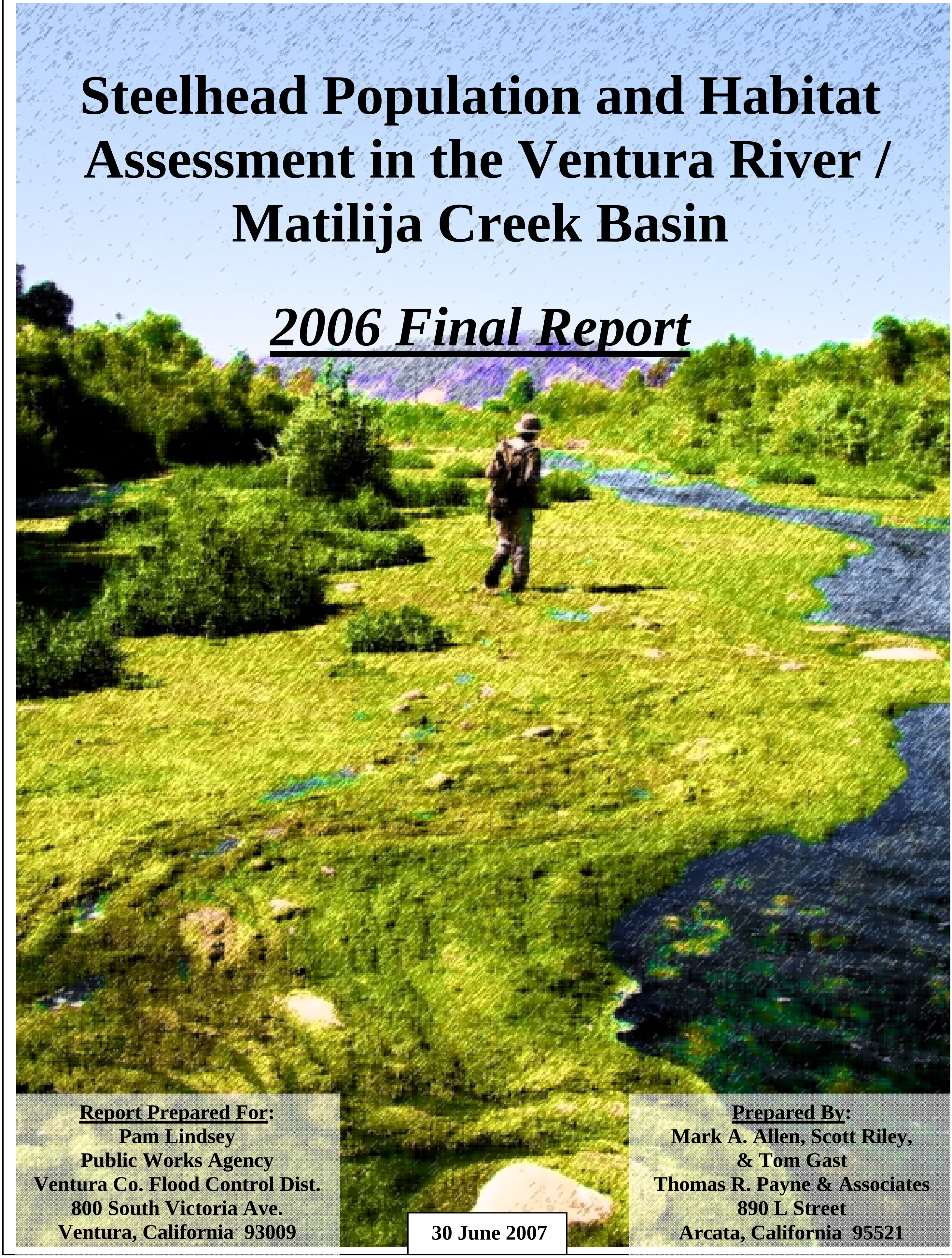

Steelhead Population and Habitat Assessment in the Ventura River / Matilija Creek Basin

2006 Final Report

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Cover Photo: Mapping habitat in the lower Ventura River. *Photo Thomas R. Payne & Associates*.

Steelhead Population and Habitat Assessment in the Ventura River / Matilija Creek Basin

ABSTRACT

Eleven study sites were sampled in the summer of 2006 to collect new Habitat Suitability Index (HSI) data for comparison with 2003 HSI data. Changes in calculated HSI scores were assessed in relation to annual changes in physical habitat, environmental conditions, and study methodologies. Most annual changes in study site HSI scores were associated with differences in the "Vs" spawning variable, which was found to highly influence the overall HSI score. The limited availability of gravel in many study sites and the randomized subsampling design resulted in highly variable Vs scores between years that were likely due to small sample sizes. Other changes in HSI variable scores were mostly associated with higher flow conditions in 2006 than in 2003, and to significant changes in riparian vegetation following flood flows that occurred during the intervening years.

Population abundance of *Oncorhynchus mykiss* was also estimated within segment, study site, and habitat type strata using multiple-pass electrofishing in shallow habitats and calibrated dive counts in deeper habitats. A total of only six *O. mykiss* were observed or captured in the lower segment of the basin below Robles Diversion Dam, which produced an estimated density of only about 0.002 fish/100ft^2 of habitat. *O. mykiss* were common in the middle segment between the diversion dam and Matilija Dam (and including the Lower North Fork Matilija Creek), with overall abundance of approximately 2,000 fry and 2,000 juvenile+ fish at densities of 0.3-0.4 fish/100ft^2 of habitat. Densities of fry were typically highest in riffles and lowest in pools, whereas juvenile+ fish were more evenly distributed in pools, riffles, and flatwaters. In the upper segment above Matilija Dam, *O. mykiss* were observed in all study sites with the highest densities in the Upper North Fork Matilija Creek and the lowest densities in the mainstem approximately one mile above the reservoir. Overall, the estimated abundance of both fry and juvenile+ fish was approximately 8,500 fish, with similar densities as the middle segment at 0.3 fish/100ft^2 of habitat. In the headwater study sites fry were abundant in all three habitat types, and juvenile+ fish were most common in the deeper pools or flatwaters and least abundant in riffles.

Statistical analysis suggested a strong positive relationship between study site HSI score and abundance of both fry (<10cm FL) and juvenile-adult *O. mykiss*. The two study sites with the highest HSI scores also contained the highest fish densities, and most of the lower segment study sites had low to moderate HSI scores and low fish densities. Additional sampling will be conducted in 2007 to further refine the HSI model for southern populations of *O. mykiss*, which appears to show promise based on the 2006 results. Additional fish population sampling in 2007 will also help to describe the annual variability that occurs towards the southern range of this endangered species.

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INTRODUCTION

The Ventura River Basin is a large southern California watershed that historically provided abundant habitat for the now endangered southern steelhead (*Oncorhynchus mykiss*) (Moore 1980a). Ocean migrant steelhead are reported to have utilized the mainstem Ventura River, as well as the principal subbasins including the Coyote Creek basin, the San Antonio Creek basin, the lower North Fork Matilija Creek basin, and the upper Matilija Creek basin. The amount of habitat available to anadromous steelhead for spawning and rearing declined over time with the construction of water supply facilities, such as Matilija Dam in 1947 (blocking access to the upper Matilija basin), Casitas Dam in 1957 (blocking access to the Coyote Creek basin), and Robles Diversion Dam in 1958, which until recently effectively blocked access to the upper portion of the Ventura River and the lower North Fork Matilija Creek. In 2004, a new fish passage facility was constructed in Robles Diversion Dam, which gives access to several miles of important spawning and rearing habitat (TRPA 2004), and sets the stage for the restoration of upper Matilija Creek. Matilija Dam was constructed for the purpose of supplying water storage and flood control, but reservoir sedimentation and construction of newer projects has reduced the necessity of the dam, and efforts are currently underway to restore access to the upper Matilija basin through removal of Matilija Dam (NMFS 2007).

Apparent declines in steelhead populations throughout southern California waters led to the federal listing of steelhead as “endangered” in 1997 for the Southern California Steelhead ESU (Federal Register 1997). The California Department of Fish & Game (CDFG) identified the Ventura River basin as a high-priority watershed having important ecological effects on the health of the Southern California Steelhead ESU. Consequently, this study was funded by CDFG through the California Steelhead Restoration Grant Program, with sponsorship and additional funding by the Ventura Watershed Protection District, with the following principal goals:

1. to assess the current distribution and abundance of *O. mykiss* (both anadromous and resident forms) in the Ventura River basin, and
2. to further test and refine the Habitat Suitability Index (HSI) model developed in 2003 (TRPA 2003, 2004) by comparison of HSI scores between years and by comparison of HSI scores with abundance of *O. mykiss*

For a thorough discussion of the quantity and quality of steelhead habitat in the Ventura River Basin and the HSI methodology in general, please refer to the 2003 HSI reports.

STUDY AREA & STRATIFICATIONS

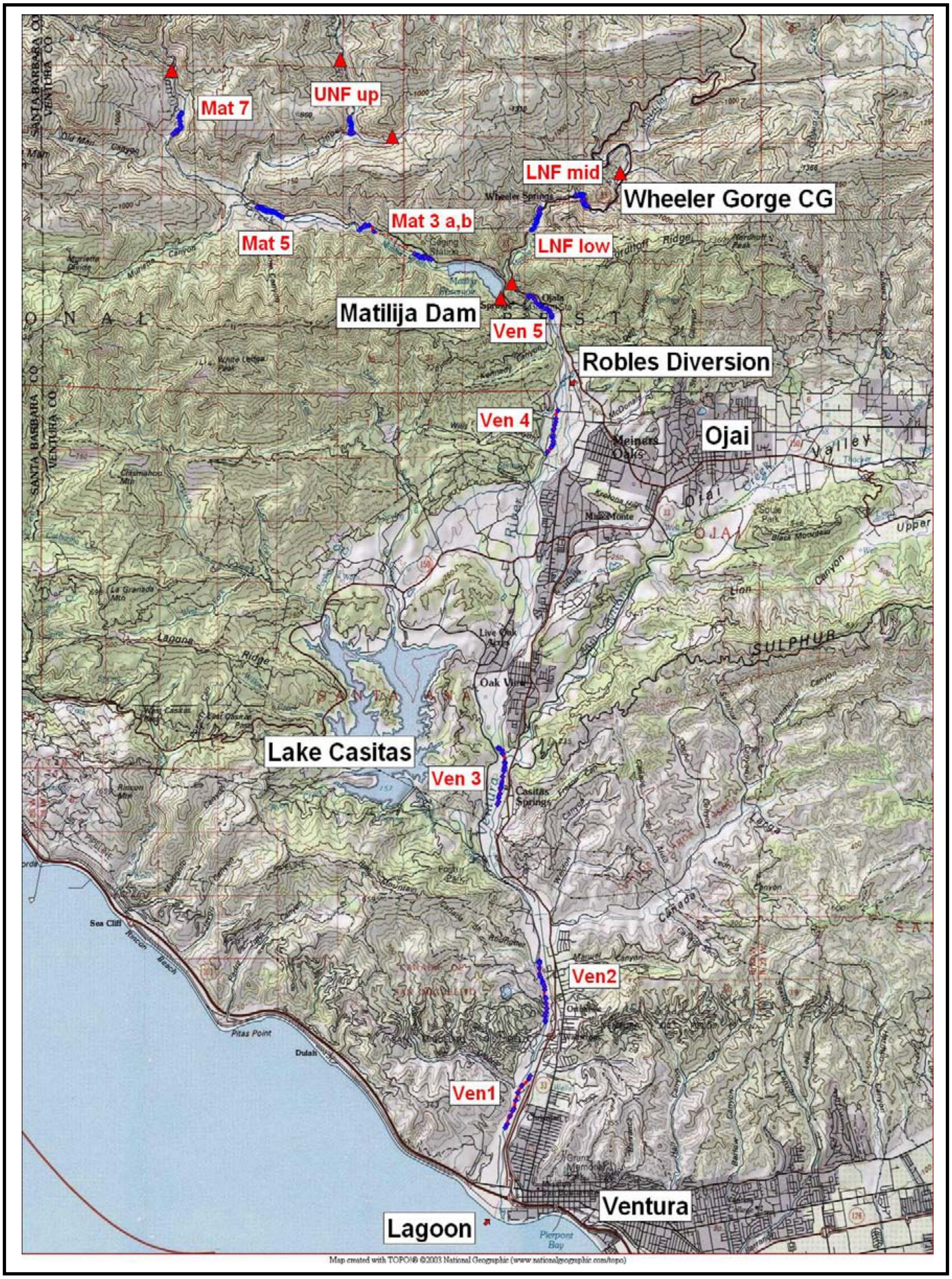
The study area includes most of the Ventura River basin and its principal tributaries, with the exception of the Coyote Creek subbasin and the San Antonio Creek subbasin. Murietta Creek, which flows into Matilija Creek above Matilija Dam, was judged to contain suitable spawning and rearing habitat for *O. mykiss* in earlier studies (TRPA 2003, 2004), but was not included in this fish distribution and abundance survey. The remainder of the basin was stratified into three *segments* and 17 *reaches*. Most study reaches contained a sampling *study site* where fish abundance and habitat mapping was conducted (Figure 1).

Study Segments

The three segment strata are based on accessibility to anadromous steelhead and the continuum of river channel characteristics. The lower segment extended upstream from the Ventura River Lagoon to Robles Diversion Dam and has been accessible to steelhead (given adequate surface flows) throughout history, and is mostly characterized as a low gradient, unconfined valley stream with significant anthropogenic influence. The middle segment included the Ventura River above Robles Diversion Dam up to Matilija Dam, including the lower North Fork Matilija Creek, and was mostly accessible to steelhead until construction of the diversion dam in 1958. Although access through the diversion dam was restored with a new fish ladder in 2004, natural and manmade barriers continue to exist in the lower North Fork Matilija Creek. This middle segment has intermediate characteristics similar to the alluvial lower segment and the mountainous and more pristine upper segment. The upper segment is entirely above Matilija Dam, and displays a wide continuum of open, alluvial channels in the lowest reaches to high gradient, confined channels in headwater reaches.

Study Reaches & Study Sites

The basis for reach stratifications were largely dictated by changes in channel morphology, riparian vegetation, and presence of barriers to upstream migration (TRPA 2003). Reaches were divided into one mile sections in the lower segment, and ½ mile sections in the middle and upper segments. One section was randomly selected from 17 of the reaches to serve as study sites for the 2003 study, and these reach and study site locations were retained for this study (with the exceptions described below). Reach descriptions and study site locations were described in prior reports (TRPA 2003, 2004). Budget allocations in 2007 limited sampling to 10 of the 17 study sites mapped in 2003; excluded sampling areas were the study sites in Murietta Creek, Old Man Creek, two of the three sites in the upper North Fork Matilija Creek, one site in the mainstem Matilija Creek, and one site in the lower North Fork Matilija Creek (above the Wheeler Gorge campground barrier). All mainstem Ventura River sites were retained in 2007, except for the site immediately below Matilija Dam, and one new site (Ven 4) was added to the lower segment in the mainstem (just below Robles diversion Dam) due to the presence of surface flow in 2006 that was absent during the 2003 study. In all, 11 study sites were



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Figure 1. Map of Ventura/Matilija Basin, showing study sites (blue dots are waypoints of sampled habitat units) and impassible barriers (red triangles).

surveyed in 2006 (Table 1). Actual sampling units (where fish abundance and habitat mapping occurred) were individual mesohabitat units selected at random within each study site.

Sampling Units

Each study site was mapped into mesohabitat types using the CDFG Level II classification of 19 individual types, excluding subchannel units (Flosi et al. 1998). Prior to selection for fish sampling and habitat measurements, the mesohabitat units were pooled into the three level I types: pools, flatwaters, and riffles. In each study site in the middle and upper segments, eight (occasionally nine) individual mesohabitat units of each of the three habitat type strata were randomly selected for fish sampling and HSI measurements (for a total of 24 sampling units per study site). In the lower segment where fish densities were extremely low, four habitat units of each mesohabitat type (e.g., pools, flatwaters, and riffles) were randomly selected, for an initial sample of 12 mesohabitat units. If an *O. mykiss* was captured or observed in any of the 12 sampling units, four additional units of each type were randomly selected for sampling, for a total of 24 sampling units (this occurred in two of the four study sites in the lower segment).

Because the habitat mapping was intended to select units for fish sampling, some modifications to the 2003 mapping protocols were employed. Habitat units less than 20 ft in length were combined with the adjacent unit of most similar type, in order to prevent selection of extremely short units for fish sampling. Fish sampling, either by diving or (especially) electrofishing, can displace fish out of the unit prior to being captured or counted (Peterson et al. 2005). This is particularly problematic when setting block nets prior to electrofishing. Consequently, we adopted the recommended protocols in Mohr and Hankin (*in press*) to combine very short units with adjacent units in order to minimize fish displacement. Unlike Mohr and Hankin, however, who suggested combining short units with the next unit upstream, we combined short units with the most similar adjacent unit, whether upstream or downstream of the short unit.

METHODS

HSI MAPPING

The HSI model, its individual variable curves, and field methods used to measure those variables were thoroughly described in a previous report (TRPA 2004). The HSI mapping protocols used in 2006 were essentially identical to the methods used in 2003, with few exceptions. The actual selection of habitat units for mapping and fish sampling differed among years, as previously described. In most study sites 24 individual habitat units were sampled in 2006, compared to 2003 when an average of 20 units were sampled. In 2006, rapid visual and qualitative methods were used to assess the physical characteristics of spawning gravels, whereas more quantitative methods were used in 2003 (TRPA 2004). In most other cases, field measurements were identical between years, and most of the HSI variables that were qualitatively estimated by eye were

Table 1. Summary of sampling statistics according to segment and study site.

									Sampled Units Only		
Segment	Study Site	'06 Survey Dates	Est Flow cfs	Water Temps °C	Habitat Type	# Units Avail	Study Site Length	% by Length	# Samp	AvLeng	AvWidth
Lower	Ven 1	7/15/06-	35.3	21.9-	All	50	4,915	100%	12	122	29.2
		7/17/06		27.5	Pools	8	1,275	26%	4	208	37.4
					Flatwaters	28	2,673	54%	4	94	22.3
					Riffles	14	967	20%	4	63	28.0
					NonSamp	0	0	0%	0	-	-
	Ven 2	7/12/06-	30.1	20.4-	All	59	5,009	100%	22	103	30.4
		7/14/06		26.3	Pools	6	956	19%	6	159	27.1
					Flatwaters	33	2,903	58%	8	93	32.2
					Riffles	19	1,134	23%	8	70	31.0
					NonSamp	1	16	0%	0	-	-
	Ven 3	7/19/06-	35.3	19.7-	All	50	4,875	100%	22	118	29.2
		7/21/06		24.5	Pools	6	1,345	28%	6	216	35.5
					Flatwaters	27	2,447	50%	8	104	30.1
					Riffles	17	1,083	22%	8	59	23.5
					NonSamp	0	0	0%	0	-	-
	Ven 4[1]	7/10/06-	1.2	20.3-	All	49	3,230	100%	12	87	36.0
		7/12/06		28.5	Pools	6	624	19%	4	144	39.5
					Flatwaters	30	1,915	59%	4	55	42.2
					Riffles	13	691	21%	4	63	26.3
					NonSamp	0	0	0%	0	-	-
Middle	Ven 5	7/24/06-	19.3	24.5-	All	58	2,834	100%	24	58	29.3
		7/27/06		28.3	Pools	16	1,033	36%	8	83	33.9
					Flatwaters	26	1,258	44%	8	58	29.4
					Riffles	15	508	18%	8	32	24.5
					NonSamp	1	35	1%	0	-	-
	LNF low[2]	8/23/06-	4.6	18.0-	All	76	2,047	100%	24	35	14.2
		8/24/06		22.6	Pools	27	957	47%	8	43	14.6
					Flatwaters	23	755	37%	8	35	14.7
					Riffles	8	220	11%	8	28	13.3
					NonSamp	18	115	6%	0	-	-
	LNF mid[2]	8/21/06-	3.0	15.5-	All	77	2,238	100%	24	31	11.5
		8/22/06		20.0	Pools	30	1,115	50%	8	33	11.9
					Flatwaters	24	787	35%	8	30	11.1
					Riffles	9	268	12%	8	29	11.5
					NonSamp	14	68	3%	0	-	-
Upper	Mat 3	8/12/06-	22.0	17.1-	All	44	2,490	100%	24	53	32.2
		8/15/06		26.5	Pools	9	615	25%	8	59	28.9
					Flatwaters	23	1,398	56%	8	51	34.3
					Riffles	8	463	19%	8	49	33.3
					NonSamp	4	14	1%	0	-	-
	Mat 5	8/8/06-	14.4	15.8-	All	59	2,380	100%	24	57	31.6
		8/11/06		24.5	Pools	12	666	28%	8	73	31.4
					Flatwaters	26	1,237	52%	8	59	24.9
					Riffles	10	390	16%	8	39	38.4
					NonSamp	11	87	4%	0	-	-
	Mat 7	8/16/06-	8.4	16.7-	All	64	2,327	100%	25	51	18.4
		8/17/06		22.2	Pools	23	1,088	47%	9	65	20.3
					Flatwaters	11	575	25%	8	45	15.8
					Riffles	8	337	14%	8	41	18.8
					NonSamp	22	327	14%	0	-	-
	UNF up	8/18/06-	3.1	14.0-	All	91	1,741	100%	25	25	10.2
		8/19/06		17.0	Pools	28	609	35%	8	19	12.0
					Flatwaters	23	590	34%	9	27	9.5
					Riffles	14	382	22%	8	28	9.1
					NonSamp	26	160	9%	0	-	-

[1] Ven 4 was dry and not sampled in 2003

[2] in the 2003 HSI report, study site LNF low was referred to as LNF "extra", and LNF mid was referred to as Ven "low"

assessed by the same individual in both studies. Several of the water quality parameters used different datasets in 2006, such as water temperatures and associated D.O. values (the latter were assumed to be at saturation given the estimated temperatures). Given the similarity in mapping methodologies, the primary cause of differences in site-specific HSI scores between years was expected to result from:

1. natural changes in habitat characteristics from 2003 to 2006 (expected due to large storm events in 2005 and 2006);
2. seasonal differences between spring 2003 and summer 2006 samples (middle and upper segments only);
3. selection of different habitat units within each study site, and calculation of mean habitat values;
4. sample size effects, where low numbers of observations for certain habitat parameters may lead to unrepresentative estimates, particularly the highly influential spawning quality score (Vs);
5. changes in datasets used to estimate water quality parameters;
6. changes in two HSI curves (the rearing temperature and spawning velocity curves); and,
7. use of different equations in study segments dominated by resident, non-anadromous fish.

Each of these potential factors are discussed below. Other modifications to specific HSI variable estimates will be described within the appropriate study site.

1. Natural Changes in Habitat Characteristics

Potentially significant differences between the 2003 and 2006 HSI scores were expected to arise from the effects of large flood events and the sustained high flows due to above average precipitation in 2005 and 2006. Large flood events occurred in the Ventura/Matilija Basin in January and February 2005 with flood flows >10,000 cfs (maximum of >20,000 cfs in January), and in April 2006 with flood flows >5,000 cfs (estimated at Ventura River gage #8500). Such flow events would be expected to have significant effects on channel morphology and substrate composition, riparian and aquatic vegetation, and fish survival.

2. Differences in Survey Periods

HSI mapping in the reaches above Matilija Dam (and also in the lower North Fork Matilija Creek) was conducted in April of 2003, but not until August of 2006 (due to contracting limitations). The principal effects on HSI data would be through differences in streamflow, and its effects on depth, velocity, cover, and substrate characteristics within sampled habitat units. Bankside and overhead vegetation could also differ in some reaches (e.g., those with more riparian vegetation). Despite the four-month difference, the high precipitation that occurred over the winter and spring of 2005-06 actually resulted in higher flows in August 2006 (about 22 cfs above the dam) than those that occurred in April of 2003 (approximately 14 cfs). In contrast, HSI mapping in the mainstem Ventura River occurred during July of both years, yet streamflows were much higher in the wet year of 2006 (25-30 cfs at Casitas Springs) than in the dry year of 2003 (approximately 10 cfs).

3. Selection of Sampling Units and Calculation of Mean Values

HSI data in 2003 was collected in an average of 20 habitat units selected by simple random sampling within each study site. This selection methodology was expected to yield sampling within habitat types that was relatively proportional to the availability of each habitat type (e.g., habitat types that were more common would be selected more often than rare habitat types). Mean values for several habitat attributes used in the HSI analysis, such as thalweg depth, percent cover, percent pools, etc., were expected to accurately represent the overall habitat in that study site. In 2006, unit selection was conducted by stratified random sampling, with an equal number of habitat units selected in each of the three principle habitat types (e.g., 8 riffles, 8 flatwaters, and 8 pools in most study sites). Mean values based on an equal number of common and rare habitat types would not be expected to represent the entire study site, but instead would be biased in favor of the rare habitat types. Consequently, habitat attributes that were influenced by habitat type were estimated using a weighted mean, with weighting factors determined by the proportional availability of each habitat type in that study site. In two study sites were *O. mykiss* were not observed or captured (Ven 1 and Ven 4), sampling effort was abbreviated at four habitat units per habitat type.

4. HSI Sensitivity to the Spawning Parameter (Vs)

Estimated means for habitat parameters that are inadequately represented are subject to inaccuracy due to sample size effects. In general the overall HSI score is relatively insensitive to variation in individual habitat variables, unless a variable produces a suitability value of zero, which also zeroes-out the overall HSI (TRPA 2004). The 2006 mapping and analysis did illustrate, however, the dramatic influence of the Vs parameter (rating spawning habitat) on the overall HSI score, and it illustrated a significant limitation of both the HSI model and how it was applied in this study. The embryo component of the HSI model is based on three variables (embryo temperature, embryo D.O., and spawning habitat) that essentially represent the “recruitment potential” into the study area through spawning success. The HSI model selects the lowest value among the three embryo component variables when calculating the overall HSI score. In most of the study sites in the Ventura/Matilija Basin in both years of study, the lowest embryo variable was the spawning habitat variable, labeled as Vs.

Vs is calculated by assessing the water velocity, substrate size, and percent fines in patches of spawning gravel. In 2006, rapid visual and qualitative methods were used to assess the physical characteristics of spawning gravels, whereas more quantitative methods were used in 2003 (TRPA 2004). As previously stated, our summer survey period did not allow measurement of water velocities during the spawning season (Jan-March), therefore we applied a universal expansion factor to multiply velocities by a factor of 2.0 in an attempt to estimate velocities during winter and spring conditions.

Using such an expansion factor adds a considerable amount of uncertainty in the calculation of Vs. Even more uncertainty is introduced when sample sizes are small, as was frequently the case in the Ventura/Matilija study sites. Our survey protocols looked for suitable spawning gravels only in the habitat units selected for HSI mapping (24 units in most study sites). For many of the study sites in this basin, areas of spawning gravel were uncommon, and consequently many of the Vs scores were calculated from insufficient sample sizes, which appeared to have led to large differences in Vs scores between years. Differences in substrate characteristics were expected between 2003 and 2006 due to the large storm events in 2005 and 2006 and the preceding drought, but the large and inconsistent changes in many Vs values suggest that sample size effects may be the overriding cause of annual changes. In 2003 and 2006, almost one-half of the study sites contained less than five gravel patches in the selected habitat units, but the sites having low sample sizes differed between years, which further exacerbated the small sample size effects.

Additional sampling in 2007 will attempt to correct this deficiency by 1) collecting spawning gravel data at all patches in the entire ½ to 1 mile study sites (i.e., not just those in selected units); and 2) assessing an alternative method to estimate “recruitment potential” that recognizes the importance of recruitment from a nearby spawning tributary (this second alternative will be further discussed under “Summary and Recommendations”).

5. Changes in Datasets

The water quality variables used in the HSI model are based on longer-term datasets than can be collected during a single summer sample. For example, the variables for average maximum daily temperatures for adult and smolt migration (for steelhead) and for egg incubation or juvenile rearing (both resident and anadromous forms) are ideally taken from continuous measurements over multiple months. Such long-term, continuous datasets were not located for the Ventura River basin, although numerous stream gages and two dams have or continue to be operated in the basin, and temperature data may be available from these sources.

Temperature data that was located included highly intermittent spot measurements associated with the basin gages, and monthly Stream Team data (http://stream-team.org/graphui/graphVenturaChemistry1Site.php, link valid on 5-22-07) from several locations in the basin. Although the gage data was used to estimate some of the 2003 temperature values, the Stream Team data contained more observations over more consistent time periods than did the intermittent gage data, and the Stream Team data appeared to represent the best available information for estimating temperatures for adult and smolt migration and for egg incubation. For juvenile rearing temperatures during summer base flow conditions, the Stream Team’s single monthly measurements were taken at various times of day (but time was not included in the website database), and thus did not appear adequate to estimate a maximum daily temperature for this critical period. Consequently we used the average maximum temperature measured during our summer surveys, which for most reaches encompassed a period of 3-6 days (Table 1).

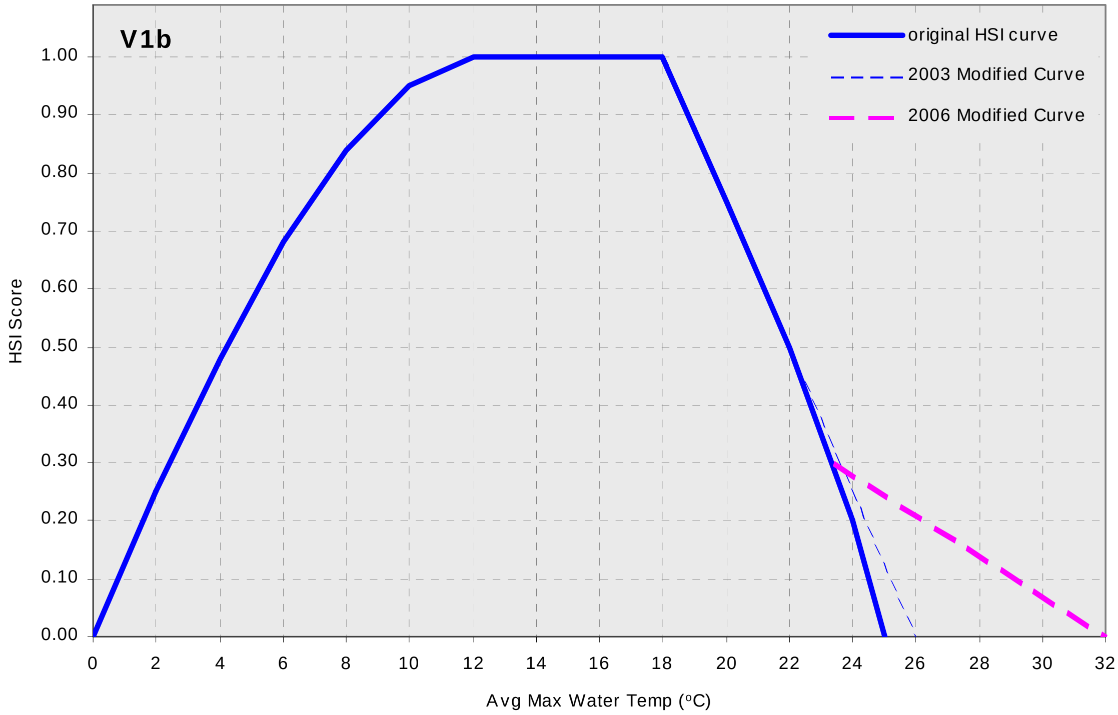
Overall, the differences between the estimated maximum temperatures used in the 2006 study and the 2003 study were relatively minimal and did not appear to have a major effect on the final HSI scores.

6. Changes in HSI Curves

Significant changes were made to several of the original HSI curves (Raleigh et al. 1984) during analysis of the 2003 results (TRPA 2004). Curve modifications are recommended by the model authors "when existing regional information indicates that the variable suitability relationship is different from that illustrated" [in the graphs]. Most of the changes involved adjustments to the various temperature curves (e.g., egg incubation, adult and smolt migration, juvenile rearing), which were felt to be unrepresentative of southern races of steelhead that commonly inhabit water temperatures that exceed the maxima of the original HSI curves (see Spina 2007 for a list of rearing temperature studies). Fish abundance sampling in 2007 illustrated that potentially high densities of *O. mykiss* could inhabit temperature regimes that were not well represented even by the 2003 modified curve (for rearing), therefore additional modifications were made to the rearing temperature variable, V1b (Figure 2, upper graph). These new modifications were made solely by TRPA using professional judgment; they were not conducted by consensus among salmonid temperature experts, which is a recommendation for future surveys. This modified rearing temperature curve was recently used in another HSI study in steelhead stream within the South-Central California coast ESU (TRPA 2007).

The spawning velocity HSI curve (variable V5) was also modified (Figure 2, lower graph) because of the uncertainty in estimating spawning velocities during summer flow conditions, and because spawning habitat requirements appeared to be poorly represented by the original HSI curves (Raleigh et al. 1984). TRPA maintains an extensive database of habitat suitability criteria for use in instream flow studies throughout the U.S. Habitat suitability curves for spawning velocities consistently show different suitability values for large anadromous steelhead, that spawn in swifter water, compared to smaller resident trout that spawn in slower water. Consequently the original V5 curve was modified to represent slower spawning velocities for resident trout in the middle and upper segments (which are dominated by small resident trout), and faster velocities for steelhead spawners in the lower segment. The existing database of habitat suitability curves that were used to modify the V5 curves are not shown in this report, but can be provided upon request.

Other assumptions were made in an attempt to better represent water velocities during the winter/spring spawning season. Like the 2003 HSI analysis, the velocities estimated over observed spawning patches in 2006 were doubled prior to comparison with the HSI velocity curve, based on the measured relationship between low-flow velocities and high-flow velocities over specific gravel patches as assessed in 2003 (see TRPA 2004 for a full description of spawning gravel assessment). In addition, it was assumed that all spawning gravels that had zero velocities in the summer of 2006 would have had some velocity during the winter/spring spawning season. Therefore, all gravel patches with measured velocities less than the HSI minima (10 cms for trout and 15 cms for steelhead,



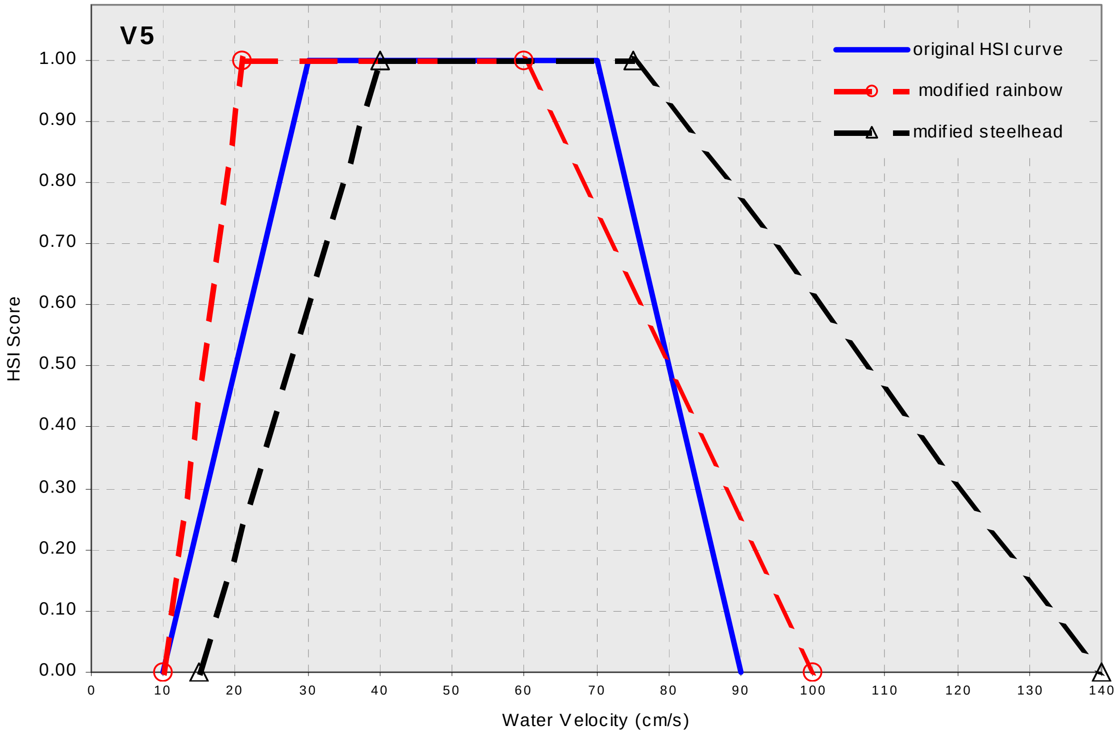


Figure 2. HSI curves modified in 2006 for rearing temperature (upper graph) and spawning velocity (lower graph). See TRPA 2004 for curves modified in 2003.

