THE CITY OF SAN BUENAVENTURA

Santa Clara River Estuary Macroinvertebrate Bioassessment Monitoring Annual Report 2005

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INTRODUCTION

This report is submitted in fulfillment of the City of San Buenaventura's bioassessment monitoring portion of National Pollutant Elimination Discharge System (NPDES) permit No. CA0052651 (Order No. 00-143). The City owns and operates the Ventura Water Reclamation Facility (VWRF) adjacent to the north edge of the Santa Clara River Estuary (SCRE). The VWRF discharges tertiary treated effluent into the Estuary at a relatively constant rate of between 7 and 10 million gallons each day. The monitoring program described herein was developed based on several past studies of the Estuary (Engineering Science 1976; Swanson 1990; USFWS 1999; ENTRIX 1999, 2002 and 2003; Aquatic Bioassay 2004 and 2005).

The main objective of this program is to assess if the effluent emanating from the VWRF is impacting the populations of organisms living in the SCRE, taking into account the influence of both physical habitat and seasonal differences between sampling locations. Potential impacts would include differences in the abundance, diversity and/or composition of organisms residing in the effluent channel (Stations B1 and B2) versus those located in the lower estuary (Station B3) and in the main river channels (Station B7).

To address this objective, Aquatic Bioassay & Consulting Laboratories scientists conducted bioassessment monitoring of the Santa Clara River Estuary during both the spring and fall of 2005, in accordance with the City's NPDES permit and the California Stream Bioassessment Protocol (CSBP 2003). The methods, findings and discussion of these surveys are presented in this report.

Site Description

The Santa Clara River is the longest free-flowing river in southern California. Its 70 mile length provides drainage to a 1,600 mi^2 watershed. Flow in the river typically reaches 100,000 cubic feet per second (cfs) during winter and spring storm flows (Swanson et al. 1990). The SCRE is located at the mouth of the river and is characterized as a typical river mouth estuary (Ferran 1989, Ferran et al. 1996). The Estuary is a highly dynamic environment due to hydrology patterns that can vary greatly during the year. The flow of water into the SCRE is influenced by dry and wet weather flow from the Santa Clara River, Pacific Ocean tides and the effluent emanating from the City of San Buenaventura's, Ventura Water Reclamation Facility (VWRF). During the winter and spring, the river is open to the ocean due to sandbar-breaching storm flows. During the summer and fall the sandbar becomes well established due to lack of rainfall, low river flow and small summer surf. Once established, the berm creates a barrier to flow and allows the Estuary to become inundated with water from the VWRF. Depth of the estuary during peak inundation can reach nearly 10 ft above Mean Sea Level (MSL) (USFWS 1999).

In 1855, the Estuary was estimated to have encompassed 870 acres (Swanson et al. 1990, State Coastal Conservancy et al. 1997), but its size has declined to its present 160 acres, due to the diversion of upstream river flow to municipal water projects

and agriculture (ENTRIX 2002). This reduction in flow has, in part, been replaced by the relatively constant flow of tertiary treated effluent (7 to 10 MGD) from the VWRF. The tertiary treatment process creates effluent essentially free of organics and is very low in nutrients. This flow provides a water source to the Estuary during periods when it would otherwise be dry. Since most southern California estuaries experience drought during the summer and fall (Zedler 1982), this has created a unique, low salinity habitat for a wide array of aquatic organisms, water birds and other vertebrates. The lack of understanding regarding the relationship between the biological resources found in the estuary and the unique habitat created by the VWRF, has prompted the use of bioassessment monitoring to elucidate the dynamics of this ecosystem.

Bioassessment Monitoring

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) have been used as a watershed management tool for surveillance and compliance of land-use best management practices (Jones and Clark 1987; Lenat and Crawford 1994; Weaver and Garman 1994; Karr 1998 and Karr et al. 2000). 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 1996).

Biological communities act to integrate the effects of water quality conditions and various anthropogenic stressors in a stream or river system 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-toxic substances (e.g. nutrients and sediment), especially when monitoring demonstrates changes over time or along concentration gradients.

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 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 combination of multi-metric and multivariate techniques. 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). Borrowing from the multi-metric approach, the California Department of Fish and Game developed the California Stream Bioassessment Procedure (CSBP) (CDFG 1999) that are currently being integrated into the NPDES monitoring programs for waste discharge agencies throughout the State and is specified for use in the City of Ventura's NPDES permit.

The evaluation of biological data collected from Santa Clara River Estuary surveys has posed an interesting analysis problem. While the organisms collected from the Estuary were typical of past surveys (Engineering Science 1976; Swanson 1990; USFWS 1999; ENTRIX 1999, 2002 and 2003) and for estuaries in general, they are not typical of the inland streams for which the metrics in the CSBP were developed. As a result, the survey data were analyzed using both multi-metric and multivariate techniques to help elucidate any population effects that may have been present as a result of the City of Ventura's effluent. This approach was taken in an attempt to glean as much information as possible from the biological data. By combining the results of these two approaches it is hoped that a better explanation of the population patterns found in the Estuary can be achieved than would be accomplished by using either technique alone.

MATERIALS AND METHODS

Sampling was conducted on May 17th, 2005 and October 25th, 2005 by Aquatic Bioassay & Consulting Laboratories biologists. All procedures were conducted as outlined in the project scope of work and in accordance with modifications to the California Department of Fish and Games, California Stream Bioassessment Protocol, their Lentic Bioassessments Procedures and the 1997-1999 USFWS study of the estuary.

Field Methods

The May and October 2005 sampling events occurred during open mouth, free flowing conditions. The October event occurred while the berm was partially breached. While not completely inundated, water levels in the Estuary were still deeper (up to three feet) than when the berm is completely breached. Stations were located using a hand held DGPS. During each survey water quality, bioassessment and particle size samples were collected at four locations (Stations B1, B2, B3 and B7) (Figure 1). These sites were selected as a subset of the stations surveyed during previous studies (USFWS 1999, ENTRIX 2002). Station B1 is located in the main effluent channel, with Station B2 located just upstream of it in the Santa Clara River. Station B3 is located inside the sand spit berm in the lower estuary and Station B7 is located on the southwest side of the Estuary in the main river channel.

Triplicate benthic samples were collected at each station using a 0.05 m^2 petite ponar grab. This sampling device replaced the PVC coring device (10.2 cm diameter) used in previous surveys. The coring device relies on vacuum pressure to keep samples intact as they are brought to the surface and work well in silty sediments, but not so well in sandy sediments. Since the Estuary sediments are composed mostly of sand and a good seal could not be formed, it was difficult to bring samples to the water surface. The petite ponar grab closes completely after the sample is collected, ensuring that sample is not lost as it is brought up through the water column. Each sample was sieved through a 0.5 mm mesh screen on shore and preserved in 95% ethanol.

In the spring (and in past surveys), a single littoral sweep was conducted at Station B1 using a kick net and samples were processed as above. However, since the Estuary provides critical habitat for the endangered tidewater goby, which can be inadvertently collected with the kick net, the littoral sweep was permanently excluded from the sampling design by the Los Angeles Regional Water Quality Control Board. As a result, only spring littoral sweep results are presented. Single samples for particle size were collected at each site.

Water quality measurements were collected using a laboratory calibrated YSI 85 handheld meter. Salinity, temperature, dissolved oxygen and pH were recorded on a modified CDFG Bioassessment Worksheet at each site. Physical habitat measurements were collected for transect length, grain size and composition.

Stream flow data was not available for 2005 because the gauging device was destroyed by large storms during the previous winter. Instead, average monthly rain

data were obtained for the Oxnard Airport from the Western Regional Climate Center in Reno, NV.

Figure 1. Site map and sampling locations in the Santa Clara River Estuary.

Laboratory Methods

Sample Processing

Elutriation

Due to the large amount of sand and gravel present in the benthic core samples after they had been passed through the 0.5 mm screen, each sample was elutriated in the field. The sample was elutriated by placing it in a 5 gallon bucket. River water that had been filtered using the 0.5 mm screen was then added to just cover the sediment. The bucket was then gently swirled gently to suspend organic material in the sample, and the supernatant was decanted through a 0.5 mm screen. This process was repeated numerous times until the supernatant was nearly clear. All of the elutriated material on the 0.5 mm screen was then rinsed into a ½ gallon wide mouth jar and preserved in 70% alcohol. The sand and gravel were placed into a separate ½ gallon wide mouth jar and preserved in 70% alcohol, and then scanned

by a supervising Biologist in the laboratory for any remaining animals. The field elutriation method successfully removed 99% of the organisms from all samples.

During sorting and taxonomic analysis, samples were transferred to Petri dishes containing 70% alcohol and examined under the microscope at 10 times magnification. Invertebrates were removed using forceps and placed in a 20 mL sample vials. Once all invertebrates had been removed, the remaining material was transferred from the Petri dish and combined with the rest of the sample.

Ostracod Sub Sampling

Ostracods were not sub sampled. All organisms that appeared to have been alive at the time of preservation were removed and identified. Ostracod counts are absolute benthic macroinvertebrates (BMIs) collected in each sample.

Littoral Sweep Sub Sampling

The littoral sweep sample collected in the spring was sub-sampled using a 30.0 by 36.0 cm Caton Tray fitted with 0.5 mm mesh. The tray was divided into 30- 6.0 x 6.0 quadrats. The entire littoral sweep sample was placed into the Caton tray and distributed to a uniform depth. Samples from five quadrats were randomly selected and removed, and the BMIs were removed and identified. Littoral sweep taxa abundances were converted to the whole sample counts by multiplying by a factor of 6.

QA / QC

Sorting

The sample matrix remaining after sorting was completed, was periodically evaluated to determine elutriation efficiency. Approximately 10% of the remains from each sample was placed into a Petri dish and observed under a microscope at 10 times magnification to verify that no BMIs had been missed during the sorting process. Sorting efficiencies were over 99.5%.

Taxonomic Effort

All of the organisms removed during the sorting process were then identified to Level 1 standard taxonomic effort in accord with the *List of California Macroinvertebrate Taxa and Standard Taxonomic Effort* (revision date: 27 January, 2003). Standard taxonomic keys used for the identifications are listed in a separate section below. Voucher specimens were retained for all unique taxa. The identified taxa from the processed portion of each sample were placed in separate vials and preserved with 70% ethanol and 5% glycerin. Chironomid reference slides were prepared in mounting compound and sealed. Of the samples (10%) that were sent to the Department of Fish and Game's Aquatic Bioassessment Laboratory in Rancho Cordova, CA, all passed the QA/QC check.

Particle Size Analysis

Sediments were analyzed for particle size distribution using a Horiba 920 particle size analyzer following Standard Methods, 20 ed. (APHA 1998). Duplicate sub-samples from each sample were re-suspended in de-ionized water, and then injected into the

analyzer. The analyzer is capable of measuring particle sizes ranging from clay (<2µ) through course sand (2000µ).

Data Analysis

Multi-metric analysis

Biological metrics were calculated as specified by the California Stream Bioassessment Procedure (CSBP) (2003) and were used to describe the benthic macroinvertebrate population. Each of the EPT metrics was zero and was, therefore, not reported. This was due to the absence of Ephemeroptera, Plecoptera and Trichoptera, upon which many of the key metrics in the CSBP are based on. Additionally, estuarine taxa predominated in the survey area, and no specific metrics have been developed for them. Tolerance values and Functional Feeding Group types identified in California Department of Fish and Game (2003) were used for most taxa. Tolerance Values and Functional Feeding Groups in Bold text in Tables 1 and 2 (Appendix B) were found in Barbour et al. (1999) and Mandaville (2002). Biological metrics were calculated with chironomid identification held to the level of subfamily. The following metrics were calculated. Their responses to impaired conditions are listed in Table 1:

1. Richness measures: taxa richness, cumulative taxa;
2. Composition measures: Shannon diversity;
3. Tolerance/intolerance measures: tolerance value, intolerant organisms (%), tolerant organisms (%), dominant taxa (%), Chironomidae (%);
4. Functional feeding group: collectors (%), filterers (%), grazers (%), predators (%), shredders (%);
5. Abundance estimates.

