SOUTH FORK GUALALA RIVER
FISHERY RESOURCE STUDY

Prepared for

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INTRODUCTION

1.1 PROJECT DESCRIPTION

In 1967, the Sea Ranch Water Company (SRWC) was issued Water Right Permit 15358 by the State Water Resources Control Board (SWRCB) allowing diversion of water by offset wells from the underflow of the South Fork Gualala River for municipal use at Sea Ranch and the adjacent area. Pursuant to this permit, SRWC presently diverts water to serve approximately 953 residences and several commercial and public facilities.

Permit 15358 includes a fisheries bypass term (Term 14) originally negotiated and agreed upon by the California Department of Fish and Game (CDFG) and SRWC and subsequently modified in 1978 by SWRCB. As modified, Term 14, is only effective once the permittee secures an alternate water supply, a goal that has not yet been realized. In 1990, SWRCB amended Permit 15358 to add, among others, the following term:

> "Permittee shall conduct a fishery study in consultation with the Board to:
>
> a) determine if the permittee's diversion is affecting the fishery of the Gualala River and,
>
> b) determine if the requirements of fishery bypass Term 14 are adequate to protect the fishery.
>
> This study shall be completed by November 30, 1993."

In addition, SWRCB ordered that:

"Permittee shall immediately commence daily flow measurements of the South Fork Gualala River at locations satisfactory to the Board. Daily flow measurements shall be made until sufficient data are collected for the fishery study or until an alternate monitoring schedule is approved by the Chief of the Division of Water Rights."

The added terms required a study to address two questions; 1) does the present SRWC diversion affect the Gualala River fishery and 2) will Term 14 bypass flows adequately protect the fishery. ENTRIX developed a study plan in consultation with SWRCB and state and federal resource agencies to address the requirements of Permit 15358 and additional concerns identified by the representatives of CDFG, SWRCB and National Marine Fisheries Service (NMFS) present at a meeting held May 17, 1991 in Sacramento (Keegan 1991).

The purpose of this study was to evaluate the effects of water diversion primarily on summer rearing habitat for juvenile steelhead and juvenile coho salmon. The consensus of the involved parties (e.g., CDFG, NMFS, SWRCB) was that summer rearing habitat is likely the most important limiting factor affecting steelhead and coho salmon production because of the potential for low summer flows on the Gualala River.

The original intent of this report was to evaluate project-related effects on steelhead *(Oncorhynchus mykiss)* and coho salmon *(Oncorhynchus kisutch)* populations. However, no coho salmon were collected during this study. Moreover, conversations with local anglers and CDFG biologists indicate that coho salmon are not (and have not for many years) utilizing the Gualala River system. This includes the North Fork Gualala River which historically had been stocked with coho salmon by CDFG and which has been repeatedly sampled by CDFG to establish the presence of absence of coho salmon. Therefore, this draft focuses on steelhead resources and habitat.

During the course of project scoping, concerns were raised regarding the effects on the fisheries of the summer dam, annually installed by Sea Ranch Association (not SRWC), pursuant to a Corps of Engineers 404 Permit. The summer dam was not constructed during the course of the study period and it was agreed that an assessment of summer dam impacts to the fishery need not be included in this study. Potential effects of the summer dam should be considered during the process for any renewal of the 404 Permit, which has no relation to SRWC's Water Right Permit 15358.

2.1 INTRODUCTION

This section discusses the study objectives and the general approach to addressing the study objectives. The emphasis of this study is on determining if the SRWC diversion on the South Fork Gualala River has or will have any discernible effect on fish resources in the river. The focus of the field program is to assess the quality and quantity of habitat for juvenile steelhead and to evaluate project effects on juvenile steelhead during summer and fall.

2.2 SAMPLING OBJECTIVES

The objectives of this study are:

- To determine if the SRWC diversion is affecting species composition and/or abundance of fishes in the Gualala River fishery by comparing habitat-specific data from upstream and downstream of the Sea Ranch wells, and

- To evaluate whether the Term 14 fishery bypass streamflows are adequate to protect habitat quality and quantity downstream of the diversion.

The study objectives were met through data collection, integration and analysis in four principal areas: habitat mapping and quantification, fish population surveys, temperature monitoring, and streamflow analysis. The study area is defined as that portion of the South Fork Gualala River between the confluences of the North Fork and the Wheatfield Fork.

2.3 SAMPLING STRATEGY AND RATIONALE

2.3.1 PROJECT RELATED EFFECTS

This study addresses the potential for project-related effects on steelhead resources by evaluating and comparing differences in juvenile steelhead utilization of habitat immediately upstream and downstream of the Sea Ranch wells. The basis for this type of analysis is that if project-related effects were occurring, they would most likely be evident immediately downstream of the wells. To this end, a stratified sampling design was developed to compare species composition and abundance data and juvenile steelhead population size among several habitat types both upstream and downstream of the wells.

Habitat mapping was completed prior to fish sampling. The information gathered allowed us to identify comparable fish sampling locations both upstream and downstream of the wells as well as assess the quality and quantity of summer rearing habitat. Quantitative measurements of physical habitat at each population sampling site were collected to assess habitat quality with and without diversion during summer and fall.

Juvenile steelhead and coho salmon distribution and abundance both above and below the wells were assessed by electrofishing surveys. Two surveys were conducted; one in July, when streamflow was expected to be moderate and young-of-the-year steelhead were present, and one in September/October when low flow conditions were expected.

Temperature and hydrology data were collected continuously through the use of temperature recording data pods and United States Geological Survey (USGS) streamflow monitoring gages. Data from the temperature pod and stream gage operation were used in a limiting factor analysis of steelhead rearing habitat.

2.3.2 EVALUATION OF TERM 14 FISHERY BYPASS ROWS

The second objective of the study was to evaluate the adequacy of Term 14 fishery bypass streamflows to protect fishery resources. This was achieved through PHABSIM (Physical Habitat Simulation) modeling by habitat type. The quantity of Weighted Usable Area

(WUA) was calculated for streamflows ranging from 3 to 10 cfs. WUA was then recalculated subtracting 0.5 cfs from each evaluated flow set to simulate worst-case conditions (i.e., that subsurface water withdrawal actually results in decreased surface flow at an identical rate). The assumption was that any effect of water withdrawl would be most pronounced at lower flow levels.

3.0

METHODOLOGY

3.1 INTRODUCTION

This section presents an overview of the methods used in collecting and analyzing data for this study.

3.2 HABITAT MAPPING

The entire study area from the confluence of the Wheatfield Fork to the North Fork, was mapped on foot. The stretch was mapped on July 13 and 14, 1991 by a two-person field crew. Discrete habitat units were identified based on a modified Bisson Index approach (Bisson et al. 1981) numbered sequentially, and described through measurements of length, average width, average depth and average velocity. Length and width measurements were made with optical range finders (Ranging, Inc., Model 610). The field crew also visually assessed amount and type of cover and substrate for each unit. From the habitat mapping task, four major habitat types were selected for sampling fish; riffles, runs, deep pools and rootwad pools (pools with an abundance of woody debris).

3.3 FISH POPULATION SAMPLING

The electrofishing survey followed a stratified sampling strategy wherein representative habitat units serve as discrete survey sites. Seven sites were sampled upstream of the Sea Ranch wells and nine sites downstream (Figure 3-l)(Table 3-1). More sites were sampled downstream because of the greater amount of habitat present downstream. Several riffles which were sampled in July, both upstream and downstream of the wells, were dry in October. New sites were established to replace those which were no longer suitable. At

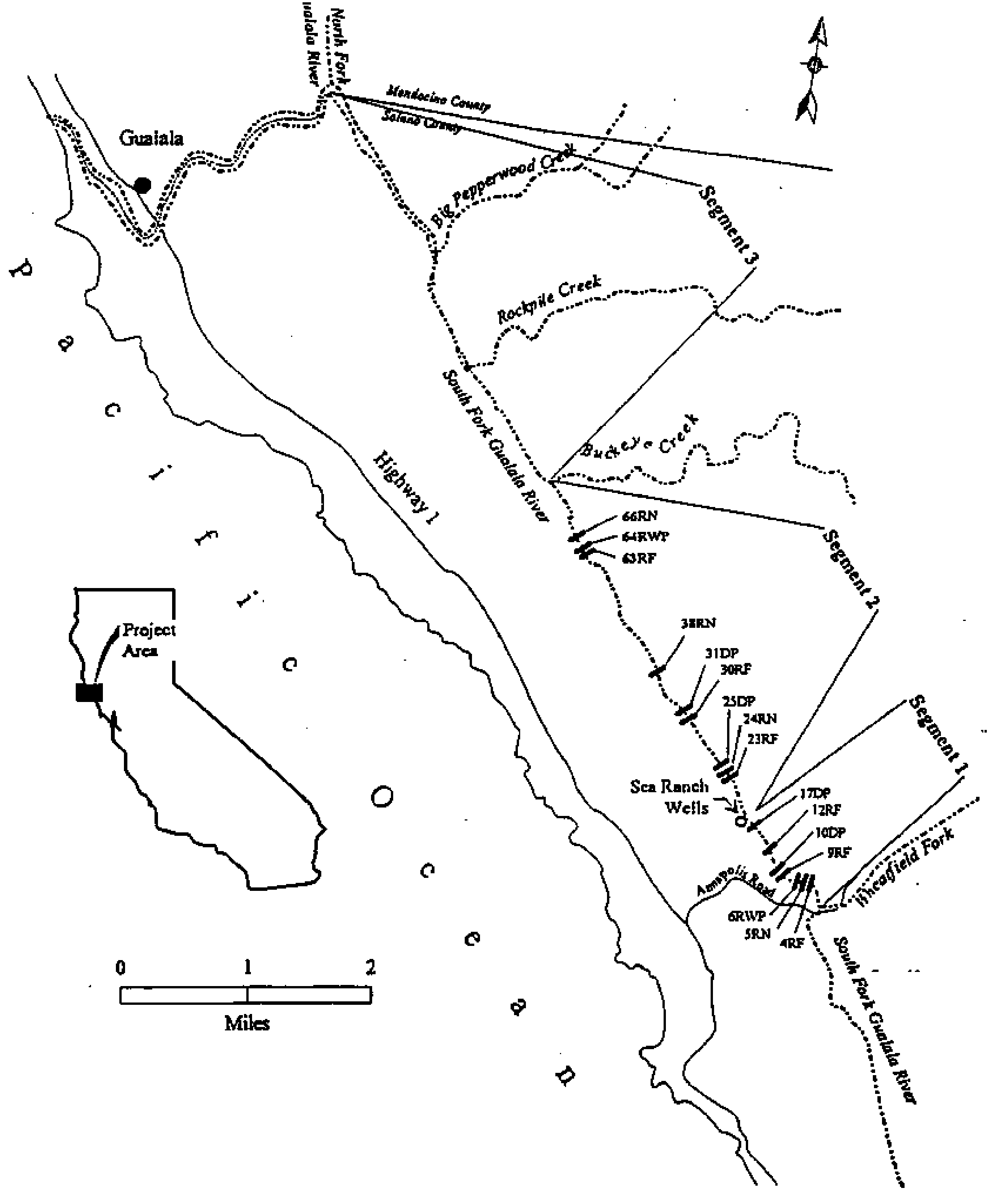


Figure 3-1. Sampling Site Location Map.

Table 3-1. Sample Site Data Summary at Time of July Sampling.

SITE	RIGHT BANK LENGTH(m)	LEFT BANK LENGTH(m)	AVERAGE LENGTH(m)	UPSTREAM WIDTH(m)	DOWNSTREAM WIDTH(m)	AVERAGE WIDTH(m)	MAXIMUM DEPTH(m)	AVERAGE DEPTH(m)	
4RF	30.8*	28.7*	29.8*	24.0*	4.6*	14.3*		0.09*	425.4*
5RN	28.0*	27.4*	27.7*	4.6*	7.6*	6.1*		0.15*	169.0*
6RWP	16.0*	9.7*	12.9*	7.4*	10.6*	9.0*	0.91*	0.61*	115.7*
9RF	12.2*	23.2*	17.7*	11.2*	18.8*	15.0*		0.10*	265.5*
10DP	29.8*	12.3*	21.1*	19.2*	9.8*	14.5*	0.91*	0.46*	305.2*
12RF	44.2*	44.2*	44.2*	4.6*	4.6*	4.6*		0.08*	202.1*
17DP	34.0*	33.8*	33.9*	12.6*	19.8*	16.2*	1.37*	0.30*	549.2*
23RF	16.	16.0	16.0	8.2	3.5	5.9		0.09	93.6
24RN	36.0	35.5	35.8	3.5	6.7	5.1		0.21	182.3
25DP	34.0	32.3	33.2	13.3	18.0	15.7	1.22	0.46	518.8
30RF	71.0	71.0	71.0	10.0	13.0	11.5		0.08	816.5
31DP	21.0	20.0	20.5	9.0	14.0	11.5	1.22	0.46	235.8
38RN	48.0	48.0	48.0	2.0	7.0	4.5	0.76	0.24	216.0
63RF	20.0	20.0	20.0	4.0	6.0	5.0		0.09	100.0
64RWP	13.5	13.5	13.5	6.0	8.0	7.0		0.21	94.5
66RN	35.0	33.0	34.0	8.0	7.0	7.5		0.21	255.0

* Upstream or wells

RF = Riffle
RN =Run
DP = Deep Pool
RWP = Rootwad Pool

the time of sampling in July 1991, streamflows were unseasonably low (approximately 3 cfs) in the South Fork Gualala River downstream of the confluence with the Wheatfield Fork. By the second sampling effort in October 1991, streamflows were intermittent. Continuous surface flow on the South Fork Gualala River resumed approximately 0.7 river miles upstream of the Sea Ranch wells.

Sampling sites both upstream and downstream of the wells were selected after habitat mapping was complete. Sites were selected based on type of habitat (i.e., riffle, run, deep pool and rootwad pool). Block nets were set at the upper and lower boundaries of the sites to prevent immigration and emigration bias in the sample. Fish were captured during multiple passes (usually three) with Smith-Root Type VIII backpack shockers in pulsed DC mode. Two shocker crews consisting of an operator and a netter sampled each site, working abreast downstream to upstream to ensure thorough coverage. Captured fish were held instream in live-cars until removed for processing. To minimize stress on the study animals, the fish were processed in small groups (20) then returned to a separate live-car for recovery. Individual fork lengths were measured to the nearest millimeter for all fish captured and individual weights measured to the nearest gram using a 500 gram scale. Scale samples were taken on any fish that was not obviously young-of-the-year. The length and weight data along with species identification and pass number were recorded on waterproof data sheets. Upon completion of the sample processing, the fish were redistributed throughout the sample area. Water quality measurements including temperature, pH, D.O., and conductivity were taken at each site on the day of fish sampling. The first sampling effort took place from July 23 to July 27, 1991; the second, from October 7 through October 10, 1991.

3.4 PHABSIM MODELING (HABITAT QUANTIFICATION)

Velocity profile data were collected from single transects located randomly within each sample site. Rebar headpins were installed at each transect and a measuring tape was strung across the river perpendicular to the direction of flow. A minimum of 20 verticals per transect were selected with a maximum cell width of three feet. Mean column velocities were taken at 6/10ths of the total depth for verticals less than 2.5 feet deep. For verticals 2.5 feet or deeper, the mean column velocity was taken to be the average of 2/10ths and 8/10ths measurements.

