AQUATIC BIOASSAY AND CONSULTING LABORATORIES

Ventura County Stormwater Monitoring Program
Ventura River Watershed
2005 Bioassessment Monitoring Report

AQUATIC BIOASSAY AND CONSULTING LABORATORIES

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Prepared August 2006

August 28th, 2006

Mr. David Thomas
County of Ventura
Watershed Protection District
800 S. Victoria Ave.
Ventura, CA 93009

Dear Mr. Thomas:

In accordance with the Consulting Services Contract AE No. 06-J14, Work Order No. PW06-381 dated March 24th, 2006 between the County of Ventura and Aquatic Bioassay and Consulting Laboratories, Inc., we are pleased to present the Ventura County Stormwater Monitoring Program, Ventura River Watershed, 2005 Bioassessment Monitoring Report. The enclosed report includes the summary results for the September 2005 annual requirements set forth by the California Regional Water Quality Control Board, Los Angeles Region.

Yours very truly,

Scott C. Johnson

Scott C. Johnson
Director of Environmental Programs
Aquatic Bioassay & Consulting Laboratories
29 N. Olive St.
Ventura, CA 93001

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Submitted to:

The County of Ventura
Watershed Protection District
800 S. Victoria Ave.
Ventura, CA 93009

Submitted by:

Aquatic Bioassay and Consulting Laboratories
29 N Olive Street
Ventura, CA 93001

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Major Findings

The following were the main findings for the fall 2005 benthic macroinvertebrate (BMI) survey of the Ventura River watershed:

- The September 2005 BMI survey was preceded by winter storms in December, January and February that dropped a combined total of 44.5 inches of rain (23.3 inches above normal) and represented the greatest amount of rain measured during the last five years since BMI sampling began. These storms produced widespread flooding, erosion and sedimentation throughout the watershed. As a result of the unusually large amount of rain, 14 of the 15 BMI sampling locations had significant flow during the 2005 survey.

- Physical habitat conditions at the fourteen sampling sites ranged from marginal to optimal. The best habitat scores were at locations on the upper main stem of the Ventura River, upper San Antonio Creek and Matilija Creek. The lowest scores were at locations on the lower Ventura River and Canada Larga Creek.

- Based on the Southern California Index of Biological Integrity (So CA IBI) the aquatic health of the Ventura Watershed during 2005 ranged from poor to fair. One site each on the Ventura River and San Antonio Creek ranked in the poor range and the other twelve sites in the watershed ranked in the fair range. The sites that ranked in the poor range were located in areas of the watershed that were impacted by either a large human transient population on the Ventura River or was located downstream of an erosion control project in the vicinity of grazing and stables.

Executive Summary

The 2005 bioassessment survey of the Ventura Watershed was conducted by staff members from the Ventura County Watershed Protection District, the Ojai Valley Sanitation District and Aquatic Bioassay and Consulting Laboratories on September 13th, 14th and 15h, 2005. Staff members from the California Department of Fish and Game (CDFG) and/or the Sustainable Land Stewardship Institute (SLSI) have been present during each of the four survey years to audit all sample collection activities and to provide data analysis and reporting services (CDFG = Jim Harrington, SLSI = Monique Born).

Fifteen benthic macroinvertebrate (BMI) sampling locations were visited during the survey, with 14 sites having sufficient flow for sample collection. Physical/habitat observations, flow and water quality samples were also collected at each site. The taxonomic identification of BMI organisms, data analysis and report generation was conducted by Aquatic Bioassay and Consulting Laboratories in Ventura, CA. All of the QC guidelines for collection, sorting and identification of BMI organisms specified in the California Stream Bioassessment Protocol (2003) were met.

The physical habitat quality of the survey stations ranged from marginal to optimal. The best habitat scores were found at Stations located on the main stem of the Ventura River just below Matilija Dam and on the North Fork of Matilija Creek. These sites were characterized by relatively high substrate complexity, were composed of high percentages of cobble and boulders, had good bank stability, had little evidence of sedimentation due to upstream erosion and had good vegetative protection. The lowest habitat scores were measured on the Ventura River just upstream of the ocean and on Canada Larga Creek just above its confluence with the Ventura River. These sites were characterized by having less instream cover and increased amounts of sedimentation and embeddedness (a measure of the amount of space surrounding cobble and gravel in the streambed). The increased sedimentation is most likely due to the large winter rain storms that caused bank erosion from areas with upstream grazing, poor bank stability and poor vegetative cover. Water quality (pH, dissolved oxygen, temperature, specific conductance) was similar at all sites during the survey.

The aquatic health of the Ventura Watershed for 2005 was assessed using the Southern California Index of Biological Integrity (So CA IBI). Based on this index, BMI communities that are ranked as poor can be considered to be impaired. The IBI rankings for the 14 stations sampled for BMIs in 2005 ranged from fair (12 stations) to poor (2 stations). The two stations that were rated as poor were located at the Main St. bridge near where the Ventura River discharges into the Pacific Ocean (Station 0) and Station 15 located on San Antonio Creek. Station 11 in the North Fork of Matilija Creek had the highest IBI score of all sites, just below the good range, indicating that the BMI community found there is comparable to other reference site locations in southern California.

During the five year period from 2001 to 2005 the average IBI scores for all sites, except Stations 0 and 1, were in the fair to very good range. The average scores for Stations 0 and 1, each located above the Main Street Bridge, were below the impairment threshold (39). IBI scores increased with elevation on the Ventura River, Canada Larga Creek (Stations 2 and 3) and San Antonio Creek (Stations 5, 7, 15, 8 and 9). The greatest average IBI score during the five year period was at Station 11 on North Fork of Matilija Creek.

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INTRODUCTION

Ventura Watershed

The 228 square mile Ventura Watershed includes rugged mountains, a coastal chaparral ecosystem and valleys that lead to the Pacific Ocean. Almost half of the watershed is in the Los Padres National Forest. The Ventura River is the main watercourse within the watershed, with several major tributaries that includes Matilija Creek, San Antonio Creek and Canada Larga Creek (Figure 1). Matilija Creek drains the mountainous northern most portion of the watershed and can be divided into the main stem of the Creek above Matilija Dam and the North Fork of Matilija Creek which discharges into the main stem below the dam. San Antonio Creek drains the northeastern portion of the watershed and has two main tributaries, Lions Canyon Creek and Stewart Canyon Creek. Canada Larga Creek drains the eastern portion of the watershed.

The land use patterns within the watershed vary, but for the most part is undeveloped land and open space (89%). There are urbanized areas (1.5%) that include the cities of Ojai and Ventura (southeast side), and unincorporated communities including Oak View, Matilija Canyon, Live Oak Acres, Meiners Oaks and Casitas Springs. The approximate human population of these communities is 20,000. The land use designations in the developed areas vary widely from rural to residential to industrial. Human impacted areas include activities related to grazing and livestock, agriculture, oil production and recreation.

Bioassessment Monitoring

Major issues facing streams and rivers in California include modification of in-stream and riparian structure, contaminated water and increases in impervious surfaces, which has led to the increased frequency of flooding. There have been many studies and reports showing the deleterious effects of land-use activities to macroinvertebrate and fish communities (Jones and Clark 1987; Lenat and Crawford 1994; Weaver and Garman 1994; and Karr 1998). A major focus of freshwater scientists has been the prevention of further degradation and restoration of streams to their more pristine conditions (Karr et al. 2000).

During the past 150 years direct measurements of biological communities including plants, invertebrates, fish, and microbial life have been used as indicators of degraded water quality. In addition, biological assessments (bioassessments) can be used as a watershed management tool for surveillance and compliance of land-use best management practices. Combined with measurements of watershed characteristics, land-use practices, in-stream habitat, and water chemistry, bioassessment can be a cost-effective tool for long-term trend monitoring of watershed conditions (Davis and Simons 1995).

Biological communities act to integrate the effects of water quality conditions in a stream by responding with changes in their population abundances and species composition over time. These populations are sensitive to multiple aspects of water and habitat quality and provide the public with more familiar expressions of ecological health than the results of chemical and toxicity tests (Gibson 1996). Furthermore, biological assessments when integrated with physical and chemical assessments, better define the effects of point-source discharges of contaminates and provide a more appropriate means for evaluating discharges of non-chemical substances (e.g. nutrients and sediment).

Water resource monitoring using benthic macroinvertebrates (BMI) is by far the most popular method used throughout the world. BMIs are ubiquitous, relatively stationary and their large species diversity provides a spectrum of responses to environmental stresses (Rosenberg and Resh 1993). Individual species of BMIs reside in the aquatic environment for a period of months to several years and are sensitive, in varying degrees, to temperature, dissolved oxygen, sedimentation, scouring, nutrient enrichment and chemical and organic pollution (Resh and Jackson 1993). Finally, BMIs represent a significant food source for aquatic and terrestrial animals and provide a wealth of ecological and bio-geographical information (Erman 1996).

In the United States the evaluation of biotic conditions from community data uses a multi-metric technique. In multi-metric techniques, a set of biological measurements ("metrics"), each representing a different aspect of the community data, is calculated for each site. An overall site score is calculated as the sum of individual metric scores. Sites are then ranked according to their scores and classified into groups with "good", "fair" and "poor" water quality. This system of scoring and ranking sites is referred to as an Index of Biotic Integrity (IBI) and is the end point of a multi-metric analytical approach recommended by the EPA for development of biocriteria (Davis and Simon 1995). The original IBI was created for assessment of fish communities (Karr 1981) but was subsequently adapted for BMI communities (Kerans and Karr 1994).

The first demonstration of a California regional IBI was applied to the Russian River watershed in 1999 (DFG 1998). As the Russian River IBI was being developed, the Department of Fish and Game (DFG) began a much larger project for the San Diego Regional Board. After a pilot project conducted on the San Diego River in 1995 and 1996, the San Diego Regional Board contracted DFG to help them incorporate bioassessment into their ambient water quality monitoring program. During 1997 through 2000, data was collected from 93 locations distributed throughout the San Diego region. Finally, between 2000 and 2003, bioassessment data were collected from the Mexican border to the south, Monterey County to the north and to the eastern extent of the coastal mountain range. These data were used to create an IBI that is applicable to southern California and is applied to the data in this report (Ode 2005).

In fulfillment of the District's NPDES storm water permit requirement, the goal of this report was to assess the aquatic health of the Ventura River and its main tributaries based on the results of the physical habitat and BMI community data collected at 14 sites in September 2005. In addition, these data were compared and contrasted to the previous four years of data to look for any spatial or temporal water quality trends.

MATERIALS AND METHODS

Sampling Site Descriptions

Fifteen BMI sampling locations were visited in the Ventura River watershed from September 13th, 14th and 15th 2005 (Figure 1, Table 1). Photographs of each site are displayed in Figure 2. The 15 sites can be grouped into four geographic areas: Stations 0, 4, 6 and 12 located in the main stem of the Ventura River; Stations 2 and 3 located in Canada Larga Creek; the upper watershed which includes Stations 10, 11, 13 and 14 in Matilija Creek and the North Fork of Matilija Creek; and Stations 5, 7, 8, 9 and 15 located in San Antonio Creek and its tributaries, Lions Canyon Creek and Stewart Canyon Creek. All stations in the watershed, except Station 6, were flowing during the 2005 survey as a result of the large rainfall events that occurred during the previous winter. This is in contrast to previous years when numerous sites were dry during the September sampling event.

Ventura River, Lower Watershed (Stations 0, 4, 6 and 12)

The stations located on the main stem of the Ventura River range in elevation from 19 ft. at Station 0 near the ocean to 1020 ft. at Station 12 below the Matilija Dam. The Ventura River is the main drainage for the entire watershed and receives runoff from three main tributary systems: the Matilija Creek system above the dam; the San Antonio Creek system; and the Canada Larga Creek system.

Station 0 is located upstream of the Main St. bridge just above where the Ventura River discharges into the Pacific Ocean. It is the first site in the Ventura River that is not influenced by salinity changes caused by tidal flushing. The river bed at Station 0 is heavily influenced by a large transient human population which lives there. The banks on each side of the river are stabilized by rock levees designed to protect the City of Ventura from flooding. The Ojai Valley Sanitation Plant is located 2.5 miles upstream of Station 0 and discharges 2.0 million gallons per day (MGD) of tertiary treated effluent, a process that includes nitrogen and phosphorus removal.

Station 4 is located at Foster Park, just upstream of a traffic bridge and has small levees stabilizing both banks. In past years sampling at this site occurred across the entire width of the river. In 2005, the north half of the reach was not flowing due to sediment deposition. The river bottom is composed of boulders and cobble. During the dry season filamentous algae is prevalent.

Station 6 is located upstream of the traffic bridge at Santa Ana Road. The channel at this site is concrete reinforced and covered with cobble on the sides and bottom. This site has been dry during September for the last five years.

Station 12 is located at the base of the Matilija Dam. The dam, which is fed by Matilija Creek, is filled with sediment and no longer serves as a flood control structure and is scheduled for removal in the future. The habitat at Station 12 is composed of boulders and natural vegetation.

Canada Larga Creek (Stations 2 and 3)

Stations 2 and 3 are located on Canada Larga Creek, the first major tributary to the Ventura River upstream of the ocean. The Canada Larga drains a rural area composed of ranch land and open space. Station 3 is located near its headwaters and above areas of heavy grazing. Station 2 is located just upstream of the Canada Larga’s confluence with the Ventura River and downstream of the heavily grazed portion of the watershed. Both of these sites were flowing during the September 2005 sampling event.

Matilija Creek, Upper Watershed (Stations 10, 11, 13 and 14)

Each of the stations in the upper watershed is located above the influence of the Matilija Dam, at elevations near or above 1,000 ft. The Matilija Creek system drains a small portion of the Los Padres National Forest and is composed of mostly rural and recreational lands. Each of the monitoring sites is located in relatively pristine areas and is composed of high gradient, bolder and cobble habitats. Stations 10 and 11 are located on the North Fork of Matilija Creek, above (Station 11) and below (Station 10) an active rock quarry. Station 10 is heavily used for recreational swimming. Stations 13 and 14 are located on the main stem of Matilija Creek, above (Station 14) and below (Station 13) a small residential community that uses septic tanks as its means of sanitation. In previous years excessive algal growth had been present at Station 13, leading to concerns that the community could be contributing nutrients to the Creek.

San Antonio Creek (Stations 5, 7, 8, 9 and 15)

Stations 5, 7, 8, 9 and 15 are located in the San Antonio Creek system and include sites on San Antonio Creek (Stations 5, 9 and 15), as well as its main tributaries, Lions Canyon Creek (Station 7) and Stewart Canyon Creek (Station 8). Station 5 is located upstream of the bike path on San Antonio Creek just above its confluence with the Ventura River. The streambed is predominantly cobble with dense bank vegetation. Station 7 is located in Lions Canyon Creek above its confluence with San Antonio Creek in an area with stables, heavy grazing and sedimentation. During the heavy winter storms this site was heavily scoured with subsequent erosion control projects after the storms subsided. Station 15 is located in San Antonio Creek upstream of Lions Canyon Creek and is composed of boulders, cobble and sand. Station 8 is located in Stewart Canyon Creek above the confluence with the San Antonio Creek and has a streambed composed of cobble, gravel and sand. Station 9 is located in San Antonio Creek upstream of Stewart Canyon Creek and is composed of cobble, gravel and sand with heavy vegetation on both banks. Both Stewart Canyon and San Antonio Creek at Stations 8 and 9 drain the City of Ojai’s downtown and residential areas.

Figure 1. Fifteen BMI sampling locations in the Ventura River watershed.

Table 1. Sampling locations descriptions for 15 locations in the Ventura River watershed. u/s = upstream; d/s = downstream.