Table 1. Bioassessment metrics used to describe characteristics of the BMI community results for the Santa Clara River Estuary.

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

Univariate and Multivariate Analysis

Descriptive statistics were calculated for each of the multi-metric community metrics and included the mean, standard deviation and coefficient of variation. These metrics were also assessed using One-Way Analysis of Variance (ANOVA) with each metric representing the dependent variable and station location representing the independent variable. Assumptions of the ANOVA test were evaluated using the skewness of normality residuals, Kurtosis of normality residuals, Omnibus normality of residuals, and the Modified-Levene Equal-Variance Test. When a data set did not pass any one of these tests, the Kruskal-Wallis One-Way ANOVA on Ranks was used. Multiple comparisons were performed using Newman-Keuls Multiple-Comparison Test for data with equal variances and Kruskal-Wallis Multiple-Comparison Z-Value Test for data with unequal variances (NCSS 2001).

Cluster analysis was used to define groups of samples, based on species presence and abundance. Identified clusters were then evaluated to define the habitat to which they belonged. In cluster analysis, samples with the greatest similarity are grouped first. Additional samples with decreasing similarity are then progressively added to the groups. The percentage dissimilarity (Bray-Curtis) metric (Gauch, 1982; Jongman et al., 1995) was used to calculate the distances between all pairs of samples. The cluster dendogram was formed using the unweighted pair-groups method using arithmetic averages (UPGMA) clustering algorithm (Sneath and Sokal, 1973). All steps were completed using the computer program MVSP (Multivariate Statistical Package, v3.12, 2000). Only the most commonly occurring species were used in the analysis, in this case only those that occurred at more than one station and season. Clusters that were created for station and species groups were merged into a single two-way table depicting the most frequently collected species by station.

RESULTS

Annual Stream Flow & Estuary Inundation

The Estuary undergoes periodic filling and draining throughout the year due to the periodic closure, then reopening, of the sand spit at its mouth. The Estuary is, on average, closed during low river flow, usually during the summer and fall. Open Estuary conditions prevail during the winter and spring, after rain events increase river flow.

Flow during 2005 on the Santa Clara River was not measured because the gauging stations were lost due to exceptional flows last winter. In previous years, stream flow was measured either at the Montalvo gauging station in Ventura, which is just upstream of the Estuary or in the Santa Clara River, just below Piru Creek. For this report, we have presented the average monthly rainfall collected at the Oxnard Airport. While clearly not a direct measure of stream flow in the Santa Clara River, these data help to illustrate the size of the winter storms during 2005.

During the period between January and December, 2005, measurable rain fell at Oxnard Airport on 59 days and totaled a record 31.36 inches (Western Regional Climate Center, Reno, Nevada; data for Oxnard Airport) (Figure 2-2). The heaviest rainfall of the year occurred in January (10.55 in) and February (15.04 in). Rainfall during all other months ranged between 2.24 and 0.02 inches, except in June, July and August when no measurable rain was recorded.

The large rain events during January and February caused widespread flooding along the Santa Clara River flood plain. The high flow in the River caused the banks to be scoured, severely eroded and denuded of vegetation. Huge quantities of sediments were washed downriver, into the Estuary, and then out to sea. As a result, large sand bars and two to three feet of new sand were present throughout the Estuary. The sand berm that normally closes the Estuary during portions of the year was completely removed, allowing the river to discharge freely to the ocean (Figure 2).

During the May sampling event, the berm at the mouth of the Estuary was still breached from the winter storms, the River was flowing freely to the ocean, and water depth ranged from 3 to 12 inches throughout the Estuary (Table 2). By the October 25th sampling event, the berm at the mouth of the Estuary was partially closed and water depth in the Estuary ranged from one to three feet. Sampling occurred over several days when there was trace rainfall (<0.01 to 0.03 inches). This light rain had little impact on the water depth of the Estuary.

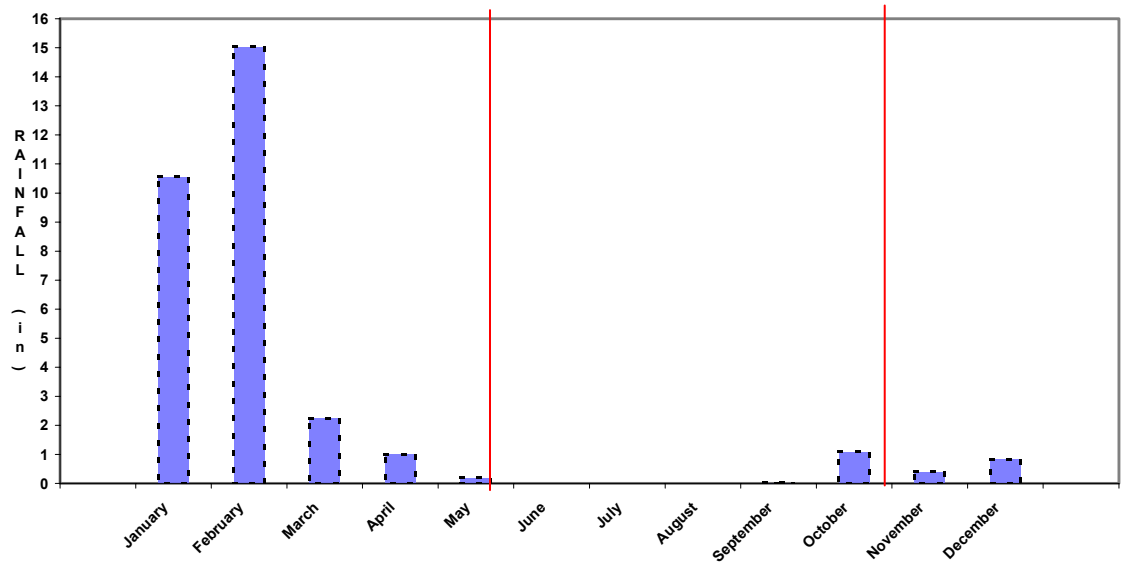


Figure 2. Monthly average rainfall recorded at Oxnard Airport, January to December, 2005. Red lines indicate days when sampling in the Estuary took place.

General Observations

During May, sampling was conducted under partly cloudy skies with 15 to 20 kilometer visibility (Table 2). Wind was from the east to southwest from 1 to 6 knots. Water color was green at Stations B1 and B3, and brown at Stations B2 and B7. The brown color was a result of the algal mats covering the sediments at these stations. In October sampling occurred under partly cloudy to clear skies with 20 to 32 km visibility. Winds were northwest from 1 to 5 knots. Water color was green at Stations B1 and B2 and brown at B3 and B7.

Physical Measurements and Water Quality

May

In May the width of the sampling transects varied from 1 to 9 meters, while the water velocity ranged from 0.0 ft/sec at Station B2 to 0.92 ft/sec at Station B3 near the mouth of the estuary (Table 2). There was little canopy cover over any of the sites and vegetation was limited to the banks of the channels. The composition of bottom sediments ranged from sand, silt and clay at Stations B1 and B2 to sand at Station B3. Consolidation of the surface sediments at Station B2 was so low that it did not support our weight. As a result, only one of the triplicate BMI samples could be collected at this site.

The pH ranged from a low at of 7.72 at Station B2 upstream of the effluent channel, to a high of 8.16 at Station B7 in the main River channel. Dissolved oxygen concentrations varied widely from 6.50 at Station B2 to 18.30 at Station B7. This extremely high dissolved oxygen reading was probably the result of oxygen production by algae. Water temperature exceeded 20 °C at all sites, except at Station B2 (17.7 ºC). Salinity was <2 ppt at all sites during sampling, except at Station B2 (2.2 ppt).

October

In October, transect widths ranged from one (Station B1) to 50 m (Station B7), and could not be measured at Station B3 because there was no clearly defined banks (Table 2). There was no measurable water velocity at any site, due to the partially inundated conditions. There was no canopy cover over any of the stations. The composition of bottom sediments ranged from mixed cobble, gravel and sand at Station B1 to sand at Stations B3 and B7.

The pH ranged from lows of 7.33 at Station B2, in the effluent channel to 9.20 at Station B7. Dissolved oxygen concentrations were lowest at Station B2 (5.31 mg/L) and greatest at Station B7 (13.89 mg/L). Water temperatures ranged from 18.3 to 19.2 °C at all sites. Salinity ranged from 2.1 ppt at Stations B1 to 17.8 ppt at Station B3, indicating the intrusion of sea water.

Table 2. Station locations, sampling weather, transect characteristics and water quality measurements collected from four sites in the Santa Clara River Estuary during both spring and fall sampling events, 2005.

Sampling Stations	Spring				Fall			
	BI	B2	B3	B7	BI	B2	B3	B7
Date	17-May-2005	17-May-2005	17-May-2005	17-May-2005	25-Oct-2005	25-Oct-2005	25-Oct-2005	25-Oct-2005
Time	9:06	8:30	7:30	11:19	9:41	9:40	8:10	12:30
Survey Program	Bioassessment Grab Littoral Sweep	Bioassessment Grab	Bioassessment Grab	Bioassessment Grab	Bioassessment Grab	Bioassessment Grab	Bioassessment Grab	Bioassessment Grab
Depth (in)	30	6	6	48	36	36	25	30
Latitude	34° 14.100	34° 14.091	34° 13.987	34° 13.887	34° 14.097	34° 14.090	34° 13.998	34° 13.888
Longitude	119° 15.792	119° 15.777	119° 15.903	119° 15.581	119° 15.793	119° 15.785	119° 15.911	119° 15.580
Weather	Partly Cloudy	Partly Cloudy	Partly Cloudy	Partly Cloudy	Partly Cloudy	Partly Cloudy	Partly Cloudy	Clear
Air Vis. (km)	20	20	15	20	32	32	32	30
Esturary Status	Open	Open	Open	Open	Open	Open	Open	Open
Wind Sp. (Kn)	2	2	1	6	5	3	1	5
Wind Dir. (°M)	90	90	90	225	315	315	315	315
Color	Green	Brown	Green	Brown	Green	Greem	Brown	Brown
Comments	Cobble in mid channel. Heavy periphyton mat.	None	None	Diatom Mat	None	None	None	None
Transect Width (m)	3	1	9	1.3	1	10	N/A[2]	50
Velocity (ft/sec)	0.89	0.00	0.92	0.50	<0.01	<0.01	<0.01	<0.01
% Canopy	0	0	0	0	0	0	0	0
Composition	Sand Silt Clay	Sand Silt Clay	Sand	Sand Silt	Clay Silt/Sand Cobble	Clay Silt Sand	Sand	Sand
Embededness (%)	100	100	100	5	100	100	100	100
Sample Depth (in)	3	3	12	3	36	30	36	24
pH	8.04	7.72	7.95	8.16	7.60	7.33	7.59	8.50
Conductance (mS/cm)	2.50	4.28	2.64	3.45	3.05	4.33	25.04	7.57
Dissolved Oxygen (mg/L)	8.63	6.50	8.07	18.30	5.31	5.78	6.30	13.89
Temperature (°C)	23.2	17.7	22.8	27.4	19.2	18.9	18.3	19.0
Salinity (ppt)	<2	2.7	<2	<2	2.1	2.6	17.8	4.8

N/A[1] - no cobble, rock or gravel present
N/A[2] - Due to inundation of estuary, no clear banks or channel.

Sediment Particle Size

The particle composition of aquatic sediments is integral to understanding the chemical and biological characteristics of a habitat. Chemical contaminants tend to adhere more strongly to finer particles since they provide a large surface area when compared to course particles. In addition, aquatic organisms that inhabit the surface and top layers of the sediments tend to have unique preferences regarding particle size and will only occur where these criteria are met. The Santa Clara River estuary is a highly dynamic environment with seasonal river flow and inundation patterns continuously modifying the composition of the surface sediments. To begin to understand the distributions of aquatic organisms within the Estuary, it is critical to first understand the distribution of sediments and any seasonal changes that may occur between surveys (Gray 1981).

