that best represents the recovery data points is the retention curve that is selected. It was necessary to make average recovery rate estimates by lumping and weighing data. For example, where the spawning survey interval was 7 days and 20 carcasses were tagged of which 4 were subsequently recovered, and, in a later survey, where the interval was 8 days and 2 fish were tagged of which none were recovered, the data was weighted and lumped as shown below:

$$\frac{7*20 + 8*2}{22} = 7.09 \text{ days} \quad \text{and} \quad \frac{4 \text{ recoveries}}{22 \text{ tagged}} = 18\%$$

Here, at a period of 7.09 days there was an 18 percent recovery rate. Where too little tagging data was available to estimate carcass retention, a retention estimate from a stream with a similar overall recovery rate, i.e., number of recoveries divided by number tagged from the entire survey, was used.

This same procedure was used to estimate the mean carcass duration for the AUC population estimation. With an estimate of the daily carcass retention rate, the number of days it would take to have a

50 percent carcass retention was estimated.

Redd-Based Spawning Population Estimates

It has been observed that only female salmon do the actual redd digging (Briggs 1953; Shapovalov and Taft 1954) and since in this survey known numbers of females were going to be released at specific locations, the number of redds above that site could be used to establish the average number of redds produced per female. This ratio could then be used to estimate the number of females spawning in other areas. Since the stream surveyors rotated between survey areas, estimates of the number of redds encountered in different survey areas should not be affected by observer bias. The number of female spawners estimated from redd counts were expanded to a total population estimate by assuming that 50 percent of the runs are composed of female spawners. The exception to this is for the South Fork Noyo and Hollowtree Creek data where a large sample of carcasses could be used determine male to female ratios. Over 70 carcasses were identified to sex in these areas. In other areas, carcass numbers were below twenty. The redd-based population estimates are derived from a range in the estimated number of redds dug by female coho varying from 1 to 4 based on data collected in the South Fork Noyo. For chinook, 1 to 1.8 redds/female is used based on data collected in Hollowtree Creek.

Most often, only the redds found through the month of January are used to estimate salmon spawning. In February, most of the redds are made by steelhead but occasionally, where supported by carcass or live fish observations, all or partial February redd counts are also used.

Where both coho and chinook were found in relatively similar numbers, the higher number of redds/female, i.e., 4, was not used and a lower figure used instead. This was done because data collected in this study indicated that chinook were not digging, on average, as many redds as coho, and that using four redds/female to set the lower range of the population size would result in low population estimates. In areas where both chinook and coho occurred together, the ratio of these species found in carcass samples is used to proportion the total salmon population estimates obtained from redd counts.

GENERAL RESULTS AND DISCUSSION

In 1991-92, seven watersheds were surveyed which encompassed 114 miles of spawning area or a total of 443 total survey miles. In Table 1., the number of miles surveyed, the stream reach length, number of surveys conducted, number of live fish per survey mile, number of redds and number of carcasses tagged are given for each stream surveyed in 1991-92. In 1990-91, 240 miles of stream were surveyed in ten watersheds (Figure 1.), encompassing over 90 miles of spawning area. The results of this survey are shown in Table 2. Data for live fish and redds are divided between surveys conducted before and after February 1st. Before February 1st, few steelhead are seen. The December through January data primarily reflect salmon spawning while February data is usually dominated by steelhead.

In 1991-92, there were 159 chinook, 206 coho, 8 steelhead and 5 unidentified carcasses tagged. Total redd counts were 1,159. In 1990-91, 6 chinook, 64 coho, 6 steelhead and 13 unidentified carcasses were tagged and 414 redds counted.

In both survey years, the greatest spawning density as evidenced by the number of live fish and redds was in the lower South Fork Noyo. This higher density is due to the return of hatchery reared coho. In January 1991-92 there were 16 live fish per survey mile and 70 redds per reach mile in the lower South Fork. In 1990-91, 12.7 live fish/mile and 25 redds/mile (R/M) were found in this same reach. Similarly, 99 coho carcasses were tagged in 1991-92 while 51 were tagged in 1990-91.

Caspar Creek, in either its North Fork or mainstem, had the second highest density of January redd counts both years. Other areas which had relatively high January redd densities were Redwood Creek, a tributary to Hollowtree Creek and Bearhaven Creek, a tributary to the Ten Mile River. The highest density of redds in the month of February was found in Pudding Creek in both years. Where normally the majority of February redd counts indicate steelhead spawning, in Pudding Creek, it was due primarily to coho spawning.

In every stream surveyed, the returns in 1991-92 were better than in 1990-91 and in many cases the difference was dramatic. In lower Hollowtree Creek, live fish counts were 11.8/mile in January 1991-92 but only 0.3 in 1990-91; the density of redds were 19/mile compared to 2.4/mile and the numbers of chinook carcasses were 137 compared to 4 in 1990-91. Similarly, Little River which had 0.6 live/mile, 4.3 redds/mile and 11 tagged coho carcasses in 1991-92 had no live fish or carcasses and only a single redd observed in 1990-91.

There were two counts of fish released above a counting station for which complete enough surveys were conducted to make population estimate comparisons. One was a release above the Noyo egg-taking station in 1991-92 and the other a release above the Hollowtree Creek Hatchery in 1990-91. In Table 3. the numbers of fish released are compared to the estimates based on the different population models. Clearly, the CR and AUC Carcass models underestimate the known populations dramatically; estimates are between

8 and 15 percent of the known releases. The live-based estimates also under-estimated the numbers released although not as significantly- between 21 and 42 percent of known releases. Thorough analysis of these estimates in relation to the numbers of fish released are found in the South Fork Noyo and Hollowtree Creek sections of this report.

In Table 4 spawning escapement estimates based on the four different estimation procedures are given for each of the non-control reach streams. The carcass derived estimates should be considered minimal estimates because coho may back downstream before dying and because tagged carcasses appear to have a higher retention rate than the general population of carcasses, especially at low spawning density levels (see the 1991-92 South Fork Noyo survey "Population Estimation" section). With all AUC live-based estimates, it was assumed that the spawning life of a fish was eleven days based on work done in Oregon (Beidler and Nickelson, 1980). The Oregon estimate was for adult fish only and its use here includes grilse. This would not be expected to cause an under estimate since studies suggest grilse coho have a longer stream residence time (Steve Jacobs, ODFW, personnel communication) An eleven day stream residence time was clearly not always appropriate for some coho spawners (See Caspar Creek Section below).

Data in Table 4. would also suggest that carcass-based population estimates are not always low to the degree that they were in the two streams with known numbers of fish released, i.e., only 8 to 15 percent of that released. For example, the lowest carcass-based coho estimates are approximately 30 percent of the <u>high</u> range of the redd-based estimates for the 1991-92 S.F. Noyo, Little River and Pudding Creek runs.

As with the density of redds and live fish, population estimates show that lower numbers of fish spawned in 1990-91. The degree to which the 1990-91 populations are lower seems fairly consistent between both natural and artificially produced runs, indicating that they were likely negatively affected by ocean conditions. The surveys in Caspar Creek and Little River covered essentially all the spawning area and the low population estimates reflect very poor spawning numbers for streams with a recent history of an established coho population. The Hollowtree Creek estimates on Table 4 need to be added to the trap count on Table 3 for complete Hollowtree Creek estimates, indicating that the total run was about half as large in 1990-91.

The timing of coho and chinook runs in 1991-92 and 1990-91 are shown in Tables 5 and 6. Here the number of carcasses tagged and redds flagged can be compared between years and streams. The months are divided into four (roughly week) periods. In 1991-92 redds and carcasses were found as early as the 3rd week of December in Caspar, Ten Mile and South Fork Noyo but not until the first week

Figure 1. Location of Streams Surveyed

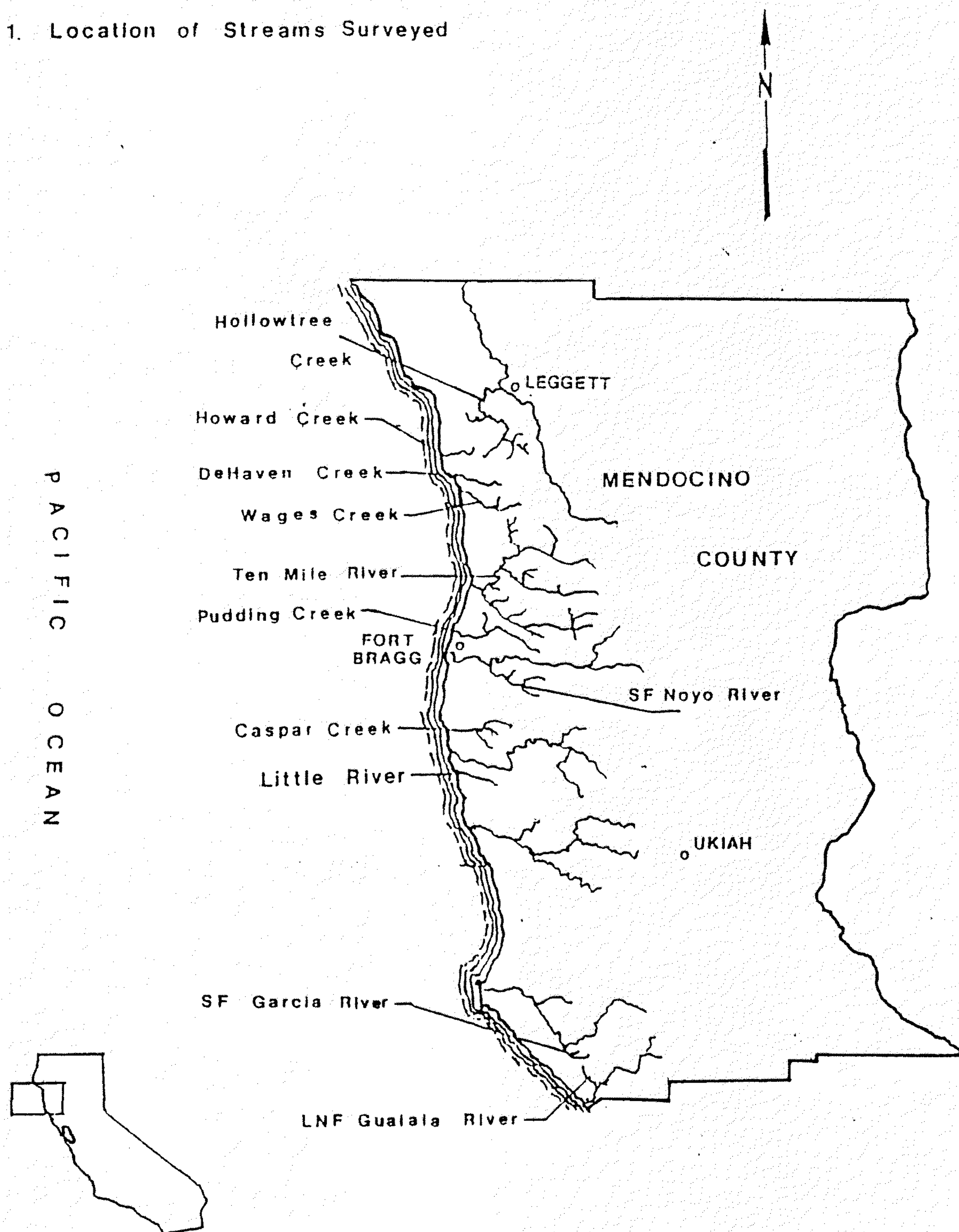


Table 1. Total number of miles surveyed, length of survey reach, number of surveys, number of live fish per survey mile, number of redds and number or carcasses jaw tagged during the 1991-1992 survey

Stream	Survey Miles	Reach Len. (mi)	# Surveys Dec-Jan	Feb-Mar	Live/mi Dec-Jan	Live/mi Feb-Mar	Redds** Dec-Jan	Redds** Feb-Mar	# Tagged carcasses by specie*** Chinook	Coho	Steelhead	Sp.?
Caspar Creek												
Mainstem	25	3	7	2	0.8	0.0	38(12.7)	2(0.7)	0	11	0	0
North Fork	13.3	1.9	5	2	1.4	0.0	54(28.4)	5(2.7)	1	9	2	1
South Fork	2.5	.5	4	1	0.0	0.0	6(12.0)	1(2.0)	0	0	0	0
Middle Fork	.5	.5	1	0	0.0	NS	0.0	NS	0	0	0	0
Hollowtree Creek												
Below Weir	62.4	7.8	6	2	11.8	0.1	151(19)	3(0.4)	126(137)	9	0	2
Above Weir*	30.5	11.3	4	3	3.6	0.8	20(1.8)	43(3.8)	11(14)	13	1	0
Huckelberry Cr	1	1	0	1	NS	0.0	NS	0.0	0	0	0	0
Redwood Cr.	.6	.3	2	0	0.0	NS	8(26.6)	NS	0	0	0	0
Michaels Cr.	.4	.4	1	0	0.0	NS	5(12.5)	NS	0	0	0	0
Bond Cr.	2	2	0	1	NS	0.5	NS	13(6.5)	0	0	1	0
Little River	32	4	5	3	0.6	0.5	17(4.3)	9(2.3)	0	8(11)	0	0
S.F. Noyo River												
North Fork	31.1	3.4	5	4	1.4	0.2	40(11.8)	9(2.6)	0	5(6)	0	0
Up. S.F.	38.9	4.8	5	4	5.7	0.6	76(22.4)	26(5.4)	0	11(17)	0	0
Parlin Cr.	2.2	1	3	0	3.6	NS	2(2.0)	NS	0	0	0	0
Low. S.F.	39	3.9	7	3	16.0	0.6	275(70)	21(5.4)	0	93(99)	0	1
Kass Cr.	11.2	1.6	4	3	5.3	0.0	51(31.9)	12(7.5)	0	13(18)	1	0
Bear Cr.	.5	.5	1	0	0.0	NS	6(12.0)	NS	0	0	0	0
Pudding Creek												
Lower	29.4	4.2	4	3	1.1	1.8	31(7.4)	39(9.3)	0	9(11)	0	0
Upper	20.5	4.1	2	3	0.2	0.3	9(2.2)	18(4.4)	0	0	0	0
Ten Mile River												
North Fork*	25.6	13	3	0	0.3	NS	25(1.9)	NS	0	0	1(2)	0
Bald Hills Cr.	1.9	1.9	1	0	0.0	NS	1(0.5)	NS	0	0	0	0
Little N. Fork	11.3	3.5	2	2	0.6	0.3	7(2.0)	23(6.6)	1	0	0	0
Middle(Clark)*	29.5	14.8	2	1	0.0	0.2	32(2.2)	36(2.4)	6(8)	1(2)	0	0
Bear Haven Cr.	10	2.5	2	2	0.2	0.0	17(6.8)	12(4.8)	0	0	1	0(1)
South Fork*	13.8	14.8	2	0	0.5	NS	14(0.9)	NS	2	1	0	0
Campbell Cr.*	2.4	1.6	2	0	0.0	NS	2(1.3)	NS	0	0	0	0
Smith Cr.	2.8	2.8	1	0	0.0	NS	0.0	NS	0	0	0	0
Willits Cr.	2.5	2.5	1	0	0	NS	0	NS	0	0	0	0

NS- Not surveyed
* Incomplete surveys of reach where fish use is believed likely
** Number of redds per reach mile in ()'s
*** Number in ()'s includes caudal punched carcasses in addition to jaw tagged carcasses

Table 2. Total number of miles surveyed, lenght of survey reach, number of surveys, number of live fish per survey mile, number of redds and number of carcasses jaw tagged during the 1990-1991 survey.

Stream	Survey Miles	Reach Len.(mi)	# Surveys Jan	# Surveys Feb.	Live/mi Jan.	Live/mi Feb.	Redds** Jan.	Redds** Feb.	# Tagged carcasses by specie*** Chinook	Coho	Steelhead	Sp.?
DeHaven Creek	9	3	2	1	0	0	0	0	0	0	0	0
Caspar Creek												
Mainstem	21	3	3	4	.05	1.8	14(4.7)	35(11.7)	0	0	1	1(2)
North Fork	9.5	1.9	1	3	0	1.1	0	20(10.5)	0	0	0	0
South Fork	2.5	.5	1	4	0	0	0	0	0	0	0	0
Garcia River SF	6	2	0	3	NS	0	NS	2(1.0)	0	0	0	0
Gualala River LNF	8.7	2.9	0	3	NS	0	NS	2(0.7)	0	0	0	0
Hollowtree Creek												
Below Weir	46.8	7.8	2	4	.3	.6	19(2.4)	48(6.2)	2(4)	3	0	3(7)
Above Weir *	48.7	11.3	3	6	.3	.2	25(2.2)	35(3.1)	1(2)	2	0	0
Huckelberry Cr	1	.5	2	0	0	NS	2(4.0)	NS	0	0	0	0
Redwood Cr.	1.5	.5	1	2	0	0	1(2.0)	4(8.0)	0	0	0	1(2)
Howard Creek	7.5	2.5	2	1	0	0	0	0	0	0	0	0
Little River	10.5	3.5	2	1	0	0	0	1(0.3)	0	0	0	0
South Fork Noyo												
Lower	26.1	3.9	3	4	12.7	1.1	97(24.9)	30(7.7)	0	33(51)	0	0
Kass Creek	.5	.5	1	0	0	NS	0	NS	0	0	0	0
Pudding Creek												
Lower	26.2	4.2	2	4	0	1.6	2(0.5)	54(12.9)	0	5	3	1(2)
Upper *	7.6	2.9	0	3	NS-0	.9	NS-0	11 (3.8)	0	2	0	0
Wages Creek	16	4	3	2	0	.3	4(1.0)	8(2.0)	0	1	1(2)	0

NS- Not surveyed

NS-0 Not surveyed but assumed to be no fish use because of low flow conditions

* Incomplete surveys of reach where fish use is believed likely

** Number of redds per reach mile in ()'s

*** Number in ()'s includes caudal punched carcasses in addition to jaw tagged carcasses of January in Pudding Creek. A much-delayed run occurred in 1990-91 where redds and carcass were not found until the second week of January in most streams, and in Pudding Creek, not until the second week of February.