Sta.ID	Name	Description and Comments	Latitude	Longitude	Elev.
0	Ventura River – Main Street Bridge	Mainstem Ventura River, first site above estuary with fresh water.	34 16 54.23	119 18 24.09	19
4	Ventura River - Foster Park	Mainstem Ventura River. Closest downstream site to confluence with San Antonio Creek. Station is also mass emission station. Bioassessment d/s from Foster Park Bridge.	34 21 07.9	119 18 23.7	200
6	Ventura River -Santa Ana Rd.	Mainstem Ventura River **Dry Not Sampled**	34 23 59.1	119 18 29.7	403
12	Ventura River - below Matilija Dam	Matilija Creek. First station below Matilija dam and first existing station above urban influence.	34 29 2.4	119 18 1.7	1020
2	Canada Larga Creek	Canada Larga Creek, d/s of grazing	34 20 31.7	119 17 08.2	293
3	Canada Larga Creek	Canada Larga Creek, above main area of grazing impact.	34 22 23.3	119 14 8.8	334
5	San Antonio Creek - near Ventura River	San Antonio Creek, first upstream site from confluence with Ventura River.	34 22 50.9	119 18 23.9	347
7	Lion Canyon Creek – u/s conf. San Antonio Creek	Lion Canyon Creek (tributary to San Antonio Creek) First u/s location from confluence. Site with heavy sediment load and influenced by nearby stables and grazing.	34 25 19.3	119 15 46.8	623
15	San Antonio Creek above Lion Creek	San Antonio Creek above Lion Creek	34 25 19.3	119 15 46.8	623
8	Stewart Canyon Creek – u/s conf. San Antonio Creek	Stewart Creek (tributary to San Antonio Creek) First u/s location from confluence. Within close proximity to the City of Ojai and less densely developed residential lots.	34 26 07.1	119 14 49.3	685
9	San Antonio Creek near Stewart Canyon Creek	San Antonio Creek. Within close proximity to the City of Ojai and less densely developed residential lots.	34 26 1.8	119 14 52.7	650
10	North Fork Matilija Creek- u/s Ventura River conf.	North Fork Matilija Creek above influence of Matilija Dam and below rock quarry.	34 29 06.0	119 17 59.4	978
11	North Fork Matilija Creek- at gauging station	North Fork Matilija Creek above influence of Matilija Dam and above rock quarry.	34 29 35.1	119 18 18.6	1,360
13	Matilija Creek - below community	Matilija Creek. Above dam and below community. Site has excessive amount of algae.	34 30 04.5	119 20 51.7	1,355
14	Matilija Creek - at gate at end of road	Matilija Creek. Above dam and above community.	34 30 16.9	119 22 26.3	1,553

Figure 2. Photos of each Ventura Watershed site.

Station 0 – Main Street Bridge

Station 4 – Foster Park

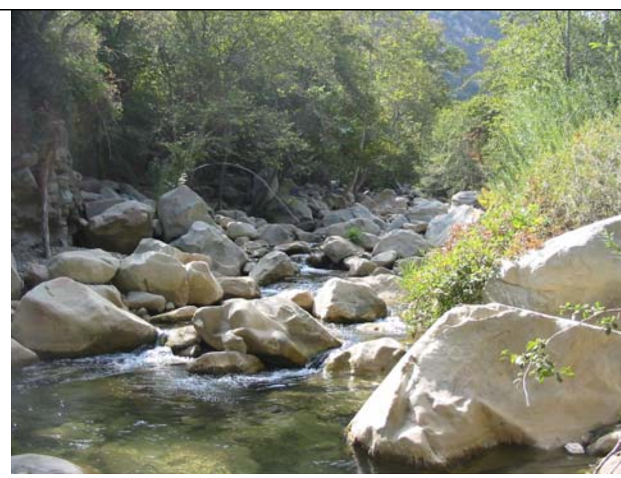
 Station 12 – Below Matilija Dam	
 Station 2 – Lower Canada Larga Creek	
 Station 3 – Upper La Canada Creek	

 Station 5 – San Antonio Creek	
 Station 7 – Lion Canyon Creek	
 Station 15 – San Antonio Creek	

Station 8 – Stewart Canyon Creek

Station 9 – San Antonio Creek, upstream of Stewart Canyon Creek

Station 10 – N. Fork of Matilija Creek, below quarry




Station 11 – N. Fork of Matilija Creek, upstream of quarry


Station 13 – Matilija Creek, below community


Station 14 – Matilija Creek, above community

Collection of Benthic Macroinvertebrates

September was chosen for sampling the BMI communities in the Ventura Watershed since fall represents the time when the water quality conditions are the most stressful for biotic communities. However, the Ventura River and its tributaries can be dry during the late summer and fall months as is typical of most southern California river systems. This was not the case for the 2004-2005 rain year when precipitation was well above normal. As a result, only one of the 15 sites was not flowing during September 2005.

Sampling and laboratory procedures for this survey followed the California Stream Bioassessment Procedure (CSBP 2003). The CSBP is a regional adaptation of the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (Barbour et al. 1999) and has been used in various parts of the world to measure biological integrity of aquatic systems (Davis et al. 1996). Sampling procedures were audited by Jim Harrington of the California Department of Fish and Game.

Benthic macroinvertebrate (BMI) samples were collected in strict adherence to the CSBP in terms of both sampling methodology and QC procedures. At each station, a 100 m reach was measured and 3 riffles were randomly selected from all the possible riffles that were present within the reach. When access to the full 100 m reach was not possible due to obstacles (i.e. heavy vegetation), riffles were chosen from the portion of the reach where access was possible. Riffles were defined as areas in the reach where the velocity of flow was greatest due to shallow water coupled with a high relief bottom. At each site the California Bioassessment Worksheet (CBW) was used to collect all of the necessary station information.

Once three riffles were randomly identified, the most downstream riffle was occupied and the length of the riffle was measured. A random number table was used to randomly establish three points along the riffle where transects were established perpendicular to stream flow. Starting with the downstream riffle, the benthos within a 2 ft^2 area was sampled upstream of a 1 ft wide, 0.5 mm mesh D-frame kick-net. Sampling of the benthos was performed manually by rubbing cobble and boulder substrates in front of the net, followed by "kicking" the upper layers of substrate to dislodge any remaining invertebrates. The duration of sampling ranged from 60-120 seconds, depending on the amount of boulder and cobble-sized substrate that required rubbing by hand; more and larger substrates required more time to process.

Three locations along each transect that were representative of habitat diversity were sampled and combined into a composite sample. Each composite sample was transferred into a 1 gallon wide-mouth plastic jar containing approximately 300 ml of 95% ethanol. This technique was repeated for each of three riffles in each reach, thus, three composite samples were collected for each site. Chain of Custody (COC) sheets were completed for samples as each station was completed.

Physical/Habitat Quality Assessment, Water Quality and Chemical Measurements

Physical habitat quality was assessed for the monitoring reaches using U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (RBPs) (Barbour et al. 1999). The team collected the physical/habitat measurements at each station and recorded the information on the CBW. These measurements are summarized as follows:

1. Water temperature, specific conductance, pH and dissolved oxygen were measured using a hand held YSI 85 water quality meter that was pre-calibrated in the laboratory.

2. Riffle length, width and depth in meters were recorded. Width measures were averages taken at each transect and depth measures were averages taken along each transect.
3. A hand held Marsh McBirney Flowmate 2000 velocity meter was used to measure current velocity. Three measures were collected along each transect and then averaged together. Flow was calculated using the cross sectional flow measurement method.
4. A densitometer was used to measure % canopy cover.
5. Substrate complexity, embeddedness, consolidation and categories (fines, gravel, cobble, boulder, and bedrock) were estimated using the CSBP Physical/Habitat Quality Form.
6. Stream gradient was estimated using a survey rod and hand level.
7. Nutrient samples for nitrate and nitrite nitrogen, and phosphate phosphorus were collected and analyzed by the Ojai Valley Sanitation District laboratory.
8. Aquatic Bioassay and Consulting Laboratories analyzed all bacterial samples. Samples were collected in sterile 250 mL plastic containers and analyzed according to *Standard Methods for the Examination of Water and Wastewater*, APHA, 19th Edition, methods 9222 (total and fecal coliforms) and 9230 (enterococcus bacteria).

Sample Analysis/Taxonomic Identification of Benthic Macroinvertebrates (BMIs)

Sample sorting and taxonomy were conducted by Aquatic Bioassay and Consulting Laboratories. Sorting was conducted in the Aquatic Bioassay laboratory in Ventura, CA and taxonomic identifications were conducted by Dr. Kim Kratz in Lake Oswego, OR. Identifications were made using standard taxonomic keys (Literature Cited, Taxonomic References). In most cases taxa for this study were identified to the species level. In adherence with Taxonomic Effort Level 1 specified in the CSBP, identifications were rolled up to the appropriate taxonomic level for the calculation of biological metrics and the Southern California IBI. Samples entering the lab were processed as follows:

A maximum number of 300 organisms were sub-sampled from the composite sample using a divided tray, and then sorted into major taxonomic groups. All remnants were stored for future reference. The 300 organisms were identified to the genus level for most insects and order or class for non-insects. As new species to the survey area were identified, examples of each were added to the voucher collection. The voucher collection includes at least one individual of each species collected and ensures that naming conventions can be maintained and changed as necessary into the future.

The taxonomic quality control (QC) procedures followed for this survey included:

- Sorting efficiencies were checked on all samples. The leftover material from each sample was inspected by the laboratory supervisor. Minimum required sorting efficiency was 95%, i.e. no more than 5% of the total number of organisms sorted from the grids could be left in the remnants. Sorting efficiency results were documented on each station's sample tracking sheet.
- Once identification work was completed, 10% of all samples were sent to the Department of Fish and Game (DF&G) offices in Rancho Cordova for a QC check. Samples were sorted by species into individual vials that included an internal label. Any discrepancies in counts or identification found by the DF&G taxonomists were discussed, and then resolved. All data sheets were corrected and, when necessary, bioassessment metrics were updated.

Data Development and Analysis

Multi-metric Analysis

As species were identified, they were included in an Excel data sheet that, once complete, automatically calculated the bioassessment metrics used to assess the spatial and temporal BMI community changes in the watershed or necessary to calculate the southern California IBI (Ode 2005). The following metrics were calculated and their responses to impaired conditions are listed in Table 2:

1. Richness measures: taxa richness, cumulative taxa, EPT taxa, cumulative EPT taxa, Coleopteran taxa.
2. Composition measures: EPT index, sensitive EPT index, Shannon diversity.
3. Tolerance/intolerance measures: mean tolerance value, intolerant organisms (%), tolerant organisms (%), dominant taxa (%), Chironomidae (%), non-insect taxa (%).
4. Functional feeding group: collectors (%), filterers (%), grazers (%), predators (%), shredders (%).

Table 2. Bioassessment metrics used to describe characteristics of the BMI community.

BMI Metric	Description	Response to Impairment
Richness Measures		
Taxa Richness	Total number of individual taxa	decrease
EPT Taxa	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	decrease
Ephemeroptera Taxa	Number of taxa in the insect order Ephemeroptera (mayflies)	decrease
Plecoptera Taxa	Number of taxa in the insect order Plecoptera (stoneflies)	decrease
Trichoptera Taxa	Number of taxa in the insect order Trichoptera (caddisflies)	decrease
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	decrease
Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with tolerance values between 0 and 3	decrease
Shannon Diversity	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963)	decrease
Tolerance / Intolerance Measures		
Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	increase
Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	decrease
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	increase
Percent Dominant Taxa	Percent composition of the single most abundant taxon	increase
Percent Hydropsychidae	Percent of organisms in the caddisfly family Hydropsychidae	increase
Percent Baetidae	Percent of organisms in the mayfly family Baetidae	increase
Functional Feeding Groups (FFG)		
Percent Collectors	Percent of macrobenthos that collect or gather fine particulate matter	increase
Percent Filterers	Percent of macrobenthos that filter fine particulate matter	increase
Percent Grazers	Percent of macrobenthos that graze upon periphyton	variable
Percent Predators	Percent of macrobenthos that feed on other organisms	variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	decrease
Estimated Abundance	Estimated number of BMIs in sample calculated by extrapolating from the proportion of organisms counted in the subsample	variable

Southern California IBI

The seven biological metric values used to compute the Southern California Index of Biological Integrity (So CA IBI) are presented in Table 3 (Ode et al. 2005). The So CA IBI is based on the calculation of biological metrics from a group of 500 organisms from a composite sample collected at each stream reach. The sampling design for the Ventura Watershed for each of the last four sampling events (2001 through 2004) included a total of 900 organisms per reach (three replicate samples, 300 organisms each). As a result, before the So CA IBI could be computed for each station, 500 individual organisms were randomly selected from the list of 900 organisms at each station. These 500 organisms were used to compute the seven biological metrics used in the IBI computation. Ode et. al. (2005) showed that this adjustment does not affect the outcome of the IBI. This adjustment was also applied to the data for the prior three years, so that historical trends could be elucidated.

Table 3. Scoring ranges for the seven metrics included in the Southern California IBI and the cumulative IBI score ranks.

Metric Score	Coleoptera Taxa	EPT Taxa		Predator Taxa	% Collector Individuals		% Intolerant Individuals		% Non-Insect Taxa	% Tolerant Taxa
	All Sites	6	8	All Sites	6	8	6	8	All Sites	All Sites
10	>5	>17	>18	>12	0-59	0-39	25-100	42-100	0-8	0-4
9		16-17	17-18	12	60-63	40-46	23-24	37-41	9-12	5-8
8	5	15	16	11	64-67	47-52	21-22	32-36	13-17	9-12
7	4	13-14	14-15	10	68-71	53-58	19-20	27-31	18-21	13-16
6		11-12	13	9	72-75	59-64	16-18	23-26	22-25	17-19
5	3	9-10	11-12	8	76-80	65-70	13-15	19-22	26-29	20-22
4	2	7-8	10	7	81-84	71-76	10-12	14-18	30-34	23-25
3		5-6	8-9	6	85-88	77-82	7-9	10-13	35-38	26-29
2	1	4	7	5	89-92	83-88	4-6	6-9	39-42	30-33
1		2-3	5-6	4	93-96	89-94	1-3	2-5	43-46	34-37
0	0	0-1	0-4	0-3	97-100	95-100	0	0-1	47-100	38-100

Cumulative IBI Scores

Very Poor	Poor	Fair	Good	Very Good
0-19	20-39	40-59	60-79	80-100

Historical Analysis

Historical IBI Scores

The So CA IBI was calculated for each station from 2001 through 2005. For the So CA IBI, data from each year were converted from 900 count species abundances to 500 using the randomization process described above.

RESULTS

Rainfall

Rainfall measured at the Stewart Creek gauging station during the 2005 to 2006 rain year (44.5 inches) was 23.3 inches above normal (21.2 inches) and was the greatest amount of rain measured during the last five years since BMI sampling began (Figure 3). Heavy rain storms in December (8.6 inches), January (16.9 inches) and February (9.4 inches) produced widespread flooding, erosion and sedimentation throughout the watershed. Typical of southern California, no rain fell between June and September. In normal rainfall years many reaches in the Ventura Watershed are dry during September when sampling for BMI's is conducted. As a result of the unusually large amount of rain that fell during the preceding winter, all BMI sampling locations (except Station 6 on the Ventura River main stem) had significant flow.

Physical Habitat Characteristics

Velocity and Flow

The physical characteristics of the riffles sampled in the Ventura Watershed during September 2005 are presented in Table 4. Riffle velocities ranged from 0.8 ft/sec at Stations 11 (N. Fork Matilija Creek) to 2.78 ft/sec at Station 15 on Lion Canyon Creek. Flow in the watershed was greatest at Station 12 (8.31 cfs) below Matilija Dam. The next greatest flow was measured at Station 13 (7.85 cfs), below the residential community in Matilija Creek. Lowest flows were measured at Station 3 (0.07 cfs) in Canada Larga Creek and Station 8 in Stewart Canyon (0.08 cfs).

Canopy Cover and Substrates

Vegetative canopy cover ranged from 0% at Stations 4 (Foster Park) and 7 (Lion Canyon Creek) to 100% at Stewart Canyon Creek (Station 8) (Table 4). Substrate complexity was relatively good at most stations in the watershed ranging from poorest (2) at Station 2 (Canada Larga Creek) to best (19) at Station 15 (Lion Canyon Creek). Other sites with low complexity scores included Station 0 (Main Street Bridge), Station 5 (San Antonio at Ventura River confluence), Station 7 (lower Lion Canyon Creek) and Station 9 on the upper San Antonio Creek. Streambed substrates in the most of the watershed were, for the most part, composed of similar percentages of fines, gravel, cobble and boulders. The exceptions to this were Stations 12 (below Matilija Dam), 13 and 14 (Matilija Creek) where boulders predominated. All of the sites were high gradient streams (≥ 2%), except Stations 0, 2 and 5 (all <2%).

Water Quality, Nutrients & Bacteria

The range for pH measurements was narrow among all sites and ranged from 8.00 at Station 9 to 8.75 at Station 0 (Table 4). Dissolved oxygen concentrations ranged from 8.01 mg/L at Station 9 to 13.32 mg/L at Station 0. Dissolved oxygen concentrations can vary widely at the same site throughout the day due to changes in water temperature and, based on the amount of available sunlight, the photosynthetic rate of oxygen producing algae. Water temperatures were typical of summer conditions and ranged from 13.9 °C to 25.3 °C on the upper and lower Canada Creek sites (Stations 2 and 3, respectively). Specific conductance was lowest at upper watershed sites 10, 11, 13 and 14, at Foster Park (Station 4) and below the Matilija Dam (Station 12) (range = 748 to 880 uS/cm). The greatest conductance was measured at Station 2 in Lower Canada Larga Creek (2414 uS/cm).

