Results of the Winter 2000 Steelhead *(Oncorhynchus mykiss)* Spawning Survey on the Noyo River, California with Comparison to Some Historic Habitat Information

Prepared By

Sean P. Gallagher
Draft 13 December 2000
California Department of Fish and Game
Steelhead Research and Monitoring Program
Fort Bragg, California

DISCLAIMER

The mention of trade names of commercial products in this report does not constitute endorsement by the California Department of Fish and Game

Cover Photograph: Steelhead redd on the North Fork Noyo River just upstream of Hayworth Creek 2 May 2000. The 1.5m staffs at lower left and lower right are for scale.

This Report Should Be Cited as:

Gallagher, S. P. 2000. Results of the Winter 2000 Steelhead *(Oncorhynchus niykiss)* Spawning Survey on the Noyo River, California with Comparison to Some Historic Habitat Information. California State Department of Fish and Game, Steelhead Research and Monitoring Program, Fort Bragg, CA., 1 December 2000. 28 pp.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Results of the Winter 2000 Steelhead *(Oncorhynchus mykiss)* Spawning Survey on the Noyo River, California with Comparison to Some Historic Habitat Information

Prepared By Scan P.
Gallagher[1]

Abstract

Spawning surveys were conducted on the Noyo River from March to May 2000 to quantitatively estimate steelhead *(Oncorhynchus mykiss)* populations. The spawning surveys were intended as the recapture portion of a mark-recapture study to estimate adult populations. Adult, carcass, and redd counts and redd areas were used to estimate adult population using the area-under-the-curve (AUC) and two redd-based methods. Information on spawning locations and distributions as well as scale and tissue samples were collected. Data were also collected on Pacific lamprey *(Lamperta tridentata)* and coho *(0. kisutch)* salmon spawning. Spawning habitat quality from historic stream surveys was compared to habitat use during 2000. A total of 110.2 km of the Noyo River was surveyed during 2000. Steelhead redds were distributed throughout 75.8 km of the Noyo River. A total of 150 steelhead, 733 lamprey, and six coho redds were observed. Uncertainty in redd identification was 16%. The average size of 141 steelhead redds was 2.82 m^2 (S.E. = 0.2) and ranged from 0.61 to 10.40 m^2. Steelhead redd density averaged 1.68/km and ranged from zero to 4.69. A total of 35 live steelhead and one carcass were observed. Live steelhead density averaged 0.24/km (S.E. = 0.21). Area-under-the-curve population estimates were only possible for five streams due to low numbers of adults observed and the late start of surveys this season. Redd based steelhead population estimates ranged from 361 (T 57) to 155 (T 24.8). A total of 60 adult steelhead were observed in the Noyo River between 14 January and 29 April 2000. Steelhead average fork length was 57.4 cm (n=47, S.E. = 0.18) and ranged from 35 to 75 cm. Steelhead female to male ratio was 0.71:1.00 (n=27). The majority (52%) of steelhead redds observed in the Noyo River during 2000 were found in March. Seven streams showed an apparent decline in habitat quality, three increased and the rest were either the same or only surveyed once previously. Live steelhead densities in the Noyo River during 2000 were lower than reported for other local streams in past years. Steelhead redd densities and life stage timing in the Noyo River during 2000 was similar to nearby streams surveyed in previous years. The difference in habitat quality between 1957, 1959, 1967 surveys and ratings based on steelhead spawning density during 2000 result from different survey methods, because earlier surveys salmonid spawning habitat included both coho and steelhead, and due to real changes in the streams over time. More information on steelhead mating systems may improve the AUC population estimation method.

Introduction

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

[1]Steelhead Research and Monitoring Program Report No. FB-01. December 2000. Philip K. Barrington Senior Biologist Supervisor, California State Department of Fish and Game, 2030 1st Street, Suite 9, Eureka, CA 95501.

listed NCU steelhead as Threatened Species under the ESA (Federal Register 2000). The listing, by in large, is due to the failure of the California Board of Forestry to change timber harvest regulations.

Little current information exists for the majority of steelhead stocks in California and basic life history and biological information is needed to understand the nature and character of populations (McEwan and Jackson 1996). The Eel River is the only stream in the NCU for which recent estimates of winter-run steelhead exist (CDFG 1998). Breeding population size (number of reproductive adults) is an important statistic for assessing population status. Four key parameters for assessing viable salmonid populations are abundance, population growth rate, population spatial structure, and diversity (McElhany et al. 2000). The NMFS focuses on the number of adults escaping to spawn in natural habitat and is mandated by the ESA and internal policy to focus on natural viability of salmon populations (Busby et al. 1996).

Existing adult steelhead information for coastal Mendocino County is limited to portions of local rivers and streams and was generally collected to examine restoration activities or coho populations. Nielsen et al. (1990) conducted spawning surveys on 82 streams in coastal Mendocino County and used carcass or live fish counts to estimate total escapement and examine the effectiveness of stream restoration projects. Although they observed some steelhead, the survey period ended in late February and their focus was on coho (0. *kisutch)* and chinook salmon *(0. tshawytscha)*. Maahs and Gilleard (1993) report the results of spawning surveys in ten watersheds during 1990-91 and seven watersheds during 1991-1992 to examine the effectiveness of over 30 years of stream restoration in Mendocino County. Maahs (1996, 1997) conducted spawning surveys on portions of the Ten Mile and Garcia rivers and Caspar Creek to examine the effects of a rearing project (Ten Mile River) and extensive restoration (Garcia River). Maahs (1999) presents the results of spawning surveys on portions of the Garcia River. These works provide information on the tuning of steelhead and coho spawning yet redds are not differentiated by species and population estimates are only made for coho. Maahs (1996) did not estimate steelhead copulations because he did not have estimates for the number of redds produced per female nor female to male ratios. Nadig (1999) presents results of spawning surveys on the Albion River conducted during 1992-93, 1995-96, and 1998-99. The emphasis of these surveys was coho salmon, the survey period was between mid-December and mid-January, and few steelhead were observed. Harris (1999a, 1999b) presents findings from spawning surveys on 14 and 16 Mendocino County streams, respectively, five of which have been surveyed annually since 1991. These reports provide no information on steelhead.

The purpose of the winter 2000 spawning survey on the Noyo River was to quantitatively estimate steelhead populations during 2000. The spawning surveys were intended as the recapture portion of a Jolly-Seber (Krebs 1989) mark-recapture study to estimate adult populations for the Noyo River. Steelhead tagged and released in the lower river (Neillands, In Preparation) were to be visually recaptured during the spawning surveys. Adult and redd counts and redd areas were used to calculate adult population estimates using the area-under-the-curve (AUC- Beidler and Nickelson 1980, English et al. 1992) and two redd-based population estimation methods described by Maahs (1997). Information on spawning locations and distributions as well as scale and tissue samples were collected. Data were also collected on Pacific lamprey *(Lamperta tridentatd)* and coho salmon redds.

Study Area

The Noyo River watershed (Fig. 1) is a forested, coastal watershed in Mendocino County, California, which drains approximately 260.3 km^2 (Table 1) immediately west ofWillits. The Noyo River flows through the coast range and into the Pacific Ocean at Fort Bragg. The Noyo River was selected to conduct a pilot adult winter run steelhead mark-recapture program to estimate adult abundance. The Noyo River was chosen because, 1) a significant proportion of the watershed is in Jackson State Demonstration Forest, 2) the remainder of the watershed is primarily owned by two timber companies, 3) CDFG operates the Noyo Egg Collecting Station (ECS) on the South Fork Noyo River,

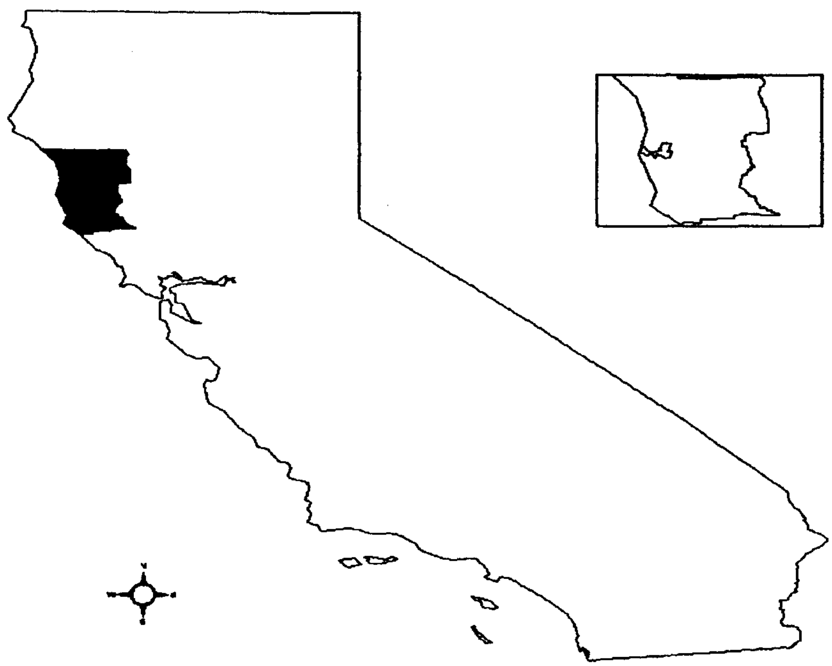


Fig. 1 Location of the Noyo River watershed and Mendocino County in California.

4) CDFG has conducted coho studies on the South Fork Noyo since 1986, and 5) CDFG has implemented many different types of habitat improvement projects in the South Fork Noyo River for many years. In addition, the Noyo River watershed is subject to several recent changes in management including no harvest of wild adult steelhead, no artificial propagation of steelhead, and different land uses due to different landowner ownership.

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

Survey Segments

The Noyo River was divided into three main areas based on property ownership (Fig. 2, Table 1) The three areas were the South Fork, the upper river and North Fork, and the main stem Noyo River below North Spur. These segments are similar to the planning area watersheds of the California Regional Water Quality Control Board (CRWQCB-1999) except I combined their headwaters and North Fork into the upper river and their lower Noyo and middle Noyo into the Noyo River below North Spur

The South Fork was divided into five survey segments based on access (Fig. 2, Table 1). The five segments

Table 1. Stream name, segment name, segment abbreviation, segment drainage area, survey length, and the upstream extent of spawning observed during steelhead spawning surveys in the Noyo River, California during 2000. Letters in parentheses are stream segment abbreviations.

Stream Name (Abbreviation)	Segment	Drainage Area (km)	Survey Length (km)	Extent of Spawning (km)	Notes
Brandon Gulch (BG)	Mouth to 2.2 km	-	2.2	0	Area includes NFSF
Burbeck Creek (BC)	Mouth to 2.1 km	-	2.1	0	Area includes above Redwood Cr.
Hayworth Creek (HC)	Mouth to 6.6 km	28.78	6.8	6.6	
Kass Creek (KC)	Mouth to 5.6 km	6.04	5.58	0.52	
Marble Gulch (MG)	Mouth to 3 km	-	2.9	0	Area includes LNF
McMullen Creek (MC)	Mouth to 1.5km	-	1.45	0.8	Area includes above Redwood Cr.
Middle Fork (MF)	Mouth to 3.4 km	6.76	3.4	2.24	
Noyo (NNStRC)	North Spur to Redwood Creek (7.6 km)	13.66	7.62	7.62	
Noyo (NaRC)	Redwood Creek to Burbeck Creek (6.1 km)	28.61	6.1	4.05	Area includes Burbeck and McMullen
Noyo (NSFtNS)	South Fork to North Spur (20.9 km)	57.42	20.9	20.9	
North Pork Hayworth Creek (NFH	Mouth to Falls (0.64 km)	-	0.64	0	Area includes Hayworth Creek
North Fork Noyo (NFL)	North Spur to Hayworth Creek (6.19 km)	17.04	6.19	6.19	Area includes Marble Gulch
North Fork Noyo (NFU)	Above Hayworth Creek (5.85 km)	11.73	5.85	4.85	Area includes Dewarren Creek
North Fork South Fork (NFSP)	Mouth to 9.57 km	26.1	9.57	8.39	Area includes Brandon Gulch
Olds Creek (OC)	Mouth to 4.13 km	11.36	4.13	1.72	
Parlin Creek (PC)	Mouth to 4.56 km	11.31	4.56	2.36	
Redwood Creek (RC)	Mouth to 5.84 km	13.61	5.84	3.71	
South Fork (SF)	Mouth to Pond (14.4 km)	27.87	14.4	5.81	
Total		260.29	110.23	75.76	

were: 1. the Little North Fork and Brandon Gulch, 2. Parlin Creek, 3. upper South Fork (above the North Fork South Fork), 4. lower south Fork (Mouth to the North Fork South Fork), and 5. Kass Creek. These segments were similar to those surveyed by Maahs and Gilleard (1993).