The velocity and depth data were used to construct preliminary IFG4 decks for each unit. The IFG4 decks were converted to MANSQ decks which were then used to calculate predicted water surface elevations. Stage-at-zero-flow measurements were not taken in the field, so deepest verticals were used for the riffles and runs. Stage-at-zero-flow measurements for deep pools and rootwad pools were taken from the depths noted for the immediate downstream habitat units.

The water surface elevations generated by MANSQ were used in the original IFG4 decks for running the IFG4 programs. The flows modeled were 3, 5, 7 and 10 cfs. The IFG4 predicted velocities were checked for viability and edge effects. Habitat decks within each segment were then combined by habitat type to form a single deck for each habitat type and segment. The transects in these decks were weighted to reflect the corresponding habitat unit length.

The models were then run through HABTAT, and then PHABSIM models were constructed by habitat type for both the upstream segment (from the confluence of the Wheatfield Fork to the Sea Ranch wells) and the downstream segment (from the Sea Ranch wells to the confluence of Buckeye Creek). Habitat suitability criteria for fry and juvenile steelhead trout were generally taken from Bovee (1978). However, fry and juvenile were observed to utilize pools with velocities lower than Bovee's criteria. Steelhead and rainbow trout are known to occupy areas of lower velocities and greater depths in pools than in riffle or run habitat (Modde and Hardy 1992). Therefore, the criteria set was slightly modified to reflect the utilization of low velocity areas in the deep pools.

3.5 TEMPERATURE MONITORING

Temperature data were collected using Omnidata recorders placed at three locations in the study section: the first just upstream of the Sea Ranch wells, the second just upstream of the confluence with Buckeye Creek and the third just upstream of the confluence with the North Fork Gualala River. The recorders were programmed to measure water temperature at five-minute intervals, electronically store these data, and then record the mean value for a two-hour time step. The average daily temperatures were then determined by averaging the twelve bihourly values. The highest and lowest two-hour values were used to represent maximum and minimum daily values.

3.6 STREAMFLOW MONITORING

Streamflow monitoring gages were installed by the USGS upstream and downstream of the SRWC wells. Daily flow data were obtained from these gages through the USGS. Streamflow records were analyzed in an attempt to determine the effect of subsurface water withdrawal (from the SRWC wells) on surface flow.

3.7 DATA ANALYSIS

Fisheries data analysis included population size, length-weight analysis, and age structure from length-frequency and fish scale analysis (Zar 1974). Population estimates were compared among the sampled habitat units for July and October. Estimates and statistics were generated using the SYSTAT and Microfish computer packages (Wilkinson 1987).

4.0

RESULTS

4.1 HABITAT SUMMARY

The South Fork Gualala River from the confluence of the Wheatfield Fork to the confluence of the North Fork Gualala was mapped on July 13 and 14, 1991. Hereon, "South Fork Gualala" will refer to the study reach. Observations on habitat type, average length, average width, average depth, maximum depth, substrate, cover, and water velocity were recorded. This summary is intended to provide a general overview of the habitat characteristics and patterns of occurrence in the mapped stretch as well as some qualitative observations on the "usability" of the habitat by rearing steelhead. It should be stressed that given the variability in flow both seasonally and between years, habitat conditions on the South Fork Gualala may differ considerably over time.

The South Fork Gualala is a low gradient river with periodic, short, moderately steep riffles and/or runs. The flood plane is narrow to moderately wide (< 100'-1500') with the active channel varying in width from several feet to occupying the entire flood plane. Substrate in the flood plane is almost completely gravel (0.25-3.0") with some pockets of silt and sand. The study reach has essentially no bedrock, boulder or cobble substrate.

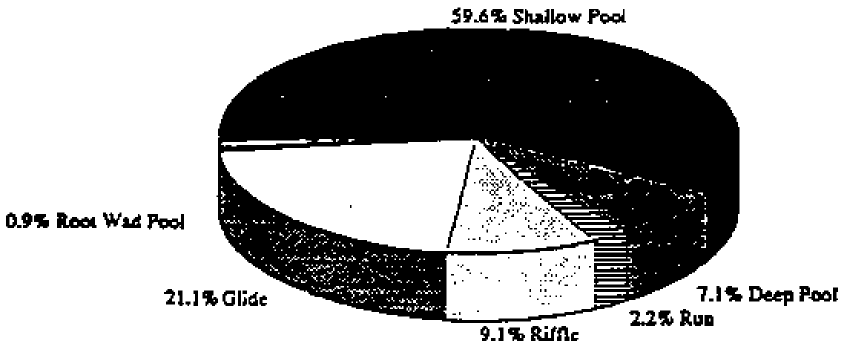
For the purposes of this study, the South Fork Gualala has been divided into three segments; (1) upstream of the Sea Ranch Wells, (2) between the Sea Ranch Wells and Buckeye Creek, and (3) downstream of Buckeye Creek to the confluence with North Fork Gualala River. The principle criteria for the divisions are the presence of the Sea Ranch Wells and the inflow of Buckeye Creek, estimated at around 1 cfs at the time of mapping. Some of the key morphological characteristics of each segment are summarized in the following paragraphs.

Segment 1, upstream from the Sea Ranch Wells to the confluence with the Wheatfield Fork, covers approximately 0.7 river miles; considerably less than the downstream segments. At the confluence, the flood plane is at its widest, spanning over 1000 feet. The active channel is generally fairly narrow, ranging from less than five feet to around fifty feet in width with willow and other riparian vegetation on either bank (rarely both). At the time of mapping, surface flow on the South Fork Gualala was intermittent upstream of the confluence with the Wheatfield Fork but was continuous from the confluence through the entire mapped reach. With a slightly higher gradient than the downstream segments, Segment 1 contains relatively large percentages of riffle and glide habitat (9.1 and 21.1% respectively) (Figure .4-1). Long, narrow (<50'), shallow (<2') pools comprise the bulk of the habitat area in Segment 1 (59.6%). The shallow pool habitat was determined to be unsuitable for juvenile salmonids because of the combination of shallow, depths, low velocities and no cover. Fish, other than Gualala roach and threespine stickleback, were rarely observed in this habitat type. Deep pool habitat was fairly limited in Segment 1 comprising only 7% of total habitat. However, those deep pools present had excellent canopy cover and relatively good stream velocity.

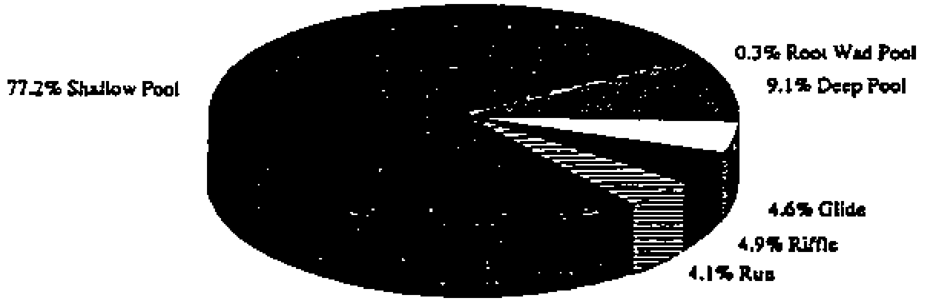
Segment 2, from Buckeye Creek to the Sea Ranch Wells, covers approximately 2.5 river miles. The broad flood plane is broken by substantial thickets of willow and other riparian vegetation. The active channel is often quite narrow, sometimes less than 5', and is marked by a thick willow riparian on one or both banks. For the most part, the active channel meanders from side to side in the flood plane with the edge of the plane forming one bank on the majority of the units. Most of the habitat area (77.2%) is long shallow pool similar to that which dominates Segment 1. Narrow (<20') riffle/run stretches connect the shallow pools. Riffle habitat comprised only about 4.9% of the total area while deep pool habitat, generally comprised 9% of the total area. However, deep pool habitat in Segment 2 was not always associated with good canopy cover as was apparent in Segment 1. Also, velocities through the deep pools were not as high as those in deep pools in Segment 1.

Segment 3, from Buckeye Creek to the confluence of the North Fork (approximately 2.9 river miles), generally has a lower gradient than the upper segments. The flood plane is narrower (<500') with established second growth forest on the margins. The active channel is broader and less likely to be confined by riparian vegetation. The active channel meanders from side to side in the flood plane, though the meanders tend to be more abrupt than in the upstream segments and flow directly to the opposite side of the plane. The predominant pattern for the downstream segment is long, wide

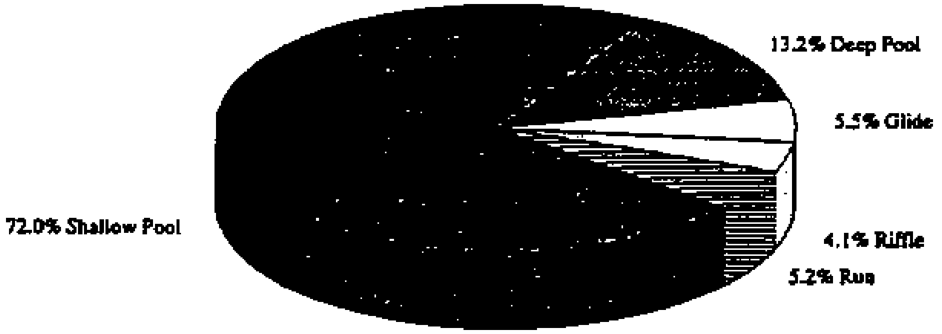
South Fork Gualala River Habitat Area Breakdown - Segment 1



Segment 2



Segment 3



Segment 1 - Upstream of Sea Ranch Wells to the confluence with Wheatfield Fork (0.7 river miles).
Segment 2 - Downstream of Sea Ranch Wells to the confluence with Buckeye Creek *(25* river miles).
Segment 3 - Downstream of Buckeye Creek to the confluence with NF Gualala River (2.9 river miles).

Figure 4-1 South Fork Gualala River Habitat Area Breakdown

(<50'), shallow pools with the edge of the flood plane as one bank separated by short, shallow riffles cutting diagonally to the opposite flood plane bank. Wide, shallow pool comprises 72.0% of the total Segment 3 habitat area. Deep pools accounted for 13% of total habitat area.

Usability of much of the shallow pool habitat in both segments is probably fairly low. The very wide, shallow pools, most of which occur downstream of Buckeye Creek, are essentially only usable in the deeper portions along the stream bank. The other bank gradually shallows up to a gravel bar. Little or no velocity was observed in the shallow flats and daytime water temperatures in excess of 20°C were noted.

4.2 FISH POPULATIONS

4.2.1 SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Seven species of fish were collected from stations in the South Fork Gualala River: steelhead *(Oncorhynchus mykiss);* coastrange sculpin *(Cottus aleuticus);* prickly sculpin *(Cottus asper);* Pacific lamprey *(Entosphenus tridentatus);* threespine stickleback *(Gasterosteus aculeatus);* green sunfish *(Lepomis cyanellus)* and California roach *(Lavinia symmetricus).* Moyle et al. (1989) has suggested that the California roach found in the Gualala river is actually a local subspecies, the Gualala roach (L. *s. parvipinnis).* No coho salmon *(Oncorhynchus kisutch)* were collected during this study.

The three most abundant species over all stations (both upstream and downstream) were juvenile steelhead, Gualala roach and threespine stickleback (Table 4.1). Gualala roach were generally dominant, although threespine stickleback were most abundant in upstream riffle habitat in July and upstream run habitat in October. Steelhead were the most abundant species in upstream run habitat in July.

Juvenile and adult Gualala roach (greater than 30 mm in length) abundance in July ranged from 148 to 977 fish/l00m upstream of the wells and from 125 to 1,474 fish/l00m downstream of the wells. October abundance ranged from 136 to 505 fish/l00m upstream and 146 to 263 fish/l00m downstream. Roach were generally

Table 4-1. Species composition and relative abundance (fish/100m) by habitat type upstream and downstream from the Sea Ranch wells for July and October, 1991.

		July		October	
Habitat Type	Species	Upstream	Downstream	Upstream	Downstream
Riffle	Steelhead	280	63	18	13
	Gualala roach	297	125	136	236
	3-spine stickleback	615	69	63	68
	Prickly sculpin	0	7	25	4
	Coastrange sculpin	0	29	20	4
	Green sunfish	0	0	0	0
	Pacific lamprey	13	13	2	3
Run	Steelhead	451	121	47	40
	Gualala roach	148	161	505	146
	3-spine stickleback	116	52	690	63
	Prickly sculpin	7	29	0	9
	Coastrange sculpin	0	4	0	5
	Green sunfish	0	0	0	1
	Pacific lamprey	69	186	11	64

Table 4-1. (concluded) Species composition and relative abundance (fish/100m) by habitat type upstream and downstream from the Sea Ranch wells for July and October, 1991.

		July		October	
Habitat Type	Species	Upstream	Downstream	Upstream	Downstream
Deep Pool:	Steelhead	135	63	80	145
	Gualala roach	200	134	231	263
	3-spine stickleback	116	110	147	115
	Prickly sculpin	76	50	78	28
	Coastrange sculpin	2	0	2	0
	Green sunfish	9	4	0	7
	Pacific lamprey	38	22	9	7
Rootwad Pool:	Steelhead	388	193	171	81
	Gualala roach	977	1474	318	178
	3-spine stickleback	380	30	326	0
	Prickly sculpin	93	133	16	22
	Coastrange sculpin	0	0	0	0
	Green sunfish	0	0	0	0
	Pacific lamprey	372	104	23	15

most abundant in rootwad pools where algae was also abundant. Roach are known to be abundant in coastal streams where other Cyprinids are absent (Moyle 1976) The Gualala roach population appears to be healthy throughout the South Fork Gualala River.

Juvenile and adult threespine stickleback populations were as high as 615 fish/l00m in July and 690 fish/100m in October in upstream riffle and run habitat. Stickleback populations were lower downstream, ranging to 110 fish/l00m in July and up to 115 fish/100m in October. Lower abundance downstream may be a reflection of their preference for cool water. Moyle (1976) states that stickleback prefer water temperatures less than 23 to 24°C for long-term survival. Temperatures over 25°C were observed downstream of the wells (see Section 4.4).

Prickly sculpin were sometimes abundant, especially in pool habitat were abundances up to 93 fish/100m were observed upstream and 133 fish/100m downstream in July. Coastrange sculpin were moderately abundant in the furthest downstream riffles and runs. Their distribution and abundance was similar to that observed by Moyle (1976) where coastrange sculpin are less common than prickly sculpin, but may be moderately abundant in swift gravel riffles in the lower sections of coastal streams.

Pacific lamprey ammocoetes (i.e., stream-dwelling juveniles) were sometimes abundant in pool and run habitat. Lamprey ammocoetes burrow into stream sediments where they remain (but not in the same location) for up to seven years before emigrating to the ocean. Green sunfish were never abundant, but were infrequently collected in pool habitat.