Since steelhead do not necessarily die after spawning and the stream surveys were conducted only through late February or early March (which leaves out the later portion of the steelhead spawning period) steelhead populations could not be estimated in this study. From the number of steelhead carcasses, live steelhead observations and February redds some inference of steelhead abundance is possible. The highest density of live steelhead was found in Caspar Creek in February 1990-91 where 1.8 steelhead/survey mile were observed in the lower section and 1.1 steelhead/survey mile in the North Fork. In February of the same year lower Hollowtree and lower Pudding Creek had 0.32 and 0.29 live steelhead/survey mile, respectively. The following year, 1991-92, no steelhead were observed in Caspar or lower Hollowtree Creek in February. Instead, the highest density were observed in upper Hollowtree at 0.79 steelhead/survey mile where none were observed the year before. In 1991-92 the second highest February steelhead density (0.71) was observed in lower Pudding Creek. As for February redd counts not attributed to coho, the highest densities were also found in Caspar and its North Fork in 1990-91 where 11.7 and 10.5 redds/reach mile were found. The second highest that year was in lower Pudding Creek at 6.9 redds/reach mile and third, lower Hollowtree at 4.4 redds/reach mile. For 1991-92, tributaries in the Ten Mile River had highest redd densities. The Little North Fork had 6.0, Bearhaven Creek 4.8, and dark Fork 3.2 redds/reach mile. Upper Pudding Creek also had 3.2 and that was followed by the North Fork Caspar which had 2.6 redds/reach mile.

The redd densities seem to follow steelhead counts fairly closely. One exception was the highest live steelhead density in upper Hollowtree in 1991-92 where the redd density was comparatively low at 1 redd/reach mile. The other exception being the relatively high Ten Mile tributary densities in 1991-92. Since Ten Mile surveys, because of a lower survey priority, tended to be done after other streams were completed, the peak time of steelhead spawning probably occurred several days prior to surveys. It is interesting to note that these were the only areas surveyed in the Ten Mile River during the month of February.

The flow and turbidity data found for 1991-92 are presented in Tables 7 and 8 and in Table 9 for 1990-91. In 1991-92 flow conditions allowed fish to migrate into upstream areas in early January and heavy rains presented conditions which made spawning surveys impossible for two weeks in mid-February. In 1990-91, water flows were quite low due to drought conditions which persisted throughout most of the spawning period except the first week of February. These low flows prevented salmon from spawning in many customary spawning areas and probably delayed spawning in others. The low numbers of fish spawning in 1990-91 in some cases may have been the result of low flow conditions. The chinook run may have spawned in the South Fork Eel rather than enter Hollowtree Creek. There were salmon redds observed just below the mouths of South Fork Noyo, South Fork Garcia, Little North Fork Gualala which would indicate that fish were destined for these tributaries but because of low flows spawned in the mainstem instead. For streams that empty directly into the ocean like Caspar, Pudding, Wages, DeHaven Creek and Little River, this option was not available. Some fish did spawn in Caspar prior to January 16th before any major rain fell, indicating, at least for Caspar Creek, that the lower reaches were accessible under the low flow conditions. Access into Caspar Creek probably came during high tide periods.

The turbidity of the water can influence the ability of surveyors to see fish or carcasses. The streams which tended to have the poorest visibility were lower Pudding Creek and the upper South Fork Noyo. The turbidity in lower Pudding Creek originates in Little Valley Creek and appears to be a natural algal coloration which is present year-around. The South Fork Noyo turbidity is associated with an upstream reservoir.

Table 3. Number of trapped salmon released into areas above the Egg-taking Station on the South Fork Noyo and upper Hollowtree Creek and the populations estimated by the CR model, AUC Carcass and AUC Live methodologies and based on Redd Counts

Area	Year	Number Released		Population Estimates: CR Model	AUC Carcass	AUC Live	Redds
SF NOYO	91 - 92	216	coho	28	33	91	NE
HOLLOWTREE	91 - 92	100	coho	NE	NE	NE	NE
		82	chin.	NE	NE	NE	NE
" "	90 - 91	39	coho	6**	3**	8	12-50*
		15	chin.	1**	1**	5	12-50*
		3	Steel.	0	0	3**	NE

NE - No estimate made.

* This estimate takes into account the fact that no chinook females had been released and ignores any redds that may have been dug by the female steelhead. This is a minimum estimate due to the fact that not all areas were surveyed.

** These estimates include fish that are believed to have passed into the survey area after the counting station was removed

Table 4. Spawning Estimates of Coho and Chinook Salmon based on CR model, AUC Carcass, Live counts and the number of Redds by year.

Stream	Season	Species	Population Model			
			CR	AUC Carc.	AUC Live	Redd
Low. SF Noyo	1991-92	coho	151	100	210	172-688
" "	1990-91	coho	80	87	102	63-254
Low. Hollowtree	1991-92	chin.	205	261	350	189-338
" "		coho	13	10	15	11-22
" "	1990-91	chin.	4	3	3	9-38
" "		coho	5	4	3	7-28
Caspar Creek	1991-92	chin.	4	5	-	-
" "		coho	55	80	15	49-196
" "	1990-91	coho	0	0	2	8-28
Dehaven Creek	1990-91	-	0	0	0	0
SF Garcia	1990-91	coho	0	0	0	0
LNF Gualala	1990-91	coho	0	0	0	0
Howard Creek	1990-91	-	0	0	0	0
Little River	1991-92	coho	14	9	23	8-32
" "	1990-91	coho	0	0	0	2
Pudding Creek	1991-92	coho	28	45	40	26-102
" "	1990-91	coho	11	10	11	20-74
Ten Mile River	1991-92	chin.	-	-	-	51-154
" "		coho	-	-	-	14-42
Wages Creek	1990-91	coho	2	2	0	2-8
Willits Creek	1991-92	-	0	0	0	0

Table 5. Number of Carcasses Tagged and Redds Observed during the 1991-92 survey by week.

	DECEMBER		JANUARY				FEBRUARY				MARCH	
Stream	3RD	4TH	1ST	2ND	3RD	4TH	1ST	2ND	3RD	4TH	1ST	2ND
COHO CARCASSES												
Caspar	0	0	2	11	7	0	0				0	0
Holl.T.	0	6		0	1	12	9				1	1
L.River			1	5	1	1	1	0			1	1
SF.Noyo	5	6	15	30	49	11	22	0			1	0
Pudd.Cr			0	3	3		4				1	0
Ten Mile	0	0	0	1	1	1					0	
CHINOOK CARCASSES												
Caspar	0		0	0	1	0	0				0	0
Holl.T.	0	1		6	19	103	19				0	0
Ten Mile	0	0	1	0	1	9					0	0
STEELHEAD CARCASSES												
Caspar	0	0	0	0	2	0	0				0	0
Holl.T.	0	0		0	0	1	0				1	0
SF.Noyo	0	0	0	0	0	1	0	0			0	0
Ten Mile	0	0	0	1	1	0					1	0
NUMBER OF REDDS												
Caspar	10	1	53	29	5	0	2				4	2
Holl.T.	0	34		46	28	75	37				20	2
L.River		4	6	4	2	1	3	0			3	3
SF.Noyo	33	173	113	104	8	18	42	4			9	13
Pudd.Cr			6	21	13		25				24	8
Ten Mile	1	3	1	38	22	25	0				71	

Table 6. Number of Carcasses Tagged and Redds Observed during the 1990-91 survey by week.

	DECEMBER		JANUARY				FEBRUARY				MARCH	
Stream	3RD	4TH	1ST	2ND	3RD	4TH	1ST	2ND	3RD	4TH	1ST	2ND
					COHO CARCASSES							
Holl.T.				0	0	0	0	1	3	1		
SF.Noyo				7	19	7	12	3		3		
Pudd.Cr				0		0	0	1	4	2		
Wages Cr				0	0	0	1	0				
					CHINOOK CARCASSES							
Holl.T.				6	19	103	19					
					STEELHEAD CARCASSES							
Caspar					0	0	0	0	1	0		
Pudd.Cr				0		0	0	1	2	0		
Wages Cr				0	0	0	0	2				
					NUMBER OF REDDS							
Caspar					14	0	10	12	23	10		
SF Garcia							0	1	1			
LNF Guala.							0	2	0			
Holl.T.				0	17	30	9	31	32	5		
SF.Noyo				60	19	18	14	6	5	5		
Pudd.Cr				0		2	5	34	16	8		
Wages Cr				0	3	1	1		7			

Table 7. Flow estimates from the 1991-92 surveys. Flows are given in cubic feet per second.

	WEEKS- SUNDAY THROUGH SATURDAY												
	DECEMBER				JANUARY				FEBRUARY			MARCH	
	15_21	22_28	29_4	5_11	12_18	19_25	26_1	2_8	9_15	16_22	23_29	1_7	8_14
	FLOWS IN CUBIC FEET PER SECOND												
Caspar Creek													
Mainstem	5.7		3.5	24.4	3.9	3.5	4.2	9.9			21.9		13.4
North Fork			3.2	30.7	4.6	2.1	2.5	7.1			17.7		13.8
South Fork				13.4	1.1	.7	.7				7.1		4.6
Middle Fork				3.5									
Hollowtree Creek													
Below Weir	18.7		49.8	145.5	37.8	30.4	62.2	55.8					295.2
Above Weir				63.9	34.3	20.5		56.5					67.4
Huckelberry Cr.											14.5		
Redwood Cr.							3.9						
Michaels Cr.							7.1						
Bond Cr.											10.6		
Little River			6	22.2	3.5		14.5	5.6	23.7		11.6		6.7
South Fork Noyo													
Lower	4.9	10.9	61.8		19.1	14.1	32.8	26.8			125.7		55.1
Kass Cr.			9.2		2.5		2.8		81.2		6		3.9
North Fork				50.9	3.2				123.6		24.7		11.6
Upper			5.7	29.7	9.2	4.2	14.1	7.8	54.4		32.5		11.3
Parlin Cr.				10.2	2.5								
Pudding Ceek													
Lower			11.6		9.5			23.3			47.3		
Upper				11.7	3.9			7.8			17.3		7.4
Ten Mile River													
North Fork		16.2			21.9								
Bald Hills C.							8.5						
Little N. Fork				40.3	5.6				62.5		21.9		
Middle (Clark)		14.5			17.3						84.4		
Bear Haven Cr.					6				83		16.6		
South Fork					13.1		13.8						
Campbell Cr.				24.7									
Willits Creek				10.9									

Table 8. Estimated carcass visibility depth (cm.) found by survey week during 1991-92 spawning surveys

WEEKS- SUNDAY THROUGH SATURDAY

STREAM	DECEMBER 15_21	22_28	29_4	JANUARY 5_11	12_18	19_25	26_1	FEBRUARY 2_8	9_15	23_29	MARCH 8_14
Caspar Creek											
Mainstem	110	130	>100	40	>100	>120		110			80
North Fork			>100	20	>100	>120		110		70	100
South Fork				35	>100	>100				80	50
Middle Fork				25							
Hollowtree Creek											
Below Weir	>200		90	>140		>100	>100	>160			>160
Above Weir				>140	>100	>100	>140	>140		95	>140
Huckelberry Cr.										95	
Redwood Cr.						>100	>60				
Michaels Cr.							>60				
Bond Cr.										>100	
Little River			>120	25	>120	>120	45	95	20	>90	>90
South Fork Noyo											
Lower	>140	>200	70(140)	90	>140	>120	>140	>100		55	>160
Kass Creek			>100	75	>50		75	90	15	50	95
North Fork				20(100)	>140		95	>100	30		>160
Upper			85	50	120	120	40	110	35	75	90
Parlin Creek						>120					
Pudding Creek											
Lower			65	30	75	70		35		55	
Upper				45				>100		70	>100
Ten Mile River											
North Fork	130	>160	70		>120						
Bald Hills C.							>100				
Little N. Fork				70	>120		>100		50	>100	
Middle (Clark)		>100			>100	>120	85			140	
Bear Haven Cr.					>90				40	>100	
South Fork					>100		>100				
Campbell Cr.				70			>100				
Willits Creek				80							

Table 9. Flow and turbidity data taken during 1990-91 surveys. Flows are given in cubic feet per second and depth at which carcasses were visible are shown as observable depth in centimeters.

	WEEKS SUNDAY THROUGH SATURDAY													
	JANUARY				FEBRUARY			JANUARY				FEBRUARY		
	13_19	20_26	27_2	3_9	10_16	17.23	24_2	13_19	20.26	27_2	3.9	10_16	17_23	24_2
STREAM	FLOW(CFS)							OBSERVABLE DEPTH (cm)'s						
DeHaven Ceek	7.8		3.9	16.2				>92		>75	70			
Caspar Creek														
Mainstem	6.0	2.8	2.1	18.1	3.9	2.8	2.1	>120	>120	120	50	>120	>100	>120
North Fork		1.4		9.5	2.1	1.9	1.1		>100		50	>140	>120	>100
South Fork		.4		1.8	.7	.4	.4		>100		47	>60	>120	>100
Garcia River, SF			1.8	6.1	2.8					>100	>100	>120		
Gualala River, LNF			2.1	6.7	4.2					>120	>130	>100		
Hollowtree Creek														
Below Weir	31.4		15.5	90.8	42.1	32.5	21.2	>200		>120	>180	>150	>200	>120
Above Weir		15.2	11.3		24.7	18.1	10.6	>110	150	>150	>180	>150	>150	>200
Huckelberry Cr.		2.8	1.1						>100					
Redwood Cr.			1.1		4.9	3.2				>100		>100	>130	
Howard Creek	4.2	3.5		8.8				>110	>95		100			
Little River	3.2	6.1		3.9				>100	>100		>120			
South Fork Noyo														
Lower	11.3	3.9	4.6	34.3	7.8	5.9	6.7	>180	>120	>150	40	>150	>150	>130
Kass Creek	.7	.7							>120					
Pudding Creek														
Lower	4.9	1.8	1.4	21.2	10.6	4.9	3.2	70		>180	35		>130	>130
Upper				12.1	3.9		1.4				73	>100		>100
Wages Creek	5.3	8.8	9.5	29.7	5.6			>100	>100	>120	90	>120		

RESULTS AND DISCUSSION FOR TWO STREAMS WITH KNOWN NUMBERS OF FISH RELEASED IN KEY SECTIONS

In the following section the results of spawning surveys and population estimation in the South Fork Noyo and Hollowtree Creek are presented. In both cases known numbers of fish were released in the upper portions of these streams which allows comparisons between population estimates and numbers released to be made. From the information obtained in these stream surveys, procedures used to estimate population in the "non-control" streams, are developed and presented in the "Summary Population Estimation Testing" portion of this report section.

SOUTH FORK NOYO RIVER

An egg-taking facility located on the South Fork is operated by the California Department of Fish & Game (CDFG). Coho salmon are trapped here to collect eggs to support a artificial propagation program. The juvenile coho are planted as yearlings into the South Fork and the trapping station is used as an imprinting facility. Surveys on the South Fork Noyo River are divided into two areas;

those above the Egg Taking Station and those below (see map Figure 2). The lower area has two reaches, Kass Creek (1.6 miles) and the lower South Fork (3.9 miles). The upper area is divided into several reaches; the North Fork (3.4 miles). South Fork from the egg-taking station to Parlin Cr.(2.4 miles), Parlin Cr. to Dam spillway (2.4 miles), Parlin Cr.(1 mile) and Bear Cr. (0.5 miles). We did not survey the upper areas of the North Fork or Parlin Creek in 1991-92 because too little spawning activity was found below these areas to indicate that spawning activity in upper areas was likely. In 1990-91, no surveys were conducted above the egg-taking station since no coho were released above the station.

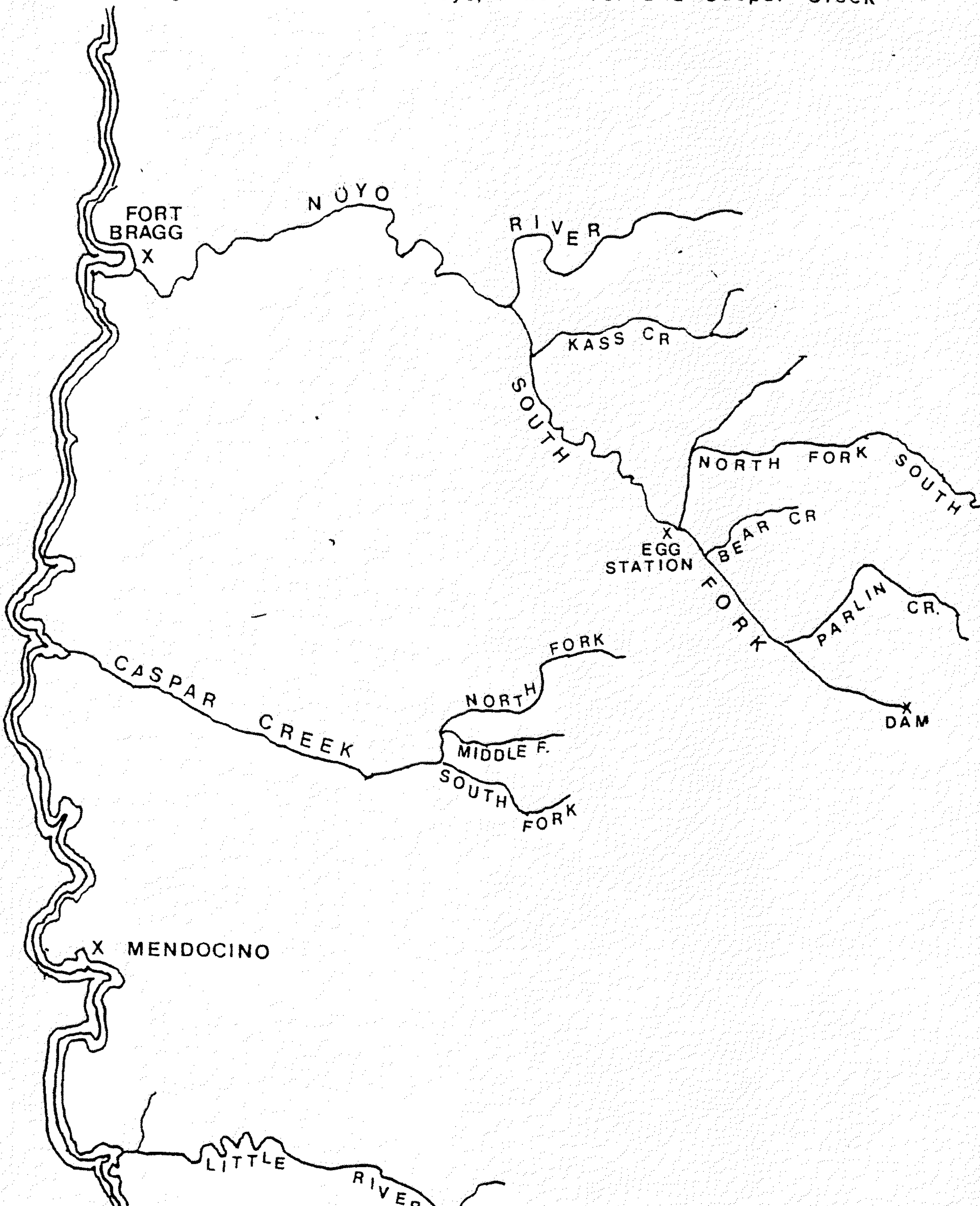
1991-1992 SURVEY

Between December 28th and January 9th, 216 coho (81 males, 38 females and 97 grilse) were released above the egg-taking station. From the 10th to 23rd of January the trap was left open during a period of low water and it is believed that no fish passed through (Alan Grass CDFG, personnel communication. 1992). From the 23rd to February 2nd, no additional fish were released upstream. From February 2nd. to February 23 fish could pass the egg-taking station without being counted.