The upper river and North Fork was divided into eight survey segments based on access (Fig. 2, Table 1). The eight segments were: 1. North Fork to Hayworth Creek including Marble Gulch, 2. North Fork from Hayworth Creek to Dewarren Creek, 3. Middle Fork, 4. Hayworth Creek from the North Fork Noyo to Soda Creek, 5. Main stem Noyo from Old Camp Seven to Irmuico, 6. Main stem Noyo including Burbeck Creek from Irmuico to 2nd road crossing on Burbeck Creek. 7. Olds Creek from Irmuico to 2nd road crossing, and 8. Redwood Creek from mouth up 4km.

The main stem Noyo River below North Spur was divided into four survey segments (Fig. 2, Table 1). The four segments were: 1. The Little North Fork Noyo, 2. The main stem North Spur to Grove including various gulches, 3. Noyo River from Grove to the South Fork, and 4. Hayshed Gulch.

Methods and Materials

Field Methods

In general, the methods employed by Nielsen et al. (1990) Maahs and Gilleard (1993), and Maahs (1996, 1997, 1999) were followed for this study. Crews of two walked and snorkeled stream reaches three times from March through mid-May 2000. Training of crews occurred during the first sampling week. The main stem Noyo River below North Spur was sampled only once by kayak. Flows after March were too low to float this section again. Kayaks were used to survey the North Fork from Hayworth Creek to North Spur (all three visits) and the main stem Noyo from Redwood Creek to North Spur during the first sample period, after which flows were too low to float this segment. Stream and air temperatures were measured and stream flows estimated daily. Tagged and untagged fish were identified to species, counted, sized, and sexed from the banks and/or by snorkeling when observed. Carcasses were identified to species, sex, fork length measured, and inspected for tags and marks. All redds observed were identified to the species assumed to have constructed them, counted, the length and width measured, substrate composition visually estimated, and locations recorded on field maps. All newly constructed redds, those without periphyton, were measured during each visit. All redds were flagged on each visit to avoid double counting. Initially flagging was only labeled with date and number of redds. During latter sampling, to avoid confusion, flags were also labeled with the species suspected of creating the nest. At the end of the spawning season some redd locations were geo-referenced with GPS.

Spawning Habitat Quality and Use

Information on spawning habitat was gleaned from stream habitat surveys conducted on the Noyo River by CDFG during 1957, 1959, and 1967 (Appendix I). These surveys were generally conducted during the summer months and only contain comments on spawning habitat quality. From general statements in these reports I developed a spawning habitat rating (Table 2) for each stream or stream segment which had been surveyed each year.

I used the number of redds observed per km of stream to develop a rating system of habitat use from the 2000 spawning survey information similar to that for the historic information. I divided the difference between the highest and lowest number of redds/km observed by four to create four classifications of spawning habitat use. This data was compared graphically with the historic data to examine trends.

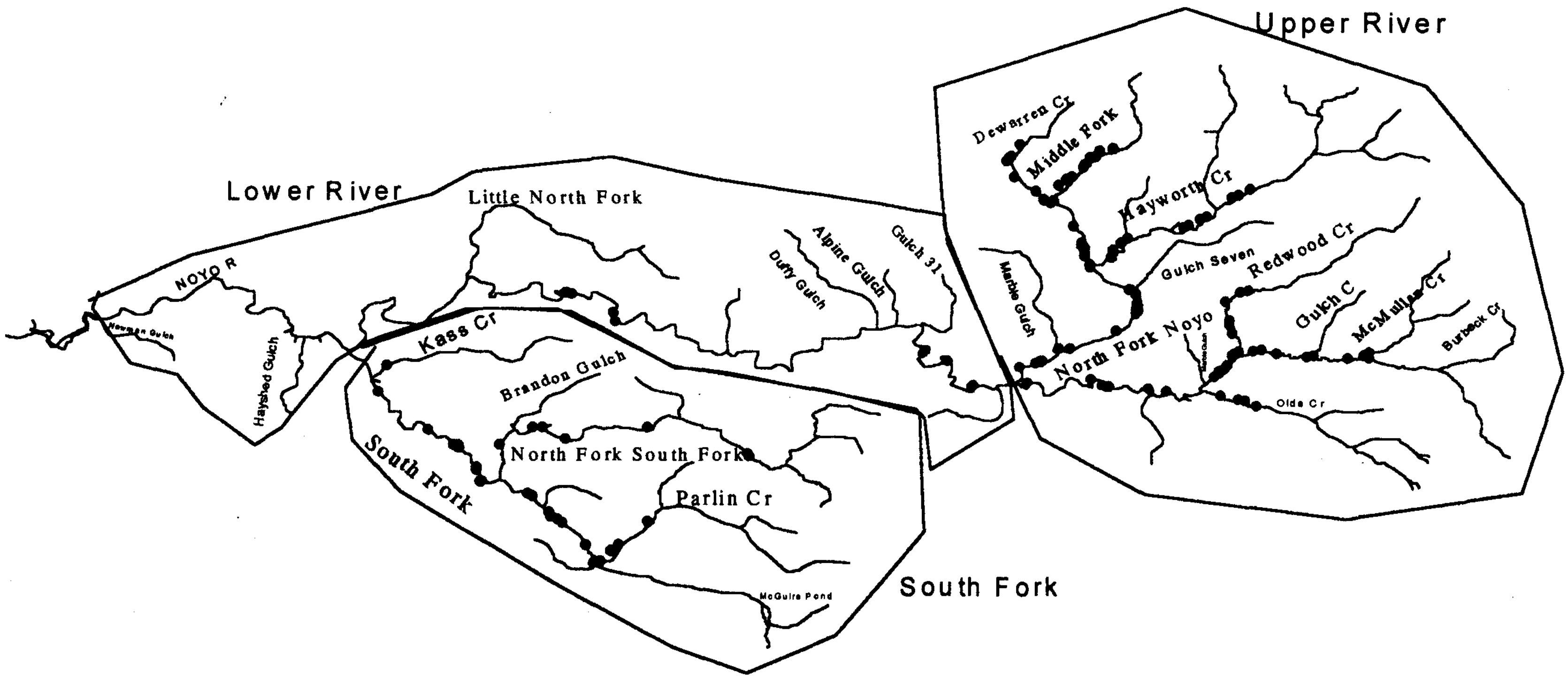


Fig. 2. Stream survey areas, stream segments, and steelhead redd distribution in the Noyo River during 2000. Circles indicate individual steelhead redds. Note: The Little North Fork and gulches below the North Fork were not surveyed during 2000.

Data Analysis

Spawning population estimates were derived from live fish observations using the AUC method (Beidler and Nickelson 1980, English et al. 1992) and the number and size of redds as described by Nielsen et al. (1990), Maahs and Gilleard (1993), and Maahs (1996, 1997). Uncertainty in redd counts was calculated from observer uncertainty in species making redds as the percentage of redds recorded on data forms as unidentified and those which the notes stated maybe another species divided by the total number of redds. Adult stream residency for steelhead was based on observations of one spawning pair in the Noyo River during 2000, time between capture and recapture of one fished tagged in the Noyo River during 2000 (Neillands, In Preparation), and estimates of 14 days stream residency for steelhead from Shapovalov and Taft (1954) and was estimated at 11 days for use in the AUC method. Population estimates based on redd numbers and area were multiplied by 1.41, the male per female ratio observed this season. Population estimates based on redd area (Maahs 1996) assumed one female could make one 5.4 m^2 area redd (Shapovalov and Taft 1954), half this effort equals half a fish, a quarter of the effort one quarter of a fish. Carcass-based population estimates were not possible. Survey distance and drainage area for each segment were estimated from USGS 7.5 series quadrangle maps. Redd area was calculated for each species. Correlation was used to examine the relation between the number of redds observed and drainage area and stream length. Redd densities (number per km) between segments were compared using t-tests. Redd spatial patterns were determined using the chi-square index of dispersion (Krebs 1989) treating the survey segments as samples. Adult steelhead observed during spawning surveys, gill netting, and in downstream traps were pooled to examine fork length, sex ratios, and life stage tuning during 2000. Male, female, and unidentified fish fork lengths were compared using t-tests and Mann-Whitney U-test when Standard Kurtosis p-values were < 0.05.

Results

The main emphasis of this study was to recapture fish marked lower in the river and estimate adult population. No recaptures were made during the spawning surveys. Only one carcass was observed and not observed a second time thus no carcass-based population estimates were made.

Reads

A total of 110.23 km of the Noyo River was surveyed during March 2000. A total of 89.33 km were surveyed once during April and once during May 2000 (Table 1). Steelhead redds were found throughout 75.76 km of the Noyo River during 2000 (Table 1, Fig. 2). The chi-square index of dispersion indicated steelhead redds were randomly distributed in the Noyo River during 2000 ($X^2 = 11.73$, n = 14). A total of 150 ($\pm$24) steelhead redds were identified during the three survey periods (Table 3). The average size of 141 steelhead redds was 2.82 m^2 (S.E. = 0.2) and ranged from 0.61 to 10.40 m^2. Uncertainty in redd identification was estimated at 16%. The Noyo River had on average 1.68 ($\pm$0.47) steelhead redds/km during 2000. The number of redds per km ranged from zero to 4.69 (Fig. 3a-c, Table 3). Treating the survey segments as samples, there was a significant difference in the number of redds per km between the upper Noyo River, which averaged 1.53 redds/km (S.E. = 2.09) and the South Fork, which averaged of 0.67 redds/km, S.E. = 0.32. (f = 8.17, n= 13:6, p =0.009). The main stem Noyo River below North Spur was not included in this analysis because it was only surveyed once. There was no relationship between the number of redds observed and stream reach length in the Noyo River during 2000 (Fig 4 a, r = 0.47, n = 14, p = 0.09). There was a significant relationship between the number of redds observed and drainage area m the Noyo River during 2000 (Fig. 4b, r = 0.55, n = 14, p = 0.04). With the one outlier removed (Fig. 4a) from the analysis there was a significant relationship between the number of redds observed and reach length r = 0.61, n = 13, p = 0.03). With the one outlier removed (Fig. 4b) fromthe analysis there was a significant relationship between the number of redds observed and drainage area r = 0.66, n = 13, p = 0.01).

Table 2. Spawning habitat descriptions for the Noyo River from 1957, 1959, 1967 stream surveys, the number of redds/km during 2000, and spawning habitat quality ratings used to compare habitat over these years.

Habitat Descriptors 1957-67	Redds/km 2000	Rating
No Data	-	0
Excellent, Abundant	>3.51	1
Ample, Considerable, Frequent, Good, Numerous, Many	2.35-3.51	2
Fair, Fairly Numerous, Satisfactory, Some	1.18-2.34	3
Few and Scattered, Not Frequent, Minor, Not Good, Occasional, Questionable, Scattered, Silted	0.1-1.17	4
None	0	5

The average size of six coho redds was 6.36 m^2, S.E. = 0.37. Only six un-flagged coho redds were observed during the surveys, five of which were in the South Fork Noyo River (Table 4). The only coho redd identified in the upper watershed was in Redwood Creek on 4 April and was considered to be very old and indistinct.