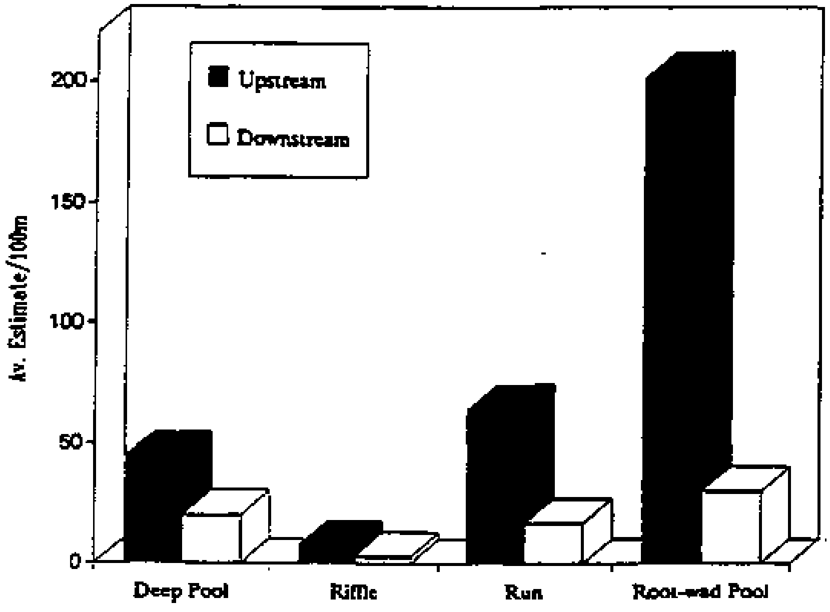
4.2.2 STEELHEAD POPULATION ESTIMATES

Juvenile steelhead population estimates are averaged by habitat type upstream and downstream of the Sea Ranch wells and are presented in Table 4-2. Young-of-the-year (YOY) steelhead were more abundant in July over all habitat types upstream of the wells, ranging from an average of 112 fish/100m in deep pools to 386 fish/100m in run habitat. (Figure 4-2 and 4-3). In the South Fork Gualala River downstream of the wells, average YOY abundance ranged from 66 to 178 fish/100m in riffle and pool habitat, respectively.

Table 4-2. Average juvenile steelhead population estimates (fish/100m) by habitat type upstream and downstream from the Sea Ranch wells for July and October, 1991.

	July		October	
	Upstream	Downstream	Upstream	Downstream
Base Population				
Riffle	8.0	3.3	0	2.5
Run	65.0	16.7	0	3.0
Deep Pool	44.5	20.0	29.0	24.0
Rootwad Pool	202.0	30.0	39.0	15.0
YOY Population				
Riffle	278.0	66.3	18.0	25.5
Run	386.0	105.7	47.0	34.7
Deep Pool	112.0	71.0	46.5	179.0
Rootwad Pool	210.0	178.0	132.0	67.0

COMPARISON OF UPSTREAM AND DOWNSTREAM POPULATION ESTIMATES FOR STEELHEAD BASE - JULY 1991



COMPARISON OF UPSTREAM AND DOWNSTREAM POPULATION ESTIMATES FOR STEELHEAD BASE - OCTOBER 1991

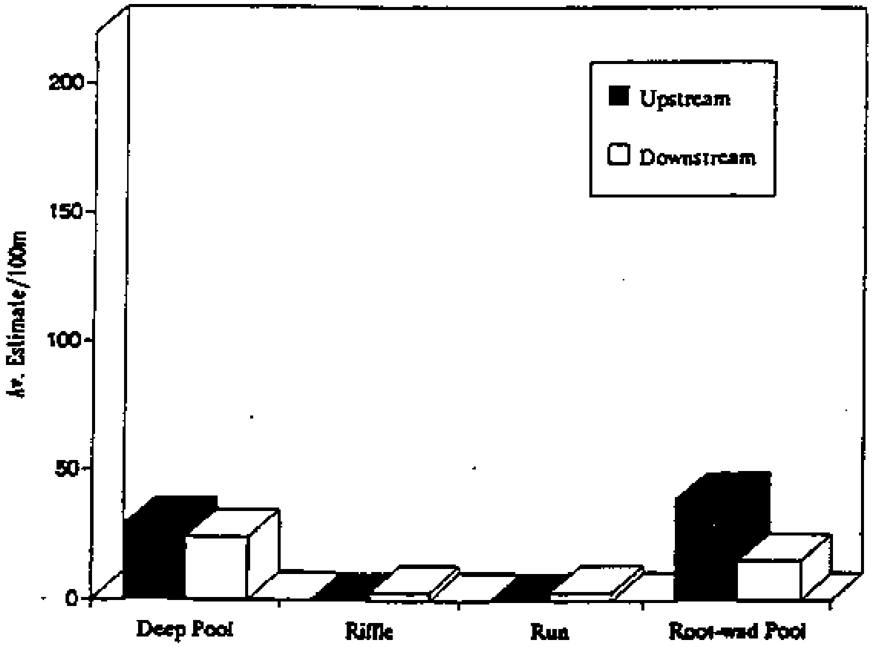
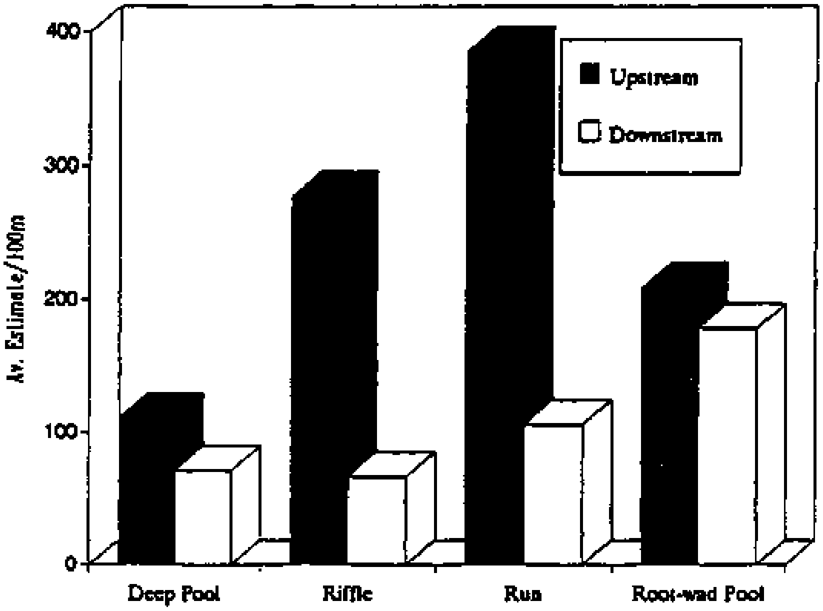


Figure 4-2 Comparison of Upstream and Downstream Base Steelhead Population Abundance by Habitat Type.

COMPARISON OF UPSTREAM AND DOWNSTREAM POPULATION
ESTIMATES FOR STEELHEAD YOY - JULY 1991



COMPARISON OF UPSTREAM AND DOWNSTREAM POPULATION
ESTIMATES FOR STEELHEAD YOY - OCTOBER 1991

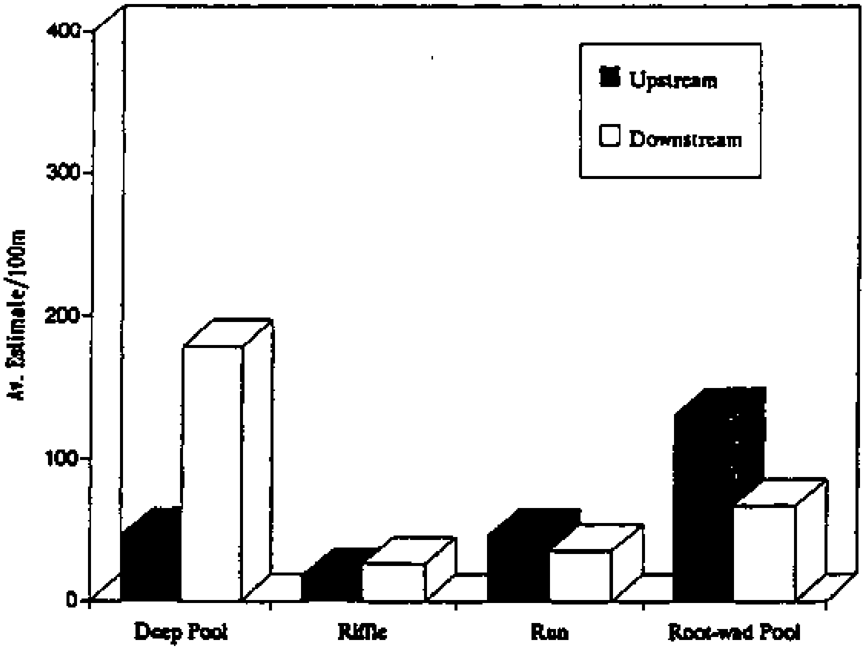


Figure 4-3 Comparison of Upstream and Downstream YOY Steelhead Population Abundance by Habitat Type.

By October, YOY abundance upstream of the wells had declined to approximately 25% of that observed in July. YOY abundance ranged from 18 fish/l00m in riffles to 132 fish/100m in rootwad pools. More substantial decline was apparent in the riffle and run habitat where YOY abundance in October was only 10% of that observed in July.

The decline in YOY abundance from July to October downstream of the Sea Ranch wells was not as substantial as had occurred upstream. Downstream YOY abundance in October ranged from 26 fish/l00m in riffles to 179 fish/l00m in deep pools. Overall, downstream YOY abundance in October had only declined to 73% of population levels observed in July.

Base population (fish of age 1 year and older) estimates reflect the degree of overall habitat quality present throughout the year. Nearly all of the base steelhead population was age 1+ with a small percentage of age 2 + fish. Upstream base population estimates in July ranged from 8 fish/l00m in riffles to 202 fish/l00m in rootwad pool habitat.

Downstream base populations in July averaged 3 fish/100m in riffles to 30 fish/l00m in rootwad pools. By October, no base population steelhead were observed in riffle or run habitats upstream of the wells. However, abundance ranged from 29 to 39 fish/100m in upstream pool habitats, indicating that older juveniles were seeking refuge pool habitat in October, a function of very low stream flow and poor to marginal habitat suitability in riffle and run habitat.

Also in October, downstream base population steelhead abundance followed a trend similar to upstream abundance, ranging from only 2 to 3 fish/l00m in riffle and run habitat, but up to 24 fish/l00m in pool habitat. Clearly, pool habitat was most important as refugia for juvenile steelhead populations in October, both upstream and downstream of the wells. Limited qualitative sampling was also conducted in the Wheatfield Fork and other tributaries to the South Fork Gualala River in July. Young-of-the-year steelhead abundance was higher (over 400 fish/100m) at all tributary sites sampled, indicating that spawning is most likely occurring in the tributaries rather than in the mainstream. Greater abundance of YOY immediately downstream of the confluence with the Wheatfield Fork in July suggests that YOY were emigrating from upstream spawning sites as streamflows declined in the tributaries. At the time of sampling in July, streamflow in the South Fork Gualala River had dropped substantially to 3 cfs from about 20 cfs three weeks earlier. Declining streamflows are an important cue for juvenile steelhead to begin emigration from spawning grounds and/or rearing areas. Downstream movement of juveniles continues until suitable rearing habitat is encountered. This could explain the higher numbers of YOY and base steelhead immediately below the confluence of the Wheatfield Fork in July where combined flows of the two tributaries resulted in increased suitable habitat.

By October, steelhead abundance was similar by habitat types both upstream and downstream of the wells. This indicates that over-summering juvenile steelhead populations had equilibrated with habitat availability throughout the South Fork Gualala River.

AGE STRUCTURE

Generally, three age classes of juvenile steelhead were found in July and October 1991 in the South Fork Gualala River (Table 4-3). The exception was a 335 mm juvenile steelhead or resident rainbow trout (greater than age 2+) which was collected upstream from the wells in October. The age structure of the juvenile steelhead population was similar between July and October in that about 85 percent of the population were young-of-the-year and about 15 percent were age 1 + fish. Only two fish collected in both July and October were age 2+.

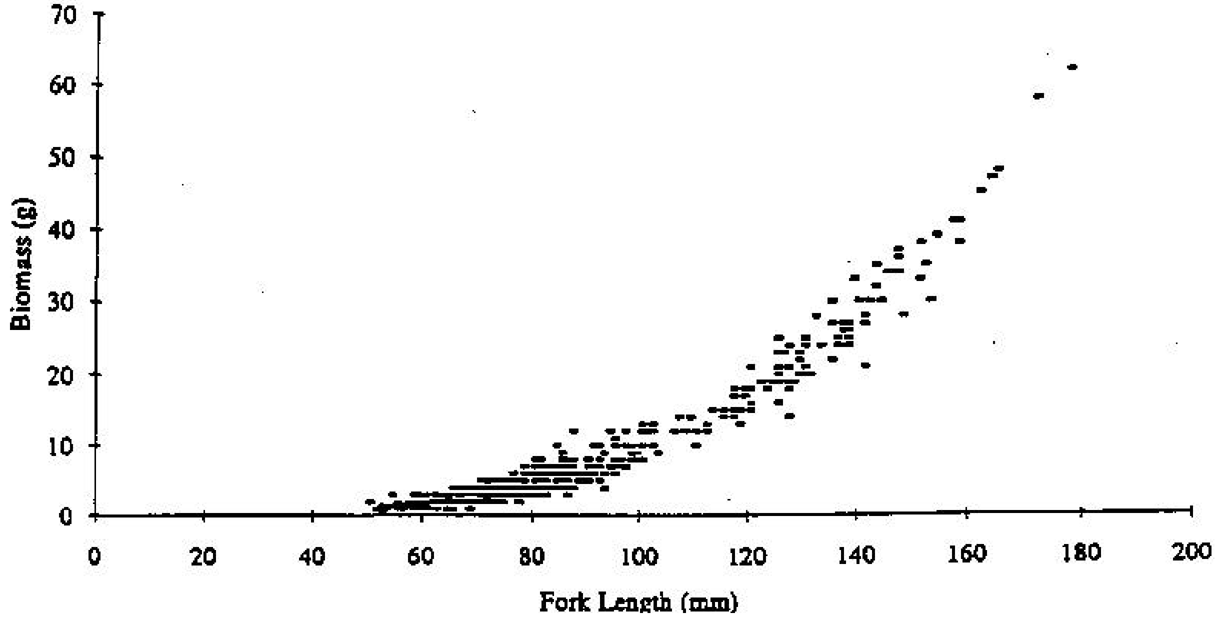
The relatively small percentage of age 1 + and older fish reflects lower than normal streamflows in the South Fork Gualala River during the past few years (i.e., drought conditions), particularly in summer and fall. Lower streamflow generally results in lower available habitat, especially for older (i.e., age 1 + and older) juveniles, which in turn, results in either early emigration or mortality of rearing juveniles. However, those fish that were present appeared to be in good health. The length-weight relationship of fish collected in both July and October shows normal growth as compared with data from other coastal streams (Figure 4-4) (Shopovalov and Taft 1953).

4.3 PHABSIM HABITAT MODELING

The Physical Habitat Simulation (PHABSIM) models constructed for the South Fork Gualala River provide information on potential changes in steelhead habitat as a result

Table 4-3. Juvenile steelhead population age structure from South Fork Gualala River, 1991.

