DISTRIBUTION AND SUMMER SURVIVAL OF JUVENILE STEELHEAD TROUT (*ONCORHYNCHUS MYKISS*) IN TWO STREAMS WITHIN THE KING RANGE NATIONAL CONSERVATION AREA, CALIFORNIA.

By

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ABSTRACT

Distribution and summer survival of juvenile steelhead trout in low (≤5%), moderate (5.1-10%), and high (≥10%) reach gradient, was determined in Oat and Spanish creeks in the King Range National Conservation Area, California during 1999 and 2000. The composition of channel units (pools, riffles, runs, and cascades) was not independent of reach gradient with increased pool and run habitat occurring more often in moderate gradient reaches. Estimated summer survival rates of juvenile steelhead during 2000, was 82.6% in Oat Creek and 74.5% in Spanish Creek when surveys encompassed late emergence of steelhead trout between sampling times. When summer survival by age class was analyzed, age 0+ survival was lower in Spanish Creek than in Oat Creek but the inverse was true for post-age 0+ juvenile steelhead trout. Using a four factor ANOVA design of Year x Stream x Reach x Channel Unit, distribution of age 0+ juvenile steelhead trout during Fall was explained by channel unit type ($p=0.0034$) with age 0+ densities highest in pool channel units. Post-age 0+ distribution was explained by reach gradient ($p=0.0044$) with moderate gradient reaches having the highest post-age 0+ densities. Results of this study contribute to recent findings that challenge observations of decreasing salmonid density with increasing stream gradient.

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

INTRODUCTION

Salmonid distribution has been intensively studied at the spatial scale of individual channel units (Bisson et al. 1988, Nickelson et al. 1992). Channel units are defined in this study as stream habitat units that are classified into various descriptive categories dependent on hydraulic characteristics such as habitats defined in McCain et al. (1990) for classifying northern California streams or the habitats detailed by Bisson et al (1982). Several abiotic and biotic factors can determine distribution of salmonid fish species within channel units such as large woody debris, depth (Everest and Chapman 1972), and temperature (Nielsen et al. 1994, Matthews and Berg 1997).

Few studies have determined reach-scale preferences of salmonids for an entire basin, or channel unit composition in reaches and abiotic factors that might affect fish distribution among several reaches in a basin. Roper et al. (1994) found that juvenile chinook and age 1+ steelhead exhibited specific reach preferences within a major basin of the South Umpqua River, Oregon during the summer, while age 0+ steelhead did not. Newman and Waters (1989) found nearly constant differences in density of brown trout for eight 305-m sections composing all of South Branch Creek, Minnesota. Herger et al. (1996) provided evidence that a basinwide stream habitat inventory identified changes in habitat availability and characteristics with changing flow, as well as changes in cutthroat trout (*Oncorhynchus clarki*) distribution in Rocky Mountain streams. These studies described distributions and did not quantify correlations of reach preference with channel unit occurrence. Maret et al. (1997) found that several environmental factors (gradient, watershed size, conductivity, and percentage of watershed covered by forest) explained distribution of some salmonid and non-salmonids in the Snake River basin over several ecoregions but did not identify or quantify channel units in sampled streams.

Variation in the frequency of channel unit types among reaches has been recognized. When looking at channel unit composition within reaches, Kershner et al. (1992) found that certain channel units appear to be more prevalent given similar reach level characteristics. An example would be cascade channel units occurring frequently in high gradient reach types, or A-stream types as identified by the Rosgen (1994) reach classification methodology.

Gradient has been identified as an important factor in determining the distribution of salmonids (Chisholm and Hubert 1986, Fausch 1989, Kozel et al. 1989, Bozek and Hubert 1992, Maret et al. 1997, Isaak and Hubert 2000,) as well as partly accounting for physical habitat features in streams (Hubert and Kozel 1993). Gradient can influence the composition of trout species within a stream (Bozek and Hubert 1992), the prevalence of certain species of salmonids within basins (Hartman and Gill 1968, Fausch 1989), the availability of habitat types and the abundance of trout (Chisholm and Hubert 1986). As gradient increases, sinuosity, gravel as a substrate, and the depth of pools decreases (Hubert and Kozel 1993).

If certain channel units are prevalent within a reach of a certain gradient, and this reach has a higher density of fish, an argument can be made that in a similar stream, with a similar reach of similar gradient would exhibit a similar trend in fish density. This relationship will most likely be true where reach channel unit composition is similar between the two streams.

The primary objective of this study was to quantify fish density within all reaches of two similar streams and determine if the distribution of juvenile steelhead within reaches was correlated to reach level abiotic factors, specifically, the occurrence of certain channel units in certain reaches based on gradient. A second objective of this study was to estimate juvenile steelhead summer survival within reaches, and within headwater streams in the King Range National Conservation Area (KRNCA), California.

Working Hypothesis

I hypothesized that juvenile steelhead trout inhabit similar reaches within streams of the KRNCA and that their distribution is related to channel unit composition. Furthermore, I hypothesized that survival of juvenile steelhead is related to channel unit availability

Study Area

The King Range is located in southwestern Humboldt County, California. It covers 24,281 ha extending along 56 km of coastline between the mouth of the Mattole River and the Sinkyone Wilderness State Park and is managed by the

Bureau of Land Management (BLM). The King Range rises from sea level to 1,246-m elevation at the summit of Kings Peak in less than 5 km (BLM 1991). The area is recognized for its diverse topography (resulting from uplift generated from the collision of three tectonic plates offshore), large amounts of rainfall (254 – 508 cm yr^{-1}), and as having the largest amount of undeveloped coastline in the lower 48 states (BLM 1991). Most of the area is managed for wildlife habitat and recreation, with cattle grazing as a secondary use (BLM 1974).

Twenty-five coastal streams drain the KRNCA. Two western slope streams were selected for this study: Spanish Creek and Oat Creek (Figure 1). The streams selected for study are similar in size, drainage area, abiotic factors, and are in close proximity to one another (Table 1, Figure 2). Spanish and Oat Creeks both enter the Pacific Ocean directly, without entering tributaries. During late spring, summer, and early fall, the streams are closed to fish movement to the ocean as sand is deposited in stream mouths by lateral transport from wave action. Stream discharge is low during these periods and sand "dams" that form cannot be flushed away. This characteristic facilitates measurement of summer survival by preventing immigration or emigration from each basin.

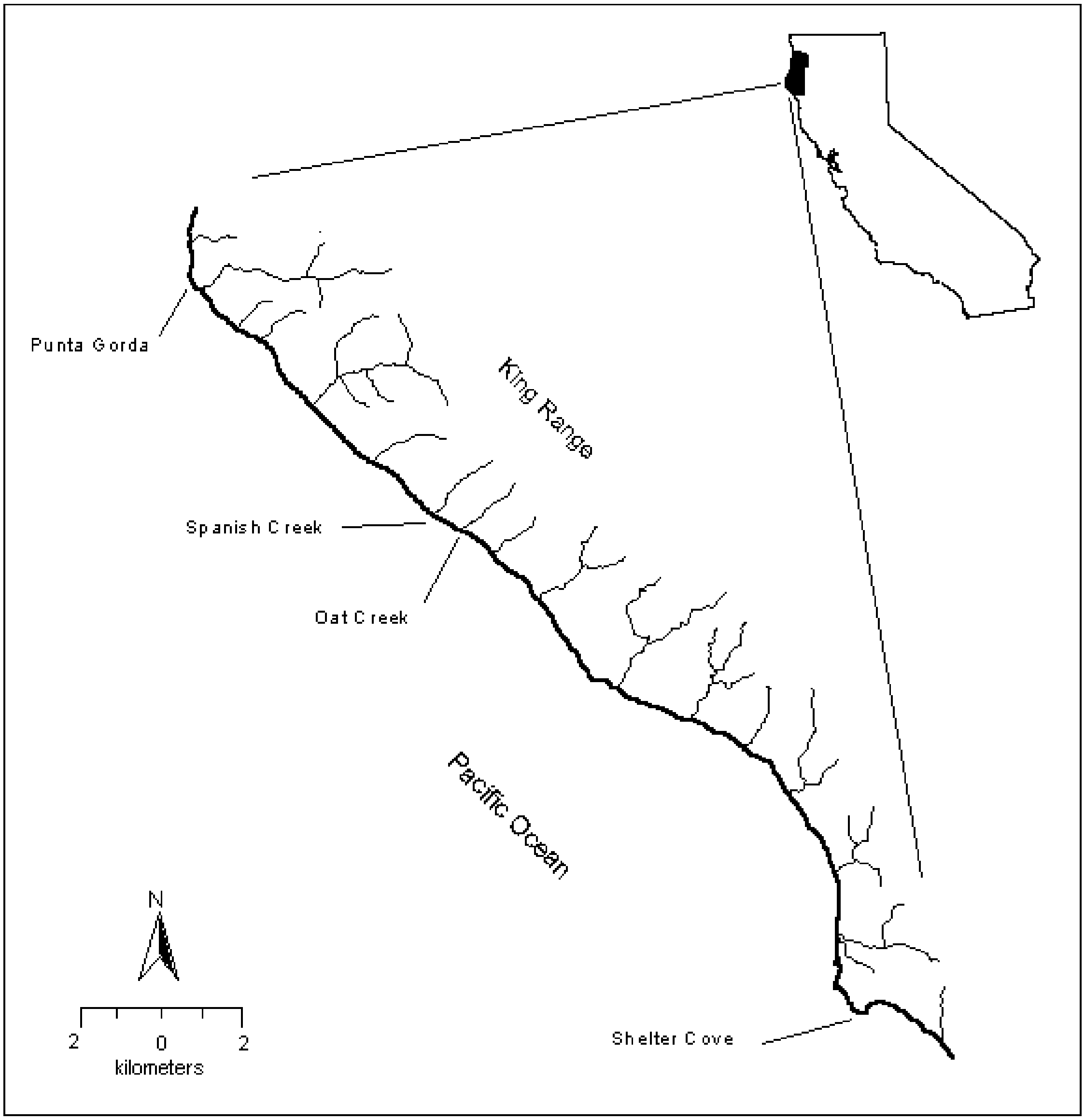


Figure 1. Map of the King Range National Conservation Area (KRNCA), California showing the location of Spanish and Oat Creeks.

Table 1. Characteristics of Spanish and Oat Creeks located within King Range National Conservation Area, California. Drainage area was determined from USGS quadrangle maps and riparian vegetation was estimated from a visual survey of the study streams.

Stream	Latitude longitude	Drainage area (km^2)	Channel slope (%)	Sampled length (m)	Order	% with immediate riparian vegetation	Dates sampled 1999	Dates sampled 2000
Spanish	40°11'2 124°15'18	4.65	13.6	2557.2	2nd	65%	July15-23 Sept. 17-26	Aug. 7-10 Nov. 6-10
Oat	40°10'44 124°14'34	4.12	13.5	2329.0	2nd	95%	July 27- Aug. 4 Sept. 24- Oct.2	Aug. 10-12 Oct. 21-23

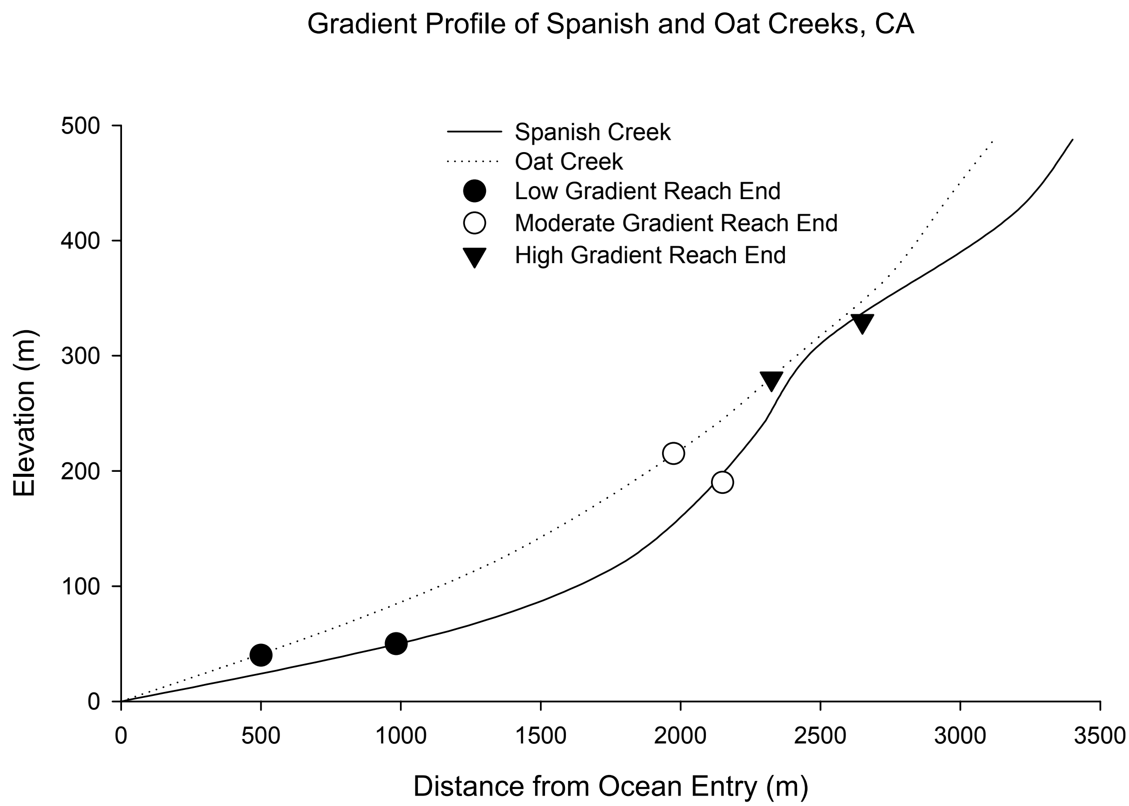


Figure 2. Stream gradient profile of Spanish and Oat Creeks located within King Range National Conservation Area, California. Elevation (m) at distance from ocean entry (m) was determined from USGS quadrangle topographic map. Reach breaks were identified during habitat and electrofishing abundance surveys. The point at which each reach type ends is indicated by a symbol. The low gradient reach began at the point of ocean entry (0 m elevation and 0 m from ocean entry).

<u>Spanish Creek</u>

Spanish Creek has been periodically inundated by debris flows as evidenced by a large alluvial fan at the bottom of the basin, two large floodplain terraces, and numerous anchored, upright stumps of red alder (*Alnus rubra*) and Douglas fir (*Pseudotsuga menziesii*) in the bankfull channel. The riparian zone in the lower section (0-980 m) of Spanish Creek is unvegetated. Prior to the 1964 flood on the north coast of California, however, Spanish Creek had a vegetated riparian zone in the lower 900 m of stream (personal communication, Dave Fuller, Bureau of Land Management, Arcata, California).

Near the start of the middle section (980 – 2035 m from ocean entry), a small fishless tributary enters Spanish Creek. Upstream of the confluence with this tributary the riparian zone is dense, consisting of red alder mixed with ferns (*Polystichum sp.*) and Douglas fir.

In the upper section (2035 –2557 m from ocean entry), Spanish Creek diverges into two streams of approximately equal flow identified as North Fork Spanish Creek and South Fork Spanish Creek for this study. North Fork Spanish Creek has a large (8 m) waterfall approximately 120 m from its confluence with the south fork. There is a barrier to anadromy in the form of a 7 m waterfall in South Fork Spanish Creek 2557 m upstream from the mouth. During the 1999 and 2000 sampling seasons, fish were absent from North Fork Spanish Creek and beyond the waterfall barrier in South Fork Spanish Creek.

Oat Creek

The lower section of Oat Creek (0-500 m from ocean entry) has dense riparian vegetation of red alder. A series of pools and falls begins 102 m from the point of ocean entry and extends 70 m upstream. Stream gradient increases rapidly from 3% at the base of the falls, increasing to 17% in the middle, and then returning to 3% at the end of the 70 m section.

The middle section of Oat creek (500 –1900 m from ocean entry) has several exposed bedrock outcroppings that form cascades and pools. California laurel (*Umbellularia californica*), Douglas fir, and red alder dominate the riparian zone. The riparian zone of the upper section of Oat Creek (1900 – 2330 m) consists primarily of Douglas fir with scattered patches of red alder. The distribution of fish in Oat Creek extends upstream 2330 m to an impassable bedrock chute. Roughly 350 m above the upstream limit of fish the creek flows subsurface during the summer months.

METHODS

Data Collection

Habitat Typing

Channel unit surveys were conducted on study streams during 1999 and 2000 using a modified form of Level II Habitat Survey and Inventory Protocol developed by California Department of Fish and Game (Flosi and Reynolds 1994). Runs, riffles, pools, and cascades were identified as most common during a pilot study which I did in 1998 and were used to characterize channel units occurring in KRNCA streams. Runs were defined as moderately deep units with moderate current velocities and little surface turbulence. Riffles were defined as relatively shallow areas with low to moderate water depth, moderate to high current velocity, and moderate to high surface turbulence (Herger et al. 1996) with areas of exposed substrate. Pools were defined as deep, low-velocity channel units with little, if any, surface turbulence. Cascades were defined as small falls and pools occurring in a stepwise progression, having high turbulence and exposed boulders (Herger et al. 1996).

Habitat surveys were performed prior to the first fish abundance surveys during each sampling year. Stream habitat surveys started at ocean entry and proceeded upstream identifying individual channel units. The presence of a number of stream cover variables were identified by the crew in each channel unit (Table 2).

A crew consisted of two people, an observer identifying channel units and a data transcriber, recorded at least two channel widths equidistant from one another and the top and bottom of each unit. Depth was recorded as the deepest point along the distance of each width measurement and in the case of pool channel units, an overall maximum depth was found in each unit.

Different observers identified channel units in the two years of the study. One observer identified channel units in both study streams during 1999, and in Oat Creek during 2000. A second observer identified channel units in Spanish Creek during 2000. Stream gradient was calculated using a clinometer and was measured over as many consecutive channel units as possible in a direct line of sight. One observer measured gradient to minimize variation in measurement method.

Table 2. Variables measured during two-stage stream habitat surveys conducted during 1999 and 2000 in Spanish and Oat Creeks, King Range National Conservation Area, California.

Variable	Description
Length (m)	Measured from the bottom to the top of the unit.
Width (m)	Measured at two equidistant points from the top and bottom of the unit.
Depth (m)	Measured at the deepest spot along the width measurement.
Maximum depth (m)	Measured at the deepest point in pool units only.
Cover (%)	Percent of the unit providing cover for fish. Usually combinations of cover types within the water and overhead vegetation.
Large woody debris (Presence/Absence)	Large woody debris (> 0.15 m width, > 2 m in length) in the wetted channel available as cover to fish.
Small woody debris (P/A)	Small woody debris (≤ 0.15 m width, ≤ 2 m in length) in the wetted channel available as cover to fish.
Root mass (P/A)	Stump or root mass located in wetted channel available as cover to fish.
Terrestrial vegetation (P/A)	Vegetation hanging directly over the stream and/or providing shade to habitat unit.
Aquatic vegetation (P/A)	Vegetation within unit (usually algae) available as cover to fish.
Bubble curtain (P/A)	Plunging or cascading water forming bubbles available as cover to fish.
Interstitial space (P/A)	Area between streambed substrate available as cover to fish.

Reach Delineation

Reaches were classified into three categories based on stream gradient: low gradient (≤5%), moderate gradient (5.1-10%), and high gradient (≥10.1%). Reach transitions were identified as points above which gradient increased 1% or more beyond the bounds of each gradient category for a distance exceeding 75m. For example, if three 50 m sections were measured consecutively upstream at 4% stream gradient, then several sections totaling more than 75 m were measured above 5% gradient, a reach break was identified at the transition point from a low gradient reach to a moderate gradient reach. Reaches could only progress into an increasing gradient category. For instance, a low gradient reach could not be identified between a moderate gradient and high gradient reach. Therefore the same reach pattern from the point of ocean entry to the end of fish distribution in the basin occurred in each study stream: low gradient, moderate gradient, and high gradient. I used the same reach boundaries during both sampling years to maintain consistency.

Water Temperature

To record water temperature in study streams, Hobo temperature loggers (Onset Corp., Pocasse, Massachusettes) were placed near the upper and lower limits of fish distribution in each stream from 1 June to 30 September, 1999. Temperature loggers were placed near the upper sections of each reach in Oat and

Spanish creeks from 1 June – 30 September 2000. In both years, I set loggers to record temperature twice an hour.

Data Analysis

Channel Unit Distribution

To test the independence of channel unit types by reach gradient, a 3 x 4 contingency table was used for each stream during 1999 and 2000. For each contingency table, the null hypothesis was the occurrence of channel units in each reach was independent of reach gradient. A significance level of $\alpha = 0.05$ was used

Abundance Estimates

A two-stage, without replacement, habitat classification and electrofishing sampling design (Hankin 1984) was used to estimate fish abundance during summer and fall in Spanish and Oat Creeks. The first stage of the design consisted of a habitat survey (previously described). The second stage was a stratified and systematic selection of sample units, with independent, random starts in each reach. This resulted in selection of 20 to 25% of habitat units within each of the four channel unit strata, in each reach of each stream being sampled. In 1999, surveys were conducted twice: July through early August, and again in late October. In 2000, surveys were conducted in mid-August and again from late October into November. The initial survey in 2000 was delayed to allow for complete emergence of young-of-the-year steelhead trout.