Surveys Above the Egg-taking Station

In Table 10 the chronology of coho releases can be compared to the

Figure 2. South Fork Noyo, Little River and Caspar Creek



numbers of live fish observed, number of redds counted and carcasses tagged in areas above the egg-taking station. On December 2nd the two major spawning areas above the station were first surveyed. Twenty-three live fish were observed in the South Fork Noyo between Parlin Creek and the Egg Station; no live fish were found in the North Fork. These surveys were conducted 3 to 5 days after 119 coho (19 females) had been released. There were 27 redds observed and 3 carcasses found.

By the 5th of February a peak live count of 52 fish had been observed, 142 redds counted and 20 coho carcasses tagged, including

7 adult (3-year-old) males, 2 adult females, 2 male grilse (2-year-old), and 1 female grilse. Females carcasses were 25 percent of the carcasses found. This compares to 18 percent of released being female. After February 5th there were 21 redds counted, one coho carcass tagged and a total of nine live fish observed (1 coho and 8 steelhead). Of 16 carcasses tagged with jaw tags, 7 (44%) were recovered.

Of the fish released above the egg-taking station, eight percent were found as carcasses. The peak live fish count was only 26 percent of the number released. The measurable adult carcasses found represented only 8.8 percent of the number of adults released and the grilse carcasses represented 3.1 percent of grilse released.

Surveys Below the Egg-taking Station

The results of lower South Fork Noyo surveys and the number of fish taken at the egg-taking station are shown on Table 11. It can be seen that spawning occurred prior to the first survey on Dec. 17th where 33 redds were observed.

In the lower South Fork a peak live count of 201 was observed on December 30th. There were 275 redds by January 29th and 21 more in February. There were 99 carcasses tagged. The sex, age and lengths of the measurable portion of these tagged fish is found on Table 12. Adult males and females composed 26 and 40 percent of carcasses while male and female grilse composed 31 and 3 percent of carcasses, respectively. Of 92 carcasses tagged with jaw tags, 36 (39%) were recovered.

The peak count of 201 live fish represents fish that did not enter the facility during that early run since only 3 fish entered the station over the next three days. A second run of fish came through from the 3rd to 9th of January, coincident with rain and increased flows. Relatively few additional fish spawned in the lower section after the initial period, evidenced by low numbers of new redds found. A surprisingly few live fish were observed on January 3rd, just 4 days after observing 201 even though visibility improved

TABLE 10. The Number of Coho Salmon Released above the Egg-taking Station in 1991-92 and the Number of Live Fish, Redds and Carcasses Tagged by Date in the North Fork, South Fork from the Egg-taking Station to Parlin Creek (SF R-1), South Fork from Parlin to Dam Spillway (SF-R2), Parlin and Bear Creeks.

	DATE																										
	DECEMBER				JANUARY																	FEBRUARY				MARCH
	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	13	14	15	20	22	28	29	4	5	11	25	10
Num. Rel.*	39	61	16	3	0	0	9	0	4	45	25	8	6	0							0	0				0	
	Number of Live Fish Observed																										
North Fork						0				0			18				4				2		0		0	0	3
SF R-1						23						14				40				16	9		6		2	3	1
SF R-2												14						0	1			0		0	0	0	0
Parlin Cr.												4						3	1								
	Number of Redds Counted																										
North Fork						4				0			23				9				4		2		3	1	3
SF R-1						23						16				16				4	4		10		1	3	8
SF R-2												12						3	1		1			2	0	1	1
Parlin Cr.												2						0	0								
Bear Creek																6											
	Number of Coho Carcasses Tagged																										
North Fork						3				0			1				0				1		0		0	0	0
SF R-1						0						1				2				2	2		8		0	1	0
SF R-2												0						0	0			0		0	0	0	0
Parlin Cr.												0						0	0								

* From 1/10 to 1/23 the trap was left open but it is believed that no fish passed because flow conditions were very low. From 1/23 to 2/1 coho yearlings were held in egg-taking station. No spawners were trapped although it is possible that a fish could have jumped the screen and passed upstream. From 2/2 until 2/23 the trap was left open. On 2/24 trap was operated while imprinting yearlings for 10 days. - No fish were trapped but it is possible a fish could have passed.

TABLE 11. The Number of Coho Trapped at the Egg-taking Station and the Number of Live Fish and Redds found and Carcasses Tagged in the Lower South Fork and Kass Creek in the 1991-92 Survey.

	DATE																												
	DECEMBER						JANUARY																FEBRUARY					MARCH	
	17	23	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	14	15	22	29	4	5	12	25	26	10	11
Coho Trapped			134	165	55	3	0	0	11	1	10	79	34	15	2	0	0	0				0				0	0		
Lower South Fork Noyo River																													
Live Fish	0	20			201				89							74				43	6	24	7			0		0	
# Redds	33	61			117				25							14				16	3	6	21			0		0	
Carcasses	0	5			6				8							17				18	25	5	14			0		1	
Kass Creek																													
Live Fish								15								16				3		0		0			0		0
# Redds								39								5				4		3		7			4		1
Carcasses								4								9				4*		1		0			0		0

* Includes one tagged steelhead

Table 12. The Number (%), Average Length and Range (fork length cm.) of coho salmon carcasses found in the lower South Fork Noyo in 1991-92 by age and sex.

	MALES			FEMALES		
Age	Number	Ave.Len.	Range	Number	Ave.Len.	Range
2	22	47.1	42-50	2	48.0	46-50
3	19	64.5	45-71	29	63.8	49-73

markedly. Between the live fish counts in lower South Fork and Kass, carcasses tagged and fish entering the Egg Station, only 130 fish can be accounted for on January 3rd. A minimal estimate (minimal due to turbidity conditions when the 201 live fish were observed) of 71 fish are unaccounted for after just 4 days. It is possible that some of these fish backed out of the South Fork and into the Noyo River.

In Kass Creek, surveys were conducted 8 times from January 2nd to March 11th. The peak live count was on January 10th at 16 coho. There were 51 redds were counted in January and 12 in February. A total of 15 carcasses were tagged including two adult males, two adult females, two male grilse and one steelhead (48 cm.in length). Of 14 tagged with jaw tags, 5 (36%) were recovered.

Population Estimation

In the area above the egg-taking station 38 females (adults and grilse) were released. Redds found in the upper South Fork surveys through February 5th are considered to have been made by fish counted through the egg-taking station. Those found after that date are considered to have been made by fish that entered upper South Fork uncounted. With a count of 142 redds and a release of 38 females, the number of redds constructed per female would be 3.7 if all of the females released did spawn above the egg-taking station.

In the lower South Fork, there were 296 redds by February 5th (none after this date). If this ratio (3.7:1) to were to hold for areas below the station, the number of spawning female coho would be 80. For comparison purposes, it would be good to be able to convert the number of females into a total run estimate. Females composed about 43 percent of the carcasses found in the lower South Fork this year, indicating that the total coho run was about 186 fish. This number is slightly below the peak live fish count of 201, indicating that the 3.7 figure may be too high for this area.

In the area above the egg-taking station, 21 redds were found after February 5th and during this period one live coho and 8 live steelhead were observed. Using the percent composition of coho in live fish counts to indicate the percentage of February redds that were coho redds, two coho redds would be estimated. Only a single pair of coho would be expected to have spawned in this area after February 5th.

To use the carcass retention (CR) model to estimate the number of spawners above the egg-taking station, an estimate of the average daily carcass retention must be made. Table 13 shows , for the all areas above the egg-taking station combined, the number of carcasses tagged and recovered under the survey intervals experienced. By lumping the days from 5-9, the recovery rate is 40 percent for a seven day averaged interval. The longer intervals had no recoveries although it is fair to expect that had more fish been tagged, some recoveries would have occurred. A constructed daily retention rate curve based on a daily retention rate of .86 passes through the 40 percent retention point estimate after seven days (see Figure 3.) and so was selected as the retention rate to model this population. [1] With this retention rate the CR model estimates a spawning population of 28 fish.

Table 13. The Number of Days between Surveys, Number of Jaw Tags and the Number of Tags recovered in the Upper South Fork Noyo in 1991-92

Days	Tagged	Recoveries
5	1	0
7	13	6
9	1	0
12	1	0
14	1	0
16	1	0
19	1	0

In the lower South Fork Noyo the carcass retention rate was .86 as well. The fit of the retention curve to the South Fork data is shown in Figure 3, where the retention curves for both the 1991-92

[1] The .86 retention rate here matches that found for the lower South Fork Noyo this year which was based on significantly greater numbers of tagged and recovered carcasses.

and 1990-91 South Fork data are shown. Using the retention rate selected, the CR model estimate for the lower South Fork is 151 coho. In Kass Creek, the CR model estimates that 24 coho spawned.

The spawning population above the egg-taking station based on the AUC method is 33 coho where a average carcass duration of 4.7 days was estimated. An AUC estimate based on live fish is 91 coho.

In the lower South Fork, the AUC carcass method would estimate 100 coho spawners and from live counts an estimate of 210 is obtained. In Kass Creek, the estimate of coho spawning is 22 fish with both live and carcass methods.

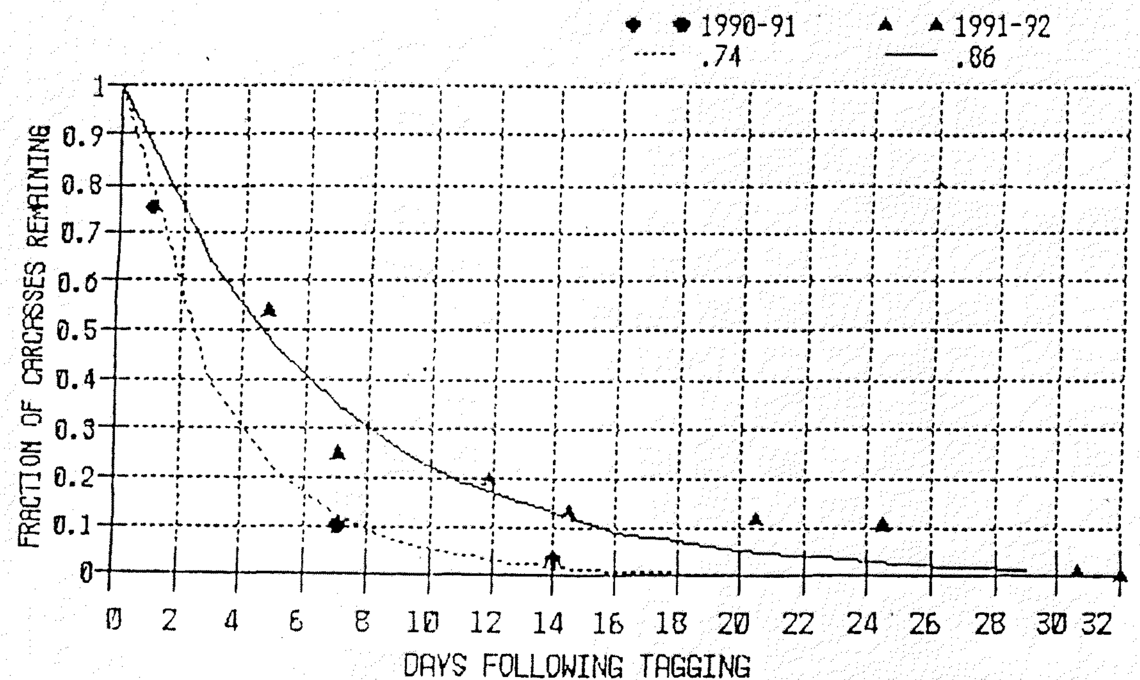
The CR and AUC carcass model estimates are about 170 fish short of the 216 coho released above the station and the live-based estimate is 125 fish short.

Part of this error may be due to the ability of fish released above the station to back down and drop over the dam. In the initial planning of this survey, it was intended that fish released above the egg-taking station would be marked so that if they dropped back down they could be identified. As this did not happen, it could be assumed either that fish released did spawn above but drifted downstream to die, or that they did not spawn above and instead backed down to spawn below. A study conducted in three tributaries to the Alsea River in Oregon found that of the coho released above a trap only 47, 57 and 61 percent of the coho originally released upstream eventually spawned in those same tributaries (Moring 1975). The majority of the other coho returned back downstream as live unspent fish. The possibility that these fish did construct redds but did not actually spawn is quite possible. Briggs (1954) found that when examining coho redds 54 percent were false or trial redds containing no eggs.

Another potential problem is that the carcass retention rates of tagged carcass may not represent the retention rates for the population as a whole. If a high proportion of carcasses are being removed from the stream by a predator or scavenger which has a particular territory, the life of a carcass within that territory may be much shorter than in an area which doesn't have that predation. This would be especially true where the spawning population is small and the predator/ scavenger can remove most or all of the carcasses. The surveyor in this instance would be most likely to find fish carcasses outside the territory of the animal where the carcasses found would have a longer retention rate than carcasses found within the territory.

The utility of the AUC live fish estimate based on an assumed "residence time" (Ames and Phinney 1977) or "survey area residence

Figure 3. Averaged Carcass Retention Rates for the Time Intervals Experienced and associated Daily Carcass Retention Curves for the Lower South Fork Noyo River in 1991-1992 and 1990-1991.



time " (Irvine et al. , 1992) for coho is limited. The residence time of coho have been found to vary considerably (Bocking et al. 1988; Perrin and Irvine 1990; Irvine et al. 1992; English et al. 1992) and AUC estimates are very sensitive to observer efficiency (English et al. 1992). Here though, the AUC live estimate comes closer to the number released than do carcass estimates.

The estimates, for the lower South Fork Noyo are 151 and 100 based on the CR and AUC carcass methods. The carcass-based estimates for the area above the egg-taking station are about 170 less than the number released. This indicates that the low carcass-based estimate in the area above the egg-taking station are not simply due to spawners dropping back down over the dam since carcass estimates in the lower section are lower than the 170 fish shortage to start. Assuming the redds/female estimate of 186 coho is correct, there are about 200 carcasses that are unaccounted for by the CR model and 256 using the AUC carcass method.

1990-91 SURVEY

In the lower South Fork Noyo, surveys were conducted seven times from January 16th through February 27th. No surveys were conducted above the egg-taking station because there were no coho released above the station in 1990-91. The egg-taking station did receive 89 adult coho and 56 grilse. (Alan Grass, CDFG, personnel communication, 1992).

On the lower South Fork, a peak live count of 138 was taken on December 16th. There were 51 coho carcasses tagged. The measurable component of this number is shown on Table 14 by number, sex, age and length. One of the males (60 cm.) appeared to be a four-year-old fish having had two years of freshwater growth. Redd counts were 97 in January and 30 in February. Of 30 jaw tagged carcasses, 6 (20%) were recovered.

The estimated carcass retention in 1990-91 was considerably lower than in 1991-92, 74 compared to 86 percent (Figure 2.). This may have been due to the lower number of fish spawning in 1990-91, resulting in a higher predation rate. The estimated spawning population in the lower South Fork Noyo based on CR model is 80 coho. The AUC carcass and live-based estimates are 87 and 102, respectively

Since there were no live steelhead or steelhead carcasses observed, all redd counts in the lower South Fork are assumed to be coho. The 127 redds would indicate 34 females (@ 3.7 redds/female) or 68 total (half of carcasses found were female) coho spawned. Two surveys in Kass Creek in the later half of January found no evidence of fish use.

Table 14. The Number (%), Average Length and Range (fork length cm.) of coho carcasses found in the Lower South Fork Noyo in 1990-91 by age and sex

	MALES			FEMALES		
Age	Number	Ave.Len.	Range	Number	Ave.Len	Range
2	2	45	43-46	1	40	-
3	3	66	62-70	5	59	52-62
4	1	60	-	0		

The fact redd-based estimate of spawners is about 80 percent of that produced by carcass models. This is not be expected since carcass models are expected to produce minimal estimates. To produce similar numbers to carcass and live-based models, the number of redds/female would have to be between 2.5 to 3.2. The number of carcasses in the lower South Fork this year is not influenced by spawners backing down from above the egg-taking station. This may give an indication that the redds/female ratio estimated for the 1991-92 season may not be appropriate for this section of the river or for this year's run and that perhaps an estimate as low as 2.5 may be more appropriate.

