THE CITY OF SAN BUENAVENTURA

Santa Clara River Estuary Macroinvertebrate Bioassessment Monitoring Annual Report 2004

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March 2005

THE CITY OF SAN BUENAVENTURA

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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).

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 2004, according to the City's NPDES permit and the California Stream Bioassessment Protocol (CSBP, 1999). 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 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 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 during the 2004 surveys 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 2004 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 the best 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 25th, 2004 and October 12th, 2004 by Aquatic Bioassay & Consulting Laboratories biologists. All procedures were conducted as outlined in the project scope of work and in accordance with 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

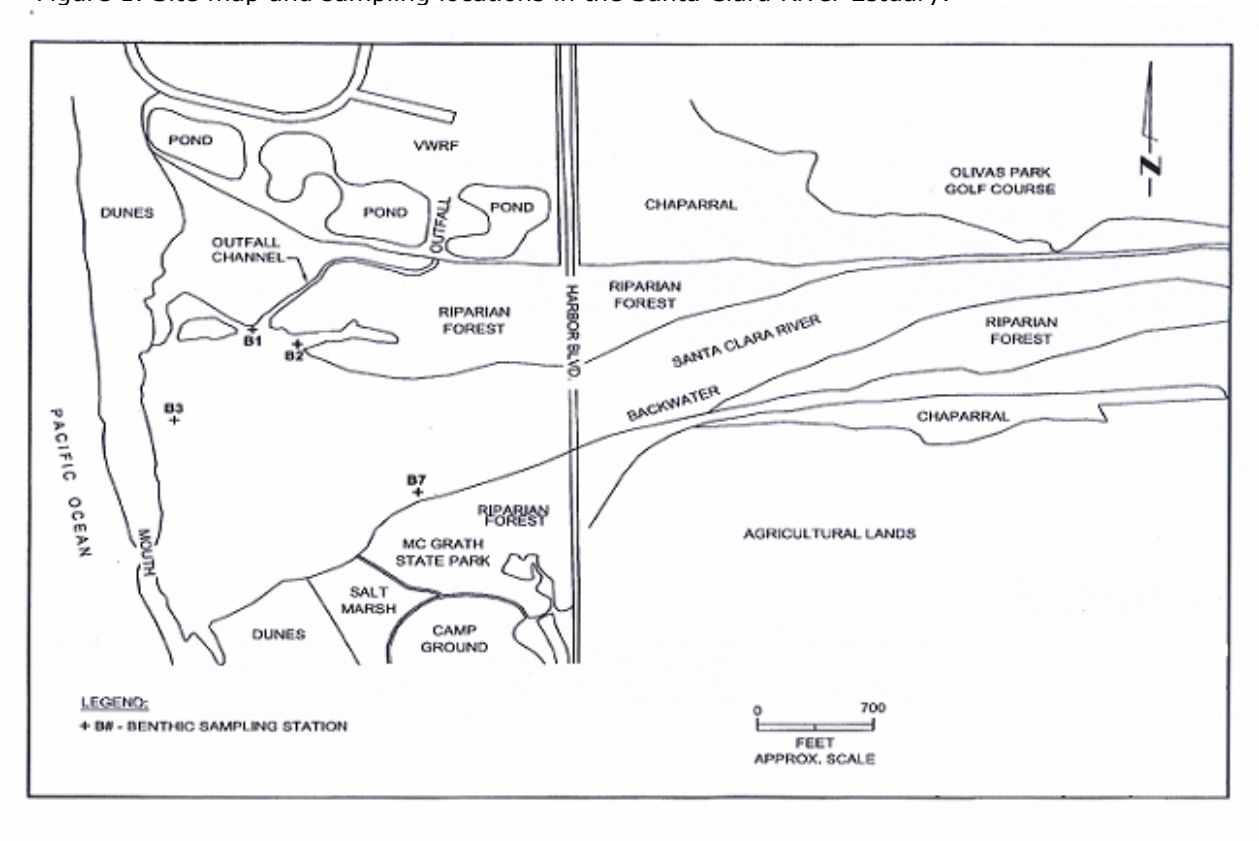
The May 2004 event occurred during open mouth, free flowing conditions. The October event occurred while the berm was partially breached. While not completely inundated, water levels in the Estuary were still deeper (up to three feet) than when the berm is completely breached. Stations were located using 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. 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. A single littoral sweep was conducted at Station B1 using a kick net and samples were processed as above. 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 for 2003 were downloaded from the United States Geologic Survey's web site at: http://waterdata.usgs.gov/ca/nwis/.

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, sorting was performed by elutriation. Six tablespoonfuls of sample material were transferred into a 2000 mL Erlhynmeyer flask filled with 1500 mL of water. The flask was swirled gently to suspend organic material in the sample and the supernatant was decanted into a 500 um sieve. The flask was gently refilled with 1500 mL of water and the sub sample decanted again. This process was completed seven times for each six spoonful sub sample. After each sub sample was completed, the remaining sample material was placed into a refuse jar. After the entire sample was completed, contents of the refuse jar were returned to the original sample container and preserved in 70% alcohol for possible future reference.