Fish abundance in selected channel units was estimated from multiple pass depletion electrofishing catches. The top and the bottom of each channel unit were closed off with block nets and two, three, or four electrofishing pass depletions were conducted using a backpack electrofishing unit (Model 12A, Smith-Root Inc., Vancouver, Washington). An electrofishing pass consisted of two people (an operator of the electrofishing unit and a netter) moving upstream from the bottom to the top of the unit, and then retracing their movements downstream to the bottom of the unit. A unit was considered depleted, and sampling ended, when the number of juvenile steelhead trout caught during a pass was ≤ 25% of the previous pass. Individual unit depletion estimates and habitat strata abundance estimates for each creek were calculated following Hankin (1984).

During the 1999 field season all captured fish were measured (nearest 1.0 mm fork length). During the 2000 field season, all fish captured in 60% of randomly selected units in Spanish and Oat Creeks were measured. In the remaining 40% of units, the total number juvenile steelhead trout in two age classes, age 0+ and post-age 0+ were recorded. Age class determinations made by survey crews in the field were aided by length-frequency histograms from the previous year suggesting size at age, for each stream and season.

Ages of juvenile steelhead trout collected were determined by scale analysis. Scales were collected from approximately 10% of all juvenile steelhead trout >80 mm in fork length during summer, and >50 mm during fall 2000.

Scales were aged by two independent observers using a 10X power microscope and projecting the scale image onto a video monitor. Sizes of juvenile steelhead trout were not known to observers to maintain unbiased age class conclusions. When age determination between the two scale observers differed, differences were mediated by conferring with one another, following Ward and Slaney (1988). Whenever the two observers could not agree on an age determination, the sample was discarded.

Summer Survival

Survival rates of juvenile steelhead trout between sampling dates during summer and fall were estimated as a ratio of fall abundance estimates divided by summer abundance estimates for all channel unit strata in each stream during 1999 and 2000 using the equation

$$\hat{S} = \frac{\hat{N}_2}{\hat{N}_1}$$

where,
$\hat{S}$ = Estimated survival rate of juvenile steelhead trout
$\hat{N}_1$ = Estimated abundance at summer sampling
$\hat{N}_2$ = Estimated abundance estimate at fall sampling

Summer survival rates for age 0+ and post-age 0+ juvenile steelhead trout were also estimated for Oat and Spanish Creeks during 2000. The computer program MIX 3.1 (McDonald 1987) was used to estimate proportions of age 0+ and post-age 0+ juvenile steelhead trout for the 2000 sampling year. Mean fork lengths and standard deviations for age classes from scale sample results were used as initial values for the program. The lowest achievable chi-square statistic and probability were used to determine optimal results. Proportions and standard error (SE) of individuals within age classes from each creek, and season, were applied to corresponding abundance estimates to determine summer survival of age 0+ and age 1+ juvenile steelhead trout. The equations used to estimate summer survival rates for specific age classes were:

$$\hat{S}_{ij} = \frac{\hat{p}_{i02}\hat{N}_2}{\hat{p}_{i01}\hat{N}_1}$$

where,

$\hat{S}_{ij}$ = Estimated survival rate of age class i in stream j

$\hat{p}_{i01}$ =Estimated proportion of age class i at summer sampling in stream j

$\hat{p}_{i02}$ =Estimated proportion of age class i at fall sampling in stream j

$\hat{N}_1$ =Estimated abundance of all juvenile steelhead trout at summer sampling in stream j

$\hat{N}_2$ =Estimated abundance of all juvenile steelhead trout at fall sampling in stream j

Using the delta method approximation (Seber 1982), an estimator for variance of survival rate estimated for the two age classes would be:

$$V\hat{a}r(\hat{S}_i) = V\hat{a}r(\hat{p}_{i02})\left(\frac{\hat{N}_2}{\hat{p}_{i01}\hat{N}_1}\right)^2 + V\hat{a}r(\hat{N}_2)\left(\frac{\hat{p}_{i02}}{\hat{p}_{i01}\hat{N}_1}\right)^2 + V\hat{a}r(\hat{p}_{i01})\left(\frac{\hat{p}_{i02}\hat{N}_2}{\hat{p}_{i01}^2\hat{N}_1}\right)^2 + V\hat{a}r(\hat{N}_2)\left(\frac{\hat{p}_{i02}\hat{N}_2}{\hat{p}_{i01}\hat{N}_1^2}\right)^2$$

$$+ 2C\hat{o}v(\hat{p}_{i02},\hat{N}_2)\frac{\hat{p}_{i02}\hat{N}_2}{(\hat{p}_{i01}\hat{N}_1)^2} - 2C\hat{o}v(\hat{p}_{i02},\hat{p}_{i01})\frac{\hat{p}_{i02}\hat{N}_2^2}{\hat{p}_{i01}^3\hat{N}_1^2} - 2C\hat{o}v(\hat{p}_{i02},\hat{N}_1)\frac{\hat{p}_{i02}\hat{N}_2^2}{\hat{p}_{i01}^2\hat{N}_1^3}$$

$$- 2C\hat{o}v(\hat{p}_{i01},\hat{N}_2)\frac{\hat{p}_{i02}^2\hat{N}_2}{\hat{p}_{i01}^3,\hat{N}_1^2} - 2C\hat{o}v(\hat{N}_1,\hat{N}_2)\frac{\hat{p}_{i02}^2\hat{N}_2}{\hat{p}_{i01}^2\hat{N}_1^3} + 2Cov(\hat{p}_{i01},\hat{N}_1)\frac{\hat{p}_{i02}^2\hat{N}_2^2}{\hat{p}_{i01}^3\hat{N}_1^3}$$

where,

$\hat{V}ar(\hat{p}_{i01})$ = Estimated variance of the age class i proportion estimate at summer sampling in stream j

$\hat{V}ar(\hat{p}_{i02})$ = Estimated variance of the age class i proportion estimate at fall sampling in stream j

$\hat{V}ar(\hat{N}_1)$ = Estimated variance of the summer abundance estimate

$\hat{V}ar(\hat{N}_2)$ = Estimated variance of the fall abundance estimate

Based on consideration of the independence of data used to estimate the N_i and p_i, all covariance terms are assumed zero except the following covariance term:

$$2C\hat{o}v(\hat{N}_1, \hat{N}_2)\frac{\hat{p}_{i02}^2 \hat{N}_2}{\hat{p}_{i01}^2 \hat{N}_1^3}$$

This term should be positive and possibly large considering that identical channel units were sampled for summer and fall sampling periods during 2000. This positive and possibly large covariance term should considerably reduce the variance estimate for age class survival but in lieu of its difficult approximation, and to report a conservative variance estimate, the contribution of this term was ignored. An age class survival analysis in the 1999 sampling year was not conducted due to insufficient scale samples and confounding abundance estimates discussed later.

Reach Distribution

A factorial ANOVA (2 x 2 x 3 x 3, Table 3) was used to analyze the influence of Year (1999 and 2000), Stream (Oat and Spanish creeks), Reach (low, moderate, and high gradient) and Channel Unit (pool, run, and riffle) on the

Table 3. Factors and possible interactions of 2 x 2 x 3 x 3 factorial design used to test for differences in density of juvenile steelhead trout among reaches and habitats in two streams within the King Range National Conservation Area, California. The levels of single factors are given in parentheses.

Factor/Interaction	Number of combinations
Year (1999 and 2000)	2
Stream (Oat and Spanish Creeks)	2
Reach (low gradient, moderate gradient, and high gradient)	3
Channel Unit (Pool, Run, and Riffle)	3
Year x Stream	4
Year x Reach	6
Year x Channel Unit	6
Stream x Reach	6
Stream x Channel Unit	6
Reach x Channel Unit	9
Year x Stream x Reach	12
Year x Stream x Channel Unit	12
Year x Reach x Channel Unit	18
Reach x Stream x Channel Unit	18
Year x Stream x Reach x Channel Unit	36

density (fish/m^2) of age 0+ and post age 0+ juvenile steelhead trout. Cascade channel units were not included in the analysis because they did not occur in all reaches in both years. All factors in the ANOVA were considered fixed and a significance level of $\alpha = 0.05$ was used. Data analysis was done using the SAS statistical program and a general linear model procedure.

The density of each age class of juvenile steelhead trout was determined for each channel unit sampled during electrofishing surveys. Juvenile steelhead trout were assigned to age groups based on length-frequency distributions from each stream, from each year, and confirmed using scale analysis. Unit depletion estimates were then split based on proportions of each age class in each unit. In units where fork length was not measured, counts of age 0+ and post age 0+ performed by survey crews were used.

Residual plots of age class data sets were examined for compliance with assumptions of normality and homoscedasticity. A square root transformation was used to approximate normality.

An error in sampling occurred during 2000 where a riffle unit in the upper reach of Oat Creek was not sampled, leaving only one riffle unit sampled in the high gradient reach of Oat Creek during 2000. To estimate a missing value for a factorial analysis with unequal replication, I used an equation in Zar (1999).

$$\hat{X} = \frac{aA_i + bB_j + cC_l + dD_m - (k-1)\sum X}{N + k - 1 - a - b - c - d}$$

where,

$\hat{X}$ = is the estimated value for a missing datum in level i of factor A (Year), level j of factor B (Stream), level l of factor C (Reach), and level m of factor D (Channel Unit)
a = number of levels of factor A (2)
b = number of levels of factor B (2)
c = number of levels of factor C (3)
d = number of levels of factor D (3)
A = sum of all other data in level i of factor A.
B = sum of all other data in level j of factor B.
C = sum of all other data in level l of factor C.
D = sum of all other data in level m of factor D.
k = number of factors (4)
$\sum X$ = sum of all other data in all levels of all factors
N = total number of data, including missing data points, in experimental design.

Where significant interactions occurred in three or more factor interactions, multiple comparisons were not performed due to possible Type I error. Single factors with significant F-values are presented even if included in significant multiple factor interactions.

RESULTS

Habitat Typing and Reach Delineation

In 1999, riffles were the most frequently identified channel units and accounted for the most area in Spanish Creek (Table 4). In Oat Creek during 1999, riffles were the most frequently identified channel unit but cascades accounted for more area. In 2000, riffles were the most frequently identified channel units and accounted for the most area in Spanish Creek (Table 5). In Oat Creek, cascades accounted for the most area but runs were more frequently identified.

Reach characteristics of study streams differed from one another but remained similar between sampling years (Tables 6 and 7). Low gradient and moderate gradient reaches in Spanish Creek were slightly different in percent total area in both 1999 (48.8 and 35.2%, respectively) and 2000 (41.2 and 40.4 %, respectively). The high gradient reach of Spanish Creek represented less than 20% of the stream area during both years. In Oat Creek, reach area varied little between years. The moderate gradient reach accounted for over 63% of total stream area in both years. Low gradient reaches were similar (22.7% in 1999 and 23.1% in 2000) and high gradient reaches were identical (15.0 %). Reach lengths varied despite fixed reach boundaries between years due to changes in stream morphology and small variations in measurements from different habitat classification crews.

Table 4. Channel unit area and number identified in each reach gradient of Oat and Spanish Creeks during 1999 in the King Range National Conservation Area, California.

	Spanish Creek				Oat Creek			
	Reach				Reach			
Measurement	Low	Moderate	High	Total	Low	Moderate	High	Total
Riffles								
Area (m^2)	3046.3	1471.6	135.8	4653.7	837.0	948.3	97.2	1882.5
Number	45	42	12	99	27	45	6	177
Pools								
Area (m^2)	477.3	236.8	250.6	964.7	314.6	913.5	211.0	1440.1
Number	4	15	18	37	19	58	15	92
Runs								
Area (m^2)	683.2	662.4	157.4	1503.0	315.4	1182.0	128.3	1626.7
Number	28	34	11	73	16	55	12	83
Cascades								
Area (m^2)	32.2	689.8	846.5	1568.5	82.0	1209.2	592.5	1883.7
Number	1	28	24	53	5	45	16	66

Table 5. Channel unit area and number identified by each reach gradient of Oat and Spanish Creeks during 2000 in the King Range National Conservation Area, California.

	Spanish Creek				Oat Creek			
	Reach				Reach			
Measurement	Low	Moderate	High	Total	Low	Moderate	High	Total
Riffles								
Area (m^2)	1910.3	1082.0	206.6	3198.9	715.5	718.5	73.0	1507.0
Number	29	54	20	103	22	36	4	62
Pools								
Area (m^2)	39.9	336.2	324.7	700.8	254.3	990.5	284.1	1528.9
Number	3	24	22	49	12	54	15	81
Runs								
Area (m^2)	890.0	1260.2	328.2	2478.4	439.9	969.6	210.3	1619.8
Number	24	50	17	91	19	43	12	74
Cascades								
Area (m^2)		107.0	411.7	518.7	43.6	1224.4	380.6	1648.6
Number		11	16	27	3	45	14	62

Table 6. Reach gradient characteristics of Oat and Spanish Creeks during 1999 within the King Range National Conservation Area, California. Field crews made all measurements during habitat surveys.

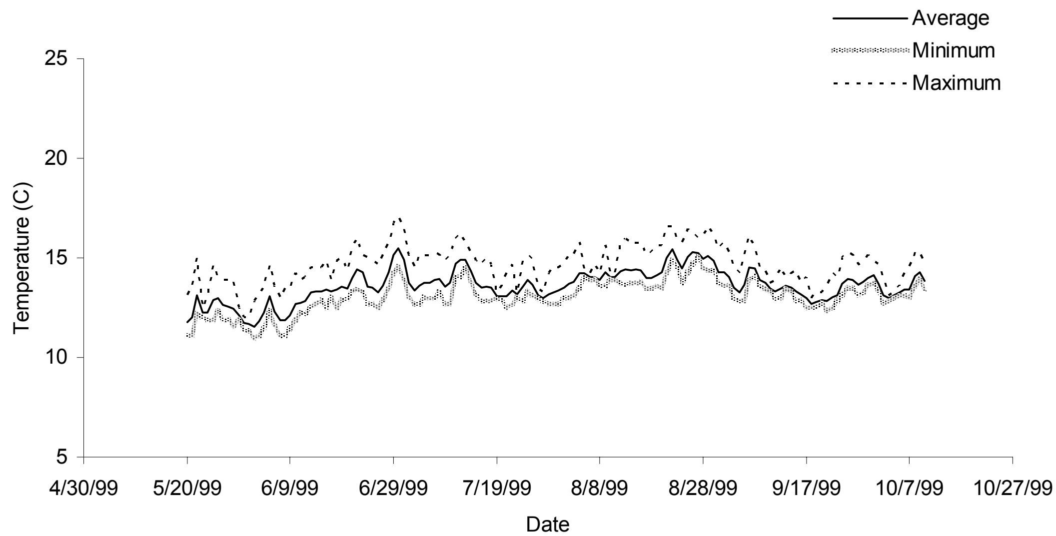
	Spanish Creek				Oat Creek			
	Reach				Reach			
Measurement	Low	Moderate	High	Total	Low	Moderate	High	Total
Length of Reach (m)	984.1	1142.5	522.5	2649.1	502.3	1473.2	353.5	2329.0
Total Area (m^2)	4239.0	3060.7	1390.3	8690.0	1549.0	4254.0	1029.9	6832.9
% of Total Stream Area	48.8	35.2	16.0	100.0	22.7	62.3	15.0	100.0
% of Total Stream Length	37.2	43.1	19.7	100.0	21.6	63.2	15.2	100.0

Table 7. Reach gradient characteristics of Oat and Spanish Creeks during 2000 within the King Range National Conservation Area, California. Field crews made all measurements during habitat surveys.

	Spanish Creek				Oat Creek			
	Reach				Reach			
Measurement	Low	Moderate	High	Total	Low	Moderate	High	Total
Length of Reach (m)	984.1	1064.6	561.8	2610.5	498.3	1402.9	306.3	2207.5
Total Area (m^2)	2840.1	2785.4	1271.2	6896.7	1453.3	3903.0	948.1	6310.4
% of Total Stream Area	41.2	40.4	18.4	100.0	23.1	61.9	15.0	100.0
% of Total Stream Length	37.7	40.8	21.5	100.0	22.6	63.5	13.9	100.0

Water Temperature

Water temperature differences between streams appeared negligible in high gradient reaches during 1999 (Figure 3 and 4). In low gradient reaches during 1999, daily average, minimum, and maximum water temperatures were higher in Spanish than Oat Creek. In 2000, water temperature in high and moderate gradient reaches of Spanish and Oat Creek were similar (Figures 5 and 6). In Spanish Creek during 2000, water temperatures in the low gradient reach were clearly higher than in the moderate and high gradient reaches. In Oat Creek, little difference in stream temperature was observed in the low gradient reach when compared to the high and moderate gradient reaches.



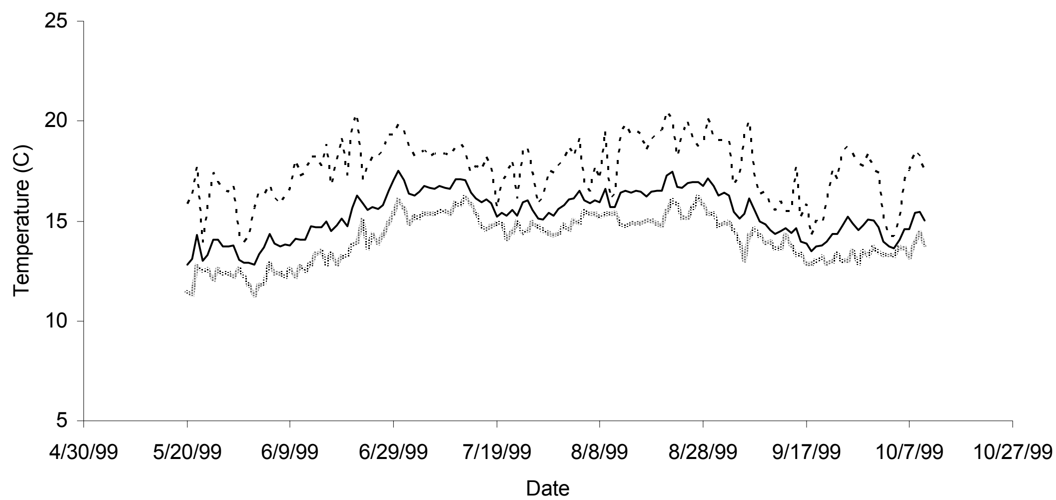
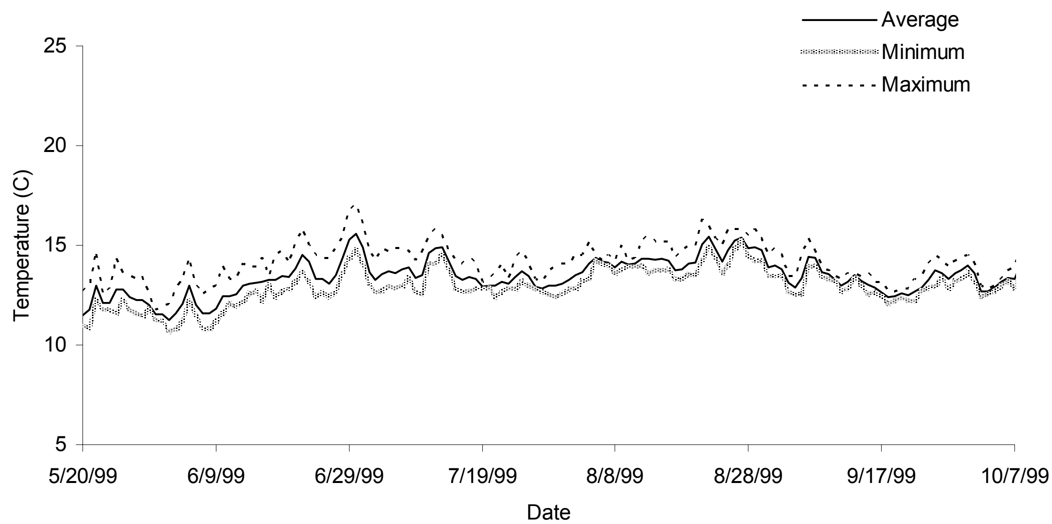


Figure 3. Daily average, minimum, and maximum water temperature (°C) for high and low gradient reaches of Spanish Creek for the 1999 sampling season in the King Range National Conservation Area, California.



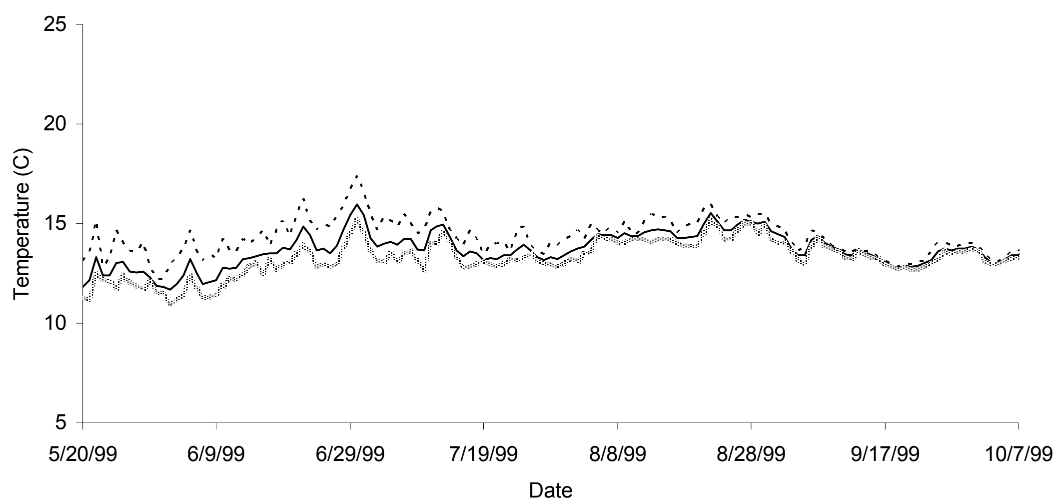


Figure 4. Daily average, minimum, and maximum water temperature (°C) for high and low gradient reaches in Oat Creek for the 1999 sampling season in the King Range National Conservation Area, California.