Age	n	Percent	Length Range (mm)
July			
0+	551	84.6	50-104
1 +	98	15.1	105-169
2+	2	0.3	170-179
October			
0+	198	84.3	60-119
1 +	34	14.5	120-179
2+	2	0.8	185-194
>3 +	1	0.4	335


Fork Length vs. Biomass for Steelhead Trout
South Fork Gualala River - July 1991

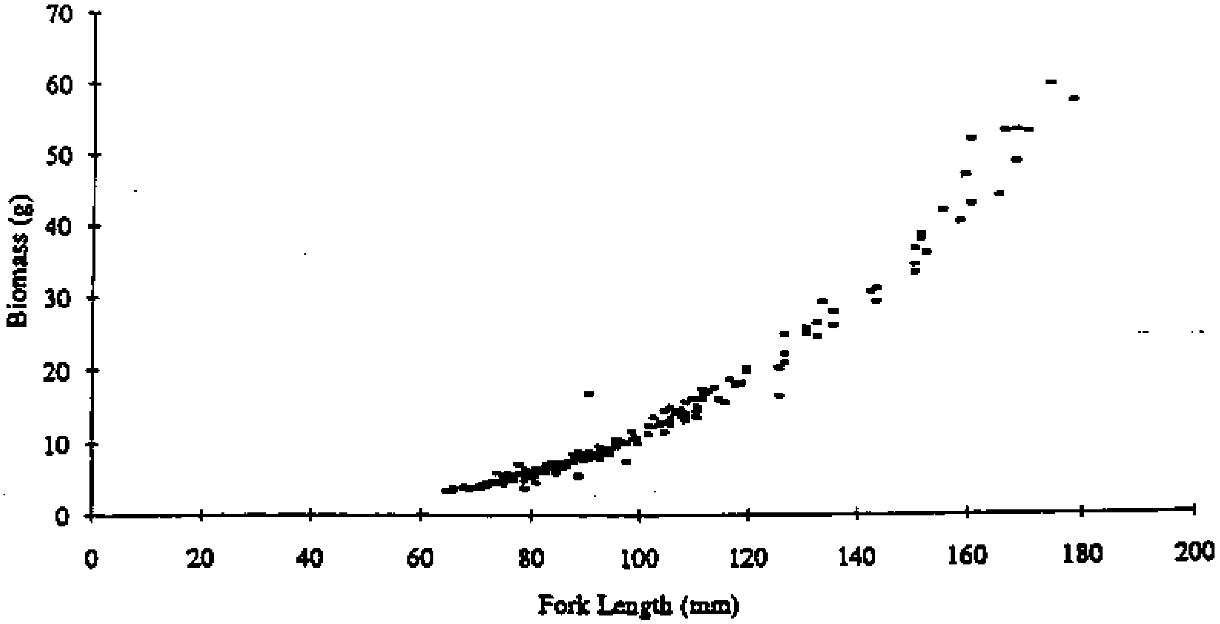

Fork Length vs. Biomass for Steelhead Trout
South Fork Gualala River - October 1991

Figure 4-4. Length-weight relationship for juvenile steelhead collected in July and October 1991 in the South Fork Gualala River.

of altering flows. These models were constructed using a single velocity set. The computed Weighted Usable Area (WUA) value should not be viewed as an absolute but rather as an index for evaluating changing conditions.

4.3.1 HABITAT QUALITY

Both upstream and downstream WUA vs. Q (i.e., streamflow) functions are presented in Appendix B. Habitat quality (given as WUA) is measured per 1,000 feet of stream. These functions are an intermediate step in determining results of downstream water withdrawl on the quantity of downstream habitat. However, these functions can be used to compare existing habitat quality both upstream and downstream of the wells. For example, the upstream riffle model for fry predicts around 20,000 sq. ft. of habitat at 10 cfs versus around 10,000 sq. ft. for the downstream model at the same flow (Appendix B). The juvenile steelhead riffle models show a similar trend in that upstream riffle habitat quality (measured in terms of WUA) is about double that calculated for the same length of riffle section downstream of the wells. This indicates that there is more suitable habitat for both fry and juveniles in the upstream riffles than downstream riffles due to more suitable velocities and depths.

This trend is also apparent for deep pool habitat. For deep pool fry habitat, the model predicts three times more habitat per stream length in the upstream units at 10 cfs as compared to the downstream deep pool units (800 sq. ft., vs. 200 sq. ft. respectively). Juvenile deep pool habitat is about four times more abundant per stream length upstream than downstream. Thus, deep pool habitat is also more suitable for fry and juvenile steelhead upstream than downstream of the wells.

The quality of run habitat appears to be similar upstream and downstream of the wells as determined by both fry and juvenile steelhead run models (Appendix B).

4.3.2 HABITAT QUANTITY

In assessing the potential impacts of flow alteration, we have made the very conservative assumption that there is a one to one relationship between the amount of subsurface water withdrawn through the wells and the actual depletion of surface flow on the South Fork Gualala River. As such, we took the maximum summer pumping rate of 0.5 cfs to be the change in surface flow over which to compare changes in habitat. This can be regarded as a worst case scenario since analysis of streamflow gages indicates that surface flow is not responding to subsurface withdrawl at the rate of 0.5 cfs.

The changes in habitat resulting from removal of 0.5 cfs of surface flow are given as a percent change in WUA per 1000 ft. of a given habitat type (Table 4-4). Riffle habitat provides important rearing areas and food production for fry (i.e., less than 80 mm in length) and juvenile steelhead. Any impacts of altering streamflow on steelhead populations should be apparent in the riffle habitat. For the riffle model evaluated for steelhead fry from 7 to 10 cfs, a 0.5 cfs change in flow would not result in a detectable change in habitat area. In the 3 to 7 cfs range, however, the slope of both WUA vs. Q functions increases substantially (Appendix B). The maximum change in total habitat for a 0.5 cfs drop in flow within the 3 to 7 cfs range could fall between 2 and 10%.

The riffle models evaluated for juvenile steelhead riffle habitat show similar patterns. In the 3 to 7 cfs range, both models predict around a 10% change in habitat for a 0.5 cfs change in flow. From 7 to 10 cfs, the curves flatten out, showing a 5% reduction in habitat with a 0.5 cfs decrease in flow.

PHABSIM models evaluated for steelhead fry in run habitat show a slight increase (1 to 5%) in WUA with a 0.5 cfs decrease in flow over the 3 to 10 cfs range. The run models for juvenile steelhead, however, show a peak at around 7 cfs. From 3 to 7 cfs, a 0.5 cfs drop in flow results in a range of 1 to 6% reduction in juvenile habitat. In the 7 to 10 cfs range, no change in WUA is apparent with a 0.5 cfs decrease in flow.

Both models (fry and juvenile) for the deep pool habitat show an increase in WUA with decreased flow. Fry habitat increases from 8 to 10% over the range of 3 to 10 cfs resulting from a 0.5 cfs reduction in flow. The deep pool model evaluated for juvenile steelhead habitat predicts a 10 to 15% increase in WUA per 0.5 cfs drop in flow over the 3 to 10 cfs range.

The rootwad pool models show a variety of responses. The model evaluated for steelhead fry peaks at around 5 cfs. From 3 to 5 cfs, a 0.5 cfs drop in flow results in around a 3% decrease in steelhead fry habitat. From 5 to 10 cfs, however, the model predicts increasing WUA (1-2%) with a 0.5 cfs decrease in flow. For juvenile

Table 4-4. Percent change in WUA for a 0.5 cfs decrease in streamflow, for three given flow ranges.

		Flow Range (cfs)		
Habitat Type	Steelhead Lifestage	3 to 5	5 to 7	7 to 10
Riffle	Fry	-10	-2	0
Riffle	Juvenile	-10	-7	-5
Run	Fry	+2	+4	+4
Run	Juvenile	-6	-1	0
Deep Pool	Fry	+ 10	+ 10	+8
Deep Pool	Juvenile	+ 10	+ 10	+ 15
Rootwad Pool	Fry	-3	+ 1	+2
Rootwad Pool	Juvenile	-8	-5	-2

steelhead habitat, a 0.5 cfs drop in flow decreases WUA by 8% in the 3 to 5 cfs range. However, from 5 to 10 cfs, WUA decreases by a range of only 5 to 2%.

4.4 WATER TEMPERATURE

For both daily average and maximum stream temperature values, temperature was lowest upstream of the Sea Ranch wells, highest downstream of the wells to Buckeye Creek, and intermediate downstream from Buckeye Creek (Figure 4-5 and Appendix C). Maximum daily water temperatures were as high as 21.5°C upstream of the wells, 25.0°C downstream of the wells, and 23.5°C downstream of Buckeye Creek. Respective average daily water temperatures were as high as 18.7°C, 21.4°C, and 20.6 °C.

This phenomenon can at least partially be explained by examining daily air temperatures (Figure 4-6 and Appendix C), and evaluating hydrologic conditions in the South Fork Gualala River. Maximum air temperatures were usually greatest in the stream portion downstream of the Sea Ranch wells. Air temperatures were cooler below Buckeye Creek, presumably a function of ocean fog extending inland.

Secondly, most of the active channel upstream of the wells is confined to one side of the flood plain or the other and is generally covered by riparian canopy. The South Fork Gualala River downstream of the wells is generally characterized as having a broad flood plain with a meandering active channel and little canopy cover. The stream gradient is lower as compared with the stream portion upstream of the wells. Thus, the downstream channel is more conducive to warming from solar radiation than upstream.

4.5 STREAMFLOW MONITORING

Data from the two USGS stream gages installed upstream and downstream from the Sea Ranch wells were analyzed to determine if subsurface water withdrawal through the wells affects Gualala River streamflow. Total streamflow ranged from 1.3 to 22.0 cfs (as measured at the upstream gage) during the time period of analysis (June 1 through September 30, 1991). Table 4-5 presents the mean daily streamflows

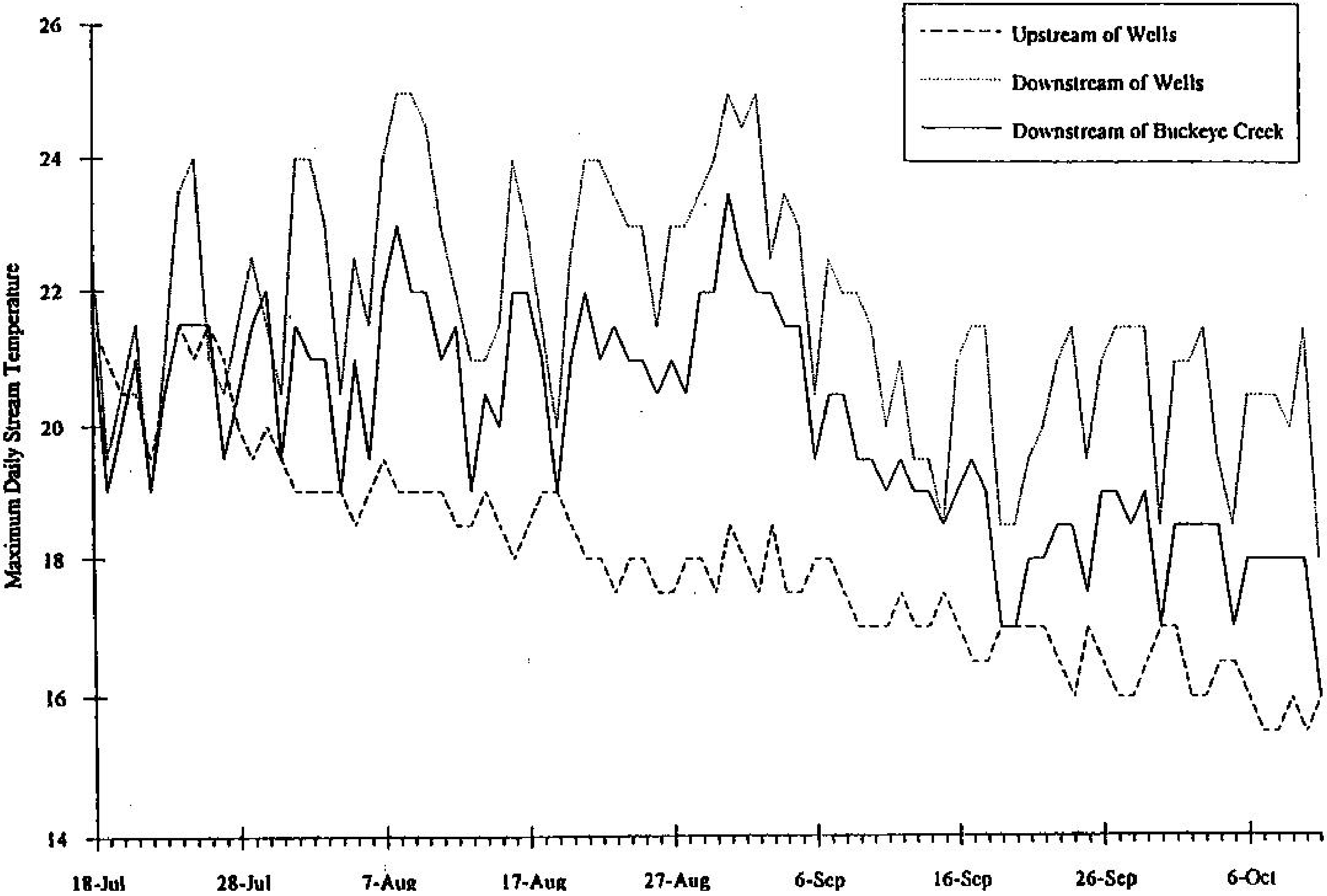


Figure 4-5. Maximum daily stream temperatures (°C) in the South Fork Gualala River, July through October, 1991.