Nitrate nitrogen was greatest at Stations 5 (66 mg/L) and was much lower (range = 0.2 to 5.7 mg/L) or below detection (0.1 mg/L) at all other sites. Nitrite nitrogen was just above detection at Stations 5 and 8, and was below detection at all other sites. Phosphate phosphorus concentrations were just above detection at Stations 3 and 8, and below detection at all others.

All three indicator bacteria concentrations were relatively low throughout the watershed. Total coliform bacteria concentrations were greatest at Station 0 (2,400 MPN/100 mL) and lowest at Station 13 below the community on Matilija Creek (22 MPN/100 mL). Fecal coliform concentrations were greatest at Stations 7 (1,600 MPN/100 mL) and were below detection (<2 MPN/100 mL) at Stations 10, 11 and 13. Enterococcus bacteria concentrations were also greatest at Station 3 in Canada Larga Creek and were below detection (<2 MPN/100 mL) at Stations 11, 13 and 14.

Physical/Habitat Scores

Assessment of the physical/habitat conditions of a stream reach is necessary for two reasons: one is to assess the overall quality of a stream reach and another is to assess the physical/habitat of the bioassessment site. In many cases organisms may not be exposed to chemical contaminants, yet their populations indicate that impairment has occurred. These population shifts can be due to degradation of the streambed and bank habitats. Excess sediment, caused by bank erosion due to human activities, is the leading pollutant in streams and rivers of the United States (Harrington and Born 2000). Sediments fill pools and interstitial areas of the stream substrate where fish spawn and invertebrates live, causing their populations to decline or to be altered. Physical/habitat characterization of the site is also important to help ensure that habitats are uniform between riffles so that population differences can be accurately assessed.

Out of a total possible score of 200, physical/habitat scores ranged from worst (38) at Station 2 on Canada Larga Creek to 174 at Station 12 below the Matilija Dam (Table 4, Figure 4). Physical habitat scores increased from downstream to upstream on the main stem of the Ventura River from Station 0 (90) to Station 12 (174) located just below the Matilija Dam. The reduction in habitat quality from Station 12 to 0 was due mostly to a reduction in streambed complexity owing to increased sediment deposition, channel alteration and decreased bank stability. Station 12 is composed mostly of boulders and cobble, and is well vegetated along its entire reach. Station 4 is located upstream of a bridge and has levees that line both banks. Station 0 is also located above a bridge and has levees on both banks, but also is impacted by a large transient population.

Conditions on Canada Larga Creek were better above the grazing zone at Station 3 (95) than near the confluence of the Ventura River at Station 2 (38). This was due mostly to better instream cover, less channel alteration, a higher frequency of riffles and a large riparian zone at Station 3.

Each of the San Antonio Creek sites scored over 100, with the best habitat found at Station 15 and Station 8. Stations 5 and 9 both lacked good instream cover and depth/velocity regimes, and were more embedded than other sites on the San Antonio. Station 7 was heavily eroded and scored low for vegetative protection, bank stability and width of the riparian zone.

The best habitat scores were measured at Stations 13 and 14 on the main stem of Matilija Creek and Stations 10 and 11 on the North Fork of Matilija Creek. These sites all were composed of a mixture of boulder, cobble and gravel, had little sediment deposition and good vegetative cover.

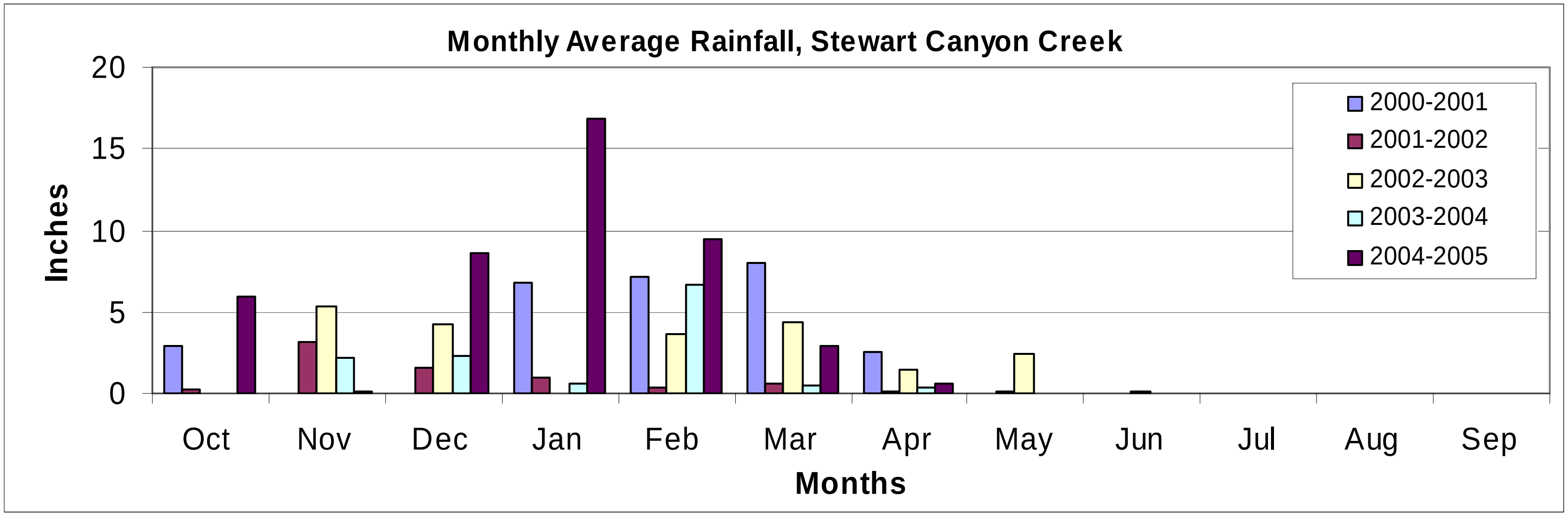


Figure 3. Monthly average rainfall (inches) at Stewart Canyon Creek for the 2000-2001 through 2004-2005 rain years.

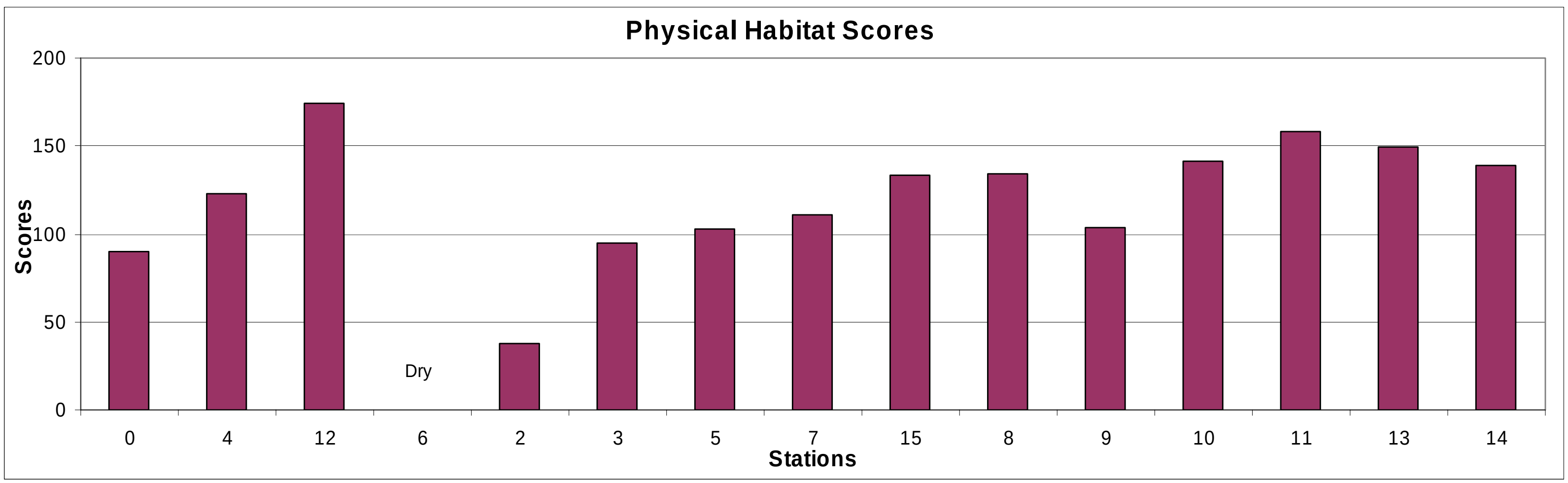


Figure 4. Physical habitat scores for reaches in the Ventura River watershed.

Table 4. Physical habitat scores and characteristics for reaches in the Ventura River Watershed (CADFG 2003).

	Ventura River				Canada Larga		San Antonio Creek					North Fork Matilija Creek		Matilija Creek	
	Main Street Bridge	Foster Park	Below Matilija Dam	@Santa Ana Rd.	Below Grazing	Above Grazing	u/s Ventura River Confluence	Lion Canyon u/s San Antonio	u/s Lion Canyon	Stewart Canyon u/s San Antonio	u/s Stewart Canyon Creek	u/s Ventura River Confluence	At gauging station	Below community	Above Community
Station	0	4	12	6 Dry	2	3	5	7	15	8	9	10	11	13	14 Dry
Physical Habitat Parameter															
1. Instream Cover	7	12	18		2	10	9	5	19	15	8	14	16	13	12
2. Embeddedness	13	8	16		14	4	8	17	17	11	7	15	12	16	13
3. Velocity/Depth Regime	10	13	18		9	10	9	17	19	13	8	19	18	15	10
4. Sediment Deposition	7	9	15		2	5	10	16	13	17	14	12	12	16	16
5. Channel Flow	6	9	19		4	7	5	6	6	12	11	14	17	10	8
6. Channel Alteration	12	10	19		1	19	11	17	19	11	18	14	18	15	18
7. Riffle Frequency	16	19	18		2	15	11	19	19	16	7	18	18	16	19
8. Bank Stability	8	18	17		1	0	17	4	3	17	9	16	16	17	16
9. Vegetative Protection	6	7	18		0	9	10	1	9	10	8	11	17	13	10
10. Riparian Vegetative Zone	5	18	16		3	16	13	9	9	12	14	8	14	18	17
Reach Total	90	123	174		38	95	103	111	133	134	104	141	158	149	139
Physical Habitat Characteristics															
Average Riffle Length (ft)	150	250	40		300	37	18	22	26	40	280	22	17	12	17
Average Riffle Width (ft)	80	60	23		6.6	4.3	17	4	8.7	5	30	18	13	27	18
Average Riffle Depth (in)	6	7.2	7.2		3.6	3.12	6.84	4.8	8.76	3.6	3.96	6.72	6	10.32	4.8
Average Riffle Velocity (ft/sec)	2.61	1.68	1.2		0.87	0.98	1.72	1.83	2.78	1.23	1.63	2.5	0.8	2	1.72
Flow (cf/sec)	1.63	0.47	8.31		0.26	0.07	0.73	0.24	0.94	0.08	0.45	0.63	0.61	1.85	1.19
Vegetative Canopy Cover (%)	10	0	24		1	26	53	0	59	100	39	36	59	N/A	N/A
Average Substrate Complexity	7	12	18		2	10	9	5	19	15	8	14	16	13	12
Average Embeddedness	13	8	16		14	4	8	17	17	11	7	15	12	16	13
Substrate Composition (%)															
Fines (<0.1 in.)	20	30	0		30	20	N/A	10	10	10	10	N/A	5	0	0
Gravel ((0.1 -2 in.)	10	30	5		33	45	N/A	10	30	13	49	N/A	15	10	0
Cobble (2-10 in)	10	20	35		33	35	N/A	10	30	30	45	N/A	60	30	30
Boulder (>10 in.)	60	20	60		3	4	N/A	30	30	20	5	N/A	20	60	70
Bedrock (solid)	0	0	0		0	0	N/A	40	0	27	0	N/A	0	0	0
Substrate Consolidation	Mod	Low	High		Low	N/A	Mod	High	High?	Mod	Mod	High	Mod	Low	Low
Percent Gradient (%)	1.5	2	3		1	6	1	2	4	N/A	N/A	N/A	4	4	2.5
Chemical Characteristics															
pH	8.75	8.33	8.37		8.82	8.3	8.45	8.01	8.3	8.13	8.00	8.47	8.38	8.37	8.31
D.O (mg/L)	13.32	10.67	8.89		12.45	8.42	10.09	9.05	9.4	6.59	8.01	8.44	8.83	8.55	8.93
Water Temperature (C°)	22.9	19.3	21.2		25.3	13.9	21.7	19.6	19.7	14.6	16.8	20	17.4	18.4	16.1
Specific Conductance (µS/cm at	1113	880	847		2414	1075	1114	1687	1046	1457	1048	764	751	769	748
Nitrate Nitrogen (mg/L)	0.2	0.4	ND		ND	ND	66	ND	4.2	1.9	5.7	1.2	ND	ND	ND
Nitrite Nitrogen (mg/L)	ND	ND	ND		ND	ND	0.35	ND	ND	0.11	ND	ND	ND	ND	ND
Phosphate-Phosphorus (mg/L)	ND	ND	ND		ND	0.2	ND	ND	ND	0.3	ND	ND	ND	ND	ND
Indicator Bacteria															
Total Coliforms (MPN/100 mL)	2400	170	66		900	110	500	1600	300	300	900	140	3000	22	27
Fecal Coliforms (MPN/100 mL)	22	30	5		170	50	70	1600	50	130	50	<2	17	<2	<2
Enterococcus (MPN/100 mL)	7	11	2		30	38	21	27	30	27	8	5	<2	<2	<2

ND = non-detected, <0.1 mg/L

BMI Community Structure

The complete taxa list including raw abundances by site and replicate are presented in Appendix A, Table A-1. The ranked abundance of the top 10 species at each site are illustrated in Table 5. The biological metrics calculated for this survey were grouped into the four categories described in Table 3 and presented in Figures 5 through 8: richness measures, composition measures, tolerance/intolerance measures and functional feeding groups. The So CA IBI scores for each station are shown in Table 7 and illustrated in Figure 9. The biological metrics are presented for each replicate and then averaged by site in Appendix A (Tables A-2 and A-3, respectively).

Species Composition

A combined total of 13,921 BMIs, represented by 72 taxa, were identified from the 42 replicate samples collected at the 14 sampling sites during the September 2005 survey (Appendix A, Table A-1). Based on this figure, the projected total abundance for all sites combined would be 241,527 individuals (Figure 5 and Appendix A, Table A-1). The composition of the BMI communities collected at each of the sites in the Ventura Watershed was very similar. By far the most abundant species collected in the Ventura Watershed was the caddisfly, Hydropsyche sp. which was either the first or second most abundant species collected at all sites except Station 2 on Canada Larga Creek (Table 6). Other species that were found in the top five species at most sites included baetid mayflies (*Fallceon quilleri* and *Baetis sp.*), midges (Chironominae), true flies (Orthocladiinae, *Caloparyphus/Euparyphus sp*., Tanypodinae) and black flies (*Simulium sp.*). Black flies were most prevalent in the upper watershed at Stations 10, 11, 13 and 14 on Matilija Creek and the North Fork of Matilija Creek.

Stoneflies, which are generally very intolerant to stressors, but were found in relatively high abundances at Station 3 in the upper Canada Larga Creek (Appendix A, Table A-1).

Biological Metrics

The biological metrics listed in Table 3, above, were calculated for this survey and are presented by group in Figures 5 through 8 and Appendix A, Table A-3.

Richness Measures**:** Taxa richness is a measure of the total number of species found at a site. This relatively simple index can provide much information about the integrity of the community. Few taxa at a site indicate that some species are being excluded, while a large number of species indicate a more healthy community. Cumulative taxa is a simultaneous count of all of the taxa from each of the three replicate samples taken at a station. Cumulative EPT taxa are the simultaneous count of all of the mayflies (Ephemeroptera), caddisflies (Trichoptera), and stoneflies (Plecoptera) present at a location. These families are generally sensitive to impairment and, when present, are usually indicative of a healthy community. Both Coleopteran and Predator taxa are included since they are used to calculate the So CA IBI.

Taxa richness ranged from 18 (Station 0, Main St. bridge) to 25 (Stations 12 below Matilija Dam and 8 on Stewart Creek) (Figure 5). EPT taxa increased slightly from the lower watershed to upper watershed with lowest numbers collected at Station 2 and greatest numbers collected at Stations 13 and 14 on Matilija Creek. Cumulative EPT taxa followed a similar trend and were fewest at Foster Park Station 4 and greatest on the North Fork of Matilija Creek, Station 13. The average numbers of Coleoptera taxa ranged from 0 to 2, while the average numbers of predator taxa ranged from 3 (Station 3) to 8 (Station 12). Average estimated abundances ranged from 8,607 at Station 5 on San Antonio Creek to 3,038 at Station 3 on the Upper Canada Larga.