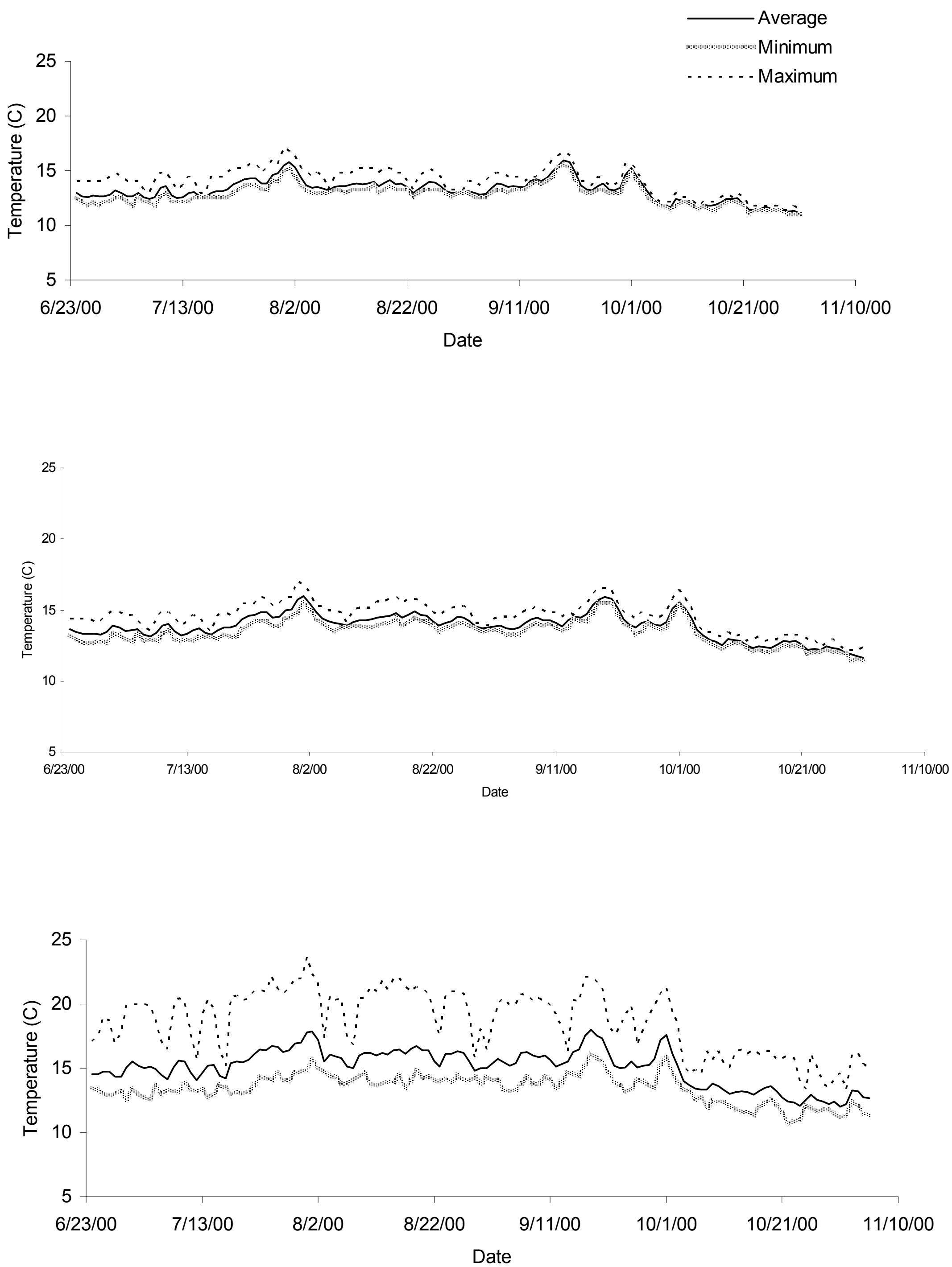
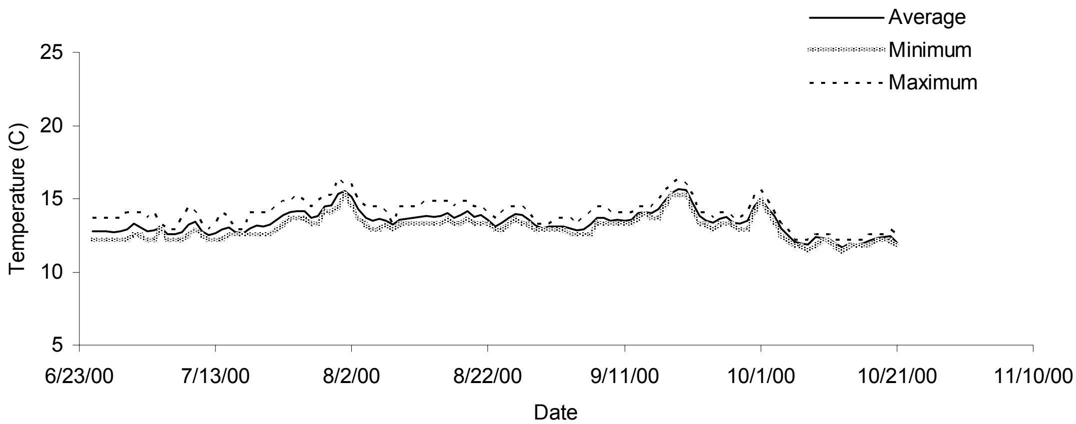
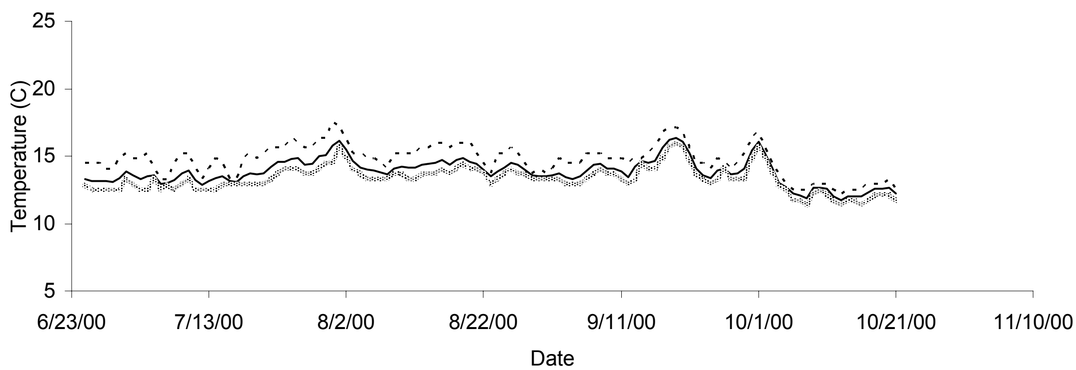


Figure 5. Daily average, minimum, and maximum water temperature (°C) for high, moderate, and low gradient reaches of Spanish Creek for the 2000 sampling season in the King Range National Conservation Area, California.





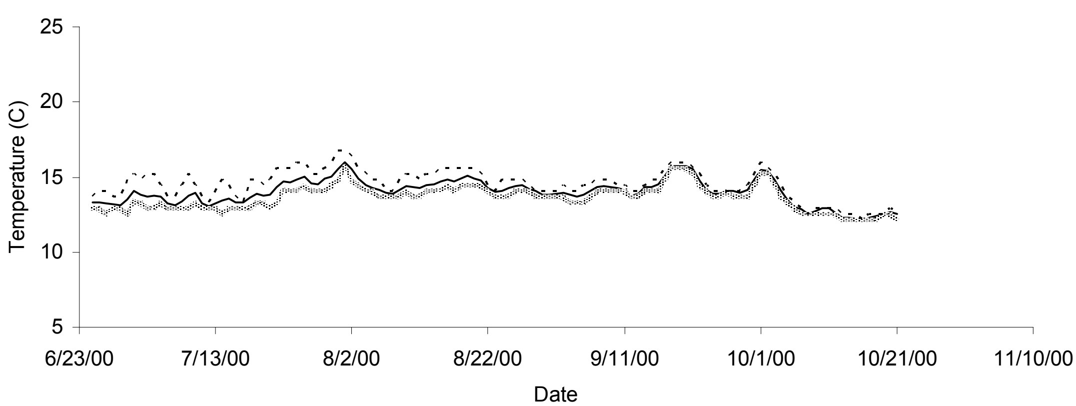


Figure 6. Daily average, minimum, and maximum water temperature (°C) for high, moderate, and low gradient reaches of Oat Creek for the 2000 sampling season in the King Range National Conservation Area, California.

Channel Unit Distribution

Chi-square contingency table tests showed that the occurrence of channel units in each reach was not independent of gradient in Spanish and Oat Creeks during 1999 and 2000. In Spanish Creek during 1999 and 2000, riffle channel units dominated low gradient reaches, riffle and run channel units dominated moderate gradient reaches, and high gradient reaches were similar in composition for both years (Table 8). In Oat Creek during 1999 and 2000, riffle channel units dominated low gradient reaches, all four types were well represented for moderate gradient reaches, and run and pool channel units dominated high gradient reaches (Table 9).

Abundance Estimates and Summer Survival

A total of 58 channel units were sampled in Spanish Creek and 66 channel units were sampled in Oat Creek during summer and fall sampling dates during 1999 (Table 10). In 2000, 63 channel units were sampled in Spanish Creek and 59 in Oat Creek (Table 11). All channel unit electrofishing removal data are presented in Appendix A. In Spanish Creek, abundance estimates and summer survival differed between years. In 1999, abundance estimates of juvenile steelhead trout in Spanish Creek during summer were 1783 and during fall 1538, yielding an 86 % summer survival rate (Table 12).

Table 8. Contingency tables for channel unit occurrence in each reach gradient of Spanish Creek during 1999 and 2000. Row and column totals were used to compute chi-square statistics for contingency table analyses. Probability values are also given for each chi-square statistic. For all χ^2 statistics degrees of freedom = 6.

	Spanish Creek 1999					Spanish Creek 2000				
	Riffle	Pool	Run	Cascade	Column Total	Riffle	Pool	Run	Cascade	Column Total
Low Gradient	45	4	28	1	78	29	3	24	0	56
Moderate Gradient	42	15	34	28	119	54	24	50	11	139
High Gradient	12	18	11	24	65	20	22	17	16	75
Row Total	99	37	73	53	262	103	49	91	27	270
$\chi^2 =$					$\chi^2_6 = 55.9$ (P<0.001)					$\chi^2_6 = 35.7$ (P<0.001)

Table 9. Contingency tables for channel unit occurrence in each reach gradient of Oat Creek during 1999 and 2000. Row and column totals were used to compute chi-square statistics for contingency table analyses. Probability values are also given for each chi-square statistic. For all χ^2 statistics degrees of freedom = 6.

	Oat Creek 1999					Oat Creek 2000				
	Riffle	Pool	Run	Cascade	Column Total	Riffle	Pool	Run	Cascade	Column Total
Low Gradient	27	19	16	5	67	22	12	19	3	56
Moderate Gradient	45	58	55	45	203	36	54	43	45	178
High Gradient	6	15	12	16	49	4	15	12	14	45
Row Total	78	92	83	66	319	62	81	74	62	279
$\chi^2 =$					χ^2_6 =19.88 (P<0.005)					χ^2_6 = 23.8(<0.001)

Table 10. Channel unit area and number sampled in each reach gradient of Spanish and Oat creeks during 1999 in the King Range National Conservation Area, California.

	Spanish Creek				Oat Creek			
	Reach				Reach			
Measurement	Low	Moderate	High	Total	Low	Moderate	High	Total
Riffles								
Area (m^2)	446.5	284.4	51.8	782.7	161.9	149.7	43.8	355.4
Number	8	9	3	20	6	9	2	17
Pools								
Area (m^2)	26.2	68.8	19.1	114.1	33.6	169.2	46.3	249.1
Number	2	5	3	10	3	12	3	18
Runs								
Area (m^2)	101.2	252.7	50.8	404.7	54.1	177.9	36.6	268.6
Number	4	8	3	15	3	11	3	17
Cascades								
Area (m^2)	32.2	170.1	279.8	482.1	18.5	298.0	97.0	413.5
Number	1	8	4	13	1	10	3	14

Table 11. Channel unit area and number sampled in each reach gradient of Spanish and Oat creeks during 2000 in the King Range National Conservation Area, California.

	Spanish Creek				Oat Creek			
	Reach				Reach			
Measurement	Low	Moderate	High	Total	Low	Moderate	High	Total
Riffles								
Area (m^2)	299.7	243.8	39.5	583.0	85.7	207.9	26.1	319.7
Number	5	12	5	22	5	8	1	14
Pools								
Area (m^2)	24.4	158.0	64.3	246.7	30.1	185.3	81.7	297.1
Number	2	7	6	15	3	11	4	18
Runs								
Area (m^2)	186.7	283.2	109.1	579.0	79.6	154.7	70.8	305.1
Number	5	12	4	21	4	8	3	15
Cascades								
Area (m^2)	0.0	12.3	22.7	35.0	0.0	181.6	67.5	249.1
Number	0	3	2	5	0	9	3	12

Table 12. Juvenile steelhead trout abundance and summer survival estimates for study streams in the King Range National Conservation Area, California during 1999 and 2000. The 95% confidence interval is also given. Estimated summer survival rate is for all age classes of juvenile steelhead trout.

	Spanish Creek			Oat Creek		
	Summer Abundance Est.	Fall Abundance Est.	Est. Summer Survival Rate	Summer Abundance Est.	Fall Abundance Est.	Est. Summer Survival Rate
1999	1783.4	1537.6	86.2	2777.8	2878.9	103.6
	CI +/-541.5	CI +/-368.9		CI +/-624.2	CI +/-511.2	
2000	5782.5	4310.0	74.5	3262.1	2695.4	82.6
	CI +/-618.2	CI +/-827.5		CI +/-627.0	CI +/- 565.7	

Reach abundance estimates were highest in the moderate gradient reach for both summer and fall (Table 13). Summer survival rates were 105% for the low gradient reach, 87% for the moderate gradient reach, and 72% for the high gradient reach. In 2000, abundance estimates of juvenile steelhead trout nearly tripled from 1999. Reach abundance estimates were also greater in 2000 than 1999, and the moderate gradient reach again had the highest abundance during summer and fall (Table 14). In 2000, reach-specific summer survival estimates were 56, 92, and 71% for low, moderate, and high gradient reaches, respectively.

In Oat Creek, abundance estimates differed slightly between 1999 and 2000 whereas reach and stream summer survival estimates were highly different. In 1999, the early start of the abundance survey confounded the estimate of summer survival. The Oat Creek early summer abundance estimate was less than the fall leading to a survival estimate of 104% (Table 12). Among reaches, the highest abundance estimates for both summer and fall were found in the moderate gradient reach. Reach summer survival rates were 76% for the low gradient reach, 117% for the moderate gradient reach, and 140% for the high gradient reach. In 2000, with a delayed start to the initial abundance survey, the summer abundance estimate in Oat Creek was greater than the fall abundance estimate yielding a summer survival of 83%. As in 1999, the moderate gradient reach had the highest summer and fall abundance estimates. Reach-specific summer survival estimates were 57% for low gradient, 95% moderate gradient, and 80% high gradient for Oat Creek during 2000.

Table 13. Juvenile steelhead trout abundance and summer survival estimates within each channel unit type in each reach gradient for Spanish Creek during 1999. The Confidence Interval (CI+/-) bounds are given for each total seasonal estimate.

	Low gradient					Moderate gradient					High gradient				
	Summer Abundance		Fall Abundance		Survival Rate (%)	Summer Abundance		Fall Abundance		Survival Rate (%)	Summer Abundance		Fall Abundance		Survival Rate (%)
	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%
Cascade	5.0	0.0	6.3	0.0	125.0	141.2	74.1	124.8	58.0	88.4	207.6	204.3	163.3	201.1	78.7
Pool	16.6	7.2	22.6	1.7	136.1	86.8	58.3	72.4	33.9	83.4	72.0	132.8	42.0	21.9	58.3
Riffle	277.7	142.0	305.7	96.2	110.1	316.2	218.5	289.2	143.2	91.5	152.0	384.1	84.7	56.3	55.7
Run	113.2	72.3	91.0	52.2	80.4	285.6	179.1	232.7	167.7	81.5	115.1	97.6	102.7	42.6	89.2
Total	407.0	159.5	425.6	219.0	104.6	829.7	297.9	719.2	230.5	86.7	546.7	465.2	392.8	214.2	71.8

Table 14. Juvenile steelhead trout abundance and summer survival estimates within each channel unit type in each reach for Spanish during 2000. The Confidence Interval (CI+/-) bounds are given for each total seasonal estimate. Cascade channel units were not identified in the low gradient reach of Spanish Creek during 2000.

	Low gradient					Moderate gradient					High gradient				
	Summer Abundance		Fall Abundance		Surv. Rate	Summer Abundance		Fall Abundance		Surv. Rate	Summer Abundance		Fall Abundance		Surv. Rate
	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%
Cascade						69.6	43.3	49.5	22.7	71.1	64.7	0.0	8.0	7.5	12.4
Pool	59.5	3.3	51.6	1.7	86.7	608.9	154.6	616.2	208.4	101.2	143.7	48.1	136.3	51.2	94.9
Riffle	1397.5	424.2	735.4	140.4	52.6	907.1	171.2	727.9	186.6	80.2	75.7	32.8	40.7	26.9	53.8
Run	1132.7	308.4	665.3	123.3	58.7	1203.8	216.1	1178.9	227.7	97.9	119.0	44.2	100.3	47.5	84.3
Total	2589.8	1048.9	1452.2	373.9	56.1	2789.6	638.1	2572.6	722.8	92.2	403.1	146.2	285.2	150.5	70.8

Table 15. Juvenile steelhead trout abundance and summer survival estimates within each channel unit type in each reach for Oat Creek during 1999. The confidence interval (CI+/-) is given for each total seasonal estimate.

	Low gradient					Moderate gradient					High gradient				
	Summer Abundance		Fall Abundance		Surv. Rate	Summer Abundance		Fall Abundance		Surv. Rate	Summer Abundance		Fall Abundance		Surv. Rate
	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%
Cascade	67.2	1.9	31.2	1.5	46.4	298.9	67.2	315.4	54.4	105.5	54.1	41.8	87.7	58.9	162.1
Pool	192.3	83.7	184.9	100.4	96.2	443.9	117.9	522.6	68.3	117.7	115.2	41.6	162.9	43.6	141.4
Riffle	550.9	227.3	402.0	171.9	73.0	308.6	65.9	364.6	59.1	118.1	16.0	13.2	18.0	9.8	112.5
Run	198.9	97.1	145.3	35.7	73.1	478.5	52.2	580.6	85.1	121.3	53.0	10.2	63.5	24.0	119.8
Total	1009.4	522.1	763.6	404.5	75.6	1530.1	319.4	1783.2	580.6	116.5	238.3	112.6	332.1	155.4	139.4

Proportions of 0+ and post age 0+ juvenile steelhead trout were determined for both streams from the combinations of fork length-frequency distributions (Figures 7 and 8) and scale aging results (Appendix B) were then applied to abundance estimates. Proportions and abundance of 0+ and post age 0+ juvenile steelhead trout varied greatly between Spanish and Oat creeks (Tables 17 and 18). In Spanish Creek during 2000, age 0+ juvenile steelhead trout summer survival was estimated at 73% and post-age 0+ at 83%. In Oat Creek during 2000 age 0+ juvenile steelhead trout summer survival was estimated at 87% and post age 0+ at 80%.

<u>Reach and Channel Unit Distribution</u>

The data sets included 203 individual density (juvenile steelhead trout/m^2) observations for age 0+ and post-age 0+. The complete data set used in the analysis is presented in Appendix A, including summer population estimates and age class proportions. Difference in density of age 0+ juvenile steelhead trout among reach types was not independent of year or stream (Year x Reach x Stream interaction $F_{2,167}$=6.92, P=0.0013, Table 19, Figure 9) suggesting that 0+ population increases between 1999 and 2000, particularly in Spanish Creek, were not similarly distributed between low, moderate, and high gradient reaches for those years. Density of age 0+ juvenile steelhead trout differed among pool, riffle and run channel units ($F_{2,167}$= 5.88, P = 0.0034, Figure 10) with pool and run densities (0.48 fish/m^2 SE =0.06 and 0.42 fish/m^2 SE=0.05, respectively) greater than riffle densities (0.28 SE=0.03).

Table 16. Juvenile steelhead trout abundance and summer survival estimates within each channel unit type in each reach for Oat Creek during 2000. The confidence interval is given for each total seasonal estimate. Cascade channel units were not identified in the low gradient reach of Oat Creek during 2000.