Figure 2) were assigned a minimum suitability value of 0.25. Note that the modified suitability value for spawning velocity is only one of several measurements used to estimate the overall spawning suitability value (Vs), which was described in a previous section.

7. HSI Equation Selections

The HSI model for *O. mykiss* contains alternative equations used to represent habitat suitability for either resident trout or for anadromous steelhead (Raleigh et al. 1984). The equations for the anadromous life history expression utilize HSI variables specific to steelhead, such as temperature requirements during upstream migration of adult spawners, and downstream migration of steelhead smolts. Because the 2003 HSI analysis was intended (in part) to assess the potential habitat quality for reintroduction of steelhead above Matilija Dam, the 2003 HSI study used steelhead equations for all reaches, including those presently inaccessible to steelhead above the dam. In contrast to the 2003 study, a goal of the 2006 study was to compare HSI scores with existing population densities of fish in each reach, whether of resident, non-anadromous parentage or of (potentially) anadromous parentage. Thus, steelhead HSI equations were used for the study sites in the lower segment (like in the 2003 analysis), but instead resident trout equations were used for sites in the middle and upper segments (unlike the 2003 analysis). In general, HSI scores based on resident trout equations were only slightly lower than scores for steelhead in the middle and upper segments, but mostly by only 0.02-0.04 points (e.g., 0.70 for trout vs. 0.73 for steelhead in study site LNF low).

FISH SAMPLING

For threatened and endangered species, state and federal agencies prefer passive fish sampling methods, such as direct observation (i.e. snorkeling), wherever feasible. In small to medium sized streams under low flow conditions, such as the Ventura River and Matilija Creek during the summer months, snorkeling is most effective where depths are sufficient for divers to navigate upstream. However, snorkeling is not effective where shallow depths prevent the diver from moving effectively through the unit. In such areas electrofishing can be highly effective to generate abundance estimates. For this study, sampling by direct observation was the preferred methodology and was used in those habitats where diving was feasible. Water depths in all of the mainstem Ventura River reaches was sufficient to allow direct observation in pool and flatwater habitat units, but electrofishing was employed in all riffles. In smaller channels where flatwaters were too shallow to conduct dive counts, electrofishing was used in riffles and flatwaters, and dive counts were only employed in pools. The determination of appropriate fish sampling methodologies for each stream reach was made during the habitat mapping survey.

Direct Observation Dive Counts

Because conventional dive counts only represent an *index* estimate of abundance and not an estimate of *total* abundance, a random subsample of the units sampled by diving was re-sampled in order to calibrate the dive count index estimates to produce estimates of total abundance. The protocols and formulas used to calibrate the dive counts, and to generate basin-wide estimates of steelhead abundance, were taken from Mohr and Hankin's Method of Bounded Counts (MBC) manuscript (*in press*). Stream reaches that were sampled using electrofishing as the primary sampling methodology (described below) did not need calibration because multiple-pass electrofishing provides estimates of total abundance.

Each pool or flatwater unit selected for conducting dive counts was sampled by one to four biologists using a single pass dive count of all observed steelhead according to two size classes (e.g., fry at <10cm FL, and juvenile+ at ≥10 cm FL). Divers cautiously entered the lower end of each habitat unit in pre-specified dive lanes, then proceeded together upstream to the unit head counting fish as they passed downstream of the diver. Diver position and observation area within each unit was determined prior to each unit being sampled. Each diver enumerated all juvenile steelhead in their dive lane by size class, with reference to an underwater ruler. The diver counts from the single pass were added to estimate an index of fish abundance within the habitat unit. The two fish size classes used in this study are consistent with the size classes utilized in previous studies in the South-Central California Coastal ESU for steelhead (TRPA 2001 [Morro Bay tributaries], TRPA 2004b [San Luis Obispo watershed], TRPA 2007 [San Luisito Creek]), and were based on the late-spring length-frequency distributions of steelhead captured in a downstream trap operated on lower San Luis Obispo Creek.

Data were recorded onto underwater slates during the dive counts, and then transferred to data sheets after each dive. Additional information collected at each habitat unit included starting and ending dive times, water temperature, underwater visibility (measured as the distance at which a diver could clearly identify a two-inch trout colored lure), photographs, and GPS location.

After conducting the single-pass dive count, the divers determined if the unit was selected for a second-stage calibration survey by removing a label concealing a "yes" or "no" previously recorded for each unit (but unknown to the divers). If the unit was not selected for calibration (labeled as a "no"), the divers continued upstream to the next selected pool (or flatwater). If the unit was selected for calibration, the divers conducted three more independent dive counts according to the MBC protocols. Each repetitive count was conducted after the water visibility had cleared sufficiently to produce visibility conditions similar to the first dive count. In most study sites, a subsample of five units of each type sampled by diving was selected by simple random sampling for calibration. Study sites in the lower segment where *O. mykiss* were not captured or observed received three or four calibration units. Thus, second-stage calibration was conducted on 50% or more of units that were selected for first-stage dive counts. All calibration surveys were conducted using the repeat dive counts; electrofishing was not used because first pass counts in all calibration units were less than the maximum count (20 fish per species/size strata) recommended for calibration by direct observation methods (Mohr and Hankin, *in press*).

Multiple-Pass Electrofishing

Multiple-pass electrofishing was employed as the primary fish sampling methodology in all riffles and in also in flatwaters for those stream reaches that were too shallow to effectively dive the flatwater habitats. Electrofishing surveys were conducted by trained personnel using procedures consistent with guidelines established by NOAA Fisheries for protecting listed species of salmonids (NMFS 2000), except that electrofishing was conducted at stream temperatures higher than the maximum recommended temperature of 18°C, and at conductivities higher than 350µS/cm. At virtually all of the mainstem Ventura River study sites, and several of the mainstem Matilija Creek sites, summer water temperatures in the morning hours already exceeded the NOAA recommended maximum, and specific conductivities throughout the entire basin were typically over 700µS/cm. Consequently, it would not be possible to utilize electrofishing within the study area under the federal guidelines. We notified NOAA of this problem and continued with our intended sampling procedures based on several assumptions and observations:

1. Southern steelhead are tolerant of warmer water conditions than steelhead in more northerly areas;
2. Repeated electrofishing in one study site (Ven 5) with maximum temperatures up to 28°C did not reveal any immediate mortality;
3. At one study site (Mat 5) with afternoon water temperatures up to 24°C, 14 *O. mykiss* captured by electrofishing in the morning were retained for 24 hrs in a net pen to assess longer-term electrofishing effects; no mortalities were observed.

Prior to electrofishing, block nets were placed at the upper and lower unit boundaries in order to prevent emigration out of the study site during sampling. On smaller habitat units, great care was taken to place the block nets in a manner to minimize displacement of fish prior to sampling (e.g., on some short units both nets were stretched simultaneously to entrap alarmed fish). Maintenance of a minimum habitat unit length (for riffles and small channel flatwaters only) of 20 ft during the mapping also helped to minimize this potential disturbance. Occasionally, the upper boundary of the sampling unit led to a cascade or high gradient riffle, which provided an effective upstream barrier, and those units did not require an upper block net. In some units in the lower segment of the Ventura River, large amounts of drifting algae and high water velocities made the maintenance of block nets extremely problematic. In such cases we periodically removed algae from the nets during each pass, but even so water would sometimes overtop the downstream net, despite supporting the net with trees or boulders on the bank and wooden posts in midstream.

Each unit was sampled using one or two backpack electrofishers (Coffelt models 11-A and 12-A) with one to two netters per shocker. The voltage and frequency settings used during electrofishing were adjusted for each stream reach to provide efficient capture of fish and to minimize physical injury to the fish. Each sampled pool received a minimum of three electrofishing passes, unless salmonids were not captured in either of the first two passes. All captured fish from each pass were temporarily held in an aerated bucket or transferred into an instream live-car until all electrofishing passes were completed. Equal effort was maintained among passes by careful attention to repeating each pass (by the same individual) in a similar manner and in a similar time frame. The "shocking seconds" and the beginning and ending times were recorded for each electrofishing pass. After electrofishing, all captured salmonids were anesthetized with CO_2 (using a 3:1 solution of water:club soda or alka-seltzer tablets dissolved in water) in order to reduce stress associated with measurement. The following data were recorded at each study site: number of fish captured (by species) during each pass, the fork length of each salmonid (to nearest mm), the number of mortalities (if any), and counts of other species collected. Fish weights were not measured. After data collection, all fish were revived in fresh water and released back into the sampled pool. In addition to the capture data we measured water temperature and conductivity at each electrofishing unit.

Estimation of Fish Abundance

The abundance and density (number/100 ft^2 of stream channel) of *O. mykiss* by size class was estimated at three spatial scales: within each individual habitat unit, within each individual study site, and within the entire upper, middle and lower segments of the watershed. Unit specific estimates of *total* fish abundance for electrofished habitats were derived for each size class using a jackknife estimator (Mohr and Hankin *in press*). For units sampled by diving, single pass dive counts were used to estimate an *index* of abundance. For dive units that were calibrated by the MBC we produced bias-adjusted estimates of *total* abundance according to the bounded count formula. A few habitat units were sampled by both the MBC (four dive passes) and electrofishing in order to compare both estimates of *total* abundance.

For estimation of fish abundance and densities at the study site scale, jackknife electrofishing estimates, or dive counts calibrated by MBC, were used according to the equations presented in Mohr and Hankin (*in press*). Habitat unit length was tested as an auxiliary variable in ratio estimators to see if the expected positive correlation between numbers of fish and unit size would increase precision of the abundance estimates. A high, positive correlation will increase the precision of ratio estimators and thus improve the ability to detect differences among spatial and temporal scales. The estimators used to represent each study site varied; ratio estimators with auxiliary variables (unit lengths) were used in many study sites and habitat types, but estimators without auxiliary variables were used in others (depending upon which estimate was most precise). Because the estimates of abundance and variances were independently derived for each habitat type, the overall study site estimates were calculated by simply adding together the respective habitat type estimates of abundance and variance. All equations used to generate such estimates were derived from the MBC protocols (Mohr and Hankin *in press*) and from Hankin (1984), and can be made available upon request.

Estimated abundance at the segment scale was calculated by summing the abundances and variances from each study site within each segment, then expanding those summed estimates to represent the total length of each segment. Because each study site was randomly selected and sampled independently, their abundances and associated variances were simply additive. Note that the *O. mykiss* abundance estimates do not include portions of tributaries above impassable barriers (TRPA 2003), or tributaries that were not sampled, such as Old Man Creek or Murietta Creek in the upper segment, and Coyote Creek or San Antonio Creek in the lower segment. The expanded segment estimates do include the entire length of the mainstem Ventura River (up to Matilija Dam), all of Matilija Creek (up to the first impassible barrier), and both forks (upper and lower) of the North Fork Matilija Creek (again, up to the first impassible barriers identified in 2003).

Ventura Lagoon Sampling

On August 25, 16 beach seine sets were made throughout the Ventura River lagoon using a 100 ft seine with a ½ inch mesh size (Figure 3). The larger mesh size was used to avoid capture of the listed tidewater goby (*Eucyclogobius newberryi*), but may have also prevented capture of small *O. mykiss* fry. Seining could not be conducted in the deep, riprap lined channel under the railroad bridge, and therefore we deployed a pole-mounted, high-resolution underwater video camera (Outland Technology UWC-300, low-lux B&W) to search for fish among the riprap boulders and in deeper water. In the shallow, flowing water immediately above the lagoon proper, electrofishing passes of 10-15 minutes each were made with a pair of backpack shockers in two separate areas. The seine sets were made during higher tidal stages, whereas the electrofishing was conducted at the head of the lagoon at lower tidal stages. Salinity was less in the upper reaches at lower tide (0.4-0.6 ppt vs. 10-16 ppt near the lagoon mouth); however, it was still high enough to inhibit electrofishing success. The lagoon was open to the ocean at the time of sampling and had probably had remained open throughout the previous months. All captured fish were identified to species, enumerated, and released back into the lagoon.

Comparison of Fish Abundance and HSI Scores

The relationship between estimates of fish abundance and HSI scores was assessed for each of the 11 study sites by simple linear regression, using the HSI score as the predictor variable and fish density (#/100ft^2) as the response variable. Separate regressions were conducted for fry density and juvenile density. HSI and fish abundance data were pooled among study sites to represent the three study segments and this relationship was visually assessed using scatterplots.

Direct comparison of specific variable and overall HSI scores between the 2003 and 2006 studies revealed the overriding influence of the spawning suitability variable (Vs) on the overall HSI scores. The potentially significant effects of limited availability of spawning patches on study site HSI scores, and its effects on the fish abundance:score relationship suggests additional modifications to the HSI model may be necessary to better account for the influence of recruitment from nearby tributaries; such modifications are discussed more fully in a later section.

Figure 3. Map showing approximate shape of Ventura River Lagoon in August, 2006 (dark green area). The locations of underwater video surveys, seine hauls, and electrofishing passes are also shown (refer to letters and numbers in Table 4). The lagoon was open to the sea during and prior to the 2006 survey.

Other Data Analysis

Length-frequency distributions of fish captured by electrofishing were created for each stream reach in order to assess possible differences in local population characteristics, and to evaluate the appropriateness of the 10cm size criterion for separating fry (young-of-year) from juvenile+ *O. mykiss* (yearling or older). The potential relationships between the observed or estimated number of steelhead in a mesohabitat unit and the physical characteristics of that unit were evaluated through scatterplot and simple correlation analysis. Other potentially influential factors, such as presence of nearby dry channels, water temperature, etc., were also considered. The reliability of using direct observation dive counts was qualitatively assessed in a limited subset of pool habitats by comparing single-pass dive counts with electrofishing estimates. A strong, positive relationship between dive counts and electrofishing estimates would suggest that dive counts can produce index estimates that are representative of true abundance, and would further support the use of this passive methodology in assessing populations of listed fish species.

RESULTS

Fish sampling and HSI mapping was conducted in the Ventura/Matilija basin from 10 July to 24 August 2006, followed by one day of sampling in the Ventura Lagoon on 25 August. Basic sampling statistics and mesohabitat proportions for each study site are presented in Table 1. Overall, 238 mesohabitat units were sampled, resulting in the electrofishing capture or dive count of 364 *O. mykiss* <10 cm in fork length (hereafter referred to as "fry"), and 394 "juvenile +" *O. mykiss* $\geq$10 cm long. The fish sampling results are presented as abundance (total # of fish) and as density (#/100 ft^2) for each study site (according to each mesohabitat type or combined across mesohabitat types), and for each study segment (combined across study sites). HSI scores from 2006 mapping are compared to the 2003 HSI scores and to the 2006 estimated fish densities for each study site. The mesohabitat mapping data is presented in Appendix A, general sampling information and water quality measurements for each sampling unit in Appendix B, physical HSI measurements for each sampled habitat unit in Appendix C, fish sampling details in Appendix D, and representative photos of each study site in Appendix E (photos of all sampled sites are available on CD upon request). GPS coordinates for all sampled habitat units are available in Appendix F.

ANNUAL DIFFERENCES IN STREAMFLOW CONDITIONS

Like most central and southern California basins, seasonal rainfall and associated streamflows in the Ventura River Basin are highly variable. Large differences in streamflows and in the overall availability and quality of fish habitat occurred between the original mapping year of 2003 and the repeat mapping and fish sampling in 2006. Historical and recent streamflow data (recent only for the lower Ventura River) was obtained from several USGS gages in the Ventura River Basin.

Mean monthly flows and 95% confidence intervals (C.I.) for the means are shown for the lower Ventura River at Foster Park, based on a 47-year period of record at Gage #8500 (Figure 4, bottom graph). Also shown are the mean monthly flows for the years 2003-2006, as well as flows estimated by TRPA field crews in the Ven 3 reach (just upstream of Foster Park) during the 2003 and 2006 surveys. The streamflow data suggest that flows in 2004 were well below normal in almost every month, whereas flows in 2003 were below normal in the winter, early spring, and fall, but were not unusually low during the summer months (despite being the second consecutive drought year). The

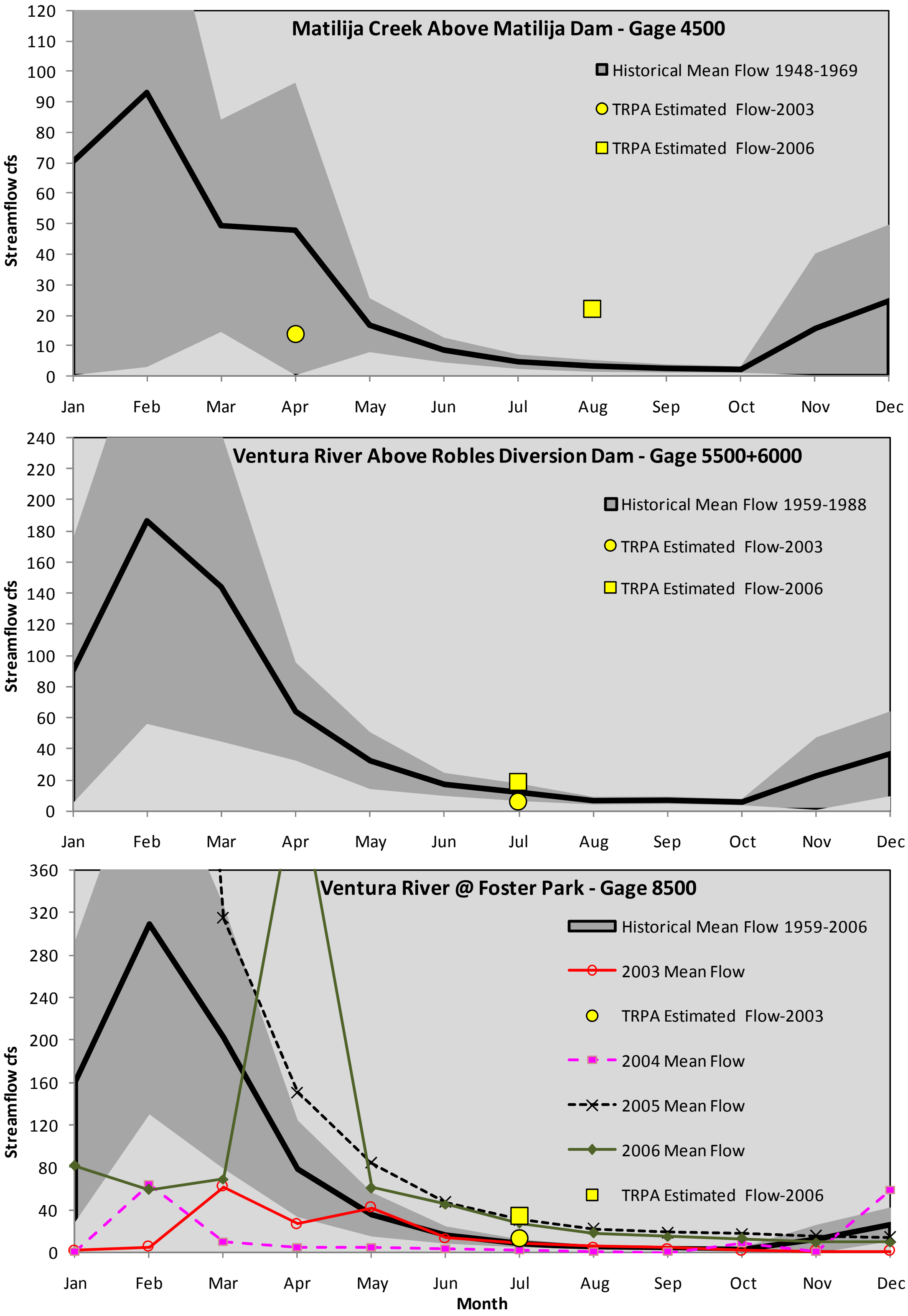


Figure 4. Mean monthly streamflows and recent point estimated flows at several locations in the study area. Lines are based on stream gages (thick black line is historical mean, dark shading is 95% C.I.'s for the means), individual points are TRPA estimates.

Figure 5. Storm flows over the Wheeler Gorge Campground barrier in the lower North Fork Matilija Creek, March 15, 2003.

TRPA estimated flow in July 2003 was slightly above the 47-year average (13 cfs vs. a mean of 9 cfs). Winter flows in 2005 were very high, with a January flood peak of over 40,000 cfs and a February peak over 10,000 cfs, which sustained summer flows well above the upper 95% confidence interval flows. In 2006, flows were lower than normal during the winter, but late-season storm events occurred in March (Figure 5) and April (April peak flows exceeded 9,000 cfs) which resulted in higher than normal flows (by 3-4 times) throughout the summer months. The TRPA estimated flow in July 2006 was also well above the normal flow (35 cfs vs. 9 cfs). Flows were high enough during the July 2006 survey to sample the Ven 4 study site just below the Robles Diversion Dam, which is an area typically dry during the summer months (Figure 1).

Historical streamflow data was also evaluated for the Ventura River above Robles Diversion Dam, by combining 1959-1988 data from gage #5500 (below Matilija Dam) and gage #6000 (from the lower North Fork Matilija Creek). Recent data was not located for this reach, although it may be available from local agencies. The field-estimated flows in the Ven 5 reach in July 2003 and 2006 suggested that flows in 2003 were just below the lower 95% confidence interval (and one-half of the mean flow), whereas the estimated flows in 2006 were just above the upper 95% confidence interval (Figure 4, middle graph).

For Matilija Creek above Matilija Dam (Figure 4, top graph), gage #4500 provided historical data for a 20-year period (1948-1969). The field estimated flow in 2003 was collected in April, which showed low flows compared to normal conditions (14 cfs measured vs. a historical mean flow of 48 cfs). In contrast, the estimated flows in August 2006 were 6 times greater than the historical mean flow (22 cfs vs. 3.5 cfs), and was well above the upper 95% C.I. flow.

This qualitative flow analysis illustrates that the HSI data collected during the 2003 season were representative of relatively low flow conditions, whereas HSI data and fish population data collected in 2006 were representative of three years of lower-than-normal flows (2002-2004), followed by two years of higher-than-normal flows that included the occurrence of a major flood event in 2005 and late-season storm events in 2006. The 2005 storm events had the potential to impact *O. mykiss* survival through displacement, direct mortality, or other stresses over the winter months, and the 2006 events likely impacted salmonid recruitment due to flood events over the period of trout spawning and/or egg incubation.

HSI MAPPING

The HSI mapping protocols used in 2006 were essentially identical to the methods used in 2003, with the exceptions previously described. Other modifications to specific HSI variable estimates will be described within the appropriate study site. The variable-specific HSI scores in Table 2 were based on the original (Raleigh et al. 1984) or modified (TRPA 2004 and Figure 2 of this report) HSI curves and the physical habitat data shown in Appendix C. Overall, changes in site-specific HSI scores were minor or moderate for most study sites, with only two scores changing by more than about 20% (Figure 6). In general, most changes in the lower segment were positive (e.g., increased scores from 2003 to 2006), whereas most scores in the tributaries and in Matilija Creek were negative.

Table 2. Summary of HSI variable, component, and overall scores by study site and segment.

HSI Variable		VEN 1	VEN 2	VEN 3	VEN 4	VEN 5	LNF low	LNF mid	Mat 3	Mat 5	Mat 7	UNF up
V1 r	max rearing temp	0.18	0.23	0.29	0.19	0.15	0.56	0.92	0.27	0.50	0.76	1.00
V1 am	max adlt migr temp	0.95	1.00	1.00	0.92	1.00	1.00	1.00	1.00	1.00	0.99	0.99
V2 sm	max smolt migr temp	0.51	0.60	0.61	0.55	0.60	0.75	0.75	0.88	0.84	0.93	0.93
V2 inc	max inc temp	0.45	0.56	0.56	0.48	0.55	0.72	0.72	0.85	0.85	0.95	0.95
V3 r	min rearing DO	0.75	0.83	0.93	0.94	0.47	0.68	0.68	0.81	0.96	0.97	1.00
V3 inc	min incub DO	0.95	0.95	0.99	0.97	1.00	0.68	0.68	0.67	1.00	1.00	1.00
V4	avg thalweg depth	1.00	0.97	0.93	0.87	1.00	1.00	1.00	0.95	0.93	0.98	0.95
V6 jv	% cover-juv	1.00	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
V6 ad	% cover-adlt	0.42	0.37	0.46	0.37	0.81	0.67	0.51	0.55	0.60	0.55	0.47
V8	% winter sub	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
V9	avg riffle sub	1.00	1.00	1.00	1.00	0.30	1.00	1.00	1.00	1.00	0.60	0.60
V10	% pools	0.65	0.52	0.55	0.55	0.90	1.00	1.00	0.82	0.91	1.00	0.96
V11	% vegetation	0.54	0.28	0.15	0.16	0.45	0.60	0.32	0.30	0.17	0.35	0.77
V12	% stable banks	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
V13	ann max/min pH	0.55	0.67	0.95	0.95	0.68	0.67	0.67	0.55	0.90	0.88	0.80
V14	low Q:avg Q	0.10	0.10	0.10	0.01	0.26	0.26	0.26	0.20	0.20	0.30	0.30
V15	pool class	0.60	1.00	0.60	1.00	1.00	0.30	0.30	0.60	0.30	0.60	0.60
V16 rr	%fines in rifs	0.50	0.96	0.61	0.73	0.75	0.77	0.93	0.90	0.60	0.42	0.98
V17	% shade	0.37	0.32	0.35	0.36	0.57	0.79	0.90	0.36	0.43	0.66	1.00
V18	migr Q:avg Q	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adult Component		0.91	0.94	0.90	0.91	0.97	0.72	0.74	0.82	0.67	0.87	0.85
Juvenile Component		0.62	0.70	0.66	0.68	0.97	0.77	0.77	0.81	0.74	0.87	0.85
Fry Component		0.68	0.71	0.66	0.69	0.88	0.94	0.98	0.88	0.84	0.81	0.98
Embryo Component		0.45	0.36	0.56	0.48	0.45	0.47	0.64	0.67	0.46	0.30	0.91
(Vs)		0.58	0.36	0.67	0.56	0.45	0.47	0.64	0.79	0.46	0.30	0.91
Other Component		0.49	0.51	0.46	0.38	0.45	0.67	0.66	0.53	0.52	0.55	0.78
Study Site Score		**0.61**	**0.61**	**0.63**	**0.60**	**0.70**	**0.70**	**0.75**	**0.73**	**0.63**	**0.63**	**0.87**
Segment Score		**0.61**				**0.71**			**0.73**			

Lower Segment

Four study sites were sampled in the lower segment below Robles Diversion Dam (Table 1). Pertinent characteristics of the lower segment reaches include widely spaced levees that border the flood channel of the lower two miles of the Ventura River, where large homeless encampments lined the stream channel above the lagoon. Upstream of the Shell Road Bridge, the Ventura River borders oil-related industrial development, and a wastewater treatment plant discharges approximately 3 cfs of treated effluent into the river between study sites Ven 2 and Ven 3 (Figure 1). The Ven 3 study site occurs in a

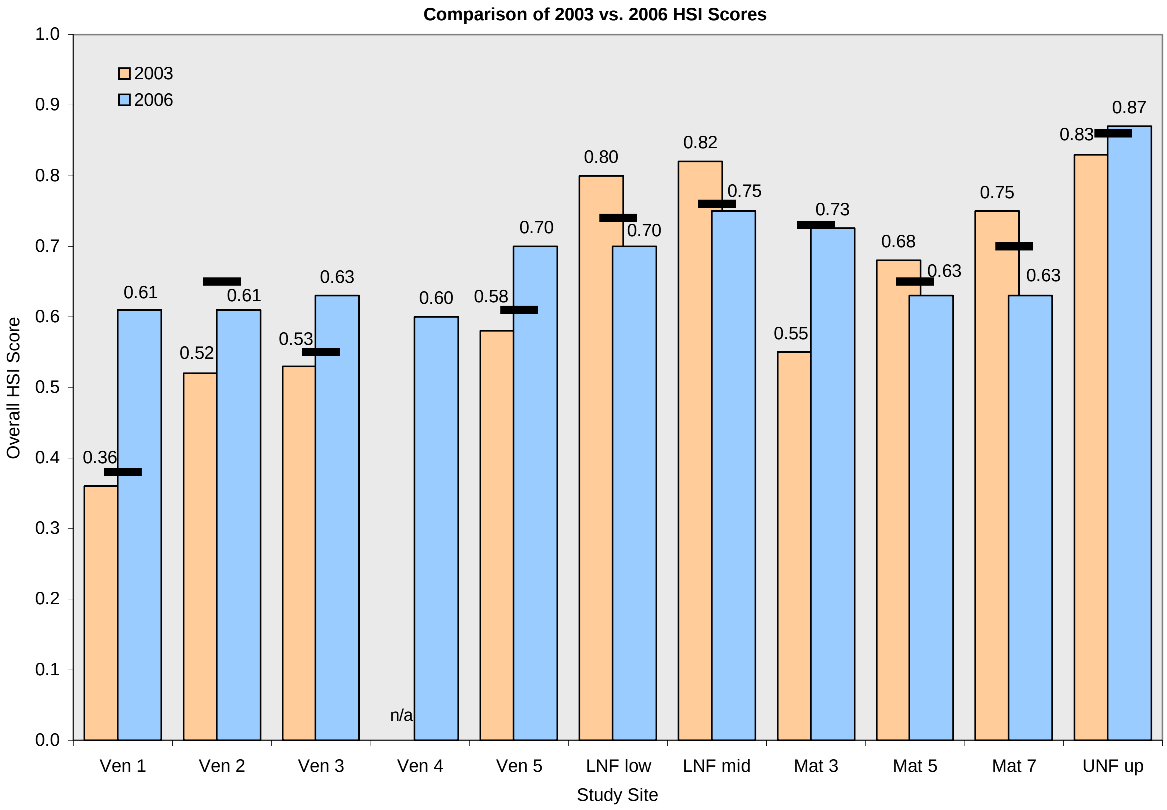


Figure 6. Comparison of 2003 and 2006 HSI scores by study site. Black dash shows what the 2006 HSI score would be if the 2003 Vs values were used.

region of rising groundwater, but that reach also contains a diversion dam and several well fields downstream of the study site. The river channel typically goes dry during spring or summer months from just above the San Antonio Creek confluence to Robles Diversion Dam, about four miles upstream, however water was present in the Ven 4 reach during the 2006 survey.

Ven 1. The lower boundary of Ven 1 was moved upstream approximately 1,500 ft from the 2003 boundary due to numerous homeless encampments that were observed to negatively influence habitat characteristics and water quality. HSI data was collected in a total of 12 habitat units, rather than the typical sample of 24 units, because *O. mykiss* were not observed during fish sampling.

The 2006 HSI score for steelhead habitat in Ven 1 was 0.61, which was substantially higher than the 2003 score of 0.36 (Figure 6). The primary cause of the 70% increase was due to the change in the Vs score, which is a measure of the suitability of spawning areas. In 2003 the calculated Vs score was only 0.04, whereas the 2006 Vs was 0.58, however the 2006 Vs score was based on only a single gravel patch (versus nine patches measured in 2003). The 2006 HSI score would reduce to 0.37 if the 2003 Vs was used (see black bars in Figure 6), which illustrates the significance of the Vs score on the overall HSI score, and the potential influence of low sample size on the Vs measurements.

Substantial changes were also evident among individual variable scores within the adult component (upper graph in Figure 7), namely the adult migration temperature (increased) and the % pools (decreased), but these contrasting changes produced little change in the adult component score and thus had little effect on the overall HSI score (Figure 7, lowest graph). The decrease in % pools was also incorporated into the juvenile and fry components, but the overall juvenile component increased. A significant and very constant change in HSI scores is evident in the % vegetation score (in the "other" component), which showed drastic decreases in every study site except for the upper North Fork site (UNF up). This decrease is undoubtedly due to the flood events in 2005 and 2006, which scoured riparian vegetation from streambanks. In the context of the overall HSI model, the basin-wide decrease in % vegetation, by itself, did not appear to have a significant effect on the final HSI score (Figure 7).

In sum, the large increase in HSI score for Ven 1 occurred due to the embryo component through the increased Vs score, which contained considerable uncertainty due to low sample size and the estimation of spawning gravel suitability during the non-spawning season. For this reason, the 2006 Ven 1 score is probably over-inflated.

Ven 2. Several large bedrock/aggregate formed pools, including the "Shell Hole", occur in the Ven 2 study site, although maximum depths (4-7 ft in six pools) were less than historical accounts. A notable difference in substrate characteristics in 2006 was the apparent scouring of the thick, black organic sediments that were common in pools in 2003, although maximum depths (5-8 ft in 2003) may not have changed.

Like Ven 1 the 2006 overall HSI score for Ven 2 (0.61) increased from 0.52 in 2003, although only by 20% (Figure 6). Unlike Ven 1 and many other study sites, however, the change was not due to a change in the Vs score (Figure 8). Instead, the cumulative increases in the adult, juvenile, and embryo components (mostly due to increased temperature scores) counteracted the decrease in the fry component (due to the decrease in % pools) to produce the overall increase. Besides the decrease in % pools, the Ven 2 study site also showed a dramatic decrease in the % vegetation HSI score (from 0.85-0.28).

Ven 3. The Ven 3 study site occurred in the upper portion of this reach, terminating about 800 ft above the confluence with San Antonio Creek (Figure 1). Habitat mapping identified several locations with cold seeps, including the large pool at the San Antonio confluence where several juvenile *O. mykiss* were observed.

Changes in the Ven 3 HSI scores from 2003 to 2006 were very similar to changes in Ven 2 (a 20% increase from 0.53 to 0.63), with increases in several temperature scores, a decrease in % pools and a strong decrease in % vegetation (Figure 9). Changes in component scores were also similar between study sites, although the embryo component increased more in Ven 3 than in Ven 2, largely because of the increase in the Vs score. If the 2003 Vs score were used with the 2006 data, the overall HSI score would have only increased by 4% from 0.53 in 2003 to 0.55 in 2006 (Figure 6). The 2003 Vs score was

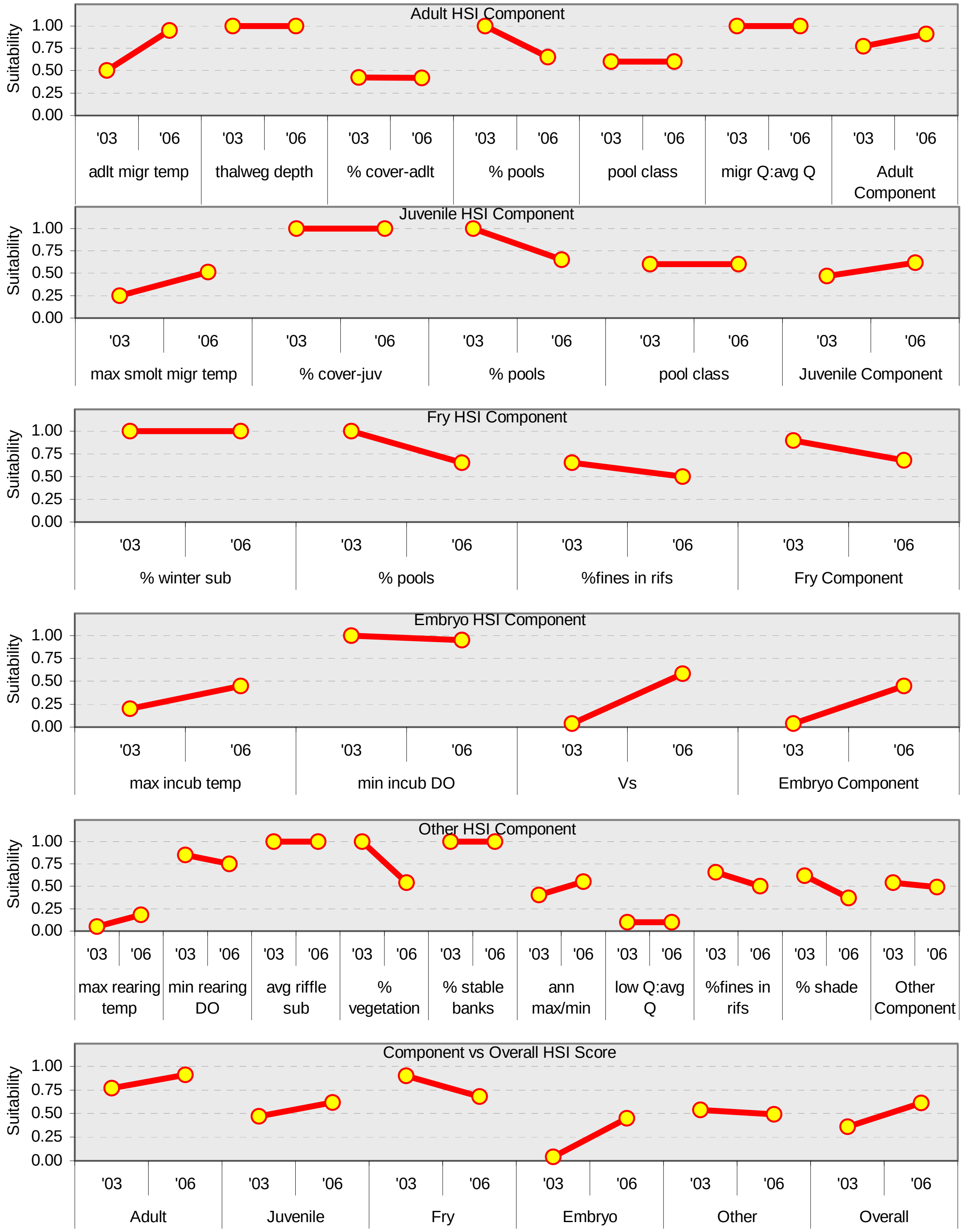


Figure 7. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the Ven 1 study site.