A total of 733 Pacific lamprey redds were observed in the Noyo River between 9 March and 9 May 2000 (Table 4). The average size of Pacific lamprey redds in the Noyo River during 2000 was 0.24 m^2 (S.E. = 0.005). Lamprey redds were found in all streams in which steelhead redds were observed, except the Middle Fork. Only one lamprey redd was found in the upper North Fork (Table 4). Although no steelhead redds were observed, lamprey redds were found in the North Fork of Hayworth Creek.

Adult Steelhead

A total of 35 steelhead were observed during spawning surveys on the Noyo River in 2000 (Table 3). Only one steelhead carcass was observed this year. Observed live steelhead density was 0.24/km (S.E. = 0.21) in the Noyo River during 2000. Population estimates based on the AUC method were only possible for five of the stream sections surveyed in the Noyo River during 2000 (Table 3). Steelhead spawning population estimates based on redd information ranged from 155 ($\pm$24.8) to 361 ($\pm$27) between 3 March and 23 May 2000. Steelhead density from the redd based estimates ranged from 2.04 $\pm$ 0.33 to 4.76 $\pm$ 0.76 per km. The AUC and population estimates based on redd area are very similar for three of the five stream segments in which fish observations were sufficient to produce AUC population estimates (Table 3).

A total of 60 adult steelhead were observed in the Noyo River between 14 January and 29 April 2000. Of these, 35 were observed during spawning surveys, six were captured at the egg collecting station, six were captured in gill nets, five were observed near gill nets, and eight were observed during downstream migration trapping. Of these fish 48 were observed in enough detail to estimate fork length. There was a significant difference between visually estimated fork lengths (median 55.0) and handled and measured fish (median 62.5: T=539, n= 18:30, p==0.04). Therefore, further statistical comparisons were only made for bandied and measured fish. Steelhead average fork length was 59.9cm, S.E. = 2.23 and ranged from 35 to 75 cm (Fig. 5a). Average male steelhead

Table 3. Number of steelhead redds, redds/km, live fish, live fish/km, and calculated number of fish by stream segment for the Noyo River during March-May 2000. Numbers in parentheses are 16% uncertainty. Calculated adult numb ers assume a 0.71:1.00 female to male ratio.

Stream Name	Segment	Number of Redds		Number of O. m. Adults Observed			Calculated Number of Adult 0. m.		
		Total	Redds/km	Total	Number/km	Area-Under-Curve	One Redd Per Female	Two Redds Per Female	Estimated by ReddArea
Brandon Gulch	Mouth to 2.2 km	0	0	0	0.00	-	0	0	0
Burbeck Creek	Mouth to 2.1 km	0	0	0	0.00	-	0	0	0
Hayworth Creek	Mouth to 6.6 km	13 (2.08)	1.97 (0.32)	12	1.82	12.27	31.3 (5.01)	15.65 (2.50)	12.05 (1.93)
Kass Creek	Mouth to 5.6 km	1 0.16	0.18 (0.03)	0	0.00	-	2.41 (0.38)	1.2 (0.19)	2.41 (0.38)
Marble Gulch	Mouth to 3 km	0	0	0	0.00	-	0	0	0
McMullen Creek	Mouth to 1.5km	2 (0.32)	1.33 (0.21)	0	0.00	-	4.82 (0.77)	2.41 (0.38)	1.2 (0.19)
Middle Fork	Mouth to 3.4 km	11 (1.76)	3.24 (0.52)	0	0.00	-	26.5 (4.24)	13.25 (2.12)	9.24 (1.48)
Noyo	North Spur to Redwood Creek (7.6 km)	18 (2.88)	2.37 (0.38)	6	0.79	7.01	43.4 (6.94)	21.7 (3.47)	18.07 (2.89)
Noyo	Redwood Creek to Burbeck Creek (6.1 km)	13 (2.08)	2.13 (0.34)	3	0.14	3.49	31.3 (5.01)	15.65 (2.50)	12.65 (2.02)
Noyo	South Fork to North Spur (20.9 km)	9 (1.44)	0.43 (0.07)	0	0.00	-	21.69 (3.47)	10.84 (1.73)	28.92 (4.63)
North Fork Hayworth Creek	Mouth to Palls (0.64 km)	0	0	0	0.00	-	0	0	0
North Fork Noyo	North Spur to Hayworth Creek (6.19 tan)	29 (4.64)	4.69 (0.75)	0	0.00	-	69.89 (11.18)	34.94 (5.92)	20.48 (3.28)
North Pork Noyo	Above Hayworth Creek (5.85 km)	16 (2.56)	2.73 (0.44)	6	0.97	12.15	38.56 (6.20)	19.28 (3.08)	12.9 (2.06
North Fork South Fork	Mouth to 9.57 km	7 (1.12)	0.73 (0.12)	0	0.00	-	16.87 (2.70)	8.43 (1.35)	4.22 (0.67)
Olds Creek	Mouth 10 4.13 km	4 (0.64)	0.97 (0.15)	0	0.00	-	9.64 (1.54)	4.82 (0.77)	4.17 (0.67)
Parlin Creek	Mouth to 4.56 km	4 (0.64)	0.88 (0.15)	0	0.00	-	9.64 (1.54)	4.82 (0.77)	5.99 (0.96)
Redwood Creek	Mouth to 5.84 km	6 (0.96)	1.03 (0.16)	3	0.51	4.28	14.46 (2.31)	7.23 (1.17)	4.82 (0.77)
South Fork	Mouth to Pond (14.4 km)	17 (2.27)	1.18 (0.19)	0	0	-	40.97 (6.55)	20.48 (3.28)	18.07 (2.89)
Total for Noyo River March to May 2000		150 (24)	-	30	0.24	39.20	361.45 (57.8)	180.72 (28.91)	155.19 (24.83)

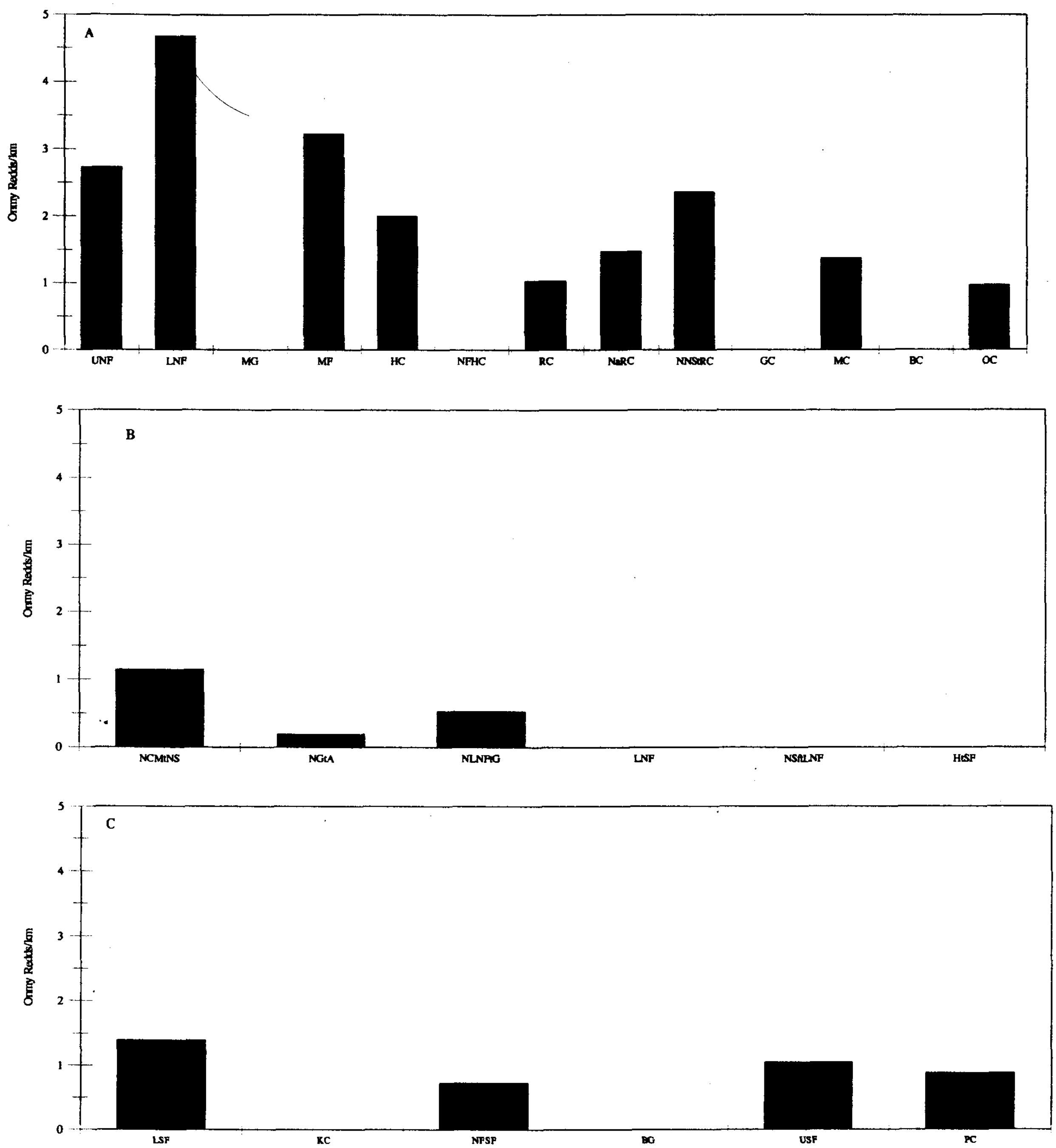
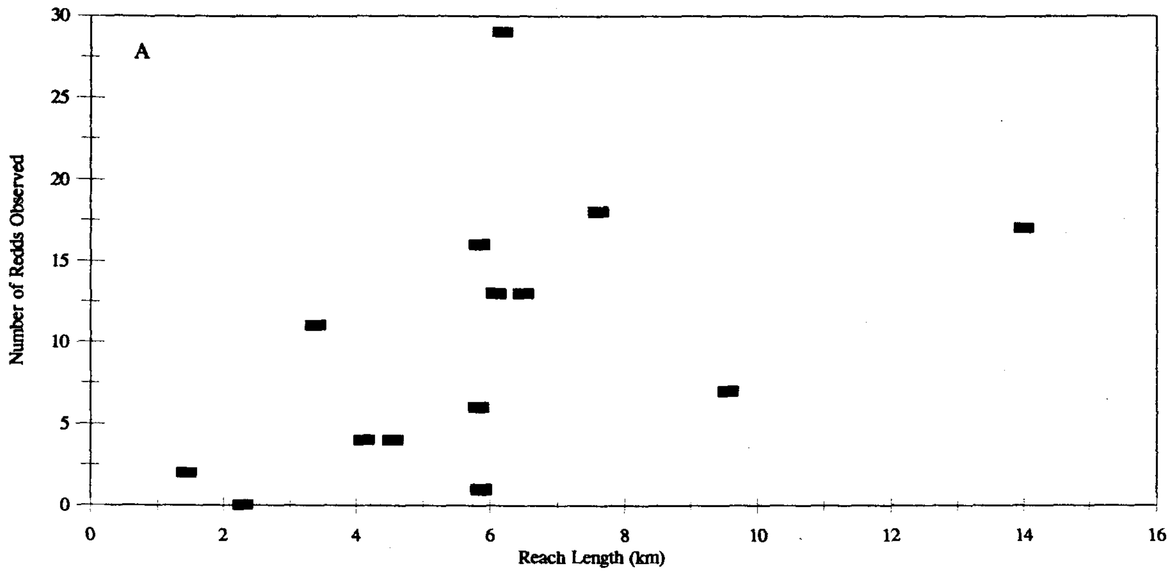


Fig. 3. Number of steelhead (Onmy) redds observed/km in the Noyo River during 2000. A). Upper river survey segments. Segment abbreviations are the same as in Table 1. B). Lower river segments. Abbreviations are the same as in Table 1, except NCMtNS is from Camp Mendocino to North Spur, NGtA is Grove to Alpine, NLNFtG is LNF to Grove, NSFtLNF is SF to LNF, and HtSF is from the Harbor to the SF. C). South Fork segments. Segments are the same as in Table 1, except that USF and LSF are the South Fork above and below the NFSF, respectively.