The physical characteristics and distribution of particles at the four Estuary stations are summarized in Table 3 and Figure 3. Results are presented in size frequency distributions in Appendix B, Table 4. Two sediment characteristics can be inferred from the graphs (Figure 3). Position of the midpoint of the curve will tend to be associated with the median particle size. If the midpoint tends to be toward the larger micron sizes, then it can be assumed that the sediments will tend to be coarser overall. If the midpoint is near the smaller micron sizes, then it can be assumed that the sediments are mostly fine. Sediment sizes that range from 2000 to 62 microns are defined as sand, sediments ranging from 62 to 3.9 microns are defined as silt, and sediments that are 3.9 microns or less are defined as clay (Wentworth Sediment Scale, see Gray 1981). A second pattern discernible from the graph is how homogeneous the distributions of sediments are. Sediments that tend to have a narrow range of sizes are considered homogeneous or well sorted. Others, which have a wide range of sizes, are considered to be heterogeneous or poorly sorted.

Sediments at all stations and during both surveys were composed of fine to coarse sand (Table 3 and Figure 3). Sediments at Stations B1 and B2 did not change between sampling events and were poorly and moderately well sorted (respectively). Sediments at Station B3 shifted slightly from moderately well sorted in the spring to well sorted in the fall, while sediments at Station B7 shifted from poorly sorted in the spring to very poorly sorted in the fall.

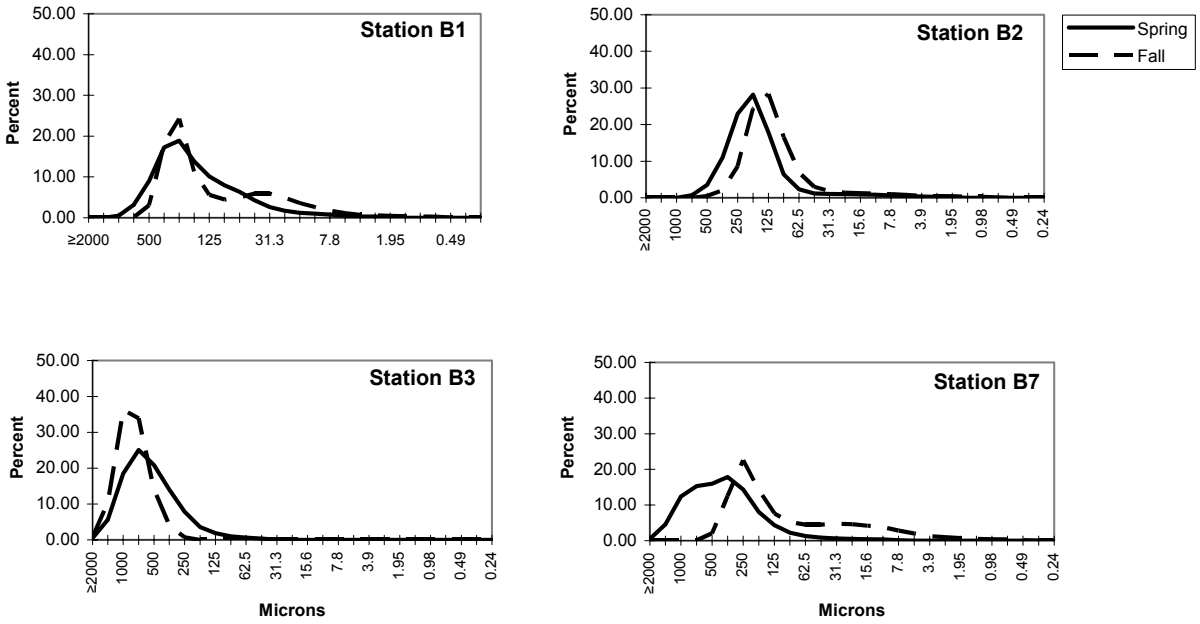
The shifts, or lack thereof, in particle size distributions between seasons at these sites are probably the result of their locations in the Estuary. Stations B1 and B2 located in or near the effluent channel are not subjected to river scouring, except after very large storms. After the deposition of sediments during the winter storms, the quiescent conditions allowed the sediments to remain relatively unchanged between sampling events. This was less pronounced at Station B3, which is more exposed to the conditions in the outer Estuary. Station B7 in the river channel is exposed to highly variable conditions, including river scour after storms, quiescent conditions during inundation and tidal inflow from the ocean.

Table 3. Sediment particle size fractions (%), percentiles (16th, 50th & 84th) and sorting index values for stations located in the Santa Clara River Estuary during the spring and fall, 2005.

Station / Season	Particle Fraction Summary (%)					Percentile (microns)			Category [2.]	Percentile (phi)			Sorting Index [3.]	Sorting [3.]
	Gravel[1.]	Sand	Silt	Clay	Fines	16%	50% [2.]	84%		16%	50%	84%		
May														
B1	0.0	87.2	12.4	0.3	12.8	53	172	331	fine sand	4.2	2.5	1.6	1.3	poorly sorted
B2	0.0	93.0	6.5	0.5	7.0	89	153	247	fine sand	3.5	2.7	2.0	0.7	moderately well sorted
B3	0.0	99.5	0.5	0.0	0.5	252	497	831	medium sand	2.0	1.0	0.3	0.9	moderately well sorted
B7	0.0	97.0	3.0	0.0	3.0	156	348	738	medium sand	2.7	1.5	0.4	1.1	poorly sorted
October														
B1	0.0	71.6	26.4	2.0	28.4	21	154	277	fine sand	5.6	2.7	1.8	1.9	poorly sorted
B2	0.0	87.5	10.9	1.6	12.5	53	105	165	fine sand	4.2	3.2	2.6	0.8	moderately sorted
B3	3.7	100.0	0.0	0.0	0.0	471	691	952	coarse sand	1.1	0.5	0.1	0.5	well sorted
B7	0.0	68.8	28.0	3.3	31.2	14	129	245	medium sand	6.2	2.9	2.0	2.1	very poorly sorted

1. Percentage of sample retained on a 2 mm sieve.
2. 0-4 = clay, 4-8 = very fine silt, 8-16 = fine silt, 16-31 = medium silt, 31-63 = coarse silt, 63-125 = very fine sand, 125-250 = fine sand, 250-500 = medium sand, 500-1000 = coarse sand.
3. <0.35 = very well sorted, 0.35-0.50 = well sorted, 0.50-0.71 = moderately well sorted, 0.71-1.00 = moderately sorted, 1.0-2.0 = poorly sorted, 2.0-4.0 = very poorly sorted, >4.0 = extremely poorly sorted.

Figure 3. Sediment particle size in microns by percent distribution (%) for spring and fall 2005 sampling surveys.



Macrobenthic Invertebrates

Summary

There were a combined total of 7,421 organisms collected from the four stations during the spring and fall bioassessment surveys (Table 4) (Appendix C, Tables 5 and 6). There were 2,783 organisms collected in the littoral sweep during the spring. A littoral sweep was not collected in the fall due to concern that it's use could be disruptive to the tidewater goby, a federally listed endangered species. The combined total number of organisms collected in the grab samples at all four stations was greater in the spring (3,178) compared to the fall (1,459).

A total of 32 unique species were collected during both surveys combined, with a total of 28 collected in the spring and 20 in the fall. There were 15 species collected in the littoral sweep sample during the spring. In the spring the greatest numbers of species were collected at outfall Station B1 (21). In the fall, the greatest numbers of species were collected at Stations B1 and B7 (15 each).

Bioassessment Metrics

Biological metrics were calculated according to the California Lentic and Stream Bioassessment protocols. The EPT (Ephemeroptera, Plecoptera, and Tricoptera) metrics could not be applied because there were no members of these indicator groups present in the estuary (Figures 4 and 5; Appendix C, Tables 7 and 8).

Total abundance is a measure of the total number of individuals found at a site. The simplest measure of resident animal health is the abundance of invertebrates collected per sampling effort. However, abundance is not a particularly good indicator of benthic infaunal health. For example, some of the most populous benthic areas are those within the immediate vicinity of organic enrichment. The reason for this apparent contradiction is that environmental stress can exclude many sensitive species from an area. Those few organisms that can tolerate the stressful condition (e.g. pollutant) flourish because they have few competitors. If the area becomes too stressful, however, even the tolerant species cannot survive, and the abundance declines, as well.

The average abundances of organisms collected at each of the four sites during the spring and fall in the Santa Clara River Estuary by both littoral sweep and grab are presented in Table 4 and Figures 4 and 5 (Appendix C, Tables 7 and 8). Spring abundance in the littoral sweep sample collected at Station B1 in the effluent channel was much greater than for any grab sample. Of the grab samples, abundances were lowest at Station B3 during both seasons (142 and 81 respectively). The greatest average abundance was found at outfall Station B1 (1,799) during the spring.

During the spring, abundances were marginally significantly different among stations (ANOVA, $p < 0.06$). In the fall, abundances were not significantly different by ANOVA.

Taxonomic richness is a simple measure of population health and is the number of separate macroinvertebrate species collected per sampling effort (i.e. one grab). Because of its simplicity, numbers of species is often underrated as an index. If the sampling effort and area sampled are the same for each station, however, this index can be one of the most informative. In general, stations with higher numbers of species per grab tend to be in areas of healthier communities.

Taxonomic richness was greatest at outfall Station B1 during both the spring (21) and fall (15) (Table 4 and Figures 4 and 5; Appendix C, Tables 7 and 8). There was no significant difference in taxa richness among stations in either the spring or fall.

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 this site is 30%. The benthic environment tends to be healthier when the dominance index is low, which indicates that more species comprise the total population at the site.

Overall, dominance was lower at all sites compared to past surveys (Aquatic Bioassay 2003 and 2004) and was greatest at Stations B2 in the spring and B7 in the fall (81% each) (Figures 4 and 5; Appendix C, Tables 7 and 8). The dominance was lowest at Station B3 (31%) in the spring. During the fall dominance was significantly greater at Stations B7 and B1 compared to B3. In the fall dominance was significantly greater at Station B7 compared to B2.

Shannon diversity: is similar to numbers of species; but contains an eveness 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. Diversity values range from 0 to 4, with values approaching four indicating greater diversity and presumably a more healthy population.

Diversity was slightly greater across most sites during 2005 compared to past surveys (Aquatic Bioassay 2003 and 2004). The lowest diversity was measured at Station B2 in the spring (0.26) and greatest at Station B3 (1.77) also in the spring (Figures 4 and 5; Appendix C, Tables 7 and 8). In the spring diversity was significantly greater at Station B3 (1.77) compared to B7 (1.24). Diversity was significantly greater in the fall at Stations B1 and B2 compared to Station B7.

Table 4. Summary of abundances by species and location during both spring and fall, 2005 bioassessment surveys of the Santa Clara River Estuary. Stations B1 thru B7 abundances are averages (n = 3; except Station B2 in the spring where n = 1); littoral sweep samples are total counts.