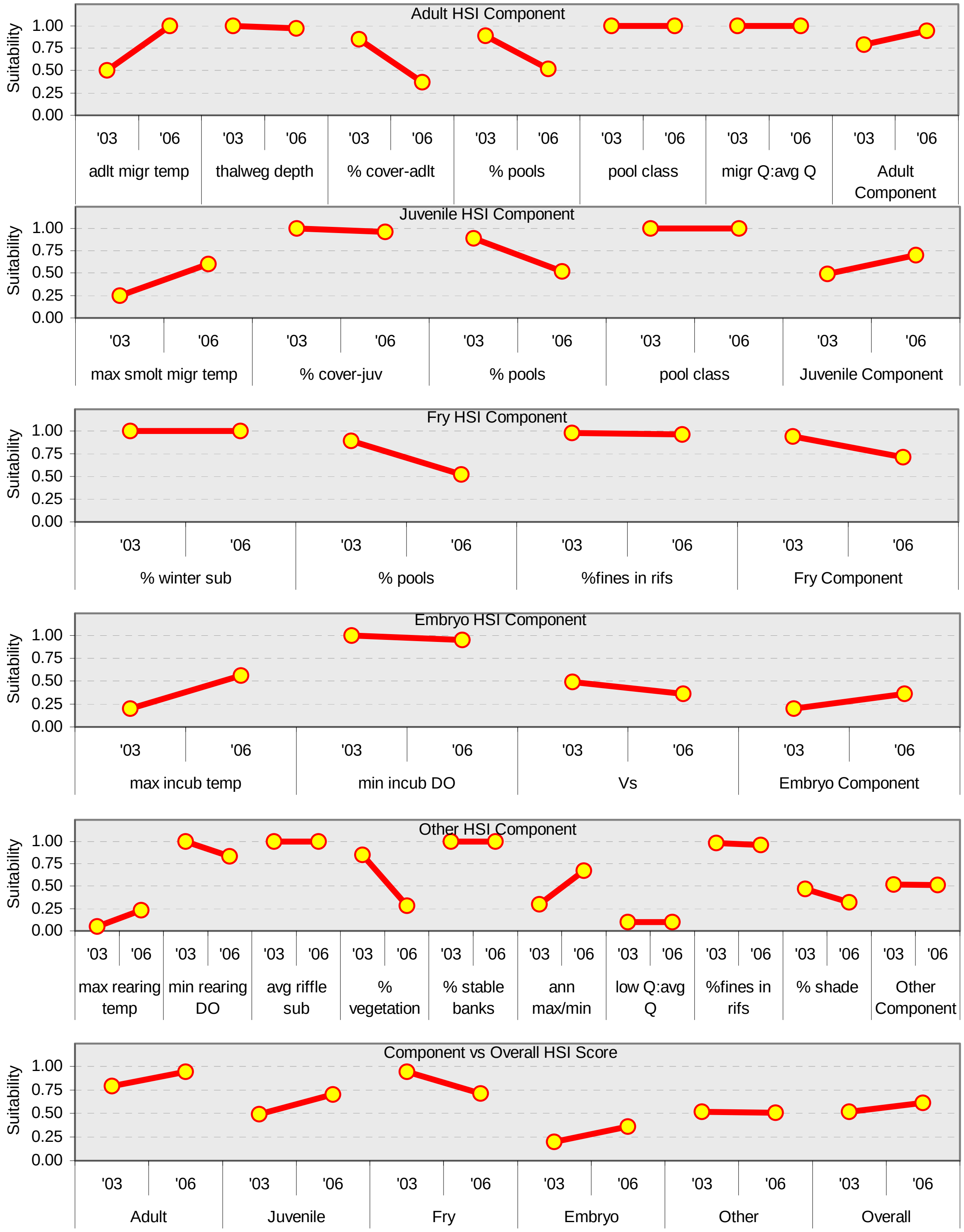


Figure 8. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the Ven 2 study site.

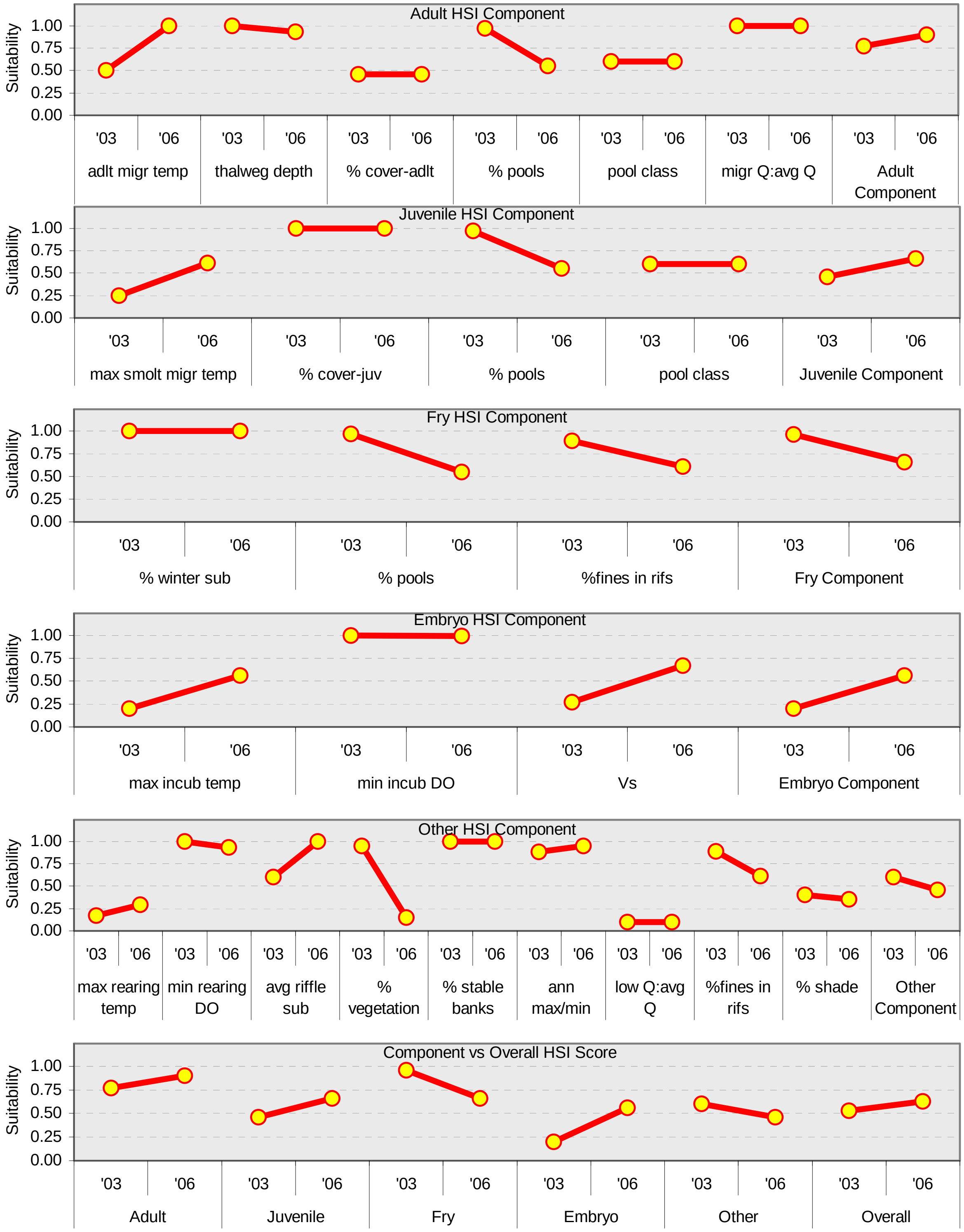


Figure 9. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the Ven 3 study site.

based on eight gravel patches, whereas the 2006 survey only identified two patches (within the 24 selected habitat units).

Ven 4. Like the Ven 2 site, the Ven 4 study site contained several large bedrock/ aggregate formed pools, which occur within the Ojai Valley Land Conservancy property and were highly popular swimming locations (we had to sample these units during morning hours to avoid potential fish disturbance by swimmers). The two largest pools were deep, with maximum depths of 6.1 ft and 10.3 ft. Streamflows were declining rapidly during the time of this survey, with an estimated water surface drop of four inches in one day. The bottom end of the study site occurred just upstream of where the channel went subsurface; the top was about 2,000 ft below the Robles Diversion Dam (Figure 1). HSI data was collected in a total of 12 habitat units, rather than the typical sample of 24 units, because *O. mykiss* were not observed during fish sampling.

Because this study site was completely dry in 2003, HSI scores are not available for comparison with the 2006 scores (Figure 6). One modification to the HSI values specific to the flow instability in Ven 4 was to decrease the V14 HSI score (the ratio of mean base flows to mean annual flows) from the curve-derived value of 0.10 (based on a calculated ratio of 5% from the Ventura River gage #11118500, 1959-2005 data) to a modified score of 0.01 (setting it to zero would produce an HSI score of zero). This modification only decreased the overall HSI score from 0.62 to the final score of 0.60 (Figure 6).

Combined Study Sites. A dramatic effect of the 2006 changes in HSI scores in the Lower Segment is the "evening-out" of the HSI scores, which in 2006 showed very little distinction in habitat quality among the four study sites (Figure 6). This is somewhat in contrast to the 2003 results where the Ven 1 site had a substantially lower score than Ven 2 or Ven 3 (Ven 4 was dry in 2003, thus provided zero habitat). When the lower four study site HSI scores were combined using a weighted mean approach (each score weighted by the length of river it represents), the overall Lower Segment HSI score was estimated at 0.61 (Table 2).

Middle Segment

The Middle Segment was represented by three HSI study sites, Ven 5 in the mainstem Ventura River and two sites in the lower North Fork Matilija Creek, LNF low, and LNF mid (Figure 1). LNF up, which was sampled for the 2003 HSI study, was not included in 2006 because of an impassable barrier below the site (at the Wheeler Gorge campground). A new barrier, formed by landslides subsequent to the 2003 study, occurred in the lower portion of the LNF downstream of the two study sites. Ven 6, immediately below Matilija Dam, was another Middle Segment study site not included in 2006, because the combination of deep pools and poor visibility would not have allowed effective fish sampling with either electrofishing or dive counting methodologies. Sampling was conducted earlier in the Ven 5 site (late July) than in the LNF sites (late August) due to logistical issues. Streamflows during sampling were approximately 20 cfs in Ven 5 and 3-5 cfs in the LNF sites (Table 1). Note that because the Middle Segment and Upper Segment study sites were evaluated using the resident trout HSI equations, some of the HSI variables used in the Lower Segment sites (e.g., adult and smolt migration) and one of the HSI curves (steelhead spawning velocity) were not utilized when calculating the HSI scores.

Ven 5. Ven 5 occurred immediately below the confluence with the lower North Fork Matilija Creek, therefore water temperatures were somewhat mediated by the North Fork from the effects of Matilija Reservoir, which produced very warm and somewhat turbid water. The 2006 HSI score for the Ven 5 study site (0.70) was approximately 20% greater than the 2003 score of 0.58 (Figure 6). As noted for Ven 1 and Ven 3, the primary cause of this difference was the increase in the Vs score (from 0.22 to 0.45, Figure 10). Replacement of the 2006 Vs score with the 2003 Vs score would have produced an overall HSI score of 0.61, an increase of only 5% from 2003. Unlike the scores from the Lower Segment sites, in Ven 5 there was little change in the % pools variable, but a substantial increase in the pool class score (the pool class score is largely based on the size of pools and the amount of obscured habitat due to depth and cover). Like almost all other reaches, the 2006 data suggested a prominent decrease in the % vegetation score.

LNF low. The lower of the two lower North Fork sites occurred about midway between the Ventura River and the Wheeler Gorge, and below some of the hot springs (Figure 1). In contrast to the downstream sites, the overall HSI score decreased from 0.80 in 2003 to 0.70 in 2006 (Figure 6). This pattern will be repeated in most tributary and Matilija Creek study sites, which generally showed a decrease in scores in 2006 versus the increased scores seen in the mainstem Ventura River. The 12% decrease in LNF low was reflected in decreased component scores for the adult, juvenile, embryo, and “other” components (Figure 11). Of those components, the embryo score appeared to most influence the overall change, particularly the Vs score (which decreased from 0.63 to 0.47), but Figure 6 shows that even with no change in the Vs parameter the overall score would have decreased somewhat. Besides the consistently decreasing % vegetation variable, decreases were also evident for the related % shade, as well as for % fines in riffle and flatwater substrates. The variable score for pool class, which influences both adult and juvenile components, also decreased in 2006 (but % pools did not decrease).

LNF mid. The LNF mid study site occurred below the Wheeler Gorge proper, but it did contain sampling units within highly confined canyon walls. Like the LNF low study site about one mile downstream, the middle site also showed a decrease in HSI score (from 0.82-0.75), but the change was relatively minor at 9% (Figure 6). The decreased adult component score was due to the decrease in suitability for pool class, a variable that also influenced the juvenile component score (Figure 12). The decrease in the embryo component score was due to the Vs score, which decreased from 0.94 in 2003 to 0.64 in 2006 (remember that the embryo component score is simply the lowest of the three variable scores, which in most study sites is the Vs score). In sum, the decreased 2006 score for LNF mid (like that in LNF low) appeared to be the combined result of decreases in most of the individual component scores, and not due to a specific variable.

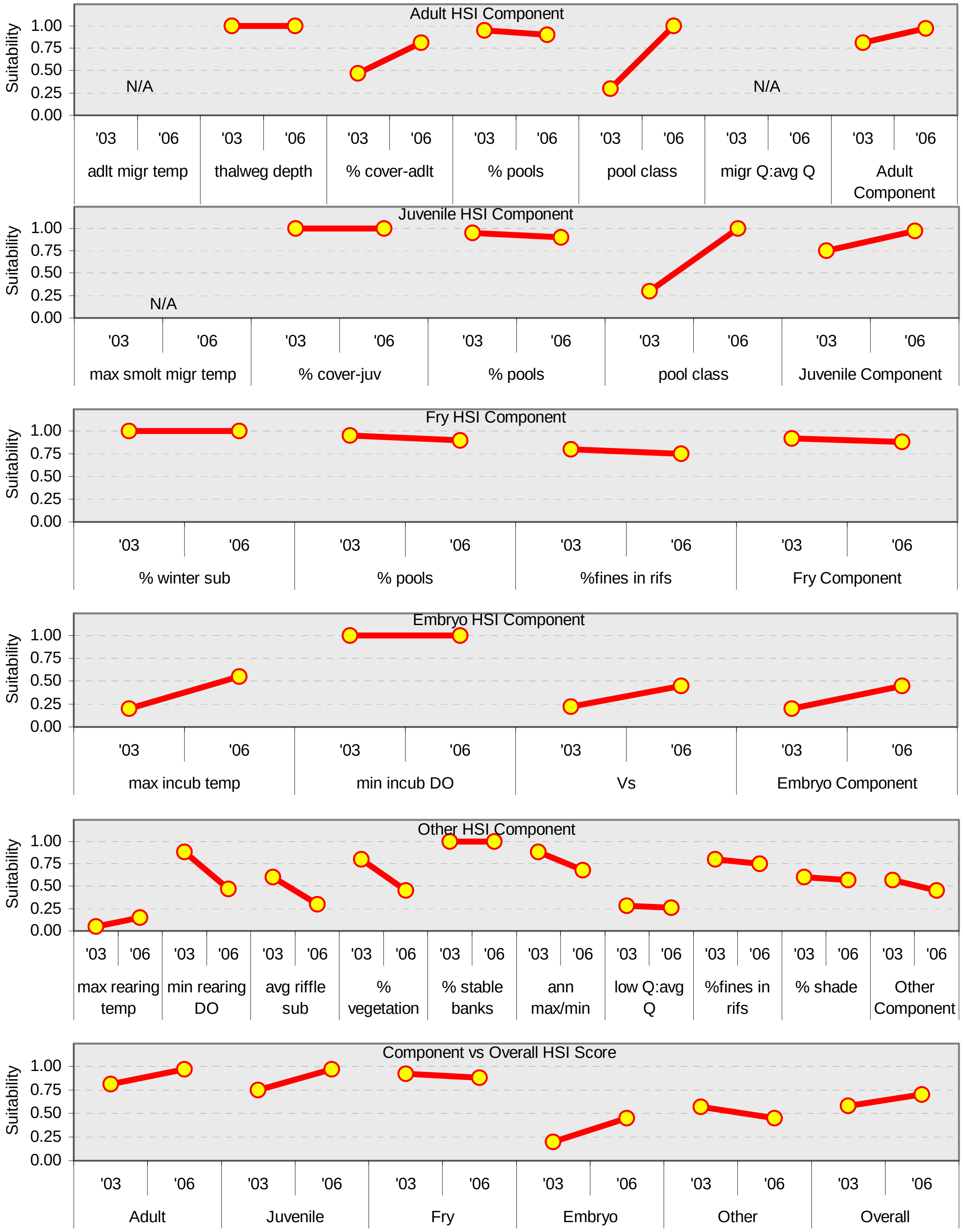


Figure 10. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the Ven 5 study site.

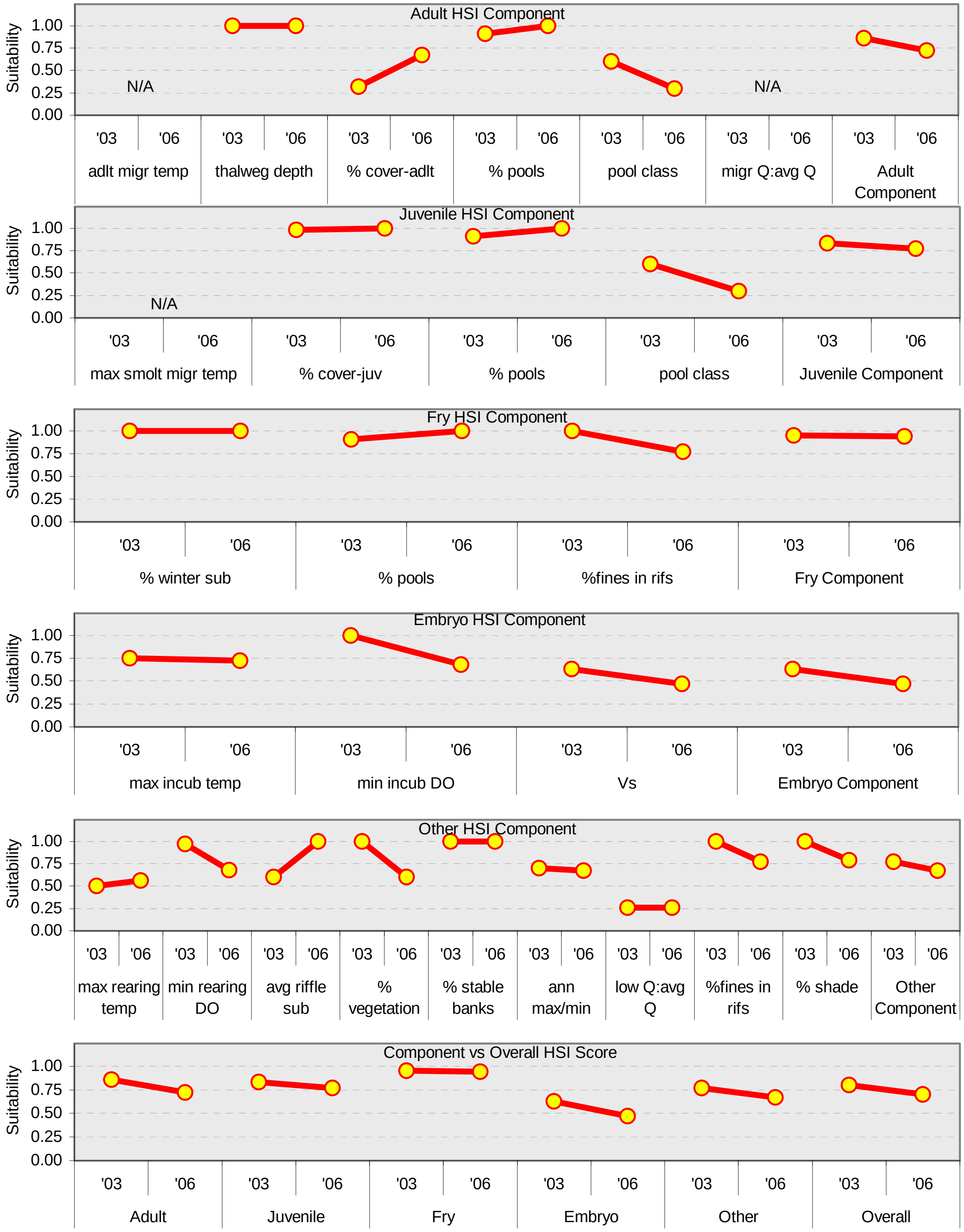


Figure 11. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the LNF low study site.

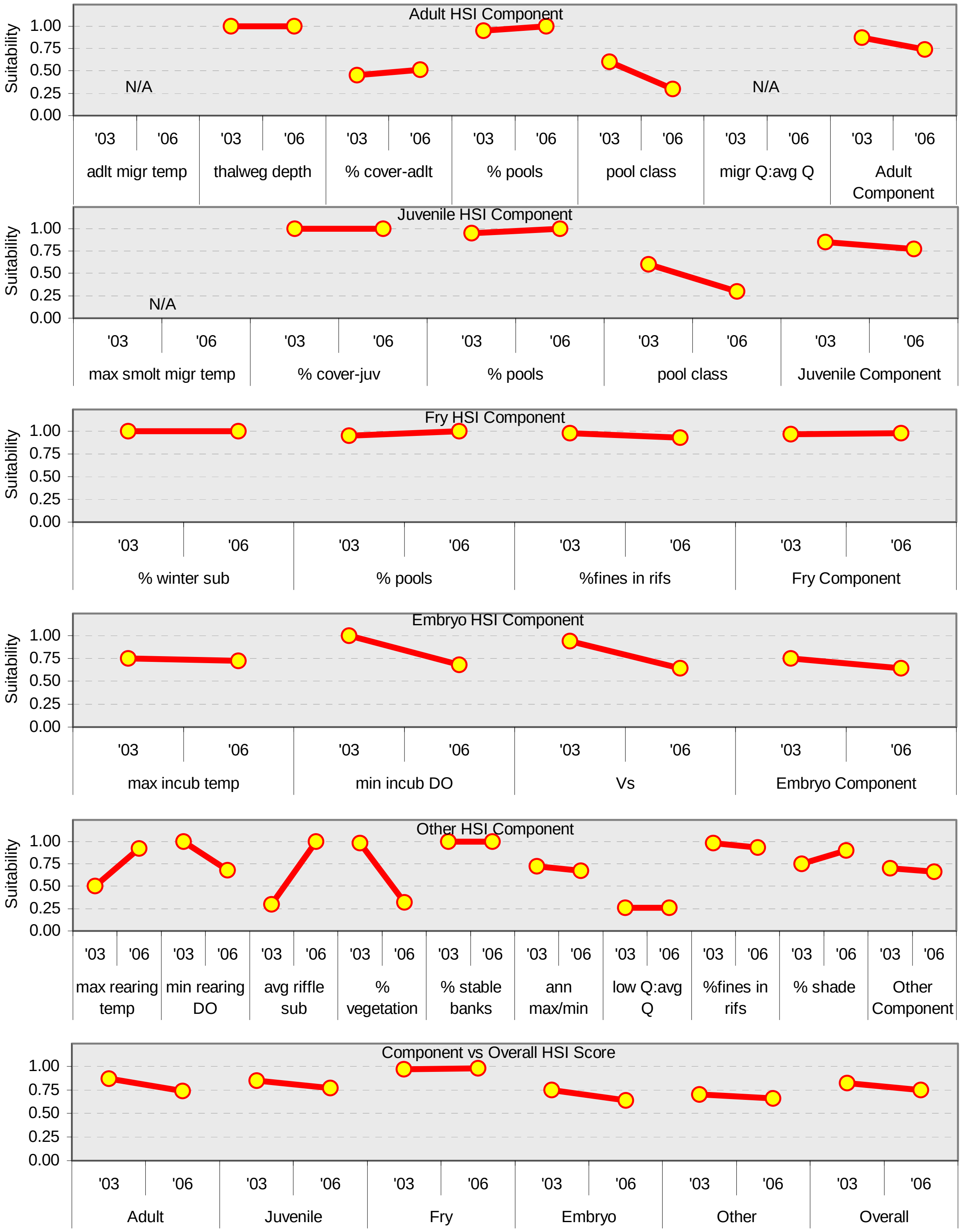


Figure 12. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the LNF mid study site.

Combined Study Sites. As noted for the Lower Segment, the 2006 changes in the HSI scores served to reduce the distinction between study sites in the Middle Segment (Table 2, Figure 6). The weighted mean HSI score for this segment is 0.71, because most of the habitat in the Middle Segment is represented by the Ven 5 and LNF low scores, with less influence by the higher score in the LNF mid study site.

Upper Segment

The Upper Segment was represented by four study sites entirely above Matilija Dam (Figure 1). Study sites Mat 3, Mat 5, and Mat 7 all occurred in the mainstem Matilija Creek, whereas UNF up occurred in the principal tributary, the Upper North Fork. The reduced level of effort in the Upper Segment in 2006, where only resident trout occur, resulted in some individual study sites representing relatively large areas or areas of somewhat different character, and two tributaries surveyed in 2003 (Old Man Creek and Murietta Creek) are not represented at all in either the HSI or the fish abundance data. Also, one mainstem study site (Mat 6) and two Upper North Fork study sites (UNF low and UNF mid) were not sampled in 2006. This reduced effort requires the existing HSI score and fish population estimates to be expanded over a greater area, and thus would be expected to affect the representativeness of the overall Upper Segment estimates (which, for the fish abundance data, is reflected in wider confidence intervals). However, the site-specific estimates for the four Upper Segment study sites are representative of those areas and the 2003 and 2006 HSI scores are directly comparable across years.

Mat 3. The Mat 3 study site was divided into two parts due to private landholdings in between where substantial hot springs enter Matilija Creek. The overall HSI score of 0.73 was a large increase (33%) from the 2003 score of 0.55 (Figure 6). This substantial increase was not due to a change in the Vs score, unlike most other study sites, but was mostly due to the large increase in the embryo component score (Figure 13). In 2003, the embryo component score was only 0.32 (due to the low score for incubation temperatures), whereas the use of different temperature and oxygen data in 2006 resulted in a minimum embryo score of 0.67. A substantial increase in the adult component score (from 0.58 in 2003 to 0.82 in 2006) also influenced the increase in the overall score, due to large increases in both the % pools and pool class variable scores. Use of the 2003 embryo and adult component scores would have produced an overall HSI score of 0.59, for an increase of only 7%.

Mat 5. The Mat 5 study site occurs upstream of the Mat 3 study site, immediately above a 1½ mi stretch of private property. The upper end of Mat 5 is only about 1,000 ft below the confluence with Murietta Creek, and ½ mi below the Upper North Fork confluence (Figure 1). The 2006 HSI score of 0.63 represented a minor decrease of 7% from the 2003 score of 0.68 (Figure 6). Of the various component scores, only the adult component score showed a substantial change (from 0.81 in 2003 to 0.67 in 2006, Figure 14). The decrease in pool class rating was somewhat offset by the increase in % pools. As seen in virtually all other study sites (except for UNF up), the % vegetation score also decreased significantly in 2006.

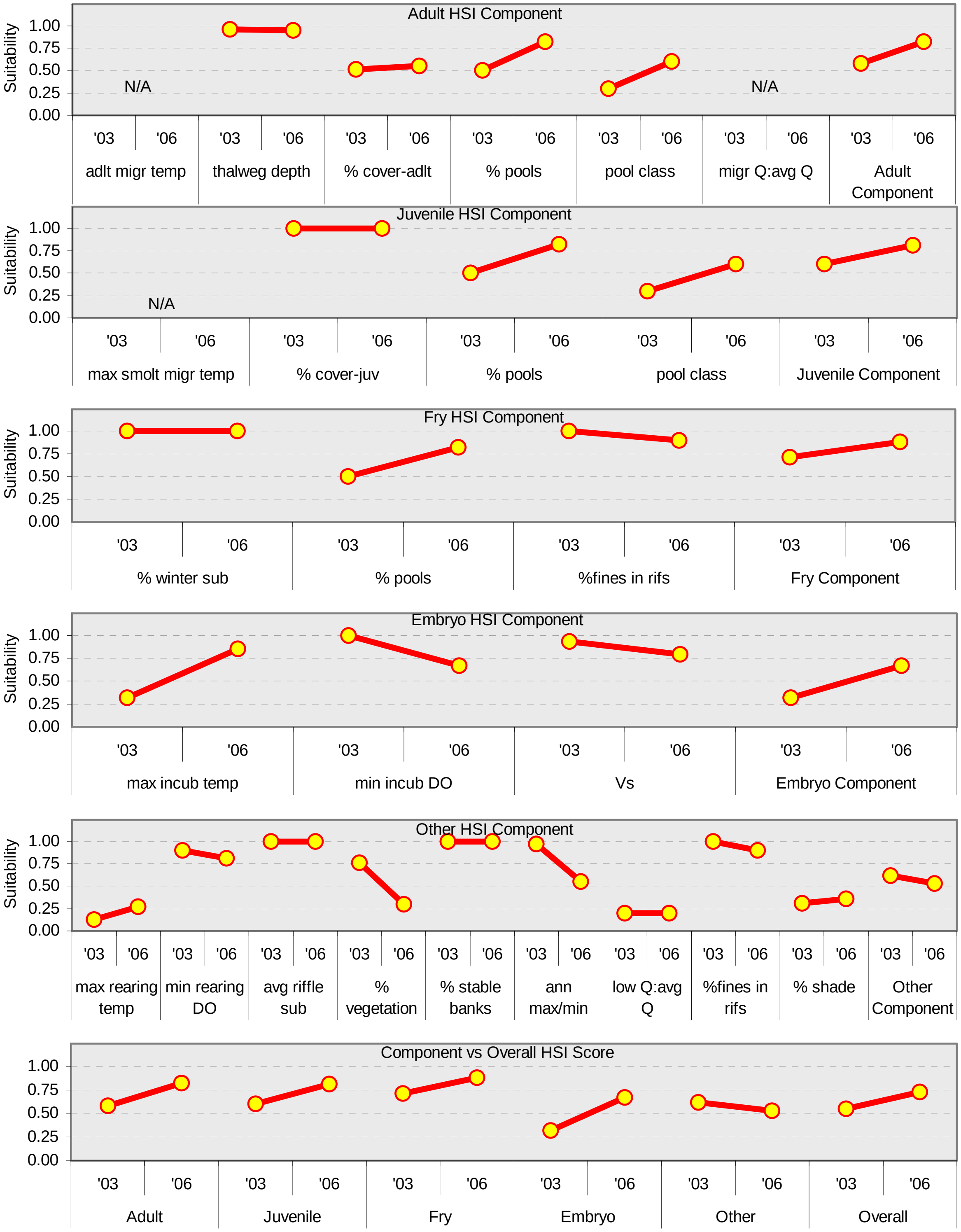


Figure 13. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the Mat 3 study site.

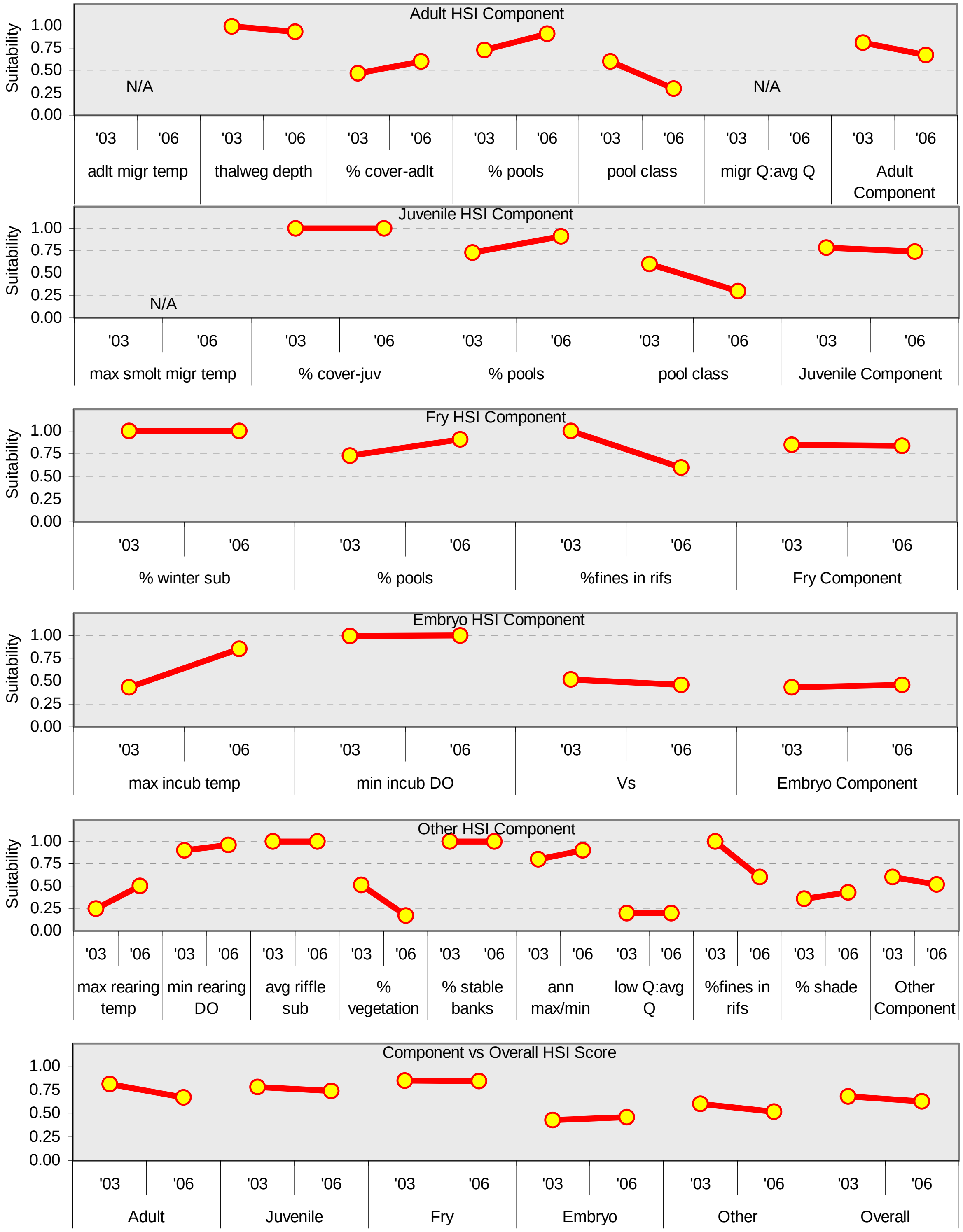


Figure 14. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the Mat 5 study site.