Table 4. Number of coho salmon (Onki) and Pacific Lamprey (Latr) redds and redds/km observed in the Noyo River during March-May 2000. Numbers in parentheses are 16% uncertainty.

Stream Name	Segment	Number of Onki Redds		Number of Latr Reads	
		Total	Redds/km	Total	Redds/km
Brandon Gulch	Mouth to 2.2 km	0.00	0.00	0.00	0.00
Burbeck Creek	Mouth to 2.1 km	0.00	0.00	0.00	0.00
Hayworth Creek	Mouth to 6.6 km	0.00	0.00	92.00 (14.74)	13.94 (2.23)
Kass Creek	Mouth 10 5.6 km	0.00		0.00	0.00
Marble Gulch	Mouth to 3 km	0.00	0.00	0.00	0.00
McMullen Creek	Mouth to 1.5 km	0.00	0.00	4.00 (0.64)	2.67 (0.43)
Middle Fork	Mouth to 3.4 km	0.00	0.00	0.00	0.00
Noyo	North Spur to Redwood Creek (7.6 km)	0.00	0.00	262.00 (41.92)	34.47 (5.51)
Noyo	Redwood Creek to Burbeck Creek (6.1 km)	0.00	0.00	190.00 (30.4)	31.15 (4.98)
Noyo	South Fork to North Spur (20.9 km)	0.00	0.00	nd	nd
North Pork Hayworth Creek	Mouth to Falls (0.64 km)	0.00	0.00	12.00 (1.92)	18.75 (3.00)
North Fork Noyo	North Spur to Hayworth Creek (6.19 tan)	0.00	0.00	48.00 (7.68)	7.75 (1.24)
North Fork Noyo	Above Hayworth Creek (5.85 km)	0.00	0.00	1.00 (0.16)	0.17 (0.02)
Norm Pork South Fork	Mouth to 9.57 km	2.00 (0.32)	0.21 (0.03)	3.00 (0.48)	0.31 (0.05)
Olds Creek	Mouth to 4.13 km	0.00	0.00	3.00 (0.48)	0.73 (0.12)
Parlin Creek	Mouth to 4.56 km	1.00 (0.16)	0.22 (0.03)	5.00 (0.80)	1.10 (0.18)
Redwood Creek	Mouth to 5.84 km	1.00 (0.16)	0.17 (0.02)	58.00 (9.28)	9.93 (1.59)
South Fork	Mouth to Pond (14.4 km)	2.00 (0.32)	0.14 (0.02)	55.00 (8.80)	3.82 (0.61)
Total for Noyo River March to May 2000		6,00 (0.96)	-	733.00 (117.28)	



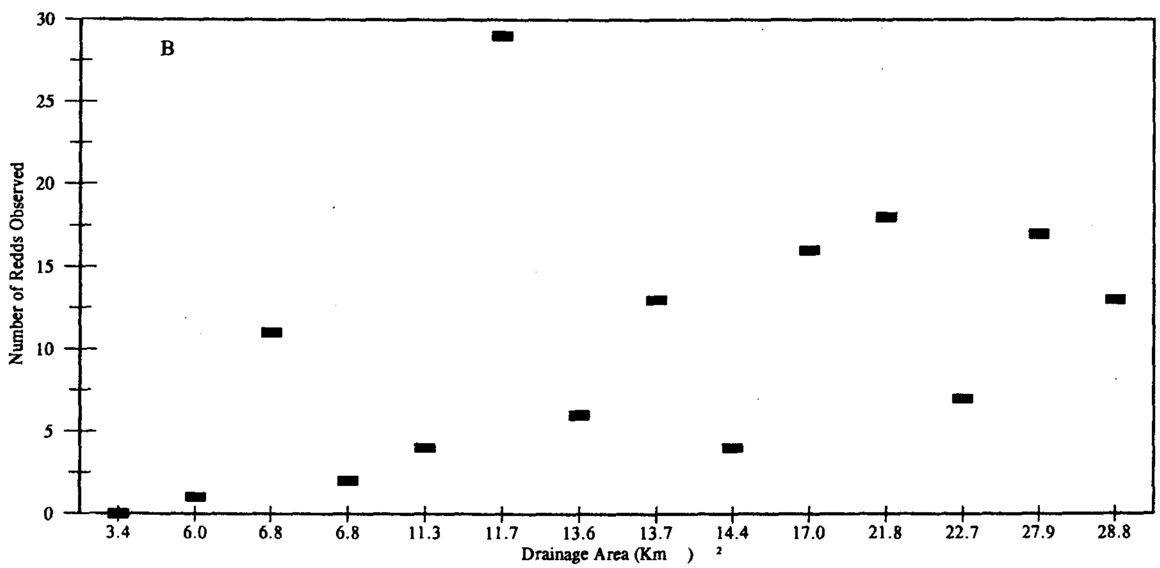


Fig. 4. Scatter plots of the number of redds observed versus reach length in km (A) and reach drainage area in km^2 (B) during spawning surveys in the Noyo River during 2000.

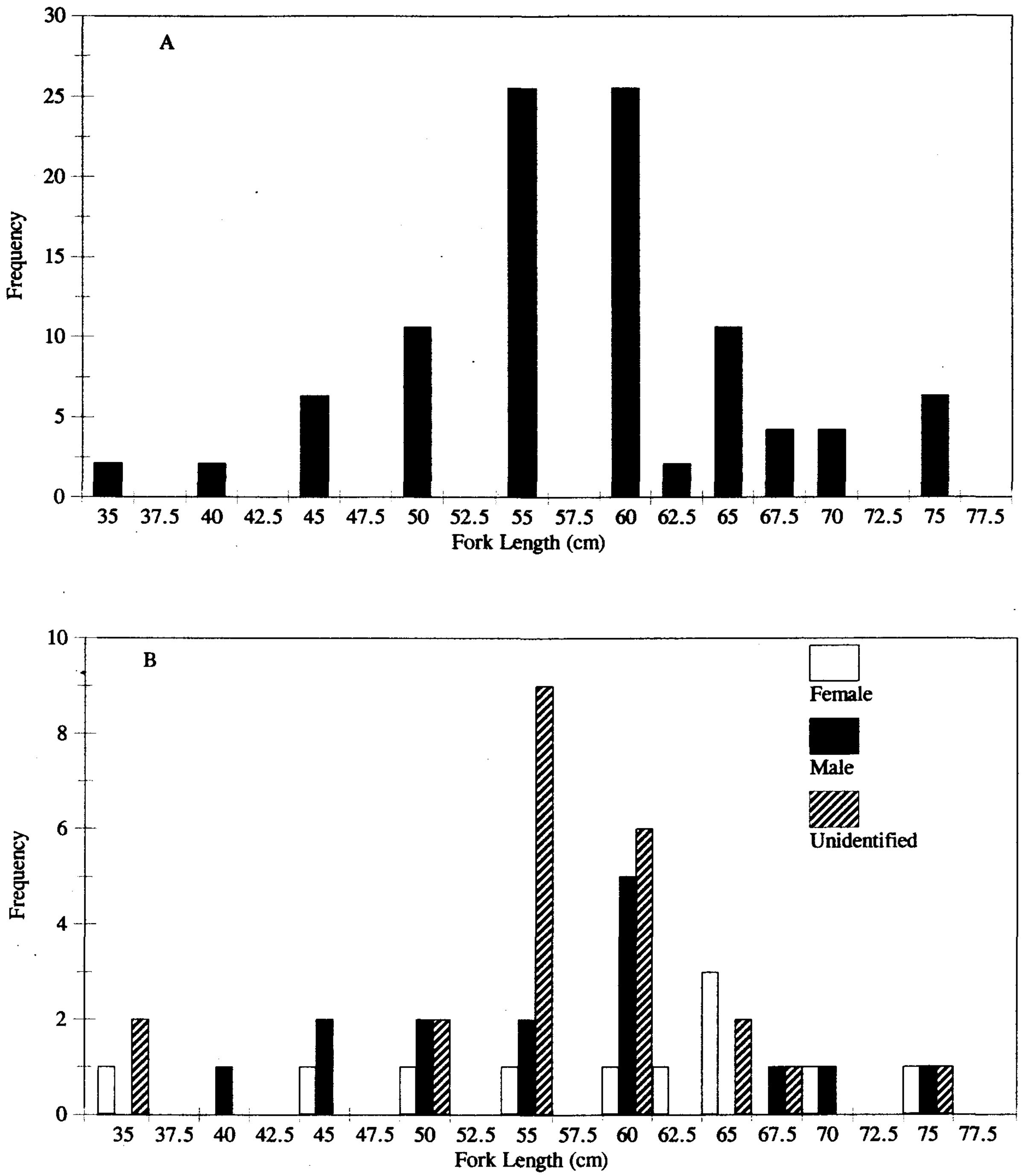


Fig. 5. Fork length frequencies of adult steelhead observed in the Noyo River during 2000. A). Combined female, male, and unidentified sex steelhead fork lengths. B). Fork length of female, male, and unidentified sex steelhead.

fork length was 57cm (n = 8, S.E. = 3.58) (Fig. 5b). Female steelhead fork length averaged 63.8cm (n= 6, S.E.= 1.93) (Fig. 5b). The average fork length of two unidentified sex steelhead was 71.1cm, S.E. = 3.33 S.E. (Fig. 5b). Male and female fork lengths were not significantly different (t =1.50, p = 0.15). Female and unidentified sex fish fork lengths were not significantly different (t = 1.79, p = 0.12). Male and unidentified sex fish fork lengths were not significantly different (t = 1.83, p = 0.10). The female to male ratio of all steelhead identified to sex was 0.71:1.00. The female to male ratio of 15 captured and handled fish was 0.75:1.00.

Adult Migration and Spawning Timing

The observation frequency of adult steelhead in the Noyo River during 2000 is shown in Fig. 6a. Steelhead were first observed in the Noyo River on 14 January 2000 when one fresh fish was captured and tagged at the ECS on the South Fork Noyo River. The first adult in spent condition was observed on 28 February when one fish was captured in a trap on the South Fork Noyo (John Hendrix, Pers. Comm). Steelhead were last observed on 29 April 2000 when two fish were captured in a downstream migration trap in Hayworth Creek. The peak period of steelhead observation in the Noyo River during 2000 was during mid-March (Fig. 6a). This corresponded with the beginning of the spawning surveys.

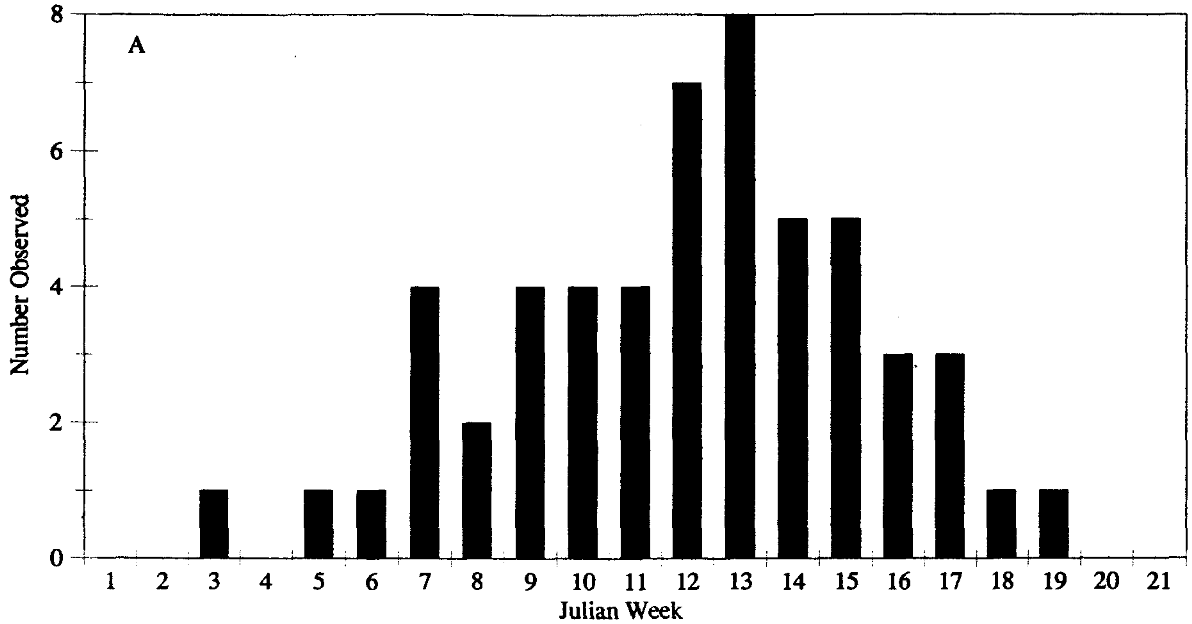
Male steelhead were observed from 14 January to 29 April 2000 (Fig. 6b). Female steelhead were observed from mid-February through early April 2000. Unidentified sex steelhead were first observed in late-February and last observed in late-March (Fig. 6b).