Species	Tolerance Value (TV)	Functional Feeding Group	Spring 05						Fall 05					
			Littoral Sweep	Grabs				Total by Grab	Littoral Sweep	Grabs				Total by Grab
			B1	B1	B2	B3	B7		B1	B1	B2	B3	B7	
Baetis sp.	5	cg	0	0	0	16	0	16	-	0	0	0	0	0
Berosus sp.	5	p	0	1	1	0	0	2	-	0	0	0	0	0
Caloparyphus/Euparyphus sp	8	cg	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.3	0.3
Chironominae	6	cg	130	212	475	26	375	1089	-	70	32	1	6	109
Coenagrionidae (imm)	9	p	0	1	0	0	0	1	-	1	0	0	0	1
Corisella sp.	8	p	1	2	7	0	0	9	-	0	0	1	0	1
Corixidae (imm)	8	p	9	8	62	1	10	82	-	0	0	0	0	0
Cyclopoida	8	cf	0	3	0	0	2	5	-	6	8	5	5	24
Cyprididae total	8	cg	50	147	3	2	30	182	-	221	1	7	35	265
Daphnia sp	8	cf	31	2	0	0	0	2	-	2	4	2	14	22
Dasyhelea sp.	6	cg	0	0	0	0	0	0	-	0	0	0	0	0
Dolichopodidae	4	p	0	0	4	0	9	13	-	0	0	0	1	1
Ephydra sp.	6	sh	0	1	0	0	3	3	-	1	2	0	5	7
Falceon quilleri	5	cg	0	0	0	1	0	1	-	0	0	0	0	0
Gonomyia sp.	3	cg	0	0	0	0	1	1	-	0	0	0	0	0
Hyalella sp.	8	cg	1171	509	2	4	0	516	-	3	0	0	0	3
Hydroptila sp.	6	sc	0	0	0	1	0	1	-	0	0	0	0	0
Hydra sp.	5	p	0	0	0	0	0	0	-	0	0	1	0	1
Isotomidae	5	cg	0	51	19	33	0	103	-	4	1	2	3	9
Limnocythere sp.	8	cg	63	90	0	7	0	97	-	133	137	10	3	283
Limnodrilus sp.	10	cg	1156	696	10	20	82	808	-	120	75	52	377	624
Lumbriculidae	5	cg	0	0	0	0	0	0	-	0	1	0	1	2
Limnophora sp.	6	p	0	0	0	0	4	4	-	0	0	0	0	0
Nematoda	5	p	0	2	2	0	0	4	-	0	0	0	0	0
Orthocladiinae	5	cg	54	24	2	18	123	167	-	4	0	0	1	5
Physa/Physella sp.	8	sc	9	8	0	0	7	15	-	0	0	0	0	0
Planariidae	4	p	33	22	0	2	0	25	-	0	0	0	0	0
Pomatiopsis sp.	8	sc	59	7	0	0	0	7	-	67	25	0	0	93
Ramellogammarus sp.	6	cg	0	1	0	1	0	1	-	1	0	0	0	1
Simulium sp.	6	cf	10	0	0	8	0	8	-	0	0	0	0	0
Tanypodinae	7	p	3	12	0	2	3	17	-	2	2	0	3	7
Tricorythodes sp.	4	cg	1	0	0	0	0	0	-	0	0	0	0	0
Total Average Abundance by Station			**2783**	**1799**	**587**	**142**	**651**	**3178**	**0**	**634**	**289**	**81**	**455**	**1459**
Average Numbers of Species			**15**	**21**	**11**	**16**	**15**	**28**	**0**	**15**	**13**	**11**	**15**	**20**

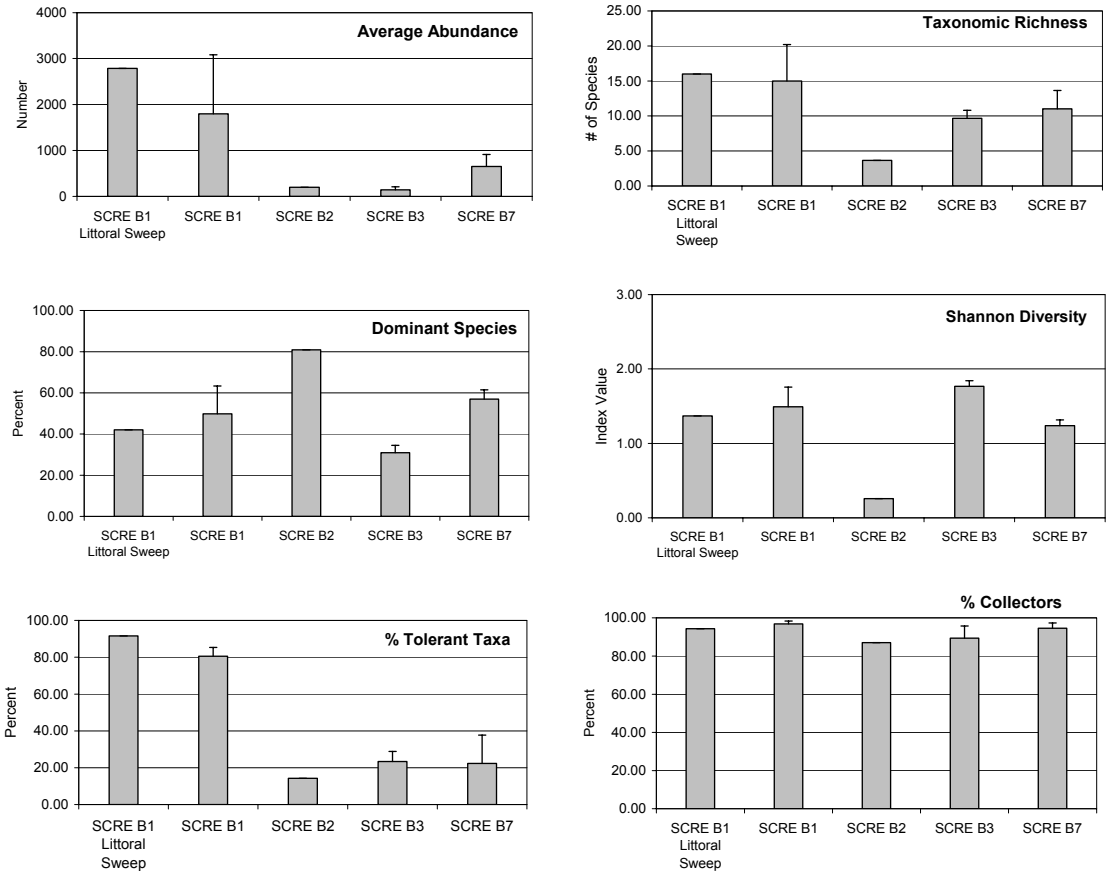


Figure 4. Bioassessment metrics calculated for populations collected from the Santa Clara River Estuary during the spring 2005.

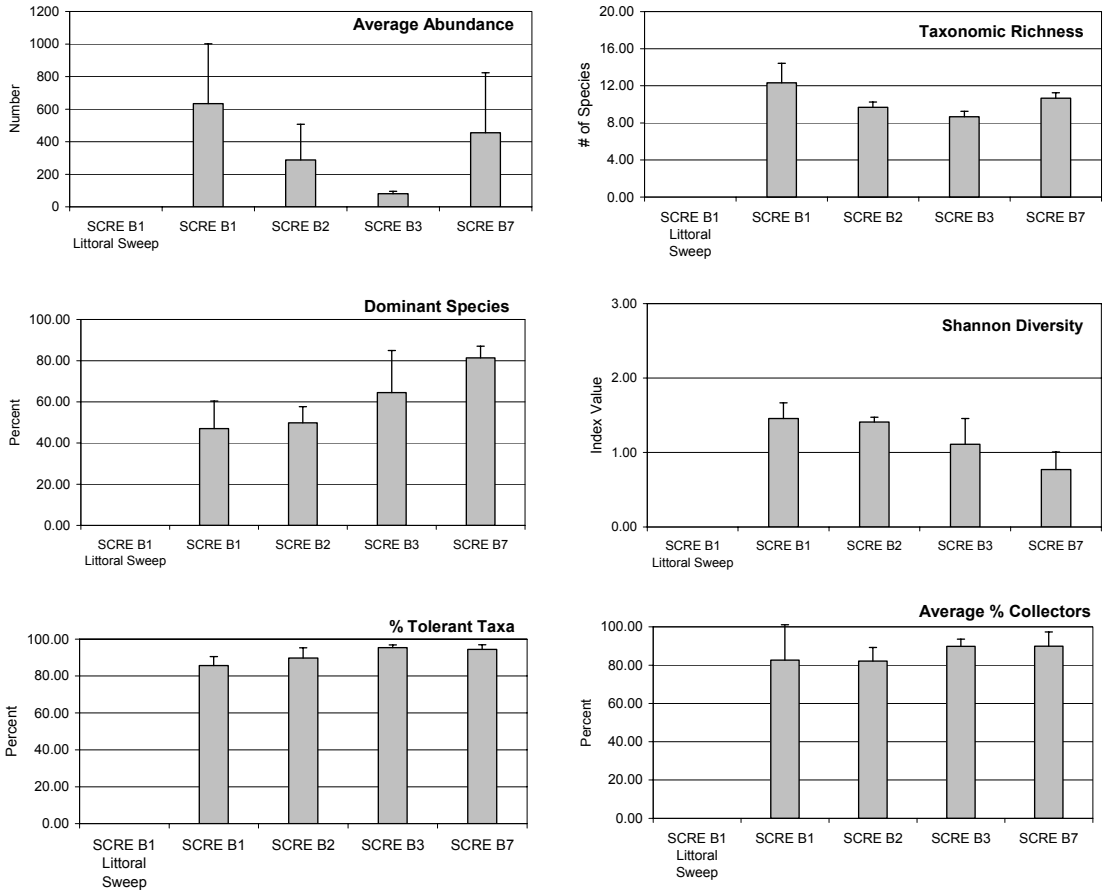


Figure 5. Bioassessment metrics calculated for populations collected from the Santa Clara River Estuary during the fall 2005 (note that no littoral sweeps were conducted in the fall).

Tolerant Taxa: The percentage of tolerant taxa collected at a site helps to assess the ability of organisms to tolerate pollution and habitat impairment. Based on the CSBP and EPA protocols, each taxon is assigned a tolerance value from 0 (highly intolerant) to 10 (highly tolerant). The Tolerance Value for a site is calculated by multiplying the tolerance value of each species with a tolerance value ranging from 8 to 10, by its abundance, then dividing by the total abundance for the site. When a large proportion of the organisms at a site are tolerant, it indicates that conditions at the site are stressful. Stressful conditions can be the result of highly variable habitat conditions or the presence of impairment due to pollution. 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 disturbance may be very insensitive to organic pollution. With these drawbacks in mind, the Tolerance Values generally depict disturbances when coupled with other metrics and can provide good information regarding the system.

The percentage of tolerant taxa was greater in the fall (all sites >80%) compared to the spring (14 to 22%), except at Station B1 (80%) (Figures 4 and 5; Appendix C, Tables 7 and 8). During the fall the percentage of tolerant organisms were significantly greater at Station B1 compared to Station B7 and B3 (ANOVA, $p < 0.01$).

Percent Collectors: The percent composition of the functional feeding groups provides 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 predators, collectors, filterers, scrapers, and shredders. The percentage of collectors is presented herein since they were by far the most dominant feeding strategy represented in the Estuary. Collectors are organisms that gather up deposited fine particulate organic matter (FPOM) by browsing or burrowing in the sediments.

The relative percentage collectors was far greater compared to any of the other feeding groups collected in the Estuary and exceeded 80% during both seasons and at each station (Figures 4 and 5; Appendix C, Tables 7 and 8). The percentage of collectors was not significantly different among stations during either the spring or fall.

Most Abundant Species

The most abundant species collected during the spring and fall by both littoral sweep at Station B1 and by core at each of the four stations are presented in Figure 6 and Appendix C, Tables 9 and 10. The composition of species in the littoral sweep sample in the spring was dominated by an oligochaete worm (*Limnodrilus sp*.) and an amphipod crustacean (*Hyalella sp.*).

In previous surveys, one of the consistently most common species collected by grab at all stations was the cypridid ostracod, *Limnocythere sp*. (Aquatic Bioassay 2003 and 2004). During the spring 2005 survey, *Limnocythere sp*. was ranked much lower at all stations. At Station B1 three species made up 78% of the population and included *Limnodrilus sp.*, *Hyalella sp*., and midge flies (Chironominae). At Station B2 midge flies dominated the population (81%). Flow at this site was nearly absent and the water depth was only 3 inches providing a good habitat for midge larvae. Station B3 was most diverse and included five species that made up 79% of the population including a collembolid (Isotomidae) insect, midge flies, *Limnodrilus sp.,* orthocladid flies (Orthocladiinae) and baetid mayflies (*Baetis sp*.). Three species made up 89% of the population at Station B7 and included midge flies, orthocladid flies and *Limnodrilus sp*.