REVIEWING SOUTH FORK NOYO POPULATION ESTIMATES

Using the number of fish released above the egg-taking station as a test of population estimation models has not been conclusive. There is no way to explain away all of the discrepancies found. If the 3.7 redds/female is correct and 186 coho spawned below the station in 1991-92, the 151 CR model and the 210 AUC live-based estimates come quite close to that number. But because the estimates above the egg-taking station are low, by 188 fish using the CR model and 125 fish using the AUC live fish-based estimate, these models appear to underestimate populations significantly.

The CR model result was an estimate that was only 13 percent of the number released and the AUC live-based estimate was only 42 percent. If the population estimates below the station are as low as above, the spawning population could be 620 based on CR model shortfall and 500 based on AUC live fish shortfall. For this to be correct, female coho would only be making 1.1 redds on average which does not come close to that observed above the egg-taking station.

There appears to be no way to resolve this discrepancy at this time. For each of the streams surveyed, this report will give the results from each model and to account for the possible error that these models produce, the redd/female estimates will vary using estimates ranging from 1 to 4 redds/female with an exception for streams where chinook make up a major portion of spawning (see

Hollowtree Creek section of this report). In the lower South Fork (including Kass Creek) this range produces estimates from 198 to 790 in 1991-92 and 63 to 254 in 1990-91.

RESTORATION EVALUATION

The runs entering the South Fork Noyo to spawn were the largest of any of the coho runs surveyed. It is not known what portion, if any, of these coho are produced through natural production because they were not marked nor identifiable though scale analysis, therefore, the benefits in terms of increased natural production from these relatively large South Fork Noyo spawning' escapements can not be evaluated. Clearly, in terms of value to fisheries, these planting of yearling coho are beneficial.

The number of coho trapped in the South Fork Noyo were 1,200 to 3,000 during the first 13 years of operation at the egg-taking station (Snyder and Sanders 1979). Since 1977-78, the numbers have averaged much less and exceeded 1200 only twice (Brown et al. 1993). Reduced coho populations since 1976 have occurred throughout Oregon, Washington and California and have been associated with poor ocean survival conditions (Gunsolous 1978; and Bottom et al. 1986) which may be the result of a change in the ocean circulation pattern which occurred in the winter of 1977 (Norton et al. 1985). The 1011 coho that were trapped in the South Fork Noyo in 1989-90 was the forth largest run since 1976 while the 145 in 1990-91 was the second lowest on record.

The South Fork has undergone habitat restoration work as have many salmon streams in California. In the early 1960's, of an estimated 16 miles of habitat in the South Fork and its tributaries, only one mile was classified as in satisfactory condition (Holman, G., & W. A. Evans, 1964) and 15 miles were "improved", or in other words, had log jams removed. Holman and Evans (1964) reported that the main benefit of the log jam removal was not, contrary to popular belief, the removal of impassable barriers but instead creating conditions in which winter flows could remove silt and gravel deposited behind log jams. He also reported a problem that there was a tendency to be over meticulous in clearing of small unimportant debris. These activities probably had a negative impact on coho production by removing from the stream the large woody debris and cover; the critical habitat required by coho (Hoar 1951; Hartman 1965; Ruggles 1966; Bustard & Narver 1975; Nickelson et al. 1992; McMahon and Holtby 1992).

HOLLOWTREE CREEK

Surveys of Hollowtree Creek are divided into two primary areas; 1, below the Hollowtree Fish Hatchery and 2, areas above the fish hatchery (Figure 4.). The area below consists of a 7.8 mile reach of the mainstem of Hollowtree Creek from its mouth to the hatchery. At the hatchery site is a weir where fish can be collected for fish propagation or counted and released above. The area above is divided into several reaches. Some upstream areas were surveyed fairly consistently while others were not surveyed at all.

The mainstem Hollowtree Creek from the hatchery to the confluence of Huckleberry Creek is 11.3 miles. No surveys were conducted above the confluence of Huckleberry Creek. The two primary reaches were from the hatchery to Eastside Rd. sign (2.5 miles) and from Redwood Creek up to Huckleberry Creek (4.6 miles). The 4.2 mile reach between the Eastside Rd. sign and Redwood Creek was not surveyed due to the difficult survey conditions combined with the lack of spawning activity found in prior survey years. This area consists of steep canyons and deep pools where swimming or floating the stream was usually required. In the upper reach (Redwood to Huckleberry), surveyors did not always have sufficient time to complete the entire reach or came out at the wrong location so some surveys did not cover the entire reach. Several tributaries were surveyed, but none on a consistent basis. These included Redwood, Huckleberry and Michaels Creek.

1991-92 SURVEY Lower Hollowtree Creek

The lower 7.8 miles of Hoilowtree Creek was surveyed 9 times from November 25th to March 12th. No evidence of fish use was found until a survey on December 31st. The number of carcasses tagged were 134 chinook, 9 coho and 2 steelhead. The peak live count was 189 on January 10th and there were 151 redds in January and 3 in February. Of 135 jaw tagged carcasses, 49 (36%) were recovered. The number, average length and range in length of aged chinook and coho carcasses found in Hollowtree Creek are shown on Table 15. The chinook run was heavily dominated by 4 and 5 year old fish.

There was a single fish found with an adipose clip. (Tag number B61509). This was a 1987 brood Hollowtree Creek Hatchery release. The hatchery released a total of 51,670 adipose clipped chinook in 1987 out of at total of 189,914 fingerlings. Expanding for untagged fish would indicate that four hatchery released fish from the 1987 brood were in the sample checked for fin clipped fish;

about 10% of the total returns of age four fish. This would indicate that between 12 and 18 of these fish spawned in Hollowtree Creek this year.

This section of river had a lot of bear sign. Fresh bear tracks were often observed. In one survey, about 15 or so carcasses were found along a bear trail which followed the stream. Some of these fish were badly decomposed and uneaten. There was one whole carcass found which had been previously tagged in the stream which the bear had hauled out but did not eat. Many of the carcasses had the top

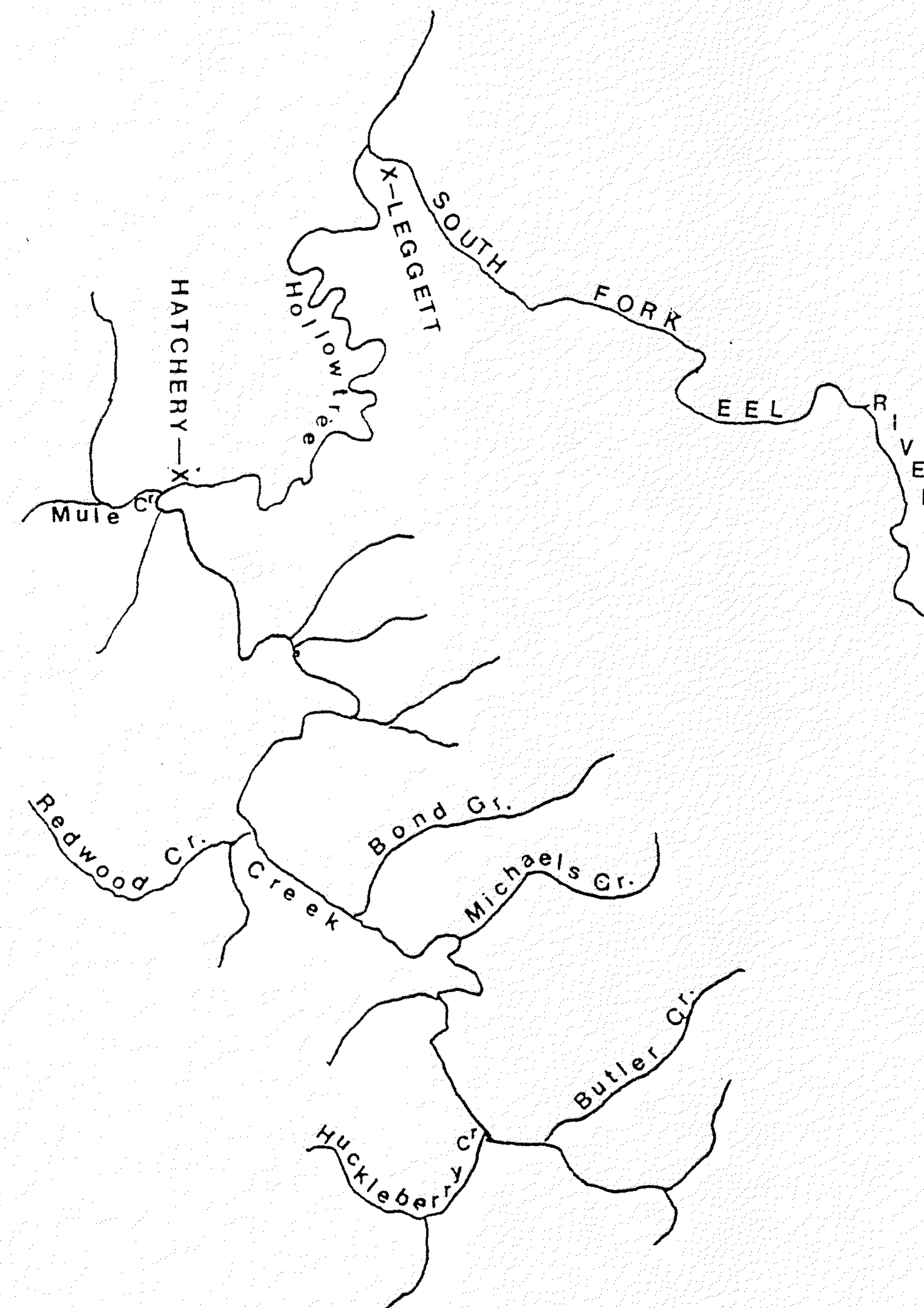


Figure 4. HOLLOWTREE CREEK

of the head and body missing with the remainder of the head, skin, backbone and tail still attached.

The estimated population of chinook salmon in lower Hollowtree is 205 fish based on the CR model where the carcass retention estimate was 0.89. The coho estimate is 13 fish. The AUC carcass-based method estimated 261 kings and 10 coho. The AUC live-based method estimated 350 chinook and 15 coho spawning in lower Hollowtree Creek (using the assumed 11 day average spawner residence time.)

The 151 January redds, using the 1 to 4 redds per female range, would estimate between 38 and 151 females, and with 42 percent of carcasses being female, there were between 90 and 360 total salmon estimated. Clearly, because 189 fish were actually counted on a single survey, estimates below this figure are too low and may indicate that chinook, at least in lower Hollowtree Creek, do not dig as many redds as do the Noyo River coho. With an absolute lower limit of 189 fish and since about 6 percent of carcasses were coho, the range based on redds is 11 to 22 coho and 178 to 338 chinook. The low end of the range is produced with a redd/female estimate of 1.8.

Upper Hollowtree Creek

At the Hollowtree Creek Hatchery, 76 adults and 6 jack chinook salmon were trapped. Of these 77, including 7 females, were released upstream. There were also 100 coho adults (including 52 females) and 3 grilse trapped and released upstream. The first fish was trapped on December 28th and the last on January 11th. (Louis Hans, Salmon Restoration Ass. personnel communication, 1992). The trap was taken down on January 31st and fish could pass without being counted after this date.

The area immediately above the hatchery was surveyed 6 times from January 10th to March 12th, including one incomplete survey on January 23rd. There were 6 chinook and 3 coho carcasses tagged. The peak live fish count was 23 on January 10th. The redd counts were 6 in January, zero in February and 2 in March. Of the 9 jaw tagged fish, 5 (56%) were recovered.

In the area between Redwood and Huckleberry Creek 6 surveys were conducted between January 10th and March 12th. Two of these surveys were from Huckleberry to Bond (3.4 miles), two were from Huckleberry to Michaels Creek (2.2 miles) and one covered the area from Bond to Redwood Creek (1.2 miles). There were 7 chinook, 10 coho and 1 steelhead tagged. The steelhead was a 33 cm. 2-year old male with one year of ocean growth. The peak live count was on March 12 where 11 steelhead were seen. The total redd count was 14 in January and 39 in February. Of the February redd count, 32 of these redds were found on an early February survey that included the area between Redwood and Michaels Creek (2.4 miles) which was not surveyed in the previous survey period; for this reason, these redds are considered to be January redds. Of 15 jaw tagged carcasses only one (7%) was recovered.

In Redwood Creek, surveys were conducted three times. In one of these (January 30th), a distance of 0.3 miles was surveyed above the bridge and the other two, January 23rd and February 6th, the area surveyed was from the bridge to the mouth (0.3 miles). No carcasses or live fish were observed. The total redd count was 6 in January and 2 in February.

Table 15. The Number (%), Average Length and Range (cm.) of Salmon Carcasses found in 1991-92 Hollowtree Creek Surveys by age.

	MALES			FEMALES		
Chinook Salmon						
Age	Number	Ave.Len.	Range	Number	Ave.Len.	Range
2	4(5%)	49	46-52	0		
3	3(4%)	71	70-71	1 (1%)	73	
4	16(21%)	91	83-98	23(30%)	91	78-94
5	19(25%)	94	82-102	8(10%)	93	85-98
6	1(1%)	104		2 (2%)	112	110-115
Coho Salmon						
2	4(25%)	45	41-48	0		
3	7(44%)	62	54-68	5(31%)	62	57-65

In Bond Creek, a single survey on February 27th. found 13 redds, one steelhead carcass and one live steelhead. The steelhead was a male 74 cm. in length. This fish could not be aged because all scales were regenerated but did appear to have had 3 years in ocean. This fish died as it tried to pass a falls but fell between boulders where it became trapped.

One survey on the lower one mile of Huckleberry Creek on February 27th found no evidence of fish use. It was also reported that this Creek was heavily silted.

The single survey in Michaels Creek on January 30th found five redds. No live fish or carcasses were found.

For all survey areas above the hatchery combined, the redd count was 63 in January and 24 after February 6th. There were 13 chinook and 16 coho tagged. These represent 17 and 16 percent of the numbers of chinook and coho released. One of these coho carcasses was found on February 27th and may have came up after the trap was taken down. Out of 24 jaw tags, 6 (25%) were recovered. The low recovery rate of tagged fish (25% compared to 36% below the hatchery) is due in some part, to the incomplete surveys.

Since Hollowtree was not surveyed above Huckleberry Creek, the 4.2 mile middle section, nor in tributaries such as Butler, Waldron and Mule Creeks, the numbers of fish released above the hatchery can't justly be used to test population estimates through the population models. Also, since the numbers of tagged fish could not always be identified as to which portion of the reach they were tagged (because of the incomplete surveys), no recovery rate could be established nor could the number of days between surveys be established for use in carcass models. What can be said is that about one redd was found for each female (coho+chinook) released.

For Hollowtree Creek the combined trap count and lower river estimates produce estimates that range from a low of 260 to 432 chinook and 111 to 122 coho this year.

1990-91 SURVEY Lower Hollowtree Creek

Lower Hollowtree Creek was surveyed 6 times from January 18th to February 28th. Chinook salmon carcasses or remains were found from the first survey until February 20th and coho from February 8th to the 20th. There were 4 chinook, 3 coho and 3 unidentified carcasses tagged. The peak live count was 9 on February 20th, 6 of which, were identified as steelhead. The number of redds were 19 in January and 48 in February. Of 7 jaw tagged carcasses, three (43%) were recovered. There was only one measurable chinook salmon. It was an unusual fish, a 38 cm. 2-year old female. The two measurable coho were males 67 and 59 cm. in length. One of these was a three-year-old male the other possibly a four-year-old fish.

The CR model would estimate 5 coho, 4 chinook and 5 unidentified fish spawning in lower Hollowtree Creek. The AUC carcass-based method estimates 4 coho, 3 chinook and 4 unidentified and AUC live-based estimates are 3 coho and 3 chinook.

In 1991-92, the low end of the redd-based range in population estimates for lower Hollowtree was estimated utilizing a 1.8 redd/female figure (based on the chinook redds/female). The proportion of carcasses that were coho that year was only 6 percent. In 1990-91, of 7 salmon carcasses 3 (42%) were coho carcasses and so the 1.8 redd/female figure is likely too low since chinook appear, at least based on this study, to produce considerably fewer redds per female on average than do coho. The

1 to 4 range would be more appropriate here where the purpose is to have the range encompass the full range likely. The 19 January redds would indicate that between 10 and 38 salmon spawned. In February, out of 14 identified live fish, 2 were coho and 2 were chinook and ten were steelhead. Using these proportions to allot redds, 14 would be salmon and 34 steelhead redds. The total number of salmon redds is estimated at 33, indicating the range for salmon is between 16' and 66. The coho range is from 7 to 28 fish and the chinook range is from 9 to 38 fish.

Upper Hollowtree Creek

At the Hollowtree Creek Hatchery trapping facility, 15 chinook were trapped and released upstream. There were no females trapped so all chinook were released. There were 39 coho trapped and released upstream: 17 males, 21 females and 1 grilse. There were also 2 male and 5 female steelhead trapped and released upstream. The trap began operation on January 6th and ended on February 10th. Chinook were trapped from January 14th to February 9th; coho were trapped from January 13th to February 8th (Louis Hans, Salmon Restoration Ass., personnel communication, 1992).

In this survey season, upper Hollowtree was divided into three sections; the trap to Eastside (2.5 miles), Eastside to Bond Cr.(5.4 miles) and Bond Cr. to Huckleberry Cr. (3.4 miles). Upper Hollowtree Creek surveys began on January 18th and continued until February 27th.

In the trap to Eastside section, one live fish was seen on February 1st, two redds by January 8th and two more on February 27th. One coho carcass was jaw tagged and a chinook tail punched on the 27th of February. In the middle section, one live coho was seen on February 13th and a total of 18 redds counted. No carcasses were tagged. In the upper section Bond Cr. to Huckleberry Creek, the peak live count was 7 coho on January 28th. The redd count for this section was 38 of which 23 were found February 13th or earlier. One coho and one chinook carcass were tagged; one (50%) of these was recovered. The chinook carcass was recovered on February 27th and was a two-year-old female 60 cm. fork length.

