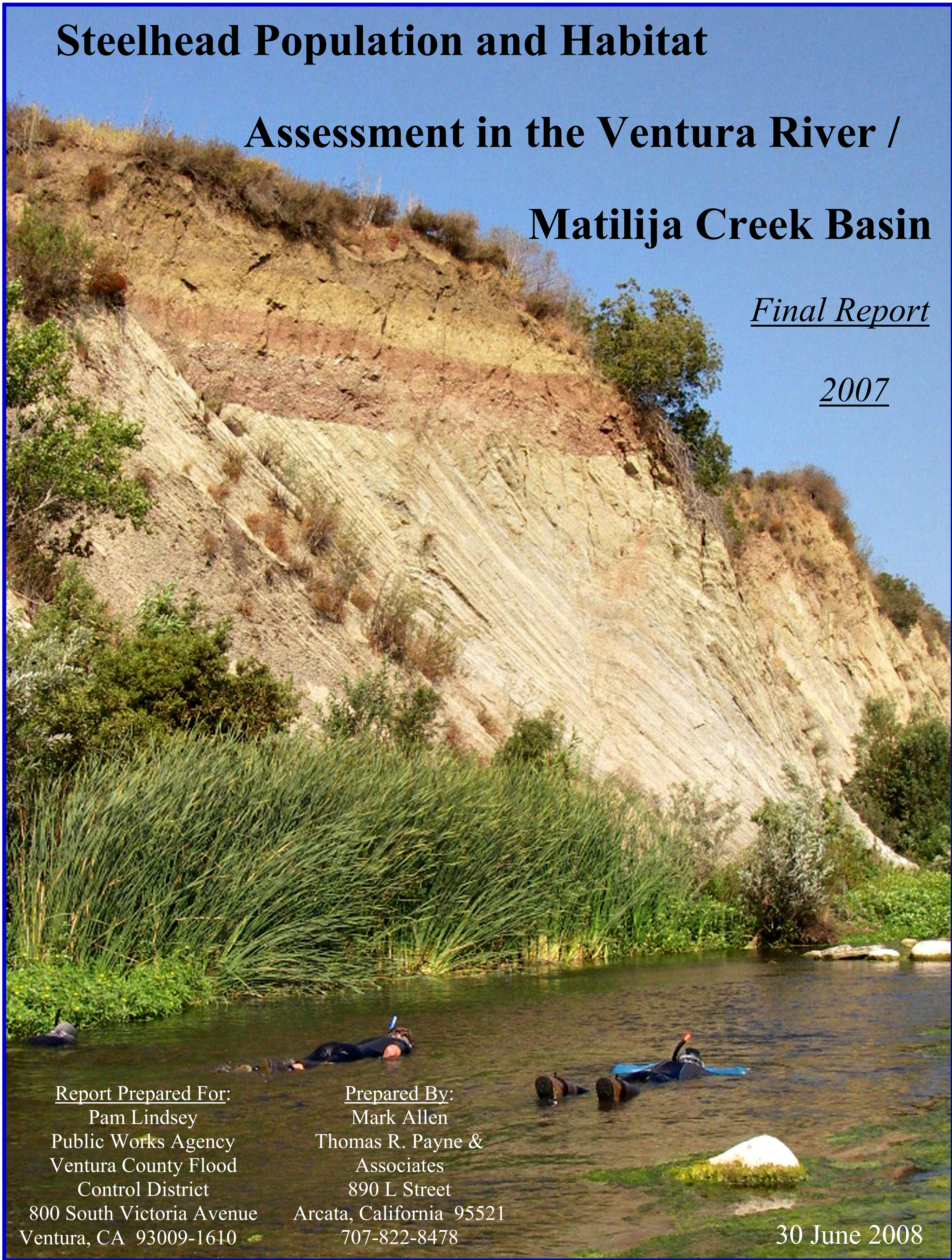
# Steelhead Population and Habitat Assessment in the Ventura River / Matilija Creek Basin

*Final Report*

*2007*

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# Steelhead Population and Habitat Assessment in the Ventura River / Matilija Creek Basin - 2007

## ABSTRACT

Eight study sites were re-sampled in the summer of 2007 to collect revised Habitat Suitability Index (HSI) data for comparison with 2003 and 2006 HSI data. Two new sites were also sampled in 2007 to further test the relationship between HSI scores and estimated fish populations. Changes in calculated HSI scores between years were assessed in relation to annual changes in physical habitat, environmental conditions, and study methodologies. Additional effort was allocated in 2007 to increase sampling of potential spawning areas to improve estimates of the spawning HSI variable "Vs", and to test the applicability of a new "tributary effects" variable for use in the embryo component of the HSI model. Increased assessment of spawning gravels produced small to moderate changes from the 2006 estimates for most HSI study sites, and the Vs variable continued to exert significant effects on the overall HSI score. The "tributary effects" variable was assessed for two mainstem areas, but suggested little influence on fry recruitment into reaches >½ mi below a spawning tributary. Changes in the physical habitat due to lower flow conditions in 2007, or due to re-growth of riparian vegetation previously impacted by flood flows, appeared to exert minimal effect on the overall HSI scores.

Population abundance of *Oncorhynchus mykiss* was also estimated in 2007 within segment, study site, and habitat type strata for 10 study sites (eight repeated from 2006 and two new sites) using multiple-pass electrofishing in shallow habitats and calibrated dive counts in deeper habitats. A total of only five *O. mykiss* were observed in the lower three study sites below Robles Diversion Dam. Two of the fish were adult steelhead observed in pools in the lowest reach; the other three were juvenile+ fish within a single pool habitat near the San Antonio Creek confluence. The overall estimated abundance and density of fry (<10cm FL) and juvenile+ *O. mykiss* (excluding adult steelhead) in this lowest segment was zero fry and 11 juvenile+ (at 0.0015 fish/100ft$^2$). Two other adult steelhead were subsequently observed by NOAA Fisheries personnel in the intervening reach. Much greater abundance and density of *O. mykiss* occurred in the middle segment above the diversion dam, which contained an estimated 4,250 (95% confidence interval ±968) fry and 524 (±217) juvenile+ fish, with densities of 0.84 (±0.22) fry/100ft$^2$ and 0.10 (±0.05) juvenile+/100ft$^2$ fish. Although the diversion dam is passable to anadromous steelhead, the majority of the middle segment *O. mykiss* population occurred in the Lower North Fork Matilija Creek upstream of a new barrier that probably prevented upstream passage by steelhead. Consequently most, if not all, of the fry (and many of the juvenile+ fish) sampled in 2007 were likely of resident trout parentage. The highest abundance of *O. mykiss* occurred in the upper segment above Matilija Dam, where an estimated 6,294 (±1,104) fry and 1,192 (±662) juvenile+ fish occurred at

densities of 0.80 (±0.18) and 0.15 (±0.08) fish/100ft$^2$, respectively. Those estimates represent abundance of resident trout in the mainstem Matilija Creek and in the Upper North Fork Matilija Creek upstream to the first impassable barrier, but do not include fish above barriers or in other tributaries. *O. mykiss* were not observed following qualitative electrofishing in approximately 2,500ft of San Antonio Creek, nor were any salmonids captured in 16 seine hauls or observed by underwater video in the Ventura Lagoon.

The 2007 estimates were consistent with 2006 estimates in showing that abundance of *O. mykiss* was zero or near zero in the lower segment below Robles Diversion Dam, intermediate in the middle segment above the diversion dam (mostly due to high densities in the Lower North Fork Matilija Creek), and highest in the upper segment above Matilija Dam. However, the 2007 results showed substantial changes in the relative size-class composition of *O. mykiss* from 2006 in virtually every middle and upper segment study site. The 2007 estimates represented statistically significant increases in abundance of *O. mykiss* fry from 2006, but significant decreases in juvenile+, in most middle and upper segment study sites. The causes for the observed changes in abundance is unknown, but differences in flow regimes during the spring spawning periods is suspected to have resulted in variable recruitment of fry. Low spawning success in 2006 due to spring flood events likely reduced fry densities in that year, and resulted in low juvenile+ densities in 2007. More stable flows during the spring of 2007 may have resulted in higher spawning success and subsequently higher densities of fry in 2007.

Despite the changes in overall abundance and relative size-class strength of *O. mykiss* in 2007, 60% to 70% of the variation in densities among the 10 study sites was explained by the study sites overall HSI score, which suggests that the HSI model is effective in distinguishing between high quality habitat and low quality habitat. The model did not effectively distinguish between study sites that contained relatively low densities of *O. mykiss* from lower Ventura River sites that contained zero or near zero abundance. This apparent insensitivity may be caused by overestimating the suitability of the lower reaches due to variable omissions or inappropriate curves in the existing HSI model, or to site-specific modifications that we applied to various HSI curves. Alternatively, the HSI model may be correctly predicting moderately suitable habitat in downstream reaches that lacked adequate recruitment of fish in 2006 and 2007. Additional sampling in years possessing greater immigration of adult steelhead (e.g., perhaps 2007-08) and/or relatively high streamflows will help to assess if the lower Ventura River is in fact capable of supporting higher abundance of *O. mykiss*, as is suggested by some historical evidence (e.g., Moore 1980).

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# Steelhead Population and Habitat Assessment in the Ventura River / Matilija Creek Basin - 2007

## 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 1980). 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 2007 distribution and abundance of *O. mykiss* (both anadromous and resident forms) in the Ventura River basin, and to compare those estimates with the 2006 results (TRPA 2007); and

2. to further test and refine the Habitat Suitability Index (HSI) model developed in 2003 and 2006 (TRPA 2004) by comparison of HSI scores between years and by comparison of HSI scores with abundance of *O. mykiss*

The 2007 study essentially repeats the HSI and fish population sampling conducted in 2006 by returning to the same mesohabitat units in eight study sites, with the addition of two new HSI/fish population study sites in 2007. The Ventura Lagoon was also resampled in 2007. Details regarding the original HSI model for *O. mykiss* can be found in Raleigh et al. (1986). All subsequent modifications to the individual HSI variables that were used in this study, as well as the methods used to collect the HSI data, were described in prior reports (TRPA 2004, 2007). Consequently, this report will only describe those changes to the collection of HSI data that were employed in 2007. Significant portions of this report were reproduced from the 2006 report (TRPA 2007).

# METHODS

## STUDY AREA & STRATIFICATIONS

The study area encompassed in the 2007 survey was identical to the 2006 study area (Figure 1), which included all of the mainstem Ventura River up to Matilija Dam (16.3 mi), and 8.2 mi up the mainstem Matilija Creek to the first impassable barrier (TRPA 2003). Two of the principal fish rearing tributaries were also represented: the Lower North Fork Matilija Creek (4.3 mi) below Matilija Dam, and the Upper North Fork Matilija Creek above the dam (4.1 mi). Limited effort was also allocated in 2007 to qualitative fish sampling in San Antonio Creek approximately 3.5 mi above its confluence with the Ventura River. HSI and fish population sampling was not conducted in other principal tributaries, such as Coyote Creek (tributary to the Ventura River), or Murietta and Old Man Creeks (both tributary to Matilija Creek above the dam). The latter two tributaries were surveyed for HSI data in 2003, when Murietta Creek appeared to provide significant rearing habitat for *O. mykiss*, but Old Man Creek did not (TRPA 2003, 2004). Consequently, the overall HSI scores and fish population estimates described in this report *do not* include potential fish habitat in any of those non-sampled tributaries, or in any mainstem or tributary reaches above impassable barriers. The sampled portion of the basin was stratified into three *segments* and 17 *reaches*. Ten of those 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, including a recent slide at the Ojai

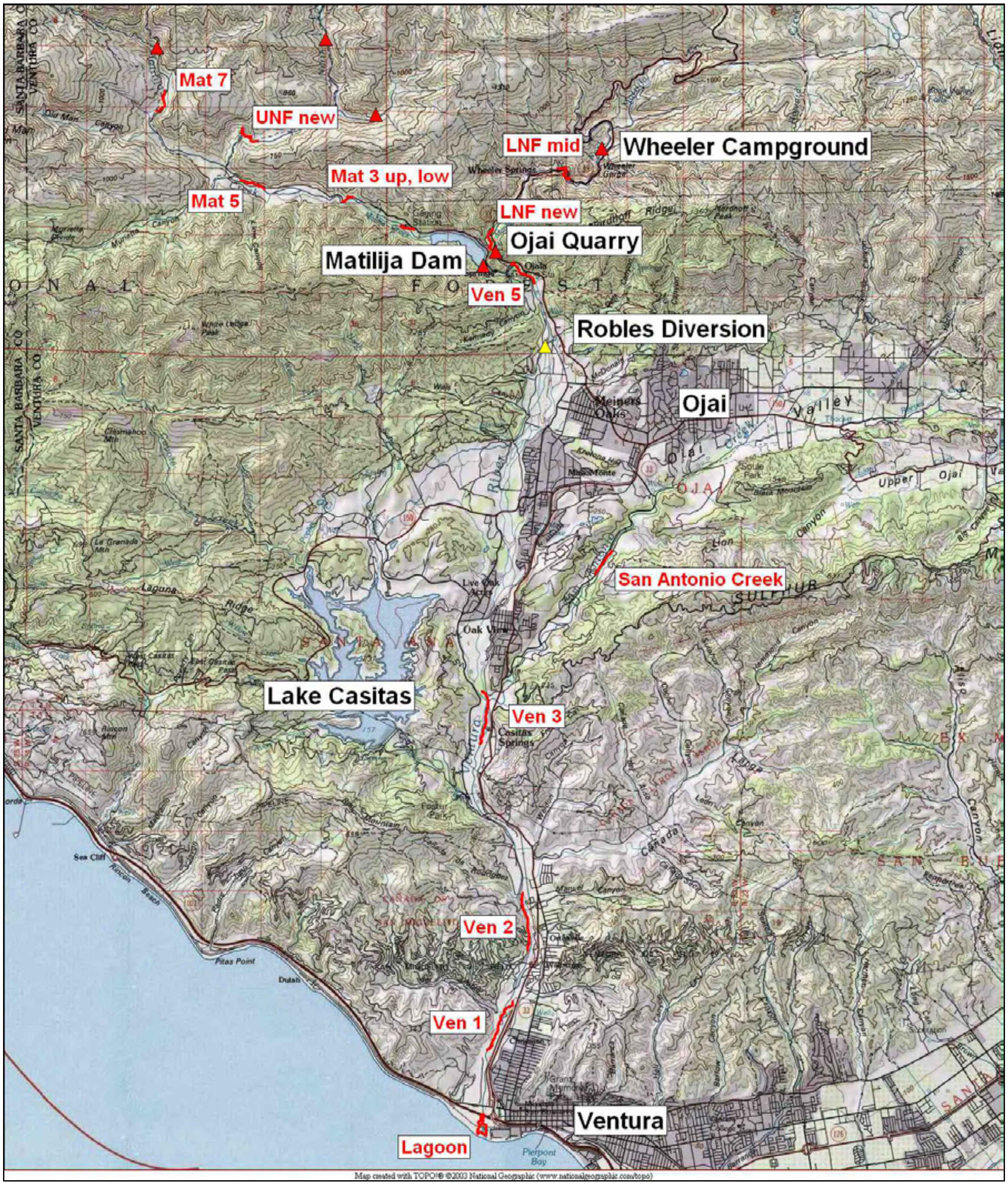


Figure 1. Map of Ventura/Matilija Basin showing landmarks, study sites (red lines), and impassable barriers (red triangles).

Quarry that reportedly occurred in the winter of 2006 (e.g., prior to the 2006 and 2007 fish population surveys). This slide was inspected by TRPA in the summer of 2007 and appeared to represent an impassable barrier at all flows. This middle segment has intermediate characteristics to the lower and upper segments, but most habitat occurs in the Lower North Fork Matilija Creek which is similar to 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 and densely vegetated 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 originally divided in 2003 into approximately one mile sections in the lower segment, and ½ mile sections in the middle and upper segments. For the 2003 HSI study, one section was randomly selected from each of the 17 reaches to represent HSI *study sites*, and these reach and study site locations were retained for this study (with the exceptions described below). Descriptions of each reach and the 17 HSI study sites were given in prior reports (TRPA 2003, 2004). Budget allocations in 2006 limited sampling to 11 of the 17 study sites mapped in 2003 (TRPA 2007).

In 2007 a total of 10 study sites were sampled: 8 of the 2006 study sites were resampled (the ninth was dry in 2007 and could not be sampled), and two new sites were added. The headwater site on the Upper North Fork Matilija Creek sampled in 2006 was replaced with another HSI site lower in the watershed ("UNF new"). This study site, originally mapped in 2003 (called "UNF low" in TRPA 2004), was intermediate in character to the upper, headwater site and the middle, unconfined HSI site, and was therefore considered to be more representative of the overall tributary. A new site, not mapped in 2003, was also added to characterize the lower portion of the Lower North Fork Matilija Creek ("LNF new"). These two new sites were selected in order to test the consistency of HSI scores among different sites within a tributary, and to provide additional comparisons of HSI scores to fish population abundance. The lower study segment was thus represented by three study sites (Ven 1, Ven 2, and Ven 3); the middle segment also contained three study sites (Ven 5, LNF new, and LNF mid); and the upper segment was represented by four study sites (Mat 3, Mat 5, Mat 7, and UNF new) (Figure 1).

Independent and qualitative fish sampling (without HSI mapping) was also conducted in San Antonio Creek and the Ventura Lagoon (Figure 1). The lower 4.5 mi of San Antonio Creek from the mouth to Lion Canyon Creek was divided into nine reaches approximately ½ mi in length, and one reach (at 3.5 mi) was randomly selected for qualitative electrofishing. Sampling in the Ventura Lagoon occurred in approximately the same locations as in 2006, with effort distributed throughout the upper and lower portions of the lagoon, including the large slough-like area along the eastern half. These supplemental surveys were intended to yield "snapshot" information on *O. mykiss* distributions in the lower segment, but were not intended or applied to estimate fish abundance in the Ventura watershed.

## Sampling Units

Each study site was mapped into mesohabitat types in 2003 using the CDFG *Level II* classification of 19 individual types, excluding subchannel units (Flosi et al. 1998).

Because flood events occurred between the 2003 and the 2006 sampling periods, each study site was remapped in the summer of 2006. Low flows occurred throughout the winter and spring of 2006-2007, therefore the 2007 survey again utilized the 2006 mesohabitat mapping data (except for the two new sites, which were mapped in 2007). Prior to selection of sampling units for collecting fish abundance and habitat measurements, the mesohabitat units were pooled into the three *Level I* mesohabitat types: pools (PL), flatwaters (FW), and riffles (RF). In each study site 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 in most study sites). A total of only 17 mesohabitat units were sampled in the Mat 5 study site because approximately one-quarter of the site contained extreme low flows and stagnant water (the channel went dry at the downstream end of the site).

Because the habitat mapping was intended to select units for fish sampling in 2006 and 2007, 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.

## HSI MAPPING

The HSI model, its individual variable curves, and field methods used to measure those variables were thoroughly described in previous reports (TRPA 2004, 2007). The HSI mapping protocols used in 2007 were identical to the methods used in 2006, except that only those variables directly associated with streamflow, the riparian zone, or spawning gravels were reassessed in 2007. The streamflow-related variables (e.g., water temperature, thalweg depth, and maximum pool depth) were reassessed because of the much lower flow conditions experienced in 2007 as compared to 2006. New HSI data was also collected for riparian variables (e.g., bank vegetation and bank stability) that were expected to show some recovery from the dramatic flood-related changes between 2003 and 2006. The evaluation of potential spawning areas was enhanced in 2007 to include any observed gravel patches within the entire HSI study site, rather than only those gravels within selected mesohabitat units. This modification to the 2006 methodology was intended to yield a larger sample of gravel measurements and, consequently, more valid estimates of the spawning variable Vs. Note that according to the original HSI model (Raleigh et al. 1984), the Vs score is compared to the incubation temperature score and the incubation dissolved oxygen score, and the lowest of these three scores is used to represent the embryo component score (e.g., recruitment potential).

Development of the "Tributary Effects" HSI Variable

The current HSI model assumes, through the Vs variable and water quality parameters related to egg survival, that recruitment of fish into the study area occurs solely by spawning and emergence within that area. No account is made for recruitment of fish into a study area from upstream (or downstream) sources. Consequently, if spawning habitat or incubation conditions are limiting, the model will assume that few fish are available to utilize that habitat even if rearing conditions are suitable for immigrant fry, juvenile, or adult fish. If fry densities within a study site are mostly associated with in-site spawning and emergence, no relationship would be expected between riffle-specific fry densities and distance to spawning tributary. However, if a negative relationship is observed between fry densities and distance, fry recruitment from tributaries may be in effect and could potentially compensate for limitations in local spawning and incubation habitat.

Consequently, as an alternative to using only the Vs and incubation variables to represent the recruitment potential of fry into a study site, fish abundance data from three study sites was evaluated to assess the potential effects of recruitment from an upstream spawning tributary. This "tributary effects" variable was evaluated using electrofishing abundance estimates of *O. mykiss* fry from riffle habitats in the Ven 5 study site due to the recruitment potential from the Lower North Fork Matilija Creek, and in the Mat 3 and Mat 5 study sites in relation to potential recruitment from the Upper North Fork Matilija Creek and Murietta Creek (specifically, the tributary source for the Mat 3 and Mat 5 sites was assumed to be the UNF diversion canal that entered the Mat 5 reach at its upstream boundary). Although San Antonio Creek enters the Ventura River near the top of the Ven 3 study site, tributary effects could not be assessed in that reach due to the unknown but probably near-zero density of *O. mykiss* and the lack of surface flow in San Antonio Creek in July 2007, and the overall rarity of *O. mykiss* in the Ven 3 study site.

The relationship between recruitment tributaries and fish abundance was evaluated by plotting riffle-specific fry densities against distance from the tributary. Only fry were used in this analysis because the trib effects variable was intended to supplement the embryo component as an alternative to the Vs variable; juvenile and adult fish are assessed by separate components (Raleigh et al. 1984). The assessment also only included riffles since *O. mykiss* fry were much more abundant in riffles than in flatwaters and pools. Prior to plotting, fry densities in individual riffles were first normalized by segment, where the highest density in the middle segment (Ven 5) study site was set to 1.0, and all lower densities were scaled accordingly. Likewise, fry densities in upper segment riffles (from the Mat 3 and mat 5 study sites) were also normalized to the highest density in those two sites. Fry densities were normalized due to the potentially large differences in fry densities between the two segments, and the desire to combine the density data in order to achieve sufficient sample sizes.

The relationship between normalized fry densities and riffle location was then fitted with a logarithmic regression curve, which was then re-normalized to yield a maximum suitability factor of 1.0 at the highest estimated density. An HSI variable score for "trib effects" was then estimated for the three pertinent study sites (Ven 5, Mat 3, and Mat 5) by reference to that curve, according to the distance from the tributary to the middle of the HSI study site. The trib effects value was then compared to the original embryo component score (which was the minimum of the Vs, incubation temperature, and incubation D.O. scores) for that study site, and the maximum of those two scores was used to represent the embryo component of the HSI model.

Annual Changes in HSI Scores

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 2006 to 2007 (e.g., expected growth of riparian vegetation);
2. lower streamflows encountered in 2007 versus 2006;
3. increased sample size to assess the highly influential spawning quality score (Vs), and;
4. the potential application of the "trib effects" variable for calculating overall HSI scores in the Ven 5, Mat 3, and Mat 5 study sites

Each of these potential factors are discussed where appropriate when comparing the annual HSI scores and environmental conditions. Note that changes from the original 2003 HSI study to the 2006 study were thoroughly discussed in a prior report (TRPA 2007), therefore this report will emphasize changes in HSI scores from 2006 to 2007.

## 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 HSI 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 2007b [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), digital photographs, and GPS coordinates.

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 only three to four calibration units. Thus, second-stage calibration was generally 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$^{o}$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 observations and procedural safeguards:

1. Southern steelhead are tolerant of warmer water conditions than steelhead in more northerly areas;
2. Repeated electrofishing in 2006 under high temperatures resulted in minimal immediate mortality, with no short-term mortality of 14 *O. mykiss* confined overnight in a net pen;
3. At the warmest study sites all captured *O. mykiss* were kept in separate buckets containing a portable aerator and a self-contained ice-pack to reduce stress; one individual was specifically assigned to ensure that the bucket water was continually refreshed, aerated, and remained cooler than the river water.

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. 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 contained a natural barrier, such as a cascade or high gradient riffle, where an upper block net was not required. 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 algae was periodically removed 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 unit. In addition to the capture data, water temperature and conductivity was measured 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, bias-adjusted estimates of *total* abundance were calculated according to the bounded count formulas.

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 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 quantitatively 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 up to the first impassible barriers identified in 2003 (but ignoring the new barrier near the mouth of the Lower North Fork).

Ventura Lagoon Sampling

On August 11, 16 beach seine sets were made throughout the Ventura River lagoon using a 100 ft seine with a ½ inch mesh size (Figure 2). 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. The initial seine sets occurred at high tide and concluded at low tide. Salinity was not measured in 2007, but sampling in similar areas in 2006 occurred at salinities of 10-16 ppt near the lagoon mouth and 0.4-0.6 ppt under the 101 bridge. Surface water temperatures in 2007 ranged from 69°F in the morning to 75°F in the afternoon. The lagoon was closed to the ocean at the time of sampling, but had remained open during the spring until April (or thereafter). All captured fish were identified to species, enumerated, and released back into the lagoon.