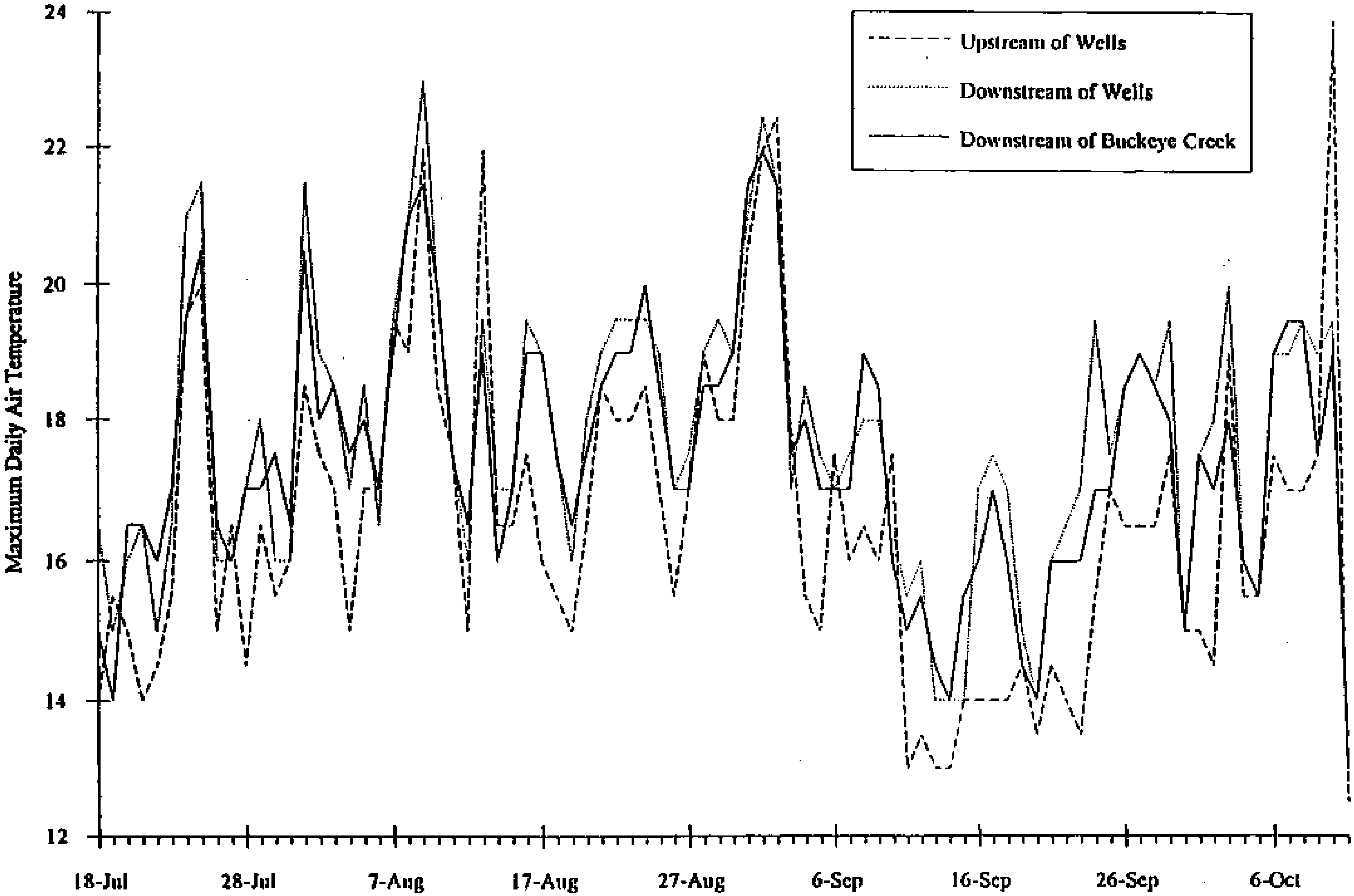


Figure 4-6. Maximum daily air temperatures (°C) in the South Fork Gualala River, July through October, 1991.

Table 4-5. Mean daily streamflows and mean daily differences (D streamflow) measured from gages upstream and downstream of the Sea Ranch wells for June 1 through September 30, 1991.

	June			July			August			September		
Day	Upstream	Downstream	↴	Upstream	Downstream	↴	Upstream	Downstream	↴	Upstream	Downstream	↴
|	22.00	22.00	0.00	15.00	16.00	-1.00	1.90	2.10	-0.20	1.70	0.73	0.97
2	21.00	21.00	0.00	12.00	14.00	-2.00	1.90	2.00	-0.10	1.60	0.65	0.95
3	18.00	20.00	-2.00	10.00	11.00	-1.00	1.60	.80	-0.20	1.60	0.76	0.84
4	18.00	19.00	-1.00	8.90	9.90	-1.00	1.50	.60	-0.10	1.60	0.82	0.78
5	18.00	18.00	0.00	7.40	8.60	-1.20	1.70	.80	-0.10	1.50	0.81	0.69
6	17.00	18.00	-1.00	7.00	7.90	-0.90	1.70	.90	-0.20	1.50	0.82	0.68
7	16.00	16.00	0.00	6.50	7.60	-1.10	1.80	.00	-0.20	1.50	1.00	0.50
8	16.00	16.00	0.00	6.00	7.00	-1.00	1.80	2.10	-0.30	1.50	0.95	0.55
9	15.00	15.00	0.00	5.90	6.90	-1.00	2.00	.90	0.10	1.50	1.00	0.50
10	15.00	14.00	1.00	5.50	6.50	-1.00	2.00	.80	0.20	1.50	0.93	0.57
11	14.00	12.00	2.00	5.30	6.30	-1.00	1.60	.70	-0.10	1.40	0.86	0.54
12	13.00	11.00	2.00	5.20	5.80	-0.60	1.90	.70	0.20	1.40	0.95	0.45
13	12.00	11.00	1.00	5.00	5.60	-0.60	2.30	.50	0.80	1.30	0.73	0.57
14	10.00	10.00	0.00	4.80	5.40	-0.60	2.50	.40	1.10	1.40	0.92	0.48
15	9.70	10.00	-0.30	4.30	5.00	-0.70	2.40	.60	0.80	1.30	0.64	0.66
16	9.50	9.70	-0.20	4.40	4.80	-0.40	1.70	.40	0.30	1.40	0.71	0.69
17	8.50	9.20	-0.70	4.30	5.10	-0.80	2.00	.20	0.80	1.40	0.62	0.78
18	8.40	9.00	-0.60	3.80	4.50	-0.70	2.10	.30	0.80	1.40	0.59	0.81
19	8.60	8.60	0.00	3.40	4.70	-1.30	2.00	.20	0.80	1.60	0.60	1 00
20	8.10	8.20	-0.10	3.30	4.40	-1.10	2.00	.30	0.70	1.60	0.54	1.06
21	8.30	8.00	0.30	3.20	3.90	-0.70	1.90	1.10	0.80	1.40	0.61	0.79
22	7.80	7.30	0.50	3.00	3.70	-0.70	1.90	1.10	0.80	1.50	0.63	0.87
23	6.20	5.20	1.00	3.20	3.70	-0.50	1.60	0.98	0.62	1.70	0.57	1.13
24	5.30	4.70	0.60	3.70	3.60	0.10	1.70	0.91	0.79	1.60	0.55	1.05
25	5.60	5.90	-0.30	2.70	3.50	-0.80	1.70	0.87	0.83	1.60	0.56	1.04
26	6.90	8.00	-1.10	2.50	2.40	0.10	1.50	0.85	065	1.50	0.54	0.96
27	7.80	10.00	-2.20	3.00	2.70	0.30	1.50	0.75	0.75	1.50	0.50	1.00
28	12.00	13.00	-1.00	2.70	2.60	0.10	1.60	0.80	0.80	1.50	0.43	1.07
29	17.00	16.00	1.00	2.50	2.50	0.00	1.40	0.68	0.72	1.40	0.38	1.02
30	19.00	19.00	0.00	2.40	2.30	0.10	1.40	0.69	0.71	1.50	0.65	0.85
31	--	--	--	2.50	2.40	0.10	1.70	0.73	0.97	...	—	—

at both stream gages and the mean daily differences for streamflow between the gages (A streamflow) for the period of record.

There does not appear to be a pattern of lower streamflows at the downstream gage (as compared to the upstream gage) until total streamflow is less than 2.5 cfs (as measured at the upstream gage). At total streamflow less than 2.5 cfs, positive A streamflow values ranging from 0.1 to 1.1 cfs are apparent. At total streamflows greater than 2.5 cfs, A streamflow values range from -2.0 to +2.2, cfs with no apparent pattern or regularity.

Daily water production from the Sea Ranch wells, recorded as daily gallons per day as well as daily cfs withdrawl, was compared against daily A streamflows to check for any consistency or correspondence between amount of water withdrawl and change in streamflow as measured by the two gages. Daily cfs values (well production) generally ranged between .3 to .6 during the period of record. Occasionally, cfs values fall outside the range of .3 to .6, but this is due to the method of recording those values over two-day periods. The result was that no consistency or correspondence between well production and A streamflow values was found.

It appears that A streamflow values are artifacts resulting from either (1) the streamflow measuring devices and methods, or (2) subtle changes in stream controls and hydrology, and may not accurately reflect actual differences in total streamflow. This is especially apparent for total streamflows less than 2.5 cfs.

5.0
SUMMARY OF CONCLUSIONS

This section summarizes the findings of this study and presents conclusions. This section is divided into two parts and addresses the two major objectives of the study: assessment of present project-related operations of the steelhead resource in the Gualala River and assessment of the adequacy of Term 14 streamflows to protect the steelhead resource. The major conclusions of this study are:

- Project-related effects on the steelhead resources in the South Fork Gualala River resulting from present subsurface groundwater withdrawl through Sea Ranch wells are non-detectable.

- No change in South Fork Gualala River surface flow downstream of the wells from subsurface water withdrawl is apparent at streamflows over 5 cfs.

- Term 14 fishery bypass streamflows are adequate to protect habitat quantity and quality for juvenile steelhead downstream of the Sea Ranch wells.

5.1 ASSESSMENT OF THE EFFECTS OF PRESENT OPERATIONS ON STEELHEAD RESOURCES

Steelhead populations in the upstream segment are generally greater than those in the downstream segment. The reasons for lowered steelhead abundance downstream of the well do not appear to be project-related, but the result of naturally-occurring factors. Analysis of the stream gage records indicate that subsurface withdrawl of water is not resulting in lowered surface flows (i.e., Gualala River streamflow) as measured by the streamgages upstream and downstream of the wells. No detectable change in streamflow equates to no detectable change in habitat for fry and juvenile steelhead. Further, a worst case assessment of potential habitat loss from 0.5 cfs surface withdrawal over a range of streamflows indicates that habitat loss downstream of the wells is negligible for total streamflows from greater than 5 cfs.

Thus, naturally occurring limiting factors are likely resulting in lowered steelhead abundance downstream of the wells. Habitat analysis of the South Fork Gualala River indicates that the habitat upstream of the wells is similar to downstream habitat in terms of percentage of habitat types. However, upstream habitat is of higher quality than downstream habitat due to slightly higher gradient (resulting in deeper riffles and higher velocities in runs) and cooler water temperature. The active channel in the upper segment has more canopy cover and thus a higher degree of shading, thereby keeping stream temperatures cool. Though comparable fish sample sites were selected upstream and downstream of the wells, there were differences in habitat quality between segments. Differences in the availability of habitat as defined by suitable depths and velocities for both fry and juvenile steelhead are apparent in the WUA vs. streamflow curves generated in PHABSIM (Appendix B). The upstream deep pools and riffles show higher habitat indices over the modeled range compared to the downstream sites. The habitat quality for runs both upstream and downstream of the wells are roughly equal and rootwad pools show higher habitat indices downstream. However, factors such as warmer stream temperatures are acting to limit fish populations downstream.

Depth and velocity were the only parameters used to define suitable habitat in the PHABSIM models. Qualitative habitat assessments made during the time of sampling indicated that the deep pools upstream generally had slightly higher streamflow velocities than those downstream resulting in better food transport through the pool. As a group, the upstream riffles were generally higher gradient with greater surface turbulence, and deeper, providing more cover for fry steelhead. The upstream run habitat had a much higher percentage of overhanging vegetation compared with the downstream runs, again providing cover for juvenile steelhead and a source of terrestrial food items.

Higher upstream fish populations are reflective of more suitable habitat conditions upstream of the wells. In July, substantially higher numbers of steelhead young-of-the-year and base population (age 1 + and older) were found in all habitat types surveyed upstream of the wells as compared to downstream populations. Greater numbers of YOY steelhead in the upstream section are likely a result of recent emigration from upstream spawning areas due to declining streamflow. Streamflows in the tributaries in the two to three weeks preceding the July sampling period had rapidly declined from moderate flow conditions to near intermittent conditions.

At the confluence with the Wheatfield Fork, habitat conditions in the Gualala River were much improved, owing to a higher volume of water. Fish populations in this reach are higher as fish emigrating from upstream spawning areas encountered suitable habitat conditions. Relatively low base population abundance both upstream and downstream of the wells is likely a result of low summer and fall streamflows during the past few years, a reflection of regional drought conditions. Declining streamflows generally result in decreased amounts of suitable habitat, particularly for older juveniles.

In October, streamflows had declined to intermittent conditions. As a result, few older juveniles were present in either riffle or run habitat both upstream and downstream of the wells. However, pool habitat was being utilized at levels similar to that observed in July. This is likely a result of movement into pools from surrounding riffle and run habitat which had become unsuitable as flows declined. Also in October, upstream and downstream YOY fish population levels were generally low in both riffle and run habitat. Pool habitat again was most heavily utilized both upstream and downstream of the wells.

This paper concludes that naturally occurring conditions in the South Fork Gualala River, notably low streamflows resulting from drought conditions, are acting to depress juvenile steelhead populations. Conditions upstream of the wells are more suitable, likely due to higher gradient, more canopy cover and cooler water temperatures. Project-related effects on juvenile steelhead populations are non-detectable.

5.2 ADEQUACY OF FISHERY BYPASS STREAMFLOWS TO PROTECT THE FISHERY

The adequacy of Term 14 bypass flows was evaluated by using a PHABSIM model which estimates quantity and quality of available habitat at various flows. From depth and velocity data collected in the field, along with application of suitability criteria, WUA was calculated for each major habitat type at flows ranging from 3 to 10 cfs. To simulate worst-case conditions (i.e., 0.5 cfs subsurface water withdrawal resulting in

0.5 cfs diversion of surface flow), the WUA was again calculated subtracting 0.5 cfs from each evaluated flow set for each habitat type downstream of the wells. The assumption was made that since the amount of diversion was constant, any effect of water withdrawal on habitat availability would be most pronounced at lower flow levels.

Comparison of WUA estimates at three flow levels, 3 to 5 cfs, 5 to 7 cfs and 7 to 10 cfs indicates greatest decline in habitat from 0.5 cfs withdrawal occurs at 3 to 5 cfs total streamflow. Percent negative change (i.e., decline) in WUA levels generally range from 5 to 10 percent in run and riffle habitat at 3 to 5 cfs. However, as total streamflows increase, the percent negative change of WUA from withdrawal of 0.5 cfs tends to decrease. Moreover, positive percent change occurs over several habitat types at the 7 to 10 cfs level.

The WUA available at 7 to 10 cfs for critical juvenile riffle and run habitat does not change when reduced by 0.5 cfs. A review of Table 4-3 indicates that at the 5 to 7 cfs total streamflow range, only riffle habitat for juvenile steelhead is moderately affected from a 0.5 cfs withdrawal. However, a review of base population levels indicate that the pool habitat is more important in terms of actual utilization by steelhead. Pool habitat indices are actually augmented (10 percent increase) by 0.5 cfs withdrawal in the 5 to 7 cfs range. Moreover, most habitat indices are unaffected by 0.5 cfs withdrawal at the 7 to 10 cfs total streamflow range indicating that further evaluation of higher flow levels is unnecessary.

No changes in habitat from a reduction of 0.5 cfs streamflow were observed to approach 15 percent at any streamflow. The 15 percent level is generally regarded by fishery experts at the USFWS Instream Flow Group as the level at which changes in fish population size may be expected. The 15 percent level is also used by other agencies in determining whether proposed water developments may affect fish populations. The 15 percent value comes from a combination of streamflow measurement error (5 percent) and modeling error (10 percent). Based on this accepted technique, this report concludes that any change in habitat quantity resulting from Sea Ranch wells is non-detectable and Term 14 fishery bypass streamflows are adequate for protecting downstream steelhead habitat and steelhead resources.