Mat 7. The HSI score for Mat 7 showed a 16% decrease from 0.75 in 2003 to 0.63 in 2006 (Figure 6). Much of the difference was again due to a decrease in the Vs score which, although low in 2003 at 0.51, decreased further to 0.30 in 2006 (Figure 15). Both Vs estimates were based on small sample sizes (n's $\leq$5), and thus the overall scores (in both years) have considerable uncertainty. Application of the larger (2003) Vs score in the 2006 HSI data would produce a minor decrease from 2003 to 2006 of only 7% (Figure 6). In addition to the effects of the lower Vs score, both the fry component score and the "other" component score decreased in 2006, in part due to a substantial decrease in the variable score for % fines in riffles (an increase in riffle fines would also be expected to decrease the Vs score). Besides the two variables just described and the ubiquitous decrease in % vegetation, very few changes were apparent among the other HSI variables.

UNF up. Very little change was noted in either the overall HSI score or in any of the component or individual variable scores for the UNF up study site (Figures 6 and 16). The overall HSI score of 0.87 (up 5% from 0.83 in 2003) was again the highest score of all HSI study sites in the Ventura/Matilija Basin. Even the % vegetation score, which showed large decreases in almost all other study sites, showed very little change in the UNF up site, which has a dense, stable riparian zone.

Combined Study Sites. The 2006 HSI scores produced a very different pattern between the four Upper Segment study sites than was seen in 2003 (Figure 6). In 2003, the HSI scores suggested progressively higher suitability in the upstream direction, which was consistent with subjective assessments of habitat quality (TRPA 2004). In contrast, the 2006 HSI score for Mat 3, the lowest site, was higher than the upper two mainstem Matilija Creek sites. This unexpected (and non-intuitive) difference was due to the increases in adult and juvenile components (from increased pool variable scores) and the embryo component in the Mat 3 study site, versus little change or decreased scores for those components in the Mat 5 and Mat 7 study sites. When the 2006 study site scores were combined, the Upper Segment weighted HSI score was 0.73, only slightly higher than the Middle Segment score (Table 2).

FISH SAMPLING

Abundance of *O. mykiss* was estimated in each sampled habitat unit using single pass dive counts in all pools, multiple-pass electrofishing in all riffles, and either of the two methods in flatwaters, depending upon the depth of flatwaters in the specific study site. Flatwaters in the mainstem Ventura River were sampled by diving, whereas flatwaters in all tributaries and in the mainstem Matilija Creek were sampled by electrofishing. The basic fish statistics for each study site are shown in Table 3, with associated figures for abundance and density in #/100ft^2 for *O. mykiss* fry (Figures 17 and 18) and juvenile+ (Figures 19 and 20). Estimates pooled among study sites to represent study segments are shown in Figures 21 and 22. Detailed information on dive counts or electrofishing captures are available in Appendix D, and photos of each sampled habitat unit are available on CD upon request.

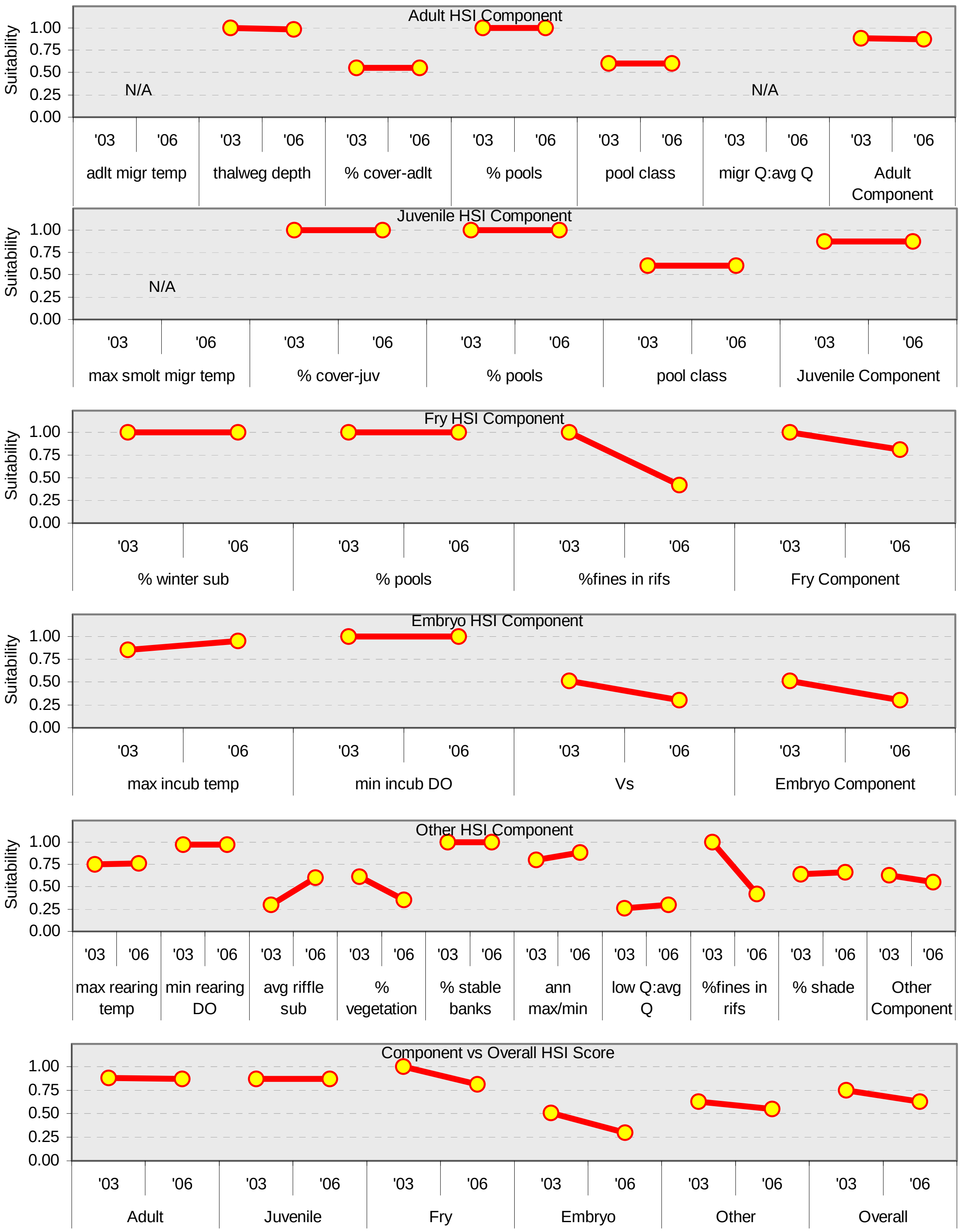


Figure 15. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the Mat 7 study site.

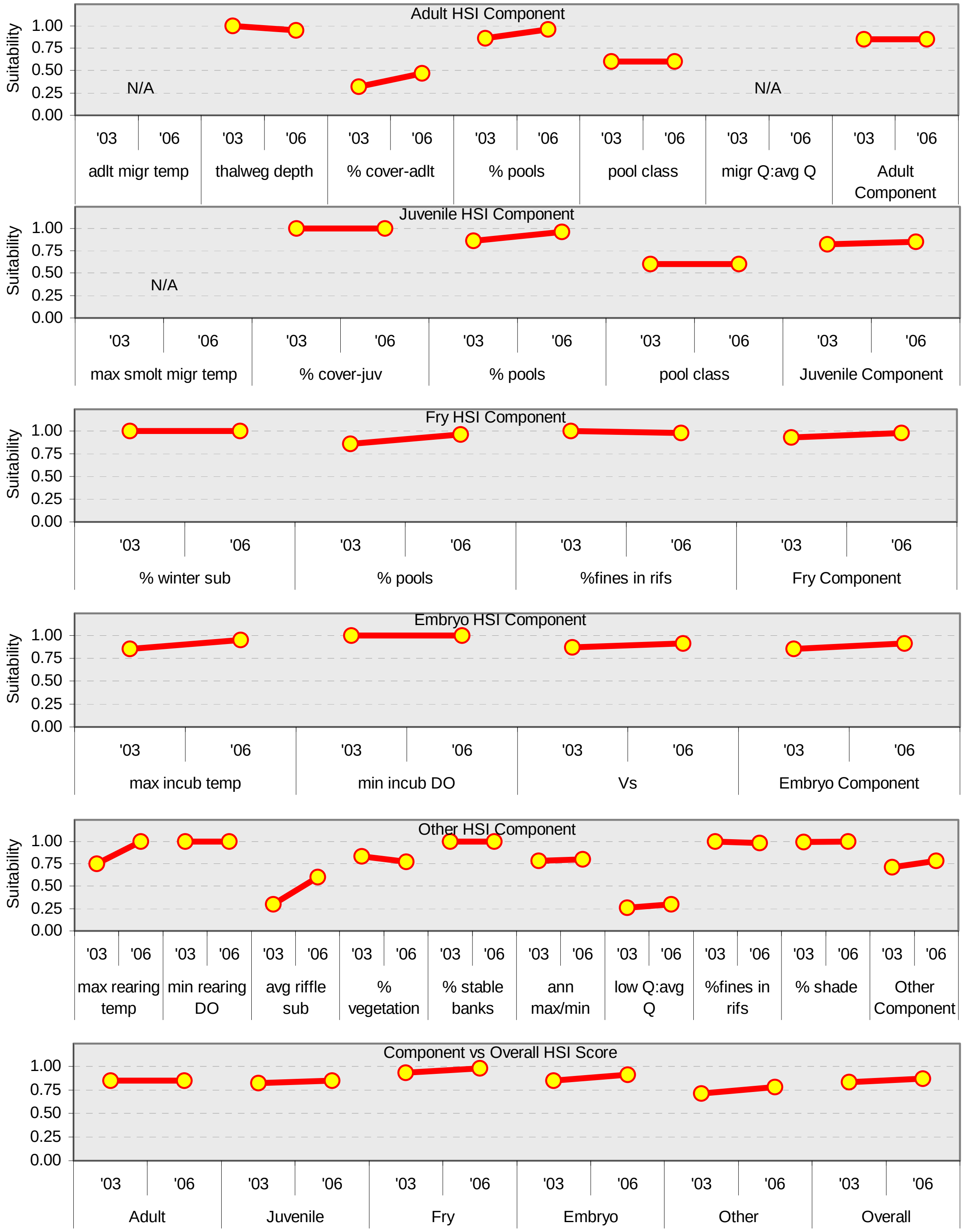


Figure 16. Change in HSI variable scores and overall scores (lowest graph) between 2003 and 2006 in the UNF up study site.

Table 3. Fish abundance estimates according to HSI study site.

Size Class	Hab Type	Statistic	Ven 1	Ven 2	Ven 3	Ven 4	Ven 5	LNF low	LNF mid	Mat 3	Mat 5	Mat 7	UNF up
Fry <10 cm	Pools	# Units Sampled	4	6	6	4	8	8	8	8	9	9	8
		Abundance	0	0	0	0	32	20	43	4	21	90	87
		Variance	0	0	0	0	329	205	223	5	72	262	273
		95% C.I.	0	0	0	0	43	34	35	6	20	37	39
		Density (#/mi)	0	0	0	0	166	112	203	36	169	438	751
		Variance (#/mi)	0	0	0	0	8,599	6,246	5,006	405	4,511	6,165	20,530
		95% C.I. (#/mi)	0	0	0	0	219	187	167	48	155	181	339
		Density (#/100ft^2)	0.00	0.00	0.00	0.00	0.09	0.14	0.32	0.02	0.10	0.41	1.19
		Variance (#/100ft^2)	0.0000	0.0000	0.0000	0.0000	0.0027	0.0105	0.0127	0.0002	0.0016	0.0054	0.0511
		95% C.I. (#/100ft^2)	0.00	0.00	0.00	0.00	0.12	0.24	0.27	0.03	0.09	0.17	0.53
	Flatwaters	# Units Sampled	4	8	8	4	8	8	8	8	8	8	8
		Abundance	0	0	0	0	85	35	74	9	85	34	71
		Variance	0	0	0	0	758	99	168	25	301	39	212
		95% C.I.	0	0	0	0	65	23	31	12	41	15	34
		Density (#/mi)	0	0	0	0	355	241	499	33	361	317	639
		Variance (#/mi)	0	0	0	0	13,356	4,821	7,574	352	5,481	3,302	16,963
		95% C.I. (#/mi)	0	0	0	0	273	164	206	44	175	136	308
		Density (#/100ft^2)	0.00	0.00	0.00	0.00	0.23	0.31	0.85	0.02	0.27	0.38	1.27
		Variance (#/100ft^2)	0.0000	0.0000	0.0000	0.0000	0.0055	0.0080	0.0221	0.0001	0.0032	0.0047	0.0674
		95% C.I. (#/100ft^2)	0.00	0.00	0.00	0.00	0.18	0.21	0.35	0.02	0.13	0.16	0.61
	Riffles	# Units Sampled	4	8	8	4	8	8	8	8	8	8	8
		Abundance	0	2	0	0	28	15	34	10	73	25	41
		Variance	0	4	0	0	107	0	35	0	125	0	43
		95% C.I.	0	4	0	0	24	0	14	0	26	0	15
		Density (#/mi)	0	9	0	0	290	360	672	114	982	392	572
		Variance (#/mi)	0	77	0	0	11,562	0	13,579	0	22,977	0	8,162
		95% C.I. (#/mi)	0	21	0	0	254	0	276	0	358	0	214
		Density (#/100ft^2)	0.00	0.006	0.00	0.00	0.22	0.51	1.11	0.06	0.48	0.39	1.19
		Variance (#/100ft^2)	0.0000	0.00003	0.0000	0.0000	0.0069	0.0000	0.0368	0.0000	0.0056	0.0000	0.0354
		95% C.I. (#/100ft^2)	0.00	0.013	0.00	0.00	0.20	0.00	0.45	0.00	0.18	0.00	0.44
	All Habitats	# Units Sampled	12	22	22	12	24	24	24	24	25	25	24
		Abundance	0	2	0	0	145	70	151	23	178	150	199
		Variance	0	4	0	0	1194	304	426	30	498	301	528
		95% C.I.	0	4	0	0	72	36	43	11	46	36	48
		Density (#/mi)	0	2.1	0	0	273	191	368	49	411	395	666
		Variance (#/mi)	0	4.0	0	0	4,250	2,269	2,525	137	2,640	2,097	5,885
		95% C.I. (#/mi)	0	4.2	0	0	136	99	104	24	107	95	160
		Density (#/100ft^2)	0.00	0.001	0.00	0.00	0.17	0.25	0.60	0.03	0.27	0.40	1.22
		Variance (#/100ft^2)	0.0000	0.000001	0.0000	0.0000	0.0017	0.0039	0.0068	0.0000	0.0011	0.0021	0.0196
		95% C.I. (#/100ft^2)	0.00	0.003	0.00	0.00	0.09	0.13	0.17	0.01	0.07	0.10	0.29
Juv+ ≥10 cm	Pools	# Units Sampled	4	6	6	4	8	8	8	8	9	9	8
		Abundance	0	0	6	0	75	53	74	34	39	118	112
		Variance	0	0	0	0	483	497	378	32	54	194	1001
		95% C.I.	0	0	0	0	52	53	46	13	17	32	75
		Density (#/mi)	0	0	24	0	384	294	352	288	311	573	967
		Variance (#/mi)	0	0	0	0	12,615	15,132	8,482	2,382	3,399	4,557	75,270
		95% C.I. (#/mi)	0	0	0	0	266	291	218	115	134	156	649
		Density (#/100ft^2)	0.00	0.00	0.013	0.00	0.21	0.38	0.56	0.19	0.19	0.53	1.53
		Variance (#/100ft^2)	0.0000	0.0000	0.0000	0.0000	0.0039	0.0255	0.0215	0.0010	0.0012	0.0040	0.1875
		95% C.I. (#/100ft^2)	0.00	0.00	0.000	0.00	0.15	0.38	0.35	0.08	0.08	0.15	1.02

Table 3. (continued)

Size Class	Hab Type	Statistic	Ven 1	Ven 2	Ven 3	Ven 4	Ven 5	LNF low	LNF mid	Mat 3	Mat 5	Mat 7	UNF up
Juv+ ≥10 cm	Flatwaters	# Units Sampled	4	8	8	4	8	8	8	8	8	8	8
		Abundance	0	0	0	0	94	42	68	48	179	24	26
		Variance	0	0	0	0	1665	153	140	358	2683	6	105
		95% C.I.	0	0	0	0	96	29	28	45	122	6	24
		Density (#/mi)	0	0	0	0	396	296	453	181	763	216	232
		Variance (#/mi)	0	0	0	0	29,332	7,493	6,318	5,106	48,876	478	8,388
		95% C.I. (#/mi)	0	0	0	0	405	205	188	169	523	52	217
		Density (#/100ft^2)	0.00	0.00	0.00	0.00	0.25	0.38	0.77	0.10	0.58	0.26	0.46
		Variance (#/100ft^2)	0.0000	0.0000	0.0000	0.0000	0.0122	0.0124	0.0184	0.0016	0.0283	0.0007	0.0333
		95% C.I. (#/100ft^2)	0.00	0.00	0.00	0.00	0.26	0.26	0.32	0.09	0.40	0.06	0.43
	Riffles	# Units Sampled	4	8	8	4	8	8	8	8	8	8	8
		Abundance	0	2	0	0	34	3	28	13	54	11	11
		Variance	0	3	0	0	50	0	15	0	63	0	6
		95% C.I.	0	4	0	0	17	0	9	0	19	0	6
		Density (#/mi)	0	9	0	0	352	72	552	148	732	172	145
		Variance (#/mi)	0	75	0	0	5,420	0	5,733	0	11,604	0	1,146
		95% C.I. (#/mi)	0	21	0	0	174	0	179	0	255	0	80
		Density (#/100ft^2)	0.00	0.006	0.00	0.00	0.27	0.10	0.91	0.08	0.36	0.17	0.30
		Variance (#/100ft^2)	0.0000	0.00003	0.0000	0.0000	0.0032	0.0000	0.0156	0.0000	0.0028	0.0000	0.0050
		95% C.I. (#/100ft^2)	0.00	0.013	0.00	0.00	0.13	0.00	0.29	0.00	0.13	0.00	0.17
	All Habitats	# Units Sampled	12	22	22	12	24	24	24	24	25	25	24
		Abundance	0	2	6	0	203	99	170	94	272	153	148
		Variance	0	3	0	0	2198	650	533	390	2800	199	1112
		95% C.I.	0	4	0	0	98	53	48	41	110	29	69
		Density (#/mi)	0	2.1	6	0	383	269	414	201	627	403	494
		Variance (#/mi)	0	3.9	0	0	7,822	4,857	3,158	1,775	14,846	1,388	12,403
		95% C.I. (#/mi)	0	4.1	0	0	184	145	117	88	253	77	232
		Density (#/100ft^2)	0.00	0.001	0.004	0.00	0.24	0.35	0.68	0.12	0.41	0.41	0.90
		Variance (#/100ft^2)	0.0000	0.000001	0.0000	0.0000	0.0031	0.0083	0.0085	0.0006	0.0063	0.0014	0.0414
		95% C.I. (#/100ft^2)	0.00	0.003	0.00	0.00	0.12	0.19	0.19	0.05	0.16	0.08	0.42
All *O. mykiss*	All Habitats	# Units Sampled	12	22	22	12	24	24	24	24	25	25	24
		Abundance	0	4	6	0	348	168	321	117	450	302	347
		Variance	0	7	0	0	3392	954	960	420	3298	500	1640
		95% C.I.	0	6	0	0	121	64	64	43	119	46	84
		Density (#/mi)	0	4	6	0	657	460	781	250	1,037	798	1,160
		Variance (#/mi)	0	8	0	0	12,072	7,126	5,683	1,912	17,487	3,486	18,289
		95% C.I. (#/mi)	0	6	0	0	228	176	157	91	274	122	281
		Density (#/100ft^2)	0.00	0.003	0.004	0.00	0.41	0.60	1.28	0.14	0.68	0.81	2.12
		Variance (#/100ft^2)	0.0000	0.000003	0.0000	0.0000	0.0048	0.0122	0.0153	0.0006	0.0074	0.0036	0.0610
		95% C.I. (#/100ft^2)	0.00	0.004	0.000	0.00	0.14	0.23	0.26	0.05	0.18	0.12	0.51

Length-frequency distributions showed dominant peaks of smaller *O. mykiss* (presumably young-of-year) in the tributary and upper mainstem study sites (Figure 23). The size of fry appeared generally smaller in the upper Matilija mainstem and the upper North Fork Matilija Creek than in the lower North Fork study sites, likely due to later spawning and emergence and/or cooler water temperatures and slower growth. The largest proportion of juvenile+ *O. mykiss* appeared to occur (based on length-frequency distributions) in the lower Matilija Creek mainstem sites, where trout >200mm were frequently captured. Several of the length-frequency distributions suggested the presence of three or four age-classes, although scale analysis would be required to verify the number or actual proportion of age-classes.

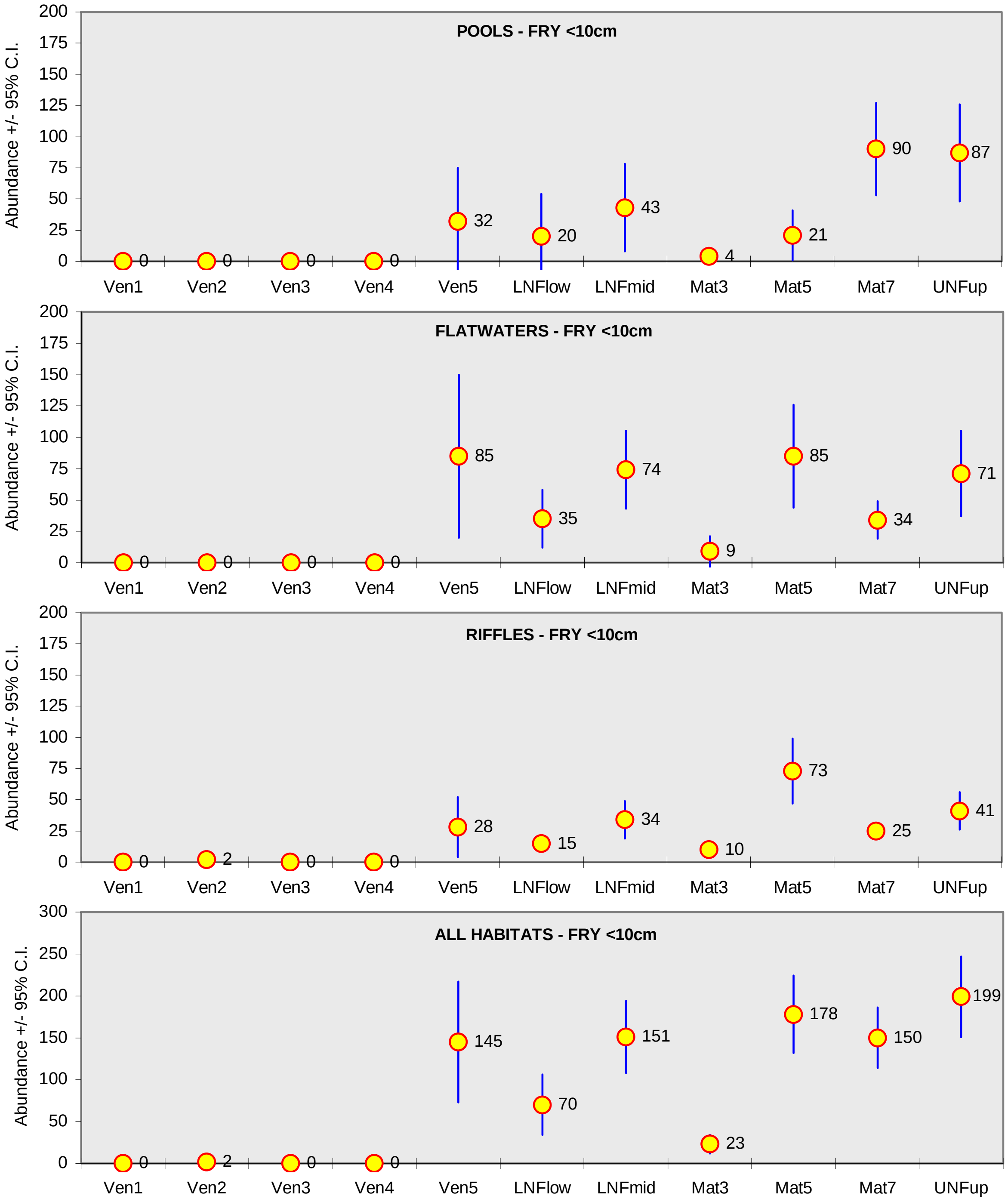


Figure 17. Estimated abundance of O. mykiss fry according to study site and habitat type. Vertical bars are 95% confidence intervals.

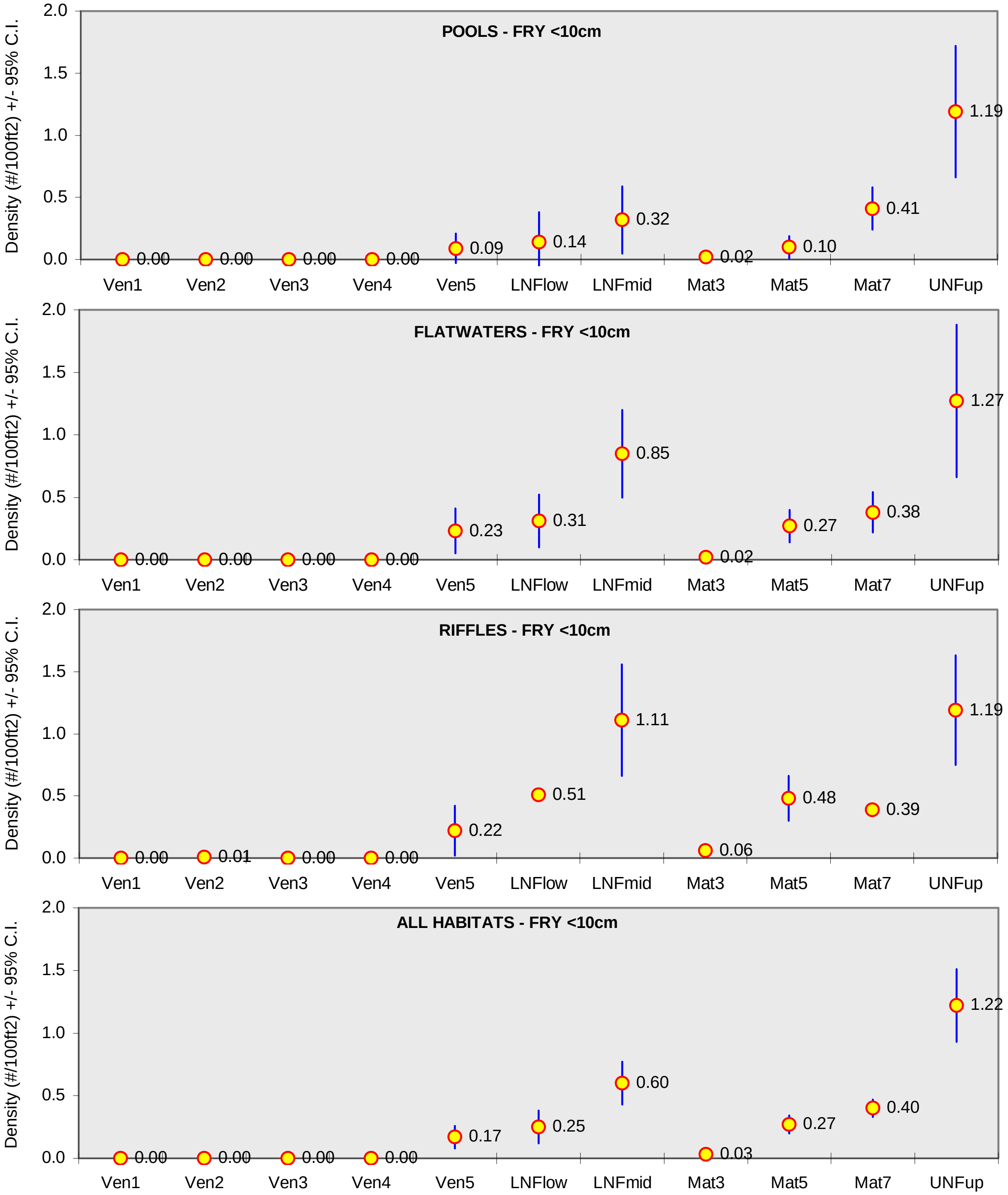


Figure 18. Estimated density (#/100ft^2) of O. mykiss fry according to study site and habitat type. Vertical bars are 95% confidence intervals.

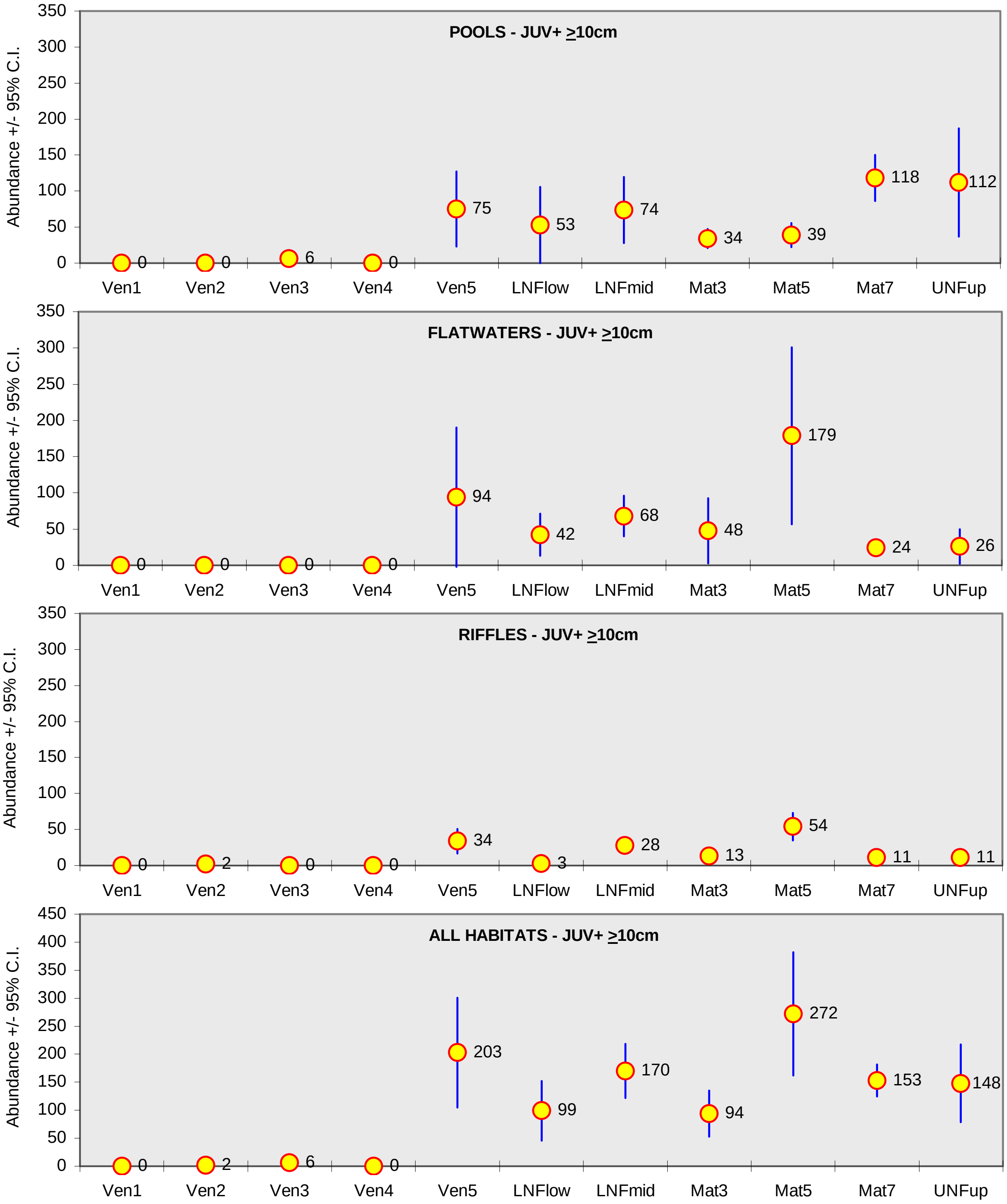


Figure 19. Estimated abundance of O. mykiss juvenile+ according to study site and habitat type. Vertical bars are 95% confidence intervals.

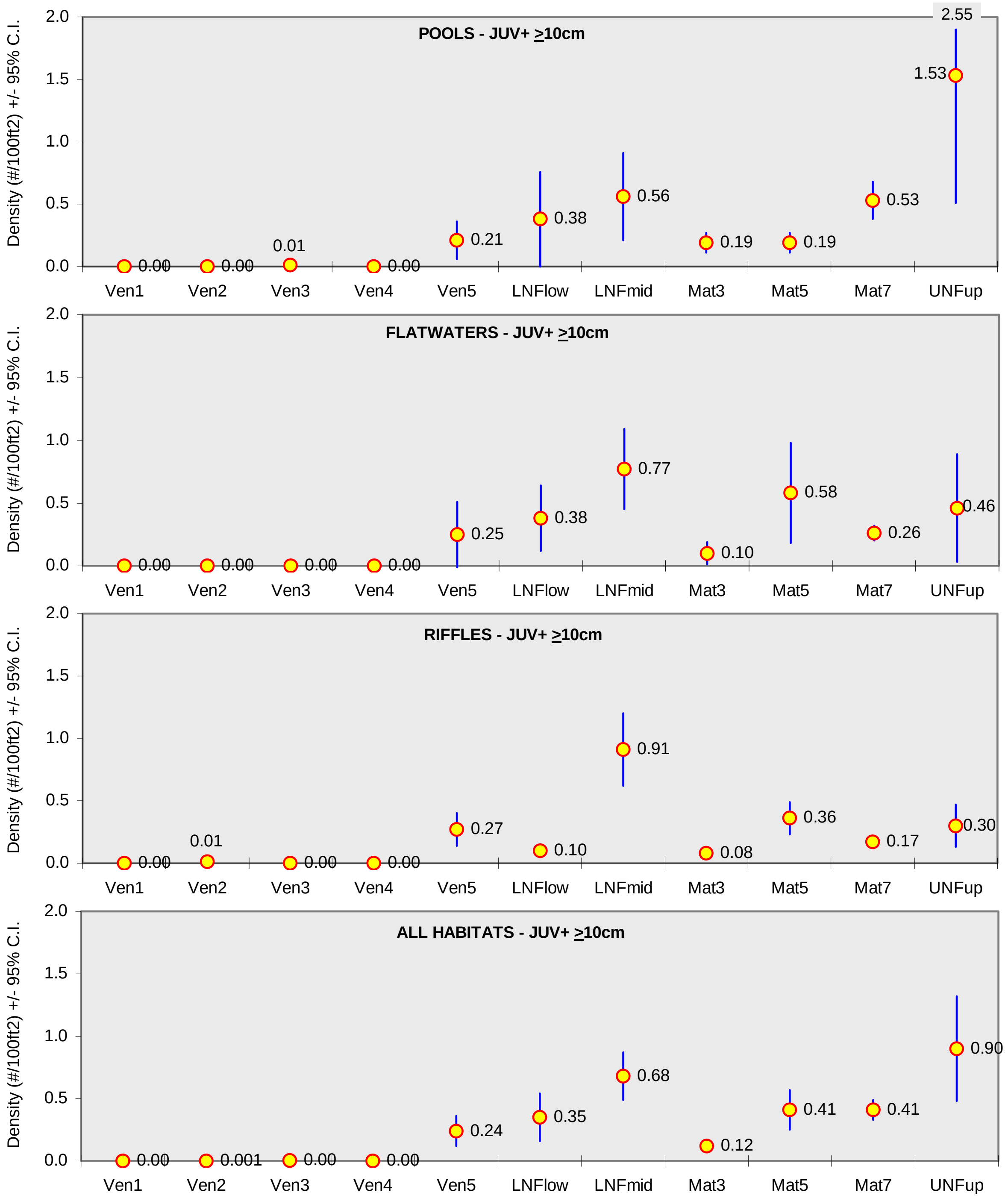


Figure 20. Estimated density (#/100ft^2) of O. mykiss juvenile+ according to study site and habitat type. Vertical bars are 95% confidence intervals.