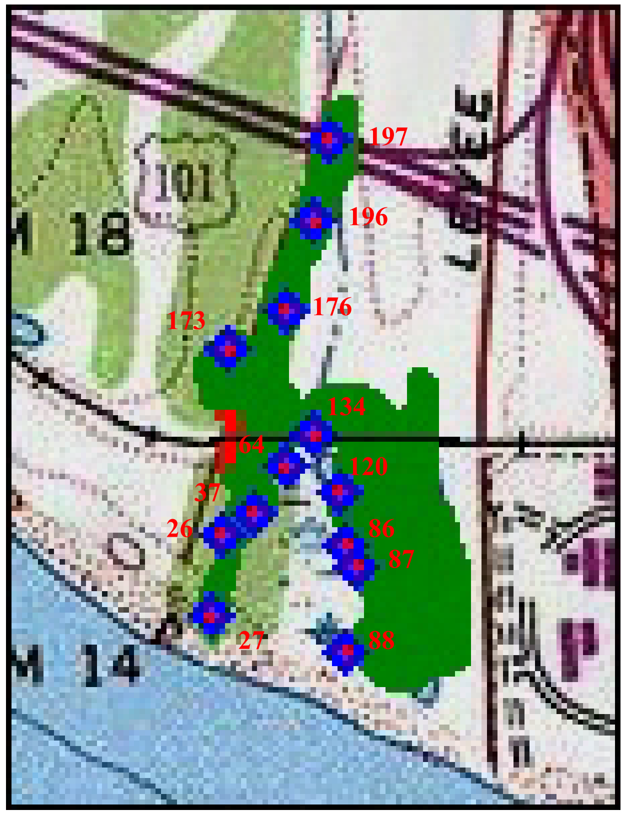

Figure 2. Map of Ventura Lagoon showing approximate wetted area, seining locations (numbered diamonds), and video sampling area (red line on west bank of RR tracks).

Comparison of Fish Abundance and HSI Scores

The relationship between estimates of fish abundance and HSI scores was assessed for each of the 10 study sites by simple linear regression, using the HSI score as the predictor variable and density (#/100ft$^2$) of either fry or juvenile+ *O. mykiss* as the response variable. HSI and fish abundance data were also pooled among study sites to represent the three study segments, and this relationship was visually assessed using scatterplots.

The relationship between first-pass dive counts and four-pass MBC estimates was assessed with scatterplots and linear regression for each calibrated sampling unit, in order to validate the expected correlation between first-pass counts and total fish abundance.

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.

# RESULTS

Fish sampling and HSI mapping was conducted in the Ventura/Matilija basin from 17 July to 10 August 2007, followed by one day of qualitative sampling in San Antonio Creek and in the Ventura Lagoon. Basic sampling statistics and mesohabitat proportions for each study site are presented in Table 1. Overall, 228 mesohabitat units were sampled, resulting in the electrofishing capture or dive count of 937 *O. mykiss* <10 cm in fork length (hereafter referred to as "fry"), and 125 "juvenile +" *O. mykiss* ≥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 2007 mapping are compared to the 2006 HSI scores and to the 2007 estimated fish densities for each study site. Habitat mapping data for the two new sites sampled in 2007 is presented in Appendix A (see TRPA 2007 for mapping data for the remaining study sites). Fish sampling details are found in Appendix B. Photographs of each sampling unit can be made available on CD upon request.

## 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 (a dry year), and the repeat mapping and fish sampling in 2006 (a wet year) and 2007 (a dry year). Historical and recent streamflow data (recent data only shown 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 48-year period of record at Gage #8500 (Figure 3, top graph). Also shown are the mean monthly flows for each year between 2003 and 2007, as well as flows estimated by TRPA field crews in the Ven 3 reach (just upstream of Foster Park) during the 2003, 2006, and 2007 surveys.

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

| Segment | Study Site | Survey Dates | Est Flow cfs | Water Temps °C | Habitat Type | # Units Avail | Study Site Length | % by Length | Sampled Units Only # Samp | AvLeng | AvWidth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower | Ven 1 | 17-19 July | 5.2 | 20-26 | All | 50 | 4,915 | 100% | 23 | 118 | 12.8 |
| | | | | | Pools | 8 | 1,275 | 26% | 7 | 208 | 27.9 |
| | | | | | Flatwaters | 28 | 2,673 | 54% | 8 | 94 | 7.6 |
| | | | | | Riffles | 14 | 967 | 20% | 8 | 63 | 7.5 |
| | | | | | NonSamp | 0 | 0 | 0% | 0 | - | - |
| | Ven 2 | 19-21 July | n/a | 20-27 | All | 59 | 5,009 | 100% | 22 | 103 | 14.7 |
| | | | | | Pools | 6 | 956 | 19% | 6 | 159 | 19.5 |
| | | | | | Flatwaters | 33 | 2,903 | 58% | 8 | 93 | 14.7 |
| | | | | | Riffles | 19 | 1,134 | 23% | 8 | 70 | 10.7 |
| | | | | | NonSamp | 1 | 16 | 0% | 0 | - | - |
| | Ven 3 | 22-24 July | 3.2 | 19-25 | All | 50 | 4,875 | 100% | 22 | 118 | 23.2 |
| | | | | | Pools | 6 | 1,345 | 28% | 6 | 216 | 29.1 |
| | | | | | Flatwaters | 27 | 2,447 | 50% | 8 | 104 | 21.8 |
| | | | | | Riffles | 17 | 1,083 | 22% | 8 | 59 | 19.0 |
| | | | | | NonSamp | 0 | 0 | 0% | 0 | - | - |
| Middle | Ven 5 | 26 July - 10-Aug | 3.0 | 20-28 | All | 58 | 2,834 | 100% | 24 | 58 | 24.7 |
| | | | | | Pools | 16 | 1,033 | 36% | 8 | 83 | 30.2 |
| | | | | | Flatwaters | 26 | 1,258 | 44% | 8 | 58 | 23.5 |
| | | | | | Riffles | 15 | 508 | 18% | 8 | 32 | 16.4 |
| | | | | | NonSamp | 1 | 35 | 1% | 0 | - | - |
| | LNF new | 27 July - 3-Aug | 0.6 | 19-23 | All | 58 | 2,204 | 100% | 24 | 35 | 16.0 |
| | | | | | Pools | 30 | 1,535 | 70% | 8 | 51 | 17.6 |
| | | | | | Flatwaters | 10 | 385 | 17% | 8 | 36 | 10.8 |
| | | | | | Riffles | 8 | 234 | 11% | 8 | 18 | 14.2 |
| | | | | | NonSamp | 10 | 50 | 2% | 0 | - | - |
| | LNF mid | 25-29 July | n/a | 17-23 | All | 77 | 2,238 | 100% | 24 | 31 | 9.9 |
| | | | | | Pools | 30 | 1,115 | 50% | 8 | 33 | 11.2 |
| | | | | | Flatwaters | 24 | 787 | 35% | 8 | 30 | 8.6 |
| | | | | | Riffles | 9 | 268 | 12% | 8 | 29 | 8.7 |
| | | | | | NonSamp | 14 | 68 | 3% | 0 | - | - |
| Upper | Mat 3 | 31 July - 10-Aug | 1.6 | 20-28 | All | 44 | 2,490 | 100% | 24 | 53 | 27.0 |
| | | | | | Pools | 9 | 615 | 25% | 8 | 59 | 26.8 |
| | | | | | Flatwaters | 23 | 1,398 | 56% | 8 | 51 | 28.2 |
| | | | | | Riffles | 8 | 463 | 19% | 8 | 49 | 23.5 |
| | | | | | NonSamp | 4 | 14 | 1% | 0 | - | - |
| | Mat 5 | 28-30 July | 0 - 1.2 | 18-27 | All | 59 | 2,380 | 100% | 17 | 60 | 12.2 |
| | | | | | Pools | 12 | 666 | 28% | 7 | 73 | 17.1 |
| | | | | | Flatwaters | 26 | 1,237 | 52% | 7 | 59 | 11.4 |
| | | | | | Riffles | 10 | 390 | 16% | 3 | 32 | 6.4 |
| | | | | | NonSamp | 11 | 87 | 4% | 0 | - | - |
| | Mat 7 | 7-Aug | 0.5 | 18-25 | All | 64 | 2,327 | 100% | 22 | 51 | 14.5 |
| | | | | | Pools | 23 | 1,088 | 47% | 8 | 65 | 18.8 |
| | | | | | Flatwaters | 11 | 575 | 25% | 7 | 45 | 8.9 |
| | | | | | Riffles | 8 | 337 | 14% | 7 | 41 | 10.3 |
| | | | | | NonSamp | 22 | 327 | 14% | 0 | - | - |
| | UNF new | 1-5 Aug | 0.2 | 16-20 | All | 71 | 2,116 | 100% | 24 | 29 | 8.9 |
| | | | | | Pools | 28 | 866 | 41% | 8 | 34 | 9.5 |
| | | | | | Flatwaters | 25 | 822 | 39% | 8 | 27 | 8.6 |
| | | | | | Riffles | 12 | 371 | 18% | 8 | 25 | 7.9 |
| | | | | | NonSamp | 6 | 57 | 3% | 0 | - | - |
| Ventura Lagoon | | 11-Aug | - | 21-24 | - | n/a | | | n/a | | |
| San Antonio Creek | | 10-Aug | <0.1 | 19-21 | - | | | | | | |

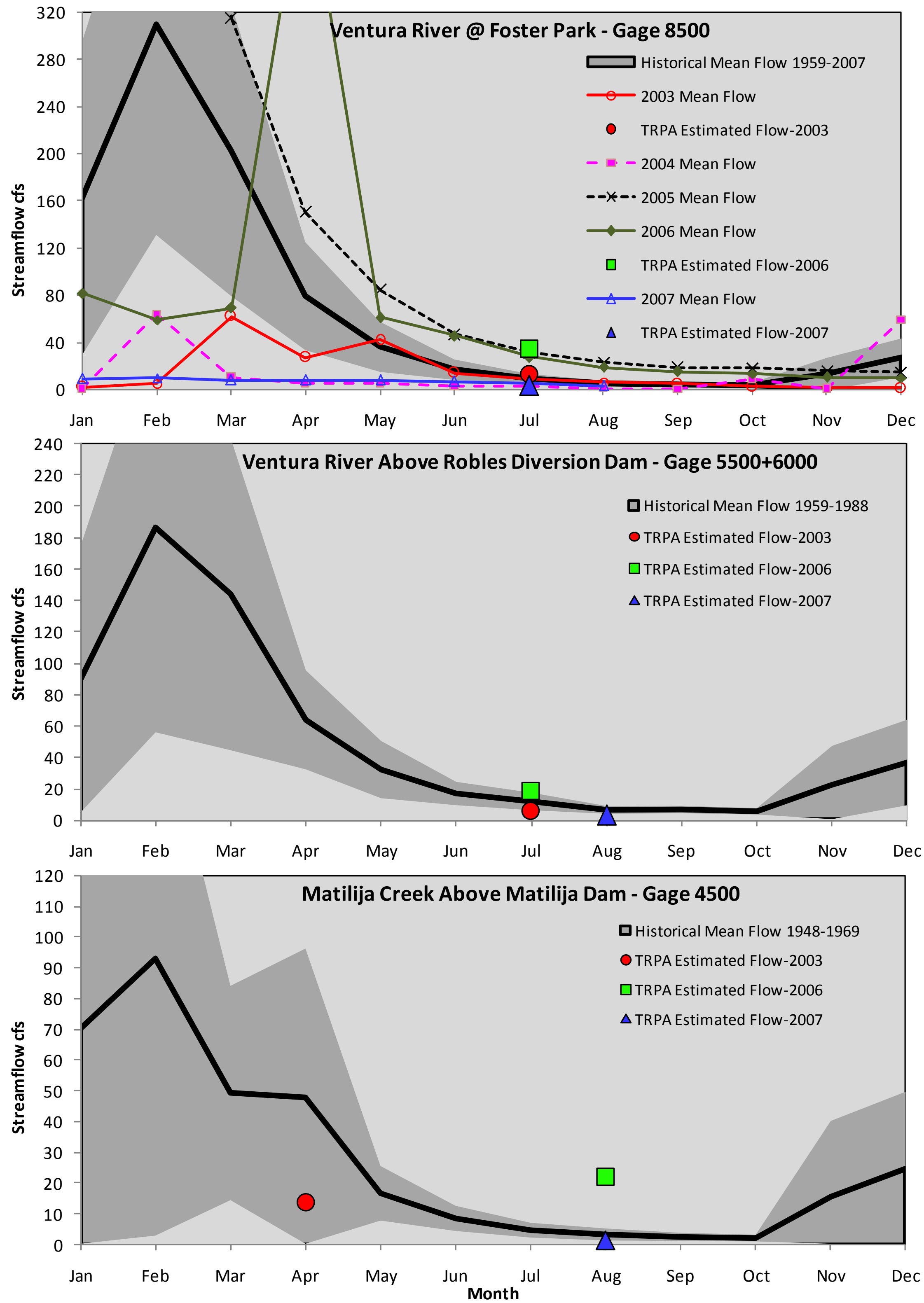


Figure 3. Historical and recent streamflows at various locations in the Ventura/Matilija Basin. Shaded band approximates 95% confidence intervals for historical mean monthly flows.

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 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 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). Streamflows throughout the late-winter, spring, and summer of 2007 were extremely low and well below the lower 95% C.I.'s for the means in most months. The TRPA-estimated flows in July and August 2007 were also much below normal in each of the three study segments.

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 and in august 2007 suggested that flows in 2003 and 2007 were below the lower 95% confidence interval (at about one-half of the mean flow), whereas the estimated flows in 2006 were just above the upper 95% confidence interval (Figure 3, middle graph).

For Matilija Creek above Matilija Dam (Figure 3, top graph), gage #4500 provided historical data over a 20-year period (1948-1969). The field estimated flow in 2003 in the Mat 3 reach 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. The estimated flow in 2007 was equal to the lower 95% C.I. flow at only 1.6 cfs.

This qualitative flow analysis illustrates that the HSI data collected during the 2003 season were representative of low flow conditions. In contrast, the HSI habitat and fish population data collected in 2006 were representative of 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. The 2007 data represented physical habitat and fish population abundance during a very dry year (with much lower rainfall than even 2003), and would be expected to impact *O. mykiss* survival and growth through low flow conditions with associated high water temperatures and limited rearing space (particularly for larger fish).

## HSI SCORES

The HSI mapping in 2007 was conducted in the same study sites and the same habitat units mapped in 2006 (with the exception of two study sites, described below). Most HSI variables used to calculate 2007 HSI scores were taken directly from the 2006 study (TRPA 2007), and were therefore unchanged from 2006. HSI mapping in 2007 was limited to several habitat parameters related to streamflow (e.g., average thalweg depth maximum pool depth and pool quality rating), riparian conditions (e.g., percentage of grass, shrub, or tree vegetation, and stable bank cover), and the spawning variable Vs (composed of particle size, % fines, and water velocity over gravel beds). The effects of any of these individual HSI variables on the overall study site HSI score will be discussed where appropriate.

Overall the changes in study site-specific HSI scores from 2006 to 2007 were relatively minor, with most scores differing by less than 8% and none greater than 13%. Changes from 2006 to 2007 were considerably less than changes observed between 2003 and 2006. The overall study site scores increased from 2006-2007 in the lower segment, decreased in the middle segment, and mostly increased in the upper segment.

Assessment of potential tributary recruitment into several HSI study sites suggested a possible relationship, leading to the development of a "tributary effects" variable for application in the embryo component of the HSI model.

### Tributary Effects Variable

The estimated densities of *O. mykiss* fry (#/100ft$^2$) in riffle habitats were plotted against the distance of the riffle from the expected source of tributary recruitment (Figure 4). The logarithmic regression curve suggested that the effects of an upstream tributary on fry densities would be largely insignificant for distances exceeding ½ mile. When the midpoint distance of each study site was used to estimate the trib effects score, the resulting values were 0.37, 0.01, and 0.50 for the Ven 5, Mat 3, and Mat 5 study sites, respectively. Only the Ven 5 trib effects score exceeded the minimum value of the original embryo component variables (the Vs, incubation temperature, and incubation D.O.), therefore the trib effects variable only influenced the overall HSI score for that study site (see below).

### Lower Segment

Three study sites were sampled in the lower segment below Robles Diversion Dam in 2007 (Table 1). A fourth study site, Ven 4 immediately below the diversion dam, was sampled in 2006 but was dry by July of 2007. 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

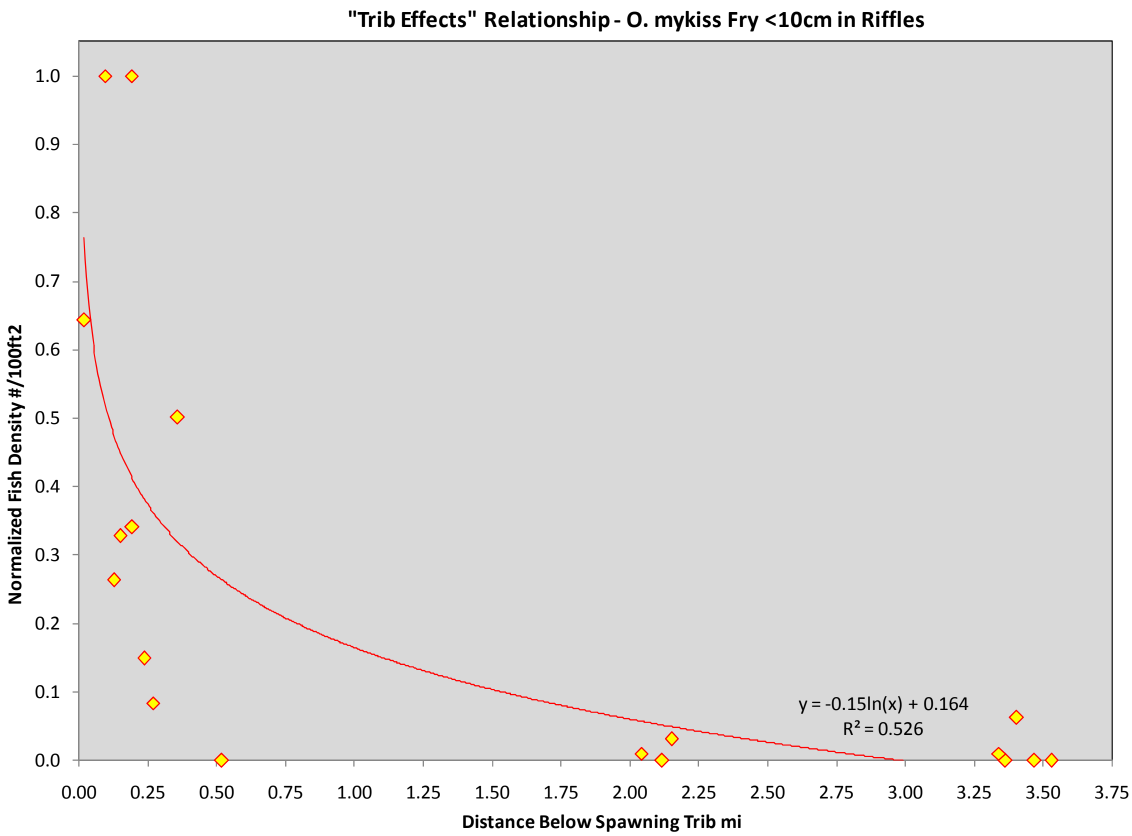


Figure 4. Observed and predicted relationship between fry densities in riffles and distance from spawning tributary. Data based on Ven 5, Mat 3, and Mat 5 study sites.

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 region of rising groundwater, but that reach also contains a diversion dam and several well fields downstream of the study site. In most normal and all dry years the river channel goes dry during spring or summer months from just above the San Antonio Creek confluence to Robles Diversion Dam, a distance of approximately four miles.

Ven 1. The Ven 1 study site was shortened by approximately 1,500 ft in 2006 due to numerous homeless encampments that occurred near the lower boundary of the original 2003 study site. Like in 2006, the aquatic habitat in 2007 was relatively open with extensive beds of rooted aquatic vegetation (mostly *Lugwigia*) that effectively confined the flowing portion of the stream channel and produced some of the narrowest mean channel widths for flatwaters and riffles among the ten study sites (however most riffles and flatwaters did contain wider portions of densely vegetated, but non-flowing, habitat). The vegetation-confined channels also produced thalwegs with swift currents and coarse substrates (Figure 5). Heavy algal mats were also common in open channel areas. HSI data was collected in only 12 habitat units, rather than the typical sample of 24 units, although 24 units were sampled for fish abundance.

The 2006 and 2007 HSI scores for steelhead habitat in Ven 1 were very similar at 0.61 and 0.63, respectively (Table 2 and Figure 6). Small decreases in bank stability and Vs from 2006 to 2007 were compensated for by the increase in the vegetation score (Figure 7). The vegetation score, which is calculated based on the combination of grass, shrub, and tree overstory along the streambank, showed some evidence of recovery from the flood events of 2005 and 2006.

Figure 5. Example of vegetation-confined riffle & flatwater habitat in the Ven 1 study site.

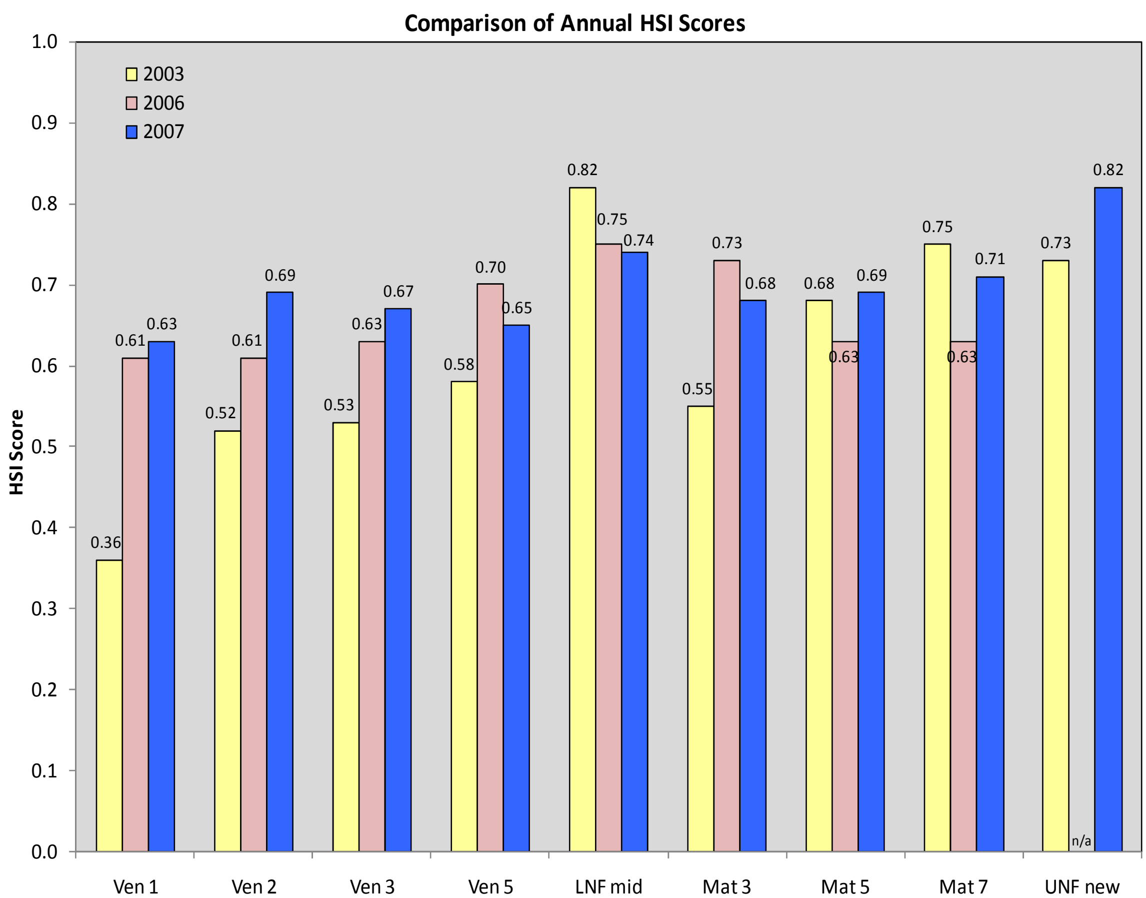


Figure 6. Comparison of overall study site HSI scores in 2003, 2006, and 2007.

The spawning variable Vs did not change between 2006 (at 0.58) and 2007 (at 0.57), although both Vs scores were based on few gravel patches despite increased effort to assess spawning habitat in 2007. The relative paucity of observable spawning areas in the Ven 1 reach and the necessity of applying a universal velocity multiplier (*2X* the observed velocity) to simulate spawning area velocities under higher winter flows (TRPA 2007), both made the assessment of recruitment potential in this lower reach highly uncertain.