6.0

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APPENDIX A

STEELHEAD POPULATION ESTIMATES

APPENDIX A - STEELHEAD POPULATION ESTIMATES

STEELHEAD BASE

	JULY				OCTOBER			
site	TOTAL CATCH	POP. EST.	CI.	FISH /l00m	TOTAL CATCH	POP. EST.	CI.	FISH /l00m
4RF	3*18	3*	3.0-4.5*	10*	DRY*			0*
5RN	18*	18*	18.0-18.1*	65*	0*	0*		0*
6RWP	25*	26*	25.0-29.9*	202*	5*	5*	5.0-8.3*	39*
9RF	1*	1*		6*	DRY*			0*
10DP	12*	12*	12.0-14.1*	57*	1*	1*		5*
12RF	NOT SAMPLED*			0*	0*	0*		0*
17DP	11*	11*	11.0-13.3*	32*	18*	18*	18.0-19.9*	53*
23RF	0	0			DRY			0
24RN	9	9	9.0-9.2	25	1	1		3
25DP	2	2		6	3	3	3.0-4.1	9
30RF	0	0		0	0	0		0
31DP	7	7	7.0-8.9	34	8	8	8.0-8.1	39
38RN	9	9	9.0-10.1	19	3	3		6
63RF	2	2		10	1	1		5
64RWP	4	4	4.0-4.7	30	2	2		15
66RN	2	2	2.0-6.9	6	0	0		0

STEELHEAD YOY

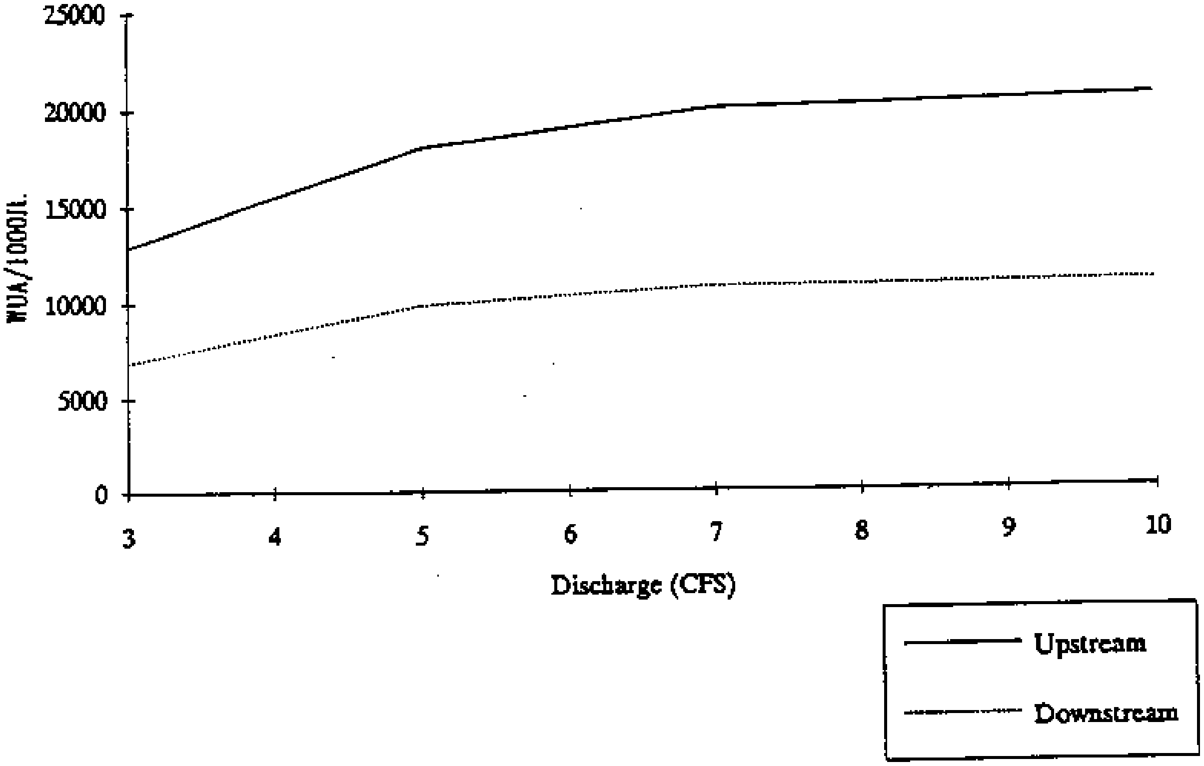
	JULY				OCTOBER			
site	TOTAL CATCH	POP. EST	C.I.	FISH /l00m	TOTAL CATCH	POP. EST.	C.I.	FISH /l00m
4RF	87*	93*	87.0-101.4*	313*	DRY*			0*
5RN	107*	107*	(SIC) 07.0-	386*	13*	13*	13.0-13.7*	47*
6RWP	25*	27*	25.0-32.6*	210*	17*	17*	17.0-17.8*	132*
9RF	42*	43*	42.0-46.6*	243*	DRY*			0*
10DP	36*	36*	36.0-37.4*	171*	11*	11*	11.0-11.5*	152*
12RF	NOT SAMPLED*			0*	8*	8*	8.0-9.2*	18*
17DP	15*	18*	15.0-28.0*	53*	14*	14*	14.0-16.2*	41*
23RF	5	5		31	Dry			0
24RN	49	50	49.0-52.9	140	13	13		36
25DP	5	5	5.0-7.2	15	4	4		12
30RF	38	41	38.0-47.4	58	1	1		1
31DP	20	26	20.0-41.9	127	63	71	63.0-82.4	346
38RN	49	51	49.0-56.0	106	24	24	24.0-26.1	50
63RF	22	22	22.0-243	110	10	10	10.0-10.9	50
64RWP	22	24	22.0-30.0	178	9	9	9.0-9.6	67
66RN	24	24	24.0-26.4	71	6	6	6.0-8.6	18

* = Upstream of wells
RF = Riffle
RN = Run
DP = Deep Pool
RWP = Rootwad Pool

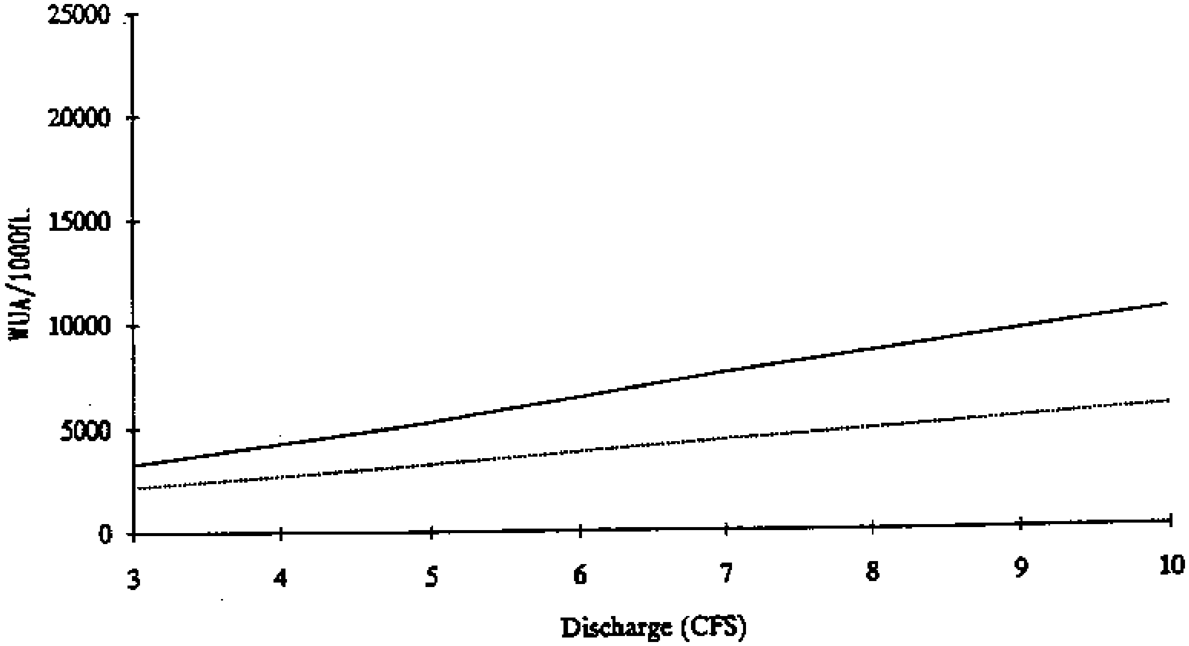
APPENDIX B

WEIGHTED USABLE AREA VS. PLOW PLOTS

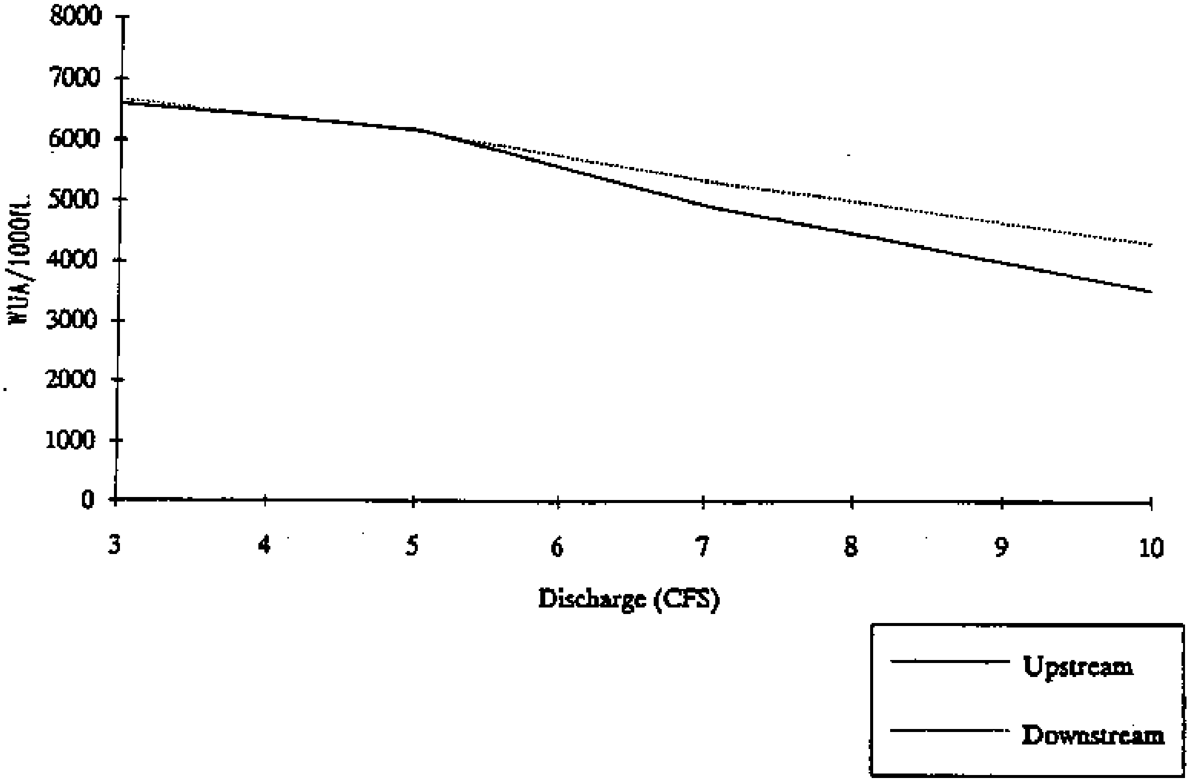
WUA vs. Q for Steelhead Fry Rimes



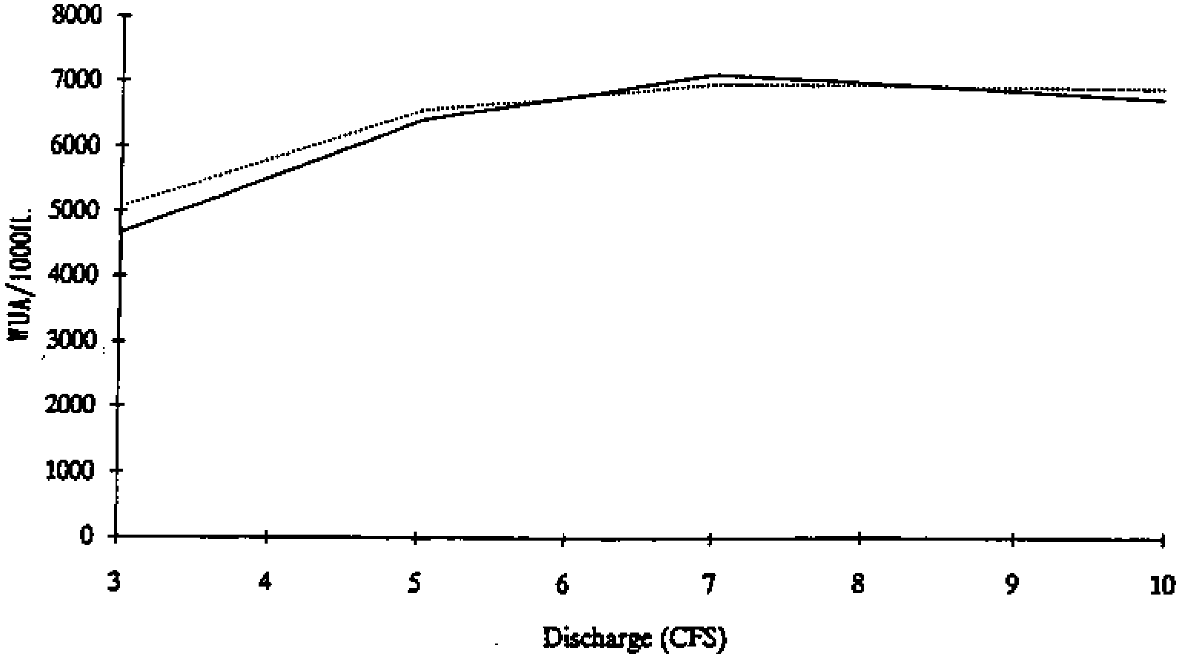
WUA vs. Q for Juvenile Steelhead Riffles