The two coho carcasses found were females 63 and 65 cm. in length. Both of these coho, based on scales, appeared to be four-year-old fish having two years of freshwater growth. Four-year-old coho are not common (Moring 1975; Shapovalov and Taft 1954) and having both these females and possibly one of the two males found below the hatchery trap all being four-years-old is noteworthy. The only other four-year coho identified in this survey was on the South Fork Noyo this same season. Perhaps some environmental factor has lead to this unusual incidence of four-year coho this year.

In Huckleberry Creek, two surveys in the lower half mile of the Creek found no live fish or carcasses in the later part of January.

There two redds were counted.

Three surveys were conducted in Redwood Creek between January 28th and February 20th. The first two surveys were in the lower 0.3 mile from the mouth to the bridge and the last extended upstream an additional 0.3 of a mile. No live spawners were seen. Two carcasses were tagged; one tail punch and one jaw tag. Neither fish could be identified to species. The single jaw tagged carcasses was recovered for a 100% recovery rate. A total of five redds were found.

The Hollowtree Creek trap was operated until February 10th. It is assumed that spawners and redds found through the February 13th survey were accountable to fish counted through the trap; through this date, 50 redds were found. This compares to 26 females (21 coho and 5 steelhead) released at the trap. At a very minimum, there were about 2 redds per female. Some tributaries and Hollowtree Creek above Huckleberry were not surveyed. With the low flow conditions that existed, most of the spawning would be expected to be in the mainstem of Hollowtree Creek. At least one fish spawned in the relatively smaller Huckleberry Creek so it is likely that some spawning occurred in the section of Hollowtree above Huckleberry Creek. Some spawning would be expected in the lower portions of some tributaries like Bond, Michaels and Mule Creeks.

If the 3.7 redds/female ratio estimated for Noyo coho applies to Hollowtree Creek, the survey area and the 50 redds found account for 14 female spawners or 66 percent of those released, but if the redds/female ratio were closer to 2, all of the females could be accounted for. The one to four redds/female range would produce salmon estimates of from 25 to 100 salmon. Since half the salmon carcasses were coho, the range for coho spawners would be 12 to 50.

In the combined areas of upper Hoilowtree Creek, there were four jaw tagged carcasses. Of these, two were tagged on the last survey and so had no opportunity to be recovered. For the two that had recovery surveys, both were recovered although one was not recovered the following survey but instead on the second survey -20 days after tagging. With the CR model and a high carcass retention rate, the model would estimate that there were 6 coho and 1 chinook. Similarly, AUC carcass method results in 3 coho and 1 chinook. The AUC live estimate is also quite low, only 8 coho and 5 chinook. These estimates compare to 54 chinook and coho salmon being released. The majority of the fish estimated by carcass data are due to carcasses found on February 27th. These carcasses could have included, or have been totally due to, fish that passed the trap uncounted since the trap was removed 17 days earlier. One of those carcasses was identified as a female chinook, and since none were released, it must be assumed that it did pass by the trap site after the trap was removed.

As with the South Fork Noyo, population estimates in the upper Hollowtree Creek basin underestimated the population. The degree depends on what fraction of the spawning areas were surveyed. It is not believed that more than 50 percent of spawning areas could have been missed. If only 50 percent of the spawning areas were surveyed, the number of spawners utilizing that area may have been 27 instead of 54. Even at that, the highest model estimate (based on live fish) is only 48 percent of this number. When accounting for the fact that only two of the carcasses tagged would likely have been fish, that were counted at Hollowtree Creek Hatchery, that, similar to the South Fork Noyo, only about 8 percent or less of the spawners were found as taggable carcasses. In the 1991-92 upper Hollowtree Creek survey, even though surveys covered less spawning area, 16 percent of the number of fish released were found as taggable carcasses.

For fish spawning in the <u>upper</u> South Fork Noyo, a distance of 0 to 3 miles separated most spawners from the <u>lower</u> river section. If they drifted that far downstream after spawning, their carcasses would be counted against areas below the release site, and a distance 4 miles further, carcasses could enter areas not surveyed at all. But in upper Hollowtree, most of the spawning occurred three to eleven miles above the release site, making the likelihood that fish backed down into areas below the release site less likely. In addition, areas below the release site are surveyed for a distance of nearly 8 miles and only 5 coho were estimated to spawn in this area based on carcass recovery. So clearly, in this case, the discrepancy can not be placed on movement of spawners out of the area.

It appears that there must be a difference in the retention rate of fish carcasses found by surveyors compared to those carcasses that are never seen. This is evidenced by the fact that both tagged carcasses in upper Hollowtree were recovered but only a small fraction of carcasses are ever seen. This may not be the case where relatively larger populations of spawners are found.

In this case, all females (the 21 coho and 5 steelhead) could be accounted for by a ratio of 2 redds per female but it is most likely that some fish spawned in areas not surveyed and that some of these females were taken by predators prior to spawning. With these considerations, 2.5 redds/female would account for 20 females and would be believed to be a good estimate of the average number of redds produced.

For Hollowtree Creek the combined trap and lower river estimates produce a range in spawning escapements from 18 to 53 chinook and from 103 to 128 coho in 1990-91.

RESTORATION EVALUATION

Many areas within the Hollowtree Creek basin have undergone considerable restoration work. A major portion of this work has been barrier/log jam removal. There has also been a considerable amount of structure added such as logs and rootwads as well as bank stabilization projects. Much of this work has occurred in tributaries such as Bond, Butler and Michaels Creek. The vast majority of chinook spawning in Hollowtree has occurred in the mainstem, mainly below the trap site. Only in one tributary, Butler Creek, were live chinook or chinook carcasses found and then only on a single survey. Because chinook were not found to use Hollowtree Creek tributaries, restoration activities are not believed to be having a significant effect on chinook^ production although reduced sediment input may be improving the survival rate of eggs deposited in Hollowtree Creek.

Coho salmon typically spawn in smaller streams than chinook and it would be expected that Hollowtree Creek tributaries would be utilized by coho salmon. The only extensive surveys in Hollowtree Creek tributaries occurred in the initial survey year. Of 17 coho carcasses found throughout all of Hollowtree Creek in 1989-90, 5 (29%) were found in tributaries (4 in Redwood Creek and 1 in Huckleberry.) Only two redds were found in each of two tributaries Redwood and Huckleberry Creek in 1990-91 and only 8 to 10 coho are estimated to have spawned in tributaries the next year. Extensive restoration work has occurred in Bond and Butler Creeks but no coho carcasses were found in either. Not a single redd was found in Bond Creek in 1989-90 even though eight surveys were conducted between December 12th and February 27th. In 1991-92, there were 13 redds were found in late February but most of these were likely steelhead redds. Results from this survey do not indicate that tributaries were being extensively used by coho for spawning but that most spawning activity occurred in the mainstem. The coho spawning in tributaries was primarily limited to Redwood and Huckleberry Creek. Both of these tributaries, especially Redwood Creek/ have ideal rearing habitat for coho, typified by slow moving water and extensive amounts of cover. Even though the amount of spawning activity in Redwood and Huckleberry Creek was minor, the upstream rearing areas may be utilized by fry which move upstream looking for suitable habitat (Neave 1949).

The release of about 190,000 fingerlings in the spring of 1988 from Hollowtree Creek Hatchery, contributed 10 percent to that broods production of chinook salmon. Comparatively, a releases of about 19/000 fingerlings from the 1985 and 1986 brood (CWT# B61515 and 065017) in Redwood Creek, a tributary to the South Fork Eel, contributed 1.2 and 1.6 percent of the age 3 and 4 chinook carcasses recovered in the South Fork Eel in the 1989-90 survey.

The overall impact of these releases toward increased Eel River production is difficult to assess. If the river system was under-seeded, increased smolt production will result in additional spawners; although if on the other hand, the estuary or other river area is already at or exceeding its carrying capacity, additional smolt output may not elevate total production and could actually lower survival rates for the general population and actually lower total production. Solazzi et al. (1990) found that increasing the rearing density of a stream with coho presmolts did not result in a change in the average spawning density of returning adults whereas supplemental feeding of under-yearling coho salmon increased the carrying capacity of a small Vancouver stream 6-7 fold (Mason 1976). With the relatively low number of spawning fish in the Eel River during this survey and with the reduced survival rates which could be expected from squawfish predation, these levels of hatchery enhancement would be expected to increase Eel River salmon production.

SUMMARY POPULATION ESTIMATION TESTING

The AUC live-based estimates (based on an assumed 11 day spawning life for coho salmon) did produce closer estimates than did carcass models to the known populations. In the upper South Fork Noyo drainage, the live-based estimate was 91 compared to about 30 from carcass estimates where 216 fish were released. Although in Hollowtree Creek, it estimated only 8 compared to 6 where 54 fish were released. Carcass based estimates appear to be useful in that the estimates can be considered minimum estimates of spawning.

The AUC carcass method has not received the review in the literature that the AUC live fish method has nor has the author found the method being used elsewhere. There is considerable variation between estimates of the two carcass models which is surprising since the carcass retention rate was used to determine the average carcass duration for the AUC model. Since the method used to determine the average carcass duration for use in the AUC method was not discussed by Beidler and Nickelson (1980) the method used in this report may not be appropriate for use in that model. For this reason the author believes that the CR model estimates are more valid than the AUC estimates derived here.

In this report, no specific numerical estimate is given for the number of fish that spawned in the surveyed streams. Instead, ranges from a low determined from the CR model and a high based on the upper end of the redd-based range are believed to encompass the likely spawning populations for the streams surveyed. Additional study is needed to better determine the relationship between female spawners and the number of redds constructed. Also, a study of the retention rate of carcasses in streams where known numbers of carcasses were deposited would be of great interest. Perhaps in the South Fork Noyo where carcasses could be obtained from the egg-taking station, the carcasses could be distributed into various streams in a controlled study to see if the retention rates determined in this study reflect the actual rates or if they are somehow biased.

CASPAR CREEK

Caspar Creek surveys are divided into four reaches: lower Caspar from its mouth to the confluence of the North and South Forks (3.0 miles); the South Fork from weir to mouth (0.5 miles); the North Fork from weir to mouth (1.9 miles); and the lower Middle Fork (0.5 miles). The weirs on the North and South Forks are operated by the U.S Forest Service but not as a fish counting station.

1991-92 SURVEY

The lower section was surveyed 10 times from December 20th to March 9th. A total of eleven coho carcasses were tagged, eight of which were found on January 13th. The peak live count was 7 on January 8th. Of eight coho carcasses jaw-tagged, none were recovered in subsequent surveys. A total of 38 redds were found through January 21st and no more were found until the final survey on March 9th where 2 were counted.

In the North Fork, 8 surveys were conducted from January 3rd to March 9th. There was 1 chinook salmon, 9 coho, 2 steelhead and 1 unidentified carcass tagged. The peak live count was 8 on January 3rd. Redd counts were 54 in January and 5 in February. Of 13 jaw tagged carcasses, only 1 (8%) was recovered.

In the South Fork, 6 surveys were conducted from January 6th to March 9th. No live fish or carcasses were found. In January, 6 redds were counted and one more on February 24th.

In the Middle Fork, one survey on January 6th was conducted. No evidence of fish use was found.

The king salmon, the first reported from Caspar Creek, was a female 78 cm in length. The measurable coho consisted of 5 adult males (averaging 62.8 and ranging from 58 to 66 cm.), and 4 adult females (averaging 64.3 and ranging from 62 to 67 cm.) Two female steelhead carcasses were 43 and 69 cm. in length; the larger was a five year old fish, the smaller couldn't be aged.

In total, out of 21 jaw tagged fish in Caspar Creek, only 1 (5%) was recovered. This is the lowest recovery for any stream surveyed. Roughly, these areas were surveyed on a six day interval. To obtain a 5% retention after 6 days, a daily carcass retention rate of 60 percent would be required. Using this figure, the CR model would estimate that 26 coho spawned in lower Caspar and 29 in the North Fork. In addition 4 king salmon, 4 unidentified fish and 7 steelhead carcasses would have also been deposited in the North Fork. No fish would be estimated in the South or Middle Forks.

The AUC carcass-based estimates were 33 fish in the lower section and 47 in the North Fork, and for live-based model, 9 and 6 in the lower section and North Fork respectively.

There were 98 redds counted in January. This would indicate that between 49 and 196 coho spawned in Caspar Creek this season; two of this estimate would be chinook.

The estimate based on live fish is much lower than the estimate based on carcasses which is unusual. The carcass retention rate was also unusually low. If Caspar Creek has a population of predators which reduces carcass retention significantly, these predators may also reduce the spawning life of a coho significantly. To bring the AUC live-based population estimate up enough to approximate the other population estimates, the.spawning life of a coho would have to be reduced from 11 to 3 days. Such a rate of loss would indicate that many fish may be killed prior to spawning.

1990-91 SURVEY

In this year, the lower section was surveyed 7 times from January 16th to February 25th. Only two carcass were tagged: a 72 cm. steelhead on February 18th and the other, unidentified to species, on February 25th. The steelhead had been shot with a gun. Neither of the tagged fish were recovered. A peak live count of 9 was made on February 25th, eight of which were identified as steelhead. Redd counts were 14 in January and 35 in February. One female coho was reportedly caught (wrestled down) by a tourist from Idaho on Caspar Beach on February 3rd as it tried to swim the bar at the mouth of Caspar Creek.

The North Fork was surveyed 4 times from January 21st to February 25th. No carcasses were tagged. A peak live count of 4 steelhead was made on February 11th. No redds were found in January, 20 were found in February. Surveys were conducted above the weir by U.S. Forest personnel. These surveys were conducted once a week from January 18th to April 29th from the weir to a distance 3524 feet upstream (Karen West, USFS, personnel communication, 1991). Live steelhead were observed from March 6th to April 29th. The peak count of live steelhead was 7 on April 17th. Most of the steelhead seen were in a small reservoir formed by the dam on the North Fork. Only one redd was reported in these surveys.

In the South Fork, 5 surveys were conducted from January 21st to February 25th. No evidence of fish use was found. Additional surveys were conducted above the South Fork weir by the U.S. Forest Service. Surveys included a distance of 2008 feet above the weir. They found a single fish on April 2nd. No other evidence of fish use was found.

Since only two carcasses were tagged and since they were both steelhead, no coho would be estimated to have spawned. From the 14 redds in January, between 4 and 7 females or between 8 and 28 coho spawned. Based on live fish, the AUC method would estimate 2 coho. Surveyors in Caspar Creek did note lots of otter and raccoon tracks and did find bear sign in one survey.

RESTORATION EVALUATION

In 1960 Federal and State agencies initiated a study of long-term effects of logging and road building on stream flow, sedimentation, aquatic habitat, and fish populations on two watersheds of Caspar Creek - the North and South Forks (Krammes and Burns 1973). No restoration projects have occurred in the drainage since the early 1970's which would interfere with on-going study (Fay Yee, Calif. Dept. of Forestry, personnel communication. Ft. Bragg, 1993).

DEHAVEN, HOWARD AND WAGES CREEK 1990-1991

All three of these streams (Figure 1.) were planted with yearling coho in the Spring of 1988. The purpose of planting Noyo River coho stocks into these drainages was to reintroduce coho since recent surveys had found no evidence of existing coho runs (Weldon Jones, CDF&G, per. corn. 1989). These spawning surveys were conducted for the purpose of determining whether or not adult coho were returning to spawn from released coho yearlings.

1990-91 SEASON
DeHaven Creek

DeHaven Creek was surveyed from the mouth to three miles upstream. There were three surveys from January 17th to February 4th. There was no evidence of spawning activity during any of these surveys.

Howard Creek

Howard Creek was surveyed three times between January 17th. and February 4th. The distances ranged from two to three miles. As for Dehaven, no evidence of fish use was found. The stream was described as having a lot of large rock and no areas considered to be good spawning gravel.

Wages Creek

This stream was surveyed five times between January 17th. and February 13th. There were three carcasses tagged; one a coho on February 4th and two steelhead on the 13th. The peak live count was two steelhead on February 13th. Four redds were found in January and eight in February. Surveys were done from the mouth to the forks, a distance of three miles. One survey was continued an additional mile upstream. Of the two jaw-tagged carcasses, only one had a subsequent survey to determine a recovery rate. This tagged fish was recovered - a 100 percent recovery rate. There was bear sign along this stream.

Based on January redds, there were 2 to 8 coho spawning in this stream. The single carcass would have estimated no more than one pair of coho spawners.

RESTORATION EVALUATION

It appears that only in Wages Creek was the release of coho smolts successful. Wages Creek flows were greater than DeHaven or Howard Creek. This may have allowed the returning salmon to enter Wages Creek where they may not have been unable to enter the other streams. Even though Wages Creek did have coho spawning, the number was very low. In Howard and DeHaven Creeks, this planting effort was not successful.

LITTLE RIVER

Little River flows through Van Damme State Park in Mendocino County. There is a road that follows the stream through the park which provides easy access to the stream. The stream surveys were conducted from the mouth to four miles upstream.

1991-92 SURVEY

There were nine surveys conducted from December 31st to March 9th. There were eleven coho carcasses tagged. The peak live count was eleven on January 5th. Redd counts were 16 in January and 9 in February. Of the 7 jaw tags applied (one additional was tagged on the last survey), 4 (57%) were recovered. There was one female (63 cm.), three males (60 to 61 cm.) and one male grilse (38 cm.) coho found during surveys. It was noted that at least one redd was out of the water because of low flow conditions.

The CR model would estimate that 14 coho spawned in Little River this year. The AUC carcass and live fish estimates would be 9 and 23 coho respectively. Based on redd counts in January, 8 to 32 coho would have spawned.

The recovery rate of carcasses on Little River was relatively high compared to other streams. This would indicate a low rate of predation and/or scavenging on this stream.

There has been concern that culverts along the creek are an impediment to fish passage and the State Park personnel had sandbagged several of these to improve passage prior to the spawning run starting. In the first survey, a redd and a live female coho were found just below the upper culvert indicating that passage was possible at all the other culverts. The other redds were below the sixth culvert down from the upper end. A survey on January 28th also found fish just below the upper culvert. It appears that the sandbagging did allow fish to pass the culverts. While no redds were found above the upper culvert, it did not appear as if it would have prevented fish passage.