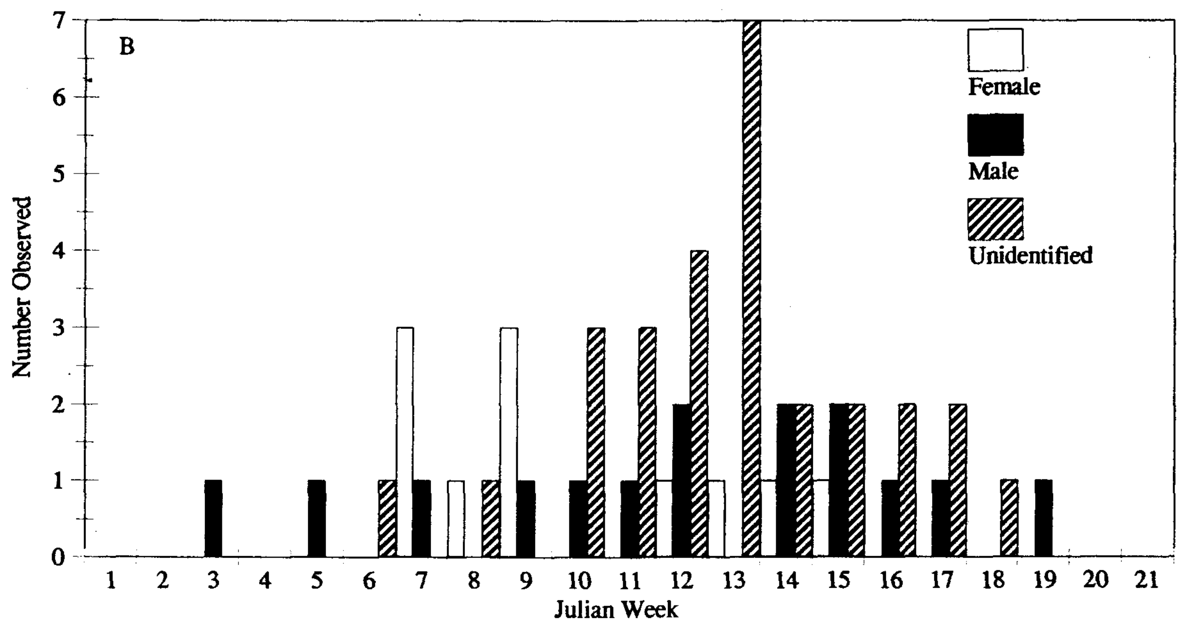
On 4 April one 50 cm female, accompanied by one 60 cm male, was observed digging a redd in the Noyo River just below the confluence of Redwood Creek. The redd digging process had apparently begun shortly before our arrival. The following day a 6.6 m^2 redd, with two distinct pots, was observed. On 10 April the smaller fish, presumably the female, was again observed on the redd. This fish was not seen again. This suggests the minimum adult stream residency was seven days. One fish captured, tagged, and released in the lower river on 28 February was recaptured in a spent condition near the confluence of the South Fork Noyo on 22 March. Based on these observations adult stream residency ranged from 7 to 23 days.

Steelhead redds were observed in the Noyo River beginning in early March (Fig. 7). The majority (52%) of redds observed m the Noyo River were found during the first spawning survey period. Thirty six percent of redds were observed during the second spawning survey period. Newly formed redds were found in late April and early May. Redds observed in May accounted for 18% of the total found during the entire survey period. Eight of the fourteen segments which were surveyed three times during 2000 had new redds during the third observation period (Fig. 7). During June, four of the eight segments which had new redds during the third survey period were surveyed again and no new redds were found. Steelhead spawned in the Noyo River between mid-February and early May 2000.

Spawning Habitat Quality and Use

Spawning habitat quality estimated from stream surveys conducted during 1957, 1959, and 1967 is shown by survey segment in Figs. 8a-e. Most of the streams and stream segments in the Noyo River were only surveyed once between 1957-1967. Of the stream segments surveyed more than once the highest overall spawning habitat quality rating was in 1967. The average difference in spawning quality ratings between 1957 and 1959 was 0.31 (S.E. =0.31, n=ll). The average difference in spawning quality ratings between 1957 and 1967 was 1.0 (S.E. = 0.74, n= 10). The average difference in spawning quality ratings between 1959 and 1967 was 1.83 (S.E. = 0.54, n=6). Both sections of the North Fork declined slightly in habitat quality between 1959 and 1967. Marble Gulch was rated the same all three years. Olds Creek was rated as having no spawning habitat in 1957 but by 1967 improved greatly (Fig. 8b). The South Fork above Parlin Creek decreased in spawning habitat quality between 1957 and 1967.





Pig. 6. Number of steelhead adults observed by Julian week in the Noyo River during 2000. A). Total number observed. B). Number of female, male, and unidentified sex steelhead adults observed. Week one is the first week of January.

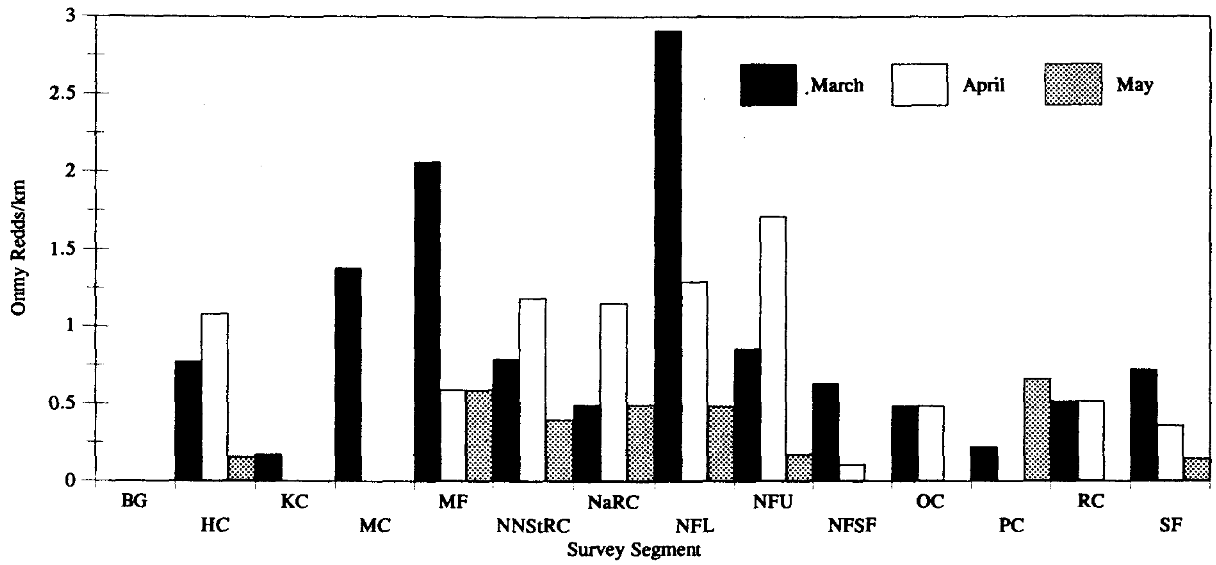


Fig. 7. Number of steelhead redds observed in each survey segment on three sampling visits during 2000. Stream segment abbreviations are the same as in Table 1 and Fig. 3.

Spawning habitat ratings for 2000 were based on the number of redds/km (Tables 2-3, Figs. 2, 3, 8a-e). Overall, spawning habitat quality was rated somewhat lower in 2000 than in other years. Spawning habitat quality was consistently higher in 1967 compared to all years (Figs. 8a-e). The average difference in spawning quality ratings between 1957 and 2000 was -0.30 (S.E. = 0.42, n=27). The average difference in spawning quality ratings between 1959 and 2000 was -0.38 (S.E. = 0.57, n= 13). The average difference in spawning quality ratings between 1967 and 2000 was -1.7 (S.E. 0.42, n=20). Overall, 28% of the stream segments appear to have a decreasing trend in habitat quality (Fig. 8a-e). Four of the seven stream segments showing an apparent decrease in spawning habitat were in the South Fork Noyo River drainage (Fig. 8c). Most streams in the South Fork watershed were rated lower in 2000 than in previous years (Figs. 8c). Although previous surveys suggested that Burbeck, Dewarren, the North Fork of Hayworth creeks and Marble and Gulch C had spawning habitat, steelhead redds were not observed in these stream during 2000 (Table 3, Figs. 8a, b, e). Similarly, no steelhead redds were found in the South Fork below Kass Creek even though this segment was previously considered to have some spawning habitat.

The main stem Noyo River was only previously surveyed during 1957. We surveyed the entire main stem Noyo River below North Spur by Kayak once during 2000. The Noyo River above North Spur was surveyed once by kayak and twice on foot during 2000. The 1957 surveys indicated some spawning habitat below the Little North Fork, during 2000 we did not observe any steelhead redds in this area (Table 3, Figs. 2, 8d). Between the Little North Fork and North Spur the habitat ratings for both years was the same. The Noyo River above North Spur had a higher value for habitat quality during 2000.