After elutriation, material accumulated on the sieve was concentrated on the sieve with water and then washed into a 250 mL sample container using 70% alcohol. This was done over a catch basin to contain any spills. During 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 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

Elutriation

The remaining sample matrix from decanted sub samples was periodically evaluated to determine elutriation efficiency. Approximately 20 mL of the remaining sample matrix from the first, last, and middle elutriated sub sample 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 by the elutriation process. Elutriation efficiency was over 99.5%.

Laboratory

Approximately 10% of the sorted samples were evaluated to determine laboratory processing efficiency. The processed matrix for these samples was inspected to determine the number of organisms missed during the initial sorting. Mean processing efficiency was 98.3%.

Taxonomic Effort

All of the organisms removed during the sorting process were then identified to Level 3 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.

Particle Size Analysis

Sediments were analyzed for particle size distribution using a Horiba 920 particle size analyzer following *Procedures for Handling and Chemical Analysis of Sediment and Water Samples*, R.H. Plumb, US EPA Contract 4805572010, May 1981; and, 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) up through course sand (2000μ).

Data Analysis

Multi-metric analysis

Biological metrics were calculated as specified by the California Stream Bioassessment Procedure (CSBP) (1999) 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).

For this report statistical significance is highlighted at two levels. For most ecologists, a pattern that is strong enough so that there is only a one chance or less in 20 that it is random is said to be statistically significant. In other words, the probability (p) is that there is only a 5% chance (0.05) or less that the pattern is random ($p \leq 0.05$). A pattern that has only one chance in ten or less (but more than one chance in 20) is said to be "marginally significant". That is, the probability is less than 10% but greater than 5% of being random ($0.05 < p \leq 0.10$).

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.

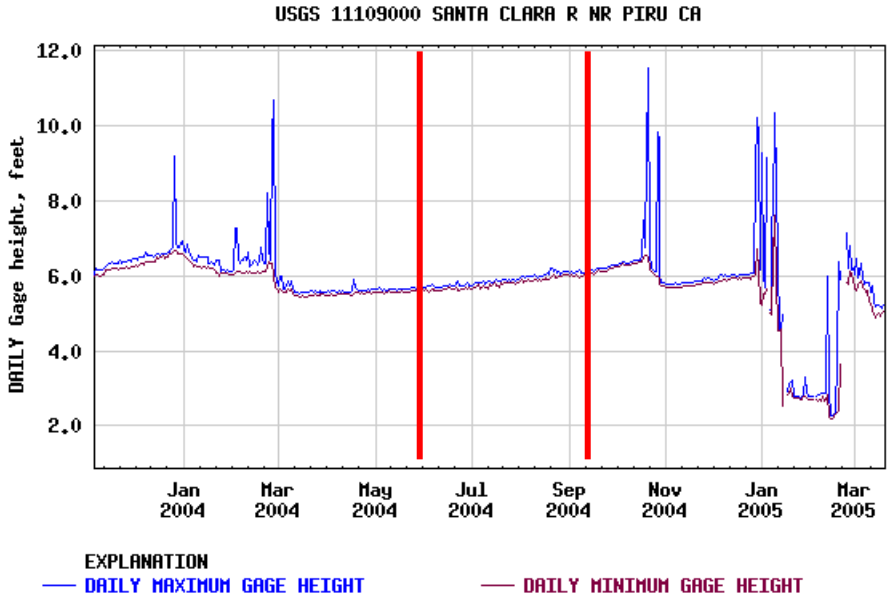
RESULTS

Annual Stream Flow & Estuary Inundation

Flow during 2004 on the Santa Clara River was measured in stream height (feet) at the Piru gauging station (USGS 11109000), located 15 miles upstream of the Estuary. Last year stream flow was measured at the Montalvo gauging station in Ventura, which is just upstream of the Estuary. This station was not operational during 2004 due to construction on the Santa Clara River Bridge at the 101 Freeway. River flow peaked following rain events in December (9 feet) and February (10.5 feet) (Figure 2). 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.

The May 25th sampling event followed nearly three months of dry weather. The berm at the mouth of the estuary was open and all river flow was discharging to the ocean. Water depth in the estuary during the May survey was deeper at Stations B1 and B2 (24 inches) in the effluent discharge, than in the river channel at Stations B3 (6 inches) and B7 (2 inches) (Table 3). The October 12th, 2004 sampling event followed six and a half months of dry weather, which is typical of southern California. The mouth of the Estuary was partially open as a result of a small breach caused by hydraulic pressure. As a result the estuary was not completely inundated and water depths ranged from 36 inches (Station B1, B3 and B7) to 42 inches (Station B2).

Figure 2. Santa Clara River stream height (ft) measured at the Piru gage station (USGS 11109000). Daily measurements are in feet. Spring and fall sampling events are indicated by red lines that bisect the date.



General Observations

During May, sampling was conducted under clear skies with 20 kilometer visibility (Table 2). Wind was from the southwest from between 3 and 12 knots. Water color at all stations was green. In October sampling occurred under partly cloudy skies with 24 km visibility. Winds were west to northwest from 4 to 22 knots. Water color was green at all sites.