By the fall survey the composition of species at the four sites had returned to an assemblage more typical of previous surveys. *Limnocythere sp*. was highly abundant at each Station, except Station B7 where it characterized <1% of the population. *Limnodrilus sp*. was in the top three most abundant species at all sites and was most abundant at Stations B3 and B7. Cypridid ostracods were most abundant at Station B1 and were in the top 10 most abundant species at all sites.

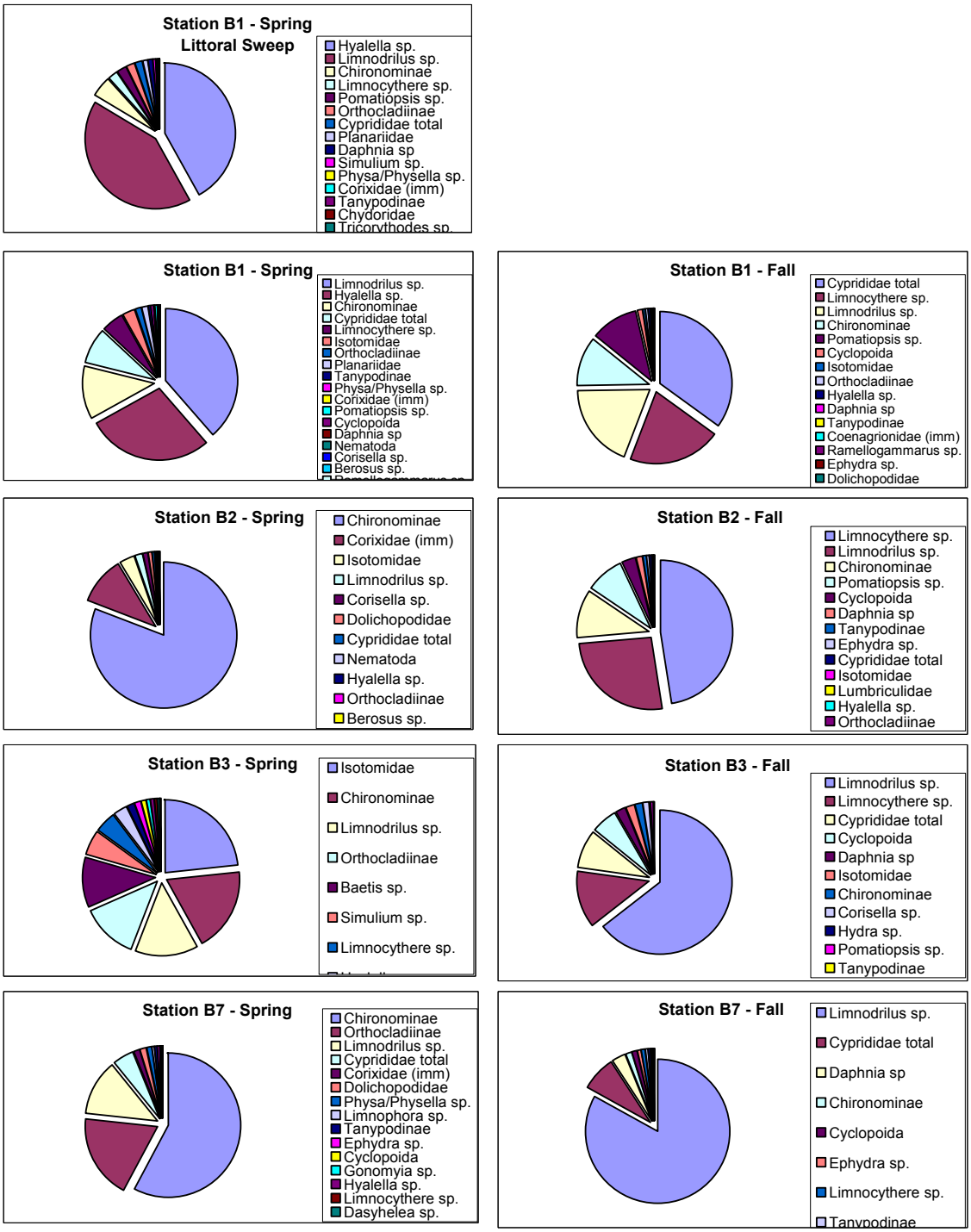


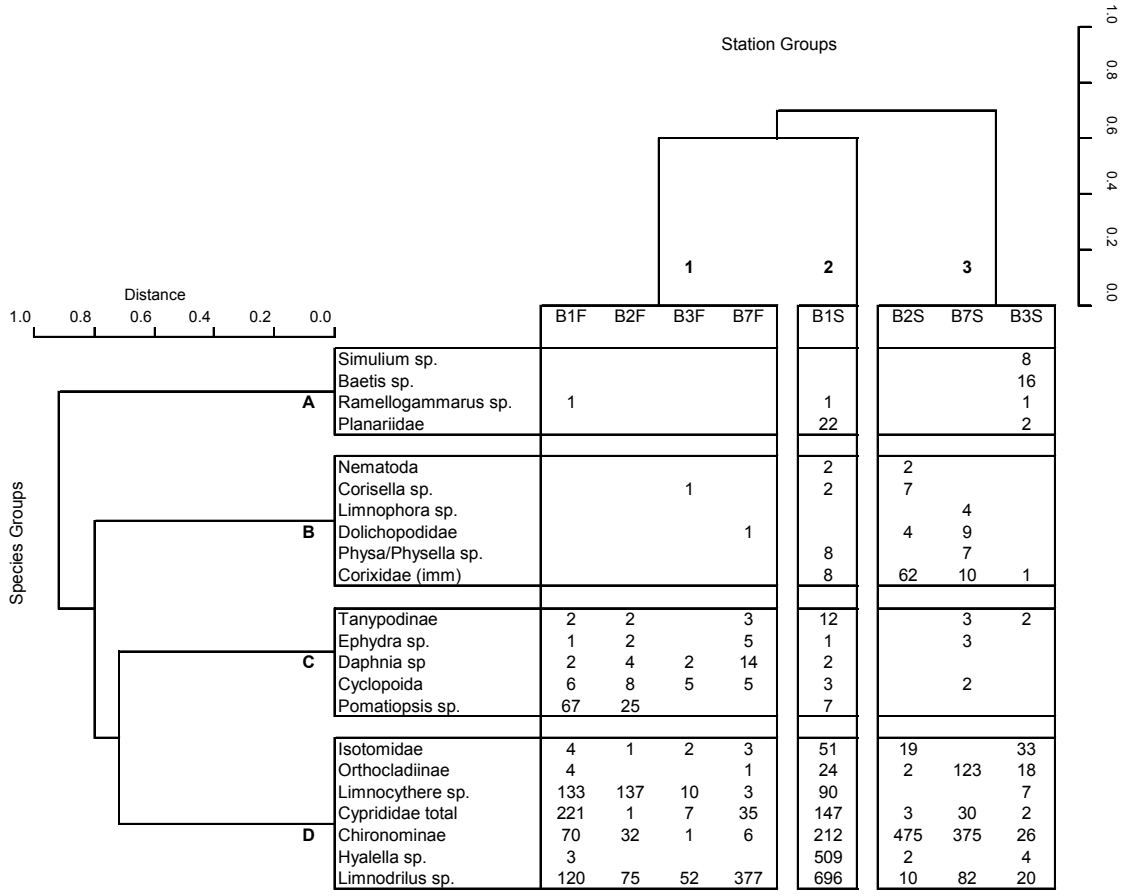
Figure 6. Cumulative percent abundance of most common species collected in the Santa Clara River Estuary from four sites during the spring and fall of 2005.

Cluster Analysis

Three station groups and four species groups were delineated by cluster analysis (Figure 7). Station group 1 included all sites collected during the fall, while groups 2 and 3 included sites sampled during the spring. Station group 2 included only the spring sample collected at Station B1 which was slightly more similar to all samples collected during the fall survey than to the remaining spring samples. Species group A was characterized by species that were relatively abundant at Station B3 and B1 in the spring and included black flies (*Simulium sp.*), mayflies (*Baetis sp*.), and flatworms (Planariidae). Species group B included species that were relatively abundant at Station B1, B2 and B7 in the spring. Species group C was characterized by species collected during the fall at all sites and Station B1 in the spring, and included two flies (Tanypodinae and *Ephydra sp*.), two arthropods (*Daphnia sp*. and Cyclopoida) and a gastropod (*Pomatiopsis sp*.). Species group D included the organisms that were ubiquitous in the survey area regardless of site or season. The most relatively abundant species group across all sites and seasons was represented by Species group D. This group included springtails (Isotomidae), flies (Orthocladiinae and Chironominae), arthropods (*Limnocythere sp., Hyalella sp.*, and Cyprididae), and oligochaetes worms (*Limnodrilus sp.*).

Of note is the clear shift in community composition between spring and fall sampling events. While several abundant species were present during both surveys (Species group D), there were several species that were relatively abundant during the spring and nearly absent in the fall (Species groups A and B). This was most likely due to the re-colonization of the Estuary by opportunistic species in the spring, when there was open habitat available after winter scouring. By fall the population had returned to one more typical of spring and fall seasons recorded during previous surveys.

Figure 7. Two-way coincidence table of species vs. station groups created by cluster analysis (UPGMA, Sneath and Sokal 1973). The Bray-Curtis dissimilarity index was used to calculate the distances among stations and species (Gauch 1982, Jongman et. al. 1995). Abundance data were square root transformed. Values associated with each cell are average (n = 3) species abundances for each station (not transformed). Only the most frequently occurring organisms were used in the analysis (n ≥ 2) which represented 99% of the total population. "F" indicates fall, and "S" indicates spring. Only grabs (no sweeps) were used for the cluster analysis.



		B1F	B2F	B3F	B7F	B1S	B2S	B7S	B3S
	Simulium sp.								8
	Baetis sp.								16
A	Ramellogammarus sp.	1				1			1
	Planariidae					22			2
	Nematoda					2	2		
	Corisella sp.			1		2	7		
	Limnophora sp.							4	
B	Dolichopodidae				1		4	9	
	Physa/Physella sp.					8		7	
	Corixidae (imm)					8	62	10	1
	Tanypodinae	2	2		3	12		3	2
	Ephydra sp.	1	2		5	1		3	
C	Daphnia sp	2	4	2	14	2			
	Cyclopoida	6	8	5	5	3		2	
	Pomatiopsis sp.	67	25			7			
	Isotomidae	4	1	2	3	51	19		33
	Orthocladiinae	4			1	24	2	123	18
	Limnocythere sp.	133	137	10	3	90			7
	Cyprididae total	221	1	7	35	147	3	30	2
D	Chironominae	70	32	1	6	212	475	375	26
	Hyalella sp.	3				509	2		4
	Limnodrilus sp.	120	75	52	377	696	10	82	20

DISCUSSION

The goal of this survey was to determine if the discharge from the Ventura Water Reclamation Facility affects the biological communities in the Santa Clara River Estuary. The 2005 bioassessment survey of the Santa Clara River Estuary included two sampling events; one when the Estuary mouth was open in the spring and the other during partially open conditions in the fall. During both seasons, water quality, sediment grain size and biological samples were collected. Biological samples were collected at each of four stations (Stations B1, B2, B3 and B7) specified in the City of San Buenaventura's NPDES permit. During this survey, a Petite Ponar grab was used instead of the coring device utilized during previous surveys (USFWS 1999). The coring device relies on vacuum pressure to keep samples intact as they are brought to the surface and works well in sediments composed of silt and clay, but not so well in sandy sediments. Since the Estuary sediments are composed mostly of sand, it was thus difficult to bring complete samples to the water surface. The Petite Ponar grab eliminated this problem since it closes completely after the sample is collected. A single littoral sweep sample was collected at Station B1 during the spring. In the spring (and past surveys), a single littoral sweep was conducted at Station B1 using a kick net. However, since the Estuary provides critical habitat for the endangered tidewater goby, which can be inadvertently collected with the kick net, the littoral sweep was permanently excluded from the sampling design by the Los Angeles Regional Water Quality Control Board.