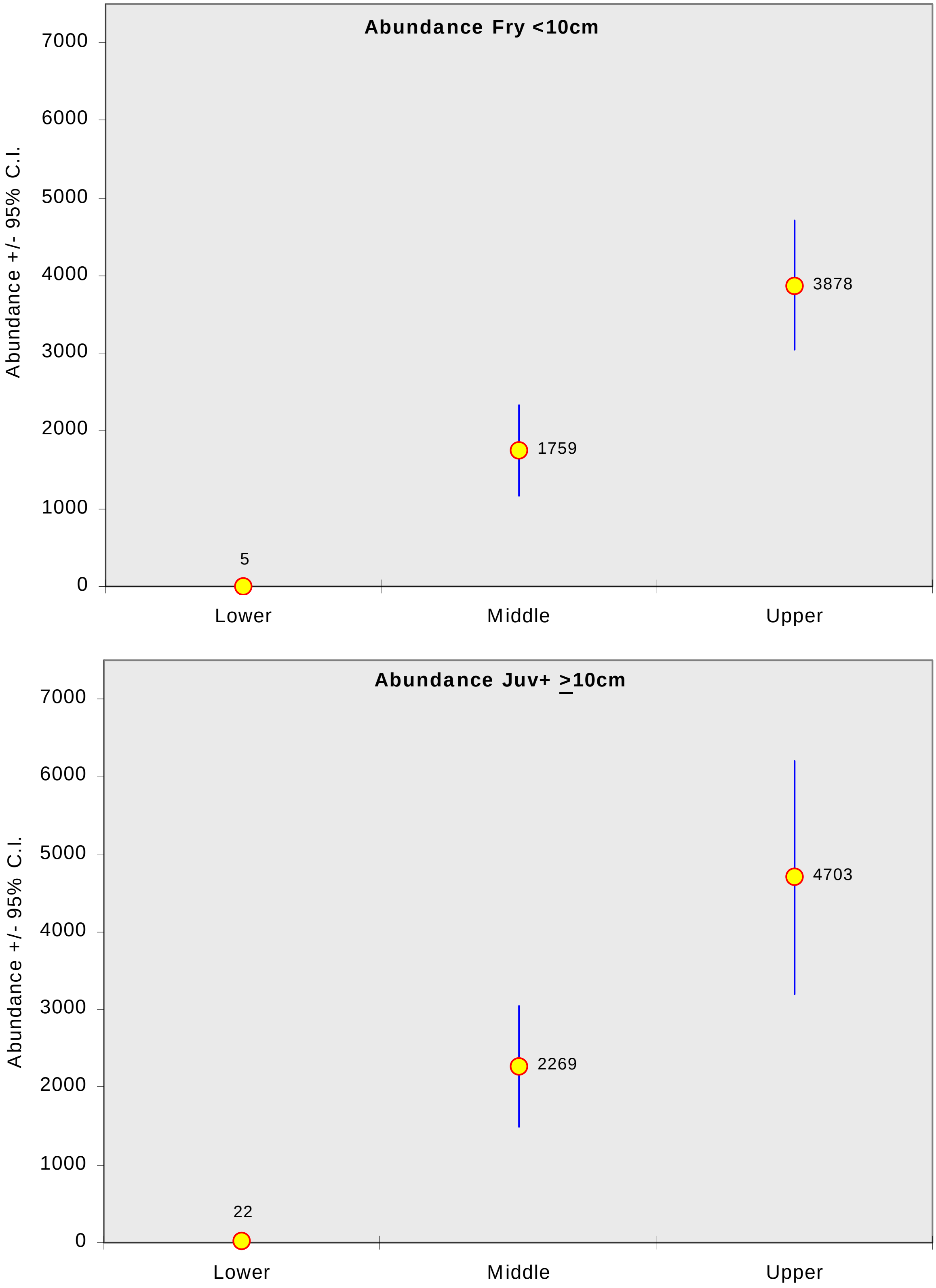


Figure 21. Estimated abundance of O. mykiss according to study segment. Vertical bars are 95% confidence intervals.

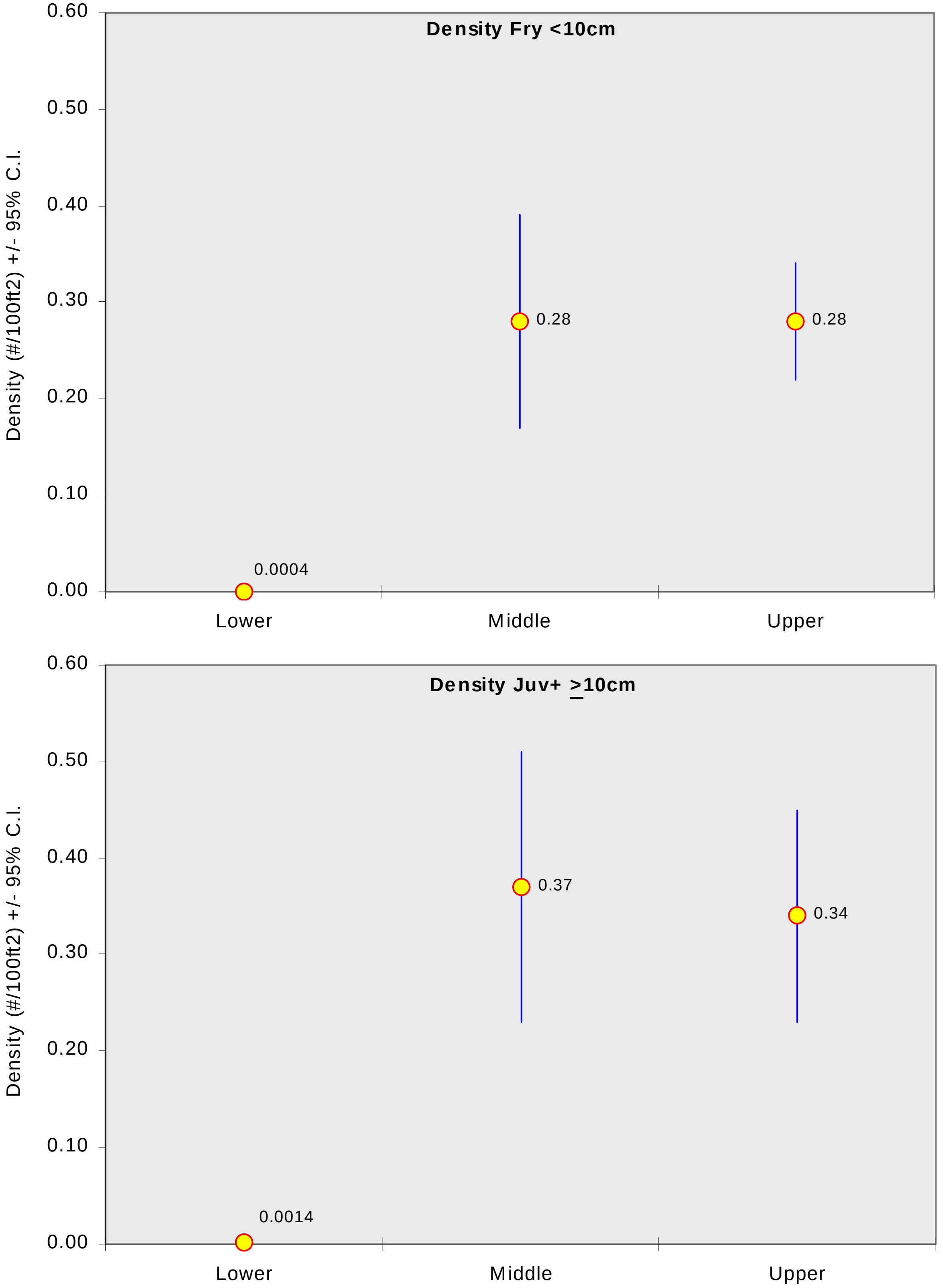


Figure 22. Estimated density (#/100ft^2) of O. mykiss according to study segment. Vertical bars are 95% confidence intervals.

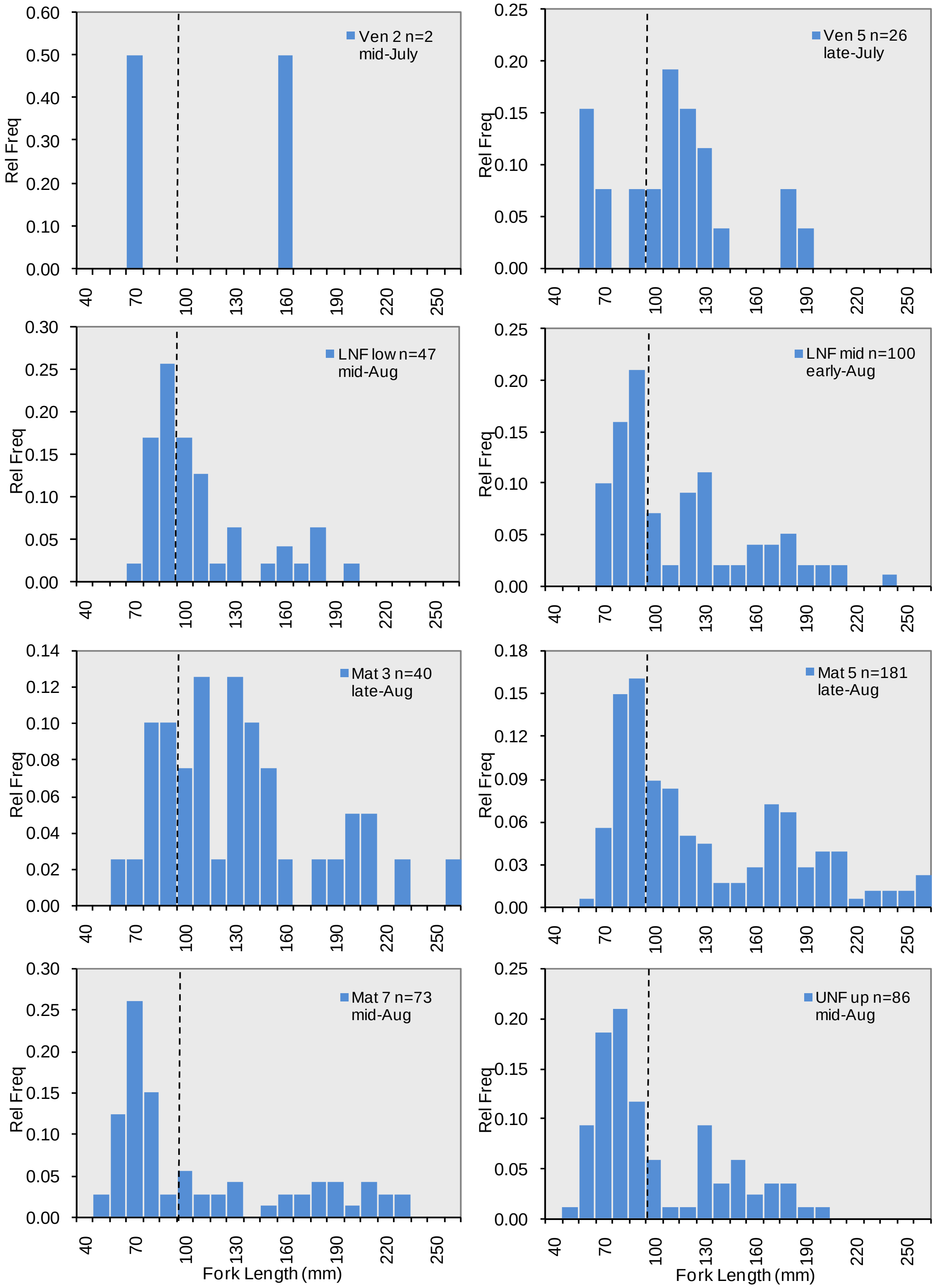


Figure 23. Length-frequency distributions of electrofished O. mykiss according to study site. Vertical dashed line shows 10cm fry/juvenile definition.

Lower Segment

Four study sites were sampled in the lower segment where *O. mykiss* were either not observed or were very rare (Table 3). Arroyo chub (*Gila orcutti*) and threespine stickleback (*Gasterosteus aculeatus*), in contrast, were observed in virtually every sampled habitat unit (Appendix D). Carp (*Cyprinus carpio*) were commonly seen in study sites Ven 1 and Ven 2, mostly in pools, but were not seen in Ven 3. Occasional sightings of crayfish, tadpoles, and turtles occurred in the lower segment, and one largemouth bass was seen in a Ven 3 pool just downstream of San Antonio Creek. The Ven 3 study site occurs in a region of rising groundwater (but also a diversion dam and several wells), which historically provided rearing habitat and high productivity for juvenile trout and steelhead (Moore 1980a). San Antonio Creek, a potentially important spawning and rearing tributary, enters the Ven 3 study site near its upper boundary. Large bedrock pools, known or suspected to have provided important holding habitat for upstream adult steelhead, occur in the Ven 2 and Ven 4 study sites (Mark Capelli, pers. comm.), although the Ven 4 study site is typically dry during summer months (including 2003 when HSI data could not be collected). Ven 4 contained numerous tadpoles, and divers observed one bass and one sunfish in a deep pool. About 2,000 ft above the top of Ven 4 is the Robles Diversion Dam, which blocked upstream migration of adult steelhead from its construction in 1958 until a new ladder was installed in 2004.

Ven 1. *O. mykiss* were not observed or captured during sampling of four riffles, four flatwaters, and four pools in the Ven 1 study site (Table 3, Figures 17-20), therefore sampling was concluded with a total survey of 12 habitat units (versus 24 units where *O. mykiss* were observed). The abbreviated sampling protocol was intended to maximize efficiency by allocating more effort where *O. mykiss* were relatively common and less effort where they were very rare. The abbreviated level of effort in Ven 1 (and in Ven 4) is not likely sufficient to confidently assess the presence or absence of *O. mykiss* from those reaches, but is expected to accurately represent the relative abundance of fish during the summer of 2006 in comparison to the remaining study sites (i.e., it shows that *O. mykiss* were, at most, very rare if not absent).

Ven 2. A full sample of 24 mesohabitat units was surveyed in Ven 2, including the “Shell Hole” and other long, bedrock pools. Although no salmonids were observed in the pool habitats, one fry was electrofished in one riffle and one juvenile+ was electrofished in a different riffle. These captures produced abundance estimates (±95% C.I.) of 2 ±4 fry and 2 ±4 juvenile+ in the Ven 2 study site, at densities of 0.0013 fish/100ft^2 (±0.0026) for each size class (Table 3, Figures 17-20).

Ven 3. Twenty-four mesohabitat units were sampled in the Ven 3 study site, but *O. mykiss* were only observed in one pool habitat. The four juvenile+ fish were observed by diving in the pool at the mouth of San Antonio Creek. Although the pool did contain small pockets of cold water along the base of the east bank (at 20^{o}C, vs. 23.5^{o}C in the pool and 26.5^{o}C in San Antonio Creek), the juveniles were not observed within the cold water (possibly due to disturbance from the divers or from swimmers who frequent this pool). Cold seeps were also noted in two other sampled units approximately 700-1,400 ft downstream of San Antonio Creek, but *O. mykiss* were not observed in those units. The overall estimates of abundance and density for juvenile+ in the Ven 3 study site was 6 fish (±0 fish) at 0.004 fish/100ft^2 (Table 3, Figures 17-20).

The 2006 densities were far lower than densities of "wild" fish (based on small size and/or non-hatchery appearance) reported by Moore in 1977 and 1978 (Moore 1980a). His July electrofishing estimates (presumed to include both fry and juveniles) ranged from a high of 1.72 fish/100ft^2 in 1977 (a drought year), to a low of 0.09 fish/100ft^2 in 1978, following a winter with major flood events. The 2006 fry and juvenile+ combined estimate of 0.004 fish/100ft2 was only 4% of Moore's lower estimate, and may reflect two consecutive years of high flow events, a decline in hatchery influences on mainstem populations, and/or a decline in anadromous returns to the Ventura River basin.

Ven 4. *O. mykiss* were not observed or captured in the Ven 4 study site, including the large, deep pools characteristic of that site (Table 3, Figures 17-20). One dead fish was found, however, in a pool on a subsequent day, but it was not possible to determine if the cause of death was from electroshocking, angling, or some other cause. The fish had a peculiar "snub-nosed" appearance with a shortened upper snout, which appeared to be a genetic deformity rather than a trauma-related injury. Cursory dive surveys within the deep pools did not detect any cold water pockets. As previously stated, streamflow was declining rapidly during the time of the Ven 4 survey.

Combined Study Sites. The estimated abundance and density of *O. mykiss* in the entire lower segment was very low at 5 (±17) fry and 22 (±15) juvenile+ (Figures 21 and 22). Estimated densities of fry and juvenile+ were only 0.0004 (±0.0011) fish/100ft^2 and 0.0014 (±0.001) fish/100ft^2, respectively.

Middle Segment

The middle segment consists of three study sites upstream of the Robles Diversion Dam, but downstream of Matilija Dam (Figure 1). A new fish ladder at the diversion dam became operational in 2004, and potentially gave steelhead new access to the middle segment for spawning and rearing. Ven 5 is in the mainstem Ventura River, about ½ miles below Matilija Dam and immediately below the confluence with the lower North Fork Matilija Creek. The other two study sites (LNF low and LNF mid) are both in the lower North Fork downstream of the passage barrier at Wheeler Springs Campground. A new, natural slide barrier was reportedly created following the flood events of either 2005 or 2006. This barrier was inspected during low flows and appeared to represent a total barrier to upstream migrant fish at all flows (Appendix E). This barrier is downstream of both LNF study sites; therefore the *O. mykiss* fry collected in those reaches in 2006 were expected to be derived from stream resident, non-anadromous parents. Arroyo chub were observed in virtually every sampled habitat unit in sites Ven 5 and LNF low, and in many pools and flatwaters in LNF mid. Crayfish, tadpoles, and sticklebacks were observed in some Ven 5 units, and one pool contained a bass. Black spot disease, a snail-borne trematode parasite, was not recorded for *O. mykiss* in the Ven 5 site, but was very common among fish in both LNF sites.

Ven 5. *O. mykiss* fry and juvenile+ were commonly observed in Ven 5 habitat units, despite having the highest water temperatures of all study sites (daily maxima >27°C over the four day sampling period). Fry were observed in 16 of the 24 sampled habitat units, which produced an overall estimate of abundance of 145 (±72) fish at a density of 0.17 (±0.09) fish/100ft^2 (Table 3, Figures 17-20). Fry abundance and density was highest in flatwater habitats, with lowest density in pools. Juvenile+ were observed in all but one habitat unit, with an estimated abundance of 203 (±98) fish at a density of 0.24 (±0.12) fish/100ft^2. Like fry, most juvenile+ occurred in flatwaters, but densities were very similar among the three mesohabitat types.

LNF low. Only two of eight pools in the LNF low study site contained *O. mykiss* fry, but 11 of 16 flatwaters and riffles contained fry for an overall abundance estimate of 70 (±36) fish at a density of 0.25 (±0.13) fish/100ft^2 (Table 3, Figures 17-20). Like in Ven 5, juvenile+ were more common than fry at 99 (±53) fish at a density of 0.35 (±0.19) fish/100ft^2. Density of fry was highest in riffle habitats, whereas juveniles occurred at highest densities in the deeper pools and flatwaters.

LNF mid. Abundant spawning activity was observed in this study site during the April 2003 HSI study (TRPA 2003), and densities of *O. mykiss* in 2006 were higher in LNF mid than in the other middle segment sites (Table 3, Figures 17-20). Fry were observed in all but two flatwaters and riffles (but were frequently absent in pools), and juveniles occurred in 20 of the 24 habitat units. Estimates of abundance of fry and juvenile+ were 151 (±43) fish and 170 (±48) fish, respectively. Estimated densities of fry were 0.60 (±0.17) fish/100ft^2 overall, with highest densities in riffles and lowest densities in pools. Densities of juvenile+ were estimated at 0.68 (±0.19) fish/100ft^2, with a somewhat more even distribution among habitat types. The overall densities of fry and juvenile+ in LNF mid were second only to the highest observed densities in the UNF study site.

Combined Study Sites. Combining data from the three middle segment study sites and expanding the estimates to the entire segment produced estimates of abundance of 1,759 (±585) fry and 2,269 (±776) juvenile+, with overall densities of 0.28 (±0.11) fish/100ft^2 and 0.37 (±0.14) fish/100ft^2, respectively (Figures 21 and 22). Although the abundance estimates for the middle segment were significantly lower than estimates from the upper segment (based on non-overlapping confidence intervals), the density estimates (the number of fish/100ft^2) were almost identical.

Upper Segment

The upper segment lies entirely above Matilija Dam, which has blocked immigration of steelhead into Matilija Creek since 1947. Three study sites occur on the mainstem Matilija Creek, and one study site represents its principal tributary, the upper North Fork Matilija Creek (Figure 1). The lowest mainstem site (Mat 3) was divided (due to private property) into a lower portion that occurs below a major hot spring, and an upper portion that contains some fairly large pools. Mat 5 occurs about 1½ miles upstream of Mat 3, but is only a short distance below the mouths of Murietta Creek (~¼ mi) and the upper

North Fork (~½ mi). Mat 5 is a wide, open channel largely comprised of boulder-strewn riffles and flatwater habitats with few pools. Mat 7 occurs within the upper mainstem canyon and supports a healthy riparian zone with a diverse variety of mesohabitat types. The upper North Fork study site is 2.7 miles up the North Fork trail and is pristine with heavy riparian growth. The UNF site also includes a portion of a major tributary, sometimes referred to as the East Fork of the North Fork. Arroyo chub and stickleback occurred in virtually all sampled units in Mat 3 and Mat 5, but neither species were observed in Mat 7 or the UNF site. Smallmouth bass were common in Mat 3, where they were observed in all but one sampled habitat unit, and bluegill were observed in four units. No turtles were observed in the UNF, but turtles were occasionally observed in sites Mat 3 and Mat 5, and were observed in almost every pool in Mat 7. Black spot disease was common among fish captured in Mat 5 and Mat 7, but was not observed in the UNF study site.

Mat 3. Mat 3 contained a number of *O. mykiss* despite the introduction of hot spring water in its lower portion, and a frequently wide, open channel. Only two of the pools contained fry, but six pools contained juvenile+ and about one-half of the flatwaters and riffles contained *O. mykiss*. Fish were observed in both sections, above and below the principal hot springs, which appeared to increase the stream temperature by approximately 3^{o}C (during the mid-August survey). The estimated abundance and density of fry was 23 (±11) fish and 0.03 (±0.01) fish/100ft^2, respectively. Juvenile+ were more abundant than fry, with 94 (±41) fish at a density of 0.12 (±0.05) fish/100ft^2 (Table 3, Figures 17-20).

Mat 5. *O. mykiss* were more abundant in Mat 5 than in Mat 3, and were observed in 22 of 25 sampled habitat units. The overall estimated abundance of fry and juvenile+ was 178 (±46) fish and 272 (±110) fish, respectively (Table 3, Figures 17 and 19). Although Mat 5 showed the highest overall abundance of juveniles and the second highest abundance of fry among all 11 study sites, the wide channel and large sampling areas resulted in density estimates that were considerably less than densities in the upper and lower North Forks (Figures 18 and 20). Overall, densities of fry and juvenile+ in Mat 5 were 0.27 (±0.07) fish/100ft^2 and 0.41 (±0.16) fish/100ft^2, respectively.

Mat 7. The Mat 7 study site differed from most other sites (except the UNF site) in that fry and juvenile+ *O. mykiss* were just as likely to occur in pool habitats as they were in flatwaters and riffles, and fish occurred in all but one sampled habitat unit. The overall abundance of fry in Mat 7 was 150 (±36) fish at a density of 0.40 (±0.10) fish/100ft^2 (Table 3, Figures 17-20). Juvenile+ trout were just as abundant with an estimated 153 (±29) fish at a density of 0.41 (±0.08) fish/100ft^2. Densities of fry were almost identical in all three habitat types, but juvenile+ occurred at higher densities in pools.

UNF up. The study site far up the upper North Fork Matilija Creek (including a portion of the "East Fork") contained abundant fry and juvenile+ *O. mykiss,* with the overall fry abundance estimate of 199 (±48) fish, which was higher than all other study sites (Table 3, Figure 17 and 19). Although the abundance estimate for juvenile+ was not particularly high at 148 (±69) fish, when converted to densities the estimates for both fry (1.22 ±0.29

fish) and juvenile+ trout (0.90 ±0.42 fish/100ft^2) were easily the highest of all study sites (Figures 18 and 20). The relatively high density in pools is consistent with other small streams, where water depths in riffles may be insufficient for rearing by larger individuals.

Combined Study Sites. The overall estimated abundance of fry and juvenile+ *O. mykiss* throughout the Upper Segment (excluding Murietta Creek, Old Man Creek, and all reaches above barriers) in the summer of 2006 was 3,878 (±827) fish and 4,703 (±1,505) fish, respectively. Although those abundance estimates were more than double the estimates for the Middle Segment, the estimated densities in the Upper Segment (0.28 ±0.06 fry/100ft^2 and 0.34 ±0.11 juvenile+/100ft^2) were almost identical to the Middle Segment estimates (Figures 21 and 22).

Ventura Lagoon

Sampling in the Ventura River Lagoon resulted in the capture and identification of 658 fish (Table 4), 96% of which were topsmelt (*Atherinops afinis*). None of the other captured species represented more than 1% of the total catch, including shiner surfperch (*Cymatogaster aggregate*), threespine stickleback, staghorn sculpin (*Leptocottus armatus*), prickly sculpin (*Cottus asper*), arroyo chub, and common carp. The latter three species are common in freshwater and were captured in the flowing portion of the lagoon in fresh or brackish water. All but 17 of the captured fish were collected with the beach seine; the remainder was collected with the backpack electrofisher. Four underwater video recordings (each 2-5 minutes in length) yielded the observation of only one fish (a shiner surfperch). Although striped mullet (*Mugil cephalus*) were commonly observed in the lagoon and even within the net sets, they always avoided capture by jumping over the floatline. The beach seine's mesh size was too large to capture fish fry or smaller species such as tidewater gobies. *O. mykiss* were never observed or captured by any sampling methodology in the lagoon.

RELATIONSHIP BETWEEN HSI SCORES AND FISH POPULATIONS

The relationship between fish abundance and habitat quality was assessed using simple linear regression with the 11 study site HSI scores as the predictor variable and fish density (#/100ft^2) for fry or juvenile+ as the response variable. Despite the reduced discrimination in HSI scores between study sites in 2006 (Figure 4), a positive and statistically significant relationship was evident for both fry ($R^2=0.69$, $P=0.001$) and juvenile+ ($R^2=0.64$, $P=0.003$) *O. mykiss* (Table 5, Figure 24). According to the regression model, approximately 65% to 70% of the variation in densities of fry and juvenile+ *O. mykiss* in the Ventura River/Matilija Creek study area in 2006 could be explained by the HSI model and its suite of 22 variables. As expected, plotting the HSI scores and fish densities according to segment also showed a positive relationship (Figure 24, bottom graph), but the distribution of the three datapoints essentially formed a two-point regression, so a statistical evaluation of these estimates was not attempted.

Table 4. Capture and observation data from sampling in the Ventura Lagoon, 25 August 2006.

Sampling Method	Set or Pass #	Map label	*O. mykiss*	Top-smelt	Arroyo Chub	Shiner Perch	Prickly Sculpin	Staghorn Sculpin	Stickle-back	Carp
Seining	1	a	0	15	0	0	0	0	0	0
	2	a	0	5	0	0	0	0	0	0
	3	a	0	1	0	0	0	0	0	0
	4	b	0	19	0	0	0	0	0	0
	5	c	0	27	0	0	0	0	0	0
	6	d	0	27	0	0	0	0	0	0
	7	e	0	20	0	0	0	0	0	0
	8	d	0	109	0	3	0	0	0	0
	9	f	0	25	0	0	0	0	0	0
	10	g	0	125	0	0	0	0	0	0
	11	h	0	118	0	2	0	0	0	0
	12	h	0	21	0	0	0	0	0	0
	13	i	0	90	0	0	0	0	0	0
	14	j	0	0	1	0	0	0	0	0
	15	k	0	0	0	0	0	0	0	0
	16	l	0	32	0	0	1	0	0	0
Electro-fishing	1	1	0	0	0	0	0	0	0	0
	2	2	0	0	3	0	5	1	1	7
Underwater Video	1	all	0	0	0	1	0	0	0	0
	2	under	0	0	0	0	0	0	0	0
	3	W bank	0	0	0	0	0	0	0	0
	4	RR brdg	0	0	0	0	0	0	0	0
Totals			**0**	**634**	**4**	**6**	**6**	**1**	**1**	**7**

Table 5. ANOVA tables for regression of HSC scores on fish densities, by size class.

Fry <10cm	df	SS	MS	*F*	Prob	Parameter	Coeff	R^2
Regression	1	0.9603	0.9603	20.24	0.001	Intercept	-2.28	0.69
Residual	9	0.4269	0.0474			HSI Score (X)	3.76	
Total	10	1.3873						

Juv+ >10cm	df	SS	MS	*F*	Prob	Parameter	Coeff	R^2
Regression	1	0.5932	0.5932	16.29	0.003	Intercept	-1.72	0.64
Residual	9	0.3278	0.0364			HSI Score (X)	2.95	
Total	10	0.9210						

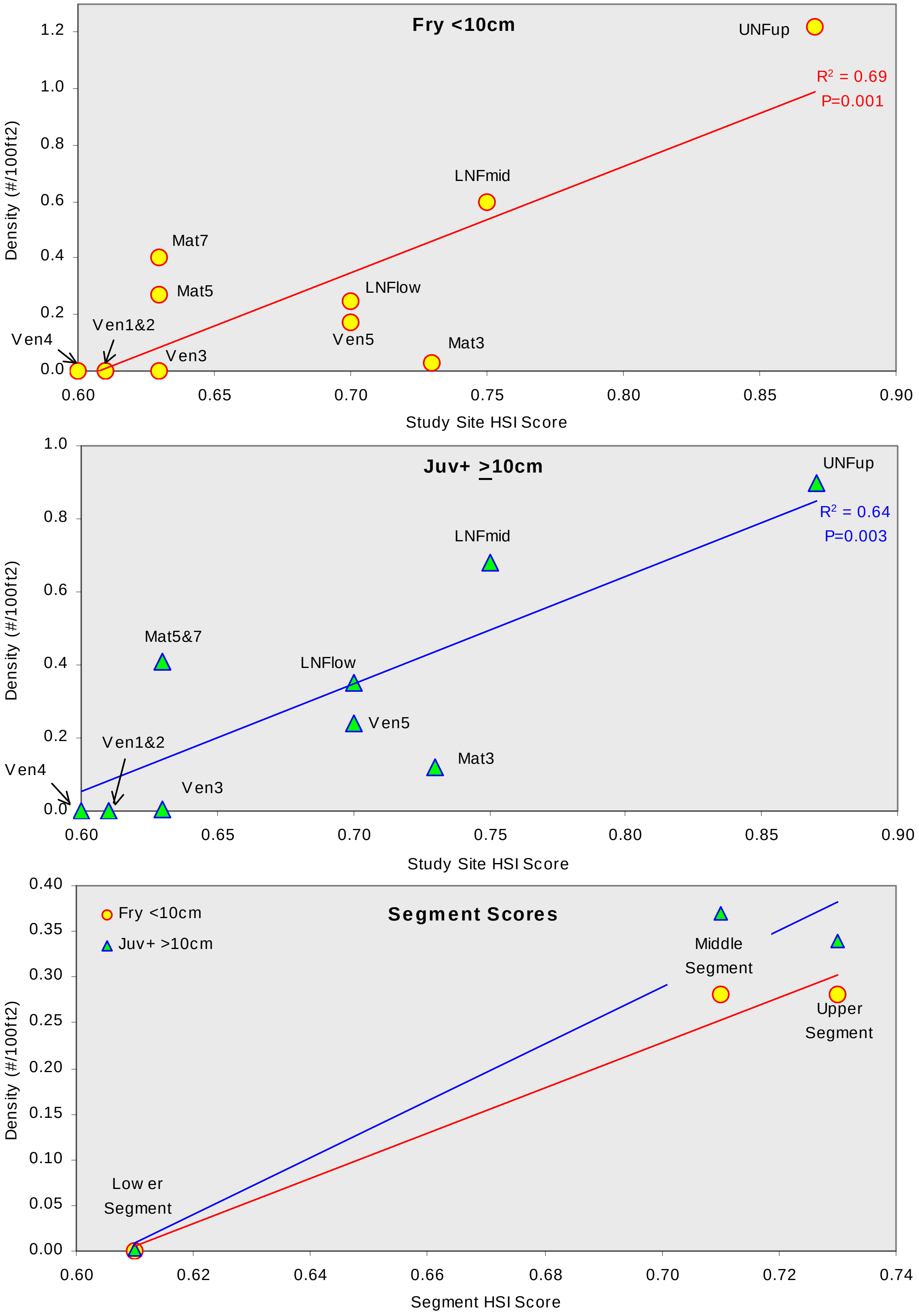


Figure 24. Relationship between HSI score and O. mykiss density.

The relationships between the 11 site-specific HSI scores and fish densities for both size classes were influenced by fish densities in several study sites, particularly the high densities in the UNF up site (Figure 24). Without the UNF up endpoint, the relationship for both size classes would remain positive but non-significant (although nearly significant, at *P*=0.07, for juvenile+). Analysis of the regression diagnostic plots (e.g., residual plots, Cook's distance plots, MathSoft 1999) suggested greater than average influence and residual deviations from each of the three mainstem Matilija Creek study sites. Mat 3, for example, had low fish densities despite a relatively high HSI score, whereas both Mat 5 and Mat 7 had higher fish densities than the HSI scores would suggest.

The comparisons of 2003 HSI scores with 2006 scores described previously in this report highlighted the substantial changes in the Mat 3 and Mat 7 study sites (Figure 6). The increased HSI score for Mat 3 in 2006 was largely due to improved scores for pool habitat variables (affecting all rearing component scores) as well as temperature-related improvements in the incubation variables (Figure 13). The large decrease in the Mat 7 HSI score was mostly due to a decreased Vs score, which was based on only five gravel patches. The relatively large residuals for both of these study sites may thus be due in part to inaccuracies in the model's assessment of recruitment potential, as represented by the embryo component score. Use of the 2003 HSI scores for Mat 5 and Mat 7 would place those datapoints very close to the estimated regression line in both the fry and juvenile+ graphs in Figure 24.

The poor model prediction for juvenile+ densities in Mat 5 (with the low HSI score and the relatively high fish densities) may also be due to recruitment effects, but not through variables included in the HSI model. The Mat 5 study site occurs immediately downstream of Murietta Creek and only a short distance downstream of the Upper North Fork Matilija Creek (and in fact a "naturalized" diversion channel runs directly from the mouth of the Upper North Fork into the top of the Mat 5 study site). Although not sampled in 2006, Murietta Creek contained high densities of trout in June 1979, and likely serves as a source of recruitment into the mainstem Matilija Creek, particularly as flows recede and rearing space becomes limiting in the small tributary (Moore 1980b). The Upper North Fork is the largest tributary to Matilija Creek and contains the highest fish densities in the basin, and therefore is likely to recruit many trout into downstream reaches of Matilija Creek, especially Mat 5.

The current HSI model for *O. mykiss* only incorporates recruitment through the direct effects of spawning, by virtue of the spawning gravel variables (gravel size, embeddedness, and water velocities) and the water quality variables for incubating eggs (temperature and D.O.). Consequently, there is no accounting for spawning-limited streams that have nearby sources of recruitment (e.g., spawning tributaries). Many larger mainstem rivers are known to support trout populations not through spawning but through rearing of older immigrants (TRPA 2004c), and such an effect may be responsible for the higher than expected densities in Mat 5.

Two other study sites that occur immediately below principal tributaries include Ven 5, just below the Lower North Fork Matilija Creek, and Ven 3 at the confluence of San Antonio Creek. The Lower North Fork Matilija Creek was found in 2006 to contain high densities of trout (densities in LNF mid was second only to UNF up) and is likely to have contributed fish into the Ven 5 study site (although 2006 fish densities were lower than predicted by the regression model, Figure 24). The only two *O. mykiss* that were observed in the Ven 3 site were in the confluence pool at San Antonio Creek, however we did not locate data on fish densities in San Antonio Creek, so it's potential recruitment effects on Ven 3 fish densities are unclear.