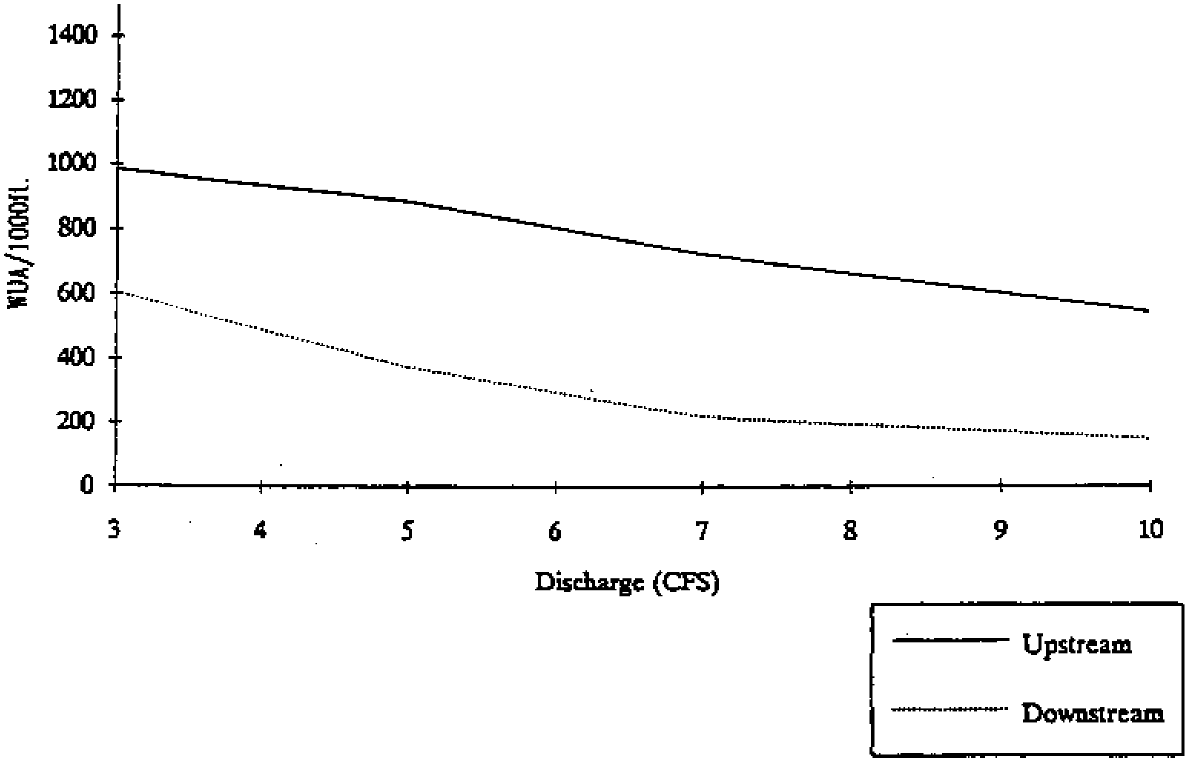
WUA vs. Q for Steelhead Fry Runs



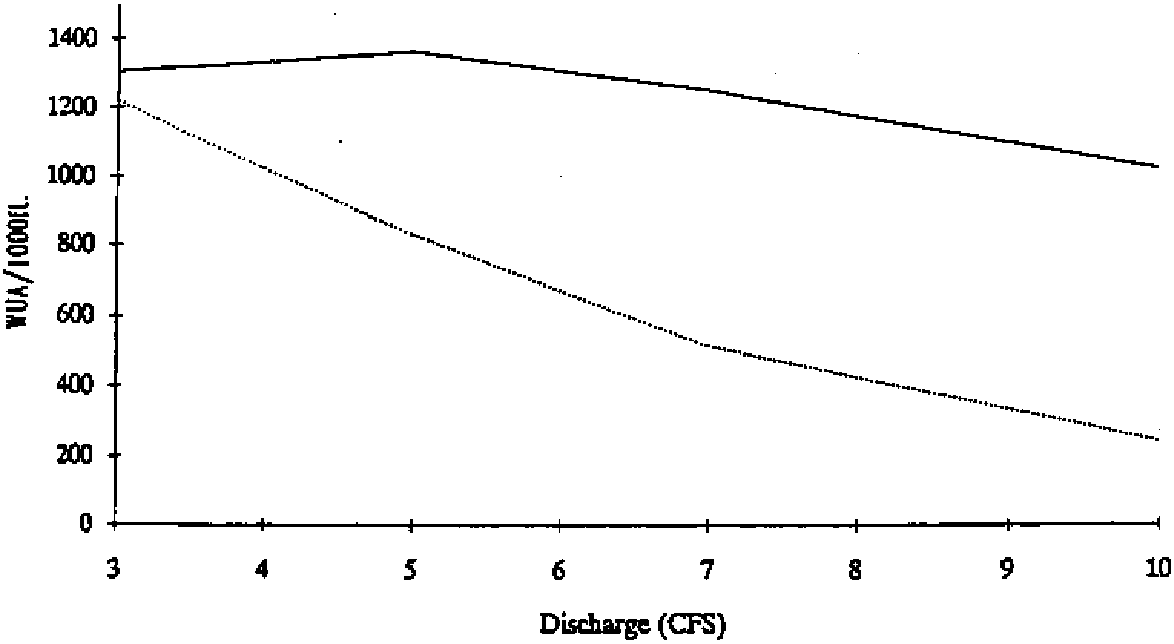
WUA vs. Q for Juvenile Steelhead Runs



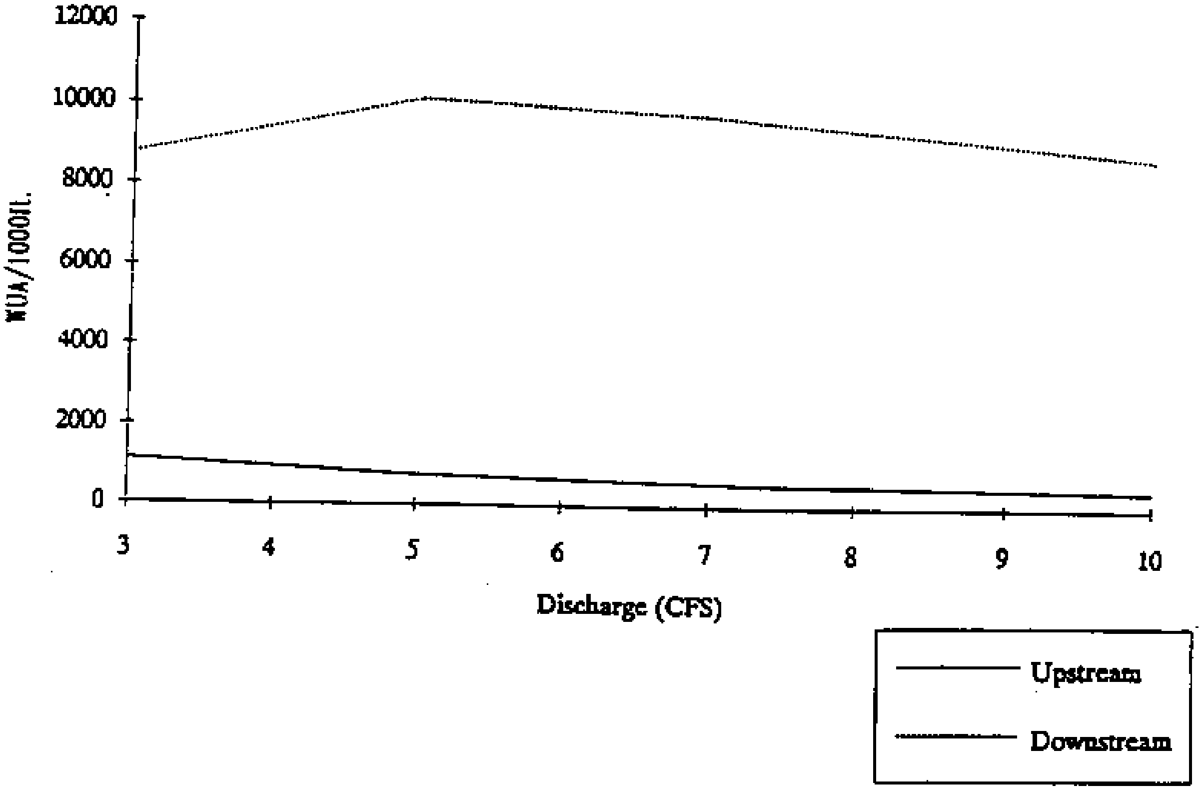
WUA vs. Q for Steelhead Fry Deep Pools



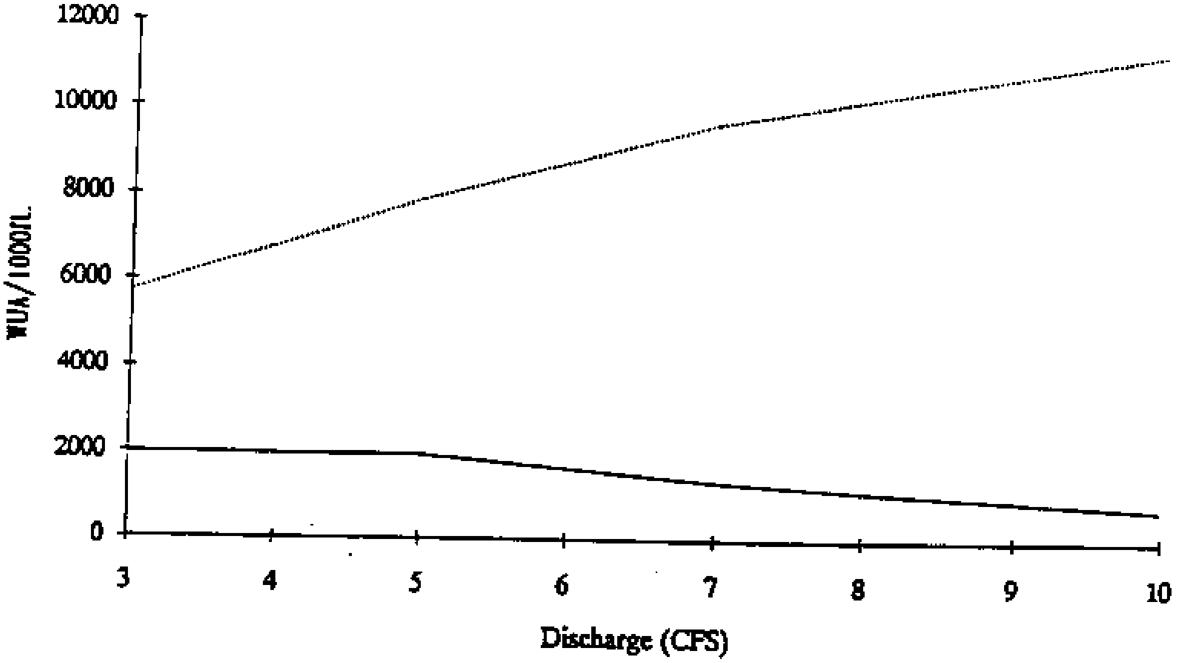
WUA vs. Q for Juvenile Steelhead Deep Pools



WUA vs. Q for Steelhead Fry Rootwad Pools



WUA vs. Q for Juvenile Steelhead Rootwad Pools



APPENDIX C

STREAM AND AIR TEMPERATURE TABLES

Table C1. Water temperatures (C) above the Sea Ranch Wells (Segment l) in the South Fork of the Gualala River, 1991.

	July			August		
Day	Avg.	Max	Min	Avg.	Max	Min
1				17.8	19.0	16.5
2				17.6	19.0	16.0
3				17.8	19.0	16.5
4				17.5	19.0	16.5
5				17.3	18.5	16.5
6				17.8	19.0	17.0
7				18.3	19.5	17.5
8				18.2	19.0	17.0
9				18.1	19.0	17.0
10				17.7	19.0	16.0
11				17.9	19.0	17.0
12				17.6	18.5	17.0
13				17.2	18.5	16.5
14				17.8	19.0	16.5
15				17.6	18.5	17.0
16				17.5	18.0	16.5
17				17.7	18.5	17.0
18	18.1	21.5	16.0	17.6	19.0	17.0
19	17.7	21.0	16.0	17.4	19.0	16.5
20	17.8	20.5	16.0	17.4	18.5	16.5
21	17.8	20.5	16.0	17.4	18.0	16.5
22	17.5	19.5	16.5	17.2	18.0	16.5
23	17.6	20.5	16.0	17.1	17.5	16.0
24	18.5	21.5	16.0	17.0	18.0	16.0
25	18.0	21.0	15.5	17.0	18.0	16.0
26	18.7	21.5	16.5	16.4	17.5	15.5
27	18.3	21.0	16.5	17.1	17.5	16.5
28	18.3	20.0	17.0	17.5	18.0	17.0
29	17.9	19.5	16.5	17.3	18.0	16.5
30	18.1	20.0	16.5	17.1	17.5	16.5
31	18.0	19.5	17.0	17.3	18.5	17.0
Mean	18.0	20.5	16.3	17.5	18.5	16.6

Table C1 (continued). Water temperatures (C) above the Sea Ranch Wells (Segment 1) in the South Fork of the Gualala River, 1991.

	September			October		
Day	Avg.	Max	Min	Avg.	Max	Min
1	17.6	18.0	17.0	16.3	17.0	15.5
2	17.1	17.5	16.0	15.5	16.0	15.0
3	17.5	18.5	16.5	15.5	16.0	15.0
4	17.1	17.5	16.5	15.5	16.5	14.5
5	16.9	17.5	16.0	16.2	16.5	16.0
6	17.3	18.0	17.0	15.5	16.0	15.0
7	17.5	18.0	17.0	14.9	15.5	14.0
8	16.8	17.5	16.0	15.0	15.5	14.5
9	16.3	17.0	15.0	15.1	16.0	14.0
10	16.3	17.0	15.5	15.0	15.5	14.5
11	16.4	17.0	16.0	15.2	16.0	14.5
12	16.5	17.5	16.0			
13	16.5	17.0	16.0			
14	16.2	17.0	15.5			
15	16.5	17.5	16.0			
16	16.5	17.0	16.0			
17	16.2	16.5	15.5			
18	16.1	16.5	15.5			
19	16.4	17.0	16.0			
20	16.4	17.0	16.0			
21	16.1	17.0	15.5			
22	16.3	17.0	16.0			
23	15.9	16.5	15.5			
24	15.7	- 16.0	15.0			
25	16.0	17.0	15.5			
26	16.1	16.5	15.5			
27	15.8	16.0	15.0			
28	15.6	16.0	15.0			
29	15.5	16.5	14.5			
30	16.3	17.0	15.5			
31						
Mean	16.4	17.1	15.8	15.4	16.0	14.8

Table C2. Water temperatures (C) below the Sea Ranch Wells (Segment 2) in the South Fork of the Gualala River, 1991.

	July			August		
Day	Avg.	Max	Min	Avg.	Max	Min
1				19.7	24.0	17.5
2				19.8	24.0	17.5
3				19.8	23.0	18.0
4				18.8	20.5	18.0
5				19.1	22.5	17.5
6				19.6	21.5	18.5
7				20.8	24.0	19.0
8				21.4	25.0	19.0
9				21.3	25.0	19.0
10				20.8	24.5	18.5
11				20.5	23.0	19.0
12				20.0	22.0	19.0
13				19.1	21.0	18.0
14				19.8	21.0	18.5
15				19.8	21.5	19.0
16				20.4	24.0	18.5
17				20.3	23.0	19.0
18	19.5	22.5	17.0	19.7	21.5	18.5
19	18.3	19.5	17.0	19.2	20.0	18.5
20	18.1	20.5	17.0	19.7	22.5	18.5
21	18.5	21.5	17.0	20.4	24.0	18.5
22	18.2	19.0	17.5	20.5	24.0	18.5
23	18.3	21.0	16.5	20.4	23.5	18.5
24	19.5	23.5	17.5	20.1	23.0	18.0
25	19.8	24.0	17.0	19.9	23.0	18.0
26	19.2	21.0	17.5	19.0	21.5	17.5
27	18.7	20.5	17.5	19.7	23.0	18.0
28	18.8	21.5	17.5	20.4	23.0	19.0
29	19.2	22.5	17.5	20.5	23.5	18.5
30	19.1	21.5	17.5	20.4	24.0	18.0
31	18.9	20.5	18.0	21.2	25.0	19.0
Mean	18.9	21.4	17.3	20.1	22.9	18.4

Table C2 (continued). Water temperatures (C) below the Sea Ranch Wells (Segment 2) in the South Fork of the Gualala River, 1991.