1990-91 SURVEY

Little River was surveyed three times from January 16th to February 9th. Only one redd was found. It was found on the last survey and was located between 3 and 3.5 miles upstream. Previous surveys had not surveyed this far upstream and the redd appeared not to be fresh so it is believed that this was a January redd. Only one pair of coho could have been expected to have spawned. No carcasses or live fish were seen.

RESTORATION EVALUATION

Adult spawning migrations are believed to have been hindered in Little River by a series of culverts. The spawning survey in 1991-92 found fish above all but the upper culvert and here it appeared that fish could have passed this culvert without difficulty. It appeared that the modifications that were made prior to the 1991-92 survey allowed fish to pass with the flows as they existed. There appeared to be very little quality spawning gravel in Little River. The stream was described as consisting of fast water with a large component of the substrate consisting of boulders. The low coho population estimate of 1 to 3 fish in 1989-90 (Nielsen et al., 1990) and only 2 in 1990-91 indicates very poor production levels. The lack of low velocity habitat in all but the very lowest section of the creek probably limits the coho rearing potential of this stream.

S. F. GARCIA AND L. N. F. GUALALA RIVER 1990-1991

Both the South Fork Garcia and Little North Fork Gualala Rivers were planted with yearling coho in the spring of 1988. The purpose for planting these fish (Noyo River stock) was to reintroduce coho into these areas since native stocks no longer existed (Weldon Jones, CDFG, per. corn., 1989). These surveys were undertaken to find out whether coho were returning from this effort.

The South Fork Garcia River was surveyed 3 times in February 1991 from the 1st to the 15th. No live fish or carcasses were seen. Two redds were observed, one on each of the last two surveys. An additional redd was reported on the Garcia River 100 feet below the mouth of the South Fork.

The Little North Fork of the Gualala River was surveyed 3 times in February 1991 from the 1st to the 15th. No live fish or carcasses were seen. Only two reads were observed in the Little North Fork, these on the 8th, but on the 15th, five redds were found on the North Fork just downstream from the mouth of the Little North Fork. These redds were, in all likelihood, from fish that would have spawned in the Little North Fork but did not due to the low water conditions that existed at the time.

Common to both the S.F. Garcia and L. N. F. Gualala were reports of high numbers of juvenile steelhead. Schools of 20 to 100 fish 4-7 cm. in length were common. Also, low flows prevented spawners from entering both these streams during the 1990-91 season. No surveys were conducted in 1991-92. It appears that even though these streams have not been producing coho salmon, steelhead production is relatively high. There were as many as 33 redds in the S.F. Garcia and 17 in the L.N..F. Gualala in 1989-90 (Nielsen et al. , 1990), many of which were in the month of January. There were at the same time several steelhead carcasses and live fish observed while there was no evidence of coho spawning. Together, the juvenile populations and spawning steelhead in these streams indicate that steelhead production in these streams is quite good.

Only one pair of fish is estimated to have spawned in these drainages this year. Since these fish did not spawn until February, it is assumed that these spawners were steelhead. In both streams, there was spawning activity just below the mouths of these streams, indicating that there would have been more fish spawning had the flow conditions been better.

RESTORATION EVALUATION

Both of these streams have been planted with yearling coho in the Spring of 1988. There were only two redds found in each stream this year and additional redds were found just below the mouths of these streams. This spawning activity is not believed to be due to returning adult coho from the yearling releases since they were not found until the second February survey.

TEN MILE RIVER 1991-92 SURVEY

The Ten Mile River (Figure 5.) surveys were done sporadically this season. This was due to the low survey priority rating given the Ten Mile by the California Department of Fish and Game. Surveys were conducted only if the other stream surveys had been completed in each survey period. The upper reaches of the South Fork and

North Fork and associated tributaries were not surveyed nor were Mill, Redwood, Churchman, or Little Bearhaven Creek. Most areas that were surveyed were only surveyed once or twice. With this low effort, no population estimates could be made except with the redd based method.

The mainstem of the Ten Mile River from the confluence of the Middle (Clark) Fork down was surveyed twice; once on December 20th and once on January 22nd. The first survey extended from Baxman's Gravel Plant to, dark Fork (3.0 miles) and from the South Fork to Clark Fork the second survey. No fish, redds or carcasses were found the first survey. On the second, 3 steelhead and 3 other unidentified fish were observed and 10 redds were found.

NORTH FORK

Clark

The North Fork was surveyed from dark Fork to the Little North Fork (1.9 miles) twice, once on December 20th and once on January 22nd. No fish, redds, or carcasses were observed the first survey but a coho and two steelhead were tagged on the 22nd and three redds were counted. The Steelhead was an 89 cm. male at least six years of age.

The area between the Little North Fork (L.N.F.) and Bald Hills Creek (5.2 miles) was surveyed three times between December 23rd and January 29th. The last survey covered only the lower 2.5 miles of this reach. Three redds were found on the first survey. Another 7 redds were found in later surveys and a single live steelhead was observed.

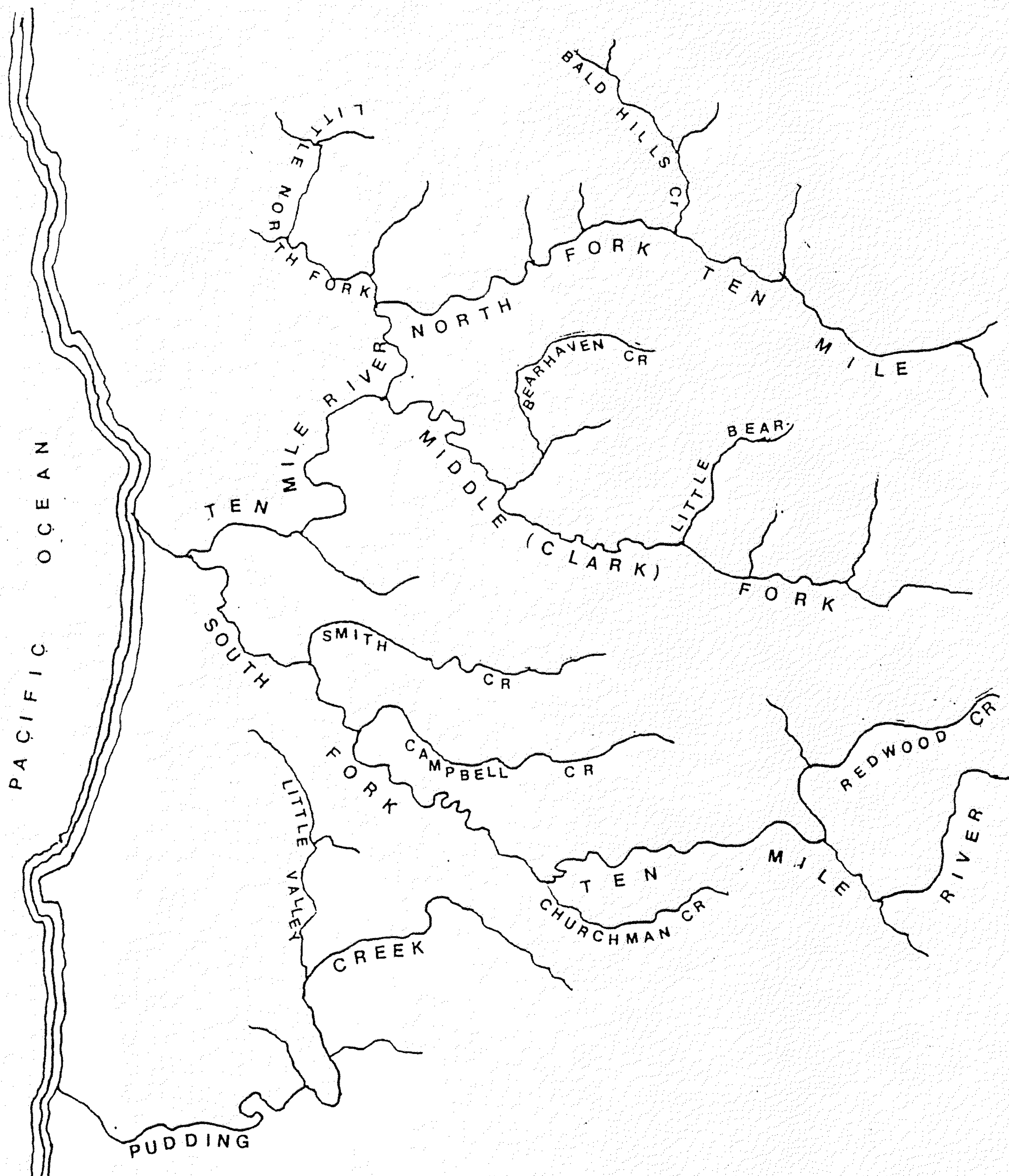
One survey was conducted above Bald Hills Creek for a distance of 2.3 miles on January 29th. No fish, redds, or carcasses were found although water visibility was not ideal.

In all, 23 redds were found in the area from 2.3 miles above Bald Hills Creek to the South Fork and a single coho carcass was found. This would indicate that 11 to 46 salmon spawned in this area.

Clark Fork

The Lower section of dark Fork from the mouth to Bearhaven Creek (3.1 miles) was surveyed once on the 22nd of December. One redd was found. This section was surveyed again one month later and one coho was tagged and six redds counted. A final survey on February 29th found a single live steelhead and 2 additional redds.

Figure 5- Ten Mile River and Pudding Cr.



The area above Bearhaven Creek (10.1 miles) was surveyed in mid to late January. In this area, for three survey dates combined, two coho, one steelhead and eight chinook carcasses were tagged. There were 25 redds counted but no live fish observed. Two carcasses were measurable; one was a 103 cm. male and the other a 96 cm. female chinook (5 years of age). On the 28th and 29th of February, 7.1 miles of this area was again surveyed. In this survey 34 redds were counted and a single live steelhead observed. No carcasses were found.

In January, there were 32 redds in the dark Fork and there were 3 coho and 8 chinook carcasses. The redd count would indicate that from 16 to 64 salmon spawned.

South Fork

The South Fork was surveyed on January 17th and 27th from Smith Creek to 1.3 miles above, the confluence of Redwood Creek (13.8 miles). Two chinook and one coho were tagged. There were 13 redds counted. The peak live count was on the 27th. These were steelhead (7) in a pool just above the lower end of the survey area. The January redds would estimate between 6 and 26 salmon spawned. In February, no surveys were conducted.

Campbell Creek

Two surveys were conducted in Campbell Creek in January; one on the 7th and one on the 26th. The first covered the lower 1.6 miles and the second the lower 0.8 miles. One redd was found on each survey. A coho skeleton was found which would indicate that there was coho spawning. No survey was conducted in February. A single pair of spawning salmon would be estimated.

Smith Creek

A single survey was conducted in the lower 2.8 miles on January 27th. No fish or signs of spawning activity were found.

Bald Hills Creek

A single survey was conducted in the lower 1.9 miles on January 29th. A single redd was found, or one pair of fish spawned.

Little North Fork

The Little North Fork was surveyed three times in January. The first survey covered the lower 1.8 miles, the second 2.7 miles and the last only the lower 0.3 miles. A total of nine redds were counted. The peak live count was three coho, one adult and two grilse, on the 29th. An 84 cm. 4-year old male chinook carcass was tagged and a coho skeleton seen. The redd count would indicate that between 5 and 18 salmon spawned.

In February, a survey was conducted on the 13th and the 28th. One live steelhead was seen on each survey and 21 redds were counted. The first February survey extended from the mouth upstream 3.5 miles and the second 3.0 miles. Since no live salmon or salmon carcasses were found, all February redds are considered steelhead redds.

Bearhaven Creek

In January, a survey on the 14th found 17 redds in the lower 2.5 miles. An survey on the 24 surveyed a mile above the previous survey; one redd was found. One live coho was found on the 14th. These 18 redds estimate 9 to 36 spawners.

Two surveys were conducted in February. One steelhead and one unidentifiable carcass were tagged. No live fish were seen and twelve redds were counted.

Ten Mile River System

In the Ten Mile River there were 98 January redds. This would estimate between 49 and 196 salmon spawners. There were 11 chinook and 3 coho tagged. Assuming that this is the relative abundance of the two species, the chinook run would be between 38 and 154 and the coho run between 11 and 42. It doesn't appear that chinook females dig more than 2 redds based on Hollowtree Creek data whereas coho appear likely to dig between 2.5 to 3.5 redds. From this information and the high proportion of chinook the lower portion of the range appears unlikely and that minimal estimates would be better estimated by a 3 redds/female estimate. At this ratio, the lower estimate for chinook and coho would be 51 and 14, respectively.

1990-91 Surveys

No surveys were conducted in the 1990-91 season.

RESTORATION EVALUATION

Surveys in 1989-90 and 1991-92 surveyed a substantial proportion of the watershed; about 70 and 55 miles respectively. These compare to an estimated total area of salmon habitat of 103 miles (California Wildlife Plan, 1965). The only area not surveyed in 1989-90 which likely had spawning activity was in the upper Clark Fork where in 1991-92 half of all chinook carcasses in the Ten Mile River system were found. In 1991-92, even though fewer miles were surveyed, surveys of spawning areas were fairly complete because they included the upper dark Fork and all of the areas where salmon carcasses were found in 1989-90.

Chinook salmon are not considered to be native to the Ten Mile River although chinook salmon have been reported caught in the river several decades ago. Chinook salmon were introduced into the Ten Mile River in the early 1980's. The last major introduction of chinook was in 1982. Some eggs were taken from chinook trapped in the Ten Mile River in the mid-1980's. The last and largest release from this group was 9000 fingerlings released in the spring of 1987. The chinook carcasses found in the Ten Mile River have been composed of various age groups and the four-year-old chinook found in 1991-92 were undoubtedly of natural origin. This indicates that the chinook introduced into the Ten Mile River are successfully reproducing. While these runs are not large, from 34 to 54 in 1989-90 and 51 to 154 in 1991-92, they are widely scattered throughout the basin, being found in the Little North, South, dark and North Forks. In addition the author observed chinook spawning in upper dark Fork in . the winter of 1993. Together, these observations indicate successful natural production of chinook salmon in the Ten Mile River. If this natural production continues, this would be one of the few successful introductions of a salmon species into a watershed along the west coast (Withler 1982).

Oregon coho stocks were planted into Ten Mile in the early 1970's. From 1974 to 1977 approximately 200,000 coho were reared and released into the Ten Mile River annually (Tayior 1978). The last of these imports of out of basin coho stocks was in 1978 when 44,000 fish were released. The only other release of coho salmon was 6,000 fingerlings in June 1987 which were the offspring of coho trapped in the Ten Mile River. Fifteen male and ten female coho were trapped that year (Salmon Restoration Ass. unpublished data).

The coho run estimates ranging from 32 to 52 in 1989-90 and 14 to 42 in 1991-92 are quite low in relation to the size of the Ten Mile River. In the early 1960's, the Ten Mile River was estimated to have a coho run of 6,000 fish (California Wildlife Plan 1965). The effort to restore this run in the mid-1970's by artificial propagation was unsuccessful due the inappropriateness of the Oregon coho stocks propagated and also the habitat problems and limitations that existed.

The California Wildlife Plan (1965) considered fishery habitat conditions in the Ten Mile River to be severely degraded by logging activity. The Ten Mile River has undergone extensive restoration activities primarily in the form of barrier removal. Areas surveyed that have had extensive work are the upper South Fork, Bearhaven and Bald Hills Creek. In the surveys conducted, the upper South Fork and Bald Hills Creek show very little salmon spawning activity. No evidence of salmon spawning was found in the South Fork above the confluence of Redwood Creek even though habitat appeared to in good condition and spawning activity in the 5 mile reach below this area was sparse; only two redds in January 1991-92 and only 1 in 1989-90. Bald Hills Creek had a single redd in 1991-92 and none in 1989-90. Bearhaven Creek had a relatively healthy coho run in 1991-92 but had only three redds in January 1989-90. Of seven sites samples for juvenile populations in the Ten Mile River in October 1991 only two had coho present (Maahs, M. unpublished report, Salmon Restoration Ass. 1992). Bearhaven Creek had a density of 0.08 coho/m2 and Bald Hills Creek 0.01 coho/m2.

It appears that coho in the Ten Mile River have been unable to recover from .low population levels even though extensive restoration work has been conducted. The upper reaches of the South Fork and North Forks did not see salmon spawning during the two survey years nor likely in 1990-91 because of the low water conditions. For these areas to be reseeded the Ten Mile will need to have large escapement levels that allow sufficient straying or artificial propagation projects. The low population level of coho found in these Ten Mile River surveys has prompted a trapping and artificial rearing project in the Ten Mile which hopefully can help restore coho stocks in the basin.

PUDDING CREEK

Pudding Creek surveys were divided into two sections. The lower section extends from the railroad tunnel upstream to the confluence of Little Valley Creek (4.2 miles). The upper section extends upstream from Little Valley Creek for 4.1 miles. The upper end of the upper reach is very bushy and difficult to survey, often reguiring surveyors to get out of the stream and try to find ways around brush. Areas farther upstream were not surveyed, primarily because this area is even more difficult to survey. While bad for surveys, these areas provide good habitat for rearing and spawning. The water in the lower section is often cloudy because of the addition of water from Little Valley Creek. This seems to be a natural condition which exists year-around. This discoloration reduces visibility and probably reduces the chances of finding carcasses and live fish. Because of the very poor visibility, Little Valley Creek was not surveyed. This creek was surveyedonce in 1989-90. Besides the poor visibility, the creek was quite deep and slow moving with large amounts of woody material. Very little spawning habitat was found in the lower 0.8 miles that was surveyed. The survey conditions in Pudding Creek probably result in surveys that miss more carcasses, live fish and redds than in other survey areas.

1991-92 SEASON

Lower Pudding Creek was surveyed seven times from January 2nd. to March 13th. Ten coho carcasses were tagged. The peak live count was 17 (11 coho and 7 steelhead) on February 3rd. The redd counts were 31 in January and 23 in February. Of 9 jaw tagged coho carcasses there were four adult males (averaging 68 cm. and ranging from 61 to 77 cm. fork length). None of the tagged carcass were recovered.