Because access to Campbell Group's property along the main stem Noyo River was not granted, most of the gulches on the Noyo River were not surveyed during 2000. Of those that were surveyed, the historic information suggests varying levels of spawning habitat existed. No steelhead redds were found in these gulches during 2000

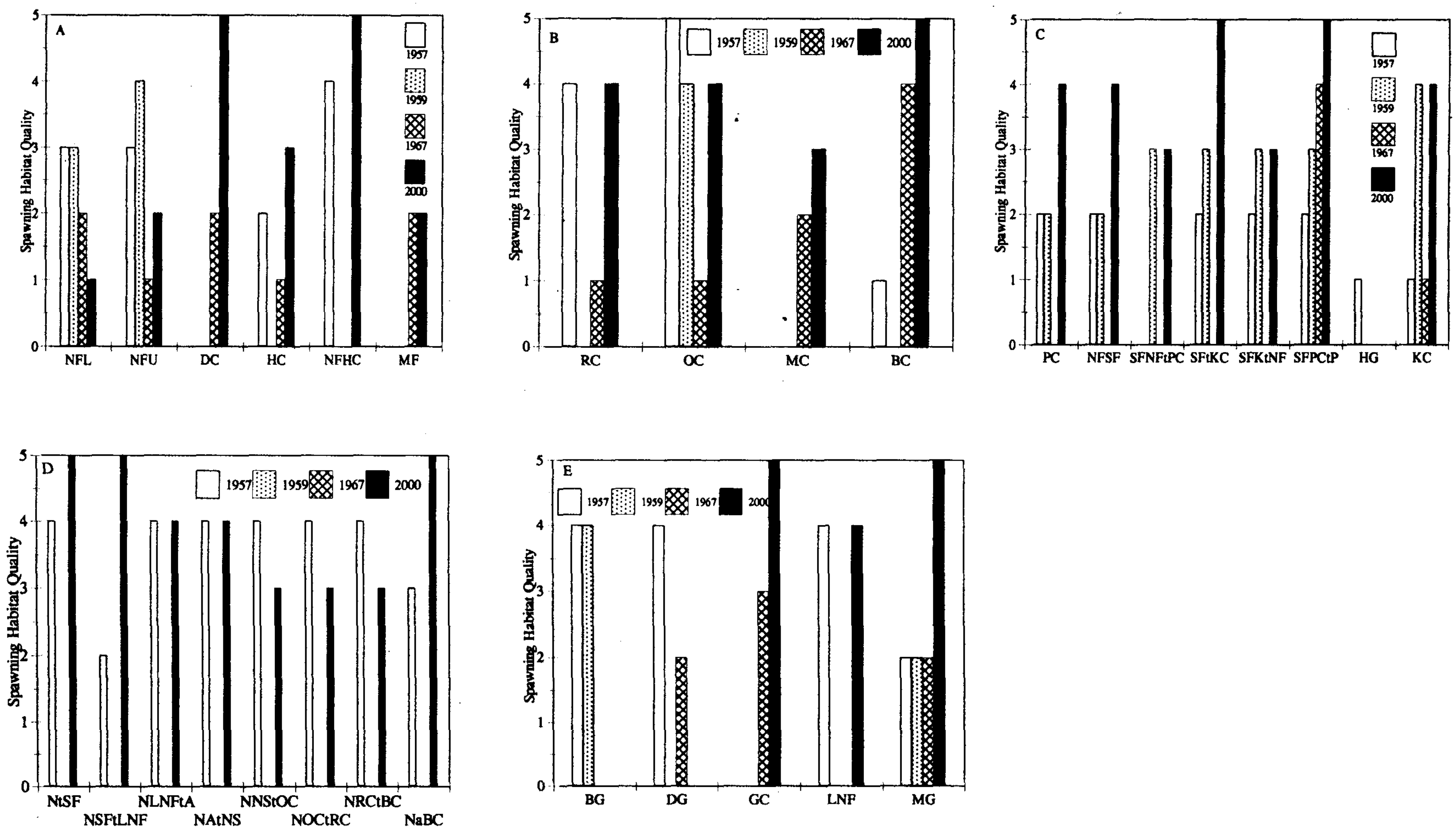


Fig. 8. Spawning habitat quality ratings by river segment for the Noyo River in 1957, 1959, and 1967 and habitat use ratings in 2000. A). Upper river segments. Abbreviations are shown in Table 1. B). Creeks in the upper river. C), South Fork segments. Abbreviations are the same as Table 1 except SFNFtPC is South from Little North Fork to PC, SftKC is from the mouth to KC, SFKtNF is from KC to LNF, and SFPCtP is PC to McGuire Pond. D). Lower River. Abbreviations are the same as Table 1 and Fig 3b. E). Major gulches and LNF. Table 2 shows habitat rating definitions.

(Fig. 8e). Of the two surveyed it appears that spawning habitat may have declined since 1957.

Effort

The entire Noyo River, excluding the main stem below North Spur, the Little North Fork, and some gulches was surveyed three times during 2000. The main stem Noyo River below North Spur was surveyed once by Kayak. Generally, two crews of two surveyed two approximately 4.85 km segments of the Noyo River each day. Two vehicles were used each day. Segments were selected each day to maximize efficiency by coordinating drop off and pick up or vehicle rendezvous points. The first survey period required 15 days and 26 vehicle trips which is approximately 53 people days. The first survey took 113.5 field and 52 driving hours. One vehicle trip was approximately 86 km. The second survey period took less time (ten days) due to our familiarity with the terrain, roads, and survey methods. This survey required about 32 people days and 15 vehicle trips consisting of 65.6 field and 30 driving hours. The third survey period required five days, seven vehicle trips, and 14 people days. The third survey took 48 field and 14 driving hours. The third survey period was much shorter due to low numbers of new redds and low flows which meant crews went much further each day. The entire spawning survey, not counting data analysis and report preparation time but including four days, four vehicle trips and eight people days in June to GPS redds totaled 30 days, 99 person days, and 48 vehicle trips. The entire survey took 227.2 field hours and 96 driving hours.

Discussion

Redds

The spawning survey on the Noyo River during 2000 was not complete because we did not have access to the Little North Fork and many gulches below North Spur. The average size of redds identified as steelhead during 2000 was smaller than the estimate of Shapovalov and Taft (1954). However, they only report information for one redd and provide no estimate of the variation in redd size.

Maahs and Gilleard (1993) report February redd (assumed to be mostly steelhead) densities ranging from 8.01 to 0.18 redds/km for eight coastal Mendocino County streams. They state that the highest density observed in February was by coho in Pudding Creek. Maahs (1996) reports late season redd (assumed to be steelhead) densities ranging from 0.87 to 6.33 redds/km for Casper Creek and portions of the Ten Mile River over three seasons. Maahs (1999) reports late season average redd density during 1998-99 in the Garcia River is 3.91 redds/km. Late season redd densities ranged from 0 to 3.21 redds/km in the Garcia River over four years of survey data (Maahs 1999). Steelhead redd densities observed during 2000 in the Noyo River were within the range previously reported for coastal Mendocino County. Nielsen et al. (1990) state that November to February 1989-90 redd densities in the South Fork Noyo River range between 1.01 and 11.85/km. They state the South Fork Noyo River had the highest density of 82 streams surveyed and attribute this to coho returning to the egg station. Early season redd counts were not available for comparison during 2000 due to the late start this year.

The spawning surveys in the Noyo River did not begin until March 2000 this season due to high flows (Fig. 9), unfamiliarity with the terrain, equipment problems, and because this was the first year and most effort in January and February was spent gill netting. The late start may explain the difference in redd density between the upper river and the South Fork. Coho redds were flagged in the South Fork in December and January by NMFS crews. Redds in the upper watershed may have been misidentified as coho redds which were not counted in the South Fork because they were already flagged. However, where flagging indicating coho redds were found in the South Fork by NMFS we did not observe any redds. This suggests all early redds were flattened by high flows and that all redds observed in the upper watershed were created after 11 February 2000, the last date of coho spawning surveys in the South Fork. However, seven of the nine stream segments in the upper river had more or equal numbers of new steelhead redds observed on the second survey, whereas most new redds in the South Fork were observed during the first visit (Fig.

7). This suggests that steelhead may have spawned earlier in the South Fork. The South Fork is 9 km and the upper river is over 29 km from the Pacific Ocean. Summer steelhead upstream movement is directly related to temperature, inversely related to stream flow, and ranged from 0.1 to 12.4 km/day in the Rogue River, Oregon (Everest 1973). If distance were the only factor the expected difference in spawning timing between the South Fork and upper river would be on the order of one to two days. Maahs (1997) separated survey periods into early (December to January) and late (February to April) to separate coho and steelhead spawning. Furthermore, when the egg collecting station has been run later in the season very few steelhead and no coho are captured (Alan Grass, Pers. Comm.).

Streams with larger drainage areas had more spawning because larger streams have more potential spawning areas. Free flowing streams with larger drainage areas have more hydrological power and therefore are likely to have higher habitat diversity (Hauer and Lamberti 1996, Richter et al. 1996, Stanford et al. 1996). In the case of steelhead spawning in the Noyo River this appears to be the case. The one outlier in Fig. 4 is from the lower North Fork. This segment had the highest number of lamprey redds (Table 4) and it is likely that confusion with lamprey redds increased the enumeration of steelhead redds in this segment. When this data point was removed from the analysis there was a significant relationship between stream length and the number of steelhead redds observed. Larger stream reaches potentially have more available habitat and thus more redds.

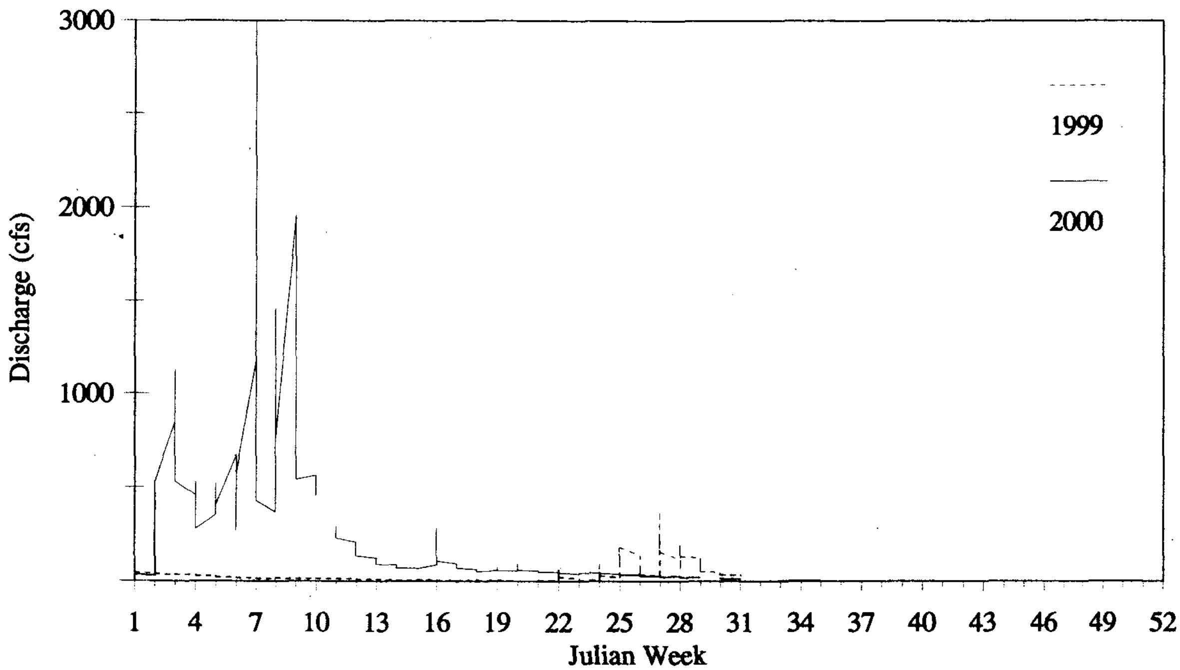


Fig. 9. Daily river discharge for the Noyo River during 1999 and 2000. Week one begins 1 January. Data from USGS gauge # 11468500 located about 1 km above the South Fork confluence.

Pacific lamprey were observed spawning in the Noyo River between 9 March and 9 May 2000. There is considerable overlap in the tuning of spawning between steelhead and lamprey. Lamprey were found in all streams in which steelhead were observed, except the upper North Fork. No lamprey were observed in Hayworth Creek above the

North Fork. Both these streams have large cascade- type waterfalls which lamprey apparently cannot pass. Further defining lamprey redd characteristics and spawning timing will improve estimates of steelhead abundance by reducing uncertainty in steelhead redd identification. Most uncertainty in redd identification this year was due to confusion with lamprey nests.

Adult Steelhead

Observed live steelhead density in the Noyo River during 2000 was lower than reported recently for other nearby streams. Maahs and Gilleard (1993) report observed February steelhead densities of 0.44 and 1.11/ km in Pudding Creek. Maahs (1996) reports observed steelhead density in the Ten Mile River at 0.99/km and in Caspar Creek at 0.50/km. Over the years 1995-96, 1996-97, and 1998-99 observed steelhead per km ranged from 0 to 0.31 in Caspar Creek and from 0.68 to 2.6 in portions of the Garcia River (Maahs 1999). However, the observed live steelhead density for the Noyo River during 2000 is for the entire river, minus the Little North Fork, whereas previous studies focused on portions of streams known to have high spawning potential. Previous surveys were conducted on a weekly basis, whereas the 2000 surveys had periods of up to three weeks between repeated visits. Annual and watershed differences in water visibility likely influence the number of live fish observed. When the adult steelhead observed per km was examined by stream reach (Table 3), the densities were within the previously reported range.