Composition Measures: The percent EPT taxa, sensitive EPT, percent non-insects and the Shannon Diversity index are all measures of community composition. Species diversity indices are similar to numbers of species; however they contain an evenness component as well. For example, two samples may have the same numbers of species and the same numbers of individuals. However, one station may have most of its numbers concentrated into only a few species while a second station may have its numbers evenly distributed among its species. The diversity index would be higher for the latter station. Percent EPT taxa are the proportion of the abundance at a site that is comprised of mayflies, stoneflies and caddisflies. Percent Sensitive EPT taxa is similar except it includes only those EPT taxa whose tolerance values range from 0 to 3. These taxa are very sensitive to impairment and, when present, can be indicative of more natural conditions. Percent non-insect taxa are used in the calculation of the So CA IBI.

The average percentage of EPT ranged from 27% at Station 2 to 76% at Station 9 on San Antonio Creek (Figure 6). The average percentage of Sensitive EPT taxa neared zero at all sites and was greatest at Station 8 in Stewart Canyon Creek (12%). Shannon Diversity just exceeded 2.0 at all sites and was lowest at Station 0 (1.7). The average percentage of non-insect species was lowest in the upper watershed, ranging from 1% at Station 13 in Matilija Creek to 17% at Stations 0 near the Main Street Bridge and 2 in Canada Larga Creek.

Tolerance Measures: The Southern California IBI uses both the percent intolerant and tolerant organisms to evaluate the overall sensitivity of organisms to pollution and habitat impairment. Each species is assigned a tolerance value from 0 (highly intolerant) to 10 (highly tolerant). The percent Intolerance Value for a site is calculated by multiplying the tolerance value of each species with a tolerance value ranging from 0 to 2, by its abundance, then dividing by the total abundance for the site. The percent Tolerant Value is similar except that only species with tolerance values ranging from 8 to 10 are included. A site with many tolerant organisms present is considered to be less pristine or more impacted by human disturbance than one that has few tolerant species. The tolerance values for each species were developed in different parts of the United States and can therefore be region specific. Also, different organisms can be tolerant to one type of disturbance, but highly sensitive to another. For example, an organism that is highly sensitive to sediment deposition may be very insensitive to organic pollution. With these drawbacks in mind, the Tolerance measures generally depict disturbances in a stream that, when coupled with other metrics, can provide good information regarding a stream reach.

Percent dominance reflects the proportion of the total abundance at a site represented by the most abundant species. For example, if 100 organisms are collected at a site and species A is the most abundant with 30 individuals, the percent dominance index score for the site is 30%. The benthic environment tends to be healthier when the dominance index is low, which indicates that more than just a few taxa make up the majority of the community.

The percent Hydropsychidae (caddisflies) and Baetidae (mayflies) present in a stream reach can indicate stressed habitat conditions when they are found in high abundance. They will not be present in highly polluted streams, but can be found in moderately polluted streams, especially when nutrients are high or there is a large amount of sedimentation.

Mean Tolerance Values were similar across sites and ranged from 4.6 at Station 8 to 5.9 at Station 2 (Figure 7). There were low percentages of intolerant organisms present at all sites, with the greatest percentage found at Stations 8 (8%). The highest percentages of tolerant organisms were found at Station 15 (23%). Percent Dominance was greatest at Stations 0 and 8 (>50% respectively) and least at Station 2 (24%). Hydropsychid caddisflies were abundant, exceeding 25% of the population at most sites in the watershed except at Stations 2, 9 and 13 where they accounted for less <25% of the population.

Baetid mayflies accounted for less than 25% of the population at all sites except Station 13 where they made up 29% of the population.

***Functional Feeding Groups*:** These indices provide information regarding the balance of feeding strategies represented in an aquatic assemblage. The combined feeding strategies of the organisms in a reach provide information regarding the form and transfer of energy in the habitat. When the feeding strategy of a stream system is out of balance it can be inferred that the habitat is stressed. For the purposes of this study, species were grouped by feeding strategy as percent collector-gatherers, collector-filterers, grazers, predators and shredders. The Southern California IBI uses the numbers of predators and percent collectors (gatherers + filterers) at a site to calculate the index.

Collecting and filtering were the predominant feeding strategies used by organisms in the watershed (Figure 8). Collectors were greatest at Stations 2, 9 and 13, and least at Stations 0, 8 and 11. The percentage of filterers ranged from 9% at Station 2 to 60% at Station 8. Grazers, predators and shredders accounted for less than 10% of the population at most sites in the watershed.

IBI Scores

Work conducted in the 1990's by the San Diego Regional Board and the California Department of Fish and Game, established an Index of Biotic Integrity (IBI) for the San Diego region and its watersheds (Ode and Harrington 2002). The index has recently been expanded to include all of southern California (Ode et. al. 2005) and is used in this section.

The IBI is a multi-metric technique that employs seven biological metrics that were each found to respond to a habitat and/or water quality impairment. Each of the seven biological metrics measured at a site are converted to an IBI score then summed. These cumulative scores can then be ranked according to very good (80-100), good (60-79), fair (40-59), poor (20-39) and very poor (0-19) habitat conditions. The threshold limit for this scoring index is 39. Despite the fact that rankings can be identified as "fair", sites with scores above 39 are within two standard deviations of the mean reference site conditions in southern California and are not considered to be impaired. Sites with scores below 39 are considered to have impaired conditions. The metric scoring ranges established for the Southern California IBI survey are listed in Table 3 and were used to classify the Ventura Watershed sites for the 2005 survey.

All but two of the fourteen Ventura Watershed sites had IBI scores in the "fair" range (40-59) for the 2005 survey (Table 7, Figure 9). Stations 0 (Main Street Bridge) and 15 (San Antonio Creek) scored 39, which is at the upper end of the "poor" range. IBI scores on the Ventura River increased from lowest at Station 0 to greatest at Station 12, located at the base of the Matilija Dam. IBI scores on the San Antonio Creek system were lowest downstream (Stations 5, 7 and 15) and greater at upstream sites on or near Stewart Canyon Creek (Stations 8 and 9). Each of the four sites in the upper watershed (North Fork of Matilija Creek and Matilija Creek; Stations 10, 11, 13 and 14) had some of the best scores in the watershed.

Historical Results (2001 to 2004)

Physical habitat and IBI scores for the first five years of the Ventura Watershed BMI monitoring program were combined and are presented graphically by site in Figures 10 and 11.

5 Year Physical Habitat Scores

The best habitat conditions during the five year period were measured at Station 12 below the Matilija Dam and worst occurred on Canada Larga Creek above its confluence with the main stem of the Ventura River (Figure 10). Physical habitat scores increased as elevation in the watershed increased, becoming progressively greater on the Ventura River main stem from Station 0 near the ocean to Station 12 below Matilija Dam and from Canada Larga Creek (Stations 2 and 3) to the North Fork of the Matilija Creek (Stations 10 to 14). The greatest variation in physical/habitat scores during the five year period were found at Stations 0 and 2. Station 0 is located just above the confluence of the Ventura River with the ocean and Station 2 is located just above the confluence of Canada Larga Creek with the Ventura River in the lower watershed. The habitats at each of these sites are strongly influenced by the severity of the storm season preceding sampling. During large storms the stream beds are scoured of vegetation and up stream sediments are deposited which decreases the amount of instream cover present for BMI's. During relatively mild storm seasons the vegetative and instream cover at these sites remains unchanged. In contrast, the upper watershed (Station 12, 10, 11, 12 and 13) are characterized as much more stable owing to a streambed composed mostly of boulder, cobble and gravel, with banks that are, for the most part, covered with dense stands of vegetation.

5 Year IBI Scores

During the five year period from 2001 to 2005 the average IBI scores for all sites, except Stations 0 and 1, were in the fair or good range (Figure 11). The average scores for Stations 0 and 1, each located above the Main Street Bridge, were below the impairment threshold (39). IBI scores increased with elevation on the Ventura River, Canada Larga Creek (Stations 2 and 3) and San Antonio Creek (Stations 5, 7, 15, 8 and 9). The greatest average IBI score during the five year period was at Station 11 on North Fork of the Matilija.

DISCUSSION

The September 2005 BMI survey was preceded by winter storms in December, January and February that dropped a combined total of 44.5 inches of rain (23.3 inches above normal) and represented the greatest amount of rain measured during the last five years since BMI sampling began. These storms produced widespread flooding, erosion and sedimentation throughout the watershed. This was especially true in the lower reaches of the watershed where the streambeds are composed more of fine sediments, gravel and cobble. This is in comparison to sites in the upper watershed where the streambeds are stabilized more by boulders. In normal rainfall years many reaches in the Ventura Watershed are dry during September when sampling for BMI's is conducted. As a result of the unusually large amount of rain, all BMI sampling locations (except Station 6 on the Ventura River main stem) had significant flow during the 2005 survey.

Ventura River

The aquatic health of the Ventura Watershed ranged from poor to fair, based on the results of the southern California IBI. Stations 0 and 15 each scored at the high end of the poor range, indicating that the BMI communities found there were impaired. Station 0 is located just upstream of where the Ventura River discharges into the Pacific Ocean. During the previous five years the average IBI score at this site was also poor. The physical habitat score at this site was either suboptimal or optimal during the previous four years (2001 to 2004) as a result of the good instream cover, vegetative protection, bank stability, and the low amounts sedimentation. The heavy winter storms during the preceding winter caused streambed and bank scouring, eliminating much of the instream and vegetative cover. The explanation for the low IBI scores are related to several factors including poor water quality, the reinforced levees present on each bank which protect the City of Ventura from flooding, the large transient human population that use the streambed for shelter and possibly the sites location 2.5 miles downstream of the Ojai Valley Sanitation Plant. This site supported no sensitive BMI species and was dominated by the caddisfly, Hydropsyche sp. Hydropsychid caddisflies, when present in large numbers, is indicative of moderately disturbed conditions that could be the result of either elevated nutrient loading or sedimentation.

Stations located above the Main Street Bridge on the main stem of the Ventura River had physical habitat and IBI scores that improved with elevation in the watershed. Stations 4 (Foster Park) and 12 (below the Matilija Dam) each had better instream cover, bank stability and riparian zones. Similar to the previous four years, Station 12 had the best physical habitat score of all sites in the watershed. IBI scores for each of these sites were in the fair range. The top species at each of these sites included the caddisfly, *Hydropsyche sp*., midge larvae (Chironominae), mayflies (*Fallceon quilleri*) and black flies (*Simulium sp*.).

Canada Larga Creek

The Canada Larga Creek drainage is impacted by grazing in its lower reaches. As a result, the physical habitat scores are much lower at Station 2 located downstream of the grazing area when compared to Stations 3, which is located above them. Station 2 had high sediment deposition, embeddedness and low bank stability due to erosion and had poor vegetative cover. While not optimal, conditions at Station 3 were characterized by better instream cover, riffle frequency, vegetative cover and riparian zone, and less channel alteration. Interestingly, the IBI scores for each of these sites were in the fair range, indicating that at least for the 2005 survey year, water quality conditions at Station 2 were good enough to overcome the apparent degradation of the habitat found there. Station 3 was the only site where the stonefly, *Malenka sp*. (a species that is highly sensitive to disturbances), appeared as one of the top 10 most abundant species.

San Antonio Creek

Of the three stations located on the main stem of San Antonio Creek (5, 15 and 9), the best physical habitat score was found at Station 15 located above the confluence of Lion Canyon Creek. This was mostly due to the presence of good instream cover, low sediment deposition, embeddedness and channel alteration. However, the IBI score at this site was in the poor range. This could be due to the fact that a portion of the Creek has stables and grazing land in its vicinity. Also, as a result of the heavy winter storms that occurred in 2005, extensive bank and streambed management operations were underway in the vicinity of the sampling reach during the BMI survey. While this reach did not appear to be directly effected by these operations, it is probable that they played a role in the reduced IBI score found at this site. Station 5 is located just above the confluence with the main stem of the Ventura River, had an IBI score in the fair range, but had the poorest habitat found on San Antonio Creek during this survey. This stream reach was characterized by poor instream cover and vegetative protection, along with high sediment deposition and embeddedness. Station 9, located upstream of the confluence with Stewart Canyon Creek, had poor instream cover, vegetative cover and bank stability. In fact, the winter storms had completely eroded the eastern bank so that it was a vertical 20 foot cliff, completely denuded of vegetation. This site had the highest IBI score of the three San Antonio Creek locations.

For most locations in the watershed there was agreement between habitat conditions and BMI community structure, so that when a low physical habitat score was found at a site, a similarly low IBI score was also found. This means that physical habitat conditions were the main influence controlling the quality of the BMI community found in the watershed. This relationship was not so evident on San Antonio Creek (Stations 5 and 9) where the physical habitat scores did not necessarily correspond to the IBI score. This indicates that other water quality conditions were probably influencing the composition of the BMI community in this portion of the Ventura Watershed.

Stations 7 and 8 are located on tributaries to San Antonio Creek. Station 7 is located on Lion Canyon Creek just upstream of its confluence with San Antonio Creek and had an IBI score just above the impairment threshold (40). The flow in this reach was extremely low during the survey and offered little instream cover, vegetative protection or bank stability. Similar to Station 15, this site is located near stables and grazed land. Conversely, Station 8 located on Stewart Canyon Creek and drains the streets and agricultural land surrounding downtown Ojai. Surprisingly, this site had a relatively high IBI score (fair range). However, the physical habitat conditions at this site were reasonable good and included decent instream cover, little sediment deposition and good bank stability.

Matilija Creek

Four stations were located in the upper watershed, above Matilija Dam: Stations 10 and 11 on the North Fork of Matilija Creek and Stations 13 and 14 located on Matilija Creek. Each of these sties had the best physical habitat conditions found in the watershed, with the exception of Station 12. In general, these sites were composed of boulders and coble, had good instream cover, little sediment deposition and good vegetative and riparian cover. All of these sites are used by the public as recreational swimming areas, especially Stations 10 and 11. Station 10 is located below Station 11 and an active rock quarry. Station 13 is located downstream of a small residential community and Station 14 is located upstream. Stations 11 and 14 are located at the highest elevations in the watershed (over 1,300 ft) and had the best IBI scores (57 and 59, respectively) in the watershed, which were at the upper threshold of the fair range. Both Stations 10 and 13 had slightly lower IBI scores (54 and 53, respectively) which might be due to the influence of the rock quarry and residential communities located upstream of these sites.

5 Year Physical Habitat and So CA IBI Scores

The best habitat conditions during the five year period were measured at Station 12 below the Matilija Dam and worst occurred on Canada Larga Creek above its confluence with the main stem of the Ventura River (Figure 10). Physical habitat scores increased as elevation in the watershed increased, becoming progressively greater on the Ventura River main stem from Station 0 near the ocean to Station 12 below Matilija Dam and from Canada Larga Creek (Stations 2 and 3) to the North Fork of the Matilija Creek (Stations 10 to 14). The greatest variation in physical/habitat scores during the five year period were found at Stations 0 and 2. Station 0 is located just above the confluence of the Ventura River with the ocean and Station 2 is located just above the confluence of Canada Larga Creek with the Ventura River in the lower watershed. The habitats at each of these sites are strongly influenced by the severity of the storm season preceding sampling. During large storms the stream beds are scoured of vegetation and up stream sediments are deposited which decreases the amount of instream cover present for BMI's. During relatively mild storm seasons the vegetative and instream cover at these sites remains unchanged. In contrast, the upper watershed (Station 12, 10, 11, 12 and 13) are characterized as much more stable owing to a streambed composed mostly of boulder, cobble and gravel, with banks that are, for the most part, covered with dense stands of vegetation.

During the five year period from 2001 to 2005 the average IBI scores for all sites, except Stations 0 and 1, were in the fair to very good range. The average scores for Stations 0 and 1, each located above the Main Street Bridge, were below the impairment threshold (39). IBI scores increased with elevation on the Ventura River, Canada Larga Creek (Stations 2 and 3) and San Antonio Creek (Stations 5, 7, 15, 8 and 9). The greatest average IBI score during the five year period was at Station 11 on North Fork of Matilija Creek.

RECOMMENDATIONS

1. It is recommended that the Ventura Watershed Protection District continue to work with the Southern California Coastal Water Research Project (SCCWRP) to assist in the development of improved BMI sampling design, sampling protocols, taxonomic identification and analysis techniques.

Table 5. The top 10 species at each station in the Ventura Watershed, ranked by % abundance, 2005.