	Low gradient					Moderate gradient					High gradient				
	Summer Abundance		Fall Abundance		Surv. Rate	Summer Abundance		Fall Abundance		Surv. Rate	Summer Abundance		Fall Abundance		Surv. Rate
	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%	Est.	SE/CI	Est.	SE/CI	%
Cascade						364.9	110.0	313.0	91.9	85.8	113.9	25.9	68.3	29.7	60.0
Pool	169.8	32.3	95.1	36.5	56.0	563.7	102.9	614.5	82.9	109.0	178.2	47.6	147.1	42.5	82.5
Riffle	415.6	120.4	237.6	67.7	57.2	452.4	79.0	333.4	76.7	73.7	4.0	0.0	20.0	0.0	500.0
Run	343.6	120.6	200.6	70.5	58.4	620.1	190.2	635.6	212.1	102.5	36.0	10.4	30.0	14.5	83.3
Total	928.9	346.9	533.3	208.8	57.4	2001.1	510.4	1896.6	514.6	94.8	332.1	110.4	265.5		80.0

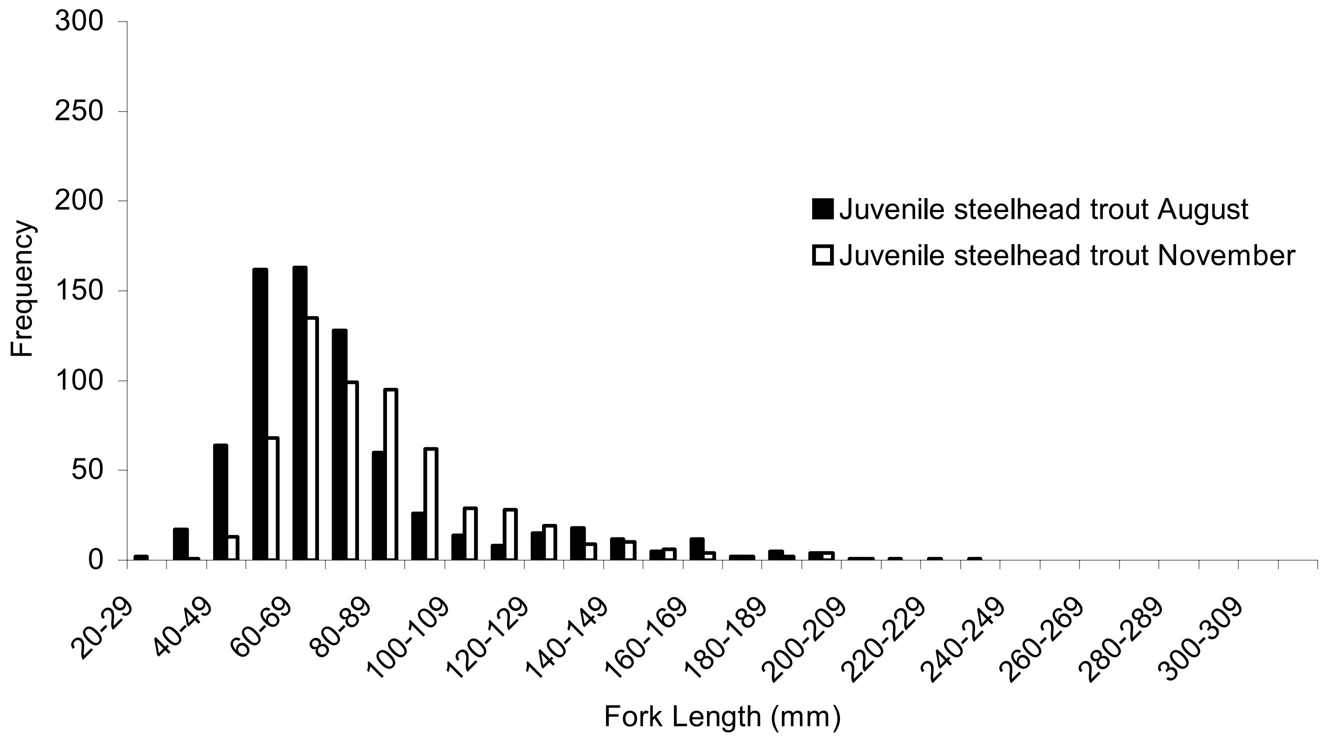


Figure 7. Fork-length distribution of juvenile steelhead trout collected from Spanish Creek, King Range National Conservation Area, California during August and November 2000.

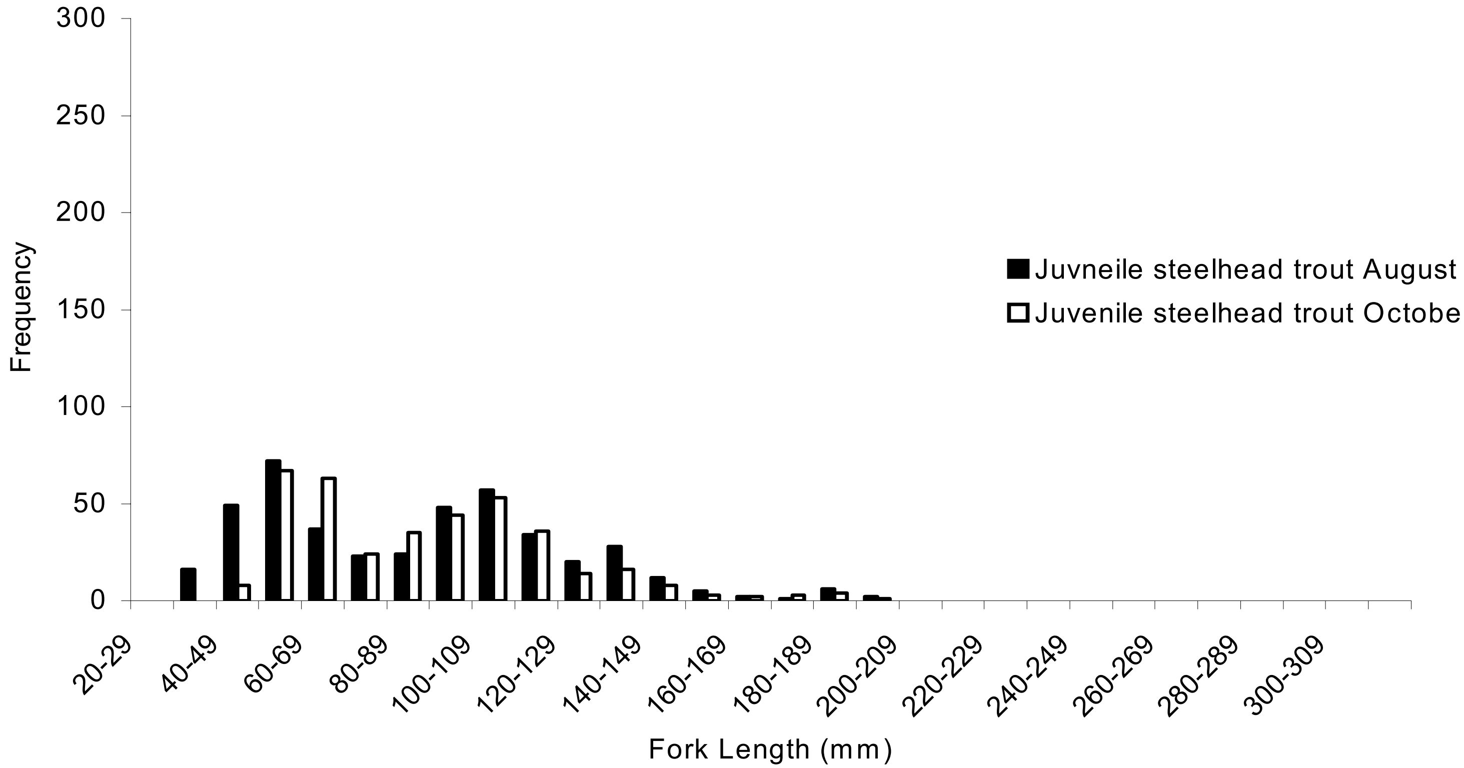


Figure 8. Fork-length frequency distribution of juvenile steelhead trout collected from Oat Creek, King Range National Conservation Area, California during August and October 2000.

Table 17. Estimated age class proportions, abundance, and percent (%) summer survival of juvenile steelhead trout in Spanish Creek, California during 2000. The standard error (SE) of proportions and summer survival are in parentheses.

	Spanish Creek				
	Summer Proportion (SE)	Summer Abundance	Fall Proportion (SE)	Fall Abundance	% Survival (SE)
Age 0+	0.864 (0.015)	4997	0.849 (0.029)	3659	73.2 (9.30)
Post-age 0+	0.136 (.015)	786	0.151 (0.029)	652	82.9 (481.5)

Table 18. Estimated age class proportions, abundance, and percent (%) summer survival of juvenile steelhead trout in Oat Creek, California during 2000. The standard error (SE) of proportions and summer survival are in parentheses.

	Oat Creek				
	Summer Proportion (SE)	Summer Abundance	Fall Proportion (SE)	Fall Abundance	% Survival (SE)
Age 0+	0.428 (0.026)	1396	0.449 (0.032)	1209	86.6 (32.2)
Post-age 0+	0.572 (0.026)	1866	0.551 (0.032)	1486	79.6 (16.3)

Table 19. Effects of Year (1999, 2000), Stream (Oat Creek, Spanish Creek), Reach (low gradient, moderate gradient, high gradient), and Channel Unit (pool, riffle, run) on the density of age 0+ juvenile steelhead trout in the King Range National Conservation Area, California.

Source	DF	SSQ	F-Value	P-value
Year	1	0.818	14.51	0.0002
Stream	1	0.024	0.43	0.5116
Reach	2	0.841	7.46	0.0008
Channel Unit	2	0.663	5.88	0.0034
Year x Stream	1	2.494	44.23	<0.0001
Year x Reach	2	1.551	13.75	<0.0001
Year x Channel Unit	2	0.264	2.34	0.0994
Stream x Reach	2	0.173	1.54	0.2181
Stream x Channel Unit	2	0.043	0.39	0.6783
Reach x Channel Unit	4	0.083	0.37	0.8282
Year x Stream x Reach	2	0.780	6.92	0.0013
Year x Stream x Channel Unit	2	0.175	1.56	0.2139
Year x Reach x Channel Unit	4	0.047	0.21	0.9315
Stream x Reach x Channel Unit	4	0.111	0.49	0.7395
Year x Stream x Reach x Channel Unit	4	0.045	0.20	0.9373
Model	35	10.424	5.28	<0.0001
Error	167	9.419		
Corrected Total	202	19.843		

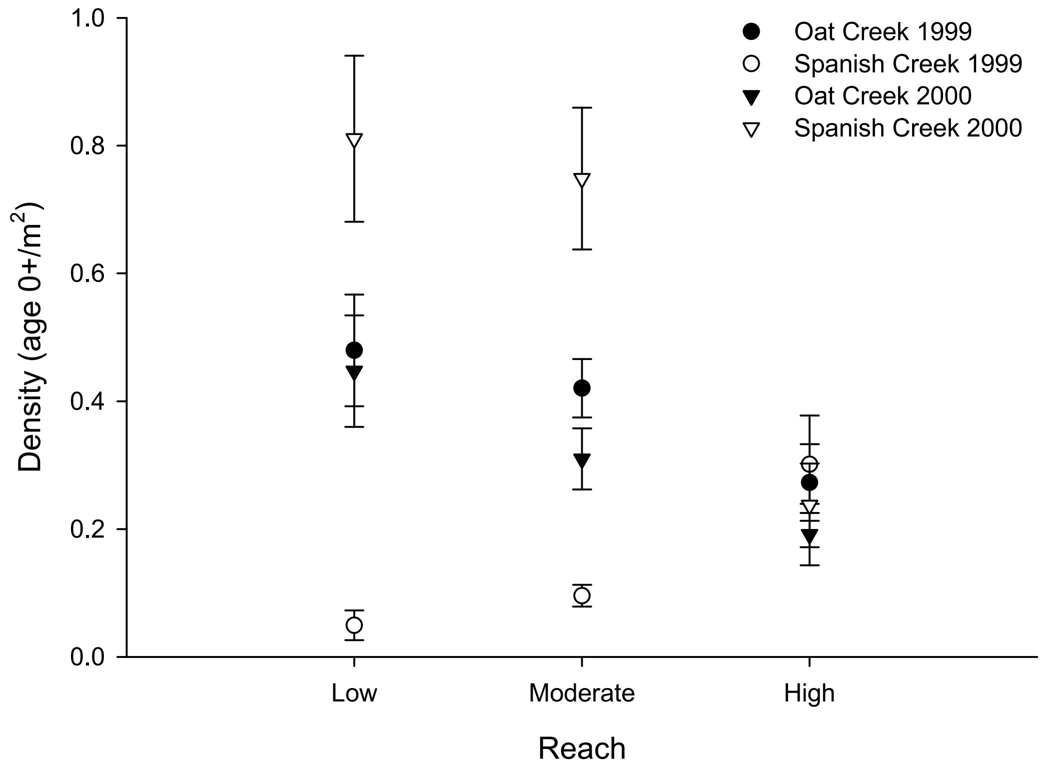


Figure 9. Mean density (number/m^2) of age 0+ juvenile steelhead trout within low, moderate, and high gradient reaches of Oat and Spanish Creeks during 1999 and 2000. Error bars are ± one standard error.

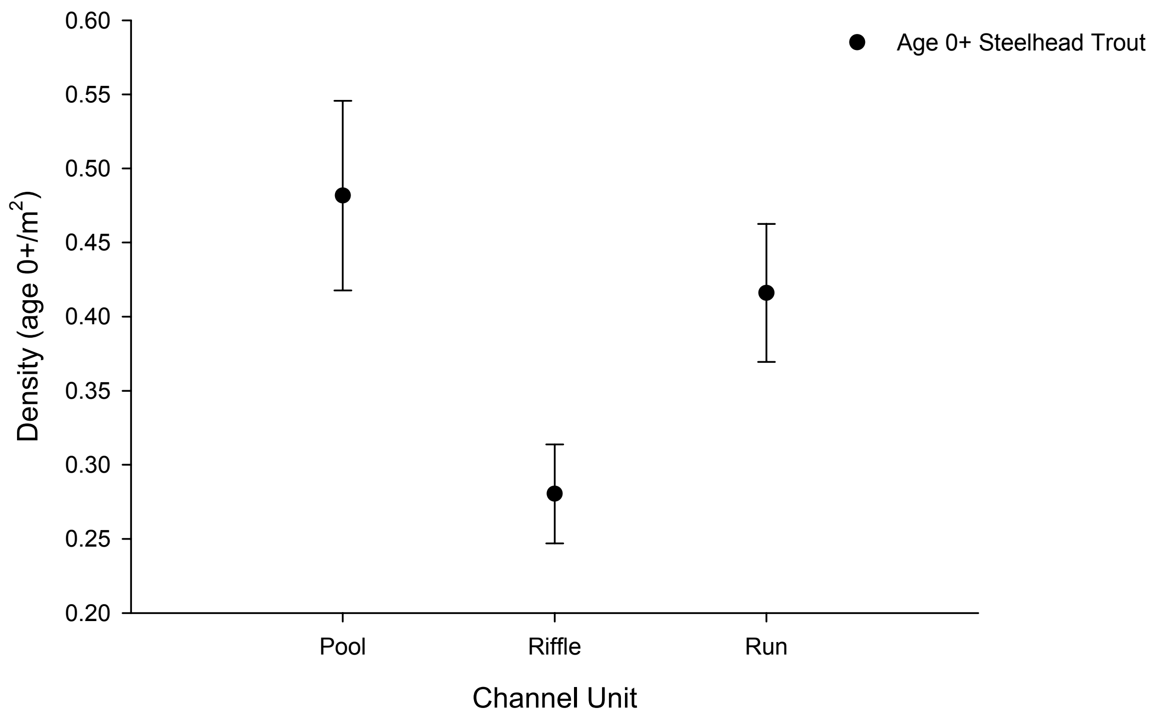


Figure 10. Mean density (number /m^2) of age 0+ juvenile steelhead trout within three channel unit types of Oat and Spanish creeks during 1999 and 2000. Error bars are ± one standard error.

Density of age 0+ juvenile steelhead trout also differed between the single factors Year ($F_{1,167}$= 14.51, P = 0.0002) and Reach ($F_{2,167}$= 7.46, P = 0.0008).

Difference in density of post-age 0+ juvenile steelhead trout among channel unit types was not independent of year or stream (Year x Stream x Channel Unit interaction $F_{2,167}$=2.97, P=0.0541, Table 20, Figure 11). Density of post-age 0+ juvenile steelhead trout differed among reaches ($F_{2,167}$=5.60, P=0.0044) however, with moderate reach density (0.23 SE=0.02) much larger than low and high reaches (0.16 fish/m^2 SE=0.03 and 0.14 fish/m^2 SE=0.02, respectively) . Density in the moderate gradient reach was significantly different than low gradient or high gradient reaches, while density in low and high gradient reaches was not significantly different (Ryan-Einot-Gabriel-Welsch Multiple Comparison Test, Figure 12). Density of post-age 0+ juvenile steelhead trout also differed between the single factors Stream ($F_{1,167}$= 10.36, P = 0.0015) and Channel Unit ($F_{2,167}$= 17.16, P < 0.0001).

Table 20. Effects of Year (1999, 2000), Stream (Oat Creek, Spanish Creek), Reach (low gradient, moderate gradient, high gradient), and Channel Unit (pool, riffle, run) on the density post-age 0+ juvenile steelhead trout in the King Range National Conservation Area, California.

Source	DF	SSQ	F-Value	P-value
Year	1	0.010	0.24	0.6221
Stream	1	0.451	10.36	0.0015
Reach	2	0.487	5.60	0.0044
Channel Unit	2	1.495	17.16	<0.0001
Year x Stream	1	0.406	9.33	0.0026
Year x Reach	2	0.145	1.67	0.1922
Year x Channel Unit	2	0.011	0.14	0.8721
Stream x Reach	2	0.039	0.46	0.6344
Stream x Channel Unit	2	0.088	1.02	0.3643
Reach x Channel Unit	4	0.216	1.24	0.2955
Year x Stream x Reach	2	0.017	0.20	0.8156
Year x Stream x Channel Unit	2	0.258	2.97	0.0541
Year x Reach x Channel Unit	4	0.122	0.70	0.5930
Stream x Reach x Channel Unit	4	0.064	0.37	0.8314
Year x Stream x Reach x Channel Unit	4	0.109	0.63	0.6422
Model	35	4.817	3.16	<0.0001
Error	167	7.278		
Corrected Total	202	12.095		

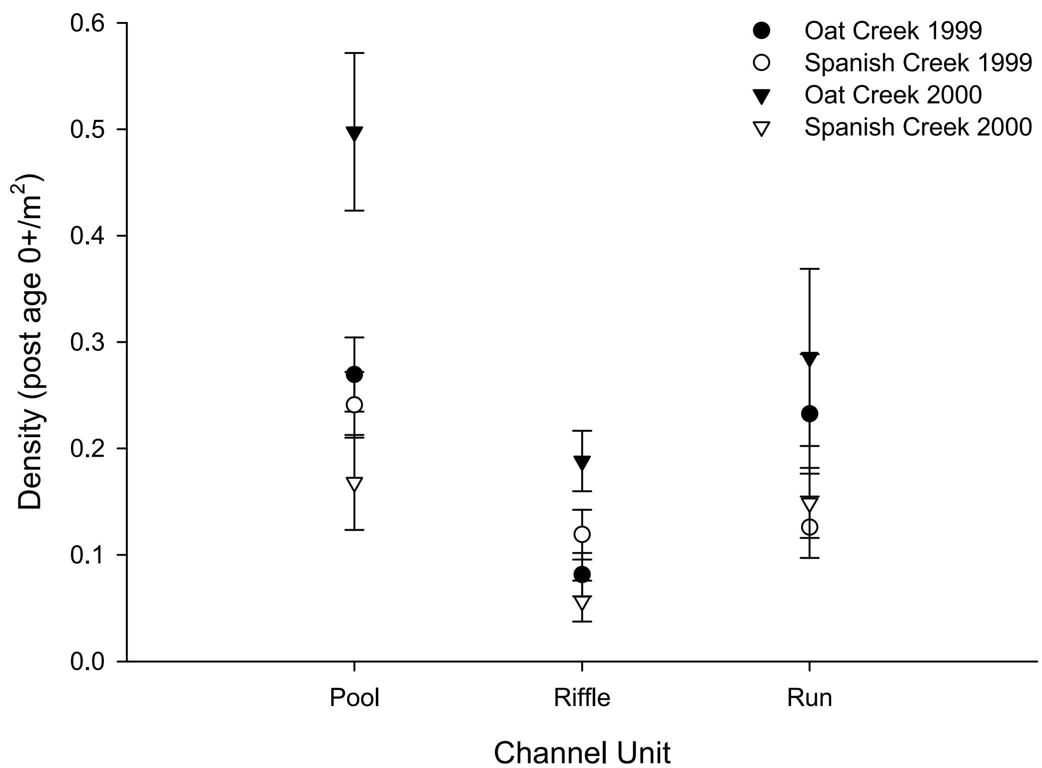


Figure 11. Mean density (number/m^2) of post-age 0+ juvenile steelhead trout within low, moderate, and high reach gradients in Oat and Spanish Creeks during 1999 and 2000. Error bars are ± one standard error.