Using mark-recapture, Boydstun (1977) estimated the steelhead population in the Gualala River to be between 3508 and 5654 adults in 1976-77. The Gualala River drains approximately 777 km^2 and has 286 km of steelhead habitat (Higgins 1998), thus it is about three tunes as large as the Noyo River. The redd-based population estimate of 361 ($\pm$ 57) adult steelhead in the Noyo River during 2000 is, considering relative stream size, still much lower than the Gualala River estimate in the 1970's. The CDFG (1965 as cited in Busby et al. 1996) estimated steelhead populations in the Gualala River at 16,000 and for the Noyo River at 8,000. This estimate is more than three times the number estimated in the 1970's for the Gualala. The CDFG 1965 estimate for the Noyo is more than 22 times the high end estimate for 2000.

Redd-based steelhead population estimates for streams surveyed during the 1990's were not possible due to the timing of the surveys and lack of information on steelhead mating systems (Maahs 1996). I used the female to male ratio observed during 2000 in the Noyo River to calculate the number of males and females present from the number of redds observed, based on two redds/female, and based on the redd area method (Maahs 1996). The wide range in the population estimates from these methods suggest further refinement is needed. Uncertainty in redd identification complicates this method.

I estimated an average stream residency for spawning steelhead of 11 days from Shapovalov and Taft's (1954) estimate of one week and observations in the Noyo River during 2000. Maahs and Gilleard (1993) found that live fish estimates using AUC dramatically underestimated spawning populations and are very sensitive to instream duration of adult coho. English et al. (1992) found the AUC method sensitive to variability in survey time and observer efficiency and that estimates based on total residency time more closely predicted known population values. I was unable to estimate a steelhead population for the Noyo River during 2000 using this method, primarily because not enough fish were observed and the long period between surveys. Estimates of observer efficiency and annual estimates of stream residency will improve this method (English et al. 1992, Irvine et al. 1992). The two stream segments for which redd based and AUC population estimates differed was likely due to confusion with lamprey redds. These two segments had 61 % of all observed lamprey redds. The Noyo River between North Spur and Redwood Creek had 35% of all lamprey redds observed (Table 4). The Noyo River above Redwood Creek had 26% of all observed lamprey redds (Table 4). Both these sections are main stem segments and are larger and cany more water than other survey segments. It is possible fish were more difficult to detect in the main stem Noyo. Better understanding of steelhead mating systems, in stream residency, increased familiarity with the Noyo River, and increasing the periodicity of surveys should improve the applicability of the AUC method for estimating steelhead populations in the Noyo River.

Steelhead captured during 2000 were within the size range reported previously for nearby streams. Boydstun (1977) reports the mean fork length for steelhead captured in the Gualala River during 1976-77 was 71.3 cm. Steelhead captured in the Gualala River during 1975-76 ranged from 30 to 90 cm fork length (Boydstun 1976). Steelhead captured in the Garcia River during 1972-73 ranged from 13 to 85 cm fork length (CDFG 1973).

In general the adult steelhead sex ratios observed in the Noyo River during 2000 were similar to those reported in other rivers, where males outnumber females. The difference between calculated sex ratios for handled and fish observed from the bank may be a result of less certain identification *from* the bank or the low number of fish captured. Erman and Hawthorne (1976) and Everest (1973) found that steelhead sex ratios had higher proportions of males in Sagehen Creek, California and the Rouge River, Oregon, respectively. Withler (1966) found steelhead sex ratios to be nearly 1:1 along the Pacific Coast from California to British Columbia. Boydstun (1976) found that un-spawned steelhead showed no trend in sex ratio, while females dominated spent fish catches in the Garcia River during 1975. Boydstun (1977) found that females vastly outnumbered males in the Garcia River during 1976 and attributed this to capture methods. Withler (1996) found that almost twice as many female as male steelhead were caught by anglers. Everest (1973) attributes the difference in sex ratio to the fact that females generally complete spawning and leave streams more rapidly than males. This is similar to the observation that late season captures in the Noyo River during 2000 consisted primarily of male and unknown sex fish (Fig. 6b).

Adult Migration and Spawning Timing

Steelhead observations in the Noyo River peaked in mid-March during 2000. The steelhead spawning run in the Noyo River began in mid-January and extended through late-April. Spawning activity peaked in mid-March corresponding with the beginning of spawning surveys in 2000. The migration timing of adult steelhead and spawning activity in the Noyo River is similar to most previous reports for nearby streams. Boydstun (1976) reported that steelhead spawning occurred between February and April, peaked in mid-February, and that fish entered the Gualala River between December and April 1975-76. He states that steelhead spawning in the Garcia occurs between February and March. Nielsen et al. (1990) reported that steelhead spawning began in early January and continued past the end of their survey in the South Fork Noyo during 1989-90. Maahs and Gilleard (1993) observed few steelhead before February in seven coastal Mendocino County streams they studied during 1990-92. Maahs (1996, 1997) found steelhead spawning began in early January 1995 and in mid- March 1996 and peaked in mid-March during both years in portions of the Garcia and Ten Mile Rivers and Caspar Creek. Spawning activity continued through mid April both years. Maahs (1999) found a similar pattern in the Garcia River during 1998-99. Steelhead begin their spawning run in early January and are found through April in most years in coastal Mendocino County streams. However, Busby et al. (1996) state that steelhead enter Pudding Creek in November and spawn between December and March. They show spawning and migration timing for Caspar Creek and Gualala River similar to that described above.

Spawning Habitat Quality and Use

Spawning habitat quality was generally considered better in 1967 than in all other years. The stream surveys in 1957, 1959, and 1967 (Appendix I) subjectively estimated spawning habitat quality by walking streams in late-summer. It is likely that the difference in habitat quality between years is due more to differences in the surveyors' perception than to actual differences in the streams. It is unlikely that differences in late-summer flows between the years (Fig. 10) account for differences in habitat ratings. Many notes on the survey forms suggest streams had been damaged by recent logging. For instance, Burbeck Creek in 1959 flowed through "virgin redwood forest" but by 1967 had "considerable" logging damage.

The difference in habitat quality between 1957, 1959, 1967 surveys and ratings based on observed steelhead spawning during 2000 are a result of the survey purpose, methods, earlier surveys "salmonid spawning habitat" included both coho and steelhead, and real changes in the streams over time. From review of the general notes of these surveys it appears their overall purpose was to identify log jams for removal. During 2000 the purpose was to document steelhead spawning distribution and habitat use. Historic stream surveys qualified spawning habitat by walking them during late-summer and identifying habitat quality visually, whereas spawning habitat use ratings were based on actual numbers of redds observed for 2000. The 1957, 1959, and 1967 surveys indicated general salmonid spawning habitat quality. Only steelhead spawning was used to rate habitat use during 2000. Spawning habitat in five streams in the upper Noyo appears to have improved since 1957. The lower North Fork flows through land owned by Charles Bellow, who has established a non profit organization committed to preservation of the area (Perrs. Comm.). Of the seven streams showing an apparent decline in spawning habitat, four are in the South Fork. Maahs and Gilleard (1993) state that "over meticulous" removal of wood occurred in the South Fork and probably had a negative impact on coho production. By the early 1960's wood had been removed from 94% of the South Fork and it's tributaries (Maahs and Gilleard 1993). Log removal continued in the South Fork as late as 1983 (Anonymous 1983). Marble Gulch had wood removed during the 1970's (G. Bradford Perrs. Comm). Logging activities and road building have also impacted spawning habitat in the Noyo River (CRWQCB-1999). In 1957 Burbeck Creek was rated as having good spawning habitat. By 1959 after logging in the watershed spawning habitat quality decreased and in 2000 no

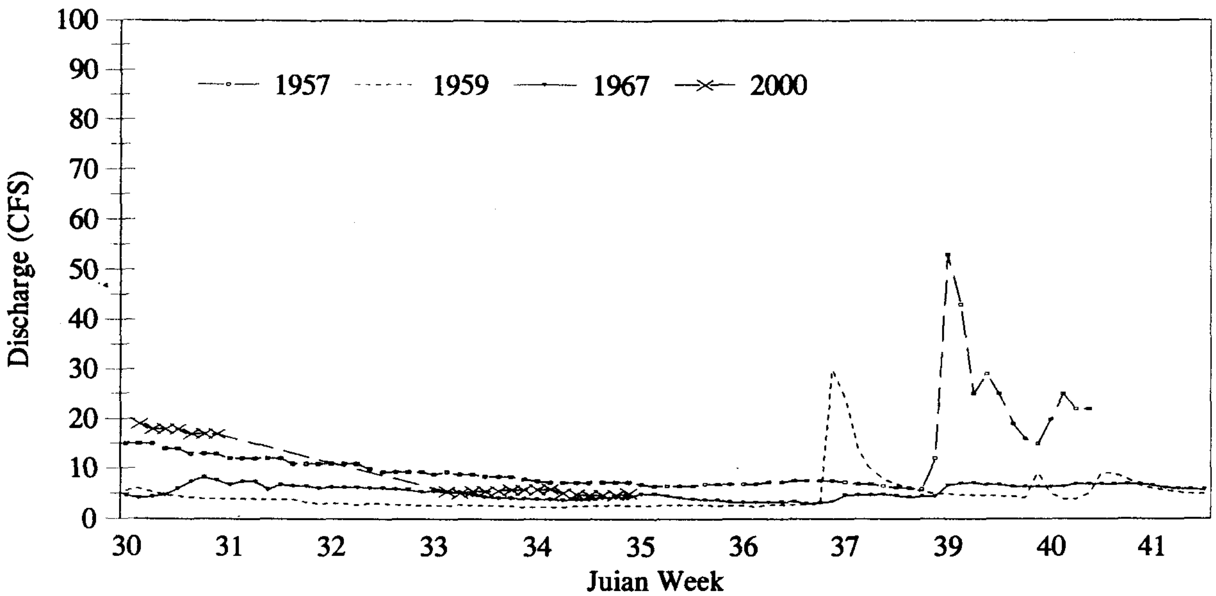


Fig. 10. Daily mid-July to mid-October flows in the Noyo River flows during 1957, 1959, 1967, and 2000. Week 34 is mid-August. Data from USGS gauge # 11468500 located about 1 km above the South Fork confluence.

spawning was observed. Evidence of past logging is found throughout the Noyo River ranging from old road crossings to roads and railroad lines going right up stream channels. Based on limited embeddedness information the CRWQCB (1999) state that coho may have trouble spawning in all parts of the Noyo River. The CDFG has recommended some streams in the Noyo River for habitat improvement and conducted work on Parlin Creek (J. Hendrix Pers. Comm.). The Noyo River watershed is under review for Total Maximum Daily Load for sediment which, when implemented, is expected to improve conditions for salmonids (CWQCB 1999). These, as well as other, actions should help improve spawning habitat quality in the Noyo River.

Effort

The entire spawning survey took 99 person days, 48 vehicle trips, 227.2 field hours, and 96 driving hours. This resulted in redd distribution, redd density, redd number, adult population estimates, and provided information on adult migration and spawning timing. This first year effort was increased due to unfamiliarity with the area and the methods and the experience level of the crew. These factors are expected to decrease and thus decrease field time next season. A longer duration and increased frequency of spawning surveys will likely increase the amount of time necessary to complete them next season. Visual observation of adults results in less precise estimates of sex ratios and fork length distributions compared to active tagging programs. During spawning surveys tissue and scale samples were not collected.