0			4			12			2			3			5			7		
Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund
Hydropsyche sp.	53.5	53.5	Hydropsyche sp.	30.7	30.7	Hydropsyche sp.	27.7	27.7	Chironominae	24.1	24.1	Hydropsyche sp.	37.3	37.3	Hydropsyche sp.	26.3	26.3	Hydropsyche sp.	26.0	26.0
Fallceon quilleri	12.2	65.7	Fallceon quilleri	17.9	48.6	Chironominae	21.9	49.6	Fallceon quilleri	13.2	37.3	Baetis sp.	20.5	57.7	Fallceon quilleri	19.3	45.6	Baetis sp.	13.7	39.7
Physa/Physella sp.	6.1	71.8	Chironominae	9.5	58.1	Simulium sp.	10.0	59.6	*Calopary/Eupary sp.	12.4	49.7	Chironominae	8.4	66.2	Chironominae	8.2	53.8	Oligochaeta	8.0	47.7
Cyprididae	4.8	76.5	Orthocladiinae	8.4	66.5	Orthocladiinae	6.3	65.9	Tanypodinae	10.6	60.4	*Calopary/Eupary sp.	6.3	72.5	Tricorythodes sp.	7.3	61.1	*Calopary/Eupary sp.	7.9	55.6
Hydroptila sp.	3.8	80.3	Hydroptila sp.	6.8	73.2	Microcylloepus sp.	5.2	71.1	Oligochaeta	10.5	70.9	Malenka sp.	5.5	77.9	Hydroptila sp.	5.6	66.7	Chironominae	6.9	62.5
Orthocladiinae	3.2	83.5	Tricorythodes sp.	5.3	78.6	Prostoma sp.	4.4	75.5	Hydropsyche sp.	8.6	79.5	Hydroptila sp.	4.0	81.9	Cyprididae	5.0	71.7	Hydroptila sp.	6.6	69.1
Tricorythodes sp.	3.0	86.5	Tanypodinae	3.6	82.1	Baetis sp.	4.1	79.6	Orthocladiinae	6.3	85.8	Orthocladiinae	3.8	85.7	Orthocladiinae	4.3	76.1	Orthocladiinae	6.0	75.1
Prostoma sp.	2.8	89.3	*Calopary/Eupary sp.	2.9	85.1	Argia sp.	2.5	82.1	Cyprididae	3.6	89.4	Fallceon quilleri	2.9	88.6	*Calopary/Eupary sp.	3.9	80.0	Fallceon quilleri	4.0	79.2
Chironominae	2.8	92.1	Baetis sp.	2.7	87.8	Petrophila sp.	1.9	84.0	Tricorythodes sp.	2.6	92.0	Oligochaeta	1.9	90.5	Baetis sp.	3.7	83.7	Sperchon sp.	3.3	82.4
Planariidae	1.9	94.0	Physa/Physella sp.	2.3	90.1	Tanypodinae	1.9	85.9	Sperchon sp.	1.6	93.6	Tanypodinae	1.7	92.1	Sperchon sp.	3.6	87.3	Dasyhelea sp.	2.9	85.3
TOTAL	94			90			86			94			92			87			85	

15			8			9			10			11			13			14		
Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund	Species	% of Total Abund	Cumulative % Abund
Hydropsyche sp.	39.6	39.6	Hydropsyche sp.	50.1	50.1	Ochrotrichia sp.	19.5	19.5	Hydropsyche sp.	29.8	29.8	Hydropsyche sp.	39.4	39.4	Baetis sp.	27.5	27.5	Hydropsyche sp.	30.8	30.8
*Calopary/Eupary sp.	20.8	60.5	Tinodes sp.	7.3	57.4	Hydropsyche sp.	13.2	32.7	Chironominae	16.9	46.7	Simulium sp.	16.4	55.8	Hydropsyche sp.	20.9	248.3	Chironominae	17.3	48.1
Baetis sp.	6.8	67.3	Chironominae	5.6	63.0	Tricorythodes sp.	12.7	45.4	Simulium sp.	8.2	54.9	Baetis sp.	10.5	66.3	Chironominae	19.6	267.9	Baetis sp.	16.9	65.0
Simulium sp.	5.6	72.9	Sperchon sp.	4.9	67.9	Hydroptila sp.	12.2	57.6	Orthocladiinae	8.1	63.0	Chironominae	7.8	74.1	Simulium sp.	10.2	278.1	Simulium sp.	13.0	78.1
Orthocladiinae	4.9	77.9	Wormaldia sp.	4.3	72.2	Fallceon quilleri	9.4	67.0	Baetis sp.	6.8	69.8	Fallceon quilleri	7.0	81.1	Orthocladiinae	4.3	282.4	Orthocladiinae	5.5	83.6
Cheumatopsyche sp.	4.0	81.8	Baetis sp.	3.6	75.8	Chironominae	8.9	75.8	Microcylloepus sp.	4.2	74.0	Maruina lanceolata	3.4	84.5	Epeorus sp.	2.6	285.0	Epeorus sp.	2.6	86.2
Fallceon quilleri	3.9	85.7	Simulium sp.	3.3	79.1	*Calopary/Eupary sp.	6.8	82.7	Hydroptila sp.	3.9	77.8	Microcylloepus sp.	2.9	87.4	Wormaldia sp.	1.6	286.6	Fallceon quilleri	1.6	87.7
Tanypodinae	2.5	88.1	Orthocladiinae	2.7	81.8	Baetis sp.	3.9	86.6	Fallceon quilleri	2.9	80.7	Orthocladiinae	2.1	89.5	Atrichopogon sp.	1.4	288.0	Ochrotrichia sp.	1.5	89.2
Chironominae	1.8	89.9	Prostoma sp.	2.2	84.0	Micrasema sp.	2.6	89.2	Tanypodinae	2.9	83.7	Torrenticola sp.	1.1	90.5	Ochrotrichia sp.	1.3	289.3	Atrichopogon sp.	1.4	90.6
Oligochaeta	1.7	91.6	Cheumatopsyche sp.	1.7	85.7	Orthocladiinae	2.5	91.7	Cheumatopsyche sp.	2.7	86.4	Cheumatopsyche sp.	0.9	91.5	Fallceon quilleri	1.1	290.4	Tricorythodes sp.	1.1	91.7
	92			86			92			86			91			90			92	

* Caloparyphus/Euparyphus sp.

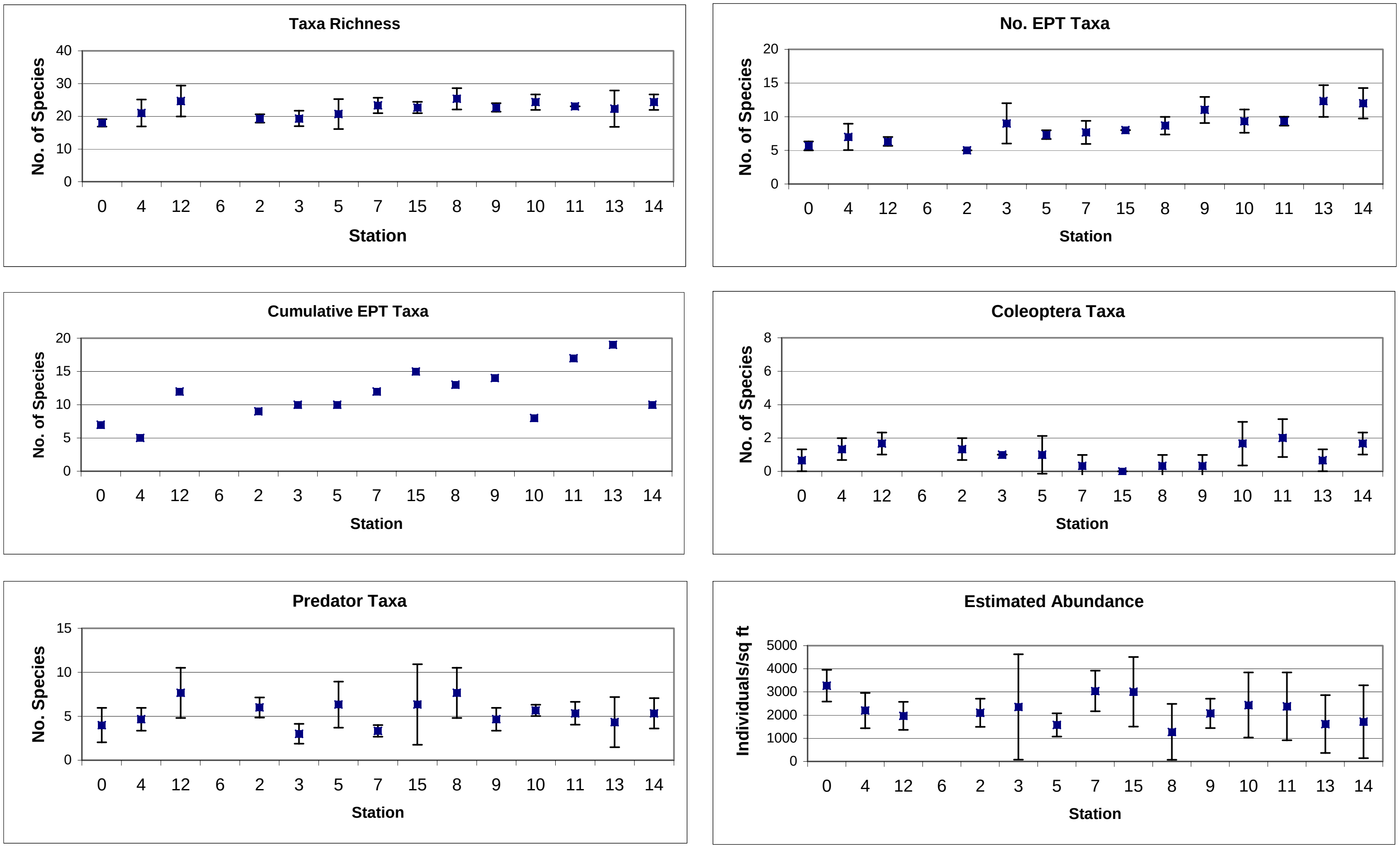


Figure 5. Richness measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura Watershed, 2005.

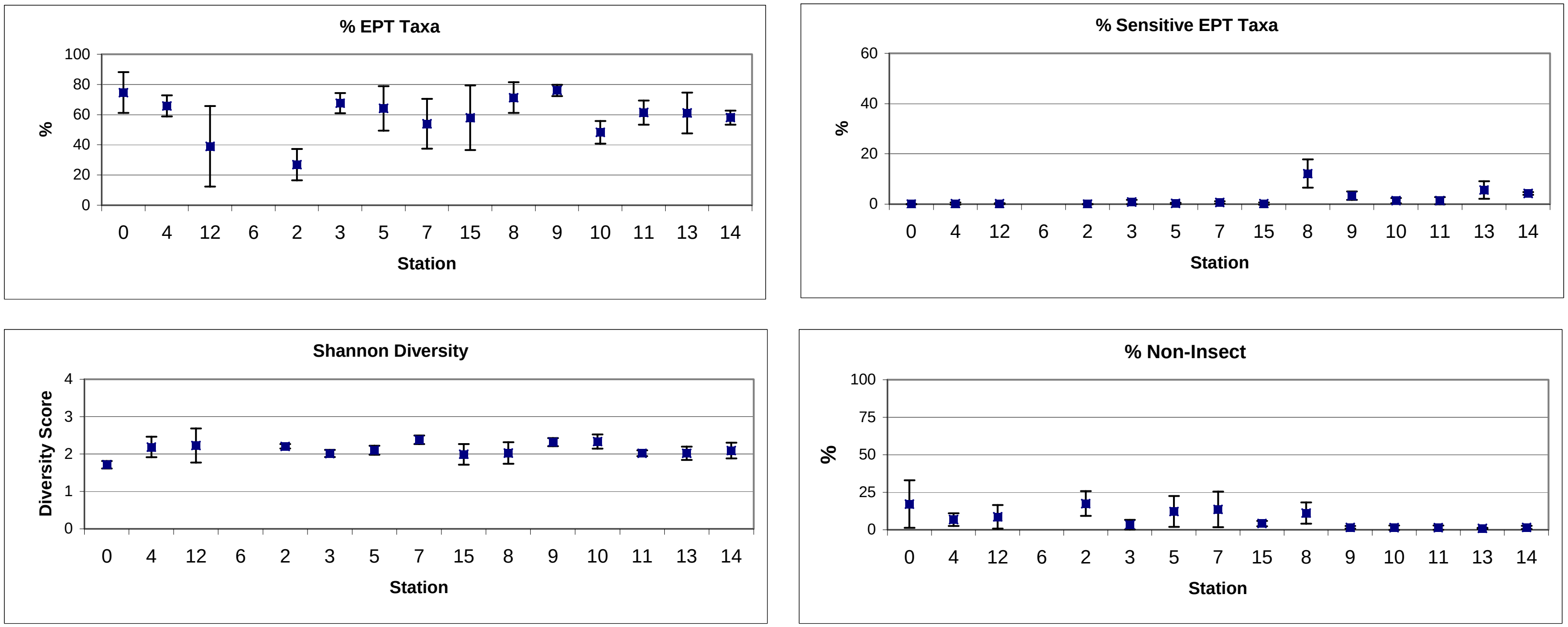


Figure 6. Composition measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura Watershed, 2005.

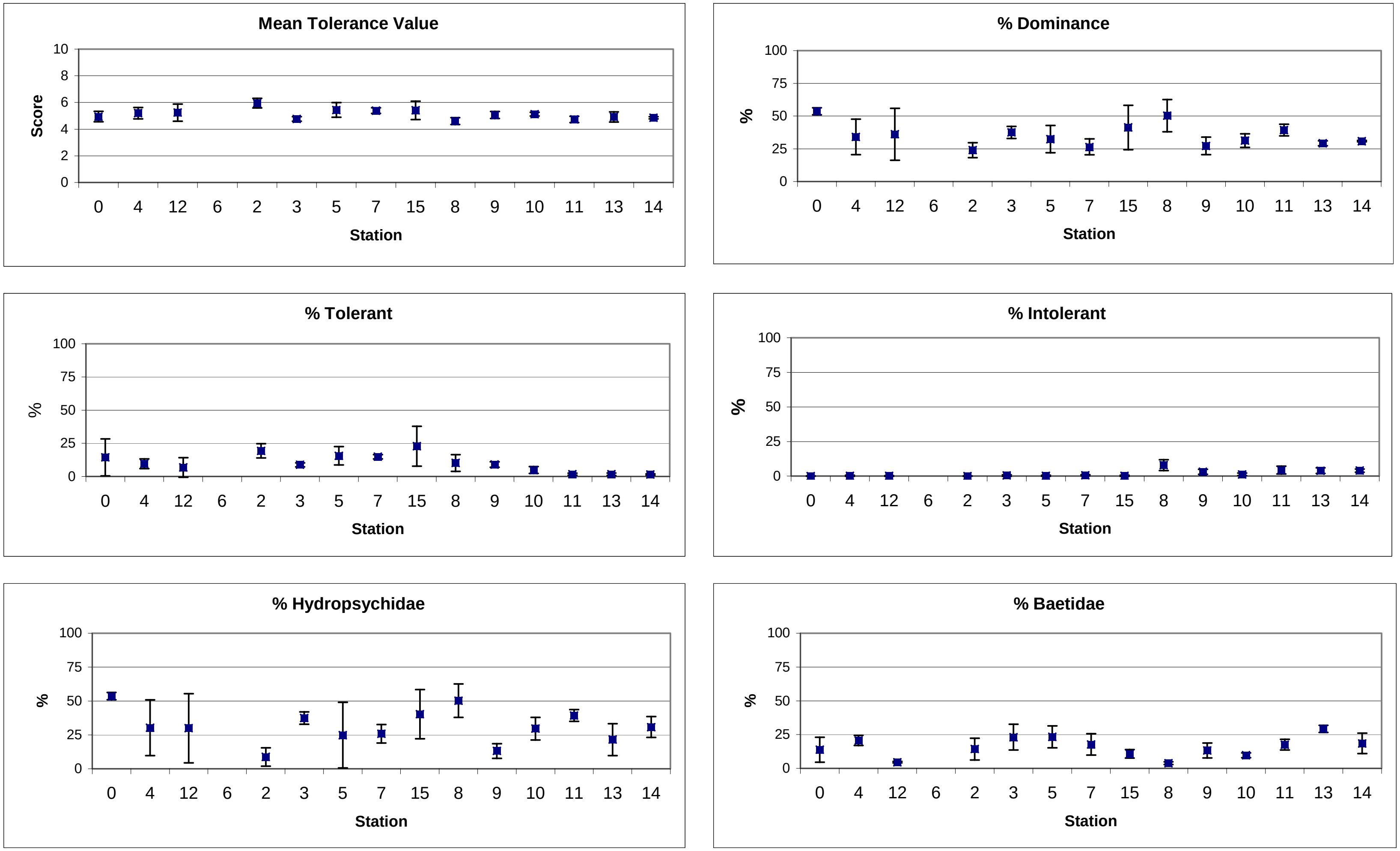


Figure 7. Tolerance/Intolerance measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura Watershed, 2005.