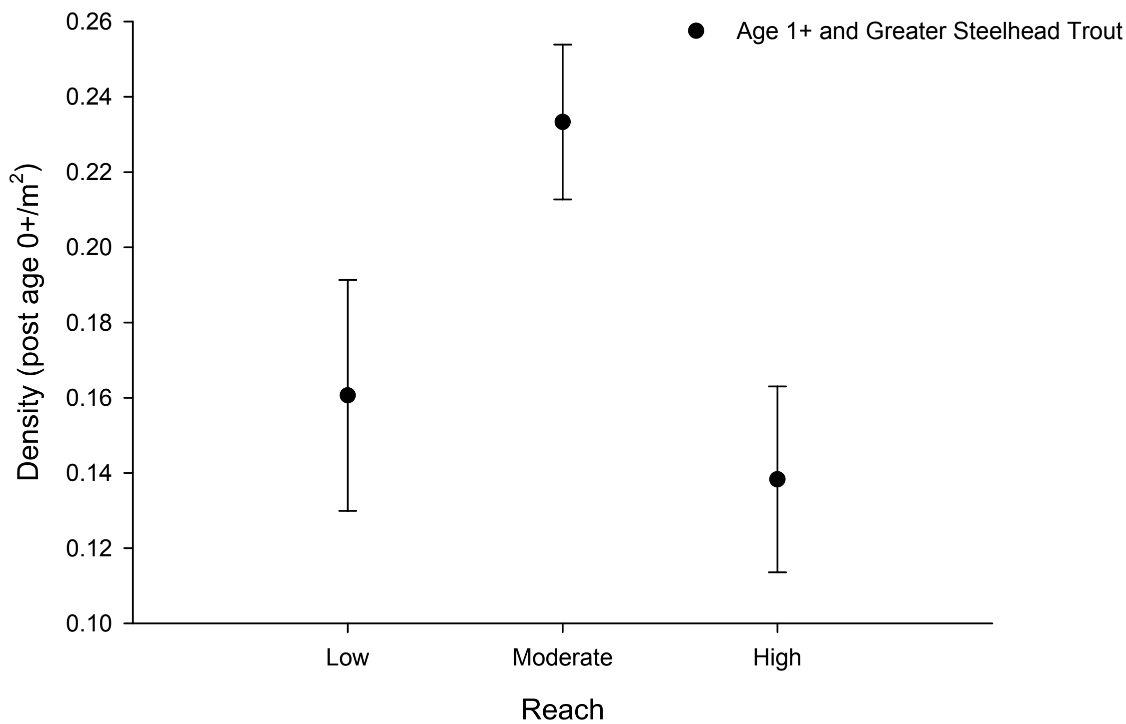


Figure 12. Mean density (number/m^2) of post-age 0+ juvenile steelhead trout within three channel unit types for Oat and Spanish Creeks during 1999 and 2000. Error bars are ± one standard error.

DISCUSSION

Channel unit compositions for all reach gradient types were very similar for both years of the study in Oat and Spanish creeks. In both streams, riffles represented a greater proportion of the total channel unit area in low gradient reaches than any other channel unit type. These data are consistent with data from streams in the east-central Sierra Nevada, where riffles predominated in low gradient reaches (Kershner et al. 1992). Runs were the second most common habitat unit type in streams within the King Range National Conservation Area, a pattern also reported by Kershner et al. (1992) in low gradient reaches of Sierra Nevada streams (Table 21). Cascade channel units made up 57-61% of the area of high gradient reaches in Oat and Spanish creeks during 1999, but only 32-40% of the area in 2000. This difference might have been caused by time of channel unit classification surveys or, more likely, by observer differences in determining cascade channel units.

The differences in channel unit composition between low, moderate, and high gradient reaches, particularly in small, high gradient streams such as Oat and Spanish creeks, could have a large effect on seasonal fish distribution. In the moderate gradient reaches of Oat and Spanish creeks, habitat unit types are more evenly represented and more deeper, slower velocity units such as pools and runs are present than in low or high gradient reaches. The increased amount of these deep, slower velocity units in the moderate reach could provide refuge for juvenile steelhead trout at decreasing water levels during late summer months. The spatial distribution of refugia from harsh environmental conditions could be a significant factor controlling fish population dynamics in headwater streams (Schlosser 1995).

My estimates of juvenile steelhead trout summer survival rates were confounded for Oat Creek in 1999 by sampling before the end of emergence which ends in July or early August. Estimated survival rates in every channel unit type of moderate and high gradient reaches exceeded 100%. During fall sampling, fork length of some juvenile steelhead trout were also smaller in these reaches than in the summer. This also suggests late emergence (Appendix D). Adult steelhead enter streams in the north coast of California any time from November through April (Barnhart 1986), and can spawn as late as June (Behnke 1992). I delayed summer sampling in 2000 to avoid collecting before the end of the emergence period. Late sampling dates should be considered when sampling juvenile steelhead trout populations.

Using later sampling dates produced more reliable survival estimates in 2000. Reach-scale survival rates were almost identical for Oat and Spanish Creeks, and highest in moderate reaches. These similarities occurred despite obvious differences in juvenile steelhead trout abundance, age class composition, and channel unit composition between the two streams. All of these factors that should affect summer survival.

Table 21. Channel unit composition of type A, B, and C channels (Rosgen 1996) from east-central Sierra Nevada, California streams compared with channel unit composition of low, moderate and high gradient reaches in streams from the King Range National Conservation Area, California. Data for Sierra Nevada streams are from Kershner et al. (1992).

Location	Classification	Channel or reach gradient (%)	Percentage composition riffle[1]	Percentage composition pool[1]	Percentage composition run[1]	Percentage composition cascade[1]
East central Sierra Nevada Mountains, California	Rosgen (1985) C channel reach	0.1-1.0	71.6	12.7	15.8	0.1
East central Sierra Nevada Mountains, California	Rosgen (1985) B channel reach	1.5-4.0	59.0	17.7	22.3	0.1
East central Sierra Nevada Mountains, California	Rosgen (1985) A channel reach	4.0-10.0	50.1	16.57	26.4	0.3
King Range National Conservation Area, California	Low gradient	0.0-5.0	62.9	7.2	26.7	3.2
King Range National Conservation Area, California	Moderate gradient	5.1-10.0	29.5	19.4	29.0	22.1
King Range National Conservation Area, California	High gradient	>10.0	14.6	19.1	24.1	42.2

[1] Mean percent composition of channel units in reaches for east central Sierra Nevada Mountains, California locations.

The very similar reach survival rates in Oat and Spanish Creeks during 2000 suggests a reach effect on the distribution of juvenile steelhead trout: either movement to the moderate gradient reach (particularly for post-age 0+) during summer months therefore increasing apparent survival rates in that reach, or that mortality in low gradient reaches is very high. Density of post-age 0+ juvenile steelhead trout was higher in moderate gradient reaches than in other reaches (Figure 12). This was not observed in age 0+ fish. Movement into moderate gradient reaches could have occurred for either age class prior to the fall sampling period. Baltz et al. (1991) found that age 0+ and 1+ rainbow trout in Rock Creek, California (Shasta County) occupied deeper habitats in fall (November) compared to summer, and suggested this movement was not related to flow. Others have found that larger fish select deeper habitats (Everest and Chapman 1972, Harvey and Stewart 1991). During summer months, age 0+ fish could move downstream into moderate gradient reaches from high gradient reaches, particularly after emergence and before territories have been established or possibly upstream from low gradient reaches. Small size may, however, limit upstream movements of age 0+ fish. Post-age 0+ juvenile steelhead trout could have moved into moderate gradient reaches from low gradient or high gradient reaches since body size and water velocity would not have limited their movement.

Juvenile steelhead trout in low gradient reaches may have suffered relatively high mortality. When considering apparent mortality (the actual numerical differences between summer and fall abundance estimates), 77.3% of the apparent total mortality in Spanish Creek and 69.8% of the apparent total mortality in Oat Creek occurred in the low gradient reach during 2000. Juvenile steelhead trout might have been exposed to more predation in the low gradient reach, in comparison to other reaches. Several predators of juvenile steelhead trout were observed in the low gradient reaches. Pacific giant salamanders (*Dicamptodon tenebrosus*) and garter snakes (*Thamnophis siritalis*) were observed frequently in the low gradient reaches of both streams as were coastrange sculpin (*Cottus aleuticus*), which were confined to the low gradient reaches of both streams.

Summer survival rates for specific age classes differed between Oat and Spanish Creeks, possibly due to intra-specific competition. When examining the entire population of juvenile steelhead trout in Spanish Creek, the age class proportion of 0+ juvenile steelhead trout was large, around 85%, and decreased slightly between sampling periods. Survival of age 0+ juvenile steelhead trout was 10% less than post-age 0+. In Oat Creek, the opposite trend was observed between sampling periods with age 0+ survival 7% higher than post-age 0+ survival. This suggests either more competition or higher predation of post-age 0+ juvenile steelhead trout in Oat Creek. Harvey and Nakamoto (1997) found that growth of larger, age 1+ steelhead trout was greater in the presence of age 0+ steelhead than in the presence of an equal biomass of age 1+ steelhead alone in deep stream sections over a 6-week period. In shallow stream sections over the same period, growth of larger, age 1+ fish was lower in the presence of age 0+

fish. Survival of age 1+ steelhead during this 6-week period was high in both treatments. Both Oat and Spanish Creeks are high gradient and lack large, deep pools that are critical habitat for older, larger salmonids, but have plentiful shallow riffle habitat that age 0+ juvenile steelhead trout could inhabit. Increased competition between age 0+ juvenile steelhead trout in Spanish Creek and between age 0+ and post-age 0+ juvenile steelhead trout in Oat Creek during 2000 might have decreased survival rates in those streams.

The principal findings of this study were that reach gradient and channel unit type were important factors in determining distribution of juvenile steelhead trout in coastal streams. Post-age 0+ juvenile steelhead trout densities were higher in moderate gradient reaches in comparison to low or high gradient reaches. This supports the contention that density of larger salmonids is affected by stream slope. Isaak and Hubert (2000) found that trout (primarily cutthroat trout, *Oncorhynchus clarki*) biomass in several streams in Wyoming and Idaho sampled during late summer was unaffected by stream slope. They used a paired reach sampling design, but when analyzing trout density and population length structure, stream slope did have an effect. In addition, the results of my study also suggest that with increasing gradient there is not a decrease in density of post-age 0+ trout, as was found by Kennedy and Strange (1982) and Moore and Gregory (1989) using different methods and analyses.

The significant three-way interactions relating to juvenile steelhead trout density were not unexpected for both age class data sets. Considering the two common factors in both age classes' significant interaction, Year and Stream, differences would be expected, particularly considering the fluctuating population dynamics of steelhead in coastal streams (Shapovalov and Taft 1954, Burns 1971, Ward and Slaney 1988). For age 0+ fish, a significant year x stream x reach interaction was most likely due to the large differences in abundance between years. The distribution of spawning adult steelhead or resident rainbow trout could have determined the distribution of age 0+ juvenile steelhead during 1999 and 2000. Reach abundance estimates clearly differed between years, particularly in Spanish Creek. For the post-age 0+ fish, fluctuations between years should not be large considering the relatively small amount of deeper, preferable channel units, such as pools and runs, in limited supply in both streams, but more so in Spanish Creek. The significant three factor interaction of year x stream x channel unit is interesting since presumably certain channel unit types, pools and runs as an example, would consistently hold increased densities of post-age 0+ steelhead trout due to their depth during the fall. Instead, densities of post-age 0+ juvenile steelhead trout differed in relation to channel units by stream and by year during the fall.

In conclusion, this study contributes to knowledge of reach-scale preferences of juvenile salmonids based on gradient and presents summer survival data of juvenile steelhead trout in small coastal streams. Additionally, the results of this study present an overlooked aspect of a basin, the occurrence of certain channel units by reach gradient. With further research into the occurrence of certain channel units by gradient, fisheries managers could identify critical areas used by species of concern for protection.

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Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California. Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Spanish	Summer	Low	6	Pool	5.9	15.1	0.0%	100.0%	3	0			3.0
1999	Spanish	Summer	Low	7	Riffle	23.9	73.3	0.0%	0.0%	0	0			0.0
1999	Spanish	Summer	Low	10	Run	13.5	34.2	50.0%	50.0%	1	1			2.0
1999	Spanish	Summer	Low	15	Riffle	40.8	110.2	66.7%	33.3%	2	1			4.0
1999	Spanish	Summer	Low	22	Run	6.5	21.2	33.3%	66.7%	3	0			3.0
1999	Spanish	Summer	Low	25	Riffle	15.6	45.8	0.0%	100.0%	9	1			10.1
1999	Spanish	Summer	Low	34	Riffle	7.2	26.9	100.0%	0.0%	4	0			4.0
1999	Spanish	Summer	Low	41	Cascade	8.7	32.2	0.0%	100.0%	5	0			5.0
1999	Spanish	Summer	Low	44	Riffle	12.8	56.3	30.0%	70.0%	9	1			10.1
1999	Spanish	Summer	Low	48	Run	13.4	39.3	37.5%	62.5%	7	1			8.2
1999	Spanish	Summer	Low	53	Riffle	17.7	87.3	55.6%	44.4%	10	1			11.1
1999	Spanish	Summer	Low	61	Riffle	4.5	13.8	0.0%	100.0%	2	0			2.0
1999	Spanish	Summer	Low	62	Run	2.8	6.4	66.7%	33.3%	1	2			3.0
1999	Spanish	Summer	Low	68	Pool	3.9	11.1	0.0%	100.0%	4	1			5.3
1999	Spanish	Summer	Low	73	Riffle	10.4	32.9	83.3%	16.7%	4	2			8.0
1999	Spanish	Summer	Moderate	74	Run	5.1	12.6	20.0%	80.0%	3	2			9.0
1999	Spanish	Summer	Moderate	75	Riffle	7.6	20.5	50.0%	50.0%	4	0			4.0
1999	Spanish	Summer	Moderate	77.1	Cascade	9.9	23.4	50.0%	50.0%	1	1			2.0
1999	Spanish	Summer	Moderate	77.2	Pool	4.4	9.1	50.0%	50.0%	3	1			4.5
1999	Spanish	Summer	Moderate	82	Run	14.1	39.0	60.0%	40.0%	9	1			10.1
1999	Spanish	Summer	Moderate	85	Riffle	13.1	33.2	0.0%	100.0%	4	1			5.3
1999	Spanish	Summer	Moderate	90	Run	25.1	73.6	20.0%	80.0%	10	0			10.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Spanish	Summer	Moderate	93	Riffle	10.1	25.6	60.0%	40.0%	5	0			5.0
1999	Spanish	Summer	Moderate	98	Run	4.2	12.7	0.0%	100.0%	1	0			1.0
1999	Spanish	Summer	Moderate	99	Cascade	4.6	11.0	0.0%	100.0%	4	0			4.0
1999	Spanish	Summer	Moderate	102	Riffle	8.6	18.1	0.0%	0.0%	0	1			1.0
1999	Spanish	Summer	Moderate	110	Riffle	8.1	30.5	50.0%	50.0%	8	4			16.0
1999	Spanish	Summer	Moderate	111	Pool	5.0	17.8	0.0%	100.0%	2	0			2.0
1999	Spanish	Summer	Moderate	114	Cascade	7.3	24.1	16.7%	83.3%	12	0			12.0
1999	Spanish	Summer	Moderate	118.1	Cascade	16.8	40.9	37.5%	62.5%	8	0			8.0
1999	Spanish	Summer	Moderate	119	Pool	3.3	9.4	0.0%	100.0%	1	0			1.0
1999	Spanish	Summer	Moderate	125	Run	16.6	40.4	28.6%	71.4%	13	1			14.1
1999	Spanish	Summer	Moderate	126	Riffle	15.6	36.9	14.3%	85.7%	9	5			20.3
1999	Spanish	Summer	Moderate	134	Run	5.7	10.6	0.0%	100.0%	1	0			1.0
1999	Spanish	Summer	Moderate	137	Riffle	33.2	71.9	37.5%	62.5%	7	1			8.2
1999	Spanish	Summer	Moderate	141	Run	5.6	13.3	33.3%	66.7%	6	0			6.0
1999	Spanish	Summer	Moderate	142	Cascade	7.1	21.1	0.0%	100.0%	1	0			1.0
1999	Spanish	Summer	Moderate	149	Cascade	7.7	21.0	0.0%	100.0%	5	0			5.0
1999	Spanish	Summer	Moderate	150	Pool	9.9	24.9	7.7%	92.3%	12	1			13.1
1999	Spanish	Summer	Moderate	153	Riffle	4.6	17.2	25.0%	75.0%	4	0			4.0
1999	Spanish	Summer	Moderate	160	Run	17.2	50.5	12.5%	87.5%	16	0			16.0
1999	Spanish	Summer	Moderate	164	Cascade	3.8	6.0	0.0%	0.0%	0	0			0.0
1999	Spanish	Summer	Moderate	165	Riffle	11.3	30.5	33.3%	66.7%	2	1			4.0
1999	Spanish	Summer	Moderate	176	Pool	3.3	7.6	14.3%	85.7%	5	2			8.3

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Spanish	Summer	Moderate	178	Cascade	8.9	22.5	28.6%	71.4%	5	2			8.3
1999	Spanish	Summer	High	182	Run	7.5	19.5	91.7%	8.3%	8	4			16.0
1999	Spanish	Summer	High	193	Pool	4.2	9.5	20.0%	80.0%	3	2			9.0
1999	Spanish	Summer	High	194	Riffle	5.6	12.3	66.7%	33.3%	2	1			4.0
1999	Spanish	Summer	High	199	Cascade	13.5	49.1	52.4%	47.6%	18	3			21.6
1999	Spanish	Summer	High	202	Run	10.6	23.7	50.0%	50.0%	12	2			14.4
1999	Spanish	Summer	High	204	Riffle	5.9	17.1	50.0%	50.0%	6	2			9.0
1999	Spanish	Summer	High	211	Cascade	3.8	12.2	50.0%	50.0%	2	2			4.0
1999	Spanish	Summer	High	215	Pool	2.5	3.4	0.0%	100.0%	2	0			2.0
1999	Spanish	Summer	High	222	Riffle	13.7	22.4	77.8%	22.2%	5	4			25.0
1999	Spanish	Summer	High	227	Cascade	26.3	83.3	66.7%	33.3%	4	2			8.0
1999	Spanish	Summer	High	228	Run	3.8	7.6	100.0%	0.0%	1	0			1.0
1999	Spanish	Summer	High	230	Pool	3.0	6.2	0.0%	100.0%	1	0			1.0
1999	Spanish	Summer	High	240	Cascade	27.8	135.3	0.0%	100.0%	1	0			1.0
1999	Spanish	Fall	Low	6	Pool	5.9	15.1	0.0%	100.0%	4	1			5.3
1999	Spanish	Fall	Low	7	Riffle	23.9	73.3	0.0%	100.0%	5	0			5.0
1999	Spanish	Fall	Low	10	Run	13.5	34.2	0.0%	100.0%	3	0			3.0
1999	Spanish	Fall	Low	15	Riffle	40.8	110.2			0	0			0.0
1999	Spanish	Fall	Low	22	Run	6.5	21.2	0.0%	100.0%	1	0			1.0
1999	Spanish	Fall	Low	25	Riffle	15.6	45.8	8.3%	91.7%	11	1			12.1
1999	Spanish	Fall	Low	34	Riffle	7.2	26.9	0.0%	100.0%	1	0			1.0
1999	Spanish	Fall	Low	41	Cascade	8.7	32.2	0.0%	100.0%	5	1			6.3