A proposed modification to the current HSI model is to include an alternate embryo component variable that accounts for recruitment from a known and nearby spawning tributary. This proposed "tributary effects" HSI curve would have maximum suitability (1.0) for study areas that contain or are bordered (upstream) by a known spawning tributary. Suitability would decline as the distance downstream of the tributary increases. At some (as of yet) undetermined distance downstream of the tributary, the "trib effects" HSI curve would go to zero, producing no effect on the embryo score. Under the current HSI model, the embryo component score simply takes the lowest (minimum) score from the three existing embryo variables: incubation temperature, incubation D.O., and spawning habitat (Vs). A potential modification to the model design would be to replace the conventional embryo component score with the HSI score from the new "trib effect" curve ***IF*** the trib score was greater (thus allowing immigration to compensate for poor spawning habitat). The conventional embryo score would be retained if it is higher than the trib effects score (e.g., assumes most recruitment would derive from within-reach spawning). In order to evaluate this potential modification to the existing HSI model, we propose to include additional sampling efforts in 2007 to generate a "trib effects" HSI curve and test its application in the Ventura/Matilija Basin (see recommendations section below).

SUMMARY & RECOMMENDATIONS

The 2006 HSI habitat assessment and *O. mykiss* distribution and abundance surveys in the Ventura River / Matilija Creek Basin showed a wide range in fish densities between the 11 study sites, but differences in HSI scores were much reduced in 2006 versus scores based on 2003 data (TRPA 2004). Despite the decreased distinction in habitat scores between reaches, a statistically significant and positive relationship ($R^2>0.60$ and $P<0.01$) was found between site-specific HSI scores and the estimated densities of *O. mykiss* in 2006.

HSI scores mostly increased from 2003 to 2006 in the Ventura River reaches, but mostly decreased in the Matilija Creek and tributary reaches. These changes resulted in a much more similar distribution of HSI scores than observed in 2003, where large differences were evident between reaches. HSI scores from 2006 habitat data differed from the 2003 scores by over 20% in only three of the 11 study sites, but few sites (3) showed a change of less than 10%. Most of the substantial changes in HSI scores between 2003 and 2006 were due to the significant effects of the spawning habitat variable, Vs, which was estimated in many reaches from an insufficient sample of gravel patches. The sampling design employed in both 2003 and 2006 did not adequately account for the relatively rare and patchy distribution of spawning gravels in most study sites. Sampling in 2007 is intended to correct this deficiency by revising many of the Vs scores with an increased sample size. Some changes in HSI scores were also due in part to substantial differences in pool habitat characteristics (% pools and pool quality), which may have resulted from flooding events that occurred between the two study years. One habitat variable, % vegetation, showed drastic declines in almost all study sites and is likely related to the flooding in 2004 and 2005. Despite the differences in site-specific HSI scores, the overall scores based on stream segment (Ventura River mouth to Robles Diversion Dam, Diversion Dam to Matilija Dam and Lower North Fork, and above Matilija Dam) were relatively consistent with 2003 results, with lowest overall scores in the lowest segment and higher and similar scores in the middle and upper segments.

Estimated fish densities were very consistent with HSI scores by segment, with very low (near zero) densities in the lower reaches of the Ventura River, but much higher and similar densities in the middle and upper segments of the study area. Highest densities of both fry (<10cm) and juvenile+ *O. mykiss* occurred in the Upper North Fork Matilija Creek, which also had the highest HSI score. Intermediate HSI scores and fish densities occurred in each of the three middle segment study sites (the Ventura River below Matilija Dam and two sites in the Lower North Fork Matilija Creek). Discrepancies between HSI scores and predicted fish densities (based on a linear regression model) occurred in the mainstem Matilija Creek study sites, where more fish than expected occurred in the lowest mainstem site, and fewer fish than expected occurred in the upper two mainstem sites. The high flows that existed in 2006 and the difficulties in estimating the spawning habitat variables (described above) may have contributed to these unpredicted results. Despite those inconsistencies, the regression model suggested a strong and highly significant relationship between site-specific HSI scores and fish densities in 2006, with 65-70% of the observed variation in fish densities by reach accounted for by the 22 habitat variables.

Sampling will continue in the Ventura River / Matilija Creek Basin thanks to a second grant from the CDFG Fisheries Restoration Grant Program. Because only a portion of the grant proposal was funded, the exact scope of the 2007 sampling has not yet been determined, however continued fish sampling and some HSI model validation will be a part of the 2007 survey. Sampling sites for the 2007 fish surveys have not been decided, but most sites are expected to be drawn from the 2006 study sites, particularly since high flows did not occur over the winter of 2006-07 and habitat conditions (besides lower flows) will likely be similar enough to relocate sampling units (pools, riffles, and flatwaters). Two to four new sites may be added, including a site in the previously unsampled San Antonio Creek, for the purposes of testing the HSI and regression models with a second year of fish density data. Study sites will be selected to allow estimation of fish densities within each study segment, although lower sample sizes are expected to yield wider confidence intervals and reduced discrimination of annual changes. Estimation of 2007 fish densities will help to assess population variability between two years of vastly different precipitation, and will also help to establish baseline conditions prior to the expected removal of Matilija Dam.

Our proposal for HSI model validation will include revisiting most (if not all) of the 2006 HSI study sites in order to revise estimates of the spawning habitat variable, Vs, with a larger sample size. The lack of high flow events between 2006 and 2007 is expected to yield similar gravel availability and substrate conditions between years, although streamflows will be substantially lower and more gravel patches will be out-of-water and thus difficult to evaluate. Another validation task proposed for 2007 sampling is to assess the effects of distance below a spawning tributary on *O. mykiss* densities in a mainstem reach. For example, sampling a series of flatwater habitats over a 1-2 mile distance in the mainstem Ventura River below the Lower North Fork of Matilija Creek, and/or over a 1-5 mile distance in the mainstem Matilija Creek below the Upper North Fork, may help to assess the effects of tributary recruitment on mainstem densities, and may allow the construction and testing of a new “tributary effects” HSI curve within the existing HSI model.

Additional validation of the USFWS HSI model for use in the Southern California Steelhead ESU will help to provide another tool for assessing habitat restoration needs, and should encourage the model’s use outside of the Ventura River Basin. Estimation of 2007 fish densities will help to assess population variability between two years of vastly different precipitation, and will also help to establish baseline conditions prior to the potential removal of Matilija Dam. These studies and the rigorous methods in which they are conducted can serve as a model for future fish and habitat work in Southern California watersheds.

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Appendix A. Mesohabitat mapping data for all HSI/fish population study sites.

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
Ven 1	7/15	*1*	GLD	114	VEN1BNEW
Ven 1	7/15	*2*	GLD	104	
Ven 1	7/15	*3*	MCP	74	35
Ven 1	7/15	*4*	RUN	137	36
Ven 1	7/15	*5*	LGR	42	
Ven 1	7/15	*6*	GLD	97	
Ven 1	7/15	*7*	MCP	94	
Ven 1	7/15	*8*	GLD	86	
Ven 1	7/15	*9*	MCP	104	
Ven 1	7/15	*10*	HGR	55	
Ven 1	7/15	*11*	RUN	65	28
Ven 1	7/15	*12*	LGR	59	
Ven 1	7/15	*13*	GLD	104	
Ven 1	7/15	*14*	MCP	175	
Ven 1	7/15	*15*	RUN	68	
Ven 1	7/15	*16*	RUN	39	
Ven 1	7/15	*17*	LGR	78	29
Ven 1	7/15	*18*	GLD	125	
Ven 1	7/15	*19*	MCP	230	30
Ven 1	7/15	*20*	RUN	115	
Ven 1	7/15	*21*	RUN	105	
Ven 1	7/15	*22*	GLD	45	
Ven 1	7/15	*23*	MCP	71	
Ven 1	7/15	*24*	LGR	81	
Ven 1	7/15	*25*	RUN	108	
Ven 1	7/15	*26*	RUN	105	
Ven 1	7/15	*27*	LGR	96	
Ven 1	7/15	*28*	LGR	67	
Ven 1	7/15	*29*	GLD	81	
Ven 1	7/15	*30*	RUN	94	
Ven 1	7/15	*31*	LGR	55	
Ven 1	7/15	*32*	LGR	97	
Ven 1	7/15	*33*	RUN	105	
Ven 1	7/15	*34*	LGR	66	31
Ven 1	7/15	*35*	RUN	82	
Ven 1	7/15	*36*	RUN	120	
Ven 1	7/15	*37*	GLD	136	
Ven 1	7/15	*38*	MCP	292	32
Ven 1	7/15	*39*	RUN	64	
Ven 1	7/15	*40*	HGR	38	
Ven 1	7/15	*41*	LGR	32	
Ven 1	7/15	*42*	POW	100	
Ven 1	7/15	*43*	RUN	110	
Ven 1	7/15	*44*	POW	60	
Ven 1	7/15	*45*	HGR	99	
Ven 1	7/15	*46*	LGR	102	
Ven 1	7/15	*47*	POW	120	
Ven 1	7/15	*48*	POW	95	
Ven 1	7/15	*49*	GLD	89	
Ven 1	7/15	*50*	MCP	235	33,34
Ven 2	7/11	*1*	RUN	83	14
Ven 2	7/11	*2*	POW	105	
Ven 2	7/11	*3*	RUN	102	
Ven 2	7/11	*4*	LSBK	149	15
Ven 2	7/11	*5*	HGR	30	
Ven 2	7/11	*6*	RUN	71	
Ven 2	7/11	*7*	POW	89	50
Ven 2	7/11	*8*	RUN	46	
Ven 2	7/11	*9*	LGR	57	16
Ven 2	7/11	*10*	GLD	120	
Ven 2	7/11	*11*	RUN	77	
Ven 2	7/11	*12*	HGR	94	
Ven 2	7/11	*13*	LGR	53	51
Ven 2	7/11	*14*	POW	97	
Ven 2	7/11	*15*	RUN	67	
Ven 2	7/11	*16*	GLD	86	
Ven 2	7/11	*17*	GLD	101	
Ven 2	7/11	*18*	LSBK	236	17
Ven 2	7/11	*19*	HGR	33	
Ven 2	7/11	*20*	LGR	111	
Ven 2	7/11	*21*	RUN	66	52
Ven 2	7/11	*22*	LGR	112	18
Ven 2	7/11	*23*	RUN	140	
Ven 2	7/11	*24*	RUN	181	
Ven 2	7/11	*25*	GLD	155	
Ven 2	7/11	*26*	POW	63	
Ven 2	7/11	*27*	LGR	59	
Ven 2	7/11	*28*	RUN	65	19
Ven 2	7/11	*29*	LGR	52	
Ven 2	7/11	*30*	LSBK	113	
Ven 2	7/11	*31*	LGR	45	54
Ven 2	7/11	*32*	RUN	58	
Ven 2	7/11	*33*	CAS	16	
Ven 2	7/11	*34*	RUN	66	
Ven 2	7/11	*35*	LGR	36	
Ven 2	7/11	*36*	RUN	76	
Ven 2	7/11	*37*	LGR	70	
Ven 2	7/11	*38*	RUN	108	55
Ven 2	7/11	*39*	LGR	100	20
Ven 2	7/11	*40*	RUN	76	
Ven 2	7/11	*41*	GLD	103	
Ven 2	7/11	*42*	RUN	61	
Ven 2	7/11	*43*	GLD	96	21
Ven 2	7/11	*44*	GLD	63	
Ven 2	7/11	*45*	LSBK	272	22
Ven 2	7/11	*46*	RUN	84	
Ven 2	7/11	*47*	HGR	30	
Ven 2	7/11	*48*	LGR	76	
Ven 2	7/11	*49*	RUN	86	
Ven 2	7/11	*50*	RUN	138	
Ven 2	7/11	*51*	LGR	31	
Ven 2	7/11	*52*	RUN	69	
Ven 2	7/11	*53*	LSBK	95	
Ven 2	7/11	*54*	RUN	53	
Ven 2	7/11	*55*	LGR	57	
Ven 2	7/11	*56*	LSBK	91	23
Ven 2	7/11	*57*	POW	52	
Ven 2	7/11	*58*	HGR	30	

Appendix A. (continued)

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label	Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
Ven 2	7/11	59	LGR	58	24	Ven4	7/1	4	LGR	48	
Ven3	7/16	1	GLD	102	VEN3B	Ven4	7/1	5	GLD	44	4
Ven3	7/16	2	RUN	131		Ven4	7/1	6	RUN	74	
Ven3	7/16	3	LGR	60	56	Ven4	7/1	7	GLD	84	
Ven3	7/16	4	LGR	61		Ven4	7/1	8	LGR	67	5
Ven3	7/16	5	RUN	73		Ven4	7/1	9	POW	57	
Ven3	7/16	6	LGR	36		Ven4	7/1	10	GLD	64	
Ven3	7/16	7	RUN	52		Ven4	7/1	11	SRN	50	
Ven3	7/16	8	POW	45	38	Ven4	7/1	12	HGR	71	
Ven3	7/16	9	RUN	36		Ven4	7/1	13	POW	20	
Ven3	7/16	10	LGR	66	39	Ven4	7/1	14	LGR	59	6
Ven3	7/16	11	LGR	55		Ven4	7/1	15	POW	89	7
Ven3	7/16	12	RUN	81		Ven4	7/1	16	RUN	50	
Ven3	7/16	13	RUN	130	61	Ven4	7/1	17	LSBK	212	13
Ven3	7/16	14	RUN	75		Ven4	7/1	18	RUN	56	
Ven3	7/16	15	LGR	89		Ven4	7/1	19	LSBK	30	
Ven3	7/16	16	GLD	100		Ven4	7/1	20	HGR	38	
Ven3	7/16	17	MCP	110	62	Ven4	7/1	21	RUN	101	
Ven3	7/16	18	HGR	80	57	Ven4	7/1	22	GLD	76	
Ven3	7/16	19	LGR	45		Ven4	7/1	23	LSBK	118	8
Ven3	7/16	20	POW	69		Ven4	7/1	24	HGR	48	9
Ven3	7/16	21	RUN	142	41	Ven4	7/1	25	DPL	20	
Ven3	7/16	22	LGR	68		Ven4	7/1	26	LGR	37	
Ven3	7/16	23	LGR	67	42	Ven4	7/1	27	POW	96	
Ven3	7/16	24	RUN	122		Ven4	7/1	28	SRN	59	
Ven3	7/16	25	LSBO	729	43	Ven4	7/1	29	POW	75	
Ven3	7/16	26	LGR	61		Ven4	7/1	30	RUN	39	10
Ven3	7/16	27	RUN	52		Ven4	7/1	31	HGR	60	
Ven3	7/16	28	DPL	135	44	Ven4	7/1	32	SRN	73	
Ven3	7/16	29	LGR	61	58	Ven4	7/1	33	GLD	46	
Ven3	7/16	30	RUN	81	63	Ven4	7/1	34	MCP	133	11
Ven3	7/16	31	RUN	120		Ven4	7/1	35	SRN	79	
Ven3	7/16	32	GLD	120		Ven4	7/1	36	RUN	69	
Ven3	7/16	33	RUN	131		Ven4	7/1	37	POW	62	
Ven3	7/16	34	LGR	48	60	Ven4	7/1	38	GLD	30	
Ven3	7/16	35	RUN	84	45	Ven4	7/1	39	POW	48	12
Ven3	7/16	36	LGR	62		Ven4	7/1	40	LGR	47	
Ven3	7/16	37	GLD	105		Ven4	7/1	41	POW	72	
Ven3	7/16	38	RUN	54		Ven4	7/1	42	GLD	30	
Ven3	7/16	39	HGR	137		Ven4	7/1	43	RUN	47	
Ven3	7/16	40	MCP	130		Ven4	7/1	44	LGR	30	
Ven3	7/16	41	GLD	110		Ven4	7/1	45	POW	134	
Ven3	7/16	42	CCP	142	46	Ven4	7/1	46	LGR	94	
Ven3	7/16	43	SRN	76		Ven4	7/1	47	POW	75	
Ven3	7/16	44	RUN	74		Ven4	7/1	48	RUN	68	
Ven3	7/16	45	LGR	35	47	Ven4	7/1	49	LGR	13	VEN4T
Ven3	7/16	46	RUN	70		Ven5	7/22	1	HGR	52	VEN5B
Ven3	7/16	47	LGR	52		Ven5	7/22	2	LGR	43	65
Ven3	7/16	48	RUN	137	48	Ven5	7/22	3	RUN	46	
Ven3	7/16	49	RUN	75		Ven5	7/22	4	RUN	29	
Ven3	7/16	50	MCP	99	49	Ven5	7/22	5	MCP	150	66
Ven4	7/1	1	MCP	111	2,VEN4B	Ven5	7/22	6	RUN	42	
Ven4	7/1	2	SRN	48		Ven5	7/22	7	MCP	112	
Ven4	7/1	3	HGR	79	3	Ven5	7/22	8	LGR	42	

Appendix A. (continued)

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
Ven5	7/22	*9*	POW	47	67
Ven5	7/22	*10*	RUN	55	
Ven5	7/22	*11*	POW	24	
Ven5	7/22	*12*	MCP	32	
Ven5	7/22	*13*	LGR	32	
Ven5	7/22	*14*	MCP	59	68
Ven5	7/22	*15*	POW	64	69,70
Ven5	7/22	*16*	MCP	37	
Ven5	7/22	*17*	RUN	55	
Ven5	7/22	*18*	HGR	29	71
Ven5	7/22	*19*	LGR	31	
Ven5	7/22	*20*	RUN	49	
Ven5	7/22	*21*	POW	91	72
Ven5	7/22	*22*	RUN	89	
Ven5	7/22	*23*	LSBO	60	
Ven5	7/22	*24*	LSBO	49	73
Ven5	7/22	*25*	CULV	35	
Ven5	7/22	*26*	MCP	29	
Ven5	7/22	*27*	LGR	34	74
Ven5	7/22	*28*	POW	64	
Ven5	7/22	*29*	LGR	33	
Ven5	7/22	*30*	POW	43	75
Ven5	7/22	*31*	LGR	36	76
Ven5	7/22	*32*	POW	80	
Ven5	7/22	*33*	MCP	25	
Ven5	7/22	*34*	RUN	21	
Ven5	7/22	*35*	HGR	31	
Ven5	7/22	*36*	RUN	50	77
Ven5	7/22	*37*	LGR	24	
Ven5	7/22	*38*	POW	20	
Ven5	7/22	*39*	MCP	81	78
Ven5	7/22	*40*	MCP	28	
Ven5	7/22	*41*	POW	38	
Ven5	7/22	*42*	MCP	157	
Ven5	7/22	*43*	LGR	24	85
Ven5	7/22	*44*	LSBO	57	
Ven5	7/22	*45*	SRN	74	
Ven5	7/22	*46*	HGR	34	80
Ven5	7/22	*47*	POW	56	
Ven5	7/22	*48*	POW	68	
Ven5	7/22	*49*	LSBO	36	
Ven5	7/22	*50*	RUN	45	
Ven5	7/22	*51*	LGR	32	
Ven5	7/22	*52*	POW	32	
Ven5	7/22	*53*	MCP	73	81
Ven5	7/22	*54*	RUN	24	
Ven5	7/22	*55*	LGR	31	82,83
Ven5	7/22	*56*	RUN	20	
Ven5	7/22	*57*	POW	32	
Ven5	7/22	*58*	LSBO	48	84
LNF low	8/23	*1*	LGR	10	LNFLOWB
LNF low	8/23	*2*	RUN	21	
LNF low	8/23	*3*	LGR	23	216
LNF low	8/23	*4*	SRN	24	
LNF low	8/23	*5*	POW	14	
LNF low	8/23	*6*	MCP	51	
LNF low	8/23	*7*	CAS	2	
LNF low	8/23	*8*	LGR	23	217
LNF low	8/23	*9*	GLD	22	218
LNF low	8/23	*10*	MCP	40	219
LNF low	8/23	*11*	LGR	6	
LNF low	8/23	*12*	RUN	31	
LNF low	8/23	*13*	SRN	14	
LNF low	8/23	*14*	MCP	30	
LNF low	8/23	*15*	SRN	45	
LNF low	8/23	*16*	MCP	75	220
LNF low	8/23	*17*	CAS	2	
LNF low	8/23	*18*	MCP	48	
LNF low	8/23	*19*	RUN	20	
LNF low	8/23	*20*	LGR	21	221
LNF low	8/23	*21*	HGR	10	222
LNF low	8/23	*22*	SRN	25	
LNF low	8/23	*23*	POW	16	
LNF low	8/23	*24*	HGR	25	223
LNF low	8/23	*25*	SRN	27	
LNF low	8/23	*26*	LGR	8	
LNF low	8/23	*27*	POW	48	
LNF low	8/23	*28*	SRN	19	224
LNF low	8/23	*29*	POW	6	
LNF low	8/23	*30*	SRN	16	
LNF low	8/23	*31*	CAS	13	
LNF low	8/23	*32*	MCP	26	
LNF low	8/23	*33*	CAS	2	
LNF low	8/23	*34*	LGR	19	225
LNF low	8/23	*35*	RUN	12	
LNF low	8/23	*36*	HGR	12	
LNF low	8/23	*37*	MCP	26	226
LNF low	8/23	*38*	CAS	2	
LNF low	8/23	*39*	SRN	29	
LNF low	8/23	*40*	PLP	13	
LNF low	8/23	*41*	RUN	20	
LNF low	8/23	*42*	CAS	3	
LNF low	8/23	*43*	RUN	33	
LNF low	8/23	*44*	LGR	25	227
LNF low	8/23	*45*	GLD	40	228
LNF low	8/23	*46*	MCP	26	
LNF low	8/23	*47*	RUN	20	
LNF low	8/23	*48*	GLD	58	
LNF low	8/23	*49*	RUN	27	
LNF low	8/23	*50*	CAS	2	
LNF low	8/23	*51*	RUN	32	229
LNF low	8/23	*52*	MCP	11	
LNF low	8/23	*53*	LGR	5	
LNF low	8/23	*54*	STP	19	
LNF low	8/23	*55*	CAS	5	
LNF low	8/23	*56*	RUN	25	
LNF low	8/23	*57*	POW	27	
LNF low	8/23	*58*	LSBK	70	230

Appendix A. (continued)

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
LNF low	8/23	*59*	STP	12	
LNF low	8/23	*60*	CAS	6	
LNF low	8/23	*61*	POW	6	
LNF low	8/23	*62*	MCP	40	
LNF low	8/23	*63*	LGR	21	231
LNF low	8/23	*64*	PLP	14	
LNF low	8/23	*65*	LGR	9	
LNF low	8/23	*66*	RUN	9	
LNF low	8/23	*67*	LSBK	28	
LNF low	8/23	*68*	CAS	8	
LNF low	8/23	*69*	LGR	6	
LNF low	8/23	*70*	MCP	20	232
LNF low	8/23	*71*	LGR	4	
LNF low	8/23	*72*	STP	19	
LNF low	8/23	*73*	CAS	3	
LNF low	8/23	*74*	TRP	43	233
LNF low	8/23	*75*	STP	10	234
LNF low	8/23	*76*	BRS	5	
LNF low	8/23	*77*	MCP	46	
LNF low	8/23	*78*	CAS	6	
LNF low	8/23	*79*	POW	9	
LNF low	8/23	*80*	MCP	42	
LNF low	8/23	*81*	HGR	17	
LNF low	8/23	*82*	LGR	12	
LNF low	8/23	*83*	SRN	29	235
LNF low	8/23	*84*	MCP	81	
LNF low	8/23	*85*	BRS	3	
LNF low	8/23	*86*	MCP	26	
LNF low	8/23	*87*	CAS	4	
LNF low	8/23	*88*	POW	20	
LNF low	8/23	*89*	CAS	31	
LNF low	8/23	*90*	RUN	23	
LNF low	8/23	*91*	PLP	14	
LNF low	8/23	*92*	CAS	2	
LNF low	8/23	*93*	MCP	63	
LNF low	8/23	*94*	RUN	9	
LNF low	8/23	*95*	PLP	13	
LNF low	8/23	*96*	CAS	10	LNFLOWT
LNF mid	8/21	*1*	MCP	38	198
LNF mid	8/21	*2*	HGR	20	
LNF mid	8/21	*3*	POW	15	
LNF mid	8/21	*4*	MCP	56	
LNF mid	8/21	*5*	CAS	2	
LNF mid	8/21	*6*	GLD	40	199
LNF mid	8/21	*7*	RUN	12	
LNF mid	8/21	*8*	CAS	2	
LNF mid	8/21	*9*	MCP	15	
LNF mid	8/21	*10*	RUN	26	
LNF mid	8/21	*11*	LGR	13	
LNF mid	8/21	*12*	MCP	44	200
LNF mid	8/21	*13*	RUN	28	
LNF mid	8/21	*14*	STP	23	
LNF mid	8/21	*15*	CAS	11	
LNF mid	8/21	*16*	PLP	59	201
LNF mid	8/21	*17*	RUN	29	202
LNF mid	8/21	*18*	POW	8	
LNF mid	8/21	*19*	CAS	2	
LNF mid	8/21	*20*	POW	12	203
LNF mid	8/21	*21*	LGR	13	
LNF mid	8/21	*22*	SRN	29	
LNF mid	8/21	*23*	CAS	3	
LNF mid	8/21	*24*	MCP	68	
LNF mid	8/21	*25*	POW	24	
LNF mid	8/21	*26*	CAS	19	
LNF mid	8/21	*27*	RUN	30	204
LNF mid	8/21	*28*	POW	5	
LNF mid	8/21	*29*	CAS	3	
LNF mid	8/21	*30*	PLP	25	205
LNF mid	8/21	*31*	RUN	6	
LNF mid	8/21	*32*	MCP	18	
LNF mid	8/21	*33*	CAS	2	
LNF mid	8/21	*34*	LSBK	58	
LNF mid	8/21	*35*	RUN	25	
LNF mid	8/21	*36*	MCP	23	
LNF mid	8/21	*37*	POW	22	
LNF mid	8/21	*38*	MCP	30	
LNF mid	8/21	*39*	LGR	6	
LNF mid	8/21	*40*	MCP	12	
LNF mid	8/21	*41*	RUN	13	
LNF mid	8/21	*42*	CAS	2	
LNF mid	8/21	*43*	MCP	26	
LNF mid	8/21	*44*	POW	26	206
LNF mid	8/21	*45*	LSBK	43	
LNF mid	8/21	*46*	LGR	26	
LNF mid	8/21	*47*	HGR	9	
LNF mid	8/21	*48*	LSBK	23	
LNF mid	8/21	*49*	POW	25	
LNF mid	8/21	*50*	LGR	6	
LNF mid	8/21	*51*	MCP	33	
LNF mid	8/21	*52*	LGR	29	
LNF mid	8/21	*53*	LSBK	62	
LNF mid	8/21	*54*	LGR	27	
LNF mid	8/21	*55*	SRN	26	
LNF mid	8/21	*56*	CAS	11	
LNF mid	8/21	*57*	RUN	27	207
LNF mid	8/21	*58*	MCP	20	
LNF mid	8/21	*59*	RUN	33	
LNF mid	8/21	*60*	MCP	35	
LNF mid	8/21	*61*	GLD	48	
LNF mid	8/21	*62*	LGR	6	
LNF mid	8/21	*63*	MCP	13	
LNF mid	8/21	*64*	CAS	3	
LNF mid	8/21	*65*	MCP	24	
LNF mid	8/21	*66*	CAS	3	
LNF mid	8/21	*67*	RUN	25	208
LNF mid	8/21	*68*	SRN	29	
LNF mid	8/21	*69*	GLD	41	
LNF mid	8/21	*70*	RUN	14	

Appendix A. (continued)

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label	Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
LNF mid	8/21	*71*	HGR	19		Mat3	8/11	*29*	LGR	18	
LNF mid	8/21	*72*	STP	14		Mat3	8/11	*30*	RUN	95	
LNF mid	8/21	*73*	CAS	2		Mat3	8/11	*31*	RUN	67	MAT3T1
LNF mid	8/21	*74*	STP	14		Mat3	8/11	*32*	GLD	73	136
LNF mid	8/21	*75*	CAS	3		Mat3	8/11	*33*	MCP	116	137
LNF mid	8/21	*76*	LSBK	11		Mat3	8/11	*34*	CAS	3	138
LNF mid	8/21	*77*	GLD	26	209	Mat3	8/11	*35*	MCP	56	
LNF mid	8/21	*78*	MCP	71		Mat3	8/11	*36*	HGR	11	147
LNF mid	8/21	*79*	LGR	17	210	Mat3	8/11	*37*	POW	22	
LNF mid	8/21	*80*	SRN	15		Mat3	8/11	*38*	HGR	16	
LNF mid	8/21	*81*	HGR	23		Mat3	8/11	*39*	POW	58	
LNF mid	8/21	*82*	MCP	59		Mat3	8/11	*40*	HGR	25	139
LNF mid	8/21	*83*	GLD	37		Mat3	8/11	*41*	DPL	17	140
LNF mid	8/21	*84*	HGR	29	211	Mat3	8/11	*42*	SRN	30	
LNF mid	8/21	*85*	RUN	25		Mat3	8/11	*43*	RUN	37	
LNF mid	8/21	*86*	LGR	5		Mat3	8/11	*44*	HGR	10	
LNF mid	8/21	*87*	RUN	14	212	Mat3	8/11	*45*	LGR	89	149
LNF mid	8/21	*88*	HGR	7		Mat3	8/11	*46*	GLD	76	
LNF mid	8/21	*89*	SRN	37		Mat3	8/11	*47*	LSBO	141	
LNF mid	8/21	*90*	HGR	10		Mat3	8/11	*48*	RUN	94	141
LNF mid	8/21	*91*	RUN	31		Mat3	8/11	*49*	SRN	26	
LNF mid	8/21	*92*	LGR	12		Mat3	8/11	*50*	CAS	6	
LNF mid	8/21	*93*	LSBK	23		Mat3	8/11	*51*	LGR	62	MAT3T2
LNF mid	8/21	*94*	RUN	6		Mat5	8/7	1	LSBO	339	89
LNF mid	8/21	*95*	LSBK	47		Mat5	8/7	2	POW	100	90
LNF mid	8/21	*96*	MCP	97	LNFMIDB	Mat5	8/7	3	LGR	20	91
Mat3	8/11	*1*	LGR	68	121	Mat5	8/7	4	PLP	14	92
Mat3	8/11	*2*	GLD	70	122	Mat5	8/7	5	CAS	6	
Mat3	8/11	*3*	LSBO	94	123	Mat5	8/7	6	RUN	18	
Mat3	8/11	*4*	CAS	3		Mat5	8/7	7	HGR	37	93
Mat3	8/11	*5*	LSBO	86	124	Mat5	8/7	8	LGR	20	94
Mat3	8/11	*6*	LGR	81	125	Mat5	8/7	9	POW	17	
Mat3	8/11	*7*	POW	106		Mat5	8/7	10	CAS	6	
Mat3	8/11	*8*	GLD	58		Mat5	8/7	11	SRN	52	
Mat3	8/11	*9*	POW	29	145	Mat5	8/7	12	HGR	22	
Mat3	8/11	*10*	RUN	48	126	Mat5	8/7	13	SRN	49	95
Mat3	8/11	*11*	STP	18	127	Mat5	8/7	14	LGR	80	96
Mat3	8/11	*12*	RUN	19		Mat5	8/7	15	RUN	37	
Mat3	8/11	*13*	CAS	2		Mat5	8/7	16	MCP	38	97
Mat3	8/11	*14*	DPL	32	128	Mat5	8/7	17	RUN	45	98
Mat3	8/11	*15*	LGR	23	129	Mat5	8/7	18	MCP	37	99
Mat3	8/11	*16*	SRN	73		Mat5	8/7	19	RUN	48	
Mat3	8/11	*17*	LGR	18		Mat5	8/7	20	LGR	30	100
Mat3	8/11	*18*	RUN	38		Mat5	8/7	21	CAS	6	
Mat3	8/11	*19*	LGR	17		Mat5	8/7	22	RUN	49	
Mat3	8/11	*20*	RUN	22		Mat5	8/7	23	SRN	45	
Mat3	8/11	*21*	LGR	47		Mat5	8/7	24	CAS	3	
Mat3	8/11	*22*	RUN	40		Mat5	8/7	25	MCP	38	101
Mat3	8/11	*23*	LGR	83	131	Mat5	8/7	26	RUN	85	102
Mat3	8/11	*24*	POW	45	132	Mat5	8/7	27	LGR	8	
Mat3	8/11	*25*	SRN	61	146	Mat5	8/7	28	MCP	39	
Mat3	8/11	*26*	POW	74		Mat5	8/7	29	RUN	46	
Mat3	8/11	*27*	MCP	36	133	Mat5	8/7	30	HGR	41	
Mat3	8/11	*28*	RUN	76		Mat5	8/7	31	CAS	31	103

Appendix A. (continued)

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label	Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
Mat5	8/7	32	MCP	53		Mat7	8/16	*22*	LSBK	55	
Mat5	8/7	33	RUN	26		Mat7	8/16	*23*	BRS	9	
Mat5	8/7	34	SRN	82		Mat7	8/16	*24*	TRP	39	
Mat5	8/7	35	HGR	25	104	Mat7	8/16	*25*	RUN	7	
Mat5	8/7	36	RUN	50	105	Mat7	8/16	*26*	CAS	12	
Mat5	8/7	37	SRN	68	106	Mat7	8/16	*27*	RUN	11	157
Mat5	8/7	38	POW	49	107	Mat7	8/16	*28*	PLP	33	
Mat5	8/7	39	PLP	26	108	Mat7	8/16	*29*	CAS	4	
Mat5	8/7	40	CAS	2		Mat7	8/16	*30*	BRS	53	
Mat5	8/7	41	RUN	20	109	Mat7	8/16	*31*	RUN	26	172
Mat5	8/7	42	CAS	6		Mat7	8/16	*32*	LGR	10	
Mat5	8/7	43	MCP	10	110	Mat7	8/16	*33*	MCP	26	
Mat5	8/7	44	CAS	6		Mat7	8/16	*34*	LGR	7	
Mat5	8/7	45	MCP	20	111	Mat7	8/16	*35*	MCP	39	
Mat5	8/7	46	SRN	42		Mat7	8/16	*36*	LGR	20	158
Mat5	8/7	47	CAS	7	112	Mat7	8/16	*37*	PLP	4	
Mat5	8/7	48	SRN	57		Mat7	8/16	*38*	CAS	4	
Mat5	8/7	49	MCP	40		Mat7	8/16	*39*	RUN	24	159
Mat5	8/7	50	LGR	20	114	Mat7	8/16	*40*	MCP	39	
Mat5	8/7	51	RUN	22		Mat7	8/16	*41*	BRS	63	
Mat5	8/7	52	POW	32		Mat7	8/16	*42*	MCP	28	
Mat5	8/7	53	RUN	42	115	Mat7	8/16	*43*	CAS	9	
Mat5	8/7	54	CAS	8		Mat7	8/16	*44*	LGR	6	
Mat5	8/7	55	MCP	12	116	Mat7	8/16	*45*	PLP	13	
Mat5	8/7	56	SRN	22		Mat7	8/16	*46*	CAS	3	
Mat5	8/7	57	CAS	6		Mat7	8/16	*47*	LGR	11	
Mat5	8/7	58	RUN	24		Mat7	8/16	*48*	MCP	18	
Mat5	8/7	59	LGR	9		Mat7	8/16	*49*	LGR	21	160
Mat5	8/7	60	RUN	30	117	Mat7	8/16	*50*	RUN	10	
Mat5	8/7	61	LGR	11		Mat7	8/16	*51*	MCP	19	
Mat5	8/7	62	SRN	18		Mat7	8/16	*52*	LGR	44	161
Mat5	8/7	63	LGR	60	118	Mat7	8/16	*53*	POW	48	
Mat5	8/7	64	SRN	69	119,MAT5T	Mat7	8/16	*54*	RUN	14	
Mat7	8/16	*1*	CAS	30	151	Mat7	8/16	*55*	HGR	14	
Mat7	8/16	*2*	LGR	59		Mat7	8/16	*56*	STP	37	
Mat7	8/16	*3*	RUN	41		Mat7	8/16	*57*	CAS	9	
Mat7	8/16	*4*	MCP	9	152	Mat7	8/16	*58*	STP	47	162
Mat7	8/16	*5*	CAS	8		Mat7	8/16	*59*	CAS	14	
Mat7	8/16	*6*	RUN	14		Mat7	8/16	*60*	BRS	27	
Mat7	8/16	*7*	CAS	6		Mat7	8/16	*61*	RUN	50	163
Mat7	8/16	*8*	STP	32		Mat7	8/16	*62*	CAS	16	
Mat7	8/16	*9*	CAS	7		Mat7	8/16	*63*	RUN	12	
Mat7	8/16	*10*	LSBK	125	153	Mat7	8/16	*64*	STP	18	
Mat7	8/16	*11*	HGR	15		Mat7	8/16	*65*	CAS	3	
Mat7	8/16	*12*	PLP	9		Mat7	8/16	*66*	STP	19	
Mat7	8/16	*13*	HGR	5		Mat7	8/16	*67*	CAS	5	
Mat7	8/16	*14*	SRN	42		Mat7	8/16	*68*	SRN	78	
Mat7	8/16	*15*	CAS	15		Mat7	8/16	*69*	CAS	3	
Mat7	8/16	*16*	MCP	33	154	Mat7	8/16	*70*	SRN	15	164
Mat7	8/16	*17*	RUN	16		Mat7	8/16	*71*	HGR	13	
Mat7	8/16	*18*	GLD	37		Mat7	8/16	*72*	RUN	6	
Mat7	8/16	*19*	SRN	62	155	Mat7	8/16	*73*	MCP	51	165
Mat7	8/16	*20*	MCP	35	156	Mat7	8/16	*74*	SRN	79	
Mat7	8/16	*21*	CAS	10		Mat7	8/16	*75*	STP	70	