Flow during 2005 on the Santa Clara River was not measured because the gauging stations were lost as a result of extraordinary winter storms. During the period between January and December, 2005, measurable rain fell at Oxnard Airport on 59 days and totaled a record 31.36 inches. The heaviest rainfall of the year occurred in January (10.55 in) and February (15.04 in). Rainfall during all other months ranged between 2.24 and 0.02 inches, except in June, July and August when no measurable rain was recorded.

The large rain events during January and February caused widespread flooding along the Santa Clara River flood plain. The high flow in the River caused the banks to be scoured, severely eroded and denuded of vegetation. Huge quantities of sediments were washed downriver, into the Estuary, and out to sea. As a result, large sand bars and two to three feet of new sand was present throughout the Estuary. The sand berm that normally closes the Estuary during portions of the year was completely removed, allowing the river to discharge freely to the ocean. During the May 17th, sampling event, the berm at the mouth of the Estuary was still breached from the winter storms and the River was flowing freely to the ocean. By the October 25th sampling event, the berm at the mouth of the Estuary was partially closed and water depth in the Estuary ranged from one to three feet.

Water quality in the Estuary during 2005 was typical of past surveys and depicted the dynamic and quickly changing environment of this system. Water temperature in the Estuary was relatively warm during both surveys and ranged from 17 to 27.4 °C. These findings were within the range of past studies (13.94 to 29.04, USFWS 1999). pH ranged from 7.3 to 8.5. Dissolved oxygen concentrations in the Estuary were highly variable ranging from 5.31 mg/L at Station B1 in fall to 18.30 mg/L during the spring at Station B7. Supersaturated dissolved oxygen values were likely caused by intense algal blooms. Temperature, pH and dissolved oxygen all fell well within the ranges reported by Greenwald et al (USFWS 1999) during a comprehensive survey in the Estuary conducted from July 1997 to July 1998. This year's water quality results

were also similar to measurements collected during 2002 (ENTRIX 2003), 2003 and 2004 (Aquatic Bioassay 2004).

Salinity has been shown in past studies to be the most controlling factor influencing the composition and distribution of invertebrates under estuarine conditions (Kennish 1986, Chapman and Wang 2001). For the 2005 survey, salinity during spring ranged from <2 to 2.7 ppt and in the fall from 2.1 in the effluent channel to 17.8 ppt at Station B3 in the lower Estuary. The higher salinity measured at Station B3 was due to its location in the outer Estuary where the inflow of higher salinity water is more common. Salinity during the 2005 survey fell within the EPA's freshwater criterion (<2.0 ppt, 95% of the time) at Stations B1, B3, and B7 in the spring and below that of brackish water (5 to 10 ppt) at every station except B3 in the fall. During the recent Metals Translator Study in the Estuary, salinity was examined over a year's time (ENTRIX 2002). In that study, low salinities (1 to 4 ppt) were observed near the discharge channel and upper Estuary where the Santa Clara River flows into the Estuary. Brackish conditions (5 to 10 ppt) were observed in the middle of the Estuary. More marine-like (>10 ppt) conditions were isolated to the area near the mouth and far southwestern portion of the Estuary, the highest salinity measurement being 30 ppt. Past studies of the Estuary by Merrit-Smith from August 1998 to January 1999 and USFWS from 1997 to 1999 indicate salinity ranges from 0.6 to 32.8 ppt, with high levels of variance both temporally and spatially (ENTRIX 1999; USFWS 1999).

After salinity, sediment particle size appears to have the greatest influence on the distribution of invertebrates in an estuary system (Kennish 1986). Sediment sizes ranged from fine to coarse sand throughout the Estuary. The shifts, or lack thereof, in particle size distributions between seasons at these sites are probably the result of their locations in the Estuary. Stations B1 and B2 located in or near the effluent channel are not subjected to river scouring, except after very large storms. After the deposition of sediments during the winter storms, the quiescent conditions allowed the sediments to remain relatively unchanged between sampling events. This was less pronounced at Station B3, which is more exposed to the conditions in the outer Estuary. Station B7 in the river channel is exposed to highly variable conditions, including river scour after storms, quiescent conditions during inundation and tidal inflow from the ocean.

The macrobenthic invertebrate community found in the Santa Clara River Estuary represents a community that has adapted to the highly dynamic conditions discussed above. As with past surveys, all of the organisms represented during the 2005 survey were those found in either freshwater or estuarine environments (USFWS 1999, ENTRIX 2003). The total numbers of organisms collected by grab in 2005 (4,637), was far less than in 2004 when a total of 12,207 organisms were collected, but greater than the numbers collected by Greenwald et al. (USFWS 1999). Greenwald, however, used a coring device (total = 1,359) across 5 stations during 12 separate surveys between 1997 and 1998. It is not known what causes these differences, but it does point out the highly dynamic nature of the Estuary environment.

The combined total number of organisms collected in the grab samples at all four stations was greater in the spring (3,178) when compared to the fall (1,459). This large increased abundance in the spring was unusual when compared to previous surveys. Normally, lower numbers of organisms might be expected during the spring due to scouring and deposition of upstream sediments during storm events. In past

surveys the numbers of organisms present in the Estuary were generally greater during the summer and fall closed estuary conditions when compared to the spring (USFWS 1999, ENTRIX 2002 and 2003). However, the magnitude of the winter storms in 2005 caused the BMI habitat to be completely removed. This probably allowed several opportunistic species to quickly occupy the open space. These organisms included midge fly larvae (Chrionomidae), Hyalella sp. (arthropod), springtails (Isotomidae), and flies in the family Orthocladiinae. In addition, the abundance of the ostracod *Limnocythere sp*., whose numbers have been in the thousands in past surveys, were far less abundant this year, especially in the spring.

A total of 32 unique species were collected during both surveys combined, with a total of 28 collected in the spring and 20 in the fall. The numbers of species collected in 2005 were greater when compared to 2003 and 2004 (Aquatic Bioassay 2004 and 2005); were similar to the 2002 spring survey (25) but were less than the fall survey (30) (ENTRIX (2003). During surveys conducted from 1997 to 1998 by Greenwald et al. (USFWS 1999) taxonomic richness averaged 24.

In previous surveys, one of the consistently most common species collected by grab at all stations was the cypridid ostracod, *Limnocythere sp*. (Aquatic Bioassay 2003 and 2004). During the spring 2005 survey *Limnocythere sp*. was ranked much lower at all stations. At Station B1 three species made up 78% of the population and included *Limnodrilus sp.*, *Hyalella sp*., and midge flies (Chironominae). At Station B2 midge flies dominated the population (81%). Flow at this site was nearly absent and the water depth was only 3 inches providing a good habitat for midge larvae. Station B3 was most diverse and included five species that made up 79% of the population including a collembolid (Isotomidae) insect, midge flies, *Limnodrilus sp.,* orthocladid flies (Orthocladiinae) and baetid mayflies (*Baetis sp*.). Three species made up 89% of the population at Station B7 and included midge flies, orthocladid flies and *Limnodrilus sp*.

By the fall survey the composition of species at the four sites had returned to an assemblage more typical of previous surveys. *Limnocythere sp*. was highly abundant at each Station, except Station B7 where it characterized <1% of the population. *Limnodrilus sp*. was in the top three most abundant species at all sites and was most abundant at Stations B3 and B7. Cypridid ostracods were most abundant at Station B1 and were in the top 10 most abundant species at all sites.

The species collected during this and past surveys were dominated by those with moderate to high tolerance values, typical of organisms capable of living under stressful conditions that include either habitat disruption or pollution (CDFG 1999). The percentage of tolerant taxa (tolerance value = 8 to 10) was less in the spring (range = 14 to 22%) compared to the fall (all sites >80%). This indicated that the opportunistic species taking advantage of the open habitat in the spring were not able to succeed in the Estuary's naturally harsh environment once normal conditions had returned by fall. While the Estuary is located downstream of heavy agricultural inputs and waste treatment facilities, the major disturbances are mostly due to shifting habitat conditions. Fluctuating salinity as a result of tidal influence, the continuous rise and fall of the water level in the Estuary and the scouring and deposition that occur as a result of seasonal storms. These combine to make this a very difficult habitat to survive in.

The composition of the biological population found at SCRE stations during the 2005 survey appear to be mostly influenced by these factors. The greatest factors affecting sites appear to be changing water levels and shifts in sediment particle size.

Additionally, the habitat in the vicinity of the effluent outfall appears to provide a modestly improved condition for BMIs as evidenced by the slightly higher diversity and taxa richness, combined with lower dominance and percent tolerance values of the community found there.

APPENDIX A - REFERENCES

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APPENDIX B – SEDIMENT PARTICLE SIZE

Table 4. Cumulative particle sizes in microns and phi for the four sampling locations in the Santa Clara River Estuary for spring and fall, 2005.

Station / Season	phi Size																										
	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	5	11	11.5	12
	Microns																										
	≥2000	1410	1000	710	500	354	250	177	125	88.4	62.5	44.2	31.3	22.1	15.6	11.1	7.8	5.5	3.9	2.8	1.95	1.38	0.98	0.69	0.49	0.35	0.24
	crs sand	crs sand	med sand	med sand	fine sand	med sand	fine sand	very fine sand	very fine sand	very fine sand	very fine sand	very fine sand	crs silt	crs silt	crs silt	silt	fine silt	very fine silt	very fine silt	clay	clay	clay	clay	clay	clay	clay	clay
May																											
B1	0.00	0.00	0.51	3.18	8.98	17.23	18.93	13.83	10.18	8.03	6.36	4.28	2.63	1.69	1.22	1.00	0.74	0.52	0.34	0.30	0.05	0.00	0.00	0.00	0.00	0.00	0.00
B2	0.00	0.00	0.00	0.67	3.54	10.98	23.00	28.20	17.89	6.42	2.30	1.21	1.03	1.02	0.95	0.84	0.65	0.48	0.34	0.32	0.15	0.00	0.00	0.00	0.00	0.00	0.00
B3	0.52	5.60	18.44	25.08	20.83	14.07	7.87	3.61	1.84	1.02	0.64	0.39	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B7	0.49	4.56	12.44	15.31	16.00	17.87	14.40	8.04	4.35	2.26	1.31	0.84	0.63	0.51	0.43	0.37	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
October																											
B1	0.00	0.00	0.00	0.10	3.06	18.17	24.27	11.02	5.56	4.41	4.99	5.88	5.91	4.91	3.56	2.60	1.69	1.11	0.71	0.60	0.45	0.36	0.33	0.27	0.04	0.00	0.00
B2	0.00	0.00	0.00	0.03	0.49	2.02	8.72	24.35	28.37	16.56	6.95	2.99	1.81	1.41	1.24	1.16	0.97	0.75	0.54	0.49	0.40	0.34	0.31	0.08	0.00	0.00	0.00
B3	0.71	10.42	36.20	33.92	14.06	3.96	0.72	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B7	0.00	0.00	0.00	0.08	2.05	12.53	22.56	14.21	7.72	5.13	4.48	4.50	4.68	4.62	4.22	3.77	2.86	2.01	1.29	1.04	0.72	0.52	0.46	0.39	0.15	0.00	0.00

APPENDIX C - MACROINVERTEBRATES

Table 5. Identified taxa for the Spring 2005 sampling event, by lifestage, by Station for Santa Clara River Estuary Stations. Only (1) replicate collected at Station B2.