Table 2. 2007 individual variable and overall HSI scores according to study site and segment.

| HSI Variable | | VEN 1 | VEN 2 | VEN 3 | VEN 5 | LNF new | LNF mid | Mat 3 | Mat 5 | Mat 7 | UNF new |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 r | max rearing temp | 0.39 | 0.50 | 0.56 | 0.42 | 0.63 | 0.63 | 0.27 | 0.50 | 0.76 | 1.00 |
| V1 am* | max adlt migr temp | 0.95 | 0.95 | 0.95 | 1.00 | - | - | - | - | - | - |
| V2 sm* | max smolt migr temp | 0.51 | 0.51 | 0.51 | 0.60 | - | - | - | - | - | - |
| V2 inc | max inc temp | 0.45 | 0.56 | 0.56 | 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 | 0.47 | 0.68 | 0.68 | 0.81 | 0.96 | 0.97 | 1.00 |
| V3 inc | min incub DO | 0.95 | 0.95 | 0.99 | 1.00 | 0.68 | 0.68 | 0.67 | 1.00 | 1.00 | 1.00 |
| V4 | avg thalweg depth | 1.00 | 1.00 | 0.93 | 1.00 | 1.00 | 1.00 | 0.80 | 0.98 | 1.00 | 0.93 |
| V5** | avg spwning veloc | - | - | - | - | - | - | - | - | - | - |
| V6 jv | % cover-juv | 1.00 | 0.96 | 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 | 0.81 | 0.67 | 0.51 | 0.55 | 0.60 | 0.55 | 0.47 |
| V7** | spwn substr size | - | - | - | - | - | - | - | - | - | - |
| V8 | % winter sub | 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 | 0.30 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.60 |
| V10 | % pools | 0.65 | 0.52 | 0.55 | 0.90 | 1.00 | 1.00 | 0.82 | 0.91 | 1.00 | 0.96 |
| V11 | % vegetation | 1.00 | 1.00 | 0.97 | 0.38 | 0.49 | 0.50 | 0.22 | 0.10 | 0.41 | 0.70 |
| V12 | % stable banks | 0.90 | 0.95 | 0.92 | 0.98 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |
| V13 | ann max/min pH | 0.55 | 0.67 | 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 | 0.26 | 0.26 | 0.26 | 0.20 | 0.20 | 0.26 | 0.26 |
| V15 | pool class | 0.60 | 1.00 | 0.60 | 1.00 | 0.60 | 0.30 | 0.60 | 0.60 | 1.00 | 0.60 |
| V16 sp** | % fines in gravel | - | - | - | - | - | - | - | - | - | - |
| V16 rr | % fines in rifs | 0.50 | 0.96 | 0.61 | 0.75 | 0.77 | 0.93 | 0.90 | 0.60 | 0.42 | 0.98 |
| V17 | % shade | 0.37 | 0.32 | 0.35 | 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 | - | - | - | - | - | - |
| Adult Component | | 0.91 | 0.93 | 0.89 | 0.99 | 0.81 | 0.74 | 0.75 | 0.85 | 1.00 | 0.84 |
| Juvenile Component | | 0.62 | 0.65 | 0.61 | 0.76 | 0.87 | 0.77 | 0.81 | 0.84 | 1.00 | 0.85 |
| Fry Component | | 0.68 | 0.71 | 0.66 | 0.88 | 0.94 | 0.98 | 0.88 | 0.84 | 0.81 | 0.98 |
| Embryo Component | | 0.45 | 0.56 | 0.56 | 0.37 | 0.58 | 0.57 | 0.52 | 0.52 | 0.40 | 0.70 |
| (Vs only)*** | | 0.45 | 0.69 | 0.63 | 0.26 | 0.58 | 0.57 | 0.52 | 0.52 | 0.40 | 0.70 |
| Other Component | | 0.60 | 0.67 | 0.66 | 0.47 | 0.65 | 0.68 | 0.51 | 0.50 | 0.56 | 0.75 |
| **Study Site Score** | | **0.63** | **0.69** | **0.67** | **0.65** | **0.76** | **0.74** | **0.68** | **0.69** | **0.71** | **0.82** |
| **Segment Score** | | | **0.67** | | | **0.72** | | | **0.74** | | |

* variables V1 am, V2 sm, and V18 are only used in the anadromous reaches
** variables V5, V7, and V16 sp are combined to calculate Vs
*** the Embryo Component score is calculated as Max ("trib effects, Min (V2 inc, V3 inc , Vs))

The large difference between the original 2003 HSI score of 0.36 (TRPA 2004) and these latter two scores, each over 0.60, also reduces confidence in the HSI assessment of this reach. Although this reach is the lowest in the watershed and *O. mykiss* are rarely observed (see below for fish observation data), the addition of flow from the upstream wastewater treatment plant and the relatively wide and unmodified floodplain (aside from the lower encampments and the broad levee system) produce what appears to be suitable aquatic habitat, given adequate fish recruitment. Thus the moderate HSI score of 0.62, versus the 2003 score of 0.36, may be a more realistic assessment of habitat quality.

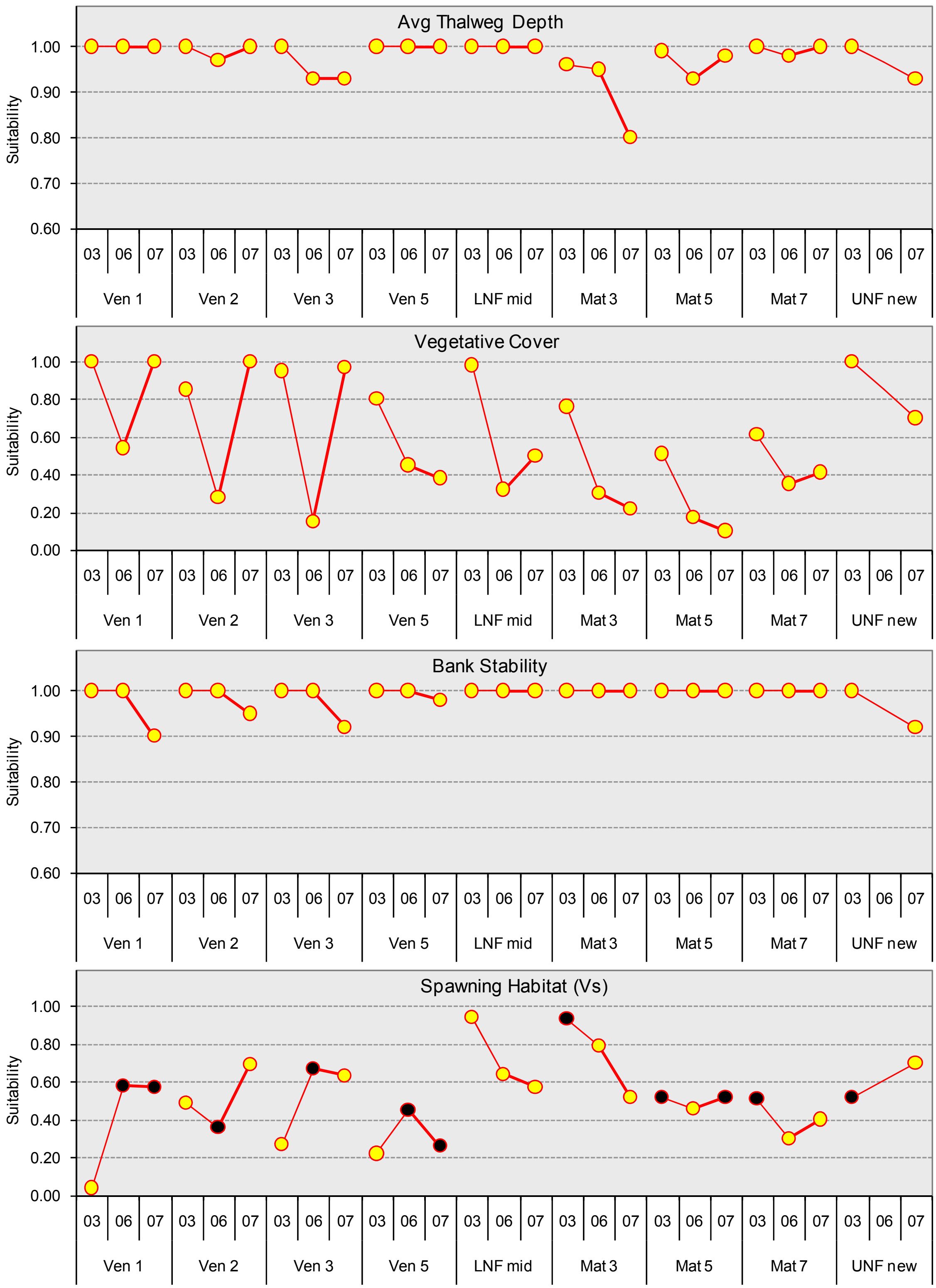


Figure 7. Annual changes in individual HSI variable scores according to study site and year. Black symbols in the Vs graph indicate scores based on <5 gravel patches.

Ven 2. The Ven 2 study site differs from the other lower segment reaches due to the presence of several large, relatively deep (4-6 ft) bedrock/aggregate formed pools, including the "Shell Hole" (Figure 8). Wide, open channel areas contained thick growths of algae as well as emergent rooted vegetation.

Figure 8. Example of bedrock/aggregate scour pool in the Ven 2 study site (the "Shell Hole").

The Ven 2 study site showed a substantial (13%) increase in HSI score from 0.61 in 2006 to 0.69 in 2007 (Table 2, Figure 6). This increase was due in part to a large increase in the bank vegetation score (from 0.28 to 1.0), presumably reflecting recovery of the lower rivers riparian zone following the 2005 and 2006 flood events. However, the increased score for the Ven 2 study site was mostly associated with an increase in the Vs score from 0.36 to 0.69 (Figure 7).

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 in 2006 identified several locations with cold seeps, including the large pool at the San Antonio confluence. However, San Antonio Creek did not contain surface flow during the 2007 sampling. Portions of the Ven 3 study site were characterized by a wide, shallow, open channel that contained heavy algal growth in both 2006 and 2007 (Figure 9).

Figure 9. Example of algae mats and riparian growth in Ven 3 FW unit #21 (7/06 left, 7/07 right).

The overall HSI score for Ven 3 showed a minor (6%) increase in 2007 from 0.63 to 0.67 (Table 2, Figure 6), mostly due to the dramatic increase in the vegetation score (from 0.15 to 0.97, Figure 7). The vegetation HSI score is a composite score representing allochthonous input that gives highest weight to the percentage of streambank with overhanging shrubs (we included multi-branched non-woody plants), intermediate weight to grasses (single-blade leaves, including *Arundo*), and lowest weight to riparian trees (Raleigh et al. 1984). The unit-specific values for almost every pool, flatwater, and riffle habitat in the Ven 2 and Ven 3 study sites showed increases in both shrub and tree coverage in 2007 (despite the reduced flows and narrower wetted channel), and decreased grass coverage (Figure 9). The overall result was the large increase in composite vegetation score.

Ven 4. The Ven 4 study site was flowing during the wet 2006 season, although flows were dropping rapidly during that survey (TRPA 2007). In the summer of 2007, and most likely in spring and summer months for all normal and dry water years, this reach is dry and consequently does not provide year-round rearing habitat for *O. mykiss*.

Combined Study Sites. The weighted average HSI score for the entire lower segment increased in from 0.61 in 2006 to 0.67 in 2007 (Table 2), mostly due to the increase in the Ven 2 study site and the loss of the Ven 4 study site (which produced a low score of 0.60 in 2006). If the Ven 4 reach was incorporated into the 2007 calculation, giving an HSI score of zero to the entire reach (rather than excluding all dry channels), the overall lower segment score would be significantly reduced. However, for the purposes of this report only the flowing water areas are considered when calculating the weighted HSI score (where each score is weighted by the length of river it represents); i.e., the quantity of habitat is not considered in the segment scores.

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 new and LNF mid (Figure 1, Table 1). The LNF low site sampled in 2006 was replaced in 2007 with the LNF new site in order to further test the HSI/fish abundance relationship with new data. It should be noted that anadromous steelhead had access to the Ven 5 site in 2006 and 2007, but a new barrier, formed by landslides at the Ojai Quarry downstream of the LNF study sites, reportedly occurred during the winter of 2006 (Figure 10).

Figure 10. Barrier to upstream migrants below the Ojai Quarry. The white rod in the lower left pool is 4 ft in height.

Consequently, the *O. mykiss* fry captured in 2006 and 2007 and most of the juvenile+ fish in 2007 are expected to be offspring of resident trout. Numerous small, resident trout and trout-sized redds were observed in the LNF during the initial habitat mapping in mid-March 2003.

Because of the difference in access to the three Middle Segment reaches, the HSI formulas differed among study sites. The anadromous formula was applied to the Ven 5 HSI data, but the resident trout formulas were used to calculate HSI scores in the LNF study sites. The anadromous equations differ from the resident equations by adding temperature and flow requirements for adult immigration, and temperature requirements for smolt outmigration (Raleigh et al. 1984). Also, slightly different HSI curves were used to define suitability of spawning velocities for steelhead and resident rainbow trout (TRPA 2007).

Ven 5. Ven 5 occurred immediately below the confluence with the lower North Fork Matilija Creek, where the very high water temperatures emerging from Matilija Dam are somewhat mediated by the cooler North Fork. The highest water temperatures recorded during the 2007 survey were in the Ven 5 reach below Matilija Dam and in Mat 3 above the dam (both at >28$^{o}$C). In mid-July 2007, the afternoon water temperature above the North Fork was 26$^{o}$C, whereas the North Fork was three degrees cooler at 23$^{o}$C. After mixing, the Ven 5 study site was 25$^{o}$C. In early July 2006, the measured water temperatures above the confluence, within the North Fork, and below the confluence, were 26.7$^{o}$C, 23.0$^{o}$C, and 25.9$^{o}$C, respectively. In addition to cooling the upper Ventura River, the abundant spawning habitat in Lower North Fork likely results in significant recruitment of *O. mykiss* into the mainstem, hence the evaluation of the "trib effects" variable for calculating the embryo component of the HSI score (Figure 4).

The overall HSI score for the Ven 5 study site decreased from 0.70 in 2006 to 0.65 in 2007 (Table 2, Figure 6). This 7% decrease was largely due to the application of the steelhead HSI model rather than the resident trout model used in 2006. A large decrease in the Vs score (from 0.45 to 0.26) was also evident in 2007 (Figure 7), however application of the "trib effects" variable produced a slightly higher value (0.37), which was therefore used to generate the embryo component score. If the "trib effects" variable was ignored and the Vs variable used instead, the overall HSI score for the Ven 5 site would have decreased yet further to 0.61, lower even than the Ven 1 score. Unlike the lower segment study sites, the Ven 5 site (and most other middle and upper segment sites) showed relatively minor changes in vegetation scores from 2006 to 2007, but the scores remained well below the 2003 values.

LNF new. This new HSI study site in the lower North Fork Matilija Creek occurred immediately above the barrier formed below the Ojai Quarry (Figure 1), but below the influence of the Wheeler hot springs (which contributed 29$^{o}$C water into the North Fork in March 2003). The LNF new site occurred between two highway bridges where it received a high degree of recreational use, as evidenced by the significant man-made alterations. Fully one-third of the pool mesohabitat units were at least partly formed by man-made rock dams, one of which was six feet high with a pool over 80 feet in length (Figure 11). Fishing-related paraphernalia was also commonly observed in this area, which suggested relatively high angler use in comparison to most HSI study sites.

Figure 11. Man-made rock dams and pools in the LNF new study site.

The resulting HSI score for the LNF new study site was 0.76 (Table 2), which was the second highest score of all 10 study sites (only the UNF new site was higher). The LNF new score was slightly higher than the LNF mid score (0.74), largely due to the increased pool class rating and adult cover variables, both of which could be directly attributable to the man-made increase in pool sizes and depths. The artificial dams also produced the highest proportion of pool habitat of any study site, at 70% by length vs. 40-50% for most other headwater sites. However, because the HSI curve for % pools gives a maximum score (of 1.0) for all percentages between 35% and 65% (Raleigh et al. 1984), the artificial increase in % pools may not have affected the overall HSI score.

LNF mid. The LNF mid study site occurred below the Wheeler Gorge proper, but it did contain sampling units within highly confined canyon walls. Unlike the LNF new site, the LNF mid site showed very little evidence of human activity, whether swimming or fishing. The 2007 HSI score of 0.74 was essentially unchanged from 2006 (Table 2, Figure 6). The only individual HSI variable that changed appreciably was for vegetative cover, which suggested a minor recovery from the 2005-2006 flood events but remained well below the 2003 value (Figure 7)

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 7). 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 13). 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.

Combined Study Sites. The weighted HSI score for the middle segment remained essentially unchanged from 0.71 in 2006 to 0.72 in 2007 (Table 2), because the high score for the LNF new study site (at 0.76) exceeded the 2006 score for the LNF low site (at 0.70), thus counteracting the decrease in the Ven 5 score. The 2007 middle segment score is approximately 7% higher than the lower segment score of 0.67, which suggests much less distinction between segments than in 2006 when the middle segment score was 16% greater than the lower segment.

Upper Segment

The upper segment was represented by four study sites entirely above Matilija Dam (Figure 1, Table 1). Study sites Mat 3, Mat 5, and Mat 7 all occurred in the mainstem Matilija Creek, whereas UNF new occurred in the principal tributary, the Upper North Fork. The UNF new site was not sampled in 2006, but comparative HSI data is available for that site from the 2003 study (TRPA 2004). Like in 2006, potential *O. mykiss* rearing habitat in headwater areas above impassable barriers and in Murietta Creek were not sampled in 2007 and thus are not accounted for in the HSI scores or fish abundance data. Unlike 2006, extensive areas of the mainstem Matilija Creek were dry in 2007, including much of the channel between Mat 3 and Mat 5, as well as the channel above the Murietta Creek confluence upstream to the beginning of the Matilija canyon below Mat 7 (Figure 1). These dry channels represent zero habitat, and the upper segment HSI score was only based on the estimated lengths of wetted channel.

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. Spot measurements of water temperatures during August fish sampling above and below the hot springs area suggested that the springs increased the stream temperature in lower Mat 3 by approximately 2-3$^{o}$C in 2006 and 3-4$^{o}$C in 2007.

The overall HSI score for Mat 3 of deceased by 7% from 0.73 in 2006 to 0.68 in (Table 2, Figure 6). This decrease was largely due to a change in the Vs score, which dropped from 0.79 to 0.52 (Figure 7). Because the estimated "trib effects" score was only 0.01, the new variable did not affect the HSI score for Mat 3. Although 7-9 gravel patches were measured for Vs variables in both years, the lower score in 2007 was partly due to the presence of a large gravel patch in one pool habitat that provided significant spawning habitat in 2006, but was heavily silted (and thus of low quality) in 2007 (Figure 12).

Figure 12. Mat 3 pool habitat with gravel deposit along right bank, 2006 (left) vs. 2007 (right).

Mat 5. The Mat 5 study site occurs upstream of the Mat 3 study site, immediately above a 1½ mi stretch of private property, much of which was dry in the summer of 2007. 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). However, a diversion canal containing Upper North Fork water flows through the Matilija Canyon Resort and discharges into Matilija Creek at the top of the Mat 5 site. Because the flow in the canal was substantial (it comprised ½ of Mat 5's 1.2 cfs in late-July 2007), well shaded, and cool (17°C vs. 25°C in the mainstem), it was assumed for the "trib effects" analysis that immigration of trout fry could occur from the canal.

Figure 13. Example of stagnant pool near the bottom of Mat 5.

Despite the direct addition of canal flow into the Mat 5 study site, the mainstem surface flow continually receded in the downstream direction until the flow went completely subsurface at the bottom boundary. Dead sticklebacks were observed in the lowermost pool, and the habitat did not appear capable of supporting trout in the lower 1,300 ft of the study site (Figure 13). Consequently, the HSI data and fish sampling was confined to the remaining portion of the study site, and the associated HSI score and fish abundance estimates only represent the upper, sampled half of the Mat 5 study site. Above Mat 5, surface flow existed in the mainstem to a point just upstream of the Murietta Creek confluence. Above that point, surface flow was non-existent until the mouth of the Matilija Canyon approximately two miles further upstream.

Because of the low flow conditions, the 2007 HSI score was based on a reduced set (17) of mesohabitat units (Table 1). Despite the reduced flow, the flow-related HSI variables showed little change (Figure 7), yet the overall HSI score for this study site increased from 0.63 in 2006 to 0.69 in 2007 (Figure 6). Most of this change was due to an increase in the pool class rating (from 0.3 to 0.6), which exerts effects on both the juvenile and adult components of the HSI score. The increase in pool class rating occurred because the largest (and therefore most influential) pool sampled in 2006 received a low quality rating, but this pool was excluded in 2007 due to its location in the lower, stagnant portion of the study site. Consequently, the overall pool class rating was greater in 2007 in the absence of that unit. A minor increase in the Vs score in 2007 from 0.46 to 0.52 also contributed to the increased study site score. Application of the "trib effects variable" in the Mat 5 study site produced a score of 0.50, which was slightly less than the Vs score; consequently the trib effects variable was not employed in calculating the overall HSI score.

Mat 7. The Mat 7 study site begins above the mouth of the Matilija Canyon and is a relatively steep, confined channel with perennial surface flow and deep bedrock and boulder-formed pools (Figure 14). This site occurs near the head of a hiking trail and thus receives significant recreational use, including swimming and (presumably) fishing. Unlike the LNF new site, however, there was little evidence of habitat alterations as the swimming "holes" were naturally ideal.

The HSI score for Mat 7 showed a 13% increase from 0.63 in 2006 to 0.71 in 2007 (Figure 6). Two factors were largely responsible for this increase: an increase in the Vs score from 0.3 to 0.4 (Figure 7), and an increase in the pool class rating (from mostly 2nd class pools to mostly 1st class pools). The pool class rating is a fairly subjective classification that may vary according to the individual mapper. Because the pool class rating exerts significant influence on both the juvenile and the adult rearing component scores, the change in pool class suitability (from 0.6 to 1.0) can have important effects on the overall study site score.

Figure 14. Example of bedrock pool in Mat 7.

UNF new. The UNF new study site was located just below an unconfined reach of the Upper North Fork (Figure 1), and extended downstream into a narrow, bedrock and boulder-dominated channel. Streamflows during the July 2007 survey declined substantially from the lower, confined portion of the study area to the upper unconfined portion, presumably due to the influence of underlying bedrock which was clearly more dominant in the lower one-half of the study site. This change in flow and channel characteristics also resulted in a gradient of mesohabitat characteristics, such as unit dimensions, water velocities, and thalweg depths (Figure 15).

Figure 15. Examples of pools in the lower (left) and upper (right) portions of UNF new site.

This study site was not sampled for HSI data or fish abundance in 2006, but an HSI was estimated in this site in 2003 (referred to as "UNF low" in TRPA 2004). The 2007 HSI scores (like the 2006 scores in other sites) were based on newly selected sampling units, therefore the revised score for the UNF new site did not use the same pools, flatwaters, and riffles as before (unless selected by chance). Consequently, changes in the HSI score from 2003 to 2007 could be due in part to differences in the randomly selected units. The 2007 HSI score of 0.82 was 12% higher than the 2003 score of 0.73 (Figure 6). There were numerous minor increases and decreases among the 20 or so individual HSI variable scores, but the changes that were most responsible for the increased overall score were the increases in % pools and Vs (Figure 7). Changes in mesohabitat type composition is not wholly unexpected given the winter and spring flood events of 2005 and 2006, however it is most likely that the much lower flow conditions that existed during mesohabitat mapping in 2007 (0.2 cfs in July) versus 2003 (3.2 cfs in March) is most responsible for the apparent increase in pool habitat. For example, as flows decrease, flatwater habitats lose velocity and often take on the appearance of shallow pools, thus the increase in % pools. If the 2007 HSI scores for % pools and Vs were replaced with the 2003 values, an overall study site score of only 0.71 would result, which is similar to the original 2003 estimate.

Combined Study Sites. When the HSI scores for the four upper segment study sites were weighted according to the channel lengths they represented, an upper segment score of 0.74 was the result (Table 2). This segment score is essentially unchanged from the 2006 score of 0.73 (TRPA 2007), and it reflects the large influence of the UNF score which represents almost four miles of high quality habitat in the Matilija Creek Basin.

## 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 were deep enough for diving only in the Ven 1 and Ven 2 study sites). Single-pass dive counts were calibrated with a subsample of multiple-count habitat units. The basic fish statistics for each study site and habitat type are shown in Table 3, with associated figures for abundance and density in #/100ft$^2$ for *O. mykiss* fry (<10cm FL) and juvenile+ (see below). Estimates pooled among study sites to represent abundance and density at the study segment scale are also presented. Detailed information on dive counts or electrofishing captures are available in Appendix B. Example photos of most study sites are presented above; photos of each habitat unit sampled in 2007 are available on CD by request. Additional photos representative of each study site from 2006 are found in TRPA 2007.

Length-frequency distributions clearly show the strong dominance of the smaller fry *O. mykiss* year-class in all study sites (Figure 16). This size class is presumed to represent mostly young-of-year fish from spawning earlier in 2007. The paucity of larger juvenile+ fish is in marked contrast to 2006 (thin red lines in Figure 16), when larger *O. mykiss* were more commonly observed or captured in all of the middle and upper segment study sites (Figure 17). The length data also showed that fry were smaller in 2007 than in 2006. These comparative length-frequency distributions differed significantly (Wilcoxon signed-rank test, *P*'s<0.01) for all study sites where *O. mykiss* were captured in both years.