In the upper section on Pudding Creek, surveys were conducted five times from January 9th to March 12th. Only one coho carcass was tagged. The peak live count was on February 5th where one coho and three steelhead were observed. There were 9 redds in January and 18 in February.

Since none of the nine jaw-tagged carcasses in lower Pudding Creek were recovered, estimating the retention rate is somewhat subjective. A retention rate of .74 was selected for use in modeling. This is the retention estimate selected the for South Fork Noyo in 1990-91 where out of 30 tags, six were recovered. At this rate, the CR model would estimate 28 spawning coho. The AUC carcass estimate is 45 coho and the live AUC estimate is 37. The live fish estimate is lower than the AUC carcass estimate but higher than the CR estimate.

The 31 redds in lower Pudding Creek in January would estimate from 16 to 62 spawning coho salmon. In February, 64 percent of live fish counts were coho. At this rate, 15 of the 23 February redds would also be coho redds, bringing the redd-based range from 23 to 92 coho.

In the upper section, 25 percent of live counts in February were coho, bringing the coho redd estimate in the upper section to 5. Coho spawners in upper Pudding Creek would be estimated to range between 3 and 10 fish. The AUC live-based estimate is 3 coho. No coho would be estimated to have spawned with carcass data since no fish were tagged with jaw tags.

The estimates for all surveyed areas of Pudding Creek are between 28 and 45 for AUC and CR models and from 26 to 102 coho based on redd counts.

1990-91 SEASON

Lower Pudding Creek was surveyed seven times from January 17th to February 25th. There were 11 tagged carcasses of which 5 were coho, 4 steelhead and 1 unidentified. The peak live count was 12 on February 11th of which half were coho and half steelhead. There were two redds in January and 54 in February. Out of seven jaw-tagged carcasses, 3 (43%) were recovered. There were four measurable carcasses, one was a 70 cm. male and two were 45 and 66 cm. coho of which the sex could not be identified. There was also a 80 cm. steelhead estimated to be four years old with three years of ocean growth.

In upper Pudding Creek, surveys were conducted three times between the 6th and 25th of February. Two coho carcasses were tagged and the peak live count was 4 coho on the first survey. There were 11 redds found. Only one of the jaw-tagged fish had a recovery survey and it was recovered for a 100% recovery rate.

Estimates of spawning in lower Pudding Creek are 8, 7 and 9 coho based on CR model, AUC carcass and AUC live counts, respectively. Population estimates for coho based on January redd counts are one pair. Some proportion of the 54 redds in February are due to coho spawning. Of the February live fish counts 46 percent were coho. This would indicate that 25 of these redds were dug by female coho, and that between 12 and 50 coho spawned in February. The additional pair of coho spawning in January brings the range to 14 to 52 coho spawners.

In upper Pudding Creek the CR model, with a 92 percent retention rate, the estimate is 3 coho; 3 coho is the AUC carcass-based estimate as well. The AUC live-based model estimate is 2 coho (even though there were actually four seen). There were 11 redds and all live fish and carcasses were coho. The redd based range is from 6 to 22 coho spawners.

The total Pudding Creek estimate for 1990-91 is 10 to 11 based on CR and AUC methods and 20 to 74 based on redd counts.

The difference between carcass and redd-based estimates are reminiscent of the upper South Fork Noyo and Hollowtree Creek. The low live-based AUC estimate in relation to the carcass estimates is likely due to the poor visibility and large amount of cover which is inherent with Pudding Creek surveys.

Restoration Summary

The Pudding Creek coho run estimates varying from 6 to 50 in 1989-90, 20 to 74 in 1990-91 and 26 to 102 in 1991-92 are considerably less than counts made at the Pudding Creek egg collecting station where from 1957-58 through 1960-61 (the first four years of operation) minimal counts of 1257, 628, 442 and 484 were made (Strohschein 1961). The dam and associated reservoir, built as a water source for the lumber mill at Fort Bragg, has probably impacted coho production in Pudding Creek. The fish-ladder is not operational until rains have raised the reservoir level. This can prevent an early run component from spawning in Pudding Creek. A similar structure would have prevented the spawning activity that occurred in Caspar Creek and South Fork Noyo in 1990-91 where some spawning activity occurred prior to significant rainfall. The heavy growth of aquatic plants and exotic warm water fish in the reservoir would not indicate advantageous conditions for coho production. Pudding Creek above the impounded water appear to provide very good rearing habitat as does Little Valley Creek.

Pudding Creek has had several log jam removal projects. These jams were not barriers to fish migration and overall these projects have not improved this streams capacity to produce coho salmon.

WILLITS CREEK

Willits Creek was surveyed only once on January 11th, 1992. No carcasses, redds or live fish were found. No fish were found in this area during the 1989-90 surveys as well. Low flow conditions have likely impacted spawning runs in this area.

CONCLUSIONS

The results of these spawning surveys indicate that coho runs are presently much smaller (if they exist at all) than they were in the early sixties even though extensive restoration work has been done since that time. Two primary factors can explain the apparent low abundance of coho spawners. Either inadequate numbers of spawners have been available to repopulate these areas since restoration or the restoration activities have been generally ineffective at improving the habitat; restoration activities may even have had negative effects overall by removal of the primary habitat needed by coho salmon.

In streams which empty directly into the ocean such as Howard, DeHaven and Wages Creek, where coho runs were lost probably due to the aggravated conditions of poor logging practices and drought, nothing short of transplants will bring back coho production in these streams. On the other hand, the Ten Mile River appears that it could sustain larger coho production than it presently has and that increased numbers of spawners may increase coho production. Ten Mile River does however lack habitat that would be considered ideal for coho rearing, deep, dark, low-velocity habitat, but would generally be considered to have some good habitat. For other streams surveyed this is not necessarily true.

In Little River, even in the year where only a single redd was observed, young-of-the-year (YOY) coho are found outmigrating and in Caspar Creek YOY coho are also regularly captured in outstream-migrate traps (Weldon Jones, CDF&G, per. corn. 1993). Mason and Chapman (1965) found a positive correlation between levels of aggression and the rate of emigration of YOY coho in streams and that levels of aggression and territory size of rearing coho were affected by the abundance of food and that sustained higher levels of food brought about greater density (reduced migration) of fish. LeCren (1965) states that territorial behavior acts as a density-determining mechanism in salmonids and Chapman (1962) found that coho fry migrating downstream in the spring were smaller than residual coho and that downstream movement would cease if fish were placed in a suitable environment. Together these studies indicate that downstream migrations of coho fry in Little River and Caspar Creek indicate that insufficient habitat quantity or quality is available. Various studies (Shapovalov 1954; Conte et al. 1966; Crone and Bond 1976; Hartman et al. 1982; Washington 1991) have found that unless emigrating coho reach one year of age and sufficient size coho juveniles will not survive to become adults. There is considerable habitat below the outmigrant trap site on Caspar Creek and some number of these YOY migrants may find suitable habitat to rear. In Little River very little rearing habitat is available below trapping site.

Presently, many coastal streams have high levels of fines in the sediment resulting from poor land use practices. Increased levels of fines have been shown (Pennak & Van Gerben, 1947; Sprules, 1947; and Kimble and Wesche 1975) to reduce the aquatic life which effects juvenile coho's ability to feed which in turn increases territory size of coho fry and reduces the carrying capacity of the stream. Stream restoration activities have concentrated for years of the removal of barriers to salmon migration and in the process have removed the vast majority of log jams and associated habitat which tend to produce the highest densities of coho (Hartman, 1959). In general, where juvenile salmonid cover is removed salmonid abundance declines (Boussu 1954; Peters & Alvord 1964; Elser 1968). Ways in which food abundance and habitat conditions can limit coho populations are demonstrated in studies attempting to increase coho production. Mason (1976) found that by supplementing food in a natural stream, the density of coho that could rear was increased 7 fold but, after supplemental feeding ceased, the populations dropped back to normal levels due to habitat limitations. Mason (1976) also found that outmigration was directly related to stocking density and that survival, growth and biomass yield were inversely related to stocking density in unfed populations. In another study where coho presmolts were released into streams, the densities of juvenile coho increased but the supplementation did not result in a change in the average spawning density of returning adults (Solazzi, 1990). Shapovalov and Taft (1954) found that increased egg deposition resulted in increased population sizes of downstream migrant coho, decreases in the average size of emigrates, reduced survival rates and increased rate of straying among returning adults.

The degree to which density-dependent factors limit coho salmon production in streams is not often studied although many studies have been done which indicate density-dependent factors are influencing production. Currently, ocean salmon fisheries harvests are being significantly reduced to provide increased numbers of spawning coho salmon into Oregon coastal streams to enhance the production of coho salmon (PFMC 1993). The success of this effort depends upon the availability of under-utilized coho rearing habitat throughout the juvenile rearing stage prior to emigration to the marine environment. Greater efforts need to be made to determine where and to what extent density-dependent factors in the fresh-water environment are limiting production. The degree to which YOY coho are emigrating the streams may be a good indicator of limitations in the first several months of the coho rearing period. Since these juvenile coho are not expected to survive and become adults, these fry could be used to stock areas believed to be underseeded.

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LITERATURE CITED

Beidler, W A. and T. E. Nickelson. 1980. An evaluation of *the* Oregon Department *of'Fish and Wildlife standard spawning fish survey system for coho salmon.* Ore. Dept. Fish Wildl.Info. Rep. Serv. 80-9: 23p.

Boussu, M. F. 1954. *Relationship between trout populations and cover on a small stream.* J. Wildl. Manage. 18:227-239.

Briggs, J. S. 1953. *The behavior and reproduction of salmonid fishes in a small coastal stream.* California Fish & Game Bull. No.94: 62p.

Brown, L. R. , P. B. Moyle, and R. M. Yosiyama. 1993. *Status of coho salmon in California.* North Amer. J. Fish. Man.

Bustard, D. R., and D. W. Narver. 1975. *Preferences of juvenile coho salmon and cutthroat trout relative to simulated alteration of winter habitat. J.* Fish. Res. Board. Can. 32:681-687.

Conte, F. P., H. H. Wagner, J. Fessler, and C. Gnose. 1966. Development or *osmotic and ionic regulation in juvenile coho salmon.* Comp. Biochem. Physiol. 18:1-15.

Crone, R. A., and C. E. Bond. 1976. *Life history of coho salmon. in Sashin Creek, Southeast Alaska.* Fish Bull. 74:897-923.

Elser, A. A. 1968. *Fish populations of a trout stream in relation to major habitat zones and channel alterations.* Trans. Am. Fish. Soc. 97(4):389-397.

English, K.K., R.C. Bocking & J.R. Irvine (1992). A *robust procedure for estimating salmon escapement based on the area-under-the-curve method.* Can. J. Fish. Aquat. Sci. Vol. 49:1982-1989.

Hartman, G. F. 1965. The role *of behavior in the ecology and interaction of under-yearling coho salmon and steelhead trout*. J. Fish. Res. Board Can. 22:1035-1081.

Hartman, G. P., B. C. Anderson, and J. C. Scrivner. 1982. Seaward movement- of coho *salmon fry in Carnation Creek, an unstable coastal stream in British Columbia*. Can. J. Fish. Aquatic Sci. 39:588-597.

Kammes, J. S. and D. M. Burns. 1973. .Road *construction on Caspar Creek watersheds. Ten year impact report*. Pac. Southwest Forest and Range Station. USDA Forest Serv. Res. Paper PSW-93

Kimble, L. A., and T. A. Wesche. 1975. *Relationship between selected physical parameters and benthic community structure in a small mountain stream*. Univ. Wyo., Laramie. Water Resour. Res. Inst. Series 55. 64 p.

McMahon, T. E., and L. B. Holtby. 1992. Behavior, habitat use, and movement *of coho salmon smolts during seaward migration*. Can. J. Fish. Aquat. Sci. 49:1478-1485.

Maahs, M. W. 1992. *Habitat and Fishery Evaluation of the Ten Mile River*. Unpublished report, Salmon Restoration Association, Fort Bragg, CA.

Moring, J. R. , and J. R. Lantz. 1974. The Alsea *watershed study: effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part 1-Biological studies*. Ore. Dept. Fish Wildl., Fish. Res. Rep. No. 9.

Neave, F. 1949. Game fish *populations of the Cowichan River*. Fish. Res. Board Ca. Bull. 4. 76p.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson and M. F. Solazzi. 1992. Seasonal *changes in habitat use by juvenile coho salmon in Oregon coastal streams*. Can. J. Aquat. Sci. 49:783-789.

Nielsen, J. L., M. Maahs, & G. Balding. 1990) *Anadromous salmonid resources of Mendocino coastal and inland rivers 1989-1990. An evaluation of rehabilitation efforts based on carcass recovery and spawning activity*. Report submitted to California Dept. of Fish and Game. Fisheries Restoration Program, Work Progress Report 1990. 98 p.

Norton, J., D. McLain, R. Brainard & D. Husby (1985). *The 1982-*

83 El Nino event off Baja California and Its ocean climate context, p. 44-72. In W.S. Wooster & D.L. Fluharty (ed.), El Nino North. Washington Sea Grant Program, Univ. of Wash.

Perrin, C.J., and J.R. Irvine. 1990. A *review of survey life history estimates as they apply to the* area-under-the-curve *method the spawning life escapement of Pacific salmon.* Can. Tech. Rep. Fish. Aquat. Sci. 1733: 49 p.

Pennak, R. W. , and E. D. Van Gerpen. 1947. *Bottom fauna production and physical nature of the substrate In a northern Colorado trout stream.* Ecology 28:42-48.

Peters, J. C. , and W. Alvord. 1964. *Man-made channel alterations in thirteen Montana streams and rivers.* Trans. North Am. Wildl. Conf. 29:93-102.

Pacific Fisheries Management Council. 1993. *Draft Amendment 11 to the Fishery Management Plan for commercial and recreational salmon fisheries off the coasts of Washington, Oregon, and California commencing in 1978.* Portland, Oregon.

Ruggles, C. P. 1966. *Depth and velocity as a factor in stream rearing and production of juvenile coho salmon.* Can. Fish Cult. 38:37-53

Shapovalov, L. & A.C. Taft. 1954. *The life histories of the steelhead rainbow trout (Saimo gairdneri gairdneri) and silver salmon.* Cal.Dept. Fish & Game, Fish Bull. No. 98.

Snyder, R. U. and S. W. Sanders. 1979. *Summary of operations Noyo River egg collecting station 1964-65 through 1977-78.* Anad. Fish. Branch Admin. Rep. 79-7.

Solazzi, M. F., T. E. Nickelson and S. L. Johnson. 1990. An evaluation *of the use of coho salmon presmolts to supplement wild production in Oregon coastal streams.* Ore. Dept. Fish. Wildl. Rep. No. 10. 22 p.

Taylor S. 1978. *California's private rearing pond programs.* Cal. Dept. Fish & Game. Sacramento, 18 p.

Willis, R. A. 1954. *The length of time that silver salmon spent before death on the spawning grounds at Spring Creek, Wilson River in 1951-52.* Fish Comm. Ore. Res. Briefs 5:27-31.

ANNUAL PERFORMANCE REPORT

FEDERAL AID IN SPORT FISH RESTORATION ACT

State: California Grant Agreement: F-51-R-13

Grant Title: Inland and Anadromous Sport Fish Management and Research

Project No. 22: North Central District Salmon and Steelhead Management

Job No. 1: Juvenile Salmon and Steelhead Stock Assessment

Period Covered: July 1, 1999 through June 30, 2000

I. Summary: During the Fiscal Year (FY) 99-00, nine stations representing five streams were electrofished by the Department of Fish and Game using the three-pass depletion/regression method to determine juvenile salmonid standing crop. These nine stations have been surveyed annually since 1986 to determine trends in standing crop density.

Both coho salmon and steelhead trout densities remained depressed, if not, in decline. The results of sampling revealed coho salmon presence in four of the five annually monitored streams: Caspar Creek, Little River, Hollow Tree Creek, and Pudding Creek. Coho salmon have not been observed in Ryan Creek since 1993. A comparison of coho salmon standing crop densities in the five annually monitored stations showed current densities were lower than those of previous years. Steelhead were collected at all stations. Steelhead trout populations were variable but were generally below the average density revealed since 1986.

Since 1986, all electrofishing has been conducted during September and October. By conducting the surveys in late summer/early fall,when water temperature has begun to decline the probability of injury to fish is lessened. Also, the populations at this time will have already experienced summer natural mortality and therefore our numbers may reflect a more real situation than if the surveys were conducted in June, July, or August.

II. Background: The salmon and steelhead populations in the five counties making up the North Central Sport Fishing District in California once supported large, vigorous sport and commercial fisheries. Already vestiges of what they once were, these populations and the fisheries they supported continue to decline. Attempts to restore salmon and steelhead populations have been conducted in the form of stream habitat improvement, rearing programs, upslope restoration, and the implementation of stricter angling regulations. However, to manage these resources more effectively we need to know more fully where salmon and steelhead production is occurring, what limiting factors are affecting the populations, and what the trend in recruitment is. We also need to know population trends over time. This information enables us to focus management efforts in areas which will yield the greatest benefits.

III. Objective: To determine trends in abundance of juvenile coho salmon and steelhead trout populations in North Central District streams.

IV. Procedures: Selected streams were surveyed to determine juvenile coho salmon and steelhead trout distribution and abundance. Included in the FY 99-00 survey season were five streams surveyed annually since 1986. Additional streams were added to the survey to increase our database as time and personnel become available. Three pass electrofishing within 30 meter transects was the method employed for the surveys.

V. Findings:

Coho: Five streams are monitored annually and this year four, Caspar Creek, Little River, Hollow Tree Creek, and Pudding Creek contained coho salmon. Among the five streams, eight stations are monitored and only four of the eight stations contained coho. Juvenile coho have not been observed in Ryan Creek since 1993.

Coho salmon densities were generally low for both, stations in coastal streams, and stations in tributaries to the Eel River. In the smaller coastal streams, coho salmon densities at stations in the annually monitored streams ranged from 0 to 0.18 fish/m^2 and averaged only 0.05 fish/m^2. In both main stem Eel River tributaries and South Fork Eel River tributaries, coho salmon densities in the annually monitored streams ranged from 0 to 0.17 fish/m^2 and also averaged only 0.05 fish/m^2.