Appendix A. (continued)

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label	Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
Mat7	8/16	*76*	CAS	3		UNF up	8/18	47	RUN	11	
Mat7	8/16	*77*	POW	17	166,167	UNF up	8/18	48	MCP	10	
Mat7	8/16	*78*	HGR	18		UNF up	8/18	49	CAS	2	
Mat7	8/16	*79*	LGR	35	168	UNF up	8/18	50	POW	20	
Mat7	8/16	*80*	MCP	126	169	UNF up	8/18	51	PLP	10	180
Mat7	8/16	*81*	BRS	20		UNF up	8/18	52	CAS	2	
Mat7	8/16	*82*	LGR	80	170	UNF up	8/18	53	RUN	0	181
Mat7	8/16	*83*	MCP	103		UNF up	8/18	54	LGR	31	
UNF up	8/18	1	HGR	12	UNFUPB	UNF up	8/18	55	RUN	14	
UNF up	8/18	2	STP	5		UNF up	8/18	56	HGR	10	
UNF up	8/18	3	HGR	6		UNF up	8/18	57	POW	12	
UNF up	8/18	4	PLP	16		UNF up	8/18	58	RUN	23	182
UNF up	8/18	5	CAS	2		UNF up	8/18	59	MCP	23	
UNF up	8/18	6	RUN	10		UNF up	8/18	60	POW	14	
UNF up	8/18	7	POW	7		UNF up	8/18	61	LGR	16	
UNF up	8/18	8	CAS	6		UNF up	8/18	62	LSBO	24	
UNF up	8/18	9	MCP	11		UNF up	8/18	63	SRN	20	
UNF up	8/18	10	LGR	10		UNF up	8/18	64	POW	20	
UNF up	8/18	11	RUN	9		UNF up	8/18	65	LSBO	21	183
UNF up	8/18	12	POW	5		UNF up	8/18	66	SRN	31	
UNF up	8/18	13	HGR	22		UNF up	8/18	67	RUN	20	
UNF up	8/18	14	MCP	17		UNF up	8/18	68	LGR	14	
UNF up	8/18	15	CAS	3	174	UNF up	8/18	69	PLP	37	
UNF up	8/18	16	POW	30		UNF up	8/18	70	CAS	5	
UNF up	8/18	17	CAS	5		UNF up	8/18	71	LGR	34	184
UNF up	8/18	18	MCP	15		UNF up	8/18	72	MCP	19	
UNF up	8/18	19	SRN	33		UNF up	8/18	73	POW	8	185
UNF up	8/18	20	CAS	2	175	UNF up	8/18	74	MCP	28	
UNF up	8/18	21	MCP	9		UNF up	8/18	75	BRS	9	
UNF up	8/18	22	HGR	18		UNF up	8/18	76	TRP	12	
UNF up	8/18	23	SRN	22		UNF up	8/18	77	BRS	23	
UNF up	8/18	24	STP	5		UNF up	8/18	78	CAS	8	
UNF up	8/18	25	CAS	2		UNF up	8/18	79	PLP	18	186
UNF up	8/18	26	STP	6		UNF up	8/18	80	CAS	3	
UNF up	8/18	27	CAS	2		UNF up	8/18	81	RUN	20	
UNF up	8/18	28	LGR	8		UNF up	8/18	82	MCP	23	
UNF up	8/18	29	RUN	7		UNF up	8/18	83	BRS	8	
UNF up	8/18	30	SRN	7		UNF up	8/18	84	RUN	26	187
UNF up	8/18	31	LGR	20	UNFUPT2	UNF up	8/18	85	LGR	19	
UNF up	8/18	32	HGR	49	177	UNF up	8/18	86	RUN	18	188
UNF up	8/18	33	STP	16		UNF up	8/18	87	STP	16	
UNF up	8/18	34	LGR	14		UNF up	8/18	88	CAS	7	
UNF up	8/18	35	HGR	4		UNF up	8/18	89	POW	20	
UNF up	8/18	36	MCP	19		UNF up	8/18	90	LGR	8	189
UNF up	8/18	37	CAS	2		UNF up	8/18	91	RUN	14	
UNF up	8/18	38	LSBK	21		UNF up	8/18	92	BRS	17	
UNF up	8/18	39	BRS	9		UNF up	8/18	93	HGR	21	
UNF up	8/18	40	RUN	15		UNF up	8/18	94	MCP	26	190
UNF up	8/18	41	HGR	9	178	UNF up	8/18	95	SRN	15	
UNF up	8/18	42	SRN	26		UNF up	8/18	96	LGR	14	
UNF up	8/18	43	PLP	11	179	UNF up	8/18	97	STP	6	
UNF up	8/18	44	CAS	3		UNF up	8/18	98	CAS	2	
UNF up	8/18	45	PLP	10		UNF up	8/18	99	HGR	24	
UNF up	8/18	46	CAS	4		UNF up	8/18	100	CRP	43	191

Appendix A. (continued)

Study Site	Date	Unit #	Habitat Type	Unit Length	WP Label
UNF up	8/18	101	RUN	26	192
UNF up	8/18	102	LGR	20	
UNF up	8/18	103	RUN	10	
UNF up	8/18	104	HGR	11	193
UNF up	8/18	105	LGR	9	
UNF up	8/18	106	MCP	55	
UNF up	8/18	107	HGR	15	194
UNF up	8/18	108	PLP	8	
UNF up	8/18	109	CAS	2	
UNF up	8/18	110	MCP	64	
UNF up	8/18	111	BRS	22	
UNF up	8/18	112	LSBO	18	
UNF up	8/18	113	RUN	4	
UNF up	8/18	114	PLP	9	
UNF up	8/18	115	CAS	4	
UNF up	8/18	116	SRN	21	195

Appendix B. HSI variable values used to calculate HSI scores for each study site (note that the anadromous variables V1am, V2sm, and V18 were only used for study sites in the Lower Segment).

	Segment >	Lower				Middle			Upper			
HSI Variable & Label	Study Site >	Ven 1	Ven 2	Ven 3	Ven 4	Ven 5	LNF low	LNF mid	Mat 3	Mat 5	Mat 7	UNF up
max rearing temp	* V1 r	22.9	22	21.4	20.6	22.7	20.9	20.9	23.8	22	19.9	16.3
max adlt migration temp	* V1 am	16.3	15.4	15.4	16.7	-	-	-	-	-	-	-
max smolt migration temp	* V2 sm	17.9	16.8	16.8	17.4	-	-	-	-	-	-	-
max incubation temp	* V2 inc	17.9	16.8	16.8	17.4	16.9	15.2	15.2	14	14	13	13
min DO during rearing	V3 r	7.2	7.6	8.2	8.3	6.2	6.9	6.9	7.5	8.4	8.5	9.1
min DO during incubation	V3 inc	8.3	8.3	8.8	8.6	8.9	6.9	6.9	6.9	10	9.8	9.8
avg thalweg depth	V4	49.2	41.6	40.0	36.4	57.3	35.2	37.1	41.2	39.7	42.9	25.0
avg spawning area vel (x2)	V5	122	134	65	15	10	22	26	35	15	4	37
% instream cover-juv	V6 jv	16%	12%	20%	50%	37%	26%	23%	26%	33%	25%	16%
% instream cover-adlt	V6 ad	4%	3%	5%	3%	14%	10%	7%	7%	8%	7%	5%
avg spawning substrate size	V7	3.8	5.3	4.8	5.1	3.6	2.8	2.3	2.6	1.9	2.0	2.9
% winter substrate	V8	62%	46%	49%	83%	72%	42%	36%	69%	78%	52%	37%
avg riffle substrate type	V9	A	A	A	A	C	A	A	A	A	B	B
% pools	V10	16%	10%	12%	12%	27%	36%	50%	24%	28%	36%	31%
% vegetation	V11	78%	53%	35%	37%	70%	85%	58%	56%	39%	61%	100%
% stable banks	V12	96%	99%	99%	85%	97%	92%	95%	95%	92%	97%	89%
annual max/min pH	V13	8.6	8.5	8.2	8.2	8.5	8.5	8.5	8.6	8.3	8.3	8.4
ratio low flow/avg flow	V14	5	5	5	5	13	13	13	10	10	10	10
pool class rating	V15	B	A	B	A	A	C	C	B	C	B	B
%fines in spawning areas	V16 sp	40	14%	28%	15%	30%	28%	26%	18%	43%	52%	12%
%fines in riffles	V16 rr	9%	11%	3%	8%	4%	3%	5%	5%	7%	2%	4%
% shade	V17	5%	2%	4%	4%	19%	35%	42%	5%	8%	26%	78%
ratio migration flow/avg flow	V18	246	246	246	246	-	-	-	-	-	-	-

* temperature data for all lower, middle, and Mat 3 study sites based on Stream Team database, other temps measured during HSI sampling

Appendix C. HSI data for each sampled mesohabitat unit. HSI variable labels are shown at the bottom of the table.

	All Habitat Types									%Ground Cover/Canopy						Pools Only			FW & RF Only		Spawning Areas Only				
Study Site	Habitat Categ	Unit #	Length ft	Avg Width ft	Surface Area ft2	Thalweg Dep cm	%Juv Cover	%Adlt Cover	%Wintr Substr	Shrub	Grass	Trees	Veg Ratio	%Stable BnkCov	%OVH Shade	%Btm Obscur	Max Depth ft	Pool Class	Dom Substr	% Fines	Vel *x2* cm/s	Size cm	% Fines	Surf Area	Wt'ed Vs
Ven 1	PL	19	230	31.4	7,222	99.1	85	35	5	75	25	0	188	100	15	35	4.3	1							
		38	292	24.3	7,096	70.1	25	15	10	10	1	25	47	15	20	15	3.4	2							
		50	235	56.4	13,254	65.5	5	2	5	25	25	0	88	85	0	0	3.5	3							
		3	74	37.3	2,760	74.1	30	5	0	50	20	0	130	100	2	2	3.0	2							
	FW	11	65	18.9	1,229	49.1	15	5	65	15	40	0	90	100	1				A	10					
		25	108	28.1	3,035	47.2	20	0	98	10	1	0	22	100	0				A	1					
		39	65	14.9	969	59.7	5	2	65	15	30	0	75	100	15				A	5	121.9	3.8	40	70	40
		8	137	27.1	3,713	42.1	10	2	90	1	50	0	77	100	4				A	35					
	RF	5	42	29.3	1,231	38.1	20	10	85	10	45	0	88	100	2				A	5					
		17	78	21.0	1,638	30.2	5	2	55	15	15	0	53	100	0				A	10					
		28	67	28.6	1,916	30.5	10	0	10	45	50	0	165	100	10				A	0					
		34	66	33.1	2,185	32.0	10	0	98	2	20	0	34	100	0				A	15					
Study Site Weighted Means:						**49.2**	**16**	**4**	**63**				**79**	**96**	**5**			**B**	**A**	**9**					**0.57**
Ven 2	PL	4	149	31.6	4,708	54.6	10	1	0	10	35	0	73	100	5	15	4.0	2							
		18	236	29.5	6,962	110.0	65	20	25	10	15	0	43	85	5	95	5.6	1							
		30	113	23.6	2,667	97.8	45	30	5	10	20	0	50	100	1	65	7.2	1							
		45	272	36.1	9,819	68.3	70	15	90	0	1	0	2	90	0	95	3.7	1							
		53	95	16.4	1,558	86.3	25	5	15	0	0	0	0	100	0	35	4.9	1							
		56	91	25.4	2,311	69.5	35	2	40	50	2	0	103	90	1	15	3.6	2			152.4	3.8	15	25	0
	FW	1	83	34.3	2,843	37.5	5	2	15	2	100	1	155	100	1				B	30					
		7	89	30.8	2,737	51.2	15	2	60	1	1	0	4	100	0				A	5					
		14	97	51.0	4,947	24.1	10	0	30	1	0	0	2	95	0				A	25					
		21	66	40.8	2,690	25.6	10	0	15	0	50	0	75	100	0				A	15					
		28	65	29.0	1,885	30.2	0	0	95	5	65	0	108	98	0				A	10	152.4	6.4	10	144	0
		38	108	22.6	2,441	39.0	10	5	90	15	25	0	68	100	10				A	2					
		43	96	21.8	2,093	45.7	5	1	20	5	2	0	13	100	0				A	40	121.9	5.1	15	300	176
		50	138	27.1	3,740	48.5	10	1	0	2	1	0	6	100	0				C	0					
	RF	9	57	21.9	1,248	31.7	5	1	15	0	0	0	0	100	0				A	5					
		13	53	28.8	1,526	39.9	2	0	65	10	1	0	22	100	1				B	20					
		22	112	51.4	5,757	25.9	10	0	15	55	45	0	178	100	1				A	5					
		31	45	19.6	882	48.8	2	1	85	0	10	0	15	100	0				A	0					
		39	100	23.3	2,330	33.5	10	0	55	40	15	5	108	100	10				A	5					
		48	76	49.9	3,792	33.5	10	2	85	0	2	0	3	100	0				A	2	152.4	3.8	20	26	0
		55	57	26.3	1,499	42.1	10	5	70	0	0	0	0	90	0				A	2					
		59	58	26.4	1,531	34.7	20	5	95	45	15	0	113	100	5				A	2					
Study Site Weighted Means:						**41.6**	**12**	**3**	**46**				**53**	**99**	**2**			**A**	**A**	**11**					**0.36**
V3	PL	17	110	24.4	2,684	57.9	25	5	5	60	2	0	123	100	0	5	2.2	2							
		25	729	62.0	45,198	61.0	15	5	10	30	10	0	75	100	0	10	4.2	2							
		28	135	27.0	3,645	55.8	20	10	35	50	10	2	117	100	35	30	2.6	1							
		40	130	33.1	4,303	78.9	40	30	5	40	15	20	123	100	30	30	5.2	1							
		42	142	43.4	6,163	110.9	10	5	25	2	5	0	12	85	5	5	6.1	1							
		50	50	23.1	1,155	84.7	30	20	40	30	2	0	63	99	20	15	3.9	2			45.7	5.1	20	30	24
	FW	1	102	56.0	5,712	26.8	25	0	5	10	20	0	50	100	0				A	0					
		8	45	29.8	1,341	41.5	25	15	75	0	5	0	8	99	0				A	0					
		13	130	21.6	2,808	33.5	15	5	15	10	2	0	23	100	0				A	0					
		21	142	24.0	3,408	42.1	5	1	20	25	20	0	80	100	10				A	0					
		30	81	16.1	1,304	39.9	30	10	85	35	25	20	128	100	5				A	0					
		35	84	22.4	1,882	38.4	15	1	75	2	4	0	10	100	0				A	10					
		41	110	46.8	5,148	43.6	20	5	15	0	20	15	45	100	2				B	25					

Appendix C. (continued)

	All Habitat Types															**Pools Only**			**FW & RF Only**		**Spawning Areas Only**				
Study Site	Habitat Categ	Unit #	Length ft	Avg Width ft	Surface Area ft2	Thalweg Dep cm	%Juv Cover	%Adlt Cover	%Wintr Substr	%Ground Cover/Canopy Shrub	Grass	Trees	Veg Ratio	%Stable BnkCov	%OVH Shade	%Btm Obscur	Max Depth ft	Pool Class	Dom Substr	% Fines	Vel *x2* cm/s	Size cm	% Fines	Surf Area	Wt'ed Vs
		48	137	23.8	3,261	42.7	45	10	70	0	0	0	0	98	0				A	2	121.9	3.8	50	10	3
	RF	3	60	37.0	2,220	32.9	15	0	5	1	2	0	5	100	0				A	0					
		10	66	25.3	1,667	27.4	5	0	30	0	0	0	0	98	0				A	0					
		18	80	23.3	1,864	39.9	15	1	85	0	0	0	0	100	0				A	0					
		23	67	17.4	1,166	30.2	5	1	95	0	0	0	0	100	0				A	0					
		29	61	21.9	1,336	20.1	10	0	80	0	30	0	45	100	0				A	1					
		34	48	29.3	1,404	27.7	20	10	90	5	15	0	33	100	2				A	5					
		45	35	10.4	364	33.5	0	0	85	0	15	0	23	100	10				A	0					
		47	52	23.4	1,217	27.4	45	0	50	0	0	0	0	100	0				A	0					
Study Site Weighted Means:						**40.0**	**20**	**5**	**49**				**35**	**99**	**3**			**B**	**A**	**3**					**0.67**
Ven 4	PL	1	111	28.5	3,164	49.7	40	25	65	0	0	0	0	65	0	15	2.8	2			0.6	1.9	60	70	16
		17	212	54.8	11,618	103.3	35	10	35	1	0	5	7	80	0	25	10.3	1			12.2	5.1	15	1,881	1,083
		23	118	36.6	4,319	110.0	55	2	65	45	0	10	100	70	0	2	6.1	2			0.0	6.4	1	240	152
		34	133	38.3	5,087	45.1	50	1	55	92	15	0	207	90	2	2	2.3	2			121.9	5.1	80	12	3
	FW	5	44	45.5	2,002	40.8	60	2	80	0	0	0	0	95	5				A	10	0.0	5.1	5	60	38
		15	89	48.5	4,317	33.8	70	1	90	0	0	2	2	65	5				A						
		30	39	16.0	624	29.9	35	1	85	70	0	0	140	85	5				A	10					
		39	48	58.8	2,820	33.2	65	2	80	5	0	0	10	95	5				A	15					
	RF	3	79	12.8	1,007	22.3	20	5	98	0	0	0	0	100	0				A	2					
		8	67	31.8	2,127	26.2	65	2	95	0	0	0	0	85	0				A	5					
		14	59	35.0	2,065	24.4	40	2	95	0	2	0	3	70	2				A	0					
		24	48	25.5	1,224	18.0	10	0	90	20	15	0	63	100	10				C	2	182.9	3.8	25	50	0
Study Site Weighted Means:						**36.4**	**50**	**3**	**83**				**37**	**85**	**4**			**A**	**A**	**8**					**0.56**
Ven 5	PL	5	150	50.8	7,613	141.1	50	35	45	5	10	90	115	95	40	50	6.6	1			6.1	5.1	20	56	28
		-																			6.1	2.5	40	55	19
		14	52	36.6	1,903	56.1	45	20	60	5	10	100	125	95	65	55	3.3	1							
		24	49	26.9	1,318	67.4	45	20	30	0	0	5	5	100	0	15	3.8	2							
		39	81	39.0	3,159	56.4	70	20	70	5	35	80	143	90	20	30	2.5	1							
		42	157	35.5	5,574	84.7	80	30	45	0	10	100	115	70	55	40	4.0	1							
		44	57	24.0	1,368	68.9	50	35	95	0	35	60	113	100	80	55	4.6	1							
		53	73	31.8	2,318	64.0	65	30	60	5	15	10	43	85	2	5	3.6	2							
		58	48	26.8	1,284	62.8	60	30	75	0	2	5	8	85	0	20	3.6	2			30.5	2.5	30	20	12
	FW	3	46	15.6	718	51.2	20	10	90	0	2	50	53	100	25				A	2					
		9	47	37.3	1,751	42.1	20	5	90	0	10	15	30	100	5				A	1					
		15	64	28.5	1,824	50.0	60	25	90	0	5	95	103	100	40				C	10					
		21	91	48.3	4,391	30.8	50	10	30	2	20	45	79	100	5				B	25					
		30	43	26.9	1,157	48.2	10	0	90	0	20	50	80	90	2				A	2					
		36	50	27.9	1,395	48.5	60	15	75	0	5	50	58	100	20				C	5					
		45	74	19.9	1,473	64.3	15	2	4	0	2	50	53	100	10				C	5					
		50	46	31.3	1,438	86.6	50	15	70	1	20	0	0	100	5				C	5					
	RF	2	43	11.5	495	63.4	10	5	90	0	5	25	33	100	10				C	0					
		18	29	13.4	389	43.6	15	5	98	1	2	45	50	100	5				C	0					
		27	34	38.8	1,319	29.0	15	2	85	5	50	10	95	100	2				A	5					
		31	36	29.8	1,073	45.7	25	15	90	50	15	2	125	100	2				C	0					
		37	24	24.7	593	37.2	30	10	85	1	5	50	60	100	30				A	2					
		43	24	23.5	564	61.0	15	5	90	0	1	80	82	100	35				C	0					
		46	34	30.6	1,040	43.9	15	2	90	2	10	10	29	100	5				C	5					
		55	31	23.9	741	55.2	20	10	90	20	10	50	105	100	10				C	1					
Study Site Weighted Means:						**57.3**	**37**	**14**	**72**				**70**	**97**	**19**			**A**	**C**	**4**					**0.45**

Appendix C. (continued)

	All Habitat Types															Pools Only			FW & RF Only		Spawning Areas Only				
Study Site	Habitat Categ	Unit #	Length ft	Avg Width ft	Surface Area ft2	Thalweg Dep cm	%Juv Cover	%Adlt Cover	%Wintr Substr	%Ground Cover/Canopy Shrub	Grass	Trees	Veg Ratio	%Stable BnkCov	%OVH Shade	%Btm Obscur	Max Depth ft	Pool Class	Dom Substr	% Fines	Vel *x2* cm/s	Size cm	% Fines	Surf Area	Wt'ed Vs
LNF low	PL	10	40	14.2	568	48.5	70	10	25	10	0	35	55	30	15	0	2.0	3			30.5	3.8	10	25	25
		16	75	12.3	923	33.2	60	25	30	1	0	90	92	80	60	2	2.0	3							
		37	26	12.5	325	40.8	25	10	35	15	1	95	127	98	55	10	1.8	2							
		46	26	19.6	510	56.7	55	50	40	0	0	100	100	92	85	15	3.0	2							
		58	70	17.3	1,211	64.9	30	20	20	5	1	100	112	99	15	5	3.9	2			0.0	2.5	35	68	24
		62	46	15.6	718	42.4	20	5	50	0	0	75	75	90	30	2	2.0	3			0.0	3.8	20	20	10
		70	20	14.0	280	41.1	20	10	35	0	0	95	95	98	55	2	2.6	3							
		74	43	11.1	477	66.8	10	5	40	0	0	65	65	100	50	1	3.2	3			6.1	1.9	60	40	9
	FW	4	38	19.1	726	29.3	10	2	20	10	0	50	70	85	15				A	10	76.2	2.5	ɜmented	20	13
		-																			61.0	1.3	50	16	7
		9	22	14.0	308	25.9	55	5	25	0	0	1	1	65	0				A	5					
		22	41	12.0	492	36.3	20	15	35	10	0	55	75	98	50				C	1					
		28	41	15.9	652	32.0	40	30	60	0	2	22	25	98	15				C	5					
		43	33	5.6	185	29.0	5	1	30	5	2	100	113	99	65				A	0					
		45	40	23.2	928	32.9	60	20	25	0	1	100	102	90	70				A	20					
		51	32	11.6	371	25.3	5	2	45	5	20	45	85	95	5				A	5					
		83	29	15.9	461	29.0	20	5	80	10	0	100	1	100	45				C	0					
	RF	3	23	19.2	442	19.2	15	1	35	0	0	85	85	95	2				A	15					
		8	23	9.6	221	23.5	20	2	50	0	0	50	50	98	0				A	2					
		20	31	9.5	295	21.6	10	2	30	5	1	50	62	98	20				C	1					
		24	25	17.7	443	19.2	5	0	45	50	10	45	160	95	5				A	5					
		34	43	7.2	310	34.4	20	10	30	50	2	65	168	98	40				A	2					
		44	25	16.0	400	27.7	15	0	60	2	0	55	59	99	35				A	1					
		63	21	11.7	246	32.3	15	2	85	0	1	80	82	99	65				C	1					
		81	29	15.4	447	21.3	15	2	70	0	0	50	50	100	40				A	2					
Study Site Weighted Means:						**35.2**	**26**	**10**	**42**				**85**	**92**	**35**			**C**	**A**	**3**					**0.47**
LNF mid	PL	1	38	12.4	471	64.9	10	2	15	2	1	5	11	95	10	2	2.5	3			30.5	1.9	15	25	23
		12	44	13.9	612	37.8	35	2	10	0	0	100	100	100	90	2	2.2	3			30.5	1.3	40	36	19
		-																			12.2	6.4	30	24	8
		-																			12.2	3.2	15	12	7
		-																			30.5	3.8	35	20	11
		14	23	12.6	290	38.1	25	5	45	7	1	25	41	95	70	10	2.3	2							
		30	25	8.7	218	45.7	25	2	15	0	0	35	35	100	25	5	2.3	2			36.6	2.5	30	32	19
		36	23	11.2	258	58.8	50	35	50	0	0	5	5	100	15	10	3.5	2							
		40	25	12.4	310	39.9	20	5	20	0	0	50	50	95	25	5	2.3	2							
		48	23	12.2	281	46.9	20	2	25	1	1	15	19	75	15	1	1.9	3			6.1	1.3	40	15	5
		53	62	11.6	719	41.5	20	5	30	25	1	20	72	95	50	1	2.5	3			6.1	1.3	15	32	18
	FW	6	52	13.1	681	26.8	20	5	40	0	2	65	68	92	45				B	25	15.2	2.5	30	30	14
		13	28	11.3	316	26.2	10	1	30	0	1	85	87	85	80				A	15	91.4	1.3	0	12	7
		27	35	7.1	249	29.3	10	0	5	0	1	75	77	100	35				C	2					
		44	26	15.7	408	36.0	65	25	85	0	10	50	65	100	50				C	2					
		57	27	10.5	284	31.4	20	5	25	0	1	30	32	100	50				B	25	30.5	1.3	25	45	28
		67	25	10.4	260	32.9	15	5	25	2	2	50	57	99	35				A	15					
		77	26	11.2	291	39.3	30	10	40	10	0	50	70	98	10				A	5					
		87	21	9.6	202	14.9	25	5	65	0	1	55	57	80	85				A	5					
	RF	2	35	9.2	322	21.6	5	0	40	75	0	55	205	100	85				C	1					
		21	25	9.7	243	37.5	25	15	65	0	2	10	13	100	5				C	5					
		46	35	7.9	277	16.5	10	0	25	1	30	85	132	100	35				A	2	73.2	6.4	0	90	78
		52	29	7.6	220	23.2	5	0	80	50	0	10	110	100	15				A	0					

Appendix C. (continued)

	All Habitat Types															Pools Only			FW & RF Only		Spawning Areas Only				
										%Ground Cover/Canopy															
Study Site	Habitat Categ	Unit #	Length ft	Avg Width ft	Surface Area ft2	Thalweg Dep cm	%Juv Cover	%Adlt Cover	%Wintr Substr	Shrub	Grass	Trees	Veg Ratio	%Stable BnkCov	%OVH Shade	%Btm Obscur	Max Depth ft	Pool Class	Dom Substr	% Fines	Vel x2 cm/s	Size cm	% Fines	Surf Area	Wt'ed Vs
		54	27	10.5	284	17.7	10	1	75	0	1	50	52	98	55				A	1					
		79	32	20.1	643	22.9	25	5	15	40	2	15	98	100	25				A	10					
		81	23	11.3	260	14.9	10	0	80	0	0	100	100	95	95				A	1					
		84	29	15.7	455	25.3	5	0	85	0	1	75	77	90	5				A	2					
Study Site Weighted Means:						**37.1**	**23**	**6**	**36**				**58**	**95**	**42**			**C**	**A**	**5**					**0.64**
MAT 3	PL	3	94	36.8	3,459	36.9	15	5	50	50	0	50	150	100	5	5	2.2	2			30.5	3.8	10	110	108
		5	86	31.9	2,743	55.2	10	2	55	50	5	20	128	100	2	5	2.4	2							
		11	37	17.5	648	49.7	25	15	25	0	0	0	0	100	0	25	2.4	2							
		14	32	21.1	675	61.3	45	30	15	0	0	0	0	100	0	40	2.9	1							
		27	36	35.4	1,274	39.9	50	1	65	0	0	55	55	90	10	0	2.3	3			61.0	1.3	35	36	20
		33	116	39.5	4,582	50.6	40	5	70	45	0	0	90	95	0	2	2.7	3			61.0	5.1	5	28	28
		35	56	23.9	1,338	49.7	65	20	65	5	0	0	10	99	0	15	3.4	2			0.0	1.3	20	15	7
		41	17	24.7	420	82.9	40	35	85	0	0	0	0	100	0	10	4.2	2							
	FW	9	29	27.6	800	36.9	20	5	75	0	0	0	0	100	0				A	10					
		10	48	21.4	1,027	49.7	30	5	70	0	0	0	0	100	0				A	10					
		24	45	47.9	2,156	32.0	35	5	70	0	10	100	115	95	10				A	5	30.5	1.9	15	33	30
		-																			30.5	1.9	15	35	32
		25	61	40.4	2,463	27.1	15	2	60	25	20	60	140	60	25				B	20	76.2	2.5	5	16	14
		32	73	69.9	5,103	29.0	30	0	30	70	0	50	190	85	0				A	1					
		37	33	28.8	950	38.1	10	5	50	0	0	0	0	100	0				C	5					
		48	94	20.3	1,908	55.2	35	15	90	0	0	15	15	100	10				A	2					
		49	26	18.4	478	48.5	35	10	90	0	0	50	50	100	10				C	1					
	RF	1	68	40.6	2,761	27.4	20	0	90	35	0	2	72	98	0				A	10					
		6	81	35.9	2,908	27.7	10	1	90	10	2	20	43	100	1				A	1					
		15	23	16.8	386	24.4	10	0	95	0	0	0	0	100	0				A	2					
		21	47	23.5	1,105	22.9	5	0	98	0	1	15	17	100	0				A	5					
		23	83	50.5	4,192	22.6	20	5	80	2	50	45	124	99	0				A	2	12.2	1.3	25	35	13
		-																			30.5	1.3	60	20	7
		40	25	27.5	688	42.1	15	10	100	0	0	0	0	100	0				C	1					
		51	62	38.4	2,381	53.3	10	2	100	0	0	0	0	100	15				A	5					
Study Site Weighted Means:						**41.2**	**26**	**7**	**69**				**56**	**95**	**5**			**B**	**A**	**5**					**0.79**
MAT 5	PL	1	339	41.3	14,001	54.9	40	5	60	45	1	1	93	95	2	2	3.4	3			6.1	2.5	40	72	24
		-																			6.1	1.3	80	120	28
		-																			6.1	1.9	80	104	24
		4	14	18.3	256	28.3	40	5	85	1	0	0	2	100	0	30	1.9	2							
		18	37	42.5	1,573	39.0	65	5	35	0	0	0	0	45	0	2	2.0	3			15.2	3.8	15	50	37
		-																			0.0	1.3	35	80	28
		25	38	27.6	1,049	65.5	85	35	60	5	0	0	10	100	1	5	3.1	2							
		28	39	24.9	971	46.6	35	15	90	0	0	0	0	100	0	10	2.0	2							
		32	53	35.0	1,855	61.3	70	60	75	0	0	0	0	98	2	15	2.7	2			6.1	2.5	50	16	5
		43	40	33.8	1,352	47.5	40	10	60	2	0	100	104	100	20	15	3.6	2							
		45	20	28.0	560	53.0	50	15	45	30	0	100	160	100	25	30	2.4	1							
	FW	2	100	35.3	3,530	27.1	50	5	70	2	0	5	9	95	5				A	20					
		17	45	30.5	1,373	48.2	55	1	90	0	0	0	0	50	0				A	25	30.5	1.3	40	35	19
		-																			0.0	2.5	30	55	20
		26	94	22.0	2,068	36.9	45	5	70	0	0	0	0	90	0				A	15					
		36	50	30.5	1,525	39.0	30	2	95	15	0	0	30	100	0				A	5					
		46	42	23.0	966	41.1	10	2	70	35	0	100	170	100	25				A	5					
		53	42	18.3	769	52.1	25	10	95	0	0	50	50	95	20				A	2					

Appendix C. (continued)

	All Habitat Types															Pools Only			FW & RF Only		Spawning Areas Only				
Study	Habitat	Unit	Length	Avg	Surface	Thalweg	%Juv	%Adlt	%Wintr	%Ground Cover/Canopy			Veg	%Stable	%OVH	%Btm	Max	Pool	Dom	%	Vel x2	Size	%	Surf	Wt'ed
Site	Categ	#	ft	Width ft	Area ft2	Dep cm	Cover	Cover	Substr	Shrub	Grass	Trees	Ratio	BnkCov	Shade	Obscur	Depth ft	Class	Substr	Fines	cm/s	cm	Fines	Area	Vs
		62	29	18.4	534	33.5	5	0	85	35	0	50	120	100	40				A	2					
		64	69	20.9	1,442	38.1	35	15	90	2	0	0	4	100	5				A	5					
	RF	3	20	29.3	586	28.3	10	2	65	0	0	2	2	95	2				A	10	30.5	1.3	30	48	28
		7	55	35.4	1,947	18.6	5	2	90	0	0	0	0	100	0				A	5					
		8	37	59.8	2,213	20.7	20	2	85	2	0	2	6	95	2				A	10	30.5	1.9	30	38	22
		-																			30.5	1.3	10	45	44
		12	22	33.8	744	23.8	5	1	85	2	0	0	4	100	0				A	10	30.5	2.5	20	42	33
		14	80	49.6	3,968	29.3	5	0	90	15	0	1	31	80	0				A	25	0.0	1.3	20	30	15
		20	30	26.8	804	32.0	25	10	65	0	0	0	0	95	0				A	5	73.2	1.3	20	35	24
		30	41	26.6	1,091	35.1	2	0	98	0	0	0	0	100	0				A	5					
		35	25	46.2	1,155	23.8	0	0	100	5	0	0	10	100	0				A	2					
Study Site Weighted Means:						**39.7**	**33**	**8**	**78**				**39**	**92**	**8**			**C**	**A**	**7**					**0.46**
MAT 7	PL	10	125	20.4	2,548	67.4	65	15	60	2	2	50	57	90	30	15	4.6	2			0.0	1.3	55	90	25
		20	35	13.3	466	61.3	45	15	55	10	1	45	67	100	15	10	2.8	2							
		28	33	17.0	561	89.9	55	25	30	1	1	15	19	100	5	20	5.6	2							
		40	39	19.6	764	49.1	10	5	5	0	2	55	58	98	40	2	2.9	3							
		48	29	30.8	893	54.6	50	25	50	10	0	95	115	100	25	15	4.6	2			0.0	3.8	5	40	25
		58	47	14.6	686	36.3	35	10	5	2	0	22	26	98	15	15	2.0	2			12.2	2.5	25	45	18
		73	51	14.0	714	48.5	65	20	80	35	0	15	85	85	25	65	2.3	1							
		80	126	25.3	3,188	60.7	40	20	25	10	40	35	115	100	25	15	4.6	2			6.1	1.9	65	186	44
		xx	103	27.6	2,843	150.3	25	15	15	25	15	55	128	95	50	55	9.9	1							
	FW	3	41	30.6	1,255	26.2	20	1	90	0	0	50	50	85	15				A	2					
		14	42	19.0	798	39.9	23	3	94	1	0	58	60	100	43				B	6	0.0	1.3	65	20	5
		19	62	14.8	918	33.8	15	2	70	2	1	30	36	100	2				A	15					
		31	26	13.3	346	19.8	15	0	15	2	0	0	4	99	1				C	2					
		39	24	14.7	353	43.3	30	2	30	0	0	40	40	100	5				C	2					
		61	50	14.3	713	34.4	45	5	5	1	1	55	59	92	60				C	20					
		68	78	11.0	858	41.1	10	1	90	20	1	60	102	99	85				A	2					
		70	34	8.8	299	24.7	10	0	85	0	0	0	0	100	0				C	1					
	RF	2	59	34.0	2,006	21.0	15	0	85	0	0	35	35	90	10				A	5					
		11	29	21.6	626	30.8	18	0	75	0	0	85	85	100	96				A	2					
		36	24	11.8	283	44.2	15	2	50	10	0	50	70	99	2				C	1					
		49	21	16.8	353	30.5	5	1	90	0	2	100	103	100	30				A	1					
		52	44	14.1	620	22.6	2	0	10	2	0	10	14	100	20				C	0					
		78	35	10.8	378	27.7	10	5	85	0	20	50	80	100	2				C	0					
		79	35	22.9	802	18.3	20	1	30	0	0	50	50	99	55				A	2					
		82	80	18.0	1,440	19.5	15	0	70	2	1	5	11	100	2				A	2					
Study Site Weighted Means:						**42.9**	**25**	**7**	**52**				**60**	**97**	**26**			**B**	**B**	**2**					**0.30**
UNF up	PL	14	17	9.3	158	20.1	20	0	15	25	0	50	100	50	30	15	1.1	2			45.7	2.5	10	24	24
		33	16	8.6	138	34.7	15	2	20	0	0	95	95	98	80	35	1.5	1							
		43	11	9.6	106	37.5	25	15	75	0	2	100	103	85	90	40	1.8	1							
		51	10	15.6	156	29.6	35	15	20	0	10	100	115	95	95	10	2.0	2							
		65	21	12.5	263	46.9	30	15	10	0	0	100	100	98	95	20	2.4	2							
		74	36	11.3	407	36.6	35	10	60	0	0	100	100	92	85	10	2.2	2			15.2	3.8	15	10	7
		79	18	15.5	279	38.7	25	15	15	45	0	100	190	100	40	50	2.3	1							
		94	26	13.6	354	49.1	20	10	2	2	0	95	99	80	92	5	2.5	2							
	FW	19	33	8.9	294	22.6	40	5	55	0	0	100	100	95	99				C	20					
		40	24	6.0	144	19.2	5	2	35	30	0	80	140	99	80				C	2					
		47	21	10.0	210	29.9	75	20	40	1	0	100	102	98	95				A	20					

Appendix C. (continued) x

	All Habitat Types															Pools Only			FW & RF Only		Spawning Areas Only				
Study Site	Habitat Categ	Unit #	Length ft	Avg Width ft	Surface Area ft2	Thalweg Dep cm	%Juv Cover	%Adlt Cover	%Wintr Substr	%Ground Cover/Canopy Shrub	Grass	Trees	Veg Ratio	%Stable BnkCov	%OVH Shade	%Btm Obscur	Max Depth ft	Pool Class	Dom Substr	% Fines	Vel x2 cm/s	Size cm	% Fines	Surf Area	Wt'ed Vs
		58	35	14.9	522	18.3	10	0	20	0	0	50	50	90	95				A	15					
		66	31	7.6	236	17.7	10	1	25	12	0	50	74	100	50				C	0					
		84	26	8.9	231	21.0	15	2	10	50	0	85	185	65	70				C	5					
		91	22	8.7	191	21.0	10	0	10	0	0	100	100	98	98				C	15					
		116	21	10.8	227	13.7	2	0	0	2	1	100	106	100	90				C	2					
		101	26	9.7	252	18.0	2	0	5	0	0	100	100	98	98				C	0					
	RF	13	22	8.1	178	18.3	15	2	80	15	0	20	50	90	5				A	5					
		32	49	7.0	343	21.3	10	0	85	1	0	100	102	85	98				A	10					
		54	31	9.1	282	27.4	5	1	45	0	0	100	100	95	65				A	2					
		71	34	13.5	459	7.9	0	0	2	5	1	65	77	50	55				C	10					
		85	19	9.1	173	18.6	5	1	65	0	0	100	100	98	90				A	2					
		99	24	10.8	259	28.3	5	5	15	0	0	100	100	90	99				C	2					
		104	21	8.0	168	16.5	2	0	65	0	0	100	100	100	95				A	1					
		107	23	6.8	156	17.7	10	5	70	0	15	90	113	99	95				C	1					
Study Site Weighted Means:						**25.0**	**15**	**5**	**37**				**102**	**89**	**78**			**B**	**B**	**4**					**0.91**
						V4	***V6 j***	***V6 a***	***V8***				***V11***	***V12***	***V17***			***V15***	***V9***	***V16rr***	***V5***	***V7***	***V16 sp***		

Appendix D. Fish observation and capture data for each sampled mesohabitat unit. Unit-specific estimates of abundance for dive count units (DO) are only presented for units with multiple counts; estimated variances are only presented for electrofished (EF) units.