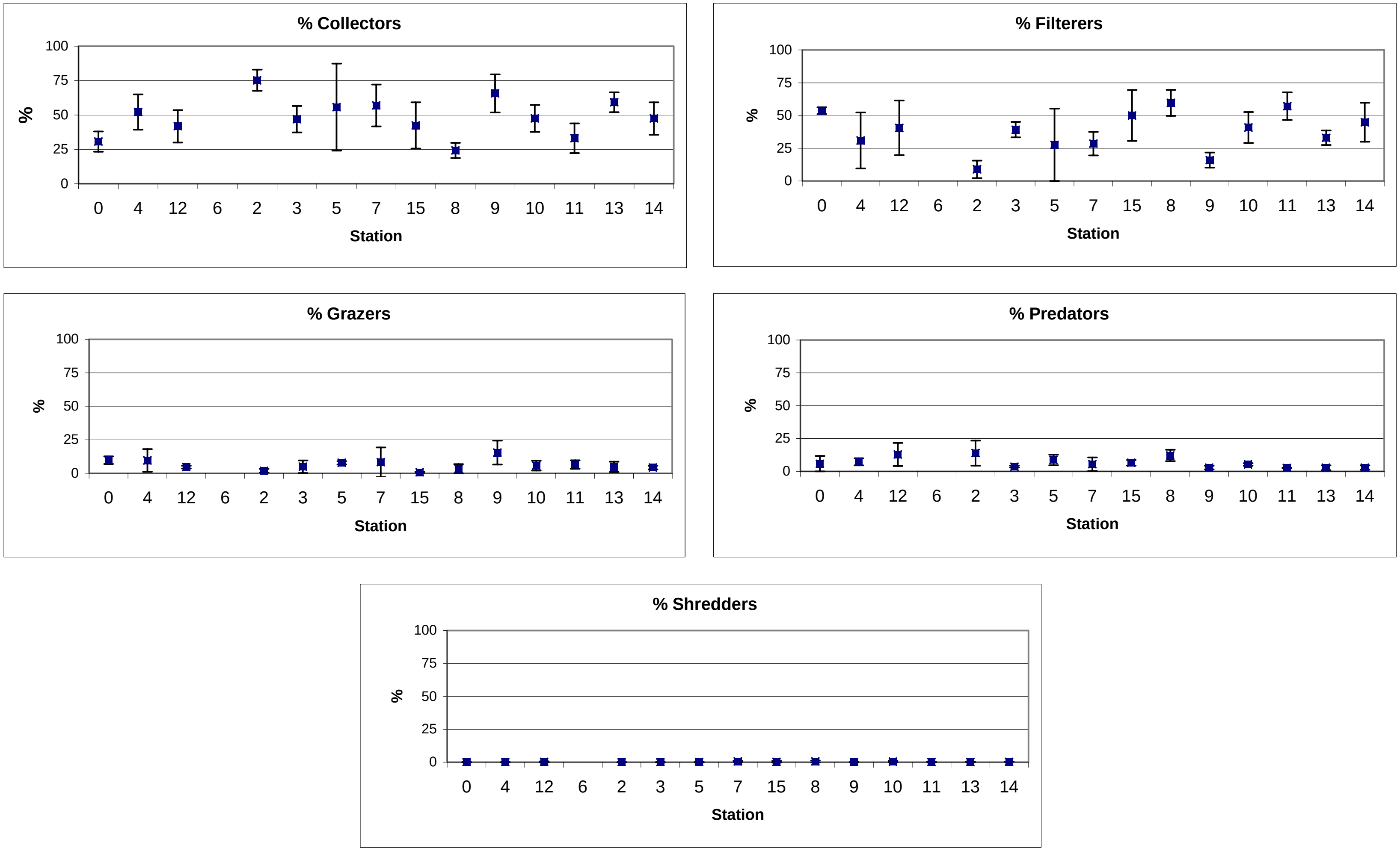


Figure 8. Functional Feeding Group measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura Watershed, 2005.

Table 6. Southern California IBI scores and ratings for sites sampled in the Ventura Watershed.

River/Stream System	Ventura River				Canada Larga		San Antonio Creek					North Fork Matilija Creek		Matilija Creek	
Station Description	Main Street Bridge	Foster Park	Below Matilija Dam	@Santa Ana Rd.	Below Grazing	Above Grazing	u/s Ventura River Confluence	Lion Canyon u/s San Antonio	u/s Lion Canyon	Stewart Canyon u/s San Antonio	u/s Stewart Canyon Creek	u/s Ventura River Confluence	At gauging station	Below community	Above Community
Biological Metric	0	4	12	6	2	3	5	7	15	8	9	10	11	13	14
Coleopteran Taxa	2	4	4		4	4	4	2	0	2	2	5	5	2	5
EPT Taxa	3	4	4		3	6	4	4	5	4	6	6	7	7	9
Predator Taxa	3	3	5		6	2	4	2	5	6	3	4	4	4	4
% Collectors (cg + cf)	2	3	5		4	3	3	3	2	4	5	3	2	2	1
% Intolerant	0	0	0		0	2	0	1	0	3	1	1	2	2	2
% Non-Insect Taxa	9	10	9		7	10	9	9	10	8	10	10	10	10	10
% Tolerant	8	9	9		5	8	7	7	5	8	9	9	10	10	10
Total	27	33	36	-	29	35	31	28	27	35	36	38	40	37	41
Adjusted Score (x 1.43)	39	47	51	-	41	50	44	40	39	50	51	54	57	53	59
So. Cal. IBI Rating	Poor	Fair	Fair		Fair	Fair	Fair	Fair	Poor	Fair	Fair	Fair	Fair	Fair	Fair

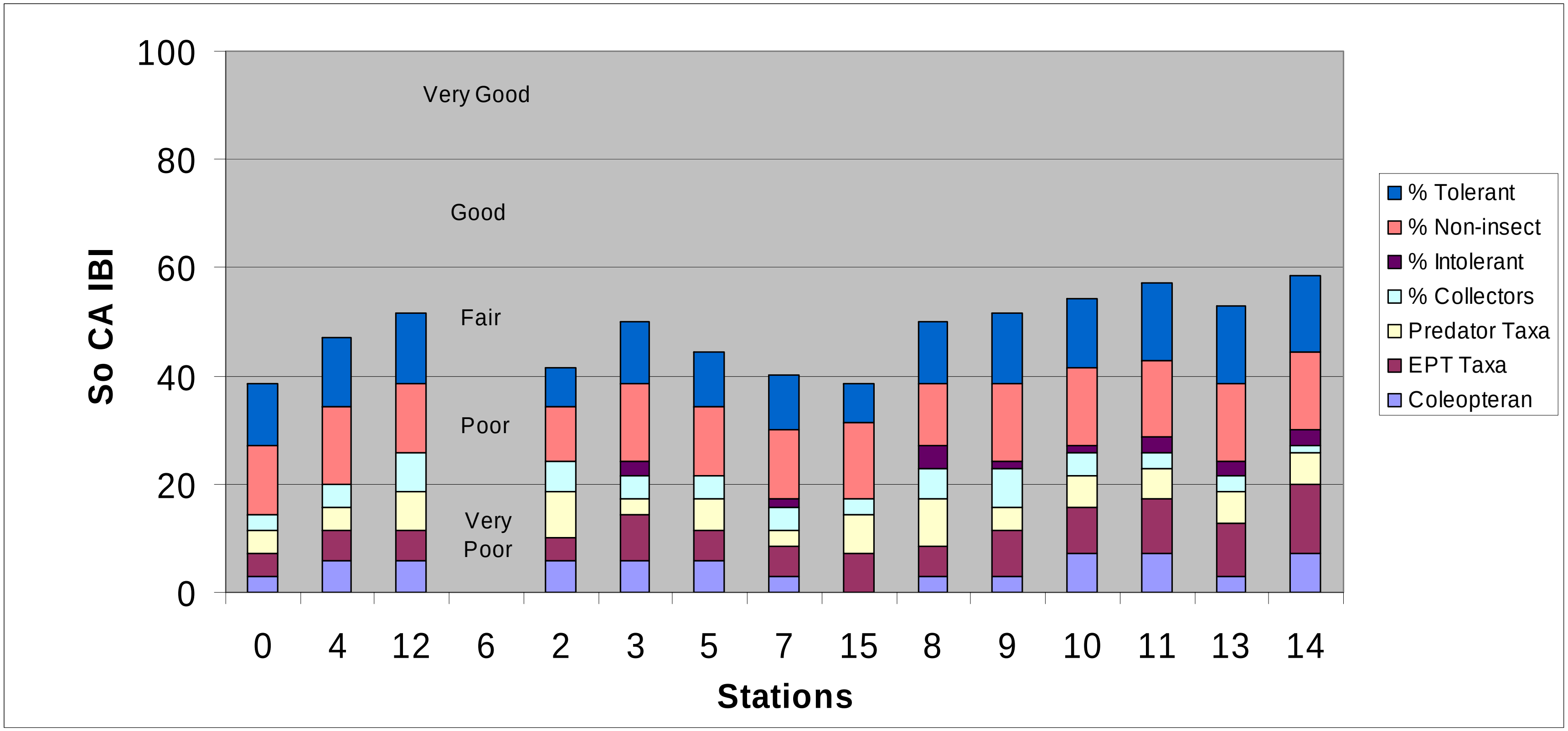


Figure 9. Southern California IBI Scores for sites in the Ventura Watershed, 2005. Histogram bars are divided by the proportion that each biological metric contributed to the total score.

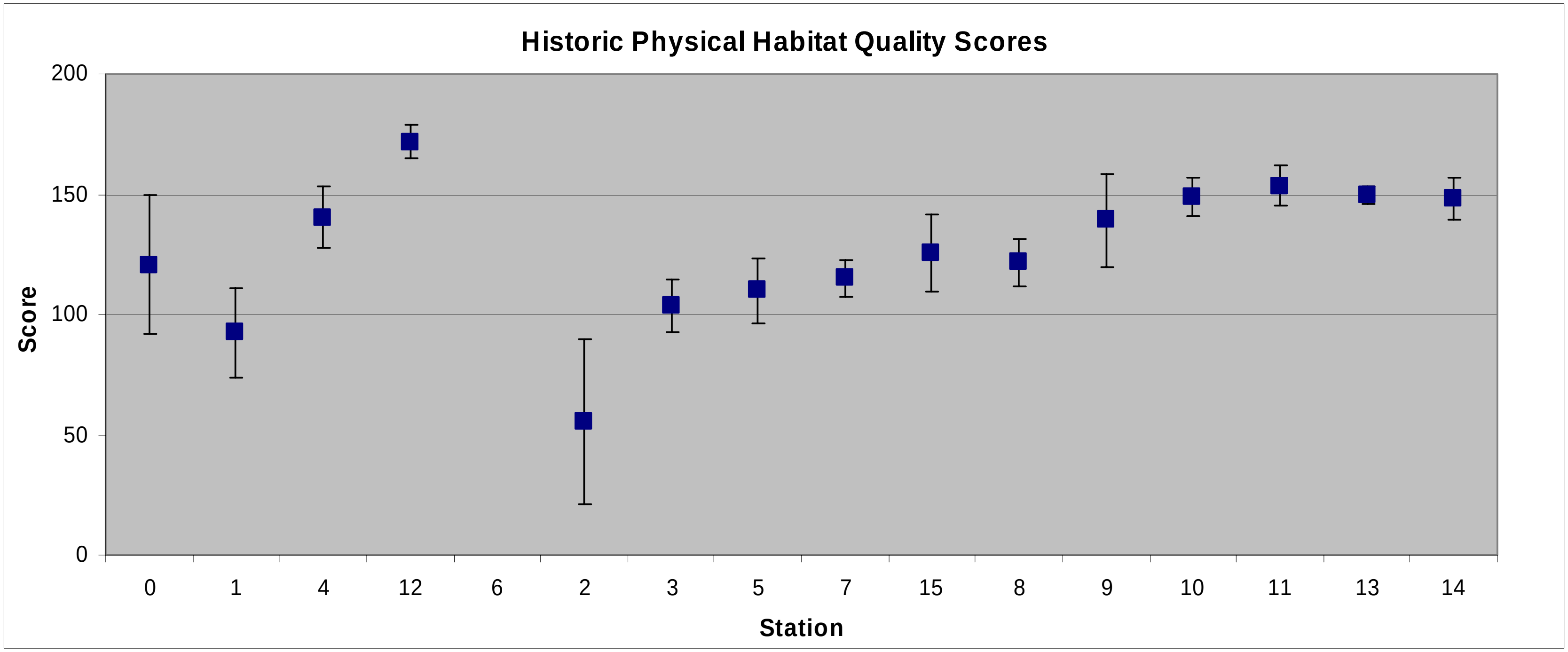


Figure 10. Average physical habitat scores (± 95% CI) for sites in the Ventura Watershed, 2001 to 2005.

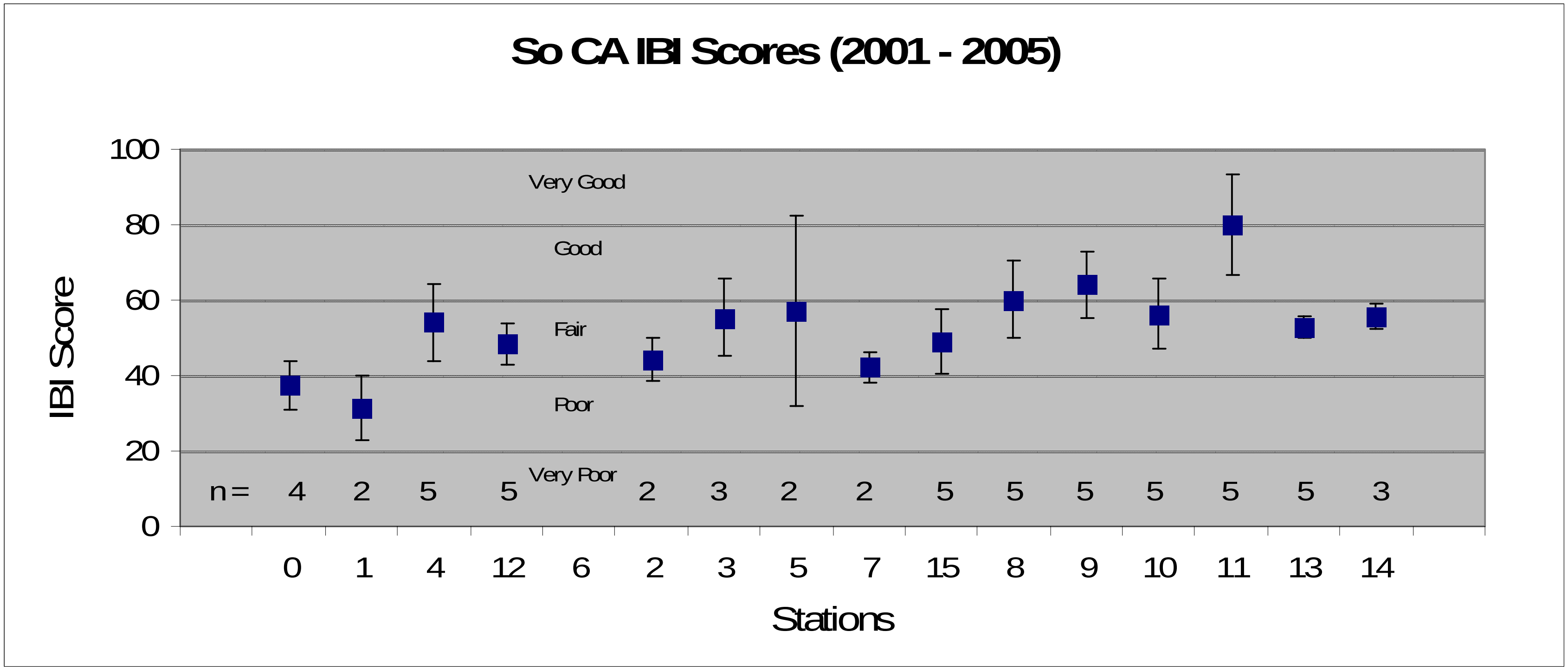


Figure 11. Average (± 95% CI) So CA IBI scores for sites in the Ventura Watershed, 2001 to 2005. Number of years included in average (n =) appears above Station label.