Table 3. 2007 fish abundance estimates according to study site.

| Size Class | Habitat Type | Statistic | Ven 1 | Ven 2 | Ven 3 | Ven 4 | Ven 5 | LNF new | LNF mid | Mat 3 | Mat 5 | Mat 7 | UNF new |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fry <10cm | Pools | # Units Sampled | 7 | 6 | 6 | 0 | 8 | 8 | 8 | 8 | 7 | 8 | 8 |
| | | Abundance | 0 | 0 | 0 | 0 | 7 | 111 | 214 | 0 | 37 | 106 | 84 |
| | | Variance | 0 | 0 | 0 | 0 | 6 | 385 | 4117 | 0 | 24 | 85 | 650 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 6 | 46 | 152 | 0 | 12 | 22 | 60 |
| | | Density (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 34.3 | 382.4 | 1,012.0 | 0.0 | 292.8 | 514.8 | 488.6 |
| | | Variance (#/mi) | 0.00 | 0.00 | 0.00 | 0.00 | 150.39 | 4,551.76 | 92,331.71 | 0.00 | 1,515.09 | 1,993.38 | 22,183.82 |
| | | 95% C.I. (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 29.0 | 159.5 | 718.5 | 0.0 | 95.2 | 105.6 | 352.2 |
| | | Density (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.41 | 1.71 | 0.00 | 0.32 | 0.52 | 0.97 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0053 | 0.2640 | 0.0000 | 0.0019 | 0.0020 | 0.0882 |
| | | 95% C.I. (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.17 | 1.22 | 0.00 | 0.11 | 0.11 | 0.70 |
| | Flatwaters | # Units Sampled | 8 | 8 | 8 | 0 | 8 | 8 | 8 | 8 | 6 | 7 | 8 |
| | | Abundance | 0 | 0 | 0 | 0 | 42 | 85 | 289 | 34 | 231 | 105 | 291 |
| | | Variance | 0 | 0 | 0 | 0 | 234 | 88 | 1421 | 216 | 3085 | 366 | 1611 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 36 | 22 | 89 | 35 | 143 | 47 | 95 |
| | | Density (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 177 | 1,166 | 1,936 | 129.1 | 986 | 967 | 1,868 |
| | | Variance (#/mi) | 0.00 | 0.00 | 0.00 | 0.00 | 4,122 | 16,524 | 63,944 | 3,084.55 | 56,210 | 30,900 | 66,463 |
| | | 95% C.I. (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 152 | 304 | 598 | 131.3 | 609 | 430 | 610 |
| | | Density (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 2.04 | 4.26 | 0.09 | 1.64 | 2.06 | 4.11 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0027 | 0.0508 | 0.3101 | 0.0014 | 0.1551 | 0.1399 | 0.3223 |
| | | 95% C.I. (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.53 | 1.32 | 0.09 | 1.01 | 0.92 | 1.34 |
| | Riffles | # Units Sampled | 8 | 8 | 8 | 0 | 8 | 8 | 8 | 8 | 4 | 7 | 8 |
| | | Abundance | 0 | 0 | 0 | 0 | 83 | 94 | 73 | 9 | 40 | 67 | 224 |
| | | Variance | 0 | 0 | 0 | 0 | 365 | 48 | 22 | 0 | 0 | 61 | 433 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 44 | 16 | 11 | 0 | 0 | 19 | 49 |
| | | Density (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 866 | 2,121 | 1,438 | 108.2 | 542 | 1,047 | 3,184 |
| | | Variance (#/mi) | 0.00 | 0.00 | 0.00 | 0.00 | 39,431 | 24,439 | 8,509 | 0.00 | 0 | 14,925 | 87,707 |
| | | 95% C.I. (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 458 | 370 | 218 | 0.0 | 0 | 299 | 700 |
| | | Density (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 2.83 | 3.13 | 0.09 | 1.60 | 1.93 | 7.63 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0526 | 0.0435 | 0.0403 | 0.0000 | 0.0000 | 0.0505 | 0.5041 |
| | | 95% C.I. (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.53 | 0.49 | 0.47 | 0.00 | 0.00 | 0.55 | 1.68 |

Table 3. (continued).

| Size Class | Habitat Type | Statistic | Ven 1 | Ven 2 | Ven 3 | Ven 4 | Ven 5 | LNF new | LNF mid | Mat 3 | Mat 5 | Mat 7 | UNF new |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fry <10cm | All Habitats | # Units Sampled | 23 | 22 | | 0 | 24 | 24 | 24 | 24 | 17 | 22 | 24 |
| | | Abundance | 0 | 0 | 0 | 0 | 132 | 290 | 575 | 44 | 308 | 278 | 598 |
| | | Variance | 0 | 0 | 0 | 0 | 605 | 521 | 5560 | 216 | 3109 | 512 | 2694 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 51 | 47 | 155 | 31 | 120 | 47 | 108 |
| | | Density (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 250 | 711 | 1,400 | 93 | 1,001 | 734 | 1,506 |
| | | Variance (#/mi) | 0.00 | 0.00 | 0.00 | 0.00 | 2,152 | 3,128 | 32,917 | 983 | 32,867 | 3,568 | 17,080 |
| | | 95% C.I. (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 96 | 116 | 377 | 65 | 389 | 125 | 272 |
| | | Density (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.84 | 2.66 | 0.07 | 1.10 | 0.96 | 3.22 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0013 | 0.0044 | 0.1193 | 0.0005 | 0.0397 | 0.0061 | 0.0780 |
| | | 95% C.I. (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.14 | 0.72 | 0.05 | 0.43 | 0.16 | 0.58 |
| Juv+ $\geq$10cm | Pools | # Units Sampled | 7 | 6 | 6 | 0 | 8 | 8 | 8 | 8 | 7 | 8 | 8 |
| | | Abundance | 0 | 0 | 4 | 0 | 0 | 16 | 51 | 0 | 29 | 52 | 79 |
| | | Variance | 0 | 0 | 0 | 0 | 0 | 48 | 205 | 0 | 0 | 127 | 849 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 0 | 16 | 34 | 0 | 0 | 27 | 69 |
| | | Density (#/mi) | 8 | 0.0 | 15.7 | 0.0 | 0.0 | 55 | 239 | 0.0 | 230 | 253.9 | 461.9 |
| | | Variance (#/mi) | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 568 | 4,603 | 0.00 | 0 | 2,993.09 | 28,971.97 |
| | | 95% C.I. (#/mi) | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 56 | 160 | 0.0 | 0 | 129.4 | 402.5 |
| | | Density (#/100ft$^2$) | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.06 | 0.40 | 0.00 | 0.25 | 0.26 | 0.92 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0007 | 0.0132 | 0.0000 | 0.0000 | 0.0030 | 0.1151 |
| | | 95% C.I. (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.27 | 0.00 | 0.00 | 0.13 | 0.80 |
| | Flatwaters | # Units Sampled | 8 | 8 | 8 | 0 | 8 | 8 | 8 | 8 | 6 | 7 | 8 |
| | | Abundance | 0 | 0 | 0 | 0 | 3 | 1 | 26 | 7 | 39 | 6 | 23 |
| | | Variance | 0 | 0 | 0 | 0 | 8 | 0 | 39 | 25 | 425 | 6 | 11 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 6 | 1 | 15 | 12 | 53 | 6 | 8 |
| | | Density (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 14 | 17 | 176 | 26 | 166 | 54 | 149 |
| | | Variance (#/mi) | 0.00 | 0.00 | 0.00 | 0.00 | 132 | 60 | 1,759 | 360 | 7,740 | 504 | 445 |
| | | 95% C.I. (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 27 | 18 | 99 | 45 | 226 | 55 | 50 |
| | | Density (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.39 | 0.02 | 0.28 | 0.11 | 0.33 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0085 | 0.0002 | 0.0214 | 0.0023 | 0.0022 |
| | | 95% C.I. (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.22 | 0.03 | 0.38 | 0.12 | 0.11 |

Table 3. (continued).

| Size Class | Habitat Type | Statistic | Ven 1 | Ven 2 | Ven 3 | Ven 4 | Ven 5 | LNF new | LNF mid | Mat 3 | Mat 5 | Mat 7 | UNF new |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Juv+ ≥10cm | Riffles | # Units Sampled | 8 | 8 | 8 | 0 | 8 | 8 | 8 | 8 | 4 | 7 | 8 |
| | | Abundance | 0 | 0 | 0 | 0 | 7 | 6 | 14 | 0 | 1 | 0 | 11 |
| | | Variance | 0 | 0 | 0 | 0 | 5 | 0 | 31 | 0 | 0 | 0 | 4 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 5 | 0 | 13 | 0 | 0 | 0 | 5 |
| | | Density (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 69 | 135 | 270 | 0 | 14 | 0 | 159 |
| | | Variance (#/mi) | 0.00 | 0.00 | 0.00 | 0.00 | 567 | 0 | 12,040 | 0 | 0 | 0 | 740 |
| | | 95% C.I. (#/mi) | 0.0 | 0.0 | 0.0 | 0.0 | 55 | 0 | 259 | 0 | 0 | 0 | 64 |
| | | Density (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.18 | 0.59 | 0.00 | 0.04 | 0.00 | 0.38 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0008 | 0.0000 | 0.0571 | 0.0000 | 0.0000 | 0.0000 | 0.0043 |
| | | 95% C.I. (#/100ft$^2$) | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.56 | 0.00 | 0.00 | 0.00 | 0.15 |
| | All Habitats | # Units Sampled | 23 | 22 | 22 | 0 | 24 | 24 | 24 | 24 | 17 | 22 | 24 |
| | | Abundance | 0 | 0 | 4 | 0 | 10 | 23 | 90 | 7 | 69 | 58 | 114 |
| | | Variance | 0 | 0 | 0 | 0 | 13 | 48 | 275 | 25 | 425 | 133 | 864 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 7 | 14 | 35 | 10 | 44 | 24 | 61 |
| | | Density (#/mi) | 0.0 | 0.0 | 4.3 | 0.0 | 19 | 57 | 220 | 15 | 159 | 154 | 286 |
| | | Variance (#/mi) | 0 | 0.00 | 0.00 | 0.00 | 45 | 290 | 1,630 | 115 | 2,252 | 927 | 5,476 |
| | | 95% C.I. (#/mi) | 0 | 0.0 | 0.0 | 0.0 | 14 | 35 | 84 | 22 | 102 | 64 | 154 |
| | | Density (#/100ft$^2$) | 0.0000 | 0.00 | 0.004 | 0.00 | 0.014 | 0.07 | 0.42 | 0.01 | 0.25 | 0.20 | 0.61 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0059 | 0.0001 | 0.0054 | 0.0016 | 0.0250 |
| | | 95% C.I. (#/100ft$^2$) | 0.000 | 0.00 | 0.00 | 0.00 | 0.011 | 0.04 | 0.16 | 0.02 | 0.16 | 0.08 | 0.33 |
| All RBT/STH | All Habitats | # Units Sampled | 23 | 22 | 22 | 0 | 24 | 24 | 24 | 24 | 17 | 22 | 24 |
| | | Abundance | 0 | 0 | 4 | 0 | 142 | 313 | 666 | 51 | 377 | 336 | 712 |
| | | Variance | 0 | 0 | 0 | 0 | 618 | 569 | 5835 | 242 | 3534 | 645 | 3558 |
| | | 95% C.I. | 0 | 0 | 0 | 0 | 52 | 50 | 159 | 32 | 128 | 53 | 124 |
| | | Density (#/mi) | 0.0 | 0 | 4 | 0.0 | 268 | 768 | 1,620 | 108 | 868 | 888 | 1,792 |
| | | Variance (#/mi) | 0 | 0 | 0 | 0.00 | 2,197 | 3,418 | 34,548 | 1,098 | 18,739 | 4,495 | 22,556 |
| | | 95% C.I. (#/mi) | 0 | 0 | 0 | 0.0 | 97 | 122 | 387 | 69 | 294 | 140 | 312 |
| | | Density (#/100ft$^2$) | 0.0000 | 0.000 | 0.004 | 0.00 | 0.21 | 0.91 | 3.08 | 0.08 | 1.35 | 1.16 | 3.83 |
| | | Variance (#/100ft$^2$) | 0.0000 | 0.000000 | 0.0000 | 0.0000 | 0.0013 | 0.0048 | 0.1252 | 0.0005 | 0.0451 | 0.0076 | 0.1030 |
| | | 95% C.I. (#/100ft$^2$) | 0.000 | 0.000 | 0.000 | 0.00 | 0.07 | 0.14 | 0.74 | 0.05 | 0.41 | 0.18 | 0.67 |

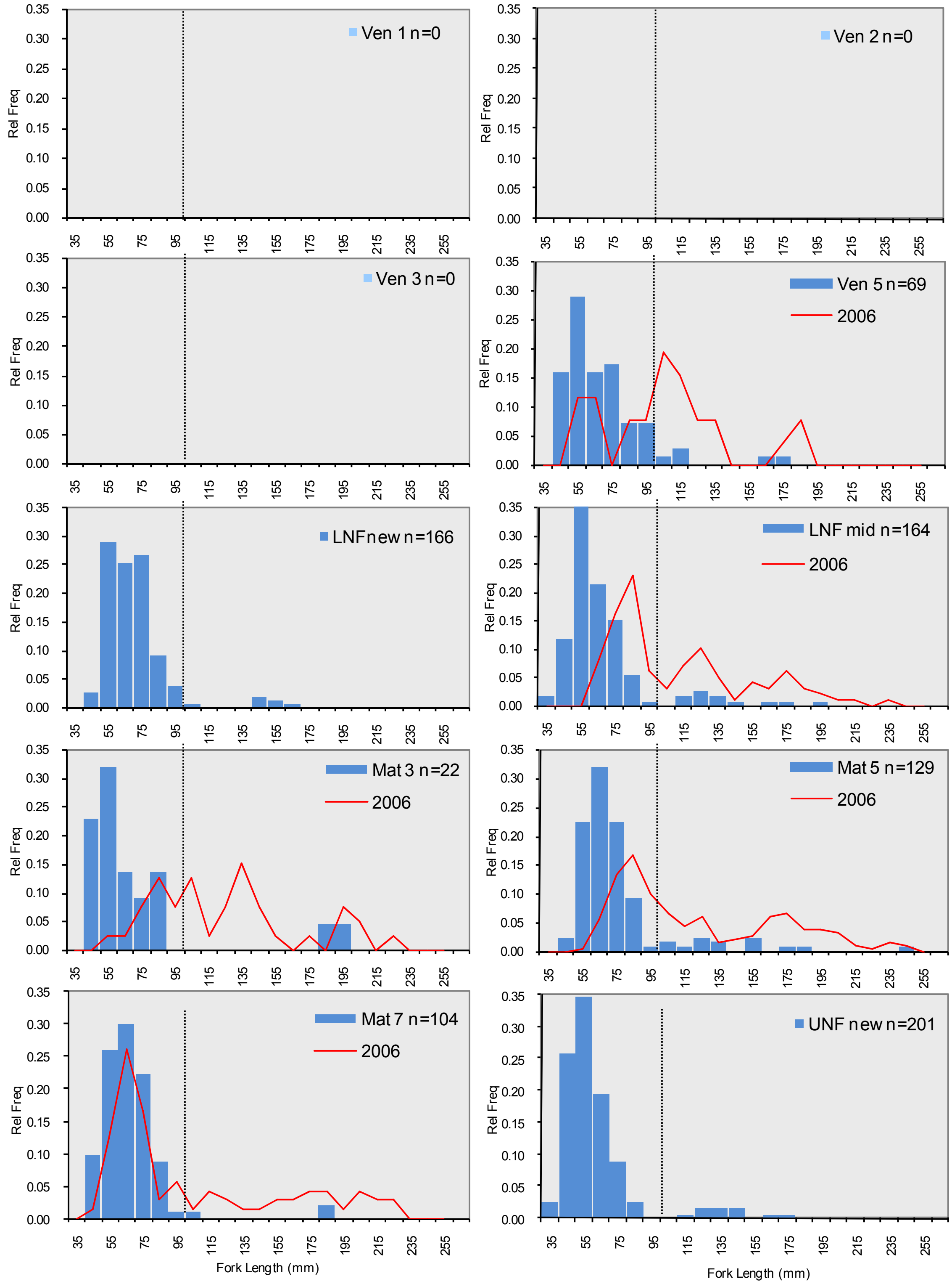


Figure 16. Relative length-frequency distributions of *O. mykiss* captured by electrofishing in 2007, according to study site. The thin red line represents the 2006 distribution (data not available for two sites). The vertical dotted line shows the fry vs. juvenile+ length criteria.

Lower Segment

Three study sites were sampled in the lower segment where *O. mykiss* were either not observed or were very rare (Figure 1, Table 3). Arroyo chub (*Gila orcutti*) and threespine stickleback (*Gasterosteus aculeatus*), in contrast, were observed in virtually every sampled habitat unit. Carp (*Cyprinus carpio*) were commonly seen in each study site, mostly in pools. Occasional sightings of crayfish and turtles occurred in the lower segment, along with one largemouth bass (*Micropterus salmoides*) and one sunfish (*Lepomis* sp.) in a Ven 3 pool just downstream of San Antonio Creek.

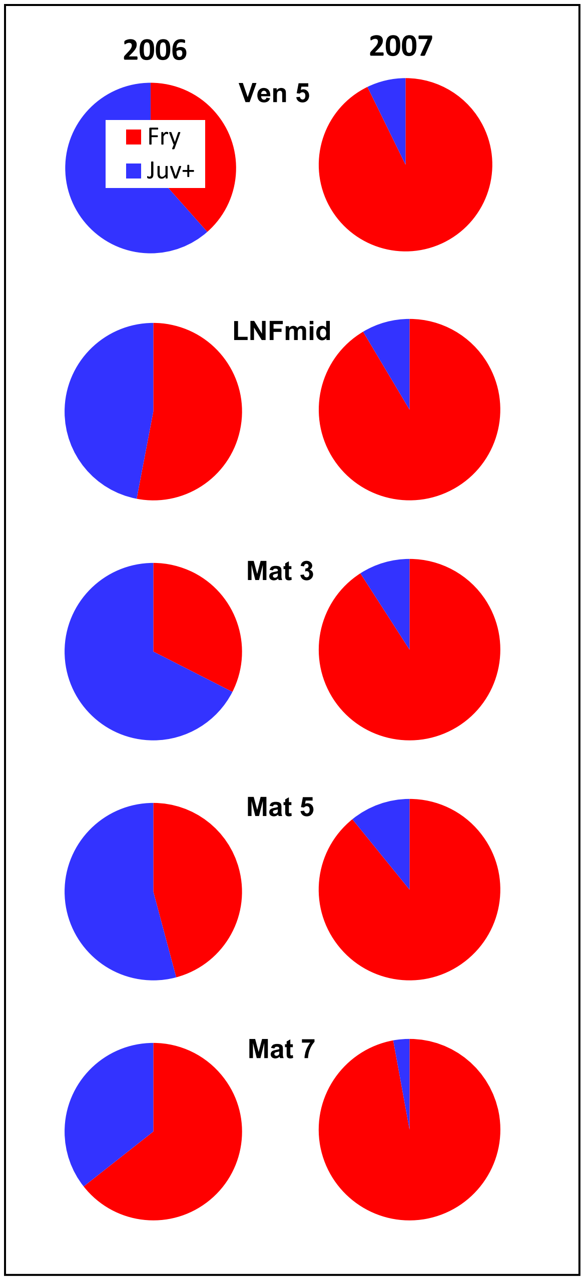


Figure 17. Relative proportion of *O. mykiss* fry and juvenile+ by year and study site.

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 1980). San Antonio Creek, a potentially important spawning and rearing tributary, meets the Ven 3 study site near its upper boundary. San Antonio Creek was flowing in the summer of 2006, but was dry at its mouth in 2007. Large bedrock pools, known or suspected to have provided important holding habitat for upstream adult steelhead (Mark Capelli, pers. comm.), occur in the Ven 2 and Ven 4 study sites, although the Ven 4 study site is typically dry during most summer months (including 2003 and 2007). The Ven 4 study site is located about 2,000 ft below 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. Fry or juvenile *O. mykiss* were not observed or captured in any of the 23 habitat units sampled in the Ven 1 study site in 2007 (Table 3, Figures 18-21), however divers observed two adult steelhead in two of the pool units. One of the adults (40-45 cm in length) displayed signs of fin rot, and was only seen on one occasion. The other, larger ($\geq$50 cm) adult was observed at the head of a pool on three consecutive days (17-19 July).

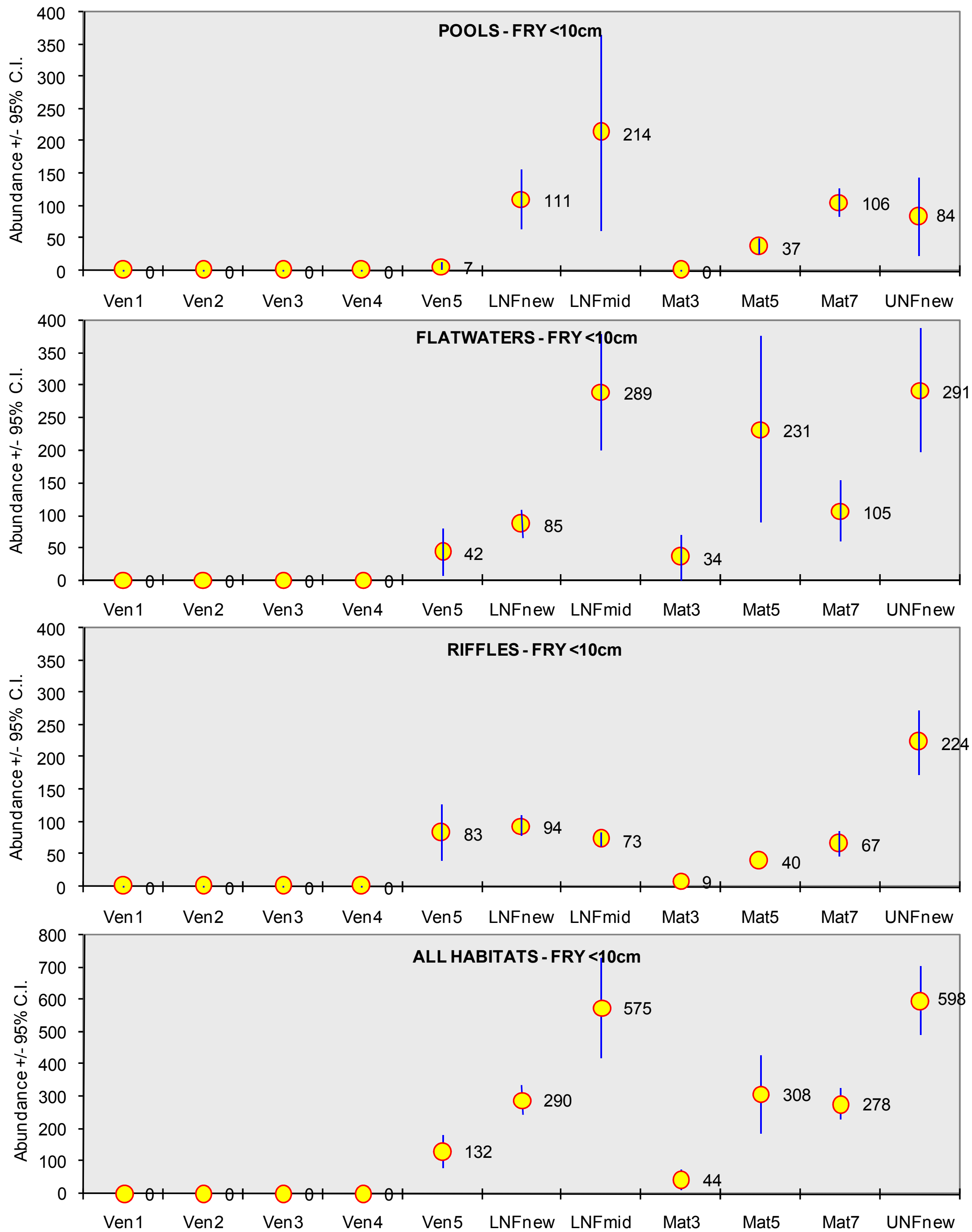


Figure 18. Estimated abundance of *O. mykiss* fry according to study site and habitat type. Vertical bars are 95% confidence intervals.

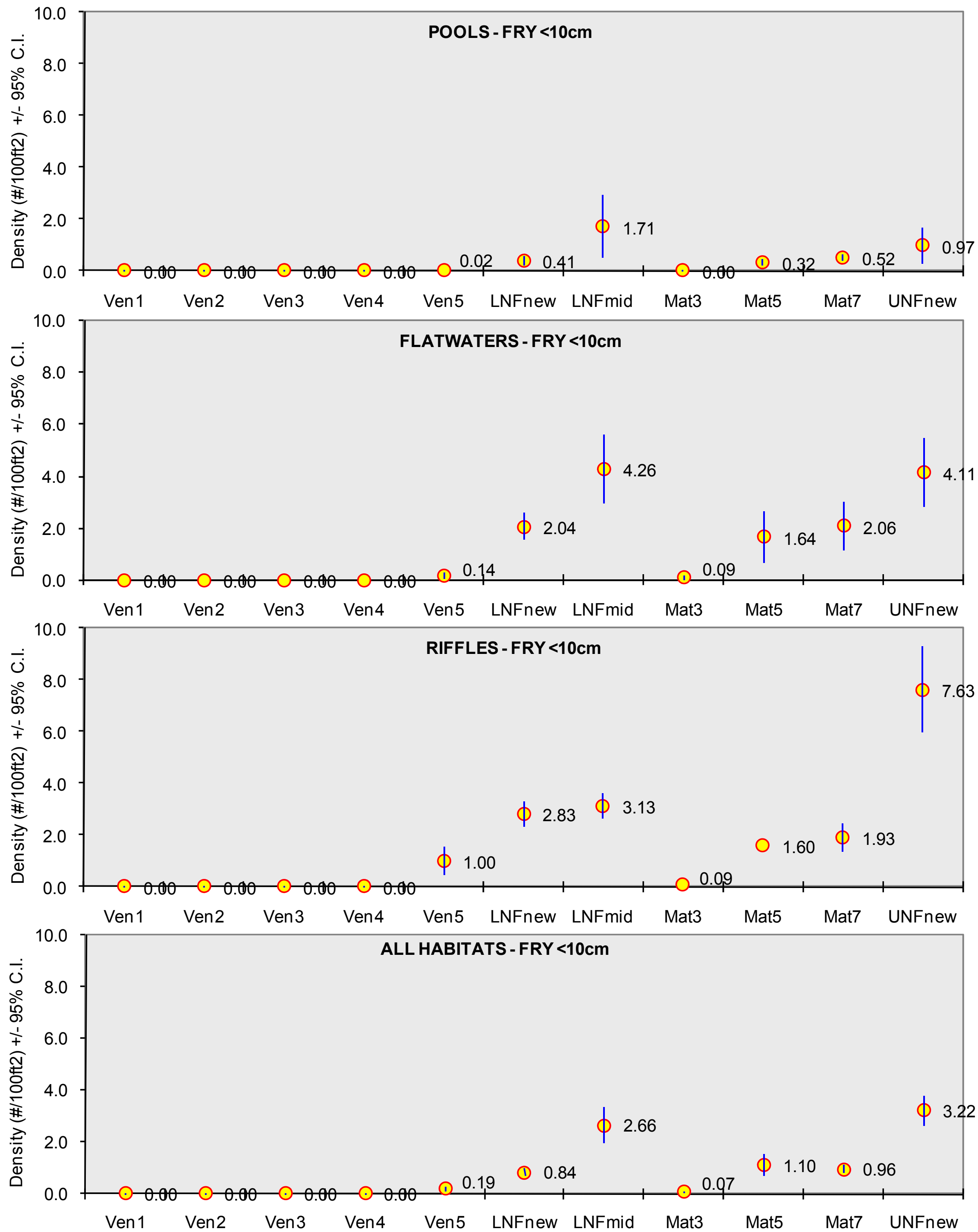


Figure 19. Estimated density (#/100ft$^2$) of *O. mykiss* fry according to study site and habitat type. Vertical bars are 95% confidence intervals.