						Tolerance Value (TV)	Functional Feeding Group (FFG)	SCRE B1 Littoral Sweep	SCRE B1			SCRE B2			SCRE B3			SCRE B7		
								1	1	2	3	1	2	3	1	2	3	1	2	3
Phylum	**Class**	**Order**	**Family**	**Genus**	**Scientific Name**															
Coelenterata	Hyrozoa	Hydroida	Hydridae	*Hydra sp.*	*Hydra sp.*	5	p													
Nematoda					Nematoda	5	p		1		4	2								
Mollusca	Gastropoda	Basommatiphora	Physidae	*Physa/Physella*	*Physa/Physella sp.*	8	sc	8	11		13							7	7	6
			Lymanaeidae	*Fossaria*	*Fossaria sp.*	8	sc													
		Mesogastropoda	Hydrobiidae	*Pomatiopsis*	*Pomatiopsis sp.*	8	sc	51	7	2	13									
Platyhelminthes	Turbellaria	Tricladida	Planariidae		Planariidae	4	p	29	25		42					7				
Annelida	Oligochaeta		Tubificidae	*Limnodrilus*	*Limnodrilus sp.*	10	cg	1002	1288	215	586	10			50		9	20	101	124
Arthropoda	Branchiopoda	Diplostraca	Chydoridae		Chydoridae	.	cf	1												
			Daphniidae	*Daphnia*	*Daphnia sp*	8	cf	27	6											
	Malacostraca	Amphipoda	Gammaridae	*Ramellogammarus*	*Ramellogammarus sp.*	6	cg		2								2			
			Talitridae	*Hyallela*	*Hyalella sp.*	8	cg	1015	619	22	886	2			6	2	5			1
		Decapoda	Astacidae	*Pacifastacus*	*Pacifasticus sp.*	6	om													
	Maxillipoda	Cycopoida			Cyclopoida	8	cf		4	3	1					1		1	3	3
		Harpacticoida			Harpacticoida	8	cf													
	Ostracoda	Podocopina	Cyprididae		Cyprididae type 1	8	cg	40	134	4	269	3				6		18	58	15
					Cyprididae type 2	8	cg		22											
					Cyprididae type 3	8	cg	1			2									
					Cyprididae type 4	8	cg	2	3		7									
					Cypridiidae total	8	cg													
			Limnocytheridae	*Limnocythere*	*Limnocythere sp.*	8	cg	55	29	10	230				1	6	13			1
	Insecta	Collembola	Isotomidae		Isotomidae	5	cg		76	52	25	19			55	18	26			
		Ephemeroptera	Baetidae	*Baetis sp.*	*Baetis sp.*	5	cg								48					
				Falceon quilleri	*Falceon quilleri*	5	cg								3					
			Leptohyphidae	*Tricorythodes sp.*	*Tricorythodes sp.*	4	cg	1												
		Zygoptera	Coenagrionidae	*Enallagma sp*	*Enallagma sp.*	9	p													
					Coenagrionidae (imm)	9	p		1		1									
		Hemiptera	Corixidae	*Corisella*	*Corisella sp.*	8	p	1			5	7								
					Corixidae (imm)	8	p	8	17		7	62			2		2	2	29	
		Trichoptera	Hydroptilidae		*Hydroptila sp.*	6	sc								3					
		Coleoptera	Dryopidae	*Helichus*	*Helichus sp.*	5	sh													
			Dytiscidae	*Hydroporus*	*Hydroporus sp.*	5	p													
			Hydrophilidae	*Berosus*	*Berosus sp.*	5	p				3	1								
		Diptera	Ceratopogonidae		Ceratopogonidae	6	p													
				Dasyhelea	*Dasyhelea sp.*	6	cg												1	
			Chironomidae		Chironomidae	.	.													
					Chironominae	6	cg													
				Chironomus sp.	*Chironomus sp.*	10	cg	4	44	4	38	17			1		2	6	19	30
				Chironomus sp. (P)	*Chironomus sp. (P)*	10	cg	1	1		4	10							5	32
					Cryptochironomus sp.	8	p									2	2			
				Dicrotendipes sp.	*Dicrotendipes sp.*	8	cg	91	271	7	94	2			3	19	42	31	41	
				Dicrotendipes sp. (P)	*Dicrotendipes sp. (P)*	8	cg		6		1									
					Paracladopelma sp.	10												2	3	
				Phaenopsectra/Tribelos sp.	*Phaenopsectra/Tribelos sp.*	7	sc										1			
				Polypedilum sp.	*Polypedilum sp.*	6	sc		1	1										
					Tanytarsini	6	cg													
				Paratanytarsus sp.	*Paratanytarsus sp.*	6	cg				2	8							1	
				Tanytarsus	*Tanytarsus*	6	cf	17	61	12	90	438					7	355	457	144
					Orthocladiinae	5	cg													
				Cricotopus	*Cricotopus sp.*	7	cg	9	19		2	1			3	4	27	109	120	36
					Cricotopus sp. (P)	7	cg	8				1			2	1	14	48	49	2
				Cricotopus Binctus Gr.	*Cricotopus Trifascia Gr.*	7	cg								1			1		
				Eukiefferiella	*Eukiefferiella sp.*	8	cg	9	2								1	1		
				Orthocladius Complex	*Orthocladius Complex*	6	cg													
					Pseudosmittia sp.	6	cg											1	1	
				Rheocricotopus	*Rheocricotopus sp.*	6	cg													
				Thienemanniella	*Thienemanniella sp.*	6	cg	11	29		10									
					Thienemanniella sp. (P)	6	cg	10	6	2	3									
					Tanypodinae	7	p													
					Pentaneurini	6	p													
				Apedilum	*Apedilum sp.*	6	p		14		1					1	3	8	1	
				Pentaneura	*Pentaneura sp.*	6	p	1	3											
				Tanypus	*Tanypus sp.*	10	p													
					Tanypus sp. (P)	10	p													
					Procladius sp.	9	p	2	10		9					1				
			Dolichopodidae		*Dolichopodidae*	4	p					4						17	11	
			Ephydridae	*Ephydra*	*Ephydra sp.*	6	sh		2									5	3	
				Hydrellia	*Hydrellia sp.*	6	sh													
			Muscidae	*Limnophora*	*Limnophora sp.*	6	p											10	3	
				Gonomyia	*Gonomyia sp.*	3	cg											2	1	
			Sciomyzidae	*Sciomyzidae*	Sciomyzidae	6	p													
			Simuliidae	*Simulium*	*Simulium sp.*	6	cf	9			1				23					
					Total BMIs/sample			2784	2714	334	2349	587	0	0	201	68	156	644	914	394

Table 5. Identified taxa for the Fall 2005 sampling event, by lifestage, by Station for Santa Clara River Estuary Stations. No littoral sweep sample collected.

								SCRE B1 Littoral Sweep	SCRE B1			SCRE B2			SCRE B3			SCRE B7		
						Tolerance Value (TV)	Functional Feeding Group (FFG)	1	1	2	3	1	2	3	1	2	3	1	2	3
Phylum	**Class**	**Order**	**Family**	**Genus**	**Scientific Name**															
Coelenterata	Hyrozoa	Hydroida	Hydridae	*Hydra*	*Hydra sp.*	5	p									1				
Nematoda					Nematoda	5	p													
Mollusca	Gastropoda	Basommatiphora	Physidae	*Physa/Physella*	*Physa/Physella sp.*	8	sc													1
			Lymanaeidae	*Fossaria*	*Fossaria sp.*	8	sc													
		Mesogastropoda	Hydrobiidae	*Pomatiopsis*	*Pomatiopsis sp.*	8	sc		28	137	37	17	32	26	1					
Platyhelminthes	Turbellaria	Tricladida	Planariidae		Planariidae	4	p													
Annelida	Oligochaeta		Lumbriculidae		Lumbriculidae	5	cg						1						1	
			Tubificidae	*Limnodrilus*	*Limnodrilus sp.*	10	cg		142	96	121	11	152	62	77	58	21	751	156	224
Arthropoda	Branchiopoda	Diplostraca	Chydoridae		Chydoridae	.	cf													
			Daphniidae	*Daphnia*	*Daphnia sp*	8	cf		4	1	0	7	2	4	3	1	1	4	15	23
	Malacostraca	Amphipoda	Gammaridae	*Ramellogammarus*	*Ramellogammarus sp.*	6	cg		2											
			Taliridae	*Hyallela*	*Hyallela sp.*	8	cg		4	3	1			1						
	Maxillipoda	Decapoda	Astacidae	*Pacifastacus*	*Pacifastacus sp.*	6	om													
		Cycopoida			Cyclopoida	8	cf		6	7	5	3	18	4	8	2	4	1	1	13
		Harpacticoida			Harpacticoida	8	cf													
	Ostracoda	Podocopina	Cyprididae		Cyprididae type 1	8	cg		1	4	652	4	27	41		13	8	89		16
					Cyprididae type 2	8	cg		3											
					Cyprididae type 3	8	cg													
					Cyprididae type 4	8	cg		4											
					Cyprididae total	8	cg													
			Limnocytheridae	Limnocythere	*Limnocythere sp.*	8	cg		201	63	135	67	248	96	2	2	27	6	3	
	Insecta	Collembola	Isotomidae		Isotomidae	5	cg		4	6	2	1	1	1	2	2	1	2	2	4
		Ephemeroptera	Baetidae	*Baetis*	*Baetis sp.*	5	cg													
				Falcon	*Falceon quilleri*	5	cg													
			Leptohyphidae	*Tricorythodes*	*Tricorythodes sp.*	4	cg													
		Zygoptera	Coenagrionidae	*Enallagma*	*Enallagma sp.*	9	p													
					Coenagrionidae (imm)	9	p		3											
		Hemiptera	Corixidae	*Corisella*	*Corisella sp.*	8	p								1	1	1	1		
					Corixidae (imm)	8	p													
		Trichoptera	Hydroptilidae	*Hydroptila*	*Hydroptila sp.*	6	sc													
		Coleoptera	Dryopidae	*Helichus*	*Helichus sp.*	5	sh													
				Hydroporus	*Hydroporus sp.*	5	p													
			Hydrophilidae	*Berosus*	*Berosus sp.*	5	p													
		Diptera	Ceratopogonidae		Ceratopogonidae	6	p													
				Dasyhelea	*Dasyhelea sp.*	6	cg													
			Chironomidae		Chironomidae	.	.													
					Chironominae	6	cg		50	63	97	3	75	17	1	2	1	11	1	6
				Chironomus	*Chironomus sp.*	10	cg													
				Chironomus	*Chironomus sp. (P)*	10	cg													
					Cryptochironomus sp.	8	p													
				Dicrotendipes	*Dicrotendipes sp.*	8	cg													
				Dicrotendipes	*Dicrotendipes sp. (P)*	8	cg													
				Paracladopelma	*Paracladopelma sp.*	10														
				Phaenopsectra/Tribelos sp.	*Phaenopsectra/Tribelos sp.*	7	sc													
				Polypedilum sp.	*Polypedilum sp.*	6	sc													
					Tanytarsini	6	cg													
				Paratanytarsus	*Paratanytarsus sp.*	6	cg													
				Tanytarsus	*Tanytarsus*	6	cf													
					Orthocladiinae	5	cg		3	3	5		1					2	1	1
				Cricotopus	*Cricotopus sp.*	7	cg													
				Cricotopus	*Cricotopus sp. (P)*	7	cg													
				Cricotopus	*Cricotopus Trifascia Gr.*	7	cg													
				Eukiefferiella	*Eukiefferiella sp.*	8	cg													
				Orthocladius	*Orthocladius Complex*	6	cg													
				Pseudosmittia	*Pseudosmittia sp.*	6	cg													
				Rheocricotopus	*Rheocricotopus sp.*	6	cg													
				Thienemanniella	*Thienemanniella sp.*	6	cg													
				Thienemanniella	*Thienemanniella sp. (P)*	6	cg													
					Tanypodinae	7	p		1	2	2	1	4	1	0	0	1	6		3
					Pentaneurini	6	p													
				Apedilum	*Apedilum sp.*	6	p													
				Pentaneura	*Pentaneura sp.*	6	p													
				Tanypus	*Tanypus sp.*	10	p													
				Tanypus	*Tanypus sp. (P)*	10	p													
				Procladius	*Procladius sp.*	9	p													
			Dolichopodidae		Dolichopodidae	4	p			1									1	1
			Ephydridae	*Ephydra*	*Ephydra sp.*	6	sh		1	1				5				3	5	7
				Hydrellia	*Hydrellia sp.*	6	sh													
			Muscidae	*Limnophora*	*Limnophora sp.*	6	p													
				Gonomyia	*Gonomyia sp.*	3	cg													
			Sciomyzidae		Sciomyzidae	6	p													
			Simuliidae	*Simulium*	*Simulium sp.*	6	cf													
			Stratiomyidae	*Caloparyphus/Eupahyphus*	*Caloparyphus/Eupahyphus sp.*	8	cg												1	
					Total BMIs/sample			0	457	387	1057	114	561	258	95	82	65	876	187	299

Table 7. Bioassessment metrics calculated for each station during the spring 2005 Santa Clara River Estuary survey. Metrics are presented as means, standard deviations and coefficients of variation (cv), including the littoral sweep at Station B1. ANOVA was used to determine significance among stations for each metric (alpha ≤0.05). Significant differences between stations were delineated using Newman-Keuls Multiple-Comparison Test. When assumptions of equal variances were not met, Kruskall Wallis One Way ANOVA on Ranks and Kruskal-Wallis Multiple-Comparison Z-Value Test were applied. Station B2 was excluded from analysis since only one sample replicate was collected.