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Spanish	Fall	Low	44	Riffle	12.8	56.3	0.0%	100.0%	8	0			8.0
1999	Spanish	Fall	Low	48	Run	13.4	39.3	11.1%	88.9%	9	0			9.0
1999	Spanish	Fall	Low	53	Riffle	17.7	87.3	35.0%	65.0%	18	2			20.3
1999	Spanish	Fall	Low	61	Riffle	4.5	13.8	80.0%	20.0%	5	0			5.0
1999	Spanish	Fall	Low	62	Run	2.8	6.4			0	0			0.0
1999	Spanish	Fall	Low	68	Pool	3.9	11.1	33.3%	66.7%	6	0			6.0
1999	Spanish	Fall	Low	73	Riffle	10.4	32.9	100.0%	0.0%	3	0			3.0
1999	Spanish	Fall	Moderate	74	Run	5.1	12.6	0.0%	100.0%	3	0			3.0
1999	Spanish	Fall	Moderate	75	Riffle	7.6	20.5	33.3%	66.7%	3	0			3.0
1999	Spanish	Fall	Moderate	77.1	Cascade	9.9	23.4	0.0%	100.0%	1	0			1.0
1999	Spanish	Fall	Moderate	77.2	Pool	4.4	9.1	60.0%	40.0%	5	0			5.0
1999	Spanish	Fall	Moderate	82	Run	14.1	39.0	50.0%	50.0%	3	2	1		7.6
1999	Spanish	Fall	Moderate	83	Riffle	13.1	33.2	20.0%	80.0%	5	0			5.0
1999	Spanish	Fall	Moderate	90	Run	25.1	73.6	0.0%	100.0%	2	1	0		3.1
1999	Spanish	Fall	Moderate	93	Riffle	10.1	25.6	37.5%	62.5%	7	1			8.2
1999	Spanish	Fall	Moderate	98	Run	4.2	12.7			0	0			0.0
1999	Spanish	Fall	Moderate	99	Cascade	4.6	11.0	25.0%	75.0%	4	0			4.0
1999	Spanish	Fall	Moderate	102	Riffle	8.6	18.1	66.7%	33.3%	3	0			3.0
1999	Spanish	Fall	Moderate	110	Riffle	8.1	30.5	25.0%	75.0%	6	3			12.0
1999	Spanish	Fall	Moderate	111	Pool	5.0	17.8	50.0%	50.0%	6	0			6.0
1999	Spanish	Fall	Moderate	114	Cascade	7.3	24.1	70.0%	30.0%	8	2			10.7
1999	Spanish	Fall	Moderate	118.1	Cascade	16.8	40.9	57.1%	42.9%	7	0			7.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Spanish	Fall	Moderate	119	Pool	3.3	9.4	50.0%	50.0%	1	0			1.0
1999	Spanish	Fall	Moderate	125	Run	16.6	40.4	41.7%	58.3%	7	3	2		13.9
1999	Spanish	Fall	Moderate	126	Riffle	15.6	36.9	11.8%	88.2%	11	5	1		17.8
1999	Spanish	Fall	Moderate	134	Run	5.7	10.6	50.0%	50.0%	2	0			2.0
1999	Spanish	Fall	Moderate	137	Riffle	33.2	71.9	60.0%	40.0%	5	0			5.0
1999	Spanish	Fall	Moderate	141	Run	5.6	13.3	40.0%	60.0%	2	2	1		8.3
1999	Spanish	Fall	Moderate	142	Cascade	7.1	21.1	40.0%	60.0%	5	0			5.0
1999	Spanish	Fall	Moderate	149	Cascade	7.7	21.0	0.0%	100.0%	2	1			4.0
1999	Spanish	Fall	Moderate	150	Pool	9.9	24.9	11.1%	88.9%	8	1			9.1
1999	Spanish	Fall	Moderate	153	Riffle	4.6	17.2	50.0%	50.0%	4	0			4.0
1999	Spanish	Fall	Moderate	160	Run	17.2	50.5	31.3%	68.8%	13	3			16.9
1999	Spanish	Fall	Moderate	164	Cascade	3.8	6.0			0	0			0.0
1999	Spanish	Fall	Moderate	165	Riffle	11.3	30.5	50.0%	50.0%	4	0			4.0
1999	Spanish	Fall	Moderate	176	Pool	3.3	7.6	33.3%	66.7%	3	0			3.0
1999	Spanish	Fall	Moderate	178	Cascade	8.9	22.5	25.0%	75.0%	4	0			4.0
1999	Spanish	Fall	High	182	Run	7.5	19.5	90.9%	9.1%	8	3			12.8
1999	Spanish	Fall	High	193	Pool	4.2	9.5	33.3%	66.7%	3	0			3.0
1999	Spanish	Fall	High	194	Riffle	5.6	12.3	50.0%	50.0%	1	1	0		2.2
1999	Spanish	Fall	High	199	Cascade	13.5	49.1	65.0%	35.0%	15	5	0		20.2
1999	Spanish	Fall	High	202	Run	10.6	23.7	64.3%	35.7%	10	4	0		14.2
1999	Spanish	Fall	High	204	Riffle	5.9	17.1	80.0%	20.0%	8	2			10.7
1999	Spanish	Fall	High	211	Cascade	3.8	12.2	100.0%	0.0%	5	0			5.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Spanish	Fall	High	215	Pool	2.5	3.4	66.7%	33.3%	3	0			3.0
1999	Spanish	Fall	High	222	Riffle	13.7	22.4	85.7%	14.3%	5	2			8.3
1999	Spanish	Fall	High	227	Cascade	26.3	83.3	100.0%	0.0%	2	0			2.0
1999	Spanish	Fall	High	228	Run	3.8	7.6	100.0%	0.0%	1	0			1.0
1999	Spanish	Fall	High	230	Pool	3.0	6.2	0.0%	100.0%	1	0			1.0
1999	Spanish	Fall	High	240	Cascade	27.8	135.3			0	0			0.0
1999	Oat	Summer	Low	7	Riffle	6.2	17.6	50.0%	50.0%	9	1			10.1
1999	Oat	Summer	Low	12.11	Riffle	6.2	10.3	100.0%	0.0%	6	2			9.0
1999	Oat	Summer	Low	12.12	Pool	7.3	12.2	78.9%	21.1%	16	3			19.7
1999	Oat	Summer	Low	15	Run	3.2	5.5	71.4%	28.6%	6	1			7.2
1999	Oat	Summer	Low	16	Cascade	7.1	18.5	63.6%	36.4%	11	2			13.4
1999	Oat	Summer	Low	21	Pool	4.1	13.0	20.0%	80.0%	4	1			5.3
1999	Oat	Summer	Low	29	Riffle	14.0	63.0	90.2%	9.8%	49	13			66.7
1999	Oat	Summer	Low	33	Run	4.4	10.0	100.0%	0.0%	3	1			4.5
1999	Oat	Summer	Low	38	Riffle	14.4	36.0	84.6%	15.4%	11	2			13.4
1999	Oat	Summer	Low	43	Riffle	7.0	18.7	75.0%	25.0%	5	3			12.5
1999	Oat	Summer	Low	47	Pool	3.2	8.4	60.0%	40.0%	4	1			5.3
1999	Oat	Summer	Low	51	Run	12.3	38.5	86.4%	13.6%	16	6			25.6
1999	Oat	Summer	Low	52	Riffle	5.5	16.3	80.0%	20.0%	8	2			10.7
1999	Oat	Summer	Moderate	61	Run	7.3	23.1	90.9%	9.1%	10	1			11.1
1999	Oat	Summer	Moderate	64	Riffle	5.0	15.8	100.0%	0.0%	5	0			5.0
1999	Oat	Summer	Moderate	66	Pool	5.2	7.1	100.0%	0.0%	1	1	0		2.2

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Oat	Summer	Moderate	73	Run	6.7	24.1	88.9%	11.1%	8	1			9.1
1999	Oat	Summer	Moderate	74	Riffle	7.2	21.1	57.1%	42.9%	7	0			7.0
1999	Oat	Summer	Moderate	82	Pool	3.1	5.7	66.7%	33.3%	5	1			6.3
1999	Oat	Summer	Moderate	86	Run	4.5	10.5	75.0%	25.0%	4	4	0		8.7
1999	Oat	Summer	Moderate	87	Riffle	8.1	22.7	72.2%	27.8%	15	3			18.8
1999	Oat	Summer	Moderate	89	Cascade	6.3	14.9	55.6%	44.4%	9	0			9.0
1999	Oat	Summer	Moderate	100	Pool	4.4	15.7	60.0%	40.0%	5	0			5.0
1999	Oat	Summer	Moderate	104	Riffle	8.0	21.9	44.4%	55.6%	8	1			9.1
1999	Oat	Summer	Moderate	105	Run	4.3	8.9	62.5%	37.5%	7	1			8.2
1999	Oat	Summer	Moderate	108	Cascade	5.8	24.6	50.0%	50.0%	4	0			4.0
1999	Oat	Summer	Moderate	116	Pool	12.0	34.2	94.4%	5.6%	13	5			21.1
1999	Oat	Summer	Moderate	118	Cascade	12.5	44.6	77.8%	22.2%	14	4			19.6
1999	Oat	Summer	Moderate	122	Run	5.2	14.0	33.3%	66.7%	5	1			6.3
1999	Oat	Summer	Moderate	129	Riffle	5.5	14.9	50.0%	50.0%	4	0			4.0
1999	Oat	Summer	Moderate	136	Pool	5.6	16.8	71.4%	28.6%	7	0			7.0
1999	Oat	Summer	Moderate	144	Run	8.0	16.0	85.7%	14.3%	4	3	0		7.4
1999	Oat	Summer	Moderate	148	Pool	5.1	13.9	70.0%	30.0%	7	3			12.3
1999	Oat	Summer	Moderate	158	Cascade	12.1	38.3	25.0%	75.0%	8	0			8.0
1999	Oat	Summer	Moderate	160	Riffle	5.3	12.9	80.0%	20.0%	4	1			5.3
1999	Oat	Summer	Moderate	165	Run	5.9	14.4	40.0%	60.0%	10	0			10.0
1999	Oat	Summer	Moderate	170	Pool	3.7	9.4	33.3%	66.7%	3	0			3.0
1999	Oat	Summer	Moderate	177	Cascade	8.2	40.7	66.7%	33.3%	5	1			6.3

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Oat	Summer	Moderate	180	Run	7.9	16.9	75.0%	25.0%	10	2			12.5
1999	Oat	Summer	Moderate	184	Pool	4.0	12.0	55.6%	44.4%	7	2			9.8
1999	Oat	Summer	Moderate	188	Riffle	3.9	11.6	33.3%	66.7%	3	0			3.0
1999	Oat	Summer	Moderate	190	Cascade	6.8	11.3	33.3%	66.7%	5	1			6.3
1999	Oat	Summer	Moderate	192	Run	7.1	21.1	50.0%	50.0%	7	3			12.3
1999	Oat	Summer	Moderate	204	Cascade	9.6	29.1	50.0%	50.0%	4	0			4.0
1999	Oat	Summer	Moderate	209	Riffle	4.6	10.7	50.0%	50.0%	3	1			4.5
1999	Oat	Summer	Moderate	210	Run	5.0	13.3	0.0%	100.0%	3	0			3.0
1999	Oat	Summer	Moderate	212	Pool	8.3	23.1	33.3%	66.7%	5	1			6.3
1999	Oat	Summer	Moderate	221	Cascade	3.9	8.5			0	0			0.0
1999	Oat	Summer	Moderate	222	Pool	4.7	13.8	75.0%	25.0%	3	1			4.5
1999	Oat	Summer	Moderate	223	Cascade	8.0	34.9	75.0%	25.0%	4	0			4.0
1999	Oat	Summer	Moderate	236	Run	5.8	15.7	42.9%	57.1%	6	1			7.2
1999	Oat	Summer	Moderate	237	Pool	3.2	4.6	50.0%	50.0%	2	0			2.0
1999	Oat	Summer	Moderate	244	Cascade	17.8	51.0	40.0%	60.0%	4	1			5.3
1999	Oat	Summer	Moderate	247	Riffle	5.5	18.2	80.0%	20.0%	5	0			5.0
1999	Oat	Summer	Moderate	248	Pool	3.8	12.9	62.5%	37.5%	5	3			12.5
1999	Oat	Summer	High	253	Run	5.7	8.6	33.3%	66.7%	3	0			3.0
1999	Oat	Summer	High	254	Pool	3.9	10.1	0.0%	100.0%	2	0			2.0
1999	Oat	Summer	High	261.1	Run	4.1	5.9	75.0%	25.0%	4	0			4.0
1999	Oat	Summer	High	261.11	Cascade	3.4	8.2	100.0%	0.0%	1	0			1.0
1999	Oat	Summer	High	263	Riffle	11.0	30.8	60.0%	40.0%	4	1			5.3

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Oat	Summer	High	268	Pool	6.2	20.9	27.3%	72.7%	6	4	1		12.3
1999	Oat	Summer	High	274	Run	8.1	22.1	33.3%	66.7%	5	1			6.3
1999	Oat	Summer	High	276	Pool	5.0	15.3	37.5%	62.5%	5	2	1		8.7
1999	Oat	Summer	High	277	Cascade	32.0	69.3	22.2%	77.8%	8	1			9.1
1999	Oat	Summer	High	288	Riffle	6.1	13.0			0	0			0.0
1999	Oat	Summer	High	289	Cascade	7.9	19.5			0	0			0.0
1999	Oat	Fall	Low	7	Riffle	6.2	17.6	71.4%	28.6%	7	0			7.0
1999	Oat	Fall	Low	12.11	Riffle	6.2	10.3	100.0%	0.0%	4	0			4.0
1999	Oat	Fall	Low	12.12	Pool	7.3	12.2	71.4%	28.6%	16	5	0		21.2
1999	Oat	Fall	Low	15	Run	3.2	5.5	57.1%	42.9%	7	0			7.0
1999	Oat	Fall	Low	16	Cascade	7.1	18.5	50.0%	50.0%	5	1			6.3
1999	Oat	Fall	Low	21	Pool	4.1	13.0	66.7%	33.3%	3	0			3.0
1999	Oat	Fall	Low	29	Riffle	14.0	63.0	94.0%	6.0%	45	5			50.6
1999	Oat	Fall	Low	33	Run	4.4	10.0	66.7%	33.3%	5	1			6.3
1999	Oat	Fall	Low	38	Riffle	14.4	36.0	80.0%	20.0%	10	0			10.0
1999	Oat	Fall	Low	43	Riffle	7.0	18.7	75.0%	25.0%	5	2	1		8.7
1999	Oat	Fall	Low	47	Pool	3.2	8.4	60.0%	40.0%	5	0			5.0
1999	Oat	Fall	Low	51	Run	12.3	38.5	85.0%	15.0%	14	0			14.0
1999	Oat	Fall	Low	52	Riffle	5.5	16.3	100.0%	0.0%	6	2			9.0
1999	Oat	Fall	Moderate	61	Run	7.3	23.1	100.0%	0.0%	11	1			12.1
1999	Oat	Fall	Moderate	64	Riffle	5.0	15.8	100.0%	0.0%	7	3	0		10.2
1999	Oat	Fall	Moderate	66	Pool	5.2	7.1	60.0%	40.0%	4	1			5.3

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Oat	Fall	Moderate	73	Run	6.7	24.1	80.0%	20.0%	14	1			15.1
1999	Oat	Fall	Moderate	74	Riffle	7.2	21.1	66.7%	33.3%	11	1			12.1
1999	Oat	Fall	Moderate	82	Pool	3.1	5.7	85.7%	14.3%	5	2	0		7.1
1999	Oat	Fall	Moderate	86	Run	4.5	10.5	83.3%	16.7%	11	1			12.1
1999	Oat	Fall	Moderate	87	Riffle	8.1	22.7	100.0%	0.0%	14	3			17.8
1999	Oat	Fall	Moderate	89	Cascade	6.3	14.9	66.7%	33.3%	5	1			6.3
1999	Oat	Fall	Moderate	100	Pool	4.4	15.7	71.4%	28.6%	5	2	0		7.1
1999	Oat	Fall	Moderate	104	Riffle	8.0	21.9	75.0%	25.0%	7	1			8.2
1999	Oat	Fall	Moderate	105	Run	4.3	8.9	46.2%	53.8%	7	4	2		15.5
1999	Oat	Fall	Moderate	108	Cascade	5.8	24.6	83.3%	16.7%	6	0			6.0
1999	Oat	Fall	Moderate	116	Pool	12.0	34.2	94.7%	5.3%	16	3			19.7
1999	Oat	Fall	Moderate	118	Cascade	12.5	44.6	81.8%	18.2%	10	1			11.1
1999	Oat	Fall	Moderate	122	Run	5.2	14.0	0.0%	100.0%	2	0			2.0
1999	Oat	Fall	Moderate	129	Riffle	5.5	14.9	55.6%	44.4%	9	0			9.0
1999	Oat	Fall	Moderate	136	Pool	5.6	16.8	72.7%	27.3%	10	1			11.1
1999	Oat	Fall	Moderate	144	Run	8.0	16.0	100.0%	0.0%	4	1			5.3
1999	Oat	Fall	Moderate	148	Pool	5.1	13.9	69.2%	30.8%	11	2			13.4
1999	Oat	Fall	Moderate	158	Cascade	12.1	38.3	75.0%	25.0%	3	1			4.5
1999	Oat	Fall	Moderate	160	Riffle	5.3	12.9	66.7%	33.3%	4	2	0		6.2
1999	Oat	Fall	Moderate	165	Run	5.9	14.4	50.0%	50.0%	6	0			6.0
1999	Oat	Fall	Moderate	170	Pool	3.7	9.4	20.0%	80.0%	5	0			5.0
1999	Oat	Fall	Moderate	177	Cascade	8.2	40.7	66.7%	33.3%	8	1			9.1

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Oat	Fall	Moderate	180	Run	7.9	16.9	57.1%	42.9%	6	1			7.2
1999	Oat	Fall	Moderate	184	Pool	4.0	12.0	28.6%	71.4%	6	1			7.2
1999	Oat	Fall	Moderate	188	Riffle	3.9	11.6	50.0%	50.0%	3	1			4.5
1999	Oat	Fall	Moderate	190	Cascade	6.8	11.3	41.7%	58.3%	9	3			13.5
1999	Oat	Fall	Moderate	192	Run	7.1	21.1	57.1%	42.9%	20	1			21.1
1999	Oat	Fall	Moderate	204	Cascade	9.6	29.1	50.0%	50.0%	3	2	1		7.6
1999	Oat	Fall	Moderate	209	Riffle	4.6	10.7	100.0%	0.0%	1	0			1.0
1999	Oat	Fall	Moderate	210	Run	5.0	13.3	62.5%	37.5%	10	0			10.0
1999	Oat	Fall	Moderate	212	Pool	8.3	23.1	40.0%	60.0%	9	1			10.1
1999	Oat	Fall	Moderate	221	Cascade	3.9	8.5	100.0%	0.0%	3	0			3.0
1999	Oat	Fall	Moderate	222	Pool	4.7	13.8	75.0%	25.0%	8	0			8.0
1999	Oat	Fall	Moderate	223	Cascade	8.0	34.9	87.5%	12.5%	8	0			8.0
1999	Oat	Fall	Moderate	236	Run	5.8	15.7	55.6%	44.4%	7	2			9.8
1999	Oat	Fall	Moderate	237	Pool	3.2	4.6	33.3%	66.7%	3	0			3.0
1999	Oat	Fall	Moderate	244	Cascade	17.8	51.0	0.0%	100.0%	1	0			1.0
1999	Oat	Fall	Moderate	247	Riffle	5.5	18.2	50.0%	50.0%	4	0			4.0
1999	Oat	Fall	Moderate	248	Pool	3.8	12.9	81.8%	18.2%	11	0			11.0
1999	Oat	Fall	High	253	Run	5.7	8.6	100.0%	0.0%	3	0			3.0
1999	Oat	Fall	High	254	Pool	3.9	10.1	75.0%	25.0%	7	1			8.2
1999	Oat	Fall	High	261.1	Run	4.1	5.9	66.7%	33.3%	2	1	0		3.1
1999	Oat	Fall	High	261.11	Cascade	3.4	8.2	100.0%	0.0%	3	0			3.0
1999	Oat	Fall	High	263	Riffle	11.0	30.8	80.0%	20.0%	5	0			5.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
1999	Oat	Fall	High	268	Pool	6.2	20.9	35.3%	64.7%	15	2			17.3
1999	Oat	Fall	High	274	Run	8.1	22.1	55.6%	44.4%	7	2			9.8
1999	Oat	Fall	High	276	Pool	5.0	15.3	28.6%	71.4%	5	2	0		7.1
1999	Oat	Fall	High	277	Cascade	32.0	69.3	15.4%	84.6%	11	2			13.4
1999	Oat	Fall	High	288	Riffle	6.1	13.0	100.0%	0.0%	1	0			1.0
1999	Oat	Fall	High	289	Cascade	7.9	19.5	0.0%	0.0%	0	0			0.0
2000	Spanish	Summer	Low	3	Riffle	12.0	51.5	97.9%	2.1%	43	2			45.1
2000	Spanish	Summer	Low	6	Run	13.3	35.2	91.6%	8.4%	52	24	6		86.8
2000	Spanish	Summer	Low	13	Riffle	39.2	154.7	38.7%	61.3%	94	11			106.5
2000	Spanish	Summer	Low	18	Run	23.3	58.2	94.6%	5.4%	68	6			74.6
2000	Spanish	Summer	Low	23.1	Riffle	15.8	35.6	100.0%	0.0%	16	1			17.1
2000	Spanish	Summer	Low	28	Run	6.1	15.4	94.7%	5.3%	16	3			19.7
2000	Spanish	Summer	Low	35	Riffle	13.9	33.4	86.0%	14.0%	50	2			52.1
2000	Spanish	Summer	Low	39	Run	5.2	14.8	86.7%	13.3%	14	1			15.1
2000	Spanish	Summer	Low	39.1	Riffle	12.6	24.6	90.0%	10.0%	18	2			20.3
2000	Spanish	Summer	Low	40	Pool	3.2	8.4	57.1%	42.9%	18	3			21.6
2000	Spanish	Summer	Low	48	Pool	6.1	16.0	88.9%	11.1%	17	1			18.1
2000	Spanish	Summer	Low	50	Run	20.4	63.2	89.5%	10.5%	34	5			39.9
2000	Spanish	Summer	Moderate	53	Run	8.9	26.8	85.4%	14.6%	41	7			49.4
2000	Spanish	Summer	Moderate	58	Riffle	16.4	40.2	83.3%	16.7%	18	5	1		24.4
2000	Spanish	Summer	Moderate	61	Pool	23.1	82.0	77.0%	23.0%	50	11			64.1
2000	Spanish	Summer	Moderate	63	Run	11.9	30.4	100.0%	0.0%	32	7			41.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Spanish	Summer	Moderate	68	Riffle	4.1	13.0	90.0%	10.0%	10	0			10.0
2000	Spanish	Summer	Moderate	71	Run	9.7	25.8	95.8%	4.2%	21	3			24.5
2000	Spanish	Summer	Moderate	76	Pool	4.2	9.1	87.1%	12.9%	28	3			31.4
2000	Spanish	Summer	Moderate	78	Riffle	9.9	34.6	87.0%	13.0%	37	5			42.8
2000	Spanish	Summer	Moderate	81	Run	13.8	35.2	98.3%	1.7%	43	11	5	0	60.8
2000	Spanish	Summer	Moderate	84	Cascade	3.9	4.9	40.0%	60.0%	8	2			10.7
2000	Spanish	Summer	Moderate	87	Riffle	8.1	22.4	100.0%	0.0%	24	3			27.4
2000	Spanish	Summer	Moderate	88	Pool	9.3	27.4	71.4%	28.6%	31	4			35.6
2000	Spanish	Summer	Moderate	88.2	Pool	3.5	5.3	90.9%	9.1%	10	1			11.1
2000	Spanish	Summer	Moderate	98	Riffle	8.0	16.7	78.9%	21.1%	18	1			19.1
2000	Spanish	Summer	Moderate	101	Run	5.6	11.7	75.0%	25.0%	11	1			12.1
2000	Spanish	Summer	Moderate	105	Cascade	1.7	4.5	50.0%	50.0%	2	0			2.0
2000	Spanish	Summer	Moderate	108	Pool	6.0	13.5	76.5%	23.5%	15	2			17.3
2000	Spanish	Summer	Moderate	111	Riffle	8.0	21.1	100.0%	0.0%	4	0			4.0
2000	Spanish	Summer	Moderate	114	Run	19.1	51.7	75.0%	25.0%	18	2			20.3
2000	Spanish	Summer	Moderate	116.1	Riffle	15.2	28.9	100.0%	0.0%	21	5			27.6
2000	Spanish	Summer	Moderate	120	Run	8.7	26.4	84.6%	15.4%	12	1			13.1
2000	Spanish	Summer	Moderate	129.2	Pool	3.1	6.5	100.0%	0.0%	9	1			10.1
2000	Spanish	Summer	Moderate	131	Run	6.7	11.1	85.7%	14.3%	12	1			13.1
2000	Spanish	Summer	Moderate	132	Riffle	11.7	22.9	81.0%	19.0%	19	2			21.2
2000	Spanish	Summer	Moderate	138	Run	4.1	5.7	80.0%	20.0%	4	1			5.3
2000	Spanish	Summer	Moderate	142	Riffle	4.2	8.0	80.0%	20.0%	4	1			5.3