LITERATURE CITED

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Revision to rapid bioassessment protocols for use in stream and rivers: periphyton, BMIs and fish. EPA 841-D-97-002. U.S. Environmental Protection Agency. Washington DC.

CSBP, Harrington, J.M. 2003. California stream bioassessment procedures. California Department of Fish and Game, Water Pollution Control Laboratory. Rancho Cordova, CA.

DFG, Department of Fish and Game. 1998. An Index of Biological Integrity for Russian River First to Third Order Tributary Streams, A Water Quality Inventory Report. Water Pollution Control Laboratory, Rancho Cordova, CA.

Davis, W. S. and T.P. Simons, eds. 1995. Biological Assessment and Criteria: Tools for Resource Planning and Decision Making. Lewis Publishers. Boca Raton, FL.

Davis, W.S., B.D. Syder, J.B. Stribling and C. Stoughton. 1996. Summary of state biological assessment program for streams and wadeable rivers. EPA 230-R-96-007. U.S. Environmental Protection Agency; Office of Policy, Planning and Evaluation: Washington, DC.

Erman, N.A. 1996. Status of Aquatic Invertebrates. in: Sierra Nevada Ecosystem Project: Final Report to Congress, Vol II, Assessments and Scientific Basis for Management Options. University of California Davis, Centers for Water and Wildland Resources.

Gibson, G.R. 1996. Biological Criteria: Technical guidance for streams and small rivers. EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Harrington, J.M. and M. Born. 2000. Measuring the health of California streams and rivers. Sustainable Land Stewardship International Institute, Sacramento, CA.

Jones, R.C. and Clark, C.C. 1987. Impact of watershed urbanization on stream insects communities. Water Resources Bulletin 23:1047-1055.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

Karr, J.R. 1998. Rivers as sentinels: using the biology of rivers to guide landscape management. In: Naiman, R.J. and Bilby, R.E. (eds.) River Ecology and Management:Lessons from the Pacific Coastal Ecoregion. Springer, New York, 502-528.

Karr, J.R., J.D. Allan and A.C. Benke. 2000. River conservation in the United States and Canada. In: Boon, P.J., B.R. Davies, and G.E. Petts (eds) Global Perspectives on River Conservation: Science, Policy and Practice. John Wiley and Sons Ltd, West Sussex, England, 3-39.

Kerans, B.L. and J.R. Karr. 1994. A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. Ecological Applications 4: 768-785.

Lenat, D.R. and Crawford, J.K. 1994. Effects of land use on water quality and aquatic biota of three North Carolina Piedmont streams. Hydrobiologia 294:185-199.

Merritt, R.W. and K.W. Cummins. 1995. An introduction to the aquatic insects of North America. Second Edition. Kendall/Hunt Publishing Co., Dubuque, IA.

Ode, P.R., A. Rehn and J.M. Harrington. 2002. Results of May 2001 Reference Site Study and Preliminary IBI for the San Diego Regional Water Quality Control Board.

California Department of Fish and Game, Aquatic Bioassessment Laboratory. Rancho Cordova, CA.

Ode, R.E., A.C. Rehn, J.T. May. 2005. A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams. Env. Man., Vol. 35, No. 4, pp. 493-504.

Pennak, R.W. 1989. Freshwater invertebrates of the United States, 3rd Ed. John Wiley and Sons, Inc., New York, NY.

Resh, V.H. and J.K. Jackson. 1993. Rapid assessment approaches to biomonitoring using benthic macroinvertebrates. In: D.M. Rosenberg and V.H. Resh, eds., Chapman and Hall, New York.

Rosenberg, D.M. and V.H. Resh (eds). 1993. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall. New York. NY.

Stewart, K.W. and B.P.Stark. 1993. Nymphs of North American Stonefly Genera (Plecoptera). University of North Texas Press, Denton, TX.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

VCWPD. Ventura County Watershed Protection District, Water Quality Division (Sustainable Land Stewardship Institute). 2001 & 2002. Ventura river watershed biological and physical/habitat assessment, Ventura County, CA.

Weaver, L.A. and Garman, G.C. 1994. Urbanization of a watershed and historical changes in a stream fish assemblage. Transactions of the American Fisheries Society 123:162-172.

TAXONOMIC REFERENCES

Brown, H. P. 1976. Aquatic Dryopoid Beetles (Coleoptera) of the United States. U. S. EPA. Cincinnati, Ohio. 82 Pages.

Burch, J. B. 1973. Biota of Freshwater Ecosystems Identification Manual No. 11, Freshwater Unionacean Clams (Mollusca: Pelecypoda) of North America. U. S. Environmental Protection Agency, Project # 18050, Contract # 14-12-894. 176 Pages.

Burch, J. B. 1973. Freshwater Unionacean Clams (Mollusca:gastropoda) of North America. U. S. Environmental Protection Agency, EPA-600\3-82-023. Contract # 68-03-1290. 193 Pages.

Edmunds, G. F., Jr., S. L. Jensen and L. Berner. 1976. The Mayflies of North and Central America. North Central Publishing Co., St. Paul, Minnesota. 330 Pages.

John H. Epler, 2001. Identification manual for the larval chironomidae (Diptera) of North and South Carolina.

Johannsen, O. A. 1977. Aquatic Diptera: Eggs, Larvae, and Pupae of Aquatic Flies. Published by the University, Ithaca, New York. 210 Pages.

Klemm, D. J. 1972. Biota of Freshwater Ecosystems Identification Manual No. 8, Freshwater Leeches (Annelida: Hirundinea) of North America. U.S. Environmental Protection Agency. Project # 18050, Contract # 14-12-894. 53 Pages.

Klemm, D. J. 1985. A Guide to the Freshwater Annelida (Polychaeta, Naidid and Tubificid Oligochaeta and Hirudinea) of North America. Kendall/Hunt Publishing Co., Dubuque, Iowa. 198p.

McCafferty, W. P. 1981. Aquatic Entomology. Jones and Bartlett Publishers, Inc., Boston. 448 Pages.

Merritt, R. W. and K. W. Cummins (Editors). 1996. An Introduction to the Aquatic Insects of North America, Third Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa. 862 Pages.

Pennak, R. W. 1989. Freshwater Invertebrates of the United States, Third Edition, John Wiley and Sons, Inc, New York, 628 Pages.

Stewart, K. W. and B. P. Stark. 1988. Nymphs of North American Stonefly Genera (Plecoptera). University of North Texas Press, Denton Texas. 460 Pages.

Thorp J. H. and A. P. Covich (Editors). 1991. Ecology and Classification of Freshwater Invertebrates. Academic Press, Inc., San Diego, California. 911 Pages.

Wiederholm, T. (Editor) 1983. Chironomidae of the Holarctic Region. Entomologica Scandinavica. 457 Pages.

Wiggins, G. B. 1996. Larvae of North American Caddisfly Genera (Tricoptera). Second Edition, University of Toronto Press. Toronto. 457 Pages.

APPENDIX A – BMI TAXA LISTS & METRIC TABLES

Table A-1. September 2005 BMI raw taxa list for all sites in the Ventura Watershed.

Identified Taxa	Tol Val (TV)	Func Feed Grp	0			4			12			2			3			5			7			15			8			9			10			11			13			14		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Insecta Taxa																																													
Ephemeroptera																																													
Baetis sp.	5	cg	6	4	0	10	6	10	16	17	12	1	4	5	56	43	122	11	26	0	83	34	26	19	25	25	10	13	9	26	7	6	23	22	22	38	39	23	87	97	70	37	66	68
Fallceon quilleri	5	cg	54	51	17	62	64	45	2	0	4	20	62	44	21	8	2	89	35	69	10	12	20	9	11	19	0	2	1	38	29	26	11	2	16	26	22	19	7	1	2	0	6	10
Cloeodes excogitatus	4	cg	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	3	1	0	0	0
Caenis sp.	7	cg	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Serratella sp.	2	cg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	2	0
Epeorus sp.	0	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	9	2	13	5	9	12
Tricorythodes sp.	5	cg	5	15	10	6	32	13	0	0	0	13	11	1	1	2	0	9	3	61	3	1	0	3	1	0	0	0	0	21	19	86	0	0	2	2	0	0	6	3	1	2	6	3
Choroterpes sp.	2	cg	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4
Odonata																																													
Hetaerina sp.	6	p	0	0	0	0	0	0	10	7	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argia sp.	7	p	0	0	0	0	0	0	9	18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	7	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Brechmorhoga	9	p	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Paltothemis sp.	9	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Plecoptera																																													
Malenka sp.	2	sh	0	0	0	0	0	0	0	0	0	0	0	0	7	25	27	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	2	0
Calineuria californica	2	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Hemiptera																																													
Abedus sp.	8	p	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ambrysus sp.	5	p	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sigara sp.	8	p	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera																																													
Micrasema sp.	1	sc	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	2	0	0	0	0	0	0	0	0	4	0	6	7	13	0	0	1	0	2	1	0	2	1	4	1	0
Cheumatopsyche sp.	5	cf	0	0	1	0	0	4	2	3	6	0	0	0	6	4	0	0	11	0	4	3	0	5	21	14	8	0	7	7	5	2	3	10	14	1	5	3	3	0	0	1	3	3
Hydropsyche sp.	4	cf	164	175	197	120	30	144	62	73	173	16	19	47	127	144	131	105	155	2	121	73	77	101	183	117	166	116	169	57	48	26	65	104	125	119	144	112	73	35	85	129	83	100
Hydroptila sp.	6	sc	19	12	7	12	44	9	12	6	2	4	1	6	28	13	2	23	23	10	5	7	57	4	1	2	12	1	2	75	28	18	13	5	20	6	3	5	4	0	3	1	4	2
Ochrotrichia sp.	4	cg	1	1	0	6	6	5	5	4	7	0	0	0	3	1	0	4	3	2	9	1	6	8	3	1	6	3	3	24	108	62	4	2	2	3	1	0	1	7	4	7	4	4
Oxyethira sp.	3	cg	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neotrichia sp.	4	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	6	0	1	1
Lepidostoma sp.	1	sh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.	8	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marilia flexuosa	0	sh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Wormaldia sp.	3	cf	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	7	17	15	0	2	0	0	0	0	0	1	1	0	6	9	3	0	0
Polycentropus sp.	6	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	3	0	0	0	1
Tinodes sp.	2	cg	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	4	1	2	0	0	0	14	30	22	0	0	2	3	0	2	0	0	0	2	3	1	0	1	0
Rhyacophila sp.	0	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	5	0	0	0	0	0	0	1	0	0
Gumaga sp.	3	sh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Lepidoptera																																													
Petrophila sp.	5	sc	0	0	0	0	0	0	4	11	6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	14	0	0	0	1	0	0	0	0	0
Coleoptera																																													
Ochthebius sp.	5	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microcylloepus sp.	4	cg	1	0	3	4	0	2	26	20	12	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	14	13	14	16	7	5	3	5	0	3	5	2
Optioservus sp.	4	sc	0	0	0	0	1	0	0	3	5	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	2
Ordobrevia sp.	4	sc	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	1	0
Zaitzevia sp.	4	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Stictotarsus sp.	5	cg	0	0	0	0	0	0	0	0	0	0	2	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tropisternus sp.	5	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helochares sp.	5	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psephenus falli	4	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera																																													
Bezzia/Palpomyia sp.	6	p	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0	0
Dasyhelea sp.	6	cg	3	2	0	0	0	0	0	0	0	1	0	0	1	0	7	0	0	0	3	15	12	0	0	4	0	0	0	0	0	0	1	0	10	2	0	1	0	0	0	1	0	0
Atrichopogon sp.	6	cg	0	1	0	1	0	0	4	2	0	0	0	0	1	1	0	0	0	0	7	11	7	2	4	1	4	3	3	4	1	0	2	0	8	1	0	0	2	11	0	3	1	10
Chironominae	6	cg	12	11	5	27	28	36	96	112	35	88	87	54	30	49	12	14	6	62	30	24	18	13	2	3	17	21	12	20	21	47	80	49	38	22	44	8	82	42	57	57	78	40
Orthocladiinae	5	cg	11	9	12	38	30	12	36	16	18	6	29	25	11	10	20	23	14	6	14	27	22	21	11	18	6	10	8	15	4	6	28	11	41	6	9	5	13	15	12	12	24	20
Tanypodinae	7	p	0	1	0	8	17	9	9	10	2	70	20	11	7	11	0	7	11	14	2	1	4	14	3	8	1	2	7	5	1	5	10	6	13	4	1	2	2	4	3	1	5	1
Hemerodromia sp.	6	p	0	0	0	2	1	1	2	3	0	0	0	0	0	0	0	4	1	0	2	2	4	2	1	5	1	1	1	0	1	2	2	1	2	1	0	1	0	2	0	0	2	3
Neoplasta sp.	6	p	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnophora sp.	6	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Muscidae	6	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Maruina lanceolata	2	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	16	11	0	0	0	0	0	0
Pericoma/Telmatoscopus sp.	4	cg	4	1	0	0	2	1	0	0	0	0	0	0	1	0	4	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Simulium sp.	6	cf	0	0	0	0	0	2	55	44	12	1	0	0	0	3	0	2	17	1	15	4	4	27	13	17	3	22	5	4	2	6	24	36	21	49	14	93	10	84	0	67	25	40
Euparyphus sp.	8	cg	0	0	0	2	6	1	2	1	0	1	8	2	0	5	6	2	0	1	6	4	8	2	2	1	2	0	0	1	4	1	2	3	10	5	0	2	1	1	0	1	0	0
Caloparyphus/Euparyphus sp.	8	cg	0	2	0	16	11	1	4	0	2	37	51	30	22	16	30	20	18	1	30	39	13	111	20	80	2	7	3	28	26	14	5	17	5	2	1	4	0	3	0	1	0	1
Limonia sp.	6	sh	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4	2	1	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	1	0	1
Tipula sp.	4	sh	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0

Table A-1. Continued.

Identified Taxa	Tol Val (TV)	Func Feed Grp	0			4			12			2			3			5			7			15			8			9			10			11			13			14		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Non-Insecta Taxa																																													
Arachnoidea																																													
Mideopsis sp.	5	p	0	0	0	0	0	1	0	2	0	3	2	2	0	0	3	0	1	0	0	0	0	0	2	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Lebertia sp.	5	p	0	0	0	1	5	1	0	0	0	0	2	1	0	0	0	0	5	0	0	0	3	0	0	0	2	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Atractides sp.	8	p	2	0	0	0	0	0	1	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	1
Protzia sp.	8	p	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sperchon sp.	8	p	3	1	4	4	4	13	2	0	5	1	8	6	4	4	3	10	25	1	5	6	23	5	2	2	7	32	5	2	2	4	2	2	0	0	2	0	2	2	3	2	6	2
Torrenticola sp.	5	p	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	2	1	1	5	4	0	0	0	1	1	1
Ostracoda																																													
Cyprididae	8	cg	15	0	33	1	8	0	12	1	0	16	11	7	0	0	0	0	2	48	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Malacostraca																																													
Hyalella sp.	8	cg	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda																																													
Fossaria sp.	8	sc	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physa/Physella sp.	8	sc	0	0	0	0	0	1	0	2	0	3	2	2	0	0	3	0	1	0	0	0	0	0	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Nematoda	5	p	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbellaria																																													
Planariidae	4	p	2	8	9	0	0	0	11	3	5	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	7	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta	5	cg	0	2	8	0	0	2	3	3	1	41	5	54	0	0	20	0	0	1	2	79	2	5	1	11	2	1	0	0	0	0	0	3	0	0	2	0	0	1	0	0	1	0
Enopla																																													
Prostoma sp.	8	p	0	0	28	0	1	1	39	9	1	0	0	0	0	0	0	0	2	4	0	0	0	5	1	4	16	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTAL			**304**	**301**	**342**	**321**	**303**	**322**	**428**	**388**	**313**	**328**	**333**	**304**	**331**	**353**	**403**	**327**	**374**	**291**	**369**	**360**	**315**	**362**	**332**	**341**	**301**	**315**	**288**	**340**	**331**	**334**	**304**	**306**	**394**	**314**	**343**	**312**	**314**	**353**	**277**	**341**	**355**	**336**

Table A-2. September 2005 BMI metrics by replicate for each of the sample locations in the Ventura Watershed.