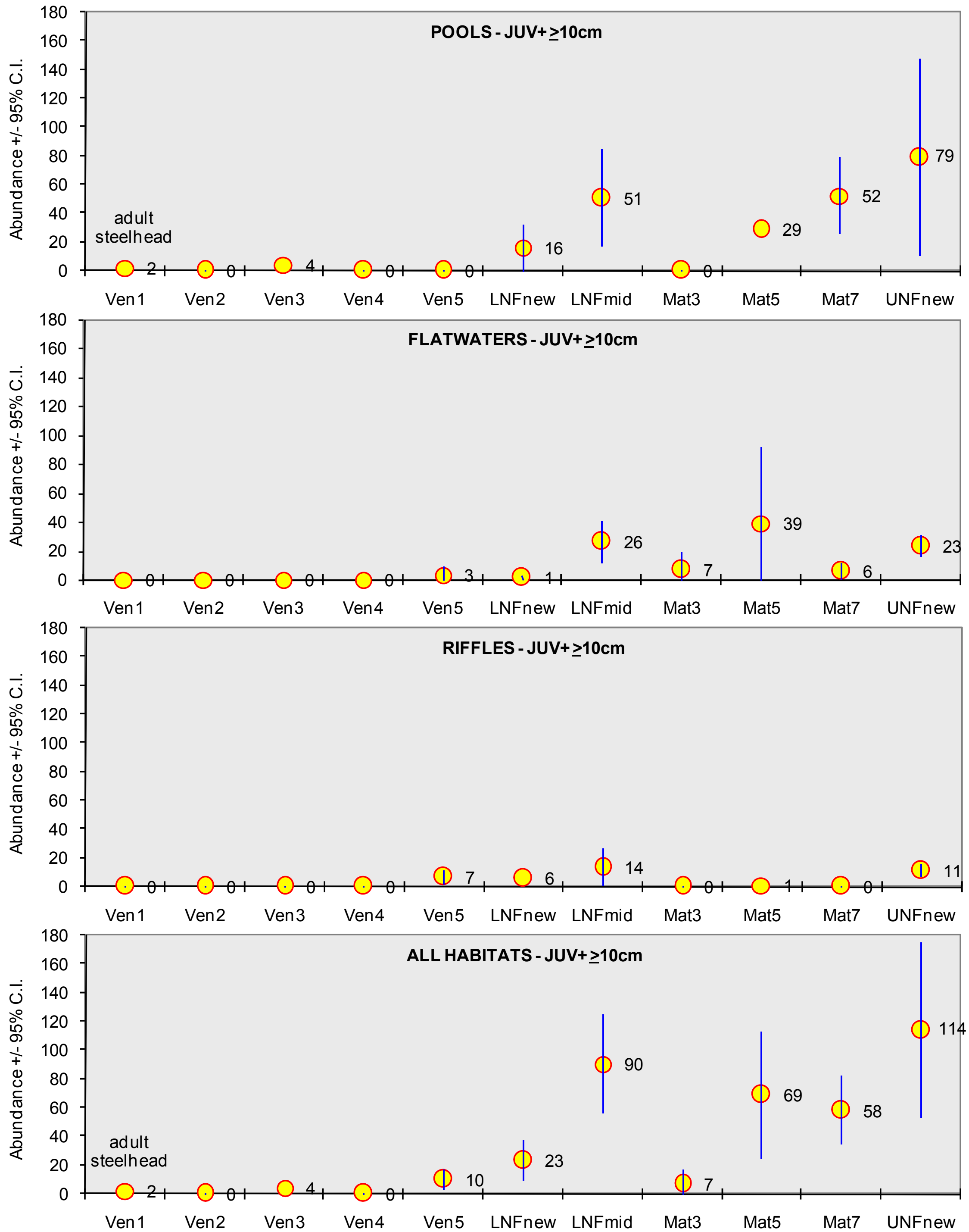


Figure 20. Estimated abundance of juvenile+ *O. mykiss* according to study site and habitat type. Vertical bars are 95% confidence intervals.

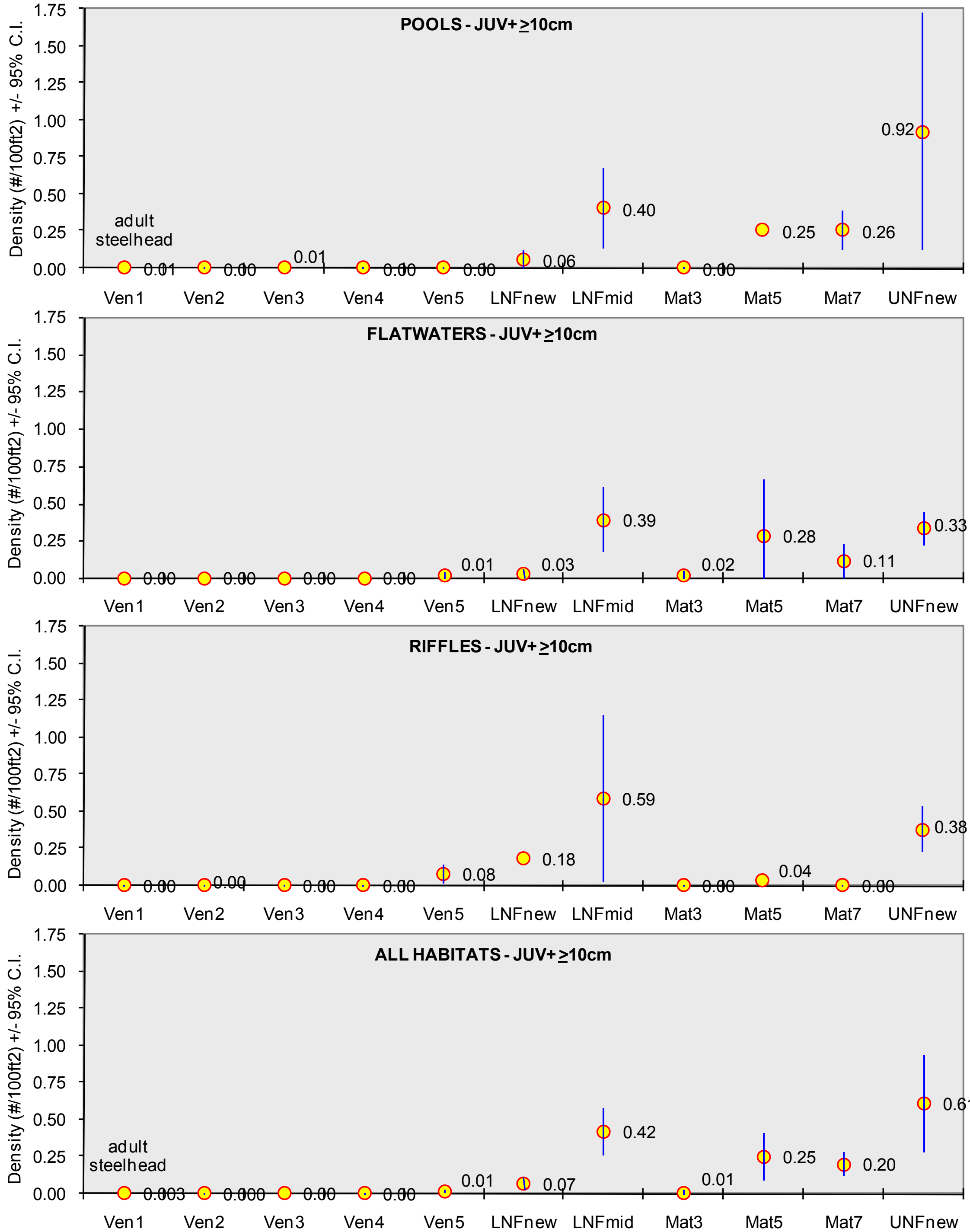


Figure 21. Estimated density (#/100ft$^2$) of juvenile+ *O. mykiss* according to study site and habitat type. Vertical bars are 95% confidence intervals.

Neither fish were observed on a subsequent visit to the two pools on 10 August, however two adult steelhead were observed by NOAA Fisheries personnel in early August farther upstream in the Ven 2 reach (Capelli 2007). These adult sightings were unusual given the midseason survey period, since adult outmigrants typically leave freshwater habitat during the spring months (Barnhart 1986), and even in July the riffle thalweg depths in Ven 1 (with a mean depth of 16 cm) and Ven 2 (mean 35 cm) appeared adequate to pass downstream migrant steelhead. Also, the Ventura Lagoon remained open during the spring of 2007.

The 2007 estimates of zero fry and zero juvenile+ (excluding the adult steelhead) were identical to the July 2006 estimates, when no fish were observed (Figures 22 and 23). Although only one *O. mykiss* 27cm in length (possibly of hatchery origin) was captured by CDFG electrofishing crews in June of 1995 (Capelli 1997), and summer rearing densities of salmonids appear consistently low in this lowermost reach, outmigrant steelhead adults and smolts must pass through this reach to enter the lagoon and ocean.

Ven 2. Twenty-two mesohabitat units were surveyed in Ven 2, including the "Shell Hole" and other long, bedrock pools (Table 3). Although no salmonids were captured or observed in July 2007 (Figures 18-21), *O. mykiss* were captured in 2006 with an estimated abundance of two fry and two juveniles (Figures 22 and 23). Also, as stated above, two adult steelhead were observed in the Ven 2 reach by NOAA Fisheries personnel in August, 2007 (Capelli 2007). Like the Ven 1 reach, salmonids do occupy the Ven 2 reach at times, but their summer densities are probably near-zero during most years.

Ven 3. Twenty-two mesohabitat units were also sampled in the Ven 3 study site, but juvenile+ *O. mykiss* were only observed in one pool habitat approximately 300 ft downstream of the San Antonio Creek mouth (Table 3, Figures 18-21). Resulting estimates of abundance were zero fry and four juvenile+ (at a density of 0.004 fish/100ft$^2$). These estimates are essentially unchanged from 2006 (Figures 22 and 23), when juvenile+ fish were only observed in the Ven 3/San Antonio Creek channel confluence pool.

The 2006 and 2007 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 1980). 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 and 2007 estimates of 0.004 fish/100ft$^2$ were only 4% of Moore's lower estimate, and may reflect a decline in hatchery influences on mainstem populations, a decline in anadromous returns to the Ventura River basin, a redistribution of steelhead spawning activities (to reaches further upstream) since the Robles fish ladder became operational, or other factors.

Ven 4. The Ven 4 study site was dry in 2007, unlike in 2006 when the deep pools were full and many riffles were flowing (although some were becoming stagnant in appearance, TRPA 2007). However, no live *O. mykiss* were captured or observed in

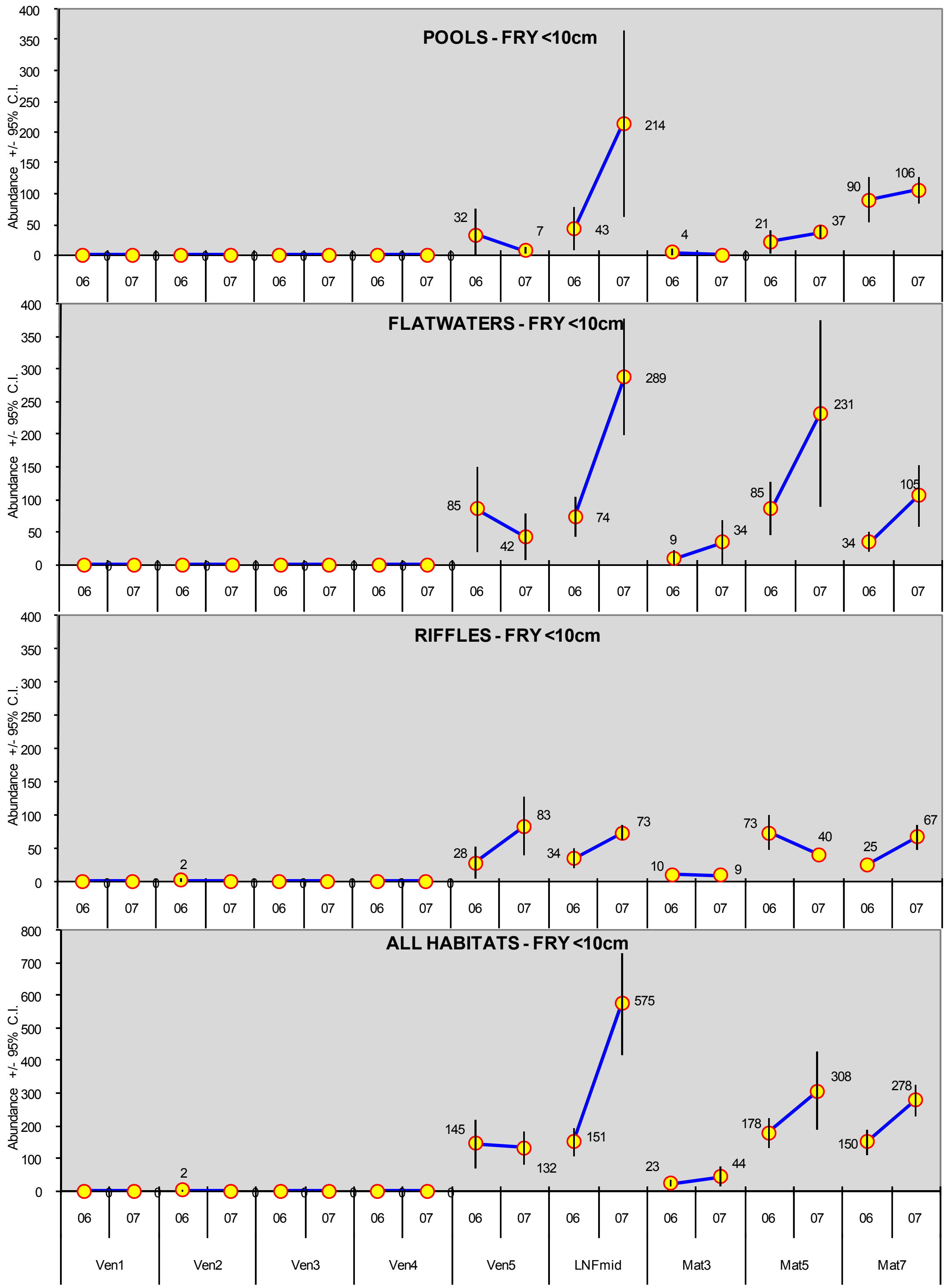


Figure 22. Annual comparison of *O. mykiss* fry abundance according to year, study site and habitat type. Vertical bars are 95% confidence intervals.

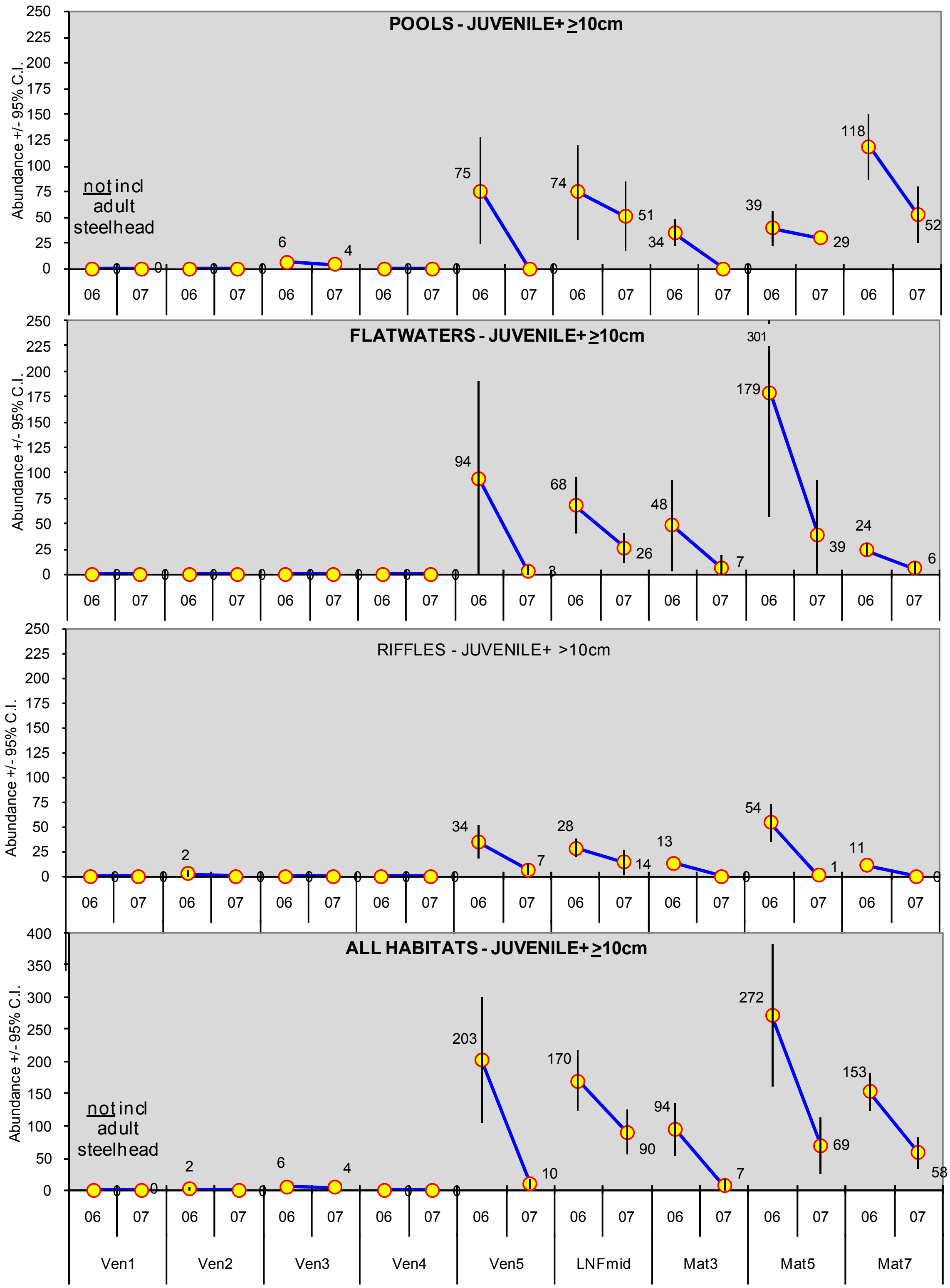


Figure 23. Annual comparison of *O. mykiss* juvenile+ abundance according to year, study site and habitat type. Vertical bars are 95% confidence intervals.

2006 (only one dead trout was found after sampling), consequently, estimates of abundance were zero in both years.

Combined Study Sites. The estimated abundance and density of *O. mykiss* in the entire lower segment in 2007 was very low at zero fry and 11 juvenile+ (0.0015 fish/100ft$^2$, excluding the adult steelhead) (Figures 24 and 25). These combined estimates are essentially unchanged from the near zero estimates from 2006 (Figures 26 and 27). *[Note that Figure 27 shows a minimal increase in estimated density occurred for juveniles in 2007, despite the lower abundance, due to the lower flows and reduced amount of habitat in the lower segment in 2007].*

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 2004-2005, and potentially gave steelhead new access to the middle segment for spawning and rearing. Four to seven, possibly anadromous, *O. mykiss*, were first observed to pass over the diversion dam during the winter and spring of 2006, thus demonstrating adult migration into the upper Ventura River (CMWD 2006). 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 new and LNF mid) are both in the lower North Fork downstream of the passage barrier at Wheeler Springs Campground, but above a new barrier at the Ojai Quarry, reportedly formed during a landslide in March of 2006 (Figure 10). Numerous small, resident trout and trout-sized redds were observed in the LNF during the initial habitat mapping in mid-March 2003 (TRPA 2003). Because of the presence of abundant rainbow trout and the formation of the quarry barrier in 2006, all of the *O. mykiss* fry captured in 2007 and many (if not all) of the juvenile+ fish were expected to be offspring of resident trout, rather than from anadromous parents.

Arroyo chub were observed in virtually every sampled habitat unit in sites Ven 5 and in many pools and flatwaters in the two LNF study sites. Sticklebacks, sunfish, and largemouth bass were also observed in the Ven 5 study site, but did not occur in the LNF. One turtle was observed in a Ven 5 pool. Black spot disease, a snail-borne trematode parasite, was present on *O. mykiss* in all of the middle segment study sites.

Ven 5. *O. mykiss* fry were observed or captured in some pools and flatwaters, and were present in all but one sampled riffle. Juvenile+ fish were less common and only occurred in four of the 24 sampled habitat units. Water temperatures in the Ven 5 study site were among the highest of all 10 study sites, with morning temperatures of 20$^o$C and afternoon maxima of 28$^o$C (Table 1). The 2007 estimates of abundance and density for fry in Ven 5 (all habitats combined) were 132 fish ±51 (95% confidence intervals) at 0.19 ±0.07 fish/100ft$^2$ (Table 3, Figures 18-19), which was very similar to the 2006 estimate of 145 fry (Figure 22). The 2007 abundance and density of juvenile+ fish (10 ±7 fish at 0.014 ±0.011 fish/100ft$^2$) was far below the 2006 estimate of 203 juvenile+ (Figure 20-21 and 23). This large and statistically significant decrease in juvenile+ abundance (based on

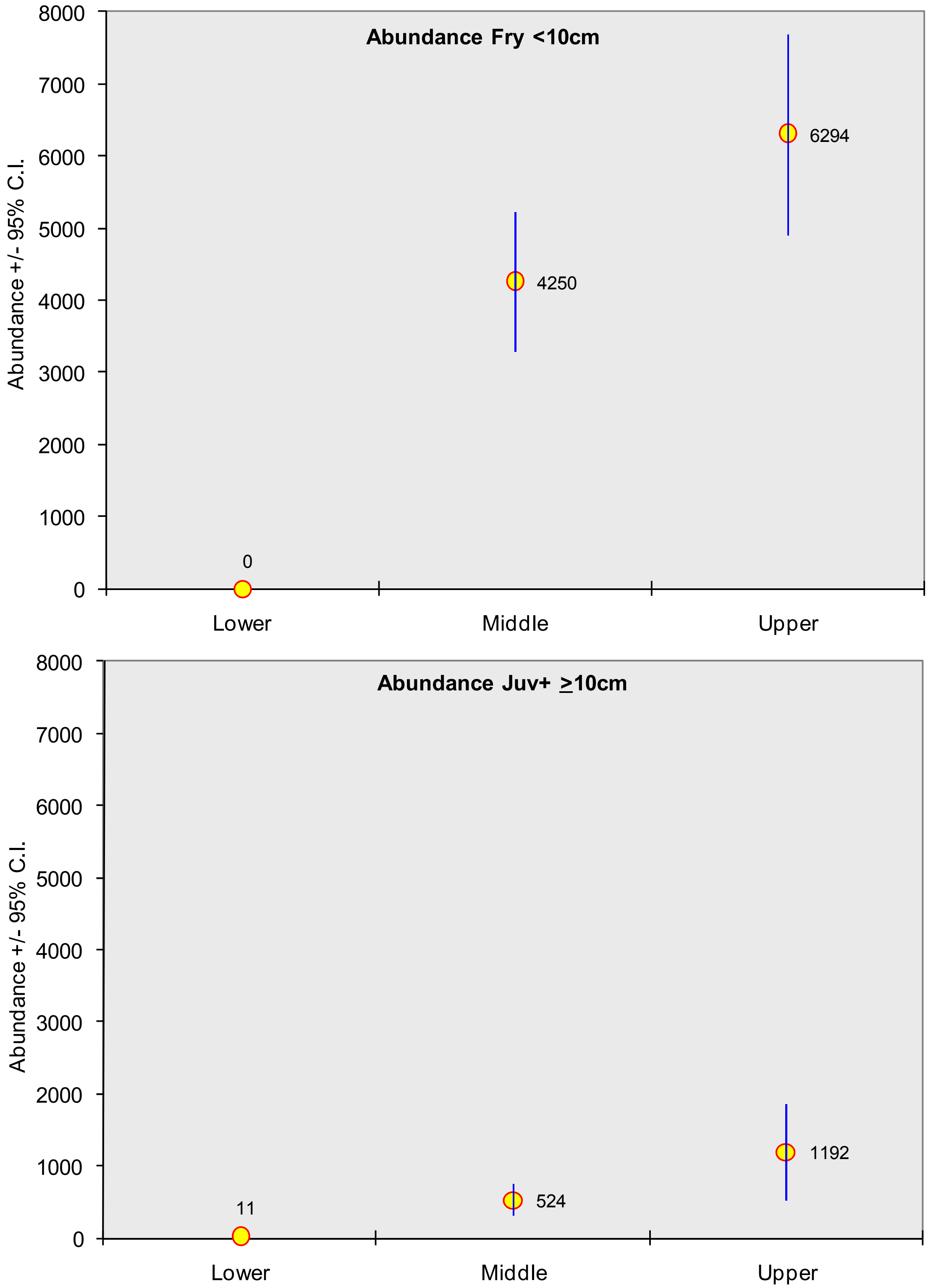


Figure 24. Estimated abundance of *O. mykiss* fry and juvenile+ according to study segment. Vertical bars are 95% confidence intervals.