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E[1]	E[2]	E[3]	E[4]	Unit Estimate
2000	Spanish	Summer	Moderate	151	Run	14.1	21.9	20.0%	80.0%	13	2			15.4
2000	Spanish	Summer	Moderate	155	Riffle	4.1	7.5	100.0%	0.0%	11	0			11.0
2000	Spanish	Summer	Moderate	161	Riffle	10.2	17.8	100.0%	0.0%	1	2	0		3.8
2000	Spanish	Summer	Moderate	162	Run	10.5	16.8	37.5%	62.5%	16	0			16.0
2000	Spanish	Summer	Moderate	164	Pool	4.9	14.2	62.5%	37.5%	8	0			8.0
2000	Spanish	Summer	Moderate	168		2.2	2.9	0.0%	0.0%	0	0			0
2000	Spanish	Summer	Moderate	173	Run	11.3	19.8	38.9%	61.1%	18	0			18.0
2000	Spanish	Summer	Moderate	177	Riffle	4.1	10.7	100.0%	0.0%	5	0			5.0
2000	Spanish	Summer	High	182	Run	19.8	70.2	33.3%	66.7%	15	0			15.0
2000	Spanish	Summer	High	186	Pool	4.4	12.7	53.8%	46.2%	12	1			13.1
2000	Spanish	Summer	High	188	Riffle	9.3	18.0	44.4%	55.6%	8	1			9.1
2000	Spanish	Summer	High	196	Pool	3.8	11.5	28.6%	71.4%	7	0			7.0
2000	Spanish	Summer	High	197	Run	3.1	5.5	66.7%	33.3%	3	0			3.0
2000	Spanish	Summer	High	208	Run	7.1	18.4	75.0%	25.0%	8	0			8.0
2000	Spanish	Summer	High	213	Riffle	4.2	6.6	100.0%	0.0%	3	0			3.0
2000	Spanish	Summer	High	214		5.8	12.5	0.0%	0.0%	0	0			0
2000	Spanish	Summer	High	223	Pool	3.6	8.2	50.0%	50.0%	3	1	0		4.0
2000	Spanish	Summer	High	226	Riffle	2.8	4.8	100.0%	0.0%	1	0			1.0
2000	Spanish	Summer	High	232	Run	7.0	15.1	50.0%	50.0%	2	0			2.0
2000	Spanish	Summer	High	236	Cascade	6.9	14.8	50.0%	50.0%	3	1	0		4.0
2000	Spanish	Summer	High	240	Pool	3.9	8.9	100.0%	0.0%	2	0			2.0
2000	Spanish	Summer	High	241	Riffle	3.0	4.2	0.0%	100.0%	2	0			2.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Spanish	Summer	High	250		4.5	10.5	0.0%	0.0%	0	0			0
2000	Spanish	Fall	Low	3	Riffle	12.0	51.5	94.1%	5.9%	12	4	1		17.5
2000	Spanish	Fall	Low	6	Run	13.3	35.2	88.1%	11.9%	35	7			43.8
2000	Spanish	Fall	Low	13	Riffle	39.2	154.7	92.6%	7.4%	26	1			27.0
2000	Spanish	Fall	Low	18	Run	23.3	58.2	93.9%	6.1%	27	6			34.7
2000	Spanish	Fall	Low	23.1	Riffle	15.8	35.6	100.0%	0.0%	17	1			18.1
2000	Spanish	Fall	Low	28	Run	6.1	15.4	94.1%	5.9%	15	2			17.3
2000	Spanish	Fall	Low	35	Riffle	13.9	33.4	95.2%	4.8%	41	4			45.4
2000	Spanish	Fall	Low	39	Run	5.2	14.8	83.3%	16.7%	11	1			12.1
2000	Spanish	Fall	Low	39.1	Riffle	12.6	24.6	100.0%	0.0%	15	3			18.8
2000	Spanish	Fall	Low	40	Pool	3.2	8.4	87.5%	12.5%	14	2			16.3
2000	Spanish	Fall	Low	48	Pool	6.1	16.0	100.0%	0.0%	17	1			18.1
2000	Spanish	Fall	Low	50	Run	20.4	63.2	93.3%	6.7%	26	4			30.7
2000	Spanish	Fall	Moderate	53	Run	8.9	26.8	92.9%	7.1%	42	12	2		56.9
2000	Spanish	Fall	Moderate	58	Riffle	16.4	40.2	93.9%	6.1%	31	3			34.3
2000	Spanish	Fall	Moderate	61	Pool	23.1	82.0	86.3%	13.7%	56	17			80.4
2000	Spanish	Fall	Moderate	63	Run	11.9	30.4	100.0%	0.0%	33	4			37.6
2000	Spanish	Fall	Moderate	68	Riffle	4.1	13.0	66.7%	33.3%	3	0			3.0
2000	Spanish	Fall	Moderate	71	Run	9.7	25.8	61.5%	38.5%	25	1			26.0
2000	Spanish	Fall	Moderate	76	Pool	4.2	9.1	84.8%	15.2%	31	2			33.1
2000	Spanish	Fall	Moderate	78	Riffle	9.9	34.6	82.8%	17.2%	26	3			29.4
2000	Spanish	Fall	Moderate	81	Run	13.8	35.2	94.3%	5.7%	34	16	4		57.3

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Spanish	Fall	Moderate	84	Cascade	3.9	4.9	75.0%	25.0%	7	1			8.2
2000	Spanish	Fall	Moderate	87	Riffle	8.1	22.4	82.9%	17.1%	25	8	2		36.0
2000	Spanish	Fall	Moderate	88	Pool	9.3	27.4	85.2%	14.8%	26	6			33.8
2000	Spanish	Fall	Moderate	88.2	Pool	3.5	5.3	100.0%	0.0%	5	0			5.0
2000	Spanish	Fall	Moderate	98	Riffle	8.0	16.7	70.6%	29.4%	14	3			17.8
2000	Spanish	Fall	Moderate	101	Run	5.6	11.7	69.2%	30.8%	13	0			13.0
2000	Spanish	Fall	Moderate	105	Cascade	1.7	4.5	100.0%	0.0%	4	1			5.3
2000	Spanish	Fall	Moderate	108	Pool	6.0	13.5	76.9%	23.1%	8	4	1		13.9
2000	Spanish	Fall	Moderate	111	Riffle	8.0	21.1	100.0%	0.0%	1	0			1.0
2000	Spanish	Fall	Moderate	114	Run	19.1	51.7	87.5%	12.5%	20	4			25.0
2000	Spanish	Fall	Moderate	116.1	Riffle	15.2	28.9	100.0%	0.0%	10	3			14.3
2000	Spanish	Fall	Moderate	120	Run	8.7	26.4	84.6%	15.4%	11	2			13.4
2000	Spanish	Fall	Moderate	129.2	Pool	3.1	6.5	100.0%	0.0%	4	1			5.3
2000	Spanish	Fall	Moderate	131	Run	6.7	11.1	60.0%	40.0%	7	3	0		10.2
2000	Spanish	Fall	Moderate	132	Riffle	11.7	22.9	93.8%	6.3%	12	4			18.0
2000	Spanish	Fall	Moderate	138	Run	4.1	5.7	66.7%	33.3%	6	1			7.2
2000	Spanish	Fall	Moderate	142	Riffle	4.2	8.0	66.7%	33.3%	2	0			2.0
2000	Spanish	Fall	Moderate	151	Run	14.1	21.9	47.4%	52.6%	16	3			19.7
2000	Spanish	Fall	Moderate	155	Riffle	4.1	7.5	100.0%	0.0%	1	0			1.0
2000	Spanish	Fall	Moderate	161	Riffle	10.2	17.8	100.0%	0.0%	2	0			2.0
2000	Spanish	Fall	Moderate	162	Run	10.5	16.8	80.0%	20.0%	8	2			10.7
2000	Spanish	Fall	Moderate	164	Pool	4.9	14.2	62.5%	37.5%	7	1			8.2

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Spanish	Fall	Moderate	168	Cascade	2.2	2.9	0.0%	0.0%	0	0			0.0
2000	Spanish	Fall	Moderate	173	Run	11.3	19.8	83.3%	16.7%	6	0			6.0
2000	Spanish	Fall	Moderate	177	Riffle	4.1	10.7	100.0%	0.0%	3	0			3.0
2000	Spanish	Fall	High	182	Run	19.8	70.2	85.7%	14.3%	12	2			14.4
2000	Spanish	Fall	High	186	Pool	4.4	12.7	58.3%	41.7%	6	4	2		15.2
2000	Spanish	Fall	High	188	Riffle	9.3	18.0	100.0%	0.0%	7	1			8.2
2000	Spanish	Fall	High	195	Riffle	3.8	5.8	0.0%	0.0%	0	0			0.0
2000	Spanish	Fall	High	196	Pool	3.8	11.5	75.0%	25.0%	8	0			8.0
2000	Spanish	Fall	High	197	Run	3.1	5.5	100.0%	0.0%	1	0			1.0
2000	Spanish	Fall	High	204	Cascade	3.0	7.9	100.0%	0.0%	1	0			1.0
2000	Spanish	Fall	High	208	Run	7.1	18.4	85.7%	14.3%	6	1			7.2
2000	Spanish	Fall	High	213	Riffle	4.2	6.6	0.0%	100.0%	1	0			1.0
2000	Spanish	Fall	High	214	Pool	5.8	12.5	81.8%	18.2%	11	0			11.0
2000	Spanish	Fall	High	223	Pool	3.6	8.2	50.0%	50.0%	2	0			2.0
2000	Spanish	Fall	High	226	Riffle	2.8	4.8	0.0%	0.0%	0	0			0.0
2000	Spanish	Fall	High	232	Run	7.0	15.1	0.0%	100.0%	1	0			1.0
2000	Spanish	Fall	High	236	Cascade	6.9	14.8	0.0%	0.0%	0	0			0.0
2000	Spanish	Fall	High	240	Pool	3.9	8.9	100.0%	0.0%	1	0			1.0
2000	Spanish	Fall	High	241	Riffle	3.0	4.2	100.0%	0.0%	1	0			1.0
2000	Spanish	Fall	High	250	Pool	4.5	10.5	0.0%	0.0%	0	0			0.0
2000	Oat	Summer	Low	8	Riffle	3.6	14.4	25.8%	74.2%	29	2			31.1
2000	Oat	Summer	Low	12	Pool	3.5	5.4	40.0%	60.0%	15	1			16.1

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Oat	Summer	Low	14	Riffle	6.1	17.5	50.0%	50.0%	7	5	0		12.6
2000	Oat	Summer	Low	17	Pool	8.8	17.0	66.7%	33.3%	16	2			18.3
2000	Oat	Summer	Low	19	Run	4.7	9.2	68.4%	31.6%	18	1			19.1
2000	Oat	Summer	Low	27	Riffle	6.0	24.7	76.5%	23.5%	30	5			36.0
2000	Oat	Summer	Low	30	Run	3.3	7.4	40.0%	60.0%	2	2	1	0	8.3
2000	Oat	Summer	Low	35	Riffle	6.1	18.0	55.6%	44.4%	8	2			10.7
2000	Oat	Summer	Low	41	Pool	2.8	7.7	12.5%	87.5%	6	2	0		8.1
2000	Oat	Summer	Low	42	Run	9.5	19.7	37.5%	62.5%	7	1			8.2
2000	Oat	Summer	Low	46	Run	16.1	43.2	54.3%	45.7%	25	8			36.8
2000	Oat	Summer	Low	47	Riffle	4.6	11.1	50.0%	50.0%	3	1	0		4.0
2000	Oat	Summer	Moderate	53	Riffle	8.2	16.5	18.2%	81.8%	10	1			11.1
2000	Oat	Summer	Moderate	56	Run	8.1	12.3	55.6%	44.4%	14	5			21.8
2000	Oat	Summer	Moderate	65	Cascade	9.4	26.6	70.6%	29.4%	14	3			17.8
2000	Oat	Summer	Moderate	67	Riffle	18.3	70.3	51.9%	48.1%	24	4			28.8
2000	Oat	Summer	Moderate	68	Run	12.5	45.1	55.8%	44.2%	38	5			43.8
2000	Oat	Summer	Moderate	69	Pool	3.4	7.1	50.0%	50.0%	6	0			6.0
2000	Oat	Summer	Moderate	83	Riffle	10.1	29.4	33.3%	66.7%	13	1			14.1
2000	Oat	Summer	Moderate	84	Pool	22.8	74.0	48.1%	51.9%	21	6	0		27.2
2000	Oat	Summer	Moderate	91	Cascade	3.1	8.8	33.3%	66.7%	3	0			3.0
2000	Oat	Summer	Moderate	95	Pool	6.4	16.9	7.1%	92.9%	11	3			15.1
2000	Oat	Summer	Moderate	100	Run	4.0	5.9	50.0%	50.0%	2	0			2.0
2000	Oat	Summer	Moderate	109	Cascade	8.7	17.0	16.7%	83.3%	6	0			6.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Oat	Summer	Moderate	113	Riffle	5.9	10.0	42.9%	57.1%	7	0			7.0
2000	Oat	Summer	Moderate	114	Pool	3.5	6.2	25.0%	75.0%	3	1	0		4.0
2000	Oat	Summer	Moderate	116	Run	14.8	36.3	25.0%	75.0%	8	4			16.0
2000	Oat	Summer	Moderate	131	Pool	4.6	11.8	55.6%	44.4%	5	2	2	0	11.4
2000	Oat	Summer	Moderate	135	Riffle	7.4	20.9	25.0%	75.0%	6	2	1	0	9.5
2000	Oat	Summer	Moderate	146	Run	7.4	25.0	30.0%	70.0%	9	1			10.1
2000	Oat	Summer	Moderate	147	Pool	5.1	10.7	20.0%	80.0%	5	0			5.0
2000	Oat	Summer	Moderate	148	Riffle	10.9	25.9	45.5%	54.5%	11	0			11.0
2000	Oat	Summer	Moderate	151.1	Cascade	10.9	19.0	50.0%	50.0%	2	0			2.0
2000	Oat	Summer	Moderate	165	Run	6.3	12.1	28.6%	71.4%	6	1			7.2
2000	Oat	Summer	Moderate	167	Pool	4.0	8.4	37.5%	62.5%	3	2	3	0	8.0
2000	Oat	Summer	Moderate	171	Riffle	9.0	25.6	58.3%	41.7%	12	0			12.0
2000	Oat	Summer	Moderate	172	Cascade	12.8	44.1	56.5%	43.5%	21	1			22.1
2000	Oat	Summer	Moderate	183	Run	4.0	8.9	11.1%	88.9%	3	1			4.5
2000	Oat	Summer	Moderate	184	Pool	4.3	18.0	0.0%	100.0%	14	1			15.1
2000	Oat	Summer	Moderate	190	Cascade	3.0	6.9	100.0%	0.0%	2	0			2.0
2000	Oat	Summer	Moderate	195	Pool	4.2	11.2	100.0%	0.0%	5	0			5.0
2000	Oat	Summer	Moderate	203	Riffle	4.1	9.3	42.9%	57.1%	7	0			7.0
2000	Oat	Summer	Moderate	208	Run	4.3	8.9	40.0%	60.0%	10	0			10.0
2000	Oat	Summer	Moderate	209	Cascade	7.4	14.1	14.3%	85.7%	7	0			7.0
2000	Oat	Summer	Moderate	214	Pool	4.1	13.6	55.6%	44.4%	9	0			9.0
2000	Oat	Summer	Moderate	221	Cascade	7.2	28.1	20.0%	80.0%	5	0			5.0

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Oat	Summer	Moderate	228	Pool	2.6	7.4	33.3%	66.7%	9	0			9.0
2000	Oat	Summer	High	232	Riffle	10.9	26.1	0.0%	100.0%	1	0			1.0
2000	Oat	Summer	High	234.15	Run	4.0	7.1	75.0%	25.0%	4	0			4.0
2000	Oat	Summer	High	235	Pool	6.5	15.6	22.2%	77.8%	16	2			18.3
2000	Oat	Summer	High	239	Pool	6.5	24.6	25.0%	75.0%	11	4	1		16.6
2000	Oat	Summer	High	245	Run	4.9	13.4	25.0%	75.0%	4	0			4.0
2000	Oat	Summer	High	248	Pool	4.7	18.1	20.0%	80.0%	8	2			10.7
2000	Oat	Summer	High	249	Cascade	14.0	31.2	50.0%	50.0%	9	1			10.1
2000	Oat	Summer	High	259	Cascade	8.0	17.1	16.7%	83.3%	4	2	0		6.1
2000	Oat	Summer	High	263	Run	15.2	50.3	0.0%	100.0%	1	0			1.0
2000	Oat	Summer	High	264	Pool	9.0	23.5	0.0%	100.0%	2	0			2.0
2000	Oat	Fall	Low	8	Riffle	3.6	14.4	42.9%	57.1%	6	1			7.2
2000	Oat	Fall	Low	12	Pool	3.5	5.4	41.7%	58.3%	11	1			12.1
2000	Oat	Fall	Low	14	Riffle	6.1	17.5	62.5%	37.5%	7	1			8.2
2000	Oat	Fall	Low	17	Pool	8.8	17.0	100.0%	0.0%	1	0			1.0
2000	Oat	Fall	Low	19	Run	4.7	9.2	100.0%	0.0%	3	0			3.0
2000	Oat	Fall	Low	27	Riffle	6.0	24.7	79.2%	20.8%	21	3			24.5
2000	Oat	Fall	Low	30	Run	3.3	7.4	83.3%	16.7%	6	1			7.2
2000	Oat	Fall	Low	35	Riffle	6.1	18.0	55.6%	44.4%	8	1			9.1
2000	Oat	Fall	Low	41	Pool	2.8	7.7	60.0%	40.0%	8	2			10.7
2000	Oat	Fall	Low	42	Run	9.5	19.7	66.7%	33.3%	7	2			9.8
2000	Oat	Fall	Low	46	Run	16.1	43.2	61.9%	38.1%	17	4			22.2