Coho salmon density trends based on a three year life history pattern, revealed a continued decline at all stations (Figure 1a,b). Caspar Creek stations, upper and lower, were 6% and 17%, of the year class mean, respectively. Coho salmon density at the lower station on Little River was 9% of the year class mean and no coho were collected at the upper station. Absence of coho salmon at the upper station on Little River was most likely due to an instream barrier located approximately 75 meters downstream.

Coho salmon trends based on juvenile density are equally depressed in the tributaries to the Eel River compared to the coastal streams. Most disturbing, is the absence of coho salmon in Ryan Creek since 1993. It is very likely all three year classes have been extirpated and this absence is backed by data collected during adult salmon spawning stock surveys conducted throughout the Outlet Creek system. Juvenile coho salmon have not been observed in Outlet Creek, which Ryan Creek is tributary to, since 1993. The trend in Hollow Tree Creek, similar to the coastal streams, reflects decline. In 1999, the density of coho salmon was 39% of the year class mean at the upper station, and 7% of the year class mean at the middle station. Only once, in 1994, during the past 15 years have coho salmon been collected at the lower station on Hollow Tree Creek.

Overall, juvenile coho salmon density was depressed when compared to data collected since 1986. Despite restoration efforts, coho salmon populations remain depressed among the streams monitored through this project. Five separate

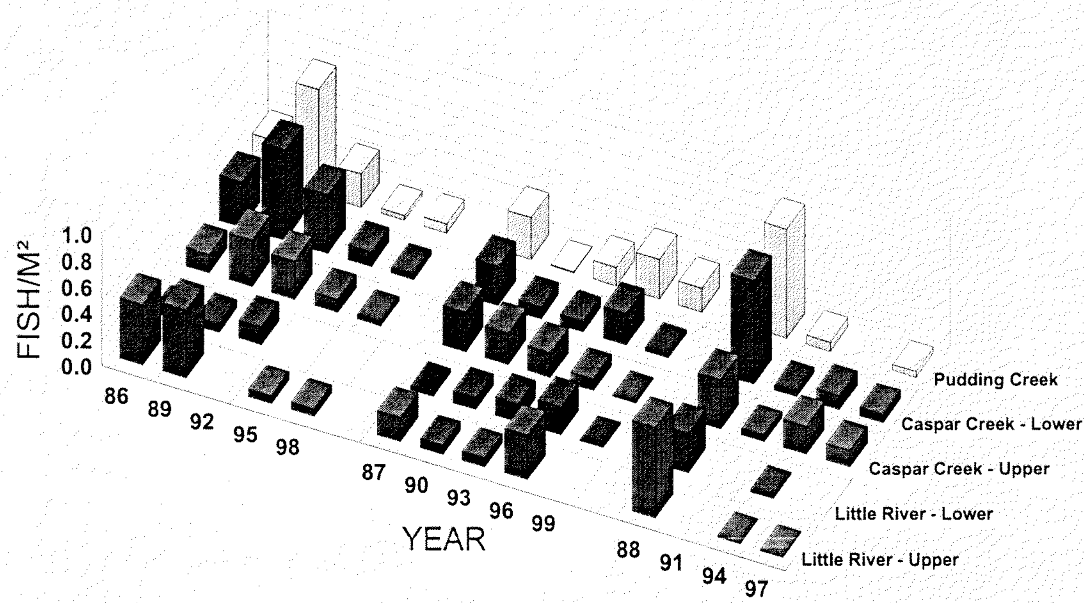

Figure1a.Juvenile coho salmon trends based on three year life history pattern, coastal Mendocino County, 1986 to 1999.

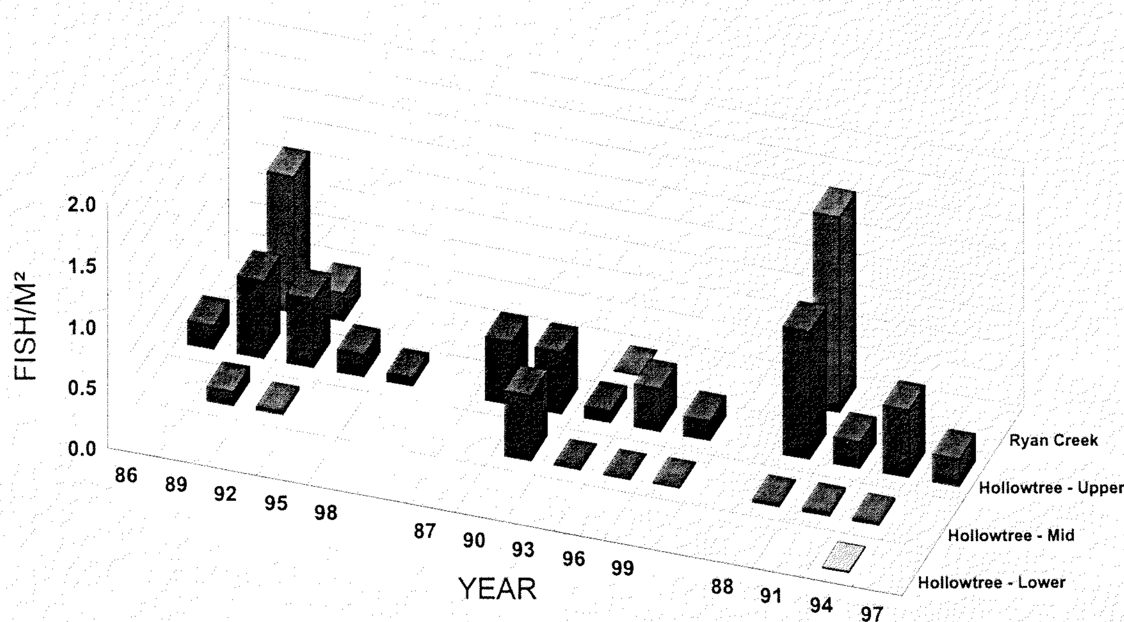

Figure 1b. Juvenile coho salmon trends based on three year life history pattern, Eel River tributaries, 1986 to 1999.

watersheds are monitored through this project and each is managed differently; Little River ownership is half private and half California State Parks, Caspar Creek is owned by California and managed by the Department of Forestry as an experimental watershed, Pudding Creek is primarily owned by the Campbell Timber Group, Ryan Creek is privately owned, and Hollow Tree Creek is split by private ownership and Mendocino Redwoods Company.

Steelhead: As steelhead trout do not adhere to the same predictable life cycle as coho salmon, year to year comparisons provide a general estimate of trends. In 1999, juvenile steelhead trout densities were lower at every station than the average for the previous 13 years (Figure 2 a,b). In 1999, densities as a percentage of the 13 year average ranged from 6 to 48 for coastal Mendocino stream stations, and from 27 to 87 for Eel River tributaries. Although relatively stable since 1991 or 1992, steelhead trout densities for the Little River and Pudding Creek stations were much higher in the later half of the 1980's.

Although this project reflects 14 years of data collection and inferences to trends of salmonid populations are made, it should be kept in mind that we do not know the long term fluctuations in these small coastal populations. The declines eluded to may be a very consistent trend in the overall cycle. But it may also be a very dire sign of problems associated with man's affective acceleration on limiting factors.

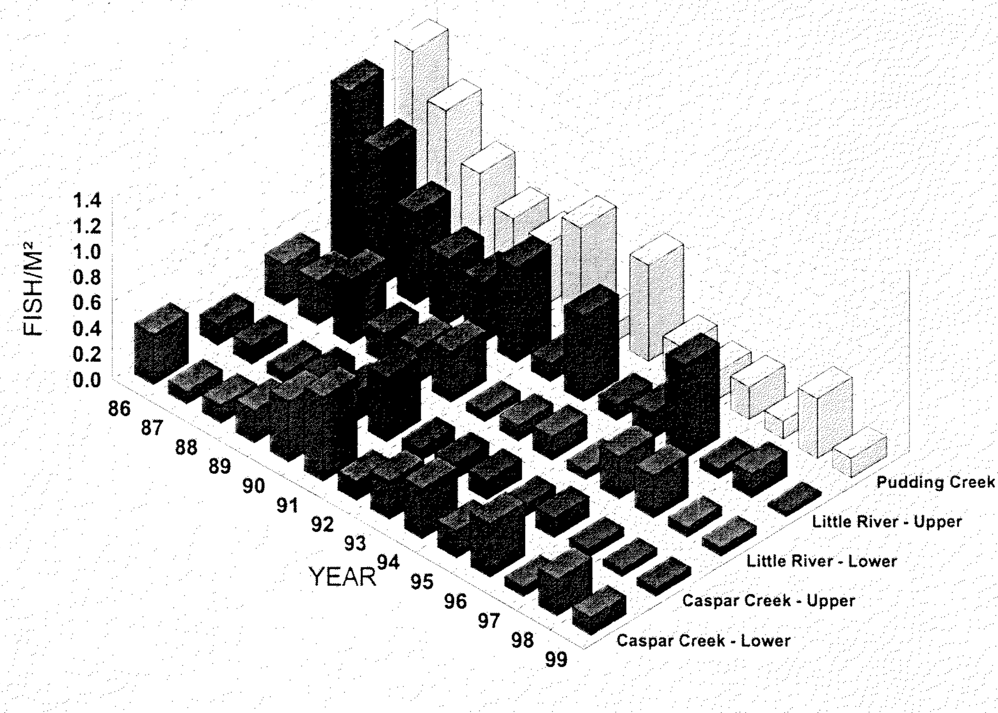

Figure 2a. Juvenile steelhead trends in density, coastal Mendocino County, 1986 to 1999.

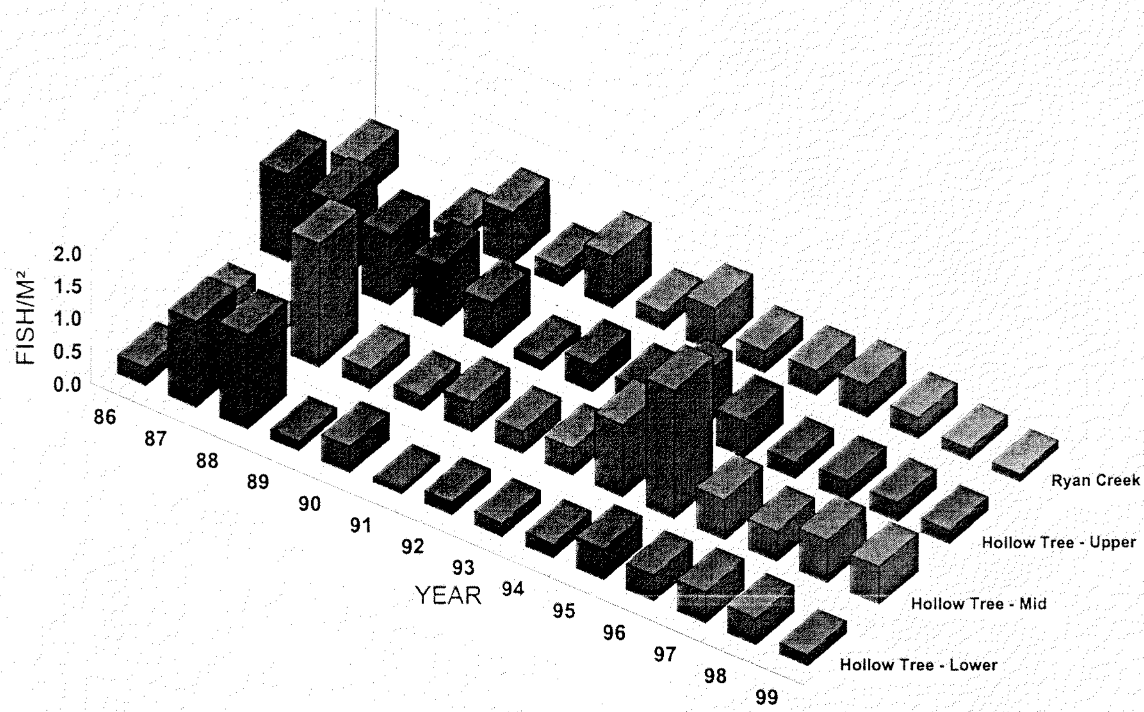

Figure 2b. Juvenile steelhead trends in density, Eel River tributaries, 1986 to 1999.

Juvenile steelhead length varied considerably between stations (Figure 3). Ryan Creek steelhead length distribution was the most platykurtic, with the Little River steelhead reflecting a similar distribution. All other stations reflected a more leptokurtic distribution. The most interesting length frequencies were revealed at Hollow Tree Creek where the population size was gradually greater with distance from the headwaters.

The pattern of small to larger fish from the headwaters to the mouth on Hollow Tree Creek was not reflected in densities of juvenile steelhead, or combining coho and steelhead for an overall juvenile salmonid density. If, in combining salmonid species, the trend from upper to lower station was high to low, respectively, a case could be made for size being density dependent. However, this was not the case and therefore other habitat factors, for instance water temperature, hence metabolism, may be one reason for smaller fish at the upper stations. There are several other conditions, acting either singly, or in combination with other conditions, that could result in the progression of sizes revealed on Hollow Tree Creek. Past studies on returning adult steelhead and subsequent scale analyses suggests that size at the time of smolting is a critical factor in population maintenance and escapement.

Overall, the low coho salmon and steelhead trout standing crop densities found during recent years may indicate we will continue to see lower numbers of adults returning to spawn in the future. Recruitment, for one reason or another, appears to be slowly failing.

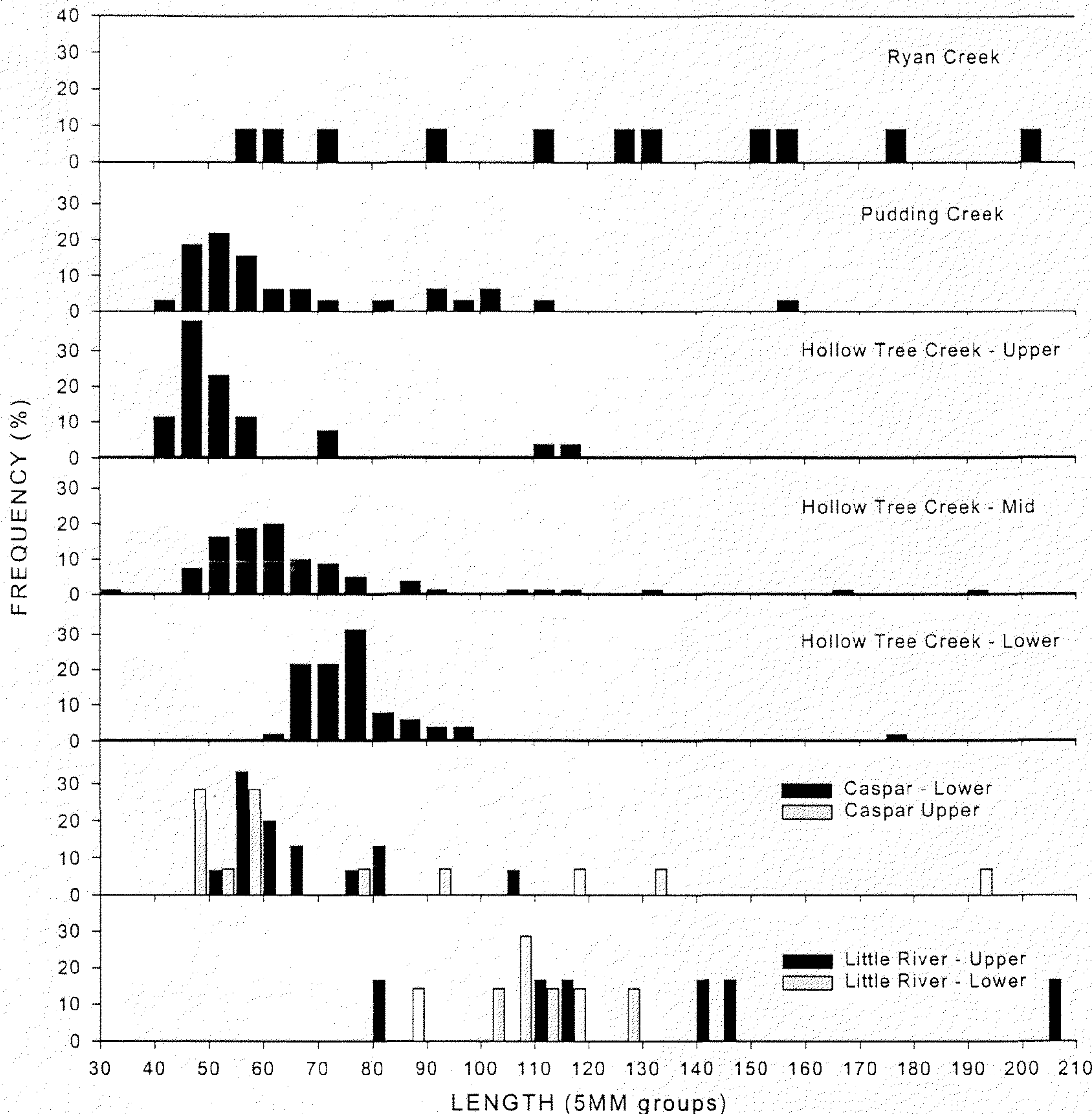

Figure 3. Juvenile steelhead length frequency, Mendocino County, 1999.

Recommendations: Electrofishing provides crucial information for estimating trends in standing crop of coho salmon and steelhead trout. Annual collection of this data illuminates trends which are essential in focusing management and restoration efforts. With the recent increase in restoration activities, it is very important to continue this monitoring as one tool to determine the effectiveness of our efforts.

These surveys were conducted on State Forest, State Park, corporate timber, and private land. All of these land owners must be made aware of the aforementioned trends and what further steps could be taken to restore these watersheds and that stewardship of the land they are responsible for is of the utmost importance.

VII. Estimated FY 99-00 Job Cost: $34,287.00

VIII. Preparer: Scott Harris, ____________________, Associate Fishery Biologist