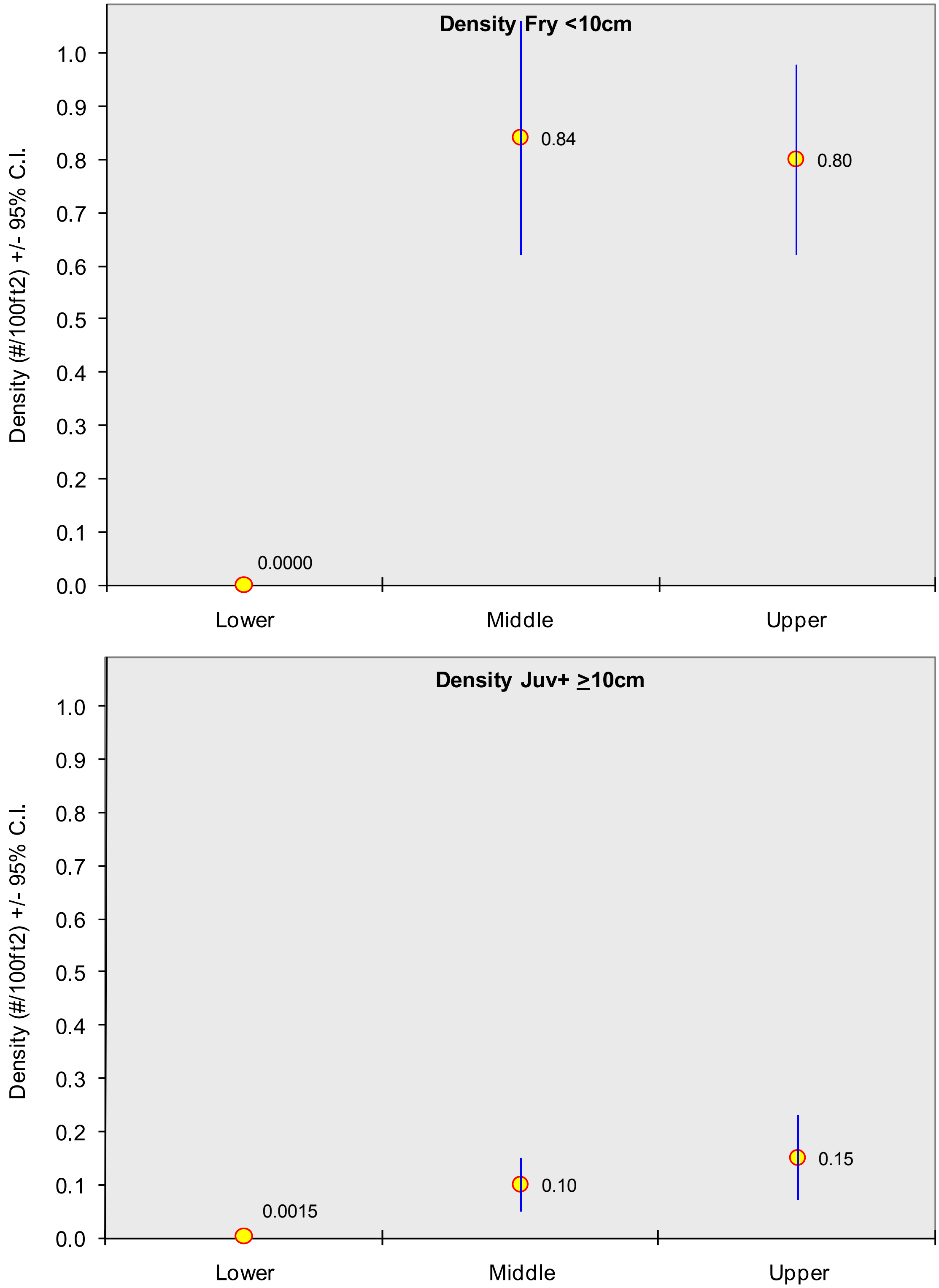


Figure 25. Estimated density (#/100ft$^2$) of *O. mykiss* fry and juvenile+ according to study segment. Vertical bars are 95% confidence intervals.

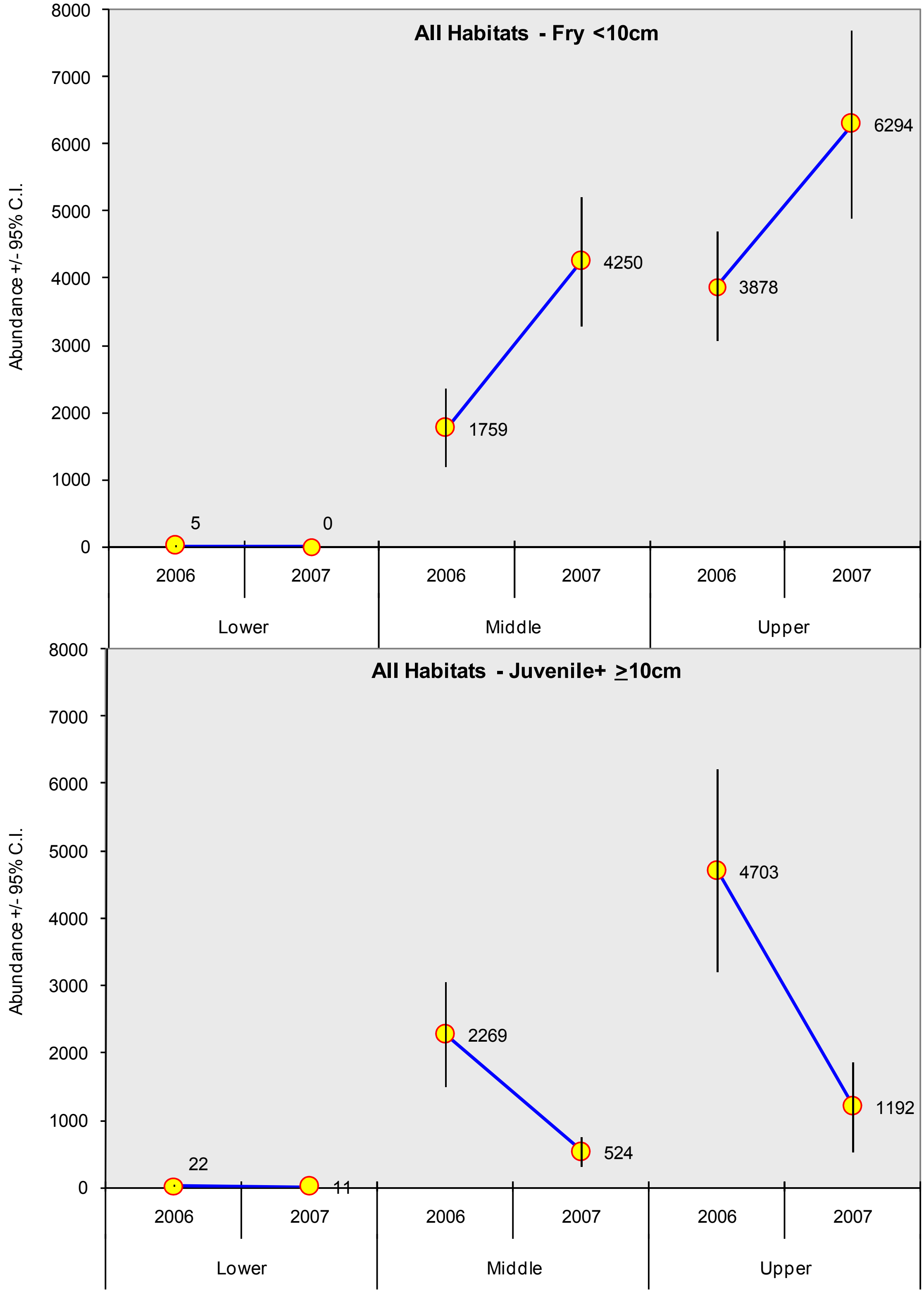


Figure 26. Annual comparison of *O. mykiss* fry and juvenile+ abundance according to year and study segment. Vertical bars are 95% confidence intervals.

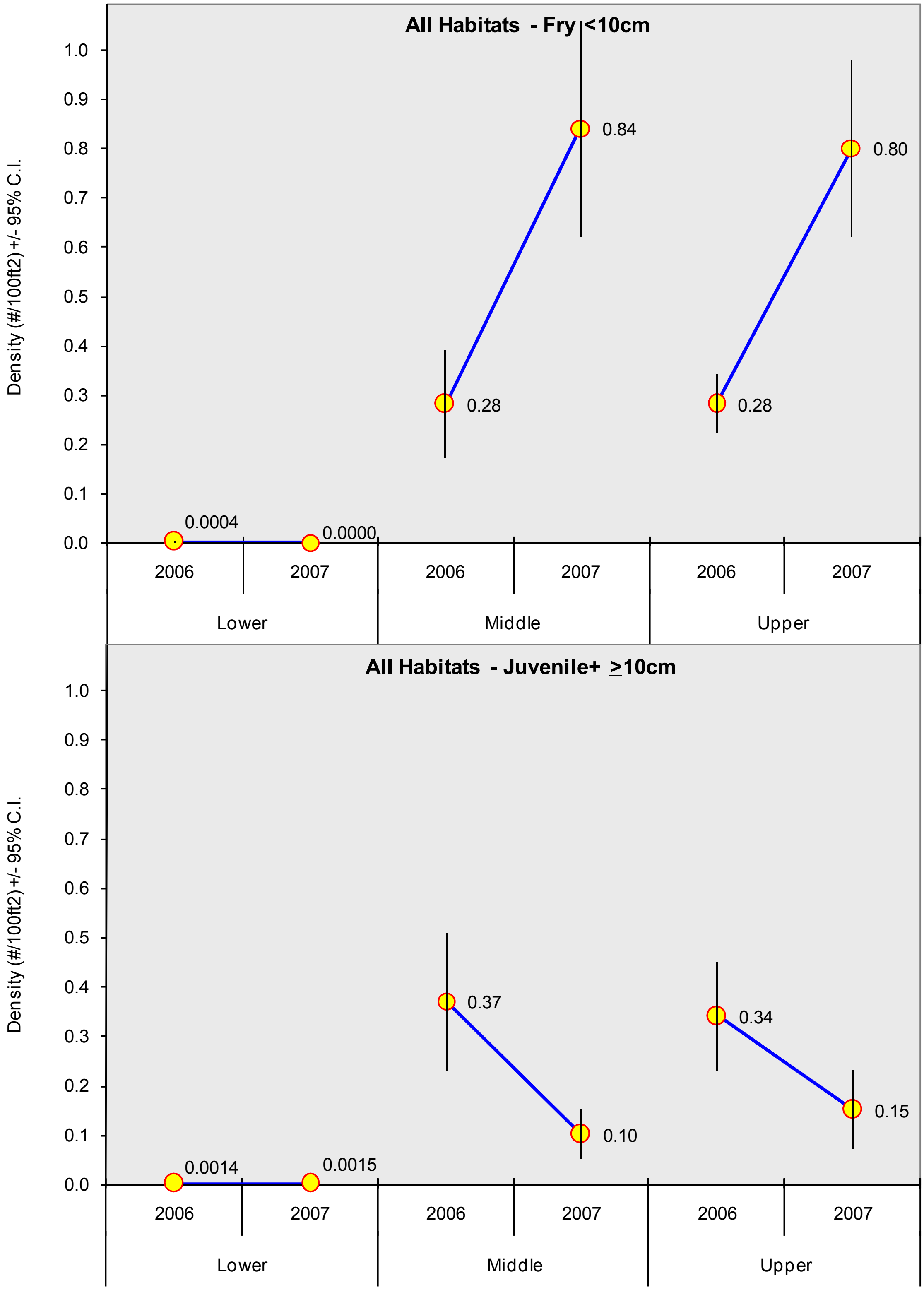


Figure 27. Annual comparison of *O. mykiss* fry and juvenile+ density (#/100ft$^2$) according to year and study segment. Vertical bars are 95% confidence intervals.

non-overlap of 95% confidence intervals) in 2007 was evident in all middle segment and upper segment study sites. In the Ven 5 study site (and most other sites with *O. mykiss*), fry densities were highest in riffles and lowest in pools. Juvenile+ fish in middle and upper segment sites did not show a consistent preference for one habitat type over another.

LNF new. This new study site on the Lower North Fork of Matilija Creek was highly altered by swimmers, who constructed many rock dams and formed a series of larger-than-normal pool habitats (Figure 11). Visual evidence also suggested significant angling in this area, in contrast to the LNF mid study site that showed little evidence of recreational use. Perhaps in part for those reasons, the abundance and density of *O. mykiss* was significantly less in the LNF new site than in the LNF mid site (Figures 18-21). An estimated 290 (±47) fry and 23 (±14) juvenile+ occurred in the new site, at densities of 0.84 (±0.14) and 0.07 (±0.04) fish/100ft$^2$, respectively (Table 3). Although fry were most abundant in pool habitats (Figure 18), densities were higher in flatwaters and highest in riffles (Figure 19). Juvenile+ fish also occurred at highest densities in riffles, similar to other middle segment study sites but unlike densities in the upper segment, where juvenile+ densities were highest in pools (Figure 21). This study site was not sampled in 2006, therefore annual changes could not be assessed.

LNF mid. Abundant spawning activity was observed in this study site during the April 2003 HSI study (TRPA 2003), and the 2007 abundance and density of fry and juvenile+ *O. mykiss* were higher in the LNF mid study site than in any other site except for the UNF new site (Figures 18-21). Fry were observed in all 24 sampled habitat unit, whereas juvenile+ fish which were observed in about one-half (13) of the units. Estimates of abundance of fry and juvenile+ were 575 (±155) fish and 90 (±35) fish, respectively (Table 3). Estimated densities of fry were 2.66 (±0.72) fish/100ft$^2$ overall, with highest densities in flatwaters and lowest densities in pools. Overall densities of juvenile+ were estimated at 0.42 (±0.16) fish/100ft$^2$, with a more even distribution among habitat types than seen for fry. The 2007 estimate of abundance for *O. mykiss* fry showed a large and statistically significant increase from 2006 (Figure 22), versus a substantial (47%), but non-significant, decrease for juvenile+ fish (Figure 23). These patterns were consistent with results from the Ven 5 study site as well as most of the upper segment study sites.

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 4,250 (±968) fry and 524 (±217) juvenile+, with overall densities of 0.84 (±0.22) fish/100ft$^2$ and 0.10 (±0.05) fish/100ft$^2$, respectively (Figures 24 and 25). These estimates were significantly higher than the near-zero estimates from the lower segment, but (for density) were similar to estimates from the upper segment above Matilija Dam. Comparison of middle segment abundance and density estimates from 2007 and 2006 reflects the site-specific results, with statistically significant increases in abundance and density of fry in 2007, and significant decreases in juvenile+ fish (Figures 26 and 27).

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 new 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). A diversion canal that carries cool water (and presumably contains *O. mykiss*) directly from the Upper North Fork enters the Mat 5 study site at its upper boundary. The Mat 5 study site is mostly a wide, open channel largely comprised of boulder-strewn riffles and flatwater habitats with few pools, and during sampling in August 2007 the lower 1,100 ft of the study site was mostly non-flowing, stagnant, and apparently devoid of fish. Consequently fish and HSI sampling was confined in 2007 to the upper portion of the study site. Mat 7 occurs within the upper mainstem canyon and supports a healthy riparian zone with a diverse variety of mesohabitat types. The new Upper North Fork study site is ¾ miles up the North Fork trail and is relatively pristine with heavy riparian growth. As previously described, this site crossed a transition from a relatively unconfined channel (with low flows) downstream into a bedrock confined channel with increased flow and water depths. This new site was expected to better represent the overall length of available habitat in the UNF, which includes both confined and unconfined reaches (TRPA 2003).

Both arroyo chub and stickleback were common in the Mat 3 and Mat 5 study sites, whereas only chub were occasionally observed in the UNF new site and neither species were observed in Mat 7. The exotic largemouth bass was observed in most Mat 3 pools (with occasional sunfish), but rarely in other habitat types and never in upstream sites. A few turtles were observed in the Mat 3 and UNF new sites, and were relatively common in Mat 7 pools. The presence of black spot disease was not reported in upper segment sites in 2007, but in 2006 it was common among *O. mykiss* captured in the Mat 5 and Mat 7 study sites.

Mat 3. Mat 3 contained *O. mykiss* despite the introduction of hot spring water in its lower portion, and a frequently wide, open channel. Although no *O. mykiss* were observed in any of the sampled pools (including the three pools that did not contain bass), fry were observed in about one-half of the flatwaters and riffles. Only two juvenile+ were observed in Mat 3, both in a single flatwater habitat near the top of the study site. Fry were observed in both sections, both above and below the principal hot springs, which appeared to increase the streams afternoon temperature by approximately 3-4$^{o}$C (in early-August). Although no *O. mykiss* were observed in pool habitats, the 2007 overall abundance in all habitats combined was 44 (±31) fry and 7 (±10) juvenile+ (Table 3, Figures 18 and 20). Associated densities for fry and juvenile+ were 0.07 (±0.05) and 0.01 (±0.02), respectively (Figures 19 and 21). The changes in estimated abundance from 2006 to 2007 in the Mat 3 study site were relatively minor for fry, with a non-significant increase from 23 fish to 44 fish (Figure 22). For juvenile+ fish, however, the decrease from 94 fish to only 7 fish in 2007 was statistically significant (Figure 23).

Mat 5. *O. mykiss* were more abundant in Mat 5 than in Mat 3, and were observed in 14 of 17 sampled habitat units. The overall estimated abundance of fry and juvenile+ was 308 (±120) fish and 69 (±44) fish, respectively, with associated densities of 1.10 (±0.43) fish/100ft$^2$ and 0.25 (±0.16) fish/100ft$^2$ (Table 3, Figures 18-21). The overall abundance and density of *O. mykiss* fry and juvenile+ in the Mat 5 study site was the third highest of all 10 study sites (exceeded only by UNF new and LNF mid). Like in most other study sites, fry occurred at highest densities in the faster water habitats (riffles and flatwaters), and at lowest densities in pools. Juvenile+ fish, in contrast, occurred at lowest densities in riffles. When compared to the 2006 estimates, the abundance of fry increased in 2007 by 73%, whereas abundance estimates of juvenile+ decreased by 75% in 2007 (Figures 22 and 23). The decline for juvenile+ was statistically significant.

Mat 7. The overall abundance and density of fry and juvenile+ *O. mykiss* in the Mat 7 study site in 2007 was relatively similar to estimates from the Mat 5 site, despite having more stable flows, thicker riparian coverage, and greater habitat diversity (but note that estimated HSI scores were almost identical at 0.69 and 0.71, Table 2). The estimated abundance and density of fry in August 2007 was 278 (±47) fish and 0.96 (±0.16) fish/100ft$^2$, respectively (Table 3, Figures 18 and 20). The corresponding estimates for juvenile+ fish were 58 (±24) fish and 0.20 (±0.08) fish/100ft$^2$, respectively (Figures 19 and 21). Densities of fry were highest in the shallower and swifter habitats (e.g., flatwaters and riffles), but densities for the larger juvenile+ fish were highest in pools. As seen in most other study sites, the 2007 estimates represented a substantial increase in abundance of fry but a large decrease in juvenile+ fish from 2006 values (Figures 22 and 23). The 2006-2007 changes for both size classes were statistically significant.

UNF new. The HSI study site in the UNF contained the highest densities of fry and juvenile+ *O. mykiss* of all 10 study sites in 2007, just as it did in 2006 (although a different site was sampled in the two years). This consistent trend supports the high HSI scores predicted for both sites in both years. In 2007, an estimated 598 fry (±108) and 114 juvenile+ (±61) inhabited the UNF new study site (Table 3, Figures 18 and 20). Estimated densities of fry and juvenile+ fish were 3.22 (±0.58) and 0.61 (±0.33) fish/100ft$^2$, respectively (Figures 19 and 21). Fry densities in the UNF new site were highest in riffles and flatwaters, as seen in Mat 7, with highest densities of juvenile+ fish in pools. These estimates cannot be statistically compared between years due to the change in sampling sites, however the fry estimates in the UNF new site are much higher than the previous year's estimates from the UNF up site. Likewise, the 2007 estimates for juvenile+ are much lower than the 2006 estimates from the upstream site.

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 2007 was 6,294 (±1,404) fish and 1,192 (±662) fish, respectively (Figure 24). Although those abundance estimates were considerably higher than the estimates for the middle segment, the estimated densities in the upper segment

(0.80 ±0.18 fry/100ft$^2$ and 0.15 ±0.08 juvenile+/100ft$^2$) were relatively similar to the middle segment estimates (Figure 25). As expected from the site-specific results, a comparison of 2007 estimates with 2006 estimates for the entire upper segment showed a statistically significant increase in fry abundance and density in 2007, and a statistically significant decrease in juvenile+ abundance and density (Figures 26 and 27).

San Antonio Creek

Qualitative electrofishing in approximately ½ mi in San Antonio Creek resulted in the capture of numerous arroyo chub and stickleback, but no *O. mykiss*. The sample site, approximately 3.5 mi upstream from the Ventura River and ½ mi downstream of Lion Canyon, consisted in part of a split channel with one channel open and algae-covered, and the other channel well shaded with deeper pools containing woody debris. Morning water temperatures during the 10 August sample ranged from 19-21$^{o}$C (Table 1).

Ventura Lagoon

*O. mykiss* were not captured in any of the 16 seine hauls, nor were they observed by deploying an underwater video camera (Figure 2). The most prevalent fish captured was topsmelt, *Atherinops affinis*, at 234 fish or 85% of the total catch (Table 4). Four other species were also captured in low numbers with the beach seine, including 36 California killifish (*Fundulus parvipinnis*) and one or two stickleback, staghorn sculpin (*Leptocottus armatus*), and prickly sculpin. Like in 2006, striped mullet (*Mugil cephalus*) were frequently observed within the seined areas but all individuals escaped by leaping over the net floats prior to reaching the bank. Schools of carp were also observed, but not captured with the seine. Many small fish were observed with the underwater video camera during approximately one hour of filming. However, shiner perch (*Cymatogaster aggregate*) was the only species positively identified by video that was not captured by seine. Tidewater gobies were neither captured nor observed during the 2007 sampling. The most notable differences from the 2006 sampling was the presence of California killifish in 2007, and the overall number of captured topsmelt was considerably less in 2007 (at 234 fish) than in 2006 (at 634 fish).

Lagoon and estuary environments are known to important rearing habitat for *O. mykiss* and other anadromous salmonids in many west coast locations (Smith 1987, Miller and Sadro 2003, Quinones and Mulligan 2005). Increased growth rates in lagoons and larger size at ocean entry has been found to result in greater ocean survival and increased returns of adult spawners (Reimers 1973, Ward and Slaney 1988). Anthropogenic impacts to lagoon physical habitat, including loss of wetland vegetation, channelization and bank armoring, and other impacts, may reduce the suitability of lagoons for *O. mykiss* rearing. Elevated water temperatures through reduced flows or loss of riparian vegetation may also reduce productivity of lagoon habitats for juvenile steelhead. In the Scott Creek Lagoon, approximately 250 mi north of the Ventura Lagoon, juvenile steelhead reared through the summer months and achieved high growth rates (Bond 2006). Although most downstream migrant juveniles in the spring appeared to emigrate directly into the ocean without over-summering in the lagoon, the lagoon-reared juveniles were found to comprise 85% of the returning adult spawners over the following years. Water temperature or other water quality information was not provided for the Scott River Lagoon, but summer temperatures in the Ventura Lagoon exceeded 23°C during the 2006 and 2007 sampling, and it is unknown to what degree water temperatures or other physio-chemical characteristics may be limiting use of the Ventura Lagoon by juvenile *O. mykiss*. In addition to potential water quality problems, the Ventura Lagoon is situated far downstream of any stream reaches found to contain substantial numbers of rearing juveniles, thus recruitment of juveniles into the lagoon is likely limited to the spring smolt migration season, when most larger individuals would be expected to pass through the lagoon into the ocean.

Table 4. Capture data from seining in the Ventura Lagoon.

| Set or Pass # | Waypt # | Topsmelt | California Killifish | Prickly Sculpin | Staghorn Sculpin | Stickle-back | Total Catch |
|---|---|---|---|---|---|---|---|
| 1 | 26 | | | | | | 0 |
| 2 | 26 | | | | | 1 | 1 |
| 3 | 27 | 102 | | | | | 102 |
| 4 | 37 | 14 | 18 | | | | 32 |
| 5 | 64 | 7 | 17 | | | | 24 |
| 6 | 86 | 3 | | | | | 3 |
| 7 | 87 | 54 | | | | | 54 |
| 8 | 88 | | 1 | | | | 1 |
| 9 | 120 | 1 | | | | | 1 |
| 10 | 134 | 4 | | | | | 4 |
| 11 | 134 | 5 | | | | | 5 |
| 12 | 173 | 1 | | | | | 1 |
| 13 | 173 | 25 | | | | | 25 |
| 14 | 176 | 10 | | | | | 10 |
| 15 | 196 | 1 | | 1 | | | 2 |
| 16 | 197 | 7 | | | 2 | | 9 |
| Total Catch | | 234 | 36 | 1 | 2 | 1 | 274 |

## INTERANNUAL RELATIONSHIPS

The changes of fish abundance estimates between years for each study site (or segment) were discussed above (Figures 22-23 and 26-27). Not clearly evident in that discussion, however, was the high correlation that existed between study site and the relative abundance of *O. mykiss* in both years. Despite the significant changes observed in fish densities and size composition between years, and differences in flow characteristics, those study sites that contained high densities of fish in 2006 also contained high densities in 2007, and likewise for low density study sites (Figure 28). Correlation coefficients (*Pearson's r*) for both size classes exceeded 0.9 (*P's* <0.01). This result was not surprising, since overall habitat quality was expected to be somewhat consistent between years. Although reduced precipitation and lower flows were expected to reduce the quantity of habitat from 2006 to 2007, evidently this reduction affected most of the reaches in a similar manner and consequently the relative ranking of high density and low density sites was preserved. Thus, the consistent relative densities among sites over the two year study period suggests that those factors that affect local fish densities (e.g., fry recruitment and habitat quality or availability) appear to operate similarly throughout the sampled basin. Such might not be expected if, say, annual differences in escapement of adult steelhead (due to downstream passage or ocean effects) resulted in higher fry densities in localized reaches. Additional sampling within the anadromous reaches would be required to assess if non-habitat related factors lead to annual changes in the relative density of fish among reaches.