Study Site	Habitat Category	Sampling Method	Size Class	Unit #	Sampling Pass #					Abund Est (y)	Var (y)
					1	2	3	4	5		
Ven 1	Pools	DO	Fry	19	0	0	0			0	-
				38	0	0	0			0	-
				50	0	0	0			0	-
				3	0					-	-
			Juv+	19	0	0	0			0	-
				38	0	0	0			0	-
				50	0	0	0			0	-
				3	0					-	-
	Flatwaters	DO	Fry	11	0	0	0			0	-
				25	0	0	0			0	-
				39	0	0	0			0	-
				4	0					-	-
			Juv+	11	0	0	0			0	-
				25	0	0	0			0	-
				39	0	0	0			0	-
				4	0					-	-
	Riffles	EF	Fry	5	0	0				0	0
				17	0	0				0	0
				28	0	0				0	0
				34	0	0				0	0
			Juv+	5	0	0				0	0
				17	0	0				0	0
				28	0	0				0	0
				34	0	0				0	0
Ven 2	Pools	DO	Fry	4	0	0	0			0	-
				18	0	0	0			0	-
				45	0	0	0			0	-
				56	0	0	0			0	-
				30	0					-	-
				53	0					-	-
			Juv+	4	0	0	0			0	-
				18	0	0	0			0	-
				45	0	0	0			0	-
				56	0	0	0			0	-
				30	0					-	-
				53	0					-	-
	Flatwaters	DO	Fry	1	0	0	0			0	-
				14	0	0	0			0	-
				28	0	0	0			0	-
				43	0	0	0			0	-
				7	0					-	-
				21	0					-	-
				38	0					-	-
				50	0					-	-
			Juv+	1	0	0	0			0	-
				14	0	0	0			0	-
				28	0	0	0			0	-
				43	0	0	0			0	-
				7	0					-	-
				21	0					-	-
				38	0					-	-
				50	0					-	-

Appendix D. (continued)

Study Site	Habitat Category	Sampling Method	Size Class	Unit #	Sampling Pass #					Abund Est (y)	Var (y)
					1	2	3	4	5		
	Riffles	EF	Fry	9	0	0				0	0
				13	0	1	0			1	0
				22	0	0				0	0
				31	0	0				0	0
				39	0	0				0	0
				48	0	0				0	0
				55	0	0				0	0
				59	0	0	0			0	0
			Juv+	9	0	0				0	0
				13	0	0	0			0	0
				22	0	0				0	0
				31	0	0				0	0
				39	0	0				0	0
				48	0	0				0	0
				55	0	0				0	0
				59	1	0	0			1	0
Ven 3	Pools	DO	Fry	25	0	0	0			0	-
				28	0	0	0			0	-
				42	0	0	0	0		0	-
				50	0	0	0			0	-
				17	0					-	-
				40	0					-	-
			Juv+	25	0	0	0			0	-
				28	0	0	0			0	-
				42	4	5	6	6		6	-
				50	0	0	0			0	-
				17	0					-	-
				40	0					-	-
	Flatwaters	DO	Fry	1	0	0	0			0	-
				8	0	0	0			0	-
				21	0	0	0			0	-
				35	0	0	0			0	-
				48	0					-	-
				13	0					-	-
				30	0					-	-
				41	0					-	-
			Juv+	1	0	0	0			0	-
				8	0	0	0			0	-
				21	0	0	0			0	-
				35	0	0	0			0	-
				48	0					-	-
				13	0					-	-
				30	0					-	-
				41	0					-	-
	Riffles	EF	Fry	3	0	0				0	0
				10	0	0				0	0
				18	0	0				0	0
				23	0	0				0	0
				29	0	0				0	0
				34	0	0				0	0
				45	0	0				0	0
				47	0	0				0	0

Appendix D. (continued)

Study	Habitat	Sampling	Size	Unit		Sampling Pass #			Abund	
Site	Category	Method	Class	#	1	2	3	4	5	Est (y)	Var (y)
			Juv+	3	0	0				0	0
				10	0	0				0	0
				18	0	0				0	0
				23	0	0				0	0
				29	0	0				0	0
				34	0	0				0	0
				45	0	0				0	0
				47	0	0				0	0
Ven 4	Pools	DO	Fry	1	0	0	0			0	-
				17	0	0	0			0	-
				23	0	0	0			0	-
				34	0	0	0			0	-
			Juv+	1	0	0	0			0	-
				17	0	0	0			0	-
				23	0	0	0			0	-
				34	0	0	0			0	-
	Flatwaters	DO	Fry	5	0	0	0			0	-
				15	0	0	0			0	-
				30	0	0	0			0	-
				39	0	0	0			0	-
			Juv+	5	0	0	0			0	-
				15	0	0	0			0	-
				30	0	0	0			0	-
				39	0	0	0			0	-
	Riffles	EF	Fry	3	0	0				0	0
				8	0	0				0	0
				14	0	0				0	0
				24	0	0				0	0
			Juv+	3	0	0				0	0
				8	0	0				0	0
				14	0	0				0	0
				24	0	0				0	0
Ven 5	Pools	DO	Fry	14	0	2	2	2		2	-
				39	0	0	0	0		0	-
				42	5	12	8	10		19	-
				58	2	1	3	3		3	-
				53	1	0	0	0		2	-
				5	0					-	-
				24	0					-	-
				44	0					-	-
			Juv+	14	2	1	3	3		3	-
				39	1	1	1	1		1	-
				42	5	7	8	10		15	-
				58	8	8	4	6		10	-
				53	1	0	0	0		2	-
				5	5					-	-
				24	2					-	-
				44	3					-	-
	Flatwaters	DO	Fry	15	0	2	1	2		2	-
				21	4	4	4	4		4	-
				36	3	3	2	3		3	-
				45	0	2	2	2		2	-
				50	0	1	1	2		3	-
				3	1					-	-
				9	2					-	-
				30	3					-	-

Appendix D. (continued)

Study	Habitat	Sampling	Size	Unit	Sampling Pass #					Abund	
Site	Category	Method	Class	#	1	2	3	4	5	Est (y)	Var (y)
			Juv+	15	0	0	1	3		9	-
				21	0	0	1	0		3	-
				36	0	0	0	1		3	-
				45	4	3	2	1		9	-
				50	2	3	2	3		5	-
				3	0					-	-
				9	0					-	-
				30	0					-	-
	Riffles	EF	Fry	2	0	0	0	0		0	0
				18	2	0	0			2	0
				27	0	2	0	0		2	0
				31	1	0	0	1	1	7	20
				37	0	0	0			0	0
				43	0	3	0			3	0
				46	0	0	0			0	0
				55	0	0				0	0
			Juv+	2	0	1	1	0		2	0
				18	1	0	0			1	0
				27	0	0	1	1		3	12
				31	2	1	1	0	0	4	0
				37	1	0	0			1	0
				43	4	0	0			4	0
				46	2	0	0			2	0
				55	0	0				0	0
LNF low	Pools	DO	Fry	10	1	0	0	1		2	-
				37	0	0	0	0		0	-
				16	2	0	0	0		4	-
				74	0	0	0	0		0	-
				58	0	0	0	0		0	-
				46	0					-	-
				70	0					-	-
				62	0					-	-
			Juv+	10	0	0	0	0		1	-
				37	2	1	1	0		3	-
				16	1	3	3	4		5	-
				74	0	0	0	0		0	-
				58	0	0	0	0		0	-
				46	1					-	-
				70	1					-	-
				62	1					-	-
	Flatwaters	EF	Fry	4	1	2	0	0		3	0
				9	0	0				0	0
				22	1	0	0			1	0
				28	4	0	0			4	0
				43	2	0	0			2	0
				45	0	0				0	0
				51	1	1	0			2	0
				83	0	0	0			0	0
			Juv+	4	2	0	0	0		2	0
				9	0	0				0	0
				22	4	0	0			4	0
				28	5	0	0			5	0
				43	1	0	0			1	0
				45	0	0				0	0
				51	0	0	0			0	0
				83	1	1	0			2	0

Appendix D. (continued)

Study Site	Habitat Category	Sampling Method	Size Class	Unit #	Sampling Pass # 1	2	3	4	5	Abund Est (y)	Var (y)
	Riffles	EF	Fry	3	0	0				0	0
				8	1	0	0			1	0
				20	0	1	0	0		1	0
				24	2	0	0			2	0
				34	5	0	0	0		5	0
				44	4	1	0			5	0
				63	1	0	0			1	0
				81	0	0				0	0
			Juv+	3	0	0				0	0
				8	1	0	0			1	0
				20	1	0	0	0		1	0
				24	0	0	0			0	0
				34	0	1	0	0		1	0
				44	0	0	0			0	0
				63	0	0	0			0	0
				81	0	0				0	0
LNF mid	Pools	DO	Fry	12	3	3	3	3		3	-
				14	1	1	1	1		1	-
				30	0	0	0	0		0	-
				36	0	0	0	0		0	-
				53	3	1	1	1		5	-
				40	0					-	-
				48	0					-	-
				1	0					-	-
			Juv+	12	1	1	1	1		1	-
				14	3	3	2	0		3	-
				30	3	3	3	3		3	-
				36	4	2	1	1		6	-
				53	1	1	1	1		1	-
				40	3					-	-
				48	1					-	-
				1	1					-	-
	Flatwaters	EF	Fry	6	4	0	1	1		6	12
				13	4	0	0			4	0
				27	5	0	0			5	0
				44	2	1	1	0		4	0
				57	0	1	0	0		1	0
				67	1	0	0			1	0
				77	0	0				0	0
				87	1	0	0			1	0
			Juv+	6	4	0	0	0		4	0
				13	0	0	0			0	0
				27	1	2	0			3	0
				44	5	0	0	0		5	0
				57	3	0	0	0		3	0
				67	3	0	0			3	0
				77	0	0				0	0
				87	2	0	0			2	0
	Riffles	EF	Fry	2	2	0	1	0		3	0
				21	6	1	1	1		10	12
				46	1	0	0			1	0
				52	0	2	0			2	0
				54	2	0	0			2	0
				79	4	3	1			9	6
				81	0	0	0	0		0	0
				84	2	0	0			2	0

Appendix D. (continued)

Study	Habitat	Sampling	Size	Unit	Sampling Pass #					Abund	
Site	Category	Method	Class	#	1	2	3	4	5	Est (y)	Var (y)
			Juv+	2	1	0	0	0		1	0
				21	11	0	0	0		11	0
				46	2	0	0			2	0
				52	0	0	0			0	0
				54	0	0	0			0	0
				79	3	0	0			3	0
				81	1	2	0	0		3	0
				84	3	0	0			3	0
Mat 3	Pools	DO	Fry	3	0	2	2	2		2	-
				5	0	0	0	0		0	-
				27	0	0	0			0	-
				35	1	1	0	0		1	-
				41	0	0	0	0		0	-
				11	0					-	-
				14	0					-	-
				33	0					-	-
			Juv+	3	12	10	11	10		13	-
				5	0	1	1	1		1	-
				27	0	0	0			0	-
				35	3	3	2	2		3	-
				41	3	4	4	4		4	-
				11	2					-	-
				14	1					-	-
				33	0					-	-
	Flatwaters	EF	Fry	9	0	0				0	0
				10	0	0				0	0
				24	0	0				0	0
				25	0	0				0	0
				32	0	0				0	0
				37	1	0	1	0		2	0
				48	0	0	0			0	0
				49	1	0	0			1	0
			Juv+	9	0	0				0	0
				10	0	0				0	0
				24	0	0				0	0
				25	0	0				0	0
				32	0	0				0	0
				37	2	1	0	0		3	0
				48	2	2	0			4	0
				49	5	2	0			7	0
	Riffles	EF	Fry	1	0	2	1	0		3	0
				6	0	1	0			1	0
				15	0	0	0			0	0
				21	0	0				0	0
				23	0	0				0	0
				40	1	1	0			2	0
				45	2	1	0			3	0
				51	1	0	0			1	0
			Juv+	1	0	0	0	0		0	0
				6	2	0	0			2	0
				15	1	0	0			1	0
				21	0	0				0	0
				23	0	0				0	0
				40	3	1	0			4	0
				45	0	0	0			0	0
				51	6	0	0			6	0

Appendix D. (continued)

Study Site	Habitat Category	Sampling Method	Size Class	Unit #	Sampling Pass #					Abund Est (y)	Var (y)
					1	2	3	4	5		
Mat 5	Pools	DO	Fry	1	0	1	1	0		1	-
				16	0	0	0			0	-
				25	0	0	0	0		0	-
				32	1	3	1	2		4	-
				43	0	0	1	0		2	-
				45	0	0	1	1		1	-
				4	1					-	-
				18	0					-	-
				28	0					-	-
			Juv+	1	11	7	9	7		13	-
				16	0	0	0			0	-
				25	1	1	1	1		1	-
				32	1	1	1	1		1	-
				43	4	0	0	0		8	-
				45	2	0	0	0		4	-
				4	3					-	-
				18	0					-	-
				28	3					-	-
	Flatwaters	EF	Fry	2	4	2	0	0		6	0
				17	0	0				0	0
				26	1	0				1	0
				36	2	0	1	0		3	0
				46	5	0	1	0		6	0
				53	1	1	0	0		2	0
				62	3	0	0			3	0
				64	4	1	0	0		5	0
			Juv+	2	3	1	1	0		5	0
				17	0	0				0	0
				26	2	0				2	0
				36	8	2	0	0		10	0
				46	5	0	0	0		5	0
				53	8	2	2	0		12	0
				62	1	0	0			1	0
				64	18	1	1	0		20	0
	Riffles	EF	Fry	3	3	0	0			3	0
				7	5	2	1			8	6
				8	1	0				1	0
				12	2	1	0	0		3	0
				14	5	1	0			6	0
				20	5	1	0			6	0
				30	14	7	1			22	6
				35	7	0	1	0		8	0
			Juv+	3	2	0	0			2	0
				7	7	5	0			12	0
				8	3	0				3	0
				12	0	1	0	0		1	0
				14	3	0	0			3	0
				20	7	0	0			7	0
				30	11	3	0			14	0
				35	1	0	0	0		1	0
Mat 7	Pools	DO	Fry	40	1	0	1	1		1	-
				20	5	5	5	5		5	-
				28	3	1	1	1		5	-
				58	1	3	2	1		4	-
				73	4	4	4	3		4	-
				10	3					-	-

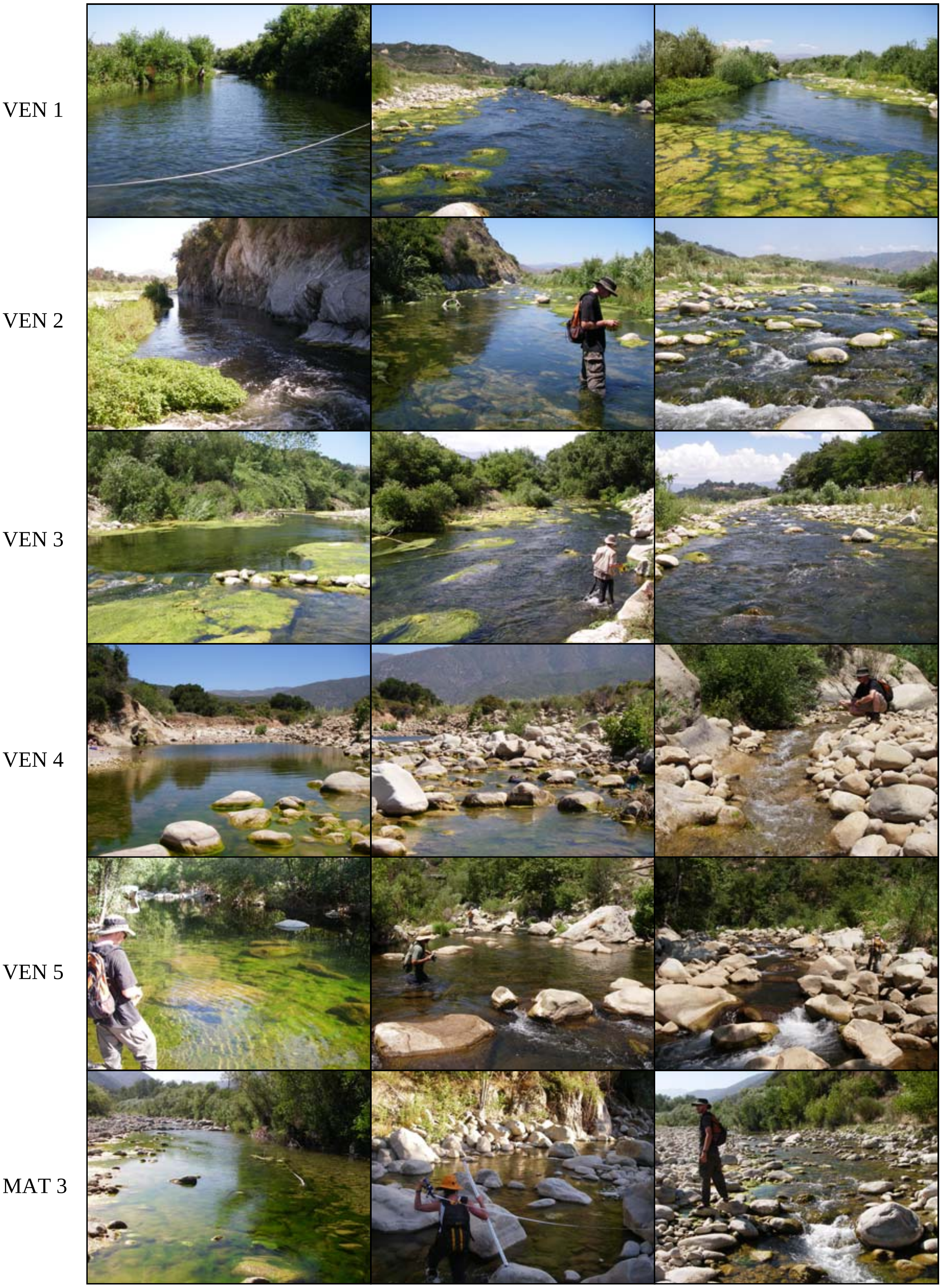
Appendix D. (continued)

Study Site	Habitat Category	Sampling Method	Size Class	Unit #	Sampling Pass #					Abund Est (y)	Var (y)
					1	2	3	4	5		
				xxx	3					-	-
				48	1					-	-
				80	5					-	-
			Juv+	40	1	0	0	0		2	-
				20	2	2	0	0		2	-
				28	4	5	5	4		6	-
				58	2	1	2	0		2	-
				73	1	2	2	2		2	-
				10	10					-	-
				xxx	8					-	-
				48	1					-	-
				80	4					-	-
	Flatwaters	EF	Fry	3	3	1	0			4	0
				14	1	0	0			1	0
				19	6	1	0	1		8	12
				31	4	0	0			4	0
				39	0	0	0			0	0
				61	1	0	1	0		2	0
				68	3	0	0			3	0
				70	0	0	0			0	0
			Juv+	3	0	0	0			0	0
				14	2	0	0			2	0
				19	2	0	1	0		3	0
				31	0	0	0			0	0
				39	1	0	0			1	0
				61	3	0	0	0		3	0
				68	4	1	0			5	0
				70	1	0	0			1	0
	Riffles	EF	Fry	2	5	0	0			5	0
				11	1	1	0			2	0
				36	1	0	0			1	0
				49	0	0	0			0	0
				52	0	0				0	0
				78	0	2	0			2	0
				79	6	0	0			6	0
				82	7	1	1	0		9	0
			Juv+	2	1	0	0			1	0
				11	3	0	0			3	0
				36	2	0	0			2	0
				49	1	0	0			1	0
				52	0	0				0	0
				78	3	0	0			3	0
				79	0	0	0			0	0
				82	1	0	0	0		1	0
UNF up	Pools	DO	Fry	14	4	4	4	4		4	-
				33	2	3	3	3		4	-
				51	3	3	3	3		4	-
				74	5	1	3	4		2	-
				94	2	3	3	3		4	-
				43	2					-	-
				65	4					-	-
				79	0					-	-
			Juv+	14	0	0	0	0		0	-
				33	1	1	0	0		1	-
				51	2	1	1	0		5	-
				74	2	1	1	1		8	-

Appendix D. (continued)

Study Site	Habitat Category	Sampling Method	Size Class	Unit #	Sampling Pass #					Abund Est (y)	Var (y)
					1	2	3	4	5		
				94	2	2	2	2		2	-
				43	1					-	-
				65	1					-	-
				79	3					-	-
	Flatwaters	EF	Fry	19	6	2	1	0		9	0
				47	2	0	0			2	0
				58	4	0	0			4	0
				66	4	0	0			4	0
				84	1	0	0			1	0
				91	1	0	0			1	0
				101	2	0	0			2	0
				116	2	1	0			3	0
			Juv+	19	2	0	1	0		3	0
				47	4	0	0			4	0
				58	0	0	0			0	0
				66	1	0	0			1	0
				84	1	0	0			1	0
				91	0	0	0			0	0
				101	0	0	0			0	0
				116	0	0	0			0	0
	Riffles	EF	Fry	13	3	0	0			3	0
				32	7	1	0			8	0
				54	3	0	0			3	0
				71	0	0				0	0
				85	2	0	0			2	0
				99	3	0	0			3	0
				104	3	0	0			3	0
				107	2	1	1	0		4	0
			Juv+	13	0	1	0			1	0
				32	0	0	0			0	0
				54	1	0	0			1	0
				71	0	0				0	0
				85	0	0	0			0	0
				99	0	1	0			1	0
				104	1	0	0			1	0
				107	2	0	0			2	0

Appendix E. Representative photographs of each study site (photos of all sampled mesohabitat units are available on CD only).



Appendix E. (continued).

MAT 5

MAT 7

UNF up

LNF low

LNF mid

Lagoon

Appendix F. GPS coordinates of all sampled mesohabitat units (WGS 84).

WP label	Deg N	Min N	Deg W	Min W	WP label	Deg N	Min N	Deg W	Min W
VEN1BNEW	34	17.699	-119	18.413	33	34	18.369	-119	17.995
VEN1T	34	18.067	-119	18.233	34	34	18.405	-119	17.982
VEN2B	34	19.167	-119	17.717	35	34	17.733	-119	18.386
VEN2T	34	19.967	-119	17.817	36	34	17.745	-119	18.379
VEN3B	34	22.141	-119	18.555	38	34	22.227	-119	18.533
VEN3T	34	22.900	-119	18.517	39	34	22.244	-119	18.527
VEN4BNEW	34	27.036	-119	17.606	40	34	22.416	-119	18.485
VEN4T	34	27.544	-119	17.494	41	34	22.415	-119	18.486
VEN5B	34	28.826	-119	17.593	42	34	22.438	-119	18.474
VEN5T	34	29.111	-119	18.012	43	34	22.516	-119	18.455
LNFLOWB	34	30.034	-119	17.949	44	34	22.597	-119	18.439
LNFLOWT	34	30.325	-119	17.799	45	34	22.719	-119	18.425
LNFMIDB	34	30.499	-119	17.188	46	34	22.836	-119	18.459
LNFMIDT	34	30.367	-119	16.983	47	34	22.870	-119	18.468
MAT3B1	34	29.617	-119	19.717	48	34	22.898	-119	18.511
MAT3T1	34	29.697	-119	20.005	49	34	22.911	-119	18.535
MAT3B2	34	30.000	-119	20.717	50	34	19.239	-119	17.724
MAT3T2	34	30.026	-119	20.969	51	34	19.329	-119	17.687
MAT5B	34	30.200	-119	22.317	52	34	19.468	-119	17.702
MAT5T	34	30.340	-119	22.762	53	34	19.467	-119	17.702
MAT7B	34	31.344	-119	24.234	54	34	19.625	-119	17.723
MAT7T	34	31.617	-119	24.083	55	34	19.680	-119	17.754
UNFUPB	34	31.355	-119	21.137	56	34	22.175	-119	18.533
UNFUPT1	34	31.564	-119	21.147	57	34	22.366	-119	18.495
UNFUPT2	34	31.362	-119	21.076	58	34	22.615	-119	18.436
2	34	27.035	-119	17.609	59	34	22.703	-119	18.419
3	34	27.067	-119	17.583	60	34	22.703	-119	18.420
4	34	27.085	-119	17.573	61	34	22.282	-119	18.502
5	34	27.123	-119	17.575	62	34	22.356	-119	18.499
6	34	27.175	-119	17.587	63	34	22.646	-119	18.431
7	34	27.191	-119	17.580	65	34	28.842	-119	17.595
8	34	27.276	-119	17.570	66	34	28.875	-119	17.608
9	34	27.293	-119	17.566	67	34	28.914	-119	17.635
10	34	27.340	-119	17.547	68	34	28.927	-119	17.666
11	34	27.393	-119	17.524	69	34	28.940	-119	17.679
12	34	27.432	-119	17.527	70	34	28.941	-119	17.680
13	34	27.202	-119	17.575	71	34	28.939	-119	17.703
14	34	19.152	-119	17.712	72	34	28.950	-119	17.730
15	34	19.224	-119	17.711	73	34	28.968	-119	17.776
16	34	19.271	-119	17.697	74	34	28.976	-119	17.793
17	34	19.399	-119	17.696	75	34	28.989	-119	17.812
18	34	19.482	-119	17.709	76	34	28.994	-119	17.819
19	34	19.588	-119	17.722	77	34	29.010	-119	17.852
20	34	19.707	-119	17.763	78	34	29.028	-119	17.868
21	34	19.759	-119	17.792	79	34	29.086	-119	17.906
22	34	19.805	-119	17.810	80	34	29.097	-119	17.914
23	34	19.954	-119	17.814	81	34	29.114	-119	17.979
24	34	19.985	-119	17.812	82	34	29.114	-119	17.992
28	34	17.847	-119	18.335	83	34	29.117	-119	17.993
29	34	17.925	-119	18.292	84	34	29.111	-119	18.010
30	34	17.959	-119	18.265	85	34	29.067	-119	17.901
31	34	18.178	-119	18.191	89	34	30.203	-119	22.338
32	34	18.270	-119	18.123	90	34	30.237	-119	22.383

Appendix F. (continued)

WP label	Deg N	Min N	Deg W	Min W
91	34	30.242	-119	22.405
92	34	30.242	-119	22.408
93	34	30.245	-119	22.411
94	34	30.251	-119	22.418
95	34	30.264	-119	22.445
96	34	30.263	-119	22.446
97	34	30.275	-119	22.464
98	34	30.275	-119	22.477
99	34	30.277	-119	22.481
100	34	30.272	-119	22.509
101	34	30.288	-119	22.526
102	34	30.293	-119	22.547
103	34	30.289	-119	22.575
104	34	30.289	-119	22.608
105	34	30.299	-119	22.601
106	34	30.294	-119	22.625
107	34	30.304	-119	22.628
108	34	30.305	-119	22.634
109	34	30.310	-119	22.639
110	34	30.309	-119	22.642
111	34	30.313	-119	22.645
112	34	30.319	-119	22.666
113	34	30.320	-119	22.666
114	34	30.316	-119	22.688
115	34	30.319	-119	22.710
116	34	30.325	-119	22.706
117	34	30.334	-119	22.730
118	34	30.334	-119	22.744
119	34	30.339	-119	22.750
121	34	29.620	-119	19.714
122	34	29.627	-119	19.725
123	34	29.643	-119	19.738
124	34	29.634	-119	19.758
125	34	29.639	-119	19.773
126	34	29.641	-119	19.828
127	34	29.639	-119	19.842
128	34	29.644	-119	19.847
129	34	29.645	-119	19.853
130	34	29.650	-119	19.885
131	34	29.652	-119	19.920
132	34	29.660	-119	19.927
133	34	29.675	-119	19.957
134	34	29.692	-119	19.994
136	34	30.092	-119	20.799
137	34	30.089	-119	20.811
138	34	30.084	-119	20.839
139	34	30.082	-119	20.872
140	34	30.086	-119	20.875
141	34	30.046	-119	20.942
142	34	30.033	-119	20.959
145	34	29.648	-119	19.815
146	34	29.665	-119	19.925
147	34	30.089	-119	20.849
148	34	30.088	-119	20.868
149	34	30.073	-119	20.884
151	34	31.344	-119	24.235
152	34	31.349	-119	24.216
153	34	31.358	-119	24.201
154	34	31.390	-119	24.180
155	34	31.392	-119	24.159
156	34	31.401	-119	24.149
157	34	31.410	-119	24.113
158	34	31.438	-119	24.097
159	34	31.440	-119	24.090
160	34	31.471	-119	24.104
161	34	31.480	-119	24.105
162	34	31.511	-119	24.107
163	34	31.524	-119	24.108
164	34	31.562	-119	24.125
165	34	31.563	-119	24.129
166	34	31.587	-119	24.113
167	34	31.590	-119	24.110
168	34	31.603	-119	24.104
169	34	31.613	-119	24.100
170	34	31.623	-119	24.094
171	34	31.635	-119	24.085
172	34	31.425	-119	24.111
174	34	31.361	-119	21.107
175	34	31.363	-119	21.096
177	34	31.353	-119	21.138
178	34	31.391	-119	21.114
179	34	31.381	-119	21.116
180	34	31.396	-119	21.114
181	34	31.395	-119	21.111
182	34	31.408	-119	21.115
183	34	31.435	-119	21.106
184	34	31.447	-119	21.119
185	34	31.457	-119	21.121
186	34	31.475	-119	21.111
187	34	31.481	-119	21.112
188	34	31.486	-119	21.114
189	34	31.500	-119	21.120
190	34	31.501	-119	21.119
191	34	31.524	-119	21.126
192	34	31.526	-119	21.129
193	34	31.529	-119	21.136
194	34	31.537	-119	21.157
195	34	31.560	-119	21.147
197	34	30.379	-119	17.018
198	34	30.359	-119	16.980
199	34	30.359	-119	17.007
200	34	30.369	-119	17.025
201	34	30.377	-119	17.041
202	34	30.387	-119	17.033
203	34	30.394	-119	17.029
204	34	30.409	-119	17.058

Appendix F. (continued)

WP label	Deg N	Min N	Deg W	Min W
205	34	30.413	-119	17.071
206	34	30.480	-119	17.074
207	34	30.454	-119	17.032
208	34	30.512	-119	17.041
209	34	30.511	-119	17.078
210	34	30.513	-119	17.097
211	34	30.503	-119	17.130
212	34	30.498	-119	17.141
216	34	30.029	-119	17.944
217	34	30.042	-119	17.924
218	34	30.039	-119	17.920
219	34	30.051	-119	17.915
220	34	30.064	-119	17.906
221	34	30.095	-119	17.895
222	34	30.101	-119	17.896
223	34	30.107	-119	17.885
224	34	30.117	-119	17.877
225	34	30.128	-119	17.866
226	34	30.140	-119	17.878
227	34	30.164	-119	17.867
228	34	30.173	-119	17.863
229	34	30.190	-119	17.851
230	34	30.210	-119	17.834
231	34	30.231	-119	17.825
232	34	30.290	-119	17.819
233	34	30.254	-119	17.809
234	34	30.255	-119	17.812
235	34	30.284	-119	17.824