Metric	0			4			12			2			3			5			7		
	Replicate			Replicate			Replicate			Replicate			Replicate			Replicate			Replicate		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Taxonomic richness	17	19	18	18	20	25	28	26	20	20	20	18	20	21	17	17	25	20	24	25	21
% dominant taxa	53	56	52	37	21	44	22	30	56	27	27	18	38	41	33	32	42	23	33	22	24
EPT taxa	6	6	5	6	6	9	6	6	7	5	5	5	10	11	6	7	8	7	9	8	6
EPT Index (%)	80	83	61	67	59	71	23	28	66	17	30	34	74	63	65	74	69	49	65	37	59
Sensitive EPT Index (%)	0	0	0	0	0	1	0	0	0	0	0	0	0	2	1	0	1	0	1	0	1
Cumulative EPT Taxa		7			5			12			9			10			10			12	
Predator Taxa	3	3	6	4	4	6	10	8	5	5	7	6	3	2	4	5	9	5	3	3	4
Coleoptera Taxa	1	0	1	1	1	2	1	2	2	1	2	1	1	1	1	1	2	0	0	1	0
Percent Chironomidae	7	7	4	23	24	17	33	37	18	50	42	30	15	20	8	13	8	28	12	15	14
Percent Non-Insect	10	8	33	2	9	8	17	5	4	19	9	24	1	2	7	3	12	21	4	25	11
Shannon Diversity	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Tolerance Value	5	5	5	5	6	5	6	5	5	6	6	6	5	5	5	5	5	6	5	5	6
Percent Intolerance Value (0-2)	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1
Percent Tolerance Value (8-10)	9	5	28	8	13	8	14	3	3	18	25	16	8	8	10	10	14	22	13	15	16
Percent Collectors	36	32	23	54	63	40	48	47	30	69	83	74	45	39	56	53	29	85	56	71	44
Percent Filterers	53	56	52	37	10	46	28	32	62	5	6	16	40	44	34	33	49	1	38	23	26
Percent Grazers	9	8	13	4	18	6	4	6	4	2	1	3	9	5	1	8	9	7	3	3	20
Percent Predators	2	4	12	5	9	8	20	14	5	23	11	7	4	4	3	6	13	7	2	3	11
Percent Shredders	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0
Percent Hydropsychidae	53	56	52	37	10	44	14	20	56	5	6	16	38	41	33	32	42	1	33	21	24
Percent Baetidae	19	18	4	22	23	17	4	5	5	6	20	16	24	14	31	31	16	23	26	13	15

Metric	15			8			9			10			11			13			14		
	Replicate			Replicate			Replicate			Replicate			Replicate			Replicate			Replicate		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Taxonomic richness	21	24	23	27	27	22	22	24	22	25	22	26	23	23	23	20	28	19	22	26	25
% dominant taxa	31	58	35	54	38	59	22	34	26	26	35	32	38	44	36	28	29	31	38	24	30
EPT taxa	8	8	8	8	10	8	9	12	12	9	8	11	9	10	9	10	13	14	10	14	12
EPT Index (%)	42	79	54	73	62	79	75	80	73	41	50	54	63	68	54	63	49	72	56	55	63
Sensitive EPT Index (%)	0	0	1	7	17	13	2	3	5	2	0	2	0	3	1	4	4	9	4	4	5
Cumulative EPT Taxa		15			13			14			8			17			19			10	
Predator Taxa	7	10	2	8	10	5	6	4	4	5	6	6	6	6	4	2	7	4	4	5	7
Coleoptera Taxa	0	0	0	1	0	0	0	1	0	1	3	1	1	3	2	1	1	0	1	2	2
Percent Chironomidae	13	5	9	8	11	9	12	8	17	39	23	24	10	16	5	31	18	26	21	32	18
Percent Non-Insect	4	3	6	15	14	4	1	1	2	1	3	0	0	3	1	1	1	1	1	3	1
Shannon Diversity	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Tolerance Value	6	5	6	5	5	4	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5
Percent Intolerance Value (0-2)	0	0	1	5	11	8	2	3	5	1	0	2	2	7	4	4	2	6	3	4	5
Percent Tolerance Value (8-10)	34	8	26	12	14	4	10	10	7	3	8	4	2	1	2	1	3	1	1	2	1
Percent Collectors	53	26	48	21	30	22	52	69	76	57	42	43	39	38	22	66	57	54	36	57	49
Percent Filterers	37	69	44	60	51	68	20	18	10	30	51	41	54	50	68	27	37	34	59	33	43
Percent Grazers	1	0	1	7	2	1	24	12	10	6	2	9	4	9	6	4	1	8	3	5	5
Percent Predators	9	5	6	12	16	8	3	2	4	5	4	6	3	3	3	1	4	3	1	4	3
Percent Shredders	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Percent Hydropsychidae	28	58	35	54	38	59	17	15	8	21	35	32	38	44	36	23	10	31	38	24	30
Percent Baetidae	8	12	13	3	5	3	19	11	10	11	8	10	20	18	14	31	30	27	11	21	23

Table A-3. Averaged biological metrics for each station in the Ventura Watershed with standard deviations, coefficients of variation and 95% confidence intervals. Grayed area denotes stations that were dry.

		Ventura River				Canada Larga		San Antonio Creek					North Fork Matilija Creek		Matilija Creek	
		Main Street Bridge	Foster Park	Below Matilija Dam	@ Santa Ana Rd.	Below Grazing	Above Grazing	u/s Ventura River Confluence	Lion Canyon u/s San Antonio	u/s Lion Canyon	Stewart Canyon u/s San Antonio	u/s Stewart Canyon Creek	u/s Ventura River Confluence	At gauging station	Below Community	Above Community
Biological Metric		0	4	12	6	2	3	5	7	15	8	9	10	11	13	14
Taxonomic richness	mean	18	21	25		19	19	21	23	23	25	23	24	23	22	24
	st. dev.	1	4	4		1	2	4	2	2	3	1	2	0	5	2
	cv	6	17	17		6	11	20	9	7	11	5	9	-	22	9
	95% CI	1	4	5		1	2	5	2	2	3	1	2	-	6	2
% dominant taxa	mean	53.6	34.0	36.1		23.9	37.5	32.3	26.4	41.3	50.3	27.2	31.3	39.3	29.2	30.8
	st. dev.	2.3	12.0	17.5		5.1	4.1	9.2	5.4	15.0	10.9	5.9	4.6	3.9	1.7	0.5
	cv	4.4	35.2	48.5		21.2	10.8	28.5	20.4	36.4	21.7	21.6	14.7	9.8	5.7	1.6
	95% CI	2.7	13.5	19.8		5.7	4.6	10.4	6.1	17.0	12.3	6.7	5.2	4.4	1.9	0.6
EPT taxa	mean	6	7	6		5	9	7	8	8	9	11	9	9	12	12
	st. dev.	1	2	1		0	3	1	2	0	1	2	2	1	2	2
	cv	10	25	9		-	29	8	20	-	13	16	16	6	17	17
	95% CI	1	2	1		-	3	1	2	-	1	2	2	1	2	2
EPT Index (%)	mean	74.7	65.8	39.0		26.9	67.6	64.2	53.9	57.9	71.3	76.1	48.3	61.4	61.1	58.0
	st. dev.	11.9	6.2	23.6		9.2	5.9	13.1	14.6	18.9	9.0	3.3	6.6	7.1	11.9	4.1
	cv	15.9	9.4	60.4		34.3	8.7	20.4	27.1	32.6	12.6	4.4	13.7	11.5	19.5	7.1
	95% CI	13	7	27		10	7	15	17	21	10	4	7	8	14	5
Sensitive EPT Index (%)	mean	0.0	0.2	0.2		0.0	0.8	0.3	0.7	0.2	12.1	3.3	1.3	1.3	5.6	4.3
	st. dev.	0.0	0.4	0.2		0.0	0.8	0.3	0.4	0.4	5.0	1.5	0.9	1.2	3.1	0.5
	cv	-	0.0	87.7		0.0	0.0	0.0	0.0	206.3	0.0	0.0	66.3	93.0	55.0	11.8
	95% CI	-	0.4	0.2		-	0.9	0.3	0.4	0.5	5.7	1.7	1.0	1.4	3.5	0.6
Cumulative EPT Taxa	mean	7	5	12		9	10	10	12	15	13	14	8	17	19	10
Predator Taxa	mean	4	5	8		6	3	6	3	6	8	5	6	5	4	5
	st. dev.	2	1	3		1	1	2	1	4	3	1	1	1	3	2
	cv	43	25	33		17	33	36	17	64	33	25	10	22	58	29
	95% CI	2	1	3		1	1	3	1	5	3	1	1	1	3	2
Coleoptera Taxa	mean	1	1	2		1	1	1	0	0	0	0	2	2	1	2
	st. dev.	1	1	1		1	0	1	1	0	1	1	1	1	1	1
	cv	87	43	35		43	-	100	173	-	173	173	69	50	87	35
	95% CI	1	1	1		1	-	1	1	-	1	1	1	1	1	1
Percent Chironomidae	mean	6.2	21.5	29.2		40.7	14.2	16.4	13.7	9.0	9.3	12.4	28.3	10.5	25.1	23.5
	st. dev.	1.5	3.6	10.2		10.2	5.9	9.9	1.2	4.1	1.5	4.7	9.2	5.8	6.6	7.1
	cv	24.7	16.8	34.7		25.1	41.8	60.5	8.8	45.7	16.2	37.7	32.5	54.9	26.1	30.2
	95% CI	1.7	4.1	11.5		11.6	6.7	11.3	1.4	4.6	1.7	5.3	10.4	6.5	7.4	8.0
Percent Non-Insect	mean	17.1	6.7	8.6		17.4	3.3	12.1	13.5	4.1	11.1	1.6	1.3	1.4	1.0	1.6
	st. dev.	14.0	3.7	7.0		7.3	2.8	9.1	10.5	1.5	6.3	0.7	1.3	1.2	0.3	0.9
	cv	82.0	55.3	80.8		41.7	84.5	74.8	77.5	37.3	56.7	42.7	95.9	83.7	30.0	59.8
	95% CI	15.8	4.2	7.9		8.2	3.2	10.3	11.9	1.7	7.1	0.8	1.4	1.4	0.3	1.1
Shannon Diversity	mean	1.7	2.2	2.2		2.2	2.0	2.1	2.4	2.0	2.0	2.3	2.3	2.0	2.0	2.1
	st. dev.	0.1	0.2	0.4		0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.2	0.1	0.2	0.2
	cv	5.2	11.1	18.0		2.4	4.2	5.1	4.3	12.2	12.6	4.1	7.2	3.4	7.8	8.8
	95% CI	0.1	0.3	0.5		0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.2	0.1	0.2	0.2
Tolerance Value	mean	4.9	5.2	5.2		5.9	4.8	5.4	5.4	5.4	4.6	5.1	5.1	4.7	4.9	4.9
	st. dev.	0.4	0.4	0.6		0.3	0.2	0.5	0.2	0.6	0.2	0.2	0.1	0.2	0.3	0.1
	cv	7.1	7.2	10.9		5.4	3.3	8.9	3.4	11.3	5.0	4.6	2.5	4.5	6.8	1.5
	95% CI	0.4	0.4	0.6		0.4	0.2	0.6	0.2	0.7	0.3	0.3	0.1	0.2	0.4	0.1
Percent Intolerance Value (0-2)	mean	0.0	0.2	0.1		0.0	0.4	0.2	0.7	0.2	7.9	3.1	1.2	4.4	3.9	4.0
	st. dev.	0.0	0.4	0.2		0.0	0.4	0.3	0.4	0.3	3.5	1.5	0.9	2.5	1.8	0.9
	cv	-	0.0	173.2		-	0.0	0.0	0.0	173.2	0.0	0.0	69.2	58.0	45.3	23.8
	95% CI	-	0.4	0.2		-	0.5	0.4	0.4	0.4	3.9	1.7	1.0	2.9	2.0	1.1
Percent Tolerance Value (8-10)	mean	14.4	9.6	6.8		19.3	8.8	15.6	14.9	22.8	10.2	9.0	4.9	1.7	1.7	1.5
	st. dev.	12.3	3.2	6.5		4.8	1.3	6.1	1.5	13.3	5.6	1.8	2.3	0.7	0.9	0.5
	cv	85.3	33.8	95.9		24.8	15.0	39.2	10.0	58.2	55.0	20.2	46.9	41.1	51.7	34.2
	95% CI	13.9	3.7	7.3		5.4	1.5	6.9	1.7	15.0	6.3	2.0	2.6	0.8	1.0	0.6
Percent Collectors	mean	30.6	52.2	41.8		75.2	46.9	55.7	57.0	42.4	24.2	65.7	47.5	33.1	59.2	47.4
	st. dev.	6.5	11.4	10.5		6.9	8.5	27.9	13.5	14.8	4.9	12.2	8.6	9.6	6.4	10.4
	cv	21.2	21.8	25.1		9.1	18.1	50.2	23.7	35.0	20.3	18.6	18.2	29.0	10.8	22.0
	95% CI	7.3	12.9	11.8		7.8	9.6	31.6	15.3	16.8	5.5	13.8	9.8	10.9	7.2	11.8
Percent Filterers	mean	53.7	31.0	40.5		8.9	39.2	27.6	28.6	50.0	59.6	16.0	40.8	57.1	32.9	44.8
	st. dev.	2.2	18.9	18.4		5.9	5.2	24.4	7.9	17.1	8.7	5.2	10.4	9.4	4.9	13.1
	cv	4.2	61.0	45.4		66.1	13.3	88.5	27.8	34.2	14.7	32.2	25.5	16.4	14.9	29.3
	95% CI	2.5	21.4	20.8		6.7	5.9	27.6	9.0	19.4	9.9	5.8	11.8	10.6	5.5	14.9
Percent Grazers	mean	9.8	9.5	4.6		1.9	4.9	7.8	8.3	0.8	3.4	15.4	5.8	6.6	4.8	4.3
	st. dev.	2.5	7.5	0.9		1.1	4.2	1.1	9.8	0.4	3.0	7.9	3.3	2.8	3.5	1.2
	cv	26.0	78.8	19.6		59.2	85.1	13.7	118.3	52.7	87.8	51.4	57.0	42.4	72.5	27.1
	95% CI	2.9	8.5	1.0		1.3	4.7	1.2	11.1	0.5	3.4	9.0	3.7	3.1	3.9	1.3
Percent Predators	mean	5.9	7.3	12.9		13.9	3.6	8.8	5.5	6.5	12.1	2.9	5.3	2.7	2.8	2.9
	st. dev.	5.2	2.4	7.8		8.4	0.6	3.6	4.5	1.9	3.9	1.2	0.9	0.1	1.6	1.5
	cv	88.6	33.2	60.3		60.4	17.0	40.5	82.3	29.4	31.7	41.7	16.1	5.2	57.7	51.8
	95% CI	5.9	2.8	8.8		9.5	0.7	4.0	5.1	2.2	4.4	1.4	1.0	0.2	1.8	1.7
Percent Shredders	mean	0.0	0.0	0.3		0.0	0.0	0.1	0.7	0.3	0.6	0.0	0.5	0.2	0.2	0.3
	st. dev.	0.0	0.0	0.3		0.0	0.0	0.2	0.4	0.5	0.7	0.0	0.5	0.2	0.2	0.0
	cv	-	-	104.8		-	-	0.0	0.0	173.2	0.0	-	98.9	86.7	86.8	1.1
	95% CI	-	-	0.3		-	-	0.2	0.4	0.6	0.8	-	0.6	0.2	0.2	0.0
Percent Hydropsychidae	mean	53.6	30.3	30.0		8.8	37.5	24.8	25.8	40.4	50.3	13.2	29.6	39.3	21.6	30.8
	st. dev.	2.3	18.2	22.5		6.0	4.1	21.4	6.1	16.0	10.9	4.8	7.3	3.9	10.4	6.8
	cv	4.4	0.0	75.2		-	-	0.0	0.0	39.7	0.0	0.0	24.6	9.8	48.4	21.9
	95% CI	2.7	20.6	25.5		6.8	4.6	24.2	6.9	18.1	12.3	5.4	8.3	4.4	11.8	7.7
Percent Baetidae	mean	13.8	20.6	4.6		14.3	23.1	23.4	17.8	10.8	3.9	13.3	9.7	17.5	29.3	18.5
	st. dev.	8.1	3.3	0.5		7.1	8.4	7.1	7.0	2.7	0.9	4.8	1.5	3.5	2.4	6.7
	cv	58.9	16.0	10.4		49.4	36.3	30.5	39.3	25.2	23.3	36.3	15.6	20.2	8.2	36.2
	95% CI	9.2	3.7	0.5		8.0	9.5	8.1	7.9	3.1	1.0	5.5	1.7	4.0	2.7	7.6
Estimated Abundance	mean	7452	5153	4797		6075	3038	8607	4098	7170	3783	6845	4917	6093	7568	4913
	st. dev.	4569	3435	1771		3380	1418	4826	583	2179	1865	2675	323	2082	3932	518
	cv	61	67	37		56	47	56	14	30	49	39	7	34	52	11
	95% CI	5170	3887	2004		3824	1604	5461	660	2466	2110	3026	366	2356	4449	586