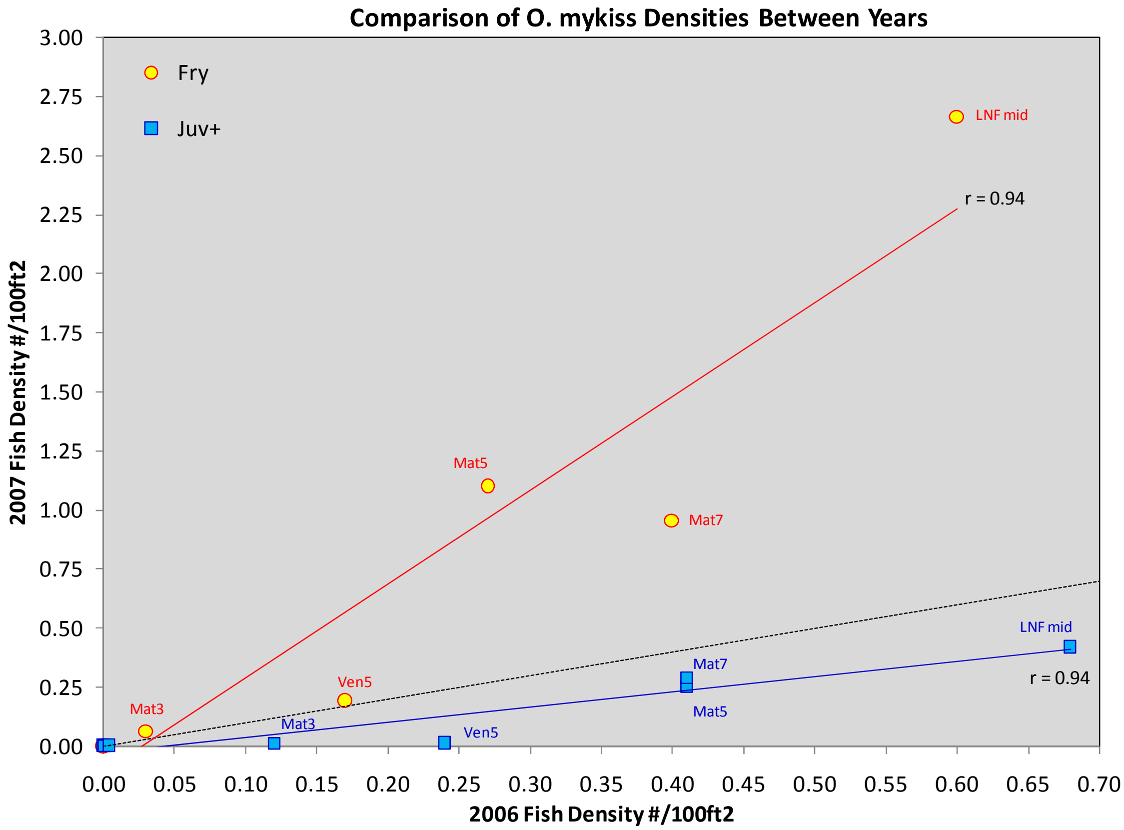


Figure 28. Correlation (*r*) in annual densities of *O. mykiss* by study site according to size class.

In addition to the strong relationship in fish densities between years for a single size class, the data also showed a strong relationship between size classes of *O. mykiss*. For example, the 2006 estimated densities of fry, which were presumed to be mostly young-of-year fish, were highly correlated with the 2007 densities of juvenile+ fish, many of which were assumed to be 1+ fish (Figure 29). A regression model that utilized the 2006 density of fry to explain the 2007 density of juvenile+ was highly significant ($R^2$=0.93, $P$<0.001).

Correlations between adjacent cohorts are not unexpected, and such correlations can help to explain otherwise confusing changes in abundance (TRPA 2005). It is possible, but unknown, that high spawning success and recruitment of fry occurred in 2005, the year prior to our study. Several flood events (>10,000 cfs) occurred during the winter of 2005, which undoubtedly mobilized instream substrates. Such events likely loosened the highly mineral-cemented gravels that are characteristic of many reaches in the middle and upper basin (TRPA 2003, Minear 2003), and may have produced (along with high base flows) optimum spawning conditions. A strong year-class of fry in 2005, along with high summer flows and good over-summering conditions, could have resulted in the relatively high densities of juvenile+ fish in 2006. In contrast, the late-season storm flows that occurred during the spawning season in March and April of 2006 (with April peak flows over 9,000 cfs) could have negatively impacted spawning activities or scoured deposited eggs and led to the relatively apparently poorer recruitment of fry in 2006, and thus to decreased abundance of juvenile+ fish in 2007.

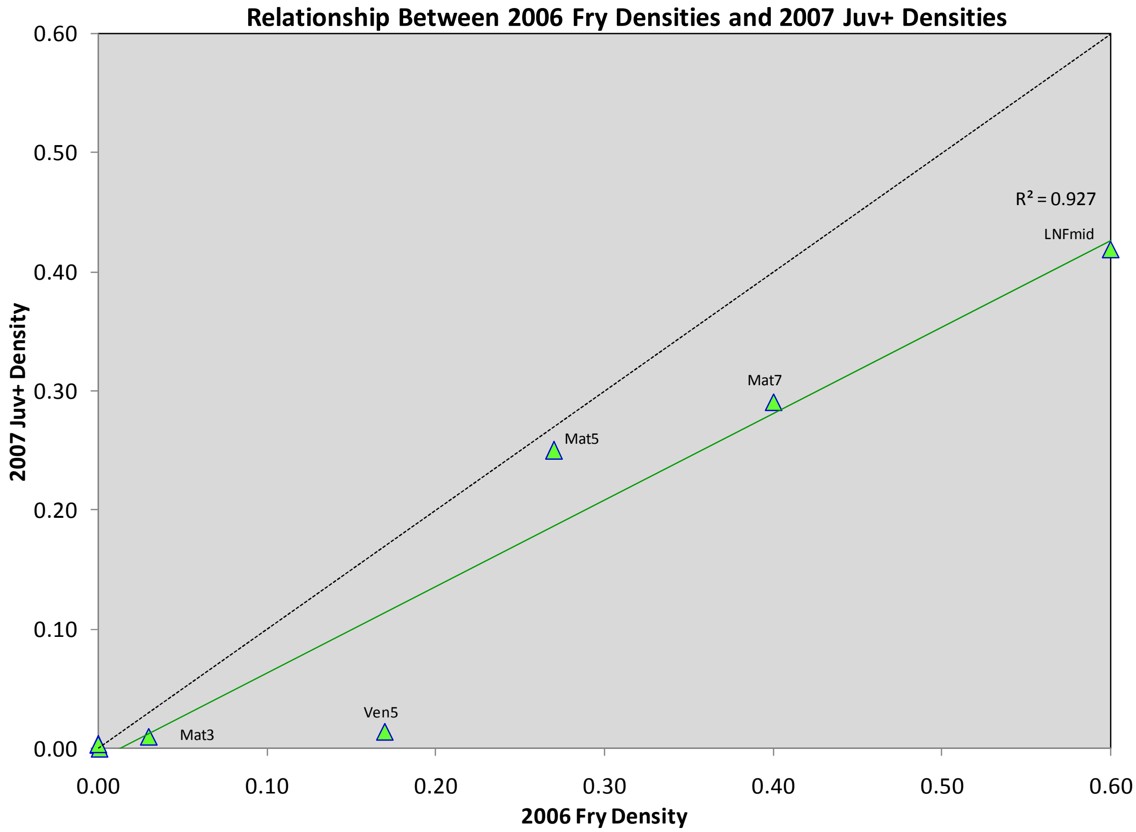


Figure 29. Relationship between densities of *O. mykiss* fry in 2006 and juvenile+ the following year, according to study site. Dotted line represents a 1:1 relationship.

A more thorough analysis of cohort relationships, such as that between fry (0+) and first-year (1+) juveniles the following year, or between adult (spawning aged) fish and fry the following year, would require a more precise assessment of age distributions, such as through scale analysis and an assessment of age-at-maturity. In smaller headwater streams, resident *O. mykiss* are known to mature and spawn by their second year of life at age 1+ (Moyle 2002), but the proportion of mature spawners in the juvenile+ size class used in this study is unknown. Certainly, extreme environmental conditions, such as flood flows or drought conditions, can override cohort-related effects on year-class strengths.

Large-magnitude changes in the abundance of salmonid fry such as seen in the Ventura/Matilija Basin in 2006 and 2007 are common in fisheries literature (Benson 1960, Seegrist and Gard 1972, House 1995, Lattrell et al. 1998, Spina et al. 2005), and may be related to changes in abundance of adult spawners or to changes in survival of eggs and fry. For anadromous populations, changes in ocean conditions or instream passage conditions can lead to significant annual differences in adult spawner escapement. Winter or early spring flood events can lead to mortality of adult spawners of anadromous and resident populations, and late spring flooding can scour developing eggs or cause displacement-related mortality of newly emerged fry. Also, this study and other studies show that the success or failure of the fry year-class can directly translate into abundance of fish in subsequent years (Hanson and Waters 1974, Lamberti et al. 1991, Nehring and Anderson 1993, Spina 2001, TRPA 2005).

## RELATIONSHIP BETWEEN HSI SCORES AND FISH POPULATIONS

The relationship between fish abundance and habitat quality was assessed using simple linear regression with the 10 study site HSI scores as the predictor variable and fish density (#/100ft$^2$) for fry or juvenile+ as the response variable. As seen in 2006, a positive and statistically significant relationship was evident for both fry ($R^2$=0.71, $P$=0.002) and juvenile+ ($R^2$=0.62, $P$=0.006) *O. mykiss* (Table 5, Figure 30). According to the regression model, approximately 62% to 71% of the variation in densities of fry and juvenile+ *O. mykiss* in the Ventura River/Matilija Creek study area in 2007 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 strong and positive relationship (Figure 30, bottom graph), however a statistical evaluation of these estimates was not attempted due to the availability of only three datapoints.

Table 5. ANOVA tables for regression of 2007 HSI scores on fish densities, according to size class.

| **Fry <10cm** | df | SS | MS | *F* | Prob | Parameter | Coeff | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| Regression | 1 | 8.610 | 8.610 | 19.416 | 0.002 | Intercept | -11.35 | 0.71 |
| Residual | 8 | 3.548 | 0.443 | | | HSI Score (X) | 17.40 | |
| Total | 9 | 12.158 | | | | | | |

| **Juv+ ≥10cm** | df | SS | MS | *F* | Prob | Parameter | Coeff | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| Regression | 1 | 0.264 | 0.264 | 13.348 | 0.006 | Intercept | -1.98 | 0.62 |
| Residual | 8 | 0.158 | 0.020 | | | HSI Score (X) | 3.04 | |
| Total | 9 | 0.422 | | | | | | |

The regression predictions of zero fish density in 2007 were very similar between size classes, with both models predicting zero densities at an HSI score of 0.65 (Figure 30). The 2006 models for both size classes also predicted zero densities at intermediate HSI scores of 0.58-0.61. The 2006 and 2007 regression models for each size class were also very similar between years in quality of fit (i.e., in $R^2$ and $P$-values), however the overall models were significantly different between years. The differences in the two juvenile+ models were barely significant ($P \approx 0.046$) due to differences in the predicted y-intercept, whereas the regression slopes were not significantly different. In contrast, the differences in fry models between 2006 and 2007 were highly significant due both to differences in intercept and slope.

In both study years, a couple of study sites were highly influential in the regression models. The two Upper North Fork sites (UNF up in 2006 and UNF new in 2007) had

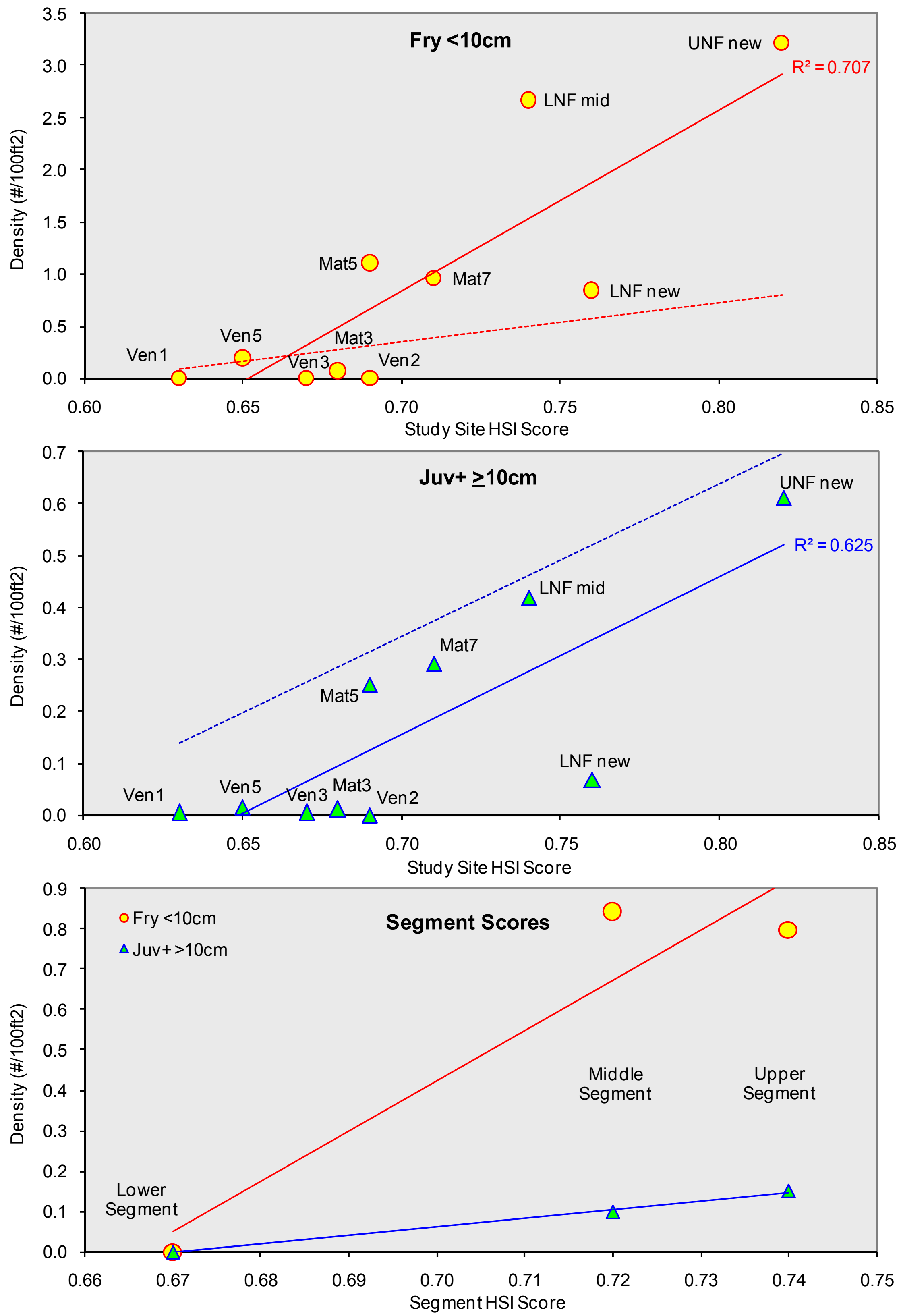


Figure 30. Relationship between HSI score and *O. mykiss* density, according to study site and size class. Dotted lines in upper two graphs represent 2006 regression relationships.

both the highest fish densities and the highest HSI scores in each year, and these sites exerted considerable (positive) effect on the regression model. In contrast, 'outlier" observations in both years degraded the relationship. In 2007, for example, the new site on the Lower North Fork did not follow the expected relationship by having relatively low densities of *O. mykiss* despite a relatively high HSI score of 0.76 (Figure 30). Cook's distance plots, which illustrate the effect of individual observations on regression coefficients (MathSoft 1999), showed that the UNF and LNF new study sites exerted the greatest influence on both the fry and juvenile+ models.

The low densities of juvenile+ fish in the LNF new site might be expected due to the high recreational use and probable angling pressure in that reach. The only other reach that appeared to receive significant recreational use was Mat 7, which did not appear to have depressed abundance of larger trout, but that reach required a substantial hike and thus likely received less use and angler harvest. The lower than expected densities of fry in the LNF new study site cannot be explained by angling pressure, but instead may be related to the artificially high proportion of pool habitat due to recreational dam-building in that reach (Figure 11). Pools comprised 70% of habitat (by length) in that reach, which was much higher than the proportion of pools found in other headwater study sites. Fry densities in virtually every middle and upper segment study sites were lower in pool habitats (often significantly) than in flatwater and riffle habitats. Although estimated densities of fry in flatwaters were also lower in the LNF new site than in the LNF mid site, fry densities in riffles were similar between reaches (Figure 19). The artificial increase in pool habitat in the LNF new study site came at the expense of flatwater and riffle habitat, thus likely resulting in overall densities of fry that were lower than predicted.

Aside from the Upper and Lower North Fork study sites mentioned above, the HSI:fish density relationship in 2007 showed little predictability for scores between 0.6 and 0.7, where five study sites contained zero or near-zero fish densities, and one site (Mat 5) contained moderate densities (Figure 30). This suggests that the HSI model used in this study, with its modified HSI curves (TRPA 2007), may not adequately discern between reaches that are capable of supporting low densities of *O. mykiss* (e.g., Ven 5 and Mat 3) from reaches that do not appear to be capable of supporting significant numbers of fish (e.g., Ven 1 and Ven 2). Further testing of this HSI model in the Ventura Basin or, preferably, in other Southern California basins, would help to determine if additional curve modifications are necessary or if perhaps a non-linear model (e.g., a logistic "S"-curve) would best describe the HSI score:fish density relationship.

Development and application of a new 'tributary effects" variable was tested in order to better account for immigration of fry into reaches that contain little spawning habitat, but are close in proximity to spawning tributaries. Very little data was available to develop the expected negative relationship between distance to tributary and density of fry; consequently the new HSI curve for trib effects is tentative (Figure 4). In application, the trib effects variable only entered into the overall HSI calculation equation for one study site (Ven 5), due to that sites paucity of spawning gravel but close proximity to the Lower North Fork. Use of the new variable increased the overall HSI score from 0.61 to 0.65, which produced a minor improvement in the regression relationship. Additional testing and refinement of the trib effects variable would be required to confidently incorporate it into other HSI models.

## SUMMARY & CONCLUSIONS

New Habitat Suitability Index (HSI) scores were calculated to represent habitat quality for *O. mykiss* in eight study sites in the Ventura River / Matilija Creek Basin in 2007, then compared to HSI estimates derived in 2006 (see TRPA 2007 for comparisons of 2006 scores with the original 2003 scores). Only a subset of the 20+ HSI variables were re-measured in 2007, therefore the high similarity in scores between years was not unexpected. However, two new HSI sites were sampled in 2007, which produced HSI scores very similar to nearby sites, and suggested good reproducibility in the HSI methodology. The highly influential "Vs" variable, which describes spawning habitat quality, was most responsible for annual changes in site-specific HSI scores, as was the case when comparing 2006 scores with 2003 scores (TRPA 2007). A new HSI variable, the "tributary effects" variable, was derived and tested in 2007 to help account for fish abundance in reaches that contained little spawning habitat (and thus received a very low Vs score), but was proximal to a spawning tributary that was likely to recruit fry. This trib effects variable was incorporated into the HSI score for one HSI study site and led to a minor improvement in the relationship between HSI score and fish abundance within study sites. The most consistent change in HSI variables between 2006 and 2007 was an increase in vegetative cover along streambanks, which was attributed to partial recovery of riparian vegetation following the flood events of 2005 and 2006. Although streamflows were much lower during the summer of 2007 than in the previous year, the effects of lower flows and shallower water did not appear to exert significant effects on the overall study site scores, although one study site sampled in 2006 was dry in 2007, and another study site was only partially wetted. Segment HSI scores, which were based on weighted HSI scores from study sites in the lower, middle, and upper portions of the basin, were nearly identical in 2006 and 2007.

Large and statistically significant changes occurred in fish abundance from 2006 to 2007, with significant increases in density (#/100ft$^2$) of *O. mykiss* fry (<10cm FL) and significant decreases in juvenile+ fish in most study sites. Changes in abundance were also significant between years at the basin segment scale. The causes for the change in size class abundance are unknown, but may not have been the result of changes in physical habitat quality or escapement of anadromous fish. It is speculated that spring flood events in 2006 may have scoured developing *O. mykiss* eggs or embryos and led to reduced densities of fry in that year, which carried-over into in low densities of juvenile+ fish in 2007. In contrast, the lower but relatively stable flows throughout the spring of 2007 may have produced better spawning and incubation conditions with subsequently higher densities of fry. Reductions in living space due to lower flows in the spring and summer of 2007 may also have limited the amount of habitat available to larger fish, with subsequent effects on juvenile+ survival and densities.

Like in 2006, the abundance of *O. mykiss* fry and juvenile+ was very low (or zero) in the lower segment study sites below Robles Diversion Dam, although several adult steelhead were observed in July-August 2007 while diving and wading. In the middle segment (between the diversion dam and Matilija Dam), abundance was again (as in 2006) much higher in the Lower North Matilija Creek than in the mainstem Ventura River. Overall densities in the middle segment were similar to densities in the upper segment above Matilija Dam. *O. mykiss* densities were highest of all sampled study sites in the Upper North Fork Matilija Creek, similar to 2006. In general, the relative ranking of *O. mykiss* densities among the eight repeated study sites was almost identical between years, and resulted in statistically significant relationships between study site HSI scores and fish abundance.

The HSI model developed for *O. mykiss* (Raleigh et al. 1984) appeared to adequately distinguish between areas containing high fish densities versus areas with low fish densities, but numerous limitations in the model appeared evident. As discussed in previous reports, many changes were required in temperature HSI relationships in order to prevent the model from predicting zero suitability in areas that consistently supported *O. mykiss* (TRPA 2004, 2007). Perhaps consequent to those curve modifications, the revised model did not appear to distinguish between areas that did not support significant numbers of *O. mykiss* (e.g., the lower segment study sites) from areas that consistently (over the two years) supported low densities of fish (e.g., Ven 5 & Mat 3). In the 2006 and 2007 studies, study sites with zero (or near zero) fish densities received HSI scores of 0.60 or greater, whereas relatively high fish densities occurred with HSI scores of 0.65-0.70.

Visual observations of the lower segment study sites suggested that physical habitat was adequate to support higher numbers of *O. mykiss* than was observed from sampling. It is possible that the HSI model accurate portrayed the lower segment as having moderate-quality habitat, but a lack of recruitment of fish into those areas (e.g., few adult steelhead spawners or adult resident trout) kept fish densities below capacity. The relatively high densities of *O. mykiss* observed in the Ven 3 reach by Moore (1980), many of which were presumed non-hatchery, suggested that the Casitas Springs area was capable of supporting much higher densities than observed in our study.

An alternative explanation for the moderate HSI score but low fish densities is that water quality parameters not included in the model or insufficiently described during our study may reduce the true suitability of those reaches below what was predicted by the HSI model. Several variables important in the HSI model were estimated with considerable uncertainty. For example, most of the water temperature variables (and associated dissolved oxygen variables) require continuous measurements to accurately estimate mean maximum values over a given time period (e.g., summer rearing, adult spawning, etc.), yet we did not locate such data but instead utilized spot measurements from various sources. The importance of the spawning variable, Vs, on the overall HSI score has been repeatedly discussed in this report and in TRPA 2007. Assessment of spawning gravel surface area, substrate conditions, and water velocities (all incorporated into the Vs score) ideally should occur during actual spawning flow conditions in late winter and early spring, but these variables were assessed during summer low flow periods (with adjustment factors for velocity) for economic and logistical reasons. Even if a separate spring assessment was feasible, determining what flow was most suitable for measuring gravel characteristics and being onsite during such a highly unpredictable event would prove very difficult. In sum, our estimation of the Vs and water quality variables contained high uncertainty and consequently the overall HSI scores may not accurately describe habitat quality in some areas, particularly the lower segment where flow and temperature-related variables are more variable (and less suitable) than in upstream areas.

Despite the above limitations, the HSI model did explain 60% to 70% of the variation in densities of *O. mykiss* among study sites in both years. Although the model should not be expected to predict actual fish densities in different years or in different basins, it does appear capable of distinguishing between reaches capable of supporting high fish densities versus those expected to contain few fish, and where restoration efforts may be most effective. Also, the 2006 and 2007 fish density results show that the MBC sampling protocol is an effective method for assessing both total abundance of *O. mykiss* in a Southern California basin, and for assessing annual changes in abundance. Both parameters will be useful for assessing the relative benefits and consequences of removing Matilija Dam. It is hoped that future surveys will continue the current time-series of fish abundance information, and that future surveys will be conducted in a manner that is statistically rigorous and fully comparable with the estimates provided in this report.