Recommendations for Further Study

There was a wide range in the estimate of adult numbers based on redd counts and the method of estimation. Starting surveys earlier, surveying the entire Noyo River, reducing the time between surveys, and conducting studies directed at understanding mating systems and the number and size of redds produced per female will help reduce the variability in redd based population estimates. More information on steelhead mating systems, length of stream residency, and estimates of observer efficiency may improve the AUC population estimation method. A study to examine mating systems using remote sensing (i.e. video equipment) should be conducted. Setting up time lapse video system focused on known spawning areas would greatly increase our knowledge of how many redds a female builds, how many males accompany each female, and how long fish remain on a redd and in the river. There are a few highly used riffles on the lower North Fork which may provide a good setting for such a study. As a control to the cameras, back up, or in case cameras do not work, surveys could monitor these riffles for a set number of hours a day or week and record behavior and numbers of spawners. As part of either or both of the above approaches, radio tagging may further our understanding of mating systems. For example, do female steelhead make more than one redd in more than one riffle and if so how far apart are they? What is travel time between spawning areas and the main stem and ocean?

Spawning surveys on the Noyo River should be continued in 2000-01. The surveys should be conducted in conjunction with the proposed mark-recapture using Alaskan type marking weirs. No tagged steelhead were visually recaptured, possibly due to the low number of steelhead captured and tagged in the lower river (Niellands In Prep.), and the late start this year. Assuming the redd based population estimates are reasonable, I estimate between 8.4 and 28% of the total steelhead population was observed while conducting spawning surveys this season. This suggests, if more fish are tagged and spawning surveys are conducted more frequently, that spawning surveys maybe an appropriate method for the recapture portion of this effort. Spawning surveys should begin in late-December or early-January next year and should attempt to cover coho spawning as well. It appears the entire Noyo River can be surveyed by two crews of two people in about 10 working days. The interval between surveys should be decreased to two weeks or less. This will require working around large flow events and may require additional crew members. Redds will be flagged and GPSed during each survey. Flagging will be labeled with the GPS point number, the species suspected of making the redd, the date, and the size of the redd. Stream flows will be determined from flow rated staff gages in the upper river and from the Noyo Gage and percent inflow for the lower river and South Fork. All this information will be recorded on field maps and data forms. Data forms will be refined to included GPS coordinates, given more area for notes, and an additional column which gives each redd a unique number will be added. Redd substrate data collection should be standardized to follow the methods of Platts et al. (1983). Streams in which no redds were observed this season should be visited at least once next season. Those streams found not to have redds again next season should be re-surveyed intensively every five years.

Acknowledgments

Aaron Nadig of the Mendocino Redwood Company was instrumental in obtaining an access agreement to company property and the upper Noyo River. Thanks to the Mendocino Redwood Company for allowing us access to the river and the use of their roads. Charles Bellow graciously allowed access to the North Fork and roads to the upper North Fork. Matt Coleman, Erik Larson, George Niellands, Brett Redfem, Jay Rowen, and John Richardson helped conduct this survey. Matt Coleman, Erik Larson, and George Niellands provided useful comments on the manuscript. This work is dedicated, in part, to the memory of Mike Maahs whose contribution to the understanding of local fisheries greatly aided this study.

References

Anonymous. 1983. Fish Habitat Improvement Completion Form. Jackson State Forest, California. 1pp.

Beidler, W. A. and T. E. Nickelson. 1980. An evaluation of the Oregon Departmentof Fish and Wildlife Standard Spawning Fish Survey System. Oregon Department of Fish and Wildlife, Oregon. 80-9. 23 pp.

Boydstun, L. B. 1976. Federal Aid Progress Report-Coastal Steelhead Study (APS-16) 1975-76. California Department of Fish and Game, California. AFS-16. 15 pp.

Boydstun, L. B. 1977. Monthly Reports for 1977- Coastal Steelhead Study. California Department of Fish and Game, California. 30pp.

Busby, P., T. Wainwright, G. Bryant, L. Lierheimer, R. Waples, W. Waknitz, and I. Lagomarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. National Oceanic and Atmospheric Administration, Springfield, VA 22161. NOAA Technical Memorandum NMFS-NWFSC-27. 261 pp.

California Department of Fish and Game. 1973. Job Progress Report: Coastal Steelhead Study AFS-16-1, June 1 1972 to 30 June 1973. California Department of Fish and Game, California. 6 pp.

California Department of Fish Game. 1998. Strategic plan for management of Northern California steelhead trout. California Department of Fish Game, Sacramento, California. 234 pp.

California Regional Water Quality Control Board. 1999. Noyo River Watershed Total Maximum Daily Load for Sediment. California Regional Water Quality Control Board North Coast Region, California. 68 pp.

English, K. K., R. C. Booking, and J. Irvine. 1992. A robust procedure for estimating salmonid escapement based on the area-under-the-curve method. Can. J. Fish. Aquat. Sci. 49:1982-1989.

Erman, D. and V. Hawthorne. 1976. The Quantitative Importance of an Intermittent Stream in the Spawning of Rainbow Trout. Trans. Am. Fish. Soc. 6:675-681.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rouge River, Oregon. Oregon State Game Commission, Corvallis, Oregon. 47 pp.

Federal Register. 2000. Endangered and Threatened Species: Threatened Status for one Steelhead Evolutionarily

Significant Unit (ESU) in California. Federal Register, Washington D.C. 65: 36704-36094.

Federal Register. 1996. Proposed Listing Determination for 15 Evolutionarily Significant Units (ESU) of steelhead in Washington, Oregon, Idaho, and California. Federal Register, Washinton D.C. 61:41514-41612.

Harris, S. 1999a. Annual Performance Report Federal Aid in Sport Fish Restoration Act: Salmon Spawning Stock Inventory. California Department of Fish and Game, California. Grant Number F-51-R-9. 4pp.

Hams, S. 1999b. Annual Performance Report Federal Aid in Sport Fish Restoration Act: Salmon Spawning Stock Inventory. California Department of Fish and Game, California. 4 pp.

Higgins, P. 1998. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy for the Redwood Coast Land Conservancy, Gualala, California. 57 pp.

Higgins, P., S. Dobush, and D. Fuller. 1992. Factors in Northern California Threatening Stocks with Extinction. Humboldt Chapter of the American Fisheries Society, Arcata, CA. 20 pp.

Hauer, R. F. and G. A. Lamberti (Eds). 1996. Methods in Stream Ecology. Academic Press. San Diego, **CA** 674 pp.

Hunington, C., W. Nehlsen, and J. Bowers. 1996. A survey of Healthy Native Stocks of Anadromous Salmonids in the Pacific Northwest and California. Fisheries 21:6-14.

Irvine, J. R., R. C. Bocking, K. K. English, and M. Labelle. 1992. Estimating coho salmon *(Oncorhynchus kisutch)* spawning escapements by conducting visual surveys in areas selected using stratified random and stratified index sampling designs. Can. . Fish. Aquat. Sci. 49:1972-1981.

Krerbs, C. . 1989. Ecological Methodology, Hapre & Row, Publishers, Inc, New York, NY. 664 pp.

Maahs, M. 1996. A Spawning and Habitat Evaluation for Portions of the Ten Mile River, Caspar Creek, and Garcia River 1995-96. Prepared for the Humboldt County Resource Conservation District. Salmon Trailers Marketing Association, Inc., Fort Bragg, California. 31 pp.

Maahs, M. 1997. The 1996-97 Salmonid Spawning Survey for Portions of the Ten Mile River, Garcia River, and Caspar Creek. Prepared for the Humboldt County Resource Conservation District. Salmon Trailers Marketing Association, Inc., Fort Bragg, California. 26 pp.

Maahs, M. 1999. Spawning Survey of the Garcia River 1989-99. Prepared for the Humboldt County Resource Conservation District. Salmon Trailers Marketing Association, Inc., Fort Bragg, California. 10 pp.

Maahs, M. and . Gilleard. 1993. Anadramous Salmonid Resources of Mendocino Coastal and Inland Rivers 1990-91 Through 1991-92: An evaluation of rehabilitation efforts based on carcass recovery and spawning activity. California Department of Fish and Game, Fisheries Division, Fisheries Restoration Program, California. Contract Number FG-9364. 66 pp.

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

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

Nadig, A. 1999. Albion River Carcass Survey 1989-1999. Mendocino Redwood Company, Fort Bragg, California. 12 p.

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

Nielsen, J., M. Maahs, and G. Balding. 1990. Anadromous Salmonid Resources of Mendocino Coastal and Inland Rivers 1989-1990: An evelauation of rehabilitation efforts based on carcass recovery and spawning activity. Prepared for the California Department of Fish and Game, Fisheries Division, Fisheries Restoration Program, Mendocino, California. 110 pp.

Plans, W.S., Megahan, W.F., and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. For. Serv. Gen. Tech. Rep. INT-138. Inter-mountain Forest and Range Experiment Station, Ogden, Utah.

Richter, B. **D.,** . V. Baumgartner, . Powell, and D. P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10:1163-1174.

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

Stanford, J. A.., . V. Ward, W. J. Liss. C. A.. Frissell, R. N. Williams, J. A. Lichatowich, and C. C. Coutant. 1996. A general protocol for rehabilitation of regulated rivers. Regulated Rivers: Research and Management 12:391-413.

Withler, I: L. 1996. Variability in life history characteristics of steelhead trout *(Saimo gairdneri) along* the Pacific Coast of North America. Fish. Res. Bd. Cananda, 23:365-393.

Personal Communications

Charles Bellow. April 2000. Resident near North Spur, CA

Gary Bradford. May 2000. Resident of North Spur, CA

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

Alan Grass. February 2000. California Department of Fish and Game, Region 3, CA

Appendix A

Historic Stream Surveys

CDFG. 1967a. Stream survey of Burbeck Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967b. Stream survey of Dewarren Creek. Unpublished report. Region 3, California Department of

Fish and Game, Yountville, CA.

CDFG. 1967c. Stream survey of Duffy Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967d. Stream survey of Gulch C. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967e. Stream survey of Hayworth Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967f. Stream survey of Kass Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967g. Stream survey of Marble Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967h. Stream survey of McMullen Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967L Stream survey of Middle Fork Noyo River. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967j. Stream survey of North Fork Noyo River. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967k. Stream survey of Olds Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1967l. Stream survey of Redwood Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA

CDFG. 1967m. Stream survey of South Fork Noyo pond to State forest boundary. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959a. Stream survey of Bear Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959b. Stream survey of Burbeck Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959c. Stream survey of Duffy Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959d. Stream survey of Kass Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959e. Stream survey of Marble Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959f. Stream survey of North Fork Noyo River. Unpublished report. Region 3, California

Department of Fish and Game, Yountville, CA.

CDFG. 1959g. Stream survey of North Fork South Fork Noyo River. Unpublished report. Regions, California Department of Fish and Game, Yountville, CA.

CDFG. 1959h. Stream survey of Olds Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959L Stream survey of Parlin Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1959j. Stream survey of South Fork Noyo River. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957a. Stream survey of Alpine Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957b. Stream survey of Bear Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957c. Stream survey of Burbeck Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957d. Stream survey of Duffy Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957e. Stream survey of Hayworth Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957f. Stream survey of Hay shed Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957g. Stream survey of Kass Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957h. Stream survey of the Little North Fork Noyo. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957L Stream survey of Marble Gulch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957J. Stream survey of North Fork Hayworth Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957k. Stream survey of Olds Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 19571. Stream survey of North Fork of the South Fork Noyo River. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957m. Stream survey of Noyo River Irmulco to Twitchell Ranch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957n. Stream survey of Noyo River from 1/8 mile above and below Irmulco. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957o. Stream survey of Noyo River from Redwood Creek to Shake City. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957p. Stream survey of Noyo River mouth to Company Ranch. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957q. Stream survey of Noyo River North Spur to Redwood Lodge. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957r. Stream survey of Noyo River to Burbeck Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957s. Stream survey of Noyo River to one mile above Railroad tunnel. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957t. Stream survey of North Fork Noyo River. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957u. Stream survey of Parlin Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957v. Stream survey of Redwood Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957w. Stream survey of South Fork Noyo McGuire Pond to four miles west of Parlin Creek. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957x. Stream survey of South Fork Noyo two miles downstream of Pyorre Road. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.

CDFG. 1957y. Stream survey of unnamed tributary to the South Fork Noyo. Unpublished report. Region 3, California Department of Fish and Game, Yountville, CA.