	September			October		
Day	Avg.	Max	Min	Avg.	Max	Min
1	21.2	24.5	19.0	18.4	21.0	17.0
2	20.9	25.0	18.5	18.3	21.0	16.5
3	20.4	22.5	18.5	18.1	21.5	16.0
4	20.2	23.5	18.5	17.8	19.5	16.0
5	19.9	23.0	18.0	17.8	18.5	17.5
6	19.6	20.5	19.0	17.9	20.5	16.0
7	20.1	22.5	19.0	17.9	20.5	16.0
8	19.3	22.0	17.5	17.9	20.5	16.0
9	18.8	22.0	17.0	17.5	20.0	15.5
10	18.9	21.5	17.0	18.0	21.5	16.0
11	18.5	20.0	17.5	17.1	18.0	16.5
12	18.5	21.0	17.0			
13	18.2	19.5	17.0			
14	18.0	19.5	17.0			
15	17.8	18.5	17.0			
16	18.6	21.0	17.5			
17	18.7	21.5	17.0			
18	18.6	21.5	17.0			
19	18.1	18.5	17.5			
20	17.9	18.5	17.5			
21	17.8	19.5	17.0			
22	18.0	20.0	17.0			
23	18.3	21.0	17.0			
24	18.4	21.5	16.5			
25	17.8	19.5	17.0			
26	18.6	21.0	17.5			
27	18.5	21.5	16.5			
28	18.4	21.5	16.5			
29	18.5	21.5	16.5			
30	17.7	18.5	17.0			
31						
Mean	18.8	21.1	17.4	17.9	20.2	16.3

Table C3. Water temperatures (C) below Buckeye Creek (Segment 3) in the South of the Gualala River, 1991.

	July			August		
Day	Avg.	Max	Min	Avg.	Max	Min
1				18.5	21.5	16.5
2				18.7	21.0	17.0
3				18.6	21.0	17.5
4				18.0	19.0	17.5
5				18.1	21.0	16.5
6				18.4	19.5	17.5
7				19.3	22.0	18.0
8				20.2	23.0	18.5
9				20.3	22.0	19.0
10				19.8	22.0	18.5
11				19.4	21.0	19.0
12				19.1	21.5	18.0
13				18.5	19.0	18.0
14				18.5	20.5	17.5
15				18.6	20.0	18.0
16				18.8	22.0	17.5
17				19.2	22.0	18.0
18	18.8	21.5	17.0	18.9	21.0	18.0
19	17.9	19.0	17.5	18.3	19.0	18.0
20	17.8	20.0	16.5	18.6	21.0	17.5
21	18.5	21.0	17.0	18.9	22.0	17.5
22	18.2	19.0	17.5	18.9	21.0	18.0
23	18.3	20.5	17.0	19.1	21.5	18.0
24	18.9	21.5	17.0	18.6	21.0	17.5
25	19.0	21.5	17.0	18.2	21.0	17.0
26	19.1	21.5	17.5	17.9	20.5	17.0
27	18.6	19.5	18.0	18.3	21.0	17.0
28	18.5	20.5	17.5	19.0	20.5	18.0
29	19.0	21.5	17.5	19.2	22.0	18.0
30	19.5	22.0	18.0	19.2	22.0	18.0
31	18.9	19.5	18.5	20.6	23.5	19.5
Mean	18.6	20.6	17.4	18.9	21.1	17.8

Table C3 (continued). Water temperatures (C) below Buckeye Creek (Segment 3) in the South Fork of the Gualala River, 1991.

	September			October		
Day	Avg.	Max	Min	Avg.	Max	Min
1	20.0	22.5	19.0	16.6	18.5	15.5
2	19.5	22.0	18.0	16.3	18.5	15.0
3	19.3	22.0	18.0	16.2	18.5	15.0
4	19.1	21.5	18.0	16.3	18.5	15.0
5	19.0	21.5	18.0	16.3	17.0	16.0
6	18.8	19.5	18.5	15.9	18.0	14.5
7	18.6	20.5	18.0	15.8	18.0	14.5
8	18.0	20.5	17.0	15.9	18.0	14.5
9	17.4	19.5	16.0	15.8	18.0	14.5
10	17.3	19.5	16.0	16.0	18.0	14.5
11	17.3	19.0	16.5	15.3	16.0	15.0
12	17.2	19.5	16.0			
13	17.2	19.0	16.5			
14	16.8	19.0	16.0			
15	16.7	18.5	16.0			
16	16.8	19.0	16.0			
17	17.0	19.5	16.0			
18	17.1	19.0	16.0			
19	16.7	17.0	16.5			
20	16.4	17.0	16.0			
21	16.2	18.0	15.5			
22	16.4	18.0	15.5			
23	16.5	18.5	15.5			
24	16.6	18.5	15.5			
25	16.3	17.5	15.5			
26	16.8	19.0	16.0			
27	16.7	19.0	15.5			
28	16.6	18.5	15.5			
29	16.7	19.0	15.5			
30	16.3	17.0	15.5			
31						
Mean	17.4	19.3	16.5	16.0	17.9	14.9

Table C4. Air temperatures (C) above the Sea Ranch Wells (Segment 1) in the South Fork of the Gualala River, 1991.

	July			August		
Day	Avg.	Max	Min	Avg.	Max	Min
1				14.5	18.5	11.0
2				13.8	17.5	10.5
3				13.6	17.0	12.0
4				13.2	15.0	12.0
5				13.8	17.0	12.0
6				14.8	17.0	13.0
7				16.9	19.5	14.5
8				16.5	19.0	13.5
9				17.3	22.0	13.5
10				15.1	18.5	11.5
11				14.9	17.5	12.5
12				13.6	15.0	12.5
13				15.3	22.0	11.5
14				14.4	16.5	13.0
15				14.6	16.5	13.5
16				14.6	17.5	12.0
17				14.3	16.0	13.0
18	12.7	14.0	11.5	14.1	15.5	13.0
19	13.0	15.5	11.5	13.8	15.0	12.0
20	13.2	15.0	12.5	14.2	16.5	13.0
21	12.7	14.0	11.5	15.0	18.5	12.5
22	13.4	14.5	12.5	14.8	18.0	12.5
23	13.3	15.5	12.0	14.0	18.0	11.5
24	15.5	19.5	13.0	14.2	18.5	10.5
25	15.2	20.0	10.5	13.1	17.0	9.5
26	13.9	15.0	12.5	12.3	15.5	9.0
27	14.0	16.5	12.5	14.4	17.0	12.0
28	13.6	14.5	12.5	16.3	19.0	14.5
29	13.6	16.5	12.0	15.4	18.0	12.5
30	13.5	15.5	12.0	15.1	18.0	11.5
31	14.0	16.0	13.0	16.4	20.5	12.5
Mean	13.7	15.9	12.1	14.7	17.6	12.2

Table C4 (continued). Air temperatures (C) above the Sea Ranch Wells (Segment 1) in the South Fork of the Gualala River, 1991.

	September			October		
Day	Avg.	Max	Min	Avg.	Max	Min
1	17.5	22.0	13.5	13.0	15.0	11.5
2	16.5	22.5	11.0	12.0	14.5	9.5
3	14.4	18.0	11.5	13.0	19.0	9.0
4	13.1	15.5	10.5	12.5	15.5	8.5
5	13.1	15.0	11.0	13.7	15.5	12.0
6	15.0	17.5	13.0	12.9	17.5	9.0
7	15.0	16.0	14.0	12.7	17.0	8.0
8	13.2	16.5	10.5	12.5	17.0	8.0
9	12.4	16.0	8.5	12.3	17.5	7.0
10	13.0	17.5	9.0	14.7	24.0	8.5
11	11.6	13.0	10.5	10.8	12.5	9.5
12	11.7	13.5	10.0			
13	11.5	13.0	10.5			
14	10.8	13.0	9.0			
15	11.9	14.0	10.0			
16	12.4	14.0	11.0			
17	11.7	14.0	9.5			
18	11.9	14.0	9.5			
19	12.9	14.5	11.5			
20	12.5	13.5	12.0			
21	12.3	14.5	10.5			
22	12.3	14.0	10.5			
23	11.3	13.5	9.0			
24	11.8	15.5	8.0			
25	12.9	17.0	9.5			
26	13.9	16.5	12.0			
27	13.0	16.5	10.0			
28	12.5	16.5	9.5			
29	13.0	17.5	9.0			
30	13.0	15.0	11.0			
31						
Mean	12.9	15.6	10.5	12.7	16.8	9.1

Table C5. Air temperatures (C) below the Sea Ranch Wells (Segment 2) in the South Fork of the Gualala River, 1991.

	July			August		
Day	Avg.	Max	Min	Avg.	Max	Min
1				15.3	21.5	11.0
2				14.4	19.0	10.0
3				14.6	18.5	12.5
4				14.0	17.0	12.5
5				14.8	18.5	12.5
6				15.0	16.5	13.5
7				17.1	19.5	15.5
8				17.1	21.0	14.0
9				17.5	23.0	13.5
10				15.4	20.0	11.0
11				14.9	17.5	13.0
12				14.3	16.0	13.0
13				14.8	19.5	11.5
14				14.8	17.0	13.5
15				15.1	17.0	14.0
16				15.0	19.5	12.0
17				15.7	19.0	13.5
18	14.2	16.5	12.0	14.9	17.5	13.5
19	13.3	15.0	12.0	14.3	16.0	12.5
20	14.0	16.0	13.0	14.8	18.0	13.0
21	13.9	16.5	12.5	15.6	19.0	13.0
22	13.8	15.0	12.5	15.2	19.5	12.0
23	14.1	16.5	12.0	14.8	19.5	11.0
24	16.2	21.0	13.5	14.5	19.5	10.0
25	15.7	21.5	10.0	13.8	19.0	9.5
26	14.1	16.0	12.0	12.8	17.0	9.0
27	14.0	16.0	12.5	14.6	17.5	12.5
28	14.5	17.0	13.0	16.5	19.0	14.5
29	14.3	18.0	12.0	15.5	19.5	12.5
30	14.0	16.0	12.0	15.2	19.0	11.5
31	14.4	16.0	13.5	16.7	21.0	13.5
Mean	14.3	16.9	12.3	15.1	18.7	12.4

Table C5 (continued). Air temperatures(C) below the Sea Ranch Wells (Segment 2) in the South Fork of the Gualala River, 1991.

	September			October		
Day	Avg.	Max	Min	Avg.	Max	Min
1	17.5	22.5	14.0	14.3	17.5	12.5
2	15.9	21.5	10.5	13.2	18.0	9.0
3	14.7	17.0	11.5	13.3	20.0	8.5
4	14.3	18.5	11.0	12.7	16.0	9.0
5	14.0	17.5	11.0	13.9	15.5	12.5
6	15.2	17.0	13.5	13.3	19.0	10.0
7	15.8	17.5	15.0	13.3	19.0	8.0
8	13.7	18.0	10.5	13.0	19.5	8.5
9	12.5	18.0	8.0	12.6	19.0	7.5
10	12.6	16.5	8.5	13.7	19.5	9.0
11	12.3	15.5	10.5	11.5	13.5	10.0
12	12.7	16.0	10.5			
13	12.2	14.0	10.5			
14	11.6	14.0	9.5			
15	12.5	14.0	11.0			
16	13.7	17.0	12.0			
17	13.2	17.5	10.5			
18	13.0	17.0	10.0			
19	13.5	15.0	12.0			
20	13.3	14.0	12.5			
21	13.0	16.0	11.5			
22	13.4	16.5	11.5			
23	13.0	17.0	10.0			
24	13.4	19.5	9.5			
25	13.5	17.5	10.5			
26	15.0	18.5	13.0			
27	13.8	19.0	10.0			
28	13.3	18.5	9.0			
29	13.8	19.5	9.0			
30	13.2	15.0	11.5			
31						
Mean	13.6	17.2	10.9	13.2	17.9	9.5

Table C6. Air temperatures (C) below Buckeye Creek (Segment 3) in the South Fork of the Gualala River, 1991.

	July			August		
Day	Avg.	Max	Min	Avg.	Max	Min
1				15.2	20.5	11.5
2				14.5	18.0	12.0
3				14.5	18.5	12.0
4				14.0	17.5	12.5
5				14.8	18.0	12.5
6				15.1	17.0	13.5
7				16.5	19.0	14.5
8				16.9	21.0	13.5
9				17.5	21.5	14.0
10				15.6	20.0	12.0
11				14.8	17.5	13.0
12				14.3	16.5	12.5
13				14.4	19.0	11.5
14				14.7	16.0	13.0
15				15.1	17.0	14.0
16				14.5	19.0	11.5
17				15.4	19.0	13.5
18	13.5	15.0	12.0	14.9	17.5	13.0
19	13.0	14.0	12.0	14.6	16.5	13.5
20	13.8	16.5	12.5	15.0	17.5	13.0
21	13.7	16.5	12.0	15.5	18.5	13.0
22	13.9	16.0	12.5	14.7	19.0	11.5
23	14.1	17.0	12.0	14.8	19.0	12.0
24	15.6	19.5	13.0	15.0	20.0	11.5
25	15.8	20.5	12.0	14.1	18.5	11.0
26	14.2	16.5	11.5	13.5	17.0	10.5
27	14.2	16.0	13.0	14.5	17.0	12.5
28	14.3	17.0	13.0	16.1	18.5	14.5
29	14.2	17.0	12.0	15.3	18.5	13.0
30	14.5	17.5	12.5	14.9	19.0	11.0
31	14.4	16.5	13.0	16.9	21.5	13.5
Mean	14.2	16.8	12.4	15.1	18.5	12.6

Table C6 (continued). Air temperatures (C) below Buckeye Creek (Segment 3) in the South Fork of the Gualala River, 1991.

	September			October		
Day	Avg.	Max	Min	Avg.	Max	Min
1	17.5	22.0	15.0	13.8	17.5	12.0
2	15.8	21.5	11.0	12.6	17.0	9.0
3	14.5	17.5	11.5	12.1	18.0	8.0
4	14.1	18.0	11.0	12.1	16.0	8.0
5	14.6	17.0	12.5	13.7	15.5	12.0
6	15.0	17.0	14.0	13.3	19.0	9.5
7	15.6	17.0	14.5	13.7	19.5	8.5
8	14.1	19.0	11.0	14.0	19.5	10.0
9	13.5	18.5	9.0	12.0	17.5	7.0
10	12.3	16.0	8.0	13.1	19.0	8.5
11	12.4	15.0	11.0	11.0	13.0	9.5
12	12.4	15.5	10.5			
13	12.1	14.5	10.5			
14	11.9	14.0	10.0			
15	12.5	15.5	11.0			
16	13.1	16.0	12.0			
17	12.6	17.0	10.0			
18	12.4	16.0	10.0			
19	13.3	14.5	12.0			
20	13.1	14.0	12.5			
21	12.8	16.0	11.0			
22	13.1	16.0	11.5			
23	12.0	16.0	9.0			
24	12.2	17.0	8.5			
25	12.9	17.0	9.5			
26	14.8	18.5	12.5			
27	13.8	19.0	10.0			
28	13.8	18.5	10.0			
29	13.0	18.0	8.5			
30	12.5	15.0	10.0			
31						
Mean	13.5	16.9	10.9	12.9	17.4	9.3