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Appendix A. Habitat mapping data for two new study sites (LNF new and UNF new) mapped on 21-23 July 2007. See TRPA 2007 for habitat mapping of the remaining study sites. Boxed units were sampled for HSI and fish abundance.

| Study Site | Unit # | Habitat Type | Unit Length | WP Label |
|---|---|---|---|---|
| LNF new | 1 | LGR | 24 | ADD |
| LNF new | 2 | RUN | 30 | 433 |
| LNF new | 3 | LSBO | 35 | |
| LNF new | 4 | HGR | 13 | |
| LNF new | 5 | LSBO | 28 | 432 |
| LNF new | 6 | STP | 57 | |
| LNF new | 7 | HGR | 23 | 431 |
| LNF new | 8 | LSBK | 47 | |
| LNF new | 9 | CAS | 5 | |
| LNF new | 10 | POW | 30 | 430 |
| LNF new | 11 | LSBK | 18 | |
| LNF new | 12 | LGR | 12 | |
| LNF new | 13 | LSBK | 57 | |
| LNF new | 14 | CAS | 6 | |
| LNF new | 15 | STR | 30 | 429 |
| LNF new | 16 | DPL | 19 | |
| LNF new | 17 | BRS | 10 | |
| LNF new | 18 | TRP | 18 | |
| LNF new | 19 | RUN | 29 | |
| LNF new | 20 | HGR | 25 | 428 |
| LNF new | 21 | MCP | 17 | |
| LNF new | 22 | LGR | 13 | |
| LNF new | 23 | STP | 51 | |
| LNF new | 24 | DPL | 31 | |
| LNF new | 25 | CAS | 2 | |
| LNF new | 26 | DPL | 14 | 427 |
| LNF new | 27 | LGR | 14 | |
| LNF new | 28 | DPL | 28 | |
| LNF new | 29 | CAS | 2 | |
| LNF new | 30 | DPL | 16 | |
| LNF new | 31 | CAS | 5 | |
| LNF new | 32 | DPL | 46 | |
| LNF new | 33 | STR | 47 | |
| LNF new | 34 | CAS | 5 | |
| LNF new | 35 | DPL | 59 | |
| LNF new | 36 | HGR | 19 | |
| LNF new | 37 | POW | 25 | 426 |
| LNF new | 38 | STP | 196 | |
| LNF new | 39 | MCP | 55 | 425 |
| LNF new | 40 | LGR | 11 | |
| LNF new | 41 | POW | 60 | |
| LNF new | 42 | CAS | 5 | |
| LNF new | 43 | DPL | 62 | |
| LNF new | 44 | STP | 88 | |
| LNF new | 45 | CAS | 5 | |
| LNF new | 46 | DPL | 40 | |
| LNF new | 47 | CAS | 5 | |
| LNF new | 48 | DPL | 82 | |
| LNF new | 49 | STP | 26 | 424 |
| LNF new | 50 | LSBK | 48 | |
| LNF new | 51 | STP | 66 | |
| LNF new | 52 | STR | 55 | 423 |
| LNF new | 53 | HGR | 25 | |
| LNF new | 54 | RUN | 26 | 422 |
| LNF new | 55 | LSBK | 31 | |
| LNF new | 56 | LGR | 38 | |
| LNF new | 57 | POW | 42 | 421 |
| LNF new | 58 | STP | 70 | |
| LNF new | 59 | HGR | 36 | 420 |
| LNF new | 60 | STP | 52 | |
| LNF new | 61 | LSBK | 108 | |
| LNF new | 62 | HGR | 44 | 419 |
| LNF new | 63 | PLP | 18 | |
| UNF new | 1 | POW | 20 | |
| UNF new | 2 | LGR | 23 | 400 |
| UNF new | 3 | STP | 36 | |
| UNF new | 4 | LSBK | 20 | |
| UNF new | 5 | LGR | 14 | 401 |
| UNF new | 6 | RUN | 13 | |
| UNF new | 7 | CAS | 4 | |
| UNF new | 8 | RUN | 20 | 402 |
| UNF new | 9 | LGR | 22 | 403 |
| UNF new | 10 | HGR | 33 | |
| UNF new | 11 | LGR | 16 | |
| UNF new | 12 | LSBK | 42 | |
| UNF new | 13 | HGR | 21 | 404 |
| UNF new | 14 | LGR | 21 | |
| UNF new | 15 | GLD | 18 | |
| UNF new | 16 | LSBK | 83 | |
| UNF new | 17 | SRN | 27 | |
| UNF new | 18 | LGR | 8 | |
| UNF new | 19 | SRN | 46 | |
| UNF new | 20 | POW | 48 | |
| UNF new | 21 | MCP | 30 | 405 |
| UNF new | 22 | GLD | 20 | |
| UNF new | 23 | LSBK | 30 | 406 |
| UNF new | 24 | RUN | 11 | |
| UNF new | 25 | HGR | 23 | |
| UNF new | 26 | RUN | 20 | |
| UNF new | 27 | MCP | 83 | 407 |
| UNF new | 28 | RUN | 10 | |
| UNF new | 29 | LSBK | 14 | |
| UNF new | 30 | LGR | 11 | |
| UNF new | 31 | MCP | 48 | |
| UNF new | 32 | SRN | 42 | |
| UNF new | 33 | LGR | 79 | |
| UNF new | 34 | RUN | 43 | |
| UNF new | 35 | LGR | 13 | |
| UNF new | 36 | RUN | 31 | |
| UNF new | 37 | CAS | 2 | |
| UNF new | 38 | MCP | 18 | |
| UNF new | 39 | CAS | 7 | |
| UNF new | 40 | LSBO | 19 | |
| UNF new | 41 | HGR | 10 | |
| UNF new | 42 | RUN | 5 | |
| UNF new | 43 | LSBO | 12 | |
| UNF new | 44 | CAS | 3 | |
| UNF new | 45 | RUN | 17 | 408 |
| UNF new | 46 | LSBO | 13 | |
| UNF new | 47 | GLD | 5 | |
| UNF new | 48 | MCP | 38 | |
| UNF new | 49 | HGR | 9 | |
| UNF new | 50 | PLP | 12 | |
| UNF new | 51 | LGR | 24 | |
| UNF new | 52 | LSBO | 25 | |
| UNF new | 53 | LGR | 5 | |
| UNF new | 54 | GLD | 17 | |
| UNF new | 55 | LSBO | 11 | 409 |
| UNF new | 56 | GLD | 8 | |
| UNF new | 57 | PLP | 18 | |
| UNF new | 58 | CAS | 5 | |
| UNF new | 59 | LGR | 15 | |
| UNF new | 60 | GLD | 30 | |
| UNF new | 61 | MCP | 20 | |
| UNF new | 62 | LSBO | 29 | 410 |
| UNF new | 63 | RUN | 13 | |
| UNF new | 64 | CAS | 2 | |
| UNF new | 65 | RUN | 30 | |
| UNF new | 66 | POW | 37 | |
| UNF new | 67 | CAS | 4 | |
| UNF new | 68 | RUN | 12 | |
| UNF new | 69 | GLD | 10 | |
| UNF new | 70 | MCP | 26 | |
| UNF new | 71 | LSBO | 13 | |
| UNF new | 72 | LGR | 14 | |
| UNF new | 73 | POW | 23 | 411 |
| UNF new | 74 | GLD | 17 | |
| UNF new | 75 | PLP | 13 | |
| UNF new | 76 | SRN | 22 | 412 |
| UNF new | 77 | HGR | 6 | |
| UNF new | 78 | GLD | 20 | |
| UNF new | 79 | LSBO | 35 | |
| UNF new | 80 | RUN | 7 | |
| UNF new | 81 | PLP | 22 | |
| UNF new | 82 | CAS | 2 | |
| UNF new | 83 | LSBO | 14 | |
| UNF new | 84 | RUN | 15 | 413 |
| UNF new | 85 | POW | 57 | |
| UNF new | 86 | RUN | 18 | |
| UNF new | 87 | LGR | 5 | |
| UNF new | 88 | MCP | 17 | 414 |
| UNF new | 89 | POW | 46 | |
| UNF new | 90 | HGR | 4 | |
| UNF new | 91 | POW | 34 | 415 |
| UNF new | 92 | LSBO | 48 | |
| UNF new | 93 | LGR | 19 | |
| UNF new | 94 | MCP | 21 | |
| UNF new | 95 | LGR | 3 | |
| UNF new | 96 | LSBO | 24 | |
| UNF new | 97 | PLP | 11 | |
| UNF new | 98 | LGR | 32 | |

Appendix B. Sampling data for fry and juvenile O. mykiss according to study site, habitat type, habitat unit, and sampling method (DO=direct observation snorkeling, EF=electrofishing). Ven 1 pools # 19 and #38 also contained adult steelhead. Estimates of habitat unit abundance and variance are only available for units sampled by electrofishing or multiple dive counts (i.e., not for single-pass dive counts). Observation or capture probabilities are means for all units (containing fish) sampled by habitat type in each study site. Other species types are: CHB=arroyo chub, STB=stickleback, CRP=carp, SCP=sculpin, GMB=gambusia, GSF=green sunfish, LMB=largemouth bass, TRT=pond turtle.

| Study | Habitat | | Samp | Fry <10cm | | | | adj MBC / Jackknife | | Capt/Obs | Juvenile+ 10cm+ | | | | adj MBC / Jackknife | | Capt/Obs | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Category | Unit # | Method | P#1 | P#2 | P#3 | P#4 | Abundance | Variance | Prob | P#1 | P#2 | P#3 | P#4 | Abundance | Variance | Prob | Species |
| Ven 1 | PL | 3 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,CRP |
| | | *19 | DO | 0 | 0 | 0 | 0 | 0 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB,STB,CRP,GMB |
| | | *38 | DO | 0 | 0 | 0 | 0 | 0 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB,STB,CRP,GMB,TRT |
| | | 50 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,CRP |
| | | 9 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,CRP |
| | | 7 | DO | 0 | | | | | | | 0 | | | | | | | CHB |
| | | 23 | DO | 0 | | | | | | | 0 | | | | | | | CHB,CRP |
| | FW | 4 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,CRP |
| | | 11 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,CRP |
| | | 25 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,CRP,SCP |
| | | 39 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,CRP,TRT |
| | | 6 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 37 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 42 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 43 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | RF | 5 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,CRP,SCP |
| | | 12 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CRP,SCP |
| | | 17 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,SCP |
| | | 28 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB,SCP |
| | | 31 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB,SCP |
| | | 34 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB,CRP,SCP |
| | | 41 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 45 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| Ven 2 | PL | 4 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,CRP |
| | | 18 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,CRP |
| | | 30 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,SCP |
| | | 53 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 56 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,CRP |
| | | 45 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB,CRP |
| | FW | 1 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 7 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 28 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 38 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 50 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,CRP |
| | | 14 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 21 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 43 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |

Appendix B. *(continued)*

| Study Site | Habitat Category | Unit # | Samp Method | Fry <10cm P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Juvenile+ 10cm+ P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Other Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RF | 9 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB,SCP |
| | | 13 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB,SCP |
| | | 22 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 31 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 39 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 48 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 55 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 59 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| Ven 3 | PL | 17 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 28 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,TRT |
| | | 40 | DO | 0 | 0 | 0 | 0 | 0 | 0.00 | | 2 | 1 | 2 | 3 | 4 | 0.67 | 0.67 | CHB,STB,CRP,GSF,LMB |
| | | 42 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 50 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 25 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB,TRT |
| | FW | 1 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 8 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 13 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 21 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 30 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 35 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 41 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 48 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | RF | 3 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 10 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 18 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 23 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 29 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 34 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 45 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 47 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| Ven 5 | PL | 5 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,GSF,LMB,TRT |
| | | 14 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 42 | DO | 1 | 2 | 1 | 2 | 2 | 0.33 | 0.78 | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB,STB,LMB |
| | | 44 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 58 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 24 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 39 | DO | 1 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 53 | DO | 0 | | | | | | | 0 | | | | | | | CHB |
| | FW | 3 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 9 | EF | 0 | 1 | 1 | 0 | 2 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB,STB |
| | | 15 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |

Appendix B. *(continued)*

| Study Site | Habitat Category | Unit # | Samp Method | Fry <10cm P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Juvenile+ 10cm+ P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Other Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 21 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 30 | EF | 4 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 36 | EF | 2 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 45 | EF | 5 | 0 | 0 | | 0 | 0.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 50 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB |
| | RF | 2 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 8 | EF | 2 | 0 | 0 | | 2 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,LMB |
| | | 18 | EF | 3 | 1 | 0 | | 4 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 27 | EF | 2 | 0 | 0 | | 2 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 31 | EF | 2 | 0 | 2 | 0 | 4 | 0.00 | | 1 | 1 | 0 | 0 | 2 | 0.00 | | CHB,STB |
| | | 37 | EF | 3 | 1 | 0 | | 4 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 43 | EF | 1 | 1 | 1 | 0 | 3 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB |
| | | 46 | EF | 13 | 3 | 3 | 0 | 19 | 0.00 | | 1 | 0 | 0 | 0 | 1 | 0.00 | | CHB |
| | | 55 | EF | 5 | 5 | 2 | 0 | 12 | 0.00 | | 1 | 0 | 0 | 0 | 1 | 0.00 | | CHB |
| LNF new | PL | 5 | DO | 2 | 2 | 3 | 4 | 5 | 0.92 | 0.67 | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB |
| | | 13 | DO | 6 | 5 | 4 | 5 | 7 | 0.67 | 0.87 | 1 | 0 | 1 | 0 | 1 | 0.33 | 0.33 | CHB |
| | | 26 | DO | 3 | 3 | 3 | 2 | 3 | 0.25 | 0.91 | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB |
| | | 39 | DO | 1 | 1 | 1 | 2 | 3 | 0.25 | 0.80 | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB |
| | | 49 | DO | 5 | 4 | 3 | 3 | 6 | 0.92 | 0.76 | 1 | 1 | 1 | 1 | 1 | 0.00 | 1.00 | CHB |
| | | 24 | DO | 1 | | | | | | | 0 | | | | | | | CHB |
| | | 55 | DO | 1 | | | | | | | 0 | | | | | | | CHB |
| | | 60 | DO | 2 | | | | | | | 1 | | | | | | | CHB |
| | FW | 2 | EF | 7 | 0 | 0 | | 7 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 10 | EF | 4 | 0 | 0 | | 4 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 15 | EF | 14 | 0 | 1 | | 15 | 6.00 | | 1 | 0 | 0 | | 2 | 0.00 | | CHB |
| | | 19 | EF | 9 | 0 | 0 | | 9 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 37 | EF | 18 | 1 | 0 | | 19 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 52 | EF | 3 | 0 | 0 | | 3 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 54 | EF | 4 | 0 | 1 | 0 | 5 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB |
| | | 57 | EF | 6 | 0 | 0 | | 6 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | RF | 1 | EF | 1 | 2 | 1 | 0 | 4 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB |
| | | 7 | EF | 4 | 1 | 0 | | 5 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 20 | EF | 9 | 2 | 1 | | 12 | 6.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 36 | EF | 18 | 5 | 3 | | 27 | 18.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 53 | EF | 7 | 3 | 1 | | 11 | 6.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 56 | EF | 10 | 0 | 0 | | 10 | 0.00 | | 0 | 1 | 0 | | 1 | 0.00 | | CHB |
| | | 59 | EF | 9 | 1 | 1 | | 11 | 6.00 | | 2 | 0 | 0 | | 2 | 0.00 | | CHB |
| | | 62 | EF | 10 | 0 | 2 | | 13 | 12.00 | | 2 | 0 | 0 | | 2 | 0.00 | | CHB |
| LNF mid | PL | 12 | DO | 9 | 8 | 12 | 15 | 20 | 10.00 | 0.09 | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB |
| | | 14 | DO | 1 | 1 | 1 | 1 | 1 | 0.00 | 1.00 | 0 | 0 | 0 | 0 | 0 | 0.00 | | |
| | | 30 | DO | 5 | 4 | 5 | 4 | 5 | 0.33 | 0.93 | 0 | 0 | 0 | 0 | 0 | 0.00 | | |

Appendix B. *(continued)*

| Study Site | Habitat Category | Unit # | Samp Method | Fry <10cm P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Juvenile+ 10cm+ P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Other Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 36 | DO | 3 | 2 | 1 | 1 | 4 | 0.92 | 0.48 | 1 | 0 | 1 | 1 | 1 | 0.25 | 0.67 | |
| | | 53 | DO | 8 | 7 | 7 | | 10 | 0.33 | 0.95 | 3 | 1 | 2 | | 4 | 1.00 | 0.50 | CHB |
| | | 1 | DO | 3 | | | | | | | 1 | | | | | | | CHB |
| | | 40 | DO | 1 | | | | | | | 2 | | | | | | | |
| | | 48 | DO | 2 | | | | | | | 3 | | | | | | | CHB |
| | FW | 6 | EF | 18 | 4 | 1 | | 23 | 6.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 13 | EF | 3 | 4 | 0 | | 7 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 27 | EF | 8 | 0 | 1 | 0 | 9 | 0.00 | | 2 | 1 | 0 | 0 | 3 | 0.00 | | |
| | | 44 | EF | 5 | 1 | 0 | | 6 | 0.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 57 | EF | 12 | 3 | 0 | | 15 | 0.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 67 | EF | 9 | 6 | 2 | | 18 | 12.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 77 | EF | 3 | 0 | 0 | | 3 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 87 | EF | 6 | 1 | 0 | | 7 | 0.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | RF | 2 | EF | 6 | 3 | 0 | | 9 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 21 | EF | 8 | 2 | 1 | | 11 | 6.00 | | 2 | 1 | 2 | | 11 | 12.00 | | |
| | | 46 | EF | 6 | 2 | 0 | | 8 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 52 | EF | 6 | 1 | 0 | | 7 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 54 | EF | 7 | 3 | 0 | | 10 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 79 | EF | 5 | 1 | 0 | | 6 | 0.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 81 | EF | 2 | 1 | 0 | | 3 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 84 | EF | 4 | 4 | 1 | | 9 | 6.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| Mat 3 | PL | 3 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | GSF,LMB |
| | | 5 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,LMB |
| | | 27 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 33 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,LMB,TRT |
| | | 35 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB,LMB |
| | | 11 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 14 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB,LMB |
| | | 41 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | FW | 9 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 10 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 24 | EF | 3 | 0 | 0 | | 3 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 25 | EF | 4 | 2 | 0 | | 6 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 32 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB |
| | | 37 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 48 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,LMB |
| | | 49 | EF | 1 | 0 | 0 | | 1 | 0.00 | | 2 | 0 | 0 | | 2 | 0.00 | | CHB,STB |
| | RF | 1 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB |
| | | 6 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 15 | EF | 2 | 1 | 0 | | 3 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 21 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |

Appendix B. *(continued)*

| Study Site | Habitat Category | Unit # | Samp Method | Fry <10cm P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Juvenile+ 10cm+ P#1 | P#2 | P#3 | P#4 | adj MBC / Jackknife Abundance | Variance | Capt/Obs Prob | Other Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 23 | EF | 3 | 1 | 0 | | 4 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 40 | EF | 2 | 0 | 0 | | 2 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 45 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | CHB,STB |
| | | 51 | EF | 1 | 0 | 0 | | 1 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| Mat 5 | PL | 43 | DO | 4 | 4 | 3 | 4 | 4 | 0.25 | 0.93 | 4 | 5 | 6 | 3 | 7 | 1.67 | 0.63 | CHB,STB |
| | | 45 | DO | 4 | 1 | 2 | 2 | 6 | 1.58 | 0.30 | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB,STB |
| | | 49 | DO | 2 | 2 | 2 | 1 | 2 | 0.25 | 0.86 | 0 | 0 | 0 | 0 | 0 | 0.00 | | CHB,STB |
| | | 55 | DO | 1 | 1 | 2 | 2 | 2 | 0.33 | 0.78 | 3 | 2 | 1 | 2 | 4 | 0.67 | 0.67 | CHB,STB |
| | | 25 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 28 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | | 32 | DO | 0 | | | | | | | 0 | | | | | | | CHB,STB |
| | FW | 26 | EF | 2 | 2 | 2 | 1,0 | 7 | 0.00 | | 0 | 0 | 0 | 0,0 | 0 | 0 | | CHB,STB |
| | | 36 | EF | 2 | 0 | 0 | | 2 | 0.00 | | 0 | 0 | 0 | | 0 | 0 | | CHB,STB |
| | | 46 | EF | 17 | 8 | 1 | | 27 | 6.00 | | 2 | 0 | 0 | | 2 | 0 | | CHB,STB |
| | | 53 | EF | 14 | 4 | 2 | | 21 | 12.00 | | 7 | 2 | 0 | | 9 | 0 | | CHB,STB |
| | | 62 | EF | 9 | 0 | 1 | 0 | 10 | 0.00 | | 1 | 0 | 0 | 0 | 1 | 0 | | CHB,STB |
| | | 64 | EF | 7 | 3 | 0 | | 10 | 0.00 | | 1 | 0 | 0 | | 1 | 0 | | CHB,STB |
| | RF | 30 | EF | 19 | 6 | 0 | | 25 | 0.00 | | 0 | 1 | 0 | | 1 | 0.00 | | CHB,STB |
| | | 35 | EF | 3 | 1 | 0 | | 4 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| | | 50 | EF | 8 | 0 | 1 | 1,0 | 10 | 0.00 | | 0 | 0 | 0 | 0,0 | 0 | 0.00 | | CHB,STB |
| | | 63 | EF | 1 | 0 | 0 | | 1 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB,STB |
| Mat 7 | PL | 10 | DO | 5 | 4 | 4 | 4 | 6 | 0.25 | 0.94 | 3 | 2 | 2 | 2 | 4 | 0.25 | 0.89 | TRT |
| | | 28 | DO | 4 | 4 | 4 | 4 | 4 | 0.00 | 1.00 | 5 | 4 | 5 | 5 | 5 | 0.25 | 0.95 | TRT |
| | | 48 | DO | 1 | 1 | 1 | 1 | 1 | 0.00 | 1.00 | 1 | 1 | 1 | 1 | 1 | 0.00 | 1.00 | |
| | | 73 | DO | 0 | 0 | 0 | 0 | 0 | 0.00 | | 1 | 1 | 1 | 1 | 1 | 0.00 | 1.00 | |
| | | 80 | DO | 4 | 5 | 2 | 5 | 5 | 2.00 | 0.50 | 6 | 3 | 4 | 3 | 8 | 2.00 | 0.50 | |
| | | 40 | DO | 2 | | | | | | | 0 | | | | | | | |
| | | 58 | DO | 18 | | | | | | | 2 | | | | | | | |
| | | 83 | DO | 5 | | | | | | | 5 | | | | | | | TRT |
| | FW | 3 | EF | 11 | 7 | 1 | | 20 | 6.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 14 | EF | 11 | 4 | 0 | | 15 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 31 | EF | 2 | 1 | 0 | | 3 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 39 | EF | 4 | 1 | 1 | 0 | 6 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | |
| | | 61 | EF | 1 | 0 | 0 | | 1 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 68 | EF | 6 | 2 | 1 | | 10 | 6.00 | | 2 | 1 | 0 | | 3 | 0.00 | | |
| | | 70 | EF | 0 | 0 | | | 0 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | |
| | RF | 2 | EF | 4 | 4 | 2 | 1 | 11 | 12.00 | | 0 | 0 | 0 | 0 | 0 | 0.00 | | |
| | | 11 | EF | 7 | 0 | 0 | | 7 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 36 | EF | 12 | 3 | 1 | | 16 | 6.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 49 | EF | 4 | 2 | 0 | | 6 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 52 | EF | 4 | 0 | 0 | | 4 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |

Appendix B. *(continued)*

| Study | Habitat | | Samp | Fry <10cm | | | | adj MBC / Jackknife | | Capt/Obs | Juvenile+ 10cm+ | | | | adj MBC / Jackknife | | Capt/Obs | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Category | Unit # | Method | P#1 | P#2 | P#3 | P#4 | Abundance | Variance | Prob | P#1 | P#2 | P#3 | P#4 | Abundance | Variance | Prob | Species |
| | | 78 | EF | 2 | 0 | 0 | | 2 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 79 | EF | 2 | 0 | | | 2 | 0.00 | | 0 | 0 | | | 0 | 0.00 | | |
| UNF new | PL | 21 | DO | 5 | 5 | 6 | 6 | 6 | 0.33 | 0.94 | 4 | 2 | 4 | 5 | 7 | 1.58 | 0.58 | CHB |
| | | 23 | DO | 4 | 4 | 3 | 3 | 4 | 0.33 | 0.90 | 3 | 3 | 4 | 5 | 7 | 0.92 | 0.76 | CHB |
| | | 27 | DO | 4 | 6 | 6 | 6 | 6 | 1.00 | 0.82 | 4 | 3 | 2 | 4 | 4 | 0.92 | 0.72 | CHB |
| | | 62 | DO | 0 | 1 | 2 | 3 | 4 | 1.67 | -0.11 | 0 | 0 | 0 | 1 | 2 | 0.25 | 0.00 | CHB |
| | | 88 | DO | 0 | 0 | 0 | | 0 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | CHB |
| | | 55 | DO | 0 | | | | | | | 0 | | | | | | | |
| | | 57 | DO | 0 | | | | | | | 0 | | | | | | | |
| | | 92 | DO | 2 | | | | | | | 1 | | | | | | | CHB |
| | FW | 8 | EF | 12 | 3 | 2 | | 18 | 12.00 | | 1 | 0 | 0 | | 1 | 0.00 | | |
| | | 22 | EF | 7 | 0 | 1 | 0 | 8 | 0.00 | | 1 | 0 | 0 | 0 | 1 | 0.00 | | |
| | | 45 | EF | 6 | 1 | 0 | | 7 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 73 | EF | 4 | 3 | 1 | | 9 | 6.00 | | 1 | 0 | 0 | | 1 | 0.00 | | |
| | | 76 | EF | 5 | 2 | 0 | | 7 | 0.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 78 | EF | 1 | 1 | 0 | | 2 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 84 | EF | 5 | 4 | 0 | | 9 | 0.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | | 91 | EF | 8 | 4 | 2 | | 15 | 12.00 | | 1 | 0 | 0 | | 1 | 0.00 | | CHB |
| | RF | 2 | EF | 17 | 5 | 2 | | 25 | 12.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 5 | EF | 14 | 8 | 2 | | 25 | 12.00 | | 2 | 0 | 0 | | 2 | 0.00 | | TRT |
| | | 9 | EF | 9 | 1 | 1 | | 11 | 6.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 13 | EF | 13 | 1 | 1 | 1 | 16 | 12.00 | | 0 | 0 | 1 | 0 | 1 | 0.00 | | |
| | | 14 | EF | 7 | 4 | 0 | | 11 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 25 | EF | 16 | 2 | 2 | | 21 | 12.00 | | 1 | 0 | 0 | | 1 | 0.00 | | |
| | | 93 | EF | 2 | 0 | 0 | | 2 | 0.00 | | 0 | 0 | 0 | | 0 | 0.00 | | |
| | | 98 | EF | 6 | 3 | 0 | | 9 | 0.00 | | 2 | 0 | 0 | | 2 | 0.00 | | CHB |