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Oat	Fall	Low	47	Riffle	4.6	11.1	40.0%	60.0%	5	0			5.0
2000	Oat	Fall	Moderate	53	Riffle	8.2	16.5	60.0%	40.0%	5	0			5.0
2000	Oat	Fall	Moderate	56	Run	8.1	12.3	47.4%	52.6%	13	7			28.2
2000	Oat	Fall	Moderate	65	Cascade	9.4	26.6	63.6%	36.4%	10	1			11.1
2000	Oat	Fall	Moderate	67	Riffle	18.3	70.3	54.2%	45.8%	17	5	2		24.9
2000	Oat	Fall	Moderate	68	Run	12.5	45.1	45.5%	54.5%	40	4			44.4
2000	Oat	Fall	Moderate	69	Pool	3.4	7.1	33.3%	66.7%	6	0			6.0
2000	Oat	Fall	Moderate	83	Riffle	10.1	29.4	50.0%	50.0%	8	1			9.1
2000	Oat	Fall	Moderate	84	Pool	22.8	74.0	38.1%	61.9%	16	5	0		21.2
2000	Oat	Fall	Moderate	91	Cascade	3.1	8.8	0.0%	100.0%	2	0			2.0
2000	Oat	Fall	Moderate	95	Pool	6.4	16.9	29.4%	70.6%	13	4			18.8
2000	Oat	Fall	Moderate	100	Run	4.0	5.9	0.0%	0.0%	0	0			0.0
2000	Oat	Fall	Moderate	109	Cascade	8.7	17.0	10.0%	90.0%	10	0			10.0
2000	Oat	Fall	Moderate	113	Riffle	5.9	10.0	33.3%	66.7%	6	0			6.0
2000	Oat	Fall	Moderate	114	Pool	3.5	6.2	33.3%	66.7%	5	1			6.3
2000	Oat	Fall	Moderate	116	Run	14.8	36.3	40.0%	60.0%	13	2			15.4
2000	Oat	Fall	Moderate	125	Cascade	8.2	17.0	100.0%	0.0%	1	0			1.0
2000	Oat	Fall	Moderate	131	Pool	4.6	11.8	60.0%	40.0%	5	4	1		11.7
2000	Oat	Fall	Moderate	135	Riffle	7.4	20.9	14.3%	85.7%	7	0			7.0
2000	Oat	Fall	Moderate	146	Run	7.4	25.0	66.7%	33.3%	7	2			9.8
2000	Oat	Fall	Moderate	147	Pool	5.1	10.7	36.4%	63.6%	10	1			11.1
2000	Oat	Fall	Moderate	148	Riffle	10.9	25.9	33.3%	66.7%	11	1			12.1

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Oat	Fall	Moderate	151.1	Cascade	10.9	19.0	100.0%	0.0%	0	1	0		1.0
2000	Oat	Fall	Moderate	165	Run	6.3	12.1	66.7%	33.3%	6	0			6.0
2000	Oat	Fall	Moderate	167	Pool	4.0	8.4	36.4%	63.6%	10	1			11.1
2000	Oat	Fall	Moderate	171	Riffle	9.0	25.6	83.3%	16.7%	6	0			6.0
2000	Oat	Fall	Moderate	172	Cascade	12.8	44.1	63.6%	36.4%	20	2			22.2
2000	Oat	Fall	Moderate	183	Run	4.0	8.9	33.3%	66.7%	8	1			9.1
2000	Oat	Fall	Moderate	184	Pool	4.3	18.0	15.4%	84.6%	12	1			13.1
2000	Oat	Fall	Moderate	190	Cascade	3.0	6.9	20.0%	80.0%	2	1	2	0	5.0
2000	Oat	Fall	Moderate	195	Pool	4.2	11.2	40.0%	60.0%	4	1			5.3
2000	Oat	Fall	Moderate	203	Riffle	4.1	9.3	75.0%	25.0%	4	0			4.0
2000	Oat	Fall	Moderate	208	Run	4.3	8.9	20.0%	80.0%	4	1			5.3
2000	Oat	Fall	Moderate	209	Cascade	7.4	14.1	28.6%	71.4%	6	1			7.2
2000	Oat	Fall	Moderate	214	Pool	4.1	13.6	44.4%	55.6%	5	2	2	0	11.4
2000	Oat	Fall	Moderate	221	Cascade	7.2	28.1	66.7%	33.3%	2	1	0		3.1
2000	Oat	Fall	Moderate	228	Pool	2.6	7.4	77.8%	22.2%	6	3	0		9.2
2000	Oat	Fall	High	232	Riffle	10.9	26.1	60.0%	40.0%	5	0			5.0
2000	Oat	Fall	High	234.1	Cascade	7.9	19.5	75.0%	25.0%	3	1			4.5
2000	Oat	Fall	High	234.15	Run	4.0	7.1	66.7%	33.3%	3	0			3.0
2000	Oat	Fall	High	235	Pool	6.5	15.6	37.5%	62.5%	11	3	2		16.9
2000	Oat	Fall	High	239	Pool	6.5	24.6	46.2%	53.8%	10	3	0		13.1
2000	Oat	Fall	High	245	Run	4.9	13.4	50.0%	50.0%	3	1			4.5
2000	Oat	Fall	High	248	Pool	4.7	18.1	25.0%	75.0%	6	1			7.2

Appendix A. Data collected for estimating juvenile steelhead trout abundance in Spanish and Oat Creeks within the KRNCA, California (continued). Number of juvenile steelhead trout captured on each electrofishing pass (E) and unit estimate are also given. For ANOVA analysis, Proportion (Prop.) of each age class, length and area of each habitat unit is also included.

Year	Stream	Season	Reach	Unit Number	Channel Unit	Length (m)	Area (m^2)	Percent 0+	Percent ≥ 1+	E^1	E^2	E^3	E^4	Unit Estimate
2000	Oat	Fall	High	249	Cascade	14.0	31.2	44.4%	55.6%	8	1			9.1
2000	Oat	Fall	High	259	Cascade	8.0	17.1	0.0%	100.0%	1	0			1.0
2000	Oat	Fall	High	263	Run	15.2	50.3	0.0%	0.0%	0	0			0.0
2000	Oat	Fall	High	264	Pool	9.0	23.5	0.0%	100.0%	2	0			2.0

Appendix B. Results of scale analysis used in estimating starting values for the computer program MIX 3.1.

Slide Number[a]	Stream	Season	Annulus[b]	Fork Length (mm)	Identical scales[c]
kr105	Oat	Summer	1	100	4
kr107	Oat	Summer	1	95	3
kr108	Oat	Summer	1	134	3
kr109	Oat	Summer	1	185	2
kr110	Oat	Summer	U	90	5
kr111	Oat	Summer	U	76	5
kr112	Oat	Summer	0	116	7
kr113	Oat	Summer	1	144	4
kr114	Oat	Summer	1	110	2
kr115	Oat	Summer	0	122	6
kr116	Oat	Summer	0	115	8
kr117	Oat	Summer	U	171	6
kr121	Oat	Summer	1	137	3
kr122	Oat	Summer	1	82	5
kr123	Oat	Summer	1	106	4
kr124	Oat	Summer	1	139	2
kr125	Oat	Summer	U	132	5
kr126	Oat	Summer	1	109	5
kr126	Oat	Summer	X		5
kr127	Oat	Summer	X	118	6
kr128	Oat	Summer	1	91	5
kr130	Oat	Summer	X	152	5
kr131	Oat	Summer	1	103	3
kr132	Oat	Summer	1	118	4
kr133	Oat	Summer	1	90	4
kr134	Oat	Summer	X	100	5
kr135	Oat	Summer	U	137	2
kr136	Oat	Summer	1	122	4
kr137	Oat	Summer	1	86	5
kr138	Oat	Summer	2		2

Appendix B. Results of scale data analysis used in estimating starting values of fork length and standard error in the computer program MIX 3.1 (continued).

Slide Number[a]	Stream	Season	Annulus[b]	Fork Length (mm)	Identical scales[c]
kr139	Oat	Summer	1		4
kr140	Oat	Summer	1		3
of01	Oat	Fall	1	120	5
of02	Oat	Fall	0	113	5
of02	Oat	Fall	1		5
of03	Oat	Fall	1	127	5
of04	Oat	Fall	1	112	3
of05	Oat	Fall	0	70	5
of06	Oat	Fall	1	110	3
of07	Oat	Fall	0	63	5
of09	Oat	Fall	0	64	5
of10	Oat	Fall	0	82	5
of10	Oat	Fall	0		5
of11	Oat	Fall	1	91	5
of12	Oat	Fall	0	115	5
of13	Oat	Fall	0	58	5
of14	Oat	Fall	0	70	5
of15	Oat	Fall	0	60	5
of16	Oat	Fall	0	60	5
of17	Oat	Fall	0	79	5
of18	Oat	Fall	0	95	5
of19	Oat	Fall	1	111	3
of20	Oat	Fall	0	105	5
of22	Oat	Fall	0	57	5
of22	Oat	Fall	0	70	5
of23	Oat	Fall	1	110	5
of24	Oat	Fall	0	57	5
of25	Oat	Fall	0	70	5
of26	Oat	Fall	1	183	1
of27	Oat	Fall	1	113	4

Appendix B. Results of scale data analysis used in estimating starting values of fork length and standard error in the computer program MIX 3.1 (continued).

Slide Number[a]	Stream	Season	Annulus[b]	Fork Length (mm)	Identical scales[c]
of28	Oat	Fall	0	54	5
of29	Oat	Fall	1	91	3
of30	Oat	Fall	1	88	5
of31	Oat	Fall	2	141	3
of32	Oat	Fall	2	135	3
of33	Oat	Fall	1	108	3
of44	Oat	Fall	1	153	2
of45	Oat	Fall	0		5
of46	Oat	Fall	1	112	3
of47	Oat	Fall	0	99	5
of48	Oat	Fall	1	100	5
of49	Oat	Fall	1	147	3
of50	Oat	Fall	0	68	5
of51	Oat	Fall	0	64	5
of65	Oat	Fall	0	62	2
of67	Oat	Fall	0	114	1
of68	Oat	Fall	0	51	3
of70	Oat	Fall	0	77	4
of71	Oat	Fall	U	140	5
of72	Oat	Fall	0	62	5
of73	Oat	Fall	0	95	1
of74	Oat	Fall	2	137	3
of77	Oat	Fall	0	68	5
of78	Oat	Fall	0	62	5
of79	Oat	Fall	0	110	2
of80	Oat	Fall	1	174	5
of81	Oat	Fall	1	99	5
of82	Oat	Fall	0	108	5
of83	Oat	Fall	0	63	5
of84	Oat	Fall	0	94	5

Appendix B. Results of scale data analysis used in estimating starting values of fork length and standard error in the computer program MIX 3.1 (continued).

Slide Number[a]	Stream	Season	Annulus[b]	Fork Length (mm)	Identical scales[c]
of85	Oat	Fall	U	138	
of86	Oat	Fall	0	86	3
kr076	Spanish	Summer	2		5
kr077	Spanish	Summer	2		4
kr078	Spanish	Summer	2	180	1
kr079	Spanish	Summer	1	164	5
kr080	Spanish	Summer	U	210	5
kr081	Spanish	Summer	1	153	5
kr082	Spanish	Summer	1	131	5
kr083	Spanish	Summer	X	207	5
kr084	Spanish	Summer	1	143	5
kr085	Spanish	Summer	0	90	5
kr086	Spanish	Summer	1	125	5
kr087	Spanish	Summer	1		5
kr088	Spanish	Summer	2		4
kr089	Spanish	Summer	1	126	4
kr090	Spanish	Summer	1	146	2
kr091	Spanish	Summer	2	137	3
kr092	Spanish	Summer	2		4
kr093	Spanish	Summer	1		5
kr094	Spanish	Summer	1	97	5
kr095	Spanish	Summer	1	123	3
kr096	Spanish	Summer	1	95	5
kr097	Spanish	Summer	2	147	3
kr098	Spanish	Summer	1	160	5
kr099	Spanish	Summer	U	142	4
kr100	Spanish	Summer	1	88	5
kr101	Spanish	Summer	0	89	5
kr102	Spanish	Summer	1	130	3
kr103	Spanish	Summer	1	128	4

Appendix B. Results of scale data analysis used in estimating starting values of fork length and standard error in the computer program MIX 3.1 (continued).

Slide Number[a]	Stream	Season	Annulus[b]	Fork Length (mm)	Identical scales[c]
sf01	Spanish	Fall	0	80	5
sf02	Spanish	Fall	0	82	5
sf03	Spanish	Fall	0	90	5
sf04	Spanish	Fall	1	114	3
sf05	Spanish	Fall	0	72	5
sf06	Spanish	Fall	0	83	4
sf08	Spanish	Fall	0	85	3
sf09	Spanish	Fall	0	117	4
sf10	Spanish	Fall	0	83	2
sf11	Spanish	Fall	0	84	4
sf12	Spanish	Fall	U	139	6
sf13	Spanish	Fall	0	77	5
sf14	Spanish	Fall	0	67	3
sf15	Spanish	Fall	0		3
sf16	Spanish	Fall	0	96	1
sf17	Spanish	Fall	1	126	
sf18	Spanish	Fall	0	105	1
sf19	Spanish	Fall	0	90	5
sf20	Spanish	Fall	0		3
sf21	Spanish	Fall	0		3
sf22	Spanish	Fall	0	75	5
sf23	Spanish	Fall	0	60	5
sf24	Spanish	Fall	U	88	3
sf25	Spanish	Fall	0	72	5
sf26	Spanish	Fall	0	82	5
sf27	Spanish	Fall	0	54	2
sf28	Spanish	Fall	0	62	4
sf29	Spanish	Fall	0	74	3
sf30	Spanish	Fall	0	84	5
sf31	Spanish	Fall	U	86	5

Appendix B. Results of scale data analysis used in estimating starting values of fork length and standard error in the computer program MIX 3.1 (continued).

Slide Number[a]	Stream	Season	Annulus[b]	Fork Length (mm)	Identical scales[c]
sf32	Spanish	Fall	1	118	3
sf33	Spanish	Fall	1	110	3
sf34	Spanish	Fall	0	106	5
sf35	Spanish	Fall	1	90	3
sf36	Spanish	Fall	1	100	5
sf37	Spanish	Fall	0	88	2
sf38	Spanish	Fall	U	170	0
sf39	Spanish	Fall	1	101	2
sf40	Spanish	Fall	1	100	2
sf41	Spanish	Fall	1	113	2
sf42	Spanish	Fall	1	87	3
sf43	Spanish	Fall	X	197	5
sf44	Spanish	Fall	0	81	5
sf45	Spanish	Fall	0	79	5
sf46	Spanish	Fall	0	70	5
sf47	Spanish	Fall	0	71	5
sf48	Spanish	Fall	0	79	5
sf49	Spanish	Fall	U	81	2
sf50	Spanish	Fall	X	66	5
sf51	Spanish	Fall	0	62	3
sf52	Spanish	Fall	0	81	5
sf54	Spanish	Fall	U	86	3
sf55	Spanish	Fall	0	69	5
sf56	Spanish	Fall	0	74	5
sf57	Spanish	Fall	X	71	5
sf58	Spanish	Fall	0	73	3
sf59	Spanish	Fall	X	76	5
sf60	Spanish	Fall	3	181	2
sf61	Spanish	Fall	0	88	5
sf62	Spanish	Fall	1	121	5

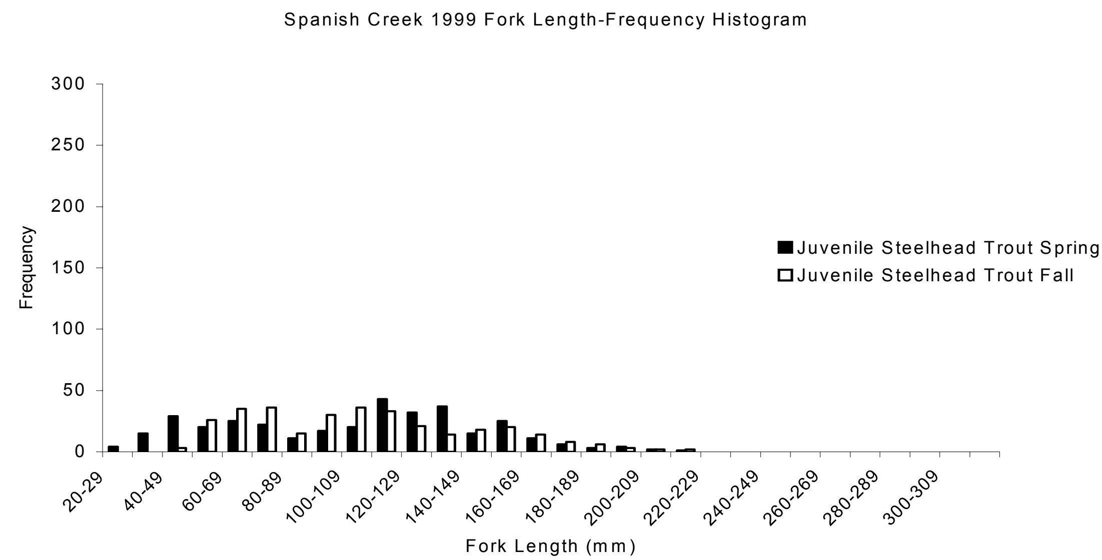
Appendix B. Results of scale data analysis used in estimating starting values of fork length and standard error in the computer program MIX 3.1 (continued).

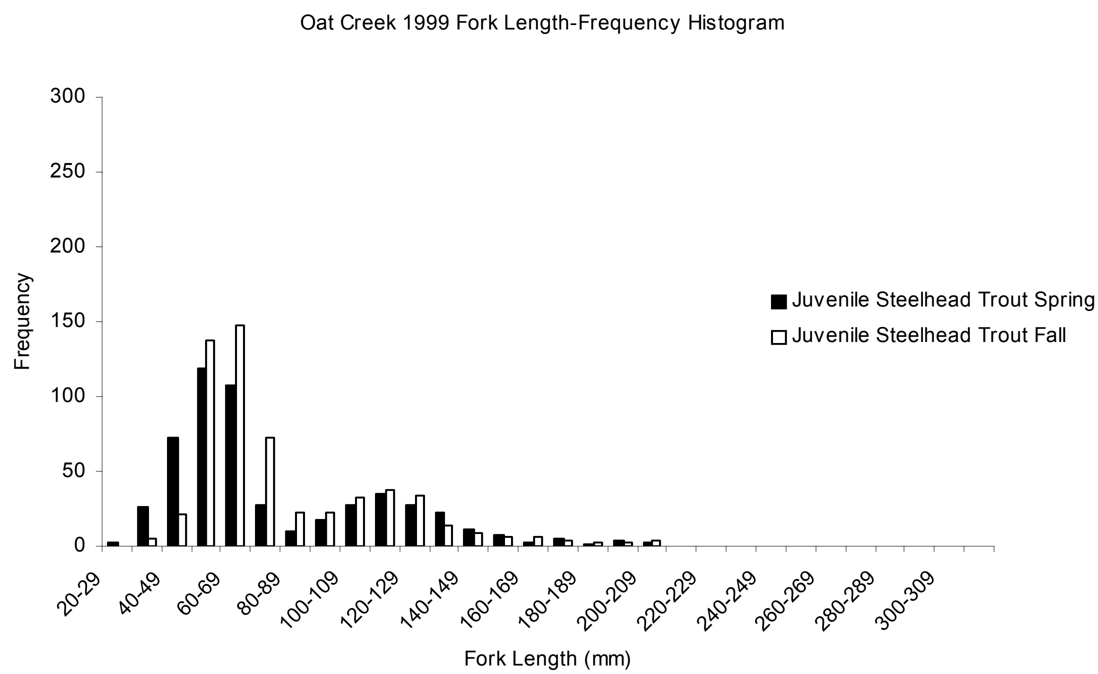
Slide Number[a]	Stream	Season	Annulus[b]	Fork Length (mm)	Identical scales[c]
sf63	Spanish	Fall	1	113	5
sf64	Spanish	Fall	0	101	5
sf65	Spanish	Fall	1	120	2
sf66	Spanish	Fall	X	135	5
sf67	Spanish	Fall	U	80	5
sf68	Spanish	Fall	0	76	3
sf69	Spanish	Fall	0	78	5
sf70	Spanish	Fall	0	84	5
sf71	Spanish	Fall	1	103	2
sf72	Spanish	Fall	1	108	4
sf73	Spanish	Fall	0		5
sf82	Spanish	Fall	X	165	5

[a]Code given to each slide for organizational purposes
[b]The number of annuli agreed upon by observers.
[c]Number of scales in each sample with identical annuli results.
U = undetermined number of annuli.
X = sample discarded due to insufficient number scales or only regenerated scales in sample.

Appendix C. Data used for fork length-frequency analysis in the program MIX 3.1. Juvenile steelhead from each stream and season are grouped by 10 mm fork length intervals. For an electronic copy of original fork length data please contact the California Cooperative Fishery Research Unit at Humboldt State University.

	Spanish Creek				Oat Creek			
	1999		2000		1999		2000	
	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall
30	4	0	2	0	2	0	0	1
40	15	0	17	1	26	6	16	0
50	29	2	64	13	73	20	49	8
60	20	27	162	68	119	137	72	67
70	25	33	163	135	107	145	37	63
80	22	36	128	98	27	73	23	24
90	11	18	60	95	10	21	24	35
100	17	32	26	62	18	22	48	44
110	20	36	14	29	27	32	57	53
120	43	32	8	28	35	35	34	36
130	32	24	15	19	27	34	20	14
140	37	15	18	9	22	14	28	16
150	15	18	12	10	11	9	12	8
160	25	19	5	6	8	6	5	3
170	11	14	12	4	3	6	2	2
180	6	8	2	3	5	4	1	3
190	3	6	5	2	1	3	6	4
200	4	3	4	4	4	2	2	0
210	2	2	1	1	2	4	0	0
220	1	2	1	0	0	0	0	0
230	0	0	1	0	0	0	0	0
240	0	0	1	0	0	0	0	0
250	0	0	0	0	0	0	0	0





Appendix D. Fork length-frequency histograms of Spanish and Oat Creeks during 1999. Age class analysis was not performed on these data in lieu of inadequate scale sampling, confounding population estimates in Oat Creek during 1999, and the inability of the computer program MIX 3.1 and the author to correctly identify proportions and age class breaks in the Spanish Creek histogram.