Metric		SCRE B1 Littoral Sweep	SCRE B1	SCRE B2	SCRE B3	SCRE B7	Comparison Among Sites			
							Overall	ANOVA F-Ratio	ANOVA p	Multiple Comparisons
Abundance	mean	2784	1799	196	142	651	1114	5.6[1.]	0.06*	
	st. dev.	.	1282	.	68	260	536			
	cv	.	71	.	48	40	53			
Taxonomic richness	mean	16.00	15.00	3.67	9.67	11.00	11.07	2.77	0.14	
	st. dev.	.	5.20	.	1.15	2.65	3.00			
	cv	.	34.64	.	11.95	24.05	23.55			
Shannon Diversity	mean	1.37	1.49	0.26	1.77	1.24	1.22	7.90	0.02**	B3 > B7
	st. dev.	.	0.26	.	0.08	0.08	0.14			
	cv	.	17.57	.	4.26	6.32	9.38			
% dominant taxa	mean	42.06	49.85	80.92	30.95	57.00	52.16	7.56	0.02**	B7, B1 > B3
	st. dev.	.	13.49	.	3.63	4.47	7.20			
	cv	.	27.05	.	11.72	7.85	15.54			
Percent Chironomidae	mean	6.76	11.93	81.26	36.54	75.15	42.33	8.65	0.02**	B7 > B3, B1
	st. dev.	.	4.81	.	29.52	12.71	15.68			
	cv	.	40.31	.	80.79	16.91	46.00			
Tolerance Value	mean	8.62	8.43	6.27	6.17	6.55	7.21	20.82	<0.01**	B1 > B3, B7
	st. dev.	.	0.25	.	0.31	0.70	0.42			
	cv	.	2.94	.	5.08	10.64	6.22			
Percent Intolerance Value (0-2)	mean	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	
	st. dev.	.	0.00	.	0.00	0.00	0.00			
	cv	.	.	.	.	.	0.00			
Percent Tolerance Value (8-10)	mean	91.59	80.51	14.31	23.33	22.40	46.43	34.46	<0.01**	B1 > B7, B3
	st. dev.	.	4.88	.	5.49	15.32	8.57			
	cv	.	6.06	.	23.54	68.41	32.67			
Percent Collectors	mean	94.32	96.84	87.05	89.39	94.57	92.43	2.54	0.19	
	st. dev.	.	1.46	.	6.43	2.83	3.57			
	cv	.	1.51	.	7.19	2.99	3.90			
Percent Filterers	mean	1.53	0.45	0.00	4.30	0.41	1.34	1.15	0.38	
	st. dev.	.	0.41	.	6.23	0.31	2.32			
	cv	.	91.59	.	144.63	75.24	103.82			
Percent Grazers	mean	2.45	0.79	0.00	0.50	1.13	0.97	0.96	0.44	
	st. dev.	.	0.28	.	0.86	0.38	0.51			
	cv	.	35.03	.	173.21	33.77	80.67			
Percent Predators	mean	1.70	1.89	12.95	5.81	3.52	5.17	0.64	0.56	
	st. dev.	.	1.66	.	6.52	3.08	3.75			
	cv	.	87.41	.	112.24	87.61	95.75			
Percent Shredders	mean	0.00	0.02	0.00	0.00	0.37	0.08	2.22	0.19	.
	st. dev.	.	0.04	.	0.00	0.39	0.14			
	cv	.	173.21	.	#DIV/0!	105.85	#DIV/0!			

1. Data does not fit assumptions of equal variances; Kruskall/Wallis One Way ANOVA on ranks used.

* Marginally Significant (0.05 < p < 0.10), difference generally not large enough for multiple comparisons to detect.

** Significant (p <0.05)

N/A - Not Applicable

Table 8. Bioassessment metrics calculated for each station during the fall 2005 Santa Clara River Estuary survey. Metrics are presented as means, standard deviations and coefficients of variation (cv), including the littoral sweep at Station B1. ANOVA was used to determine significance among stations for each metric (alpha ≤0.05). Significant differences between stations were delineated using Newman-Keuls Multiple-Comparison Test. When assumptions of equal variances were not met, Kruskall Wallis One Way ANOVA on Ranks and Kruskal-Wallis Multiple-Comparison Z-Value Test were applied. Littoral sweep sample was not collected.

Metric		SCRE B1 Littoral Sweep	SCRE B1	SCRE B2	SCRE B3	SCRE B7	Comparison Among Sites			
							Overall	ANOVA F-Ratio	ANOVA p	Multiple Comparisons
Abundance	mean		634	288	81	454	364	2.08	0.18	
	st. dev.		368	218.90	15	370	243			.
	cv		58	75.92	19	81	59			
Taxonomic richness	mean		12.33	9.67	8.67	10.67	10.33	2.33	0.15	.
	st. dev.		2.08	0.58	0.58	0.58	0.95			
	cv		16.88	5.97	6.66	5.41	8.73			
Shannon Diversity	mean		1.46	1.41	1.11	0.77	1.19	5.46	0.02**	B1, B2 > B7
	st. dev.		0.21	0.06	0.35	0.24	0.21			
	cv		14.42	4.38	31.13	30.68	20.15			
% dominant taxa	mean		47.02	49.82	64.44	81.36	60.66	4.29	0.04**	B7 > B2
	st. dev.		13.40	7.83	20.49	5.70	11.86			
	cv		28.50	15.72	31.80	7.00	20.76			
Percent Chironomidae	mean		13.08	8.93	2.19	2.19	6.60	6.61	0.01**	B1 > B7, B3
	st. dev.		4.02	5.76	1.03	1.14	2.99			
	cv		30.72	64.54	47.27	51.85	48.59			
Tolerance Value	mean		8.15	8.24	9.12	9.51	8.75	17.07	< 0.001**	B7, B3 > B1, B2
	st. dev.		0.17	0.12	0.51	0.16	0.24			
	cv		2.13	1.51	5.55	1.71	2.72			
Percent Intolerance Value (0-2)	mean		0.00	0.00	0.00	0.00	0.00	N/A	N/A	.
	st. dev.		0.00	0.00	0.00	0.00	0.00			
	cv		0.00	0.00	0.00	0.00	0.00			
Percent Tolerance Value (8-10)	mean		85.66	89.73	95.38	94.50	91.32	3.87	0.06*	.
	st. dev.		4.88	5.53	1.47	2.44	3.58			
	cv		5.70	6.16	1.54	2.58	4.00			
Percent Collectors	mean		82.64	82.17	89.82	89.98	86.15	0.49	0.70	.
	st. dev.		18.50	7.06	3.83	7.44	9.20			
	cv		22.38	8.59	4.26	8.27	10.87			
Percent Filterers	mean		1.58	5.40	7.64	7.06	5.42	1.50	0.29	.
	st. dev.		0.96	2.92	3.96	5.88	3.43			
	cv		60.73	54.05	51.82	83.34	62.48			
Percent Grazers	mean		15.01	10.96	0.35	0.11	6.61	2.04	0.19	.
	st. dev.		17.71	4.55	0.61	0.19	5.76			
	cv		117.98	41.47	173.21	173.21	126.47			
Percent Predators	mean		0.61	0.70	2.19	0.89	1.10	4.77	0.03**	B3 > B1, B2, B7
	st. dev.		0.37	0.21	1.03	0.41	0.51			
	cv		60.43	30.65	47.27	45.96	46.08			
Percent Shredders	mean		0.16	0.77	0.00	1.79	0.68	2.23	0.16	.
	st. dev.		0.14	1.33	0.00	1.26	0.68			
	cv		87.49	173.21	0.00	70.61	82.83			

1. Data does not fit assumptions of equal variances; Kruskall/Wallis One Way ANOVA on ranks used.

* Marginally Significant (0.05 < p < 0.10), difference generally not large enough for multiple comparisons to detect.

** Significant (p <0.05)

N/A - Not Applicable

Table 9. Ten most abundant species collected from each sampling site (reps = 3) in Santa Clara River Estuary during the spring 2005.

SCRE Littoral Sweep B1		SCRE B1		SCRE B2		SCRE B3		SCRE B7	
Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%
Hyalella sp.	42.1	*Limnodrilus sp.*	38.7	Chironominae	80.9	Isotomidae	23.3	Chironominae	57.7
Limnodrilus sp.	41.5	*Hyalella sp.*	28.3	Corixidae (imm)	10.6	Chironominae	18.6	Orthocladiinae	18.9
Chironominae	4.7	Chironominae	11.8	Isotomidae	3.2	*Limnodrilus sp.*	13.9	*Limnodrilus sp.*	12.6
Limnocythere sp.	2.3	Cyprididae total	8.2	*Limnodrilus sp.*	1.7	Orthocladiinae	12.5	Cyprididae total	4.7
Pomatiopsis sp.	2.1	*Limnocythere sp.*	5.0	*Corisella sp.*	1.2	*Baetis sp.*	11.3	Corixidae (imm)	1.6
Orthocladiinae	1.9	Isotomidae	2.8	Dolichopodidae	0.7	*Simulium sp.*	5.4	Dolichopodidae	1.4
Cyprididae total	1.8	Orthocladiinae	1.4	Cyprididae total	0.5	*Limnocythere sp.*	4.7	*Physa/Physella sp.*	1.0
Planariidae	1.2	Planariidae	1.2	Nematoda	0.3	*Hyalella sp.*	3.1	*Limnophora sp.*	0.7
Daphnia sp	1.1	Tanypodinae	0.7	*Hyalella sp.*	0.3	Planariidae	1.6	Tanypodinae	0.5
Simulium sp.	0.4	*Physa/Physella sp.*	0.44	Orthocladiinae	0.3	Cyprididae total	1.4	*Ephydra sp.*	0.4

Table 10. Ten most abundant species collected from each sampling site (reps = 3) in Santa Clara River Estuary during the fall 2005. Littoral sweep sample not collected.

SCRE Littoral Sweep B1		SCRE B1		SCRE B2		SCRE B3		SCRE B7	
Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%
		Cyprididae total	34.9	*Limnocythere sp.*	47.5	*Limnodrilus sp.*	64.5	*Limnodrilus sp.*	83.0
		Limnocythere sp.	21.0	*Limnodrilus sp.*	26.0	*Limnocythere sp.*	12.8	Cyprididae total	7.7
		Limnodrilus sp.	18.9	Chironominae	11.0	Cyprididae total	8.7	*Daphnia sp*	3.1
		Chironominae	11.0	*Pomatiopsis sp.*	8.7	Cyclopoida	5.8	Chironominae	1.3
		Pomatiopsis sp.	10.6	Cyclopoida	2.9	*Daphnia sp*	2.1	Cyclopoida	1.1
		Cyclopoida	0.9	*Daphnia sp*	1.5	Isotomidae	2.1	*Ephydra sp.*	1.1
		Isotomidae	0.6	Tanypodinae	0.7	Chironominae	1.7	*Limnocythere sp.*	0.7
		Orthocladiinae	0.6	*Ephydra sp.*	0.6	*Corisella sp.*	1.2	Tanypodinae	0.7
		Hyalella sp.	0.4	Cyprididae total	0.5	*Hydra sp.*	0.4	Isotomidae	0.6
		Daphnia sp	0.3	Isotomidae	0.35	*Pomatiopsis sp.*	0.41	Orthocladiinae	0.3