Physical Measurements and Water Quality

May

In May the width of the sampling transects varied from 1 to 17 meters, while the water velocity ranged from 0.0 ft/sec at Station B2 to 1.6 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 mixed cobble, gravel and sand at Station B1 to sand at all other stations. Sediment at Station B3 contained some silt.

The pH ranged from a low at of 7.14 at Station B7 in the main river channel, to a high of 8.86 at Station B2 above the outfall. Dissolved oxygen concentrations varied from 7.70 at Station B1 to 8.75 at Station B7. Water temperature exceeded 20 °C at all sites, except at Station B7 (16.4 ºC). Salinity was lowest at Stations B1 and B3 (0.00 ppt each) and highest at Station B7 (5.2 ppt). The higher salinity measurement at B7 was probably due to its location in the main river channel, which is more subject to tidal flooding than the other stations.

October

In October, a transect width measurement was only possible at Station B1 (3 meters) (Table 2). Due to the elevated water level, there were no clearly defined banks at the other sites. With the exception of Station B1 (0.10 ft/sec), there was no measurable water velocity,also as a result of inundation . There was no canopy cover over any of the stations, but Stations B1 and B2 had willows and cotton woods on the nearby banks. The composition of bottom sediments ranged from mixed cobble, gravel and sand at Station B1 to sand and cobble at Stations B3 and B7. As in the spring, Station B3 contained small amounts of silt.

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 (3.78 mg/L) and highest at Station B3 (8.97 mg/L). Water temperatures exceeded 20 °C at all sites. Salinity ranged from 0.0 ppt at Stations B1 and B2 to 7.2 ppt at Station B3.

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, 2004.

Sampling Stations	Spring				Fall			
	BI	B2	B3	B7	BI	B2	B3	B7
Date	5/25/2004	5/25/2004	5/25/2004	5/25/2004	10/12/2004	10/12/2004	10/12/2004	10/12/2004
Time	11:30	11:45	08:32	15:23	09:15	9:30	08:20	13:20
Survey Program	Bioassessment Coring Littoral Sweep	Bioassessment Coring	Bioassessment Coring	Bioassessment Coring	Bioassessment Coring Littoral Sweep	Bioassessment Coring	Bioassessment Coring	Bioassessment Coring
Depth (in)	24	6	6	3	36	42	36	36
Latitude	34° 14'103"	34° 14'091"	34° 13'987"	34° 13'887"	34° 14'103"	34° 14'091"	34° 13'987"	34° 13'887"
Longitude	119° 15'792"	119° 15'777"	119° 15'903"	119° 15'580"	119° 15'792"	119° 15'777"	119° 15'903"	119° 15'580"
Weather	Clear	Clear	Clear	Clear	Prtly Cldy	Prtly Cldy	Prtly Cldy	Prtly Cldy
Air Vis. (km)	20	20	20	20	24	24	24	24
Esturary Status	Open	Open	Open	Open	Partly Open	Partly Open	Partly Open	Partly Open
Wind Sp. (Kn)	5	4	3	12	6	4	4	22
Wind Dir. (°M)	270	270	270	270	290	290	290	270
Color	Grn	Grn	Grn	Grn	Grn	Grn	Grn	Grn
Comments	None	None	None	None	None	None	None	None
Transect Width (m)	8	8	17	1	3	N/A[2]	N/A[2]	N/A[2]
Velocity (ft/sec)	1.43	0.00	1.60	0.10	0.10	0.00	0.00	0.00
% Canopy	5	5	0	0	0	0	0	0
Composition	Sand Cobble Gravel	Sand Silt	Sand	Sand	Sand Cobble Gravel	Sand Silt	Sand Cobble	Sand Cobble
Sample Depth (in)	24	24	6	2	36	42	36	36
pH	8.01	8.86	7.91	7.14	7.69	7.33	8.44	9.20
Conductance (mS/cm)	2479	4156	2449	7664	3095	3095	11690	10750
Dissolved Oxygen (mg/L)	7.70	7.75	7.81	8.75	7.18	3.78	8.97	7.20
Temperature (°C)	23.2	20.8	22.5	16.4	22.8	21.1	20.5	21.8
Salinity (ppt)	0.0	2.4	0.0	5.2	0.0	0.0	7.2	6.4

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 were, for the most part, composed of sand during both surveys (Table 3). Sediments at all Stations and during both surveys were composed of fine to coarse sand, except at Station B7 in the spring, when the sediments tended to be coarse silt. Sediments at Stations B1, B2 and B3 were moderately well sorted in the spring, then shifted to poorly and very poorly sorted in the fall. Sediments at Station B7 shifted only slightly from poorly sorted to very poorly sorted. Sediments at Stations B1 and B2, and to a lesser extent B3, shifted from coarser to finer sediments between the spring and fall surveys (Figure 3). Station B7, located in the river channel, did not follow this trend and shifted from finer sediments in the spring to coarser 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. The shift toward finer particle sizes there during the fall was probably due to the quiescent conditions present during the summer inundation, which allowed finer particles to settle out of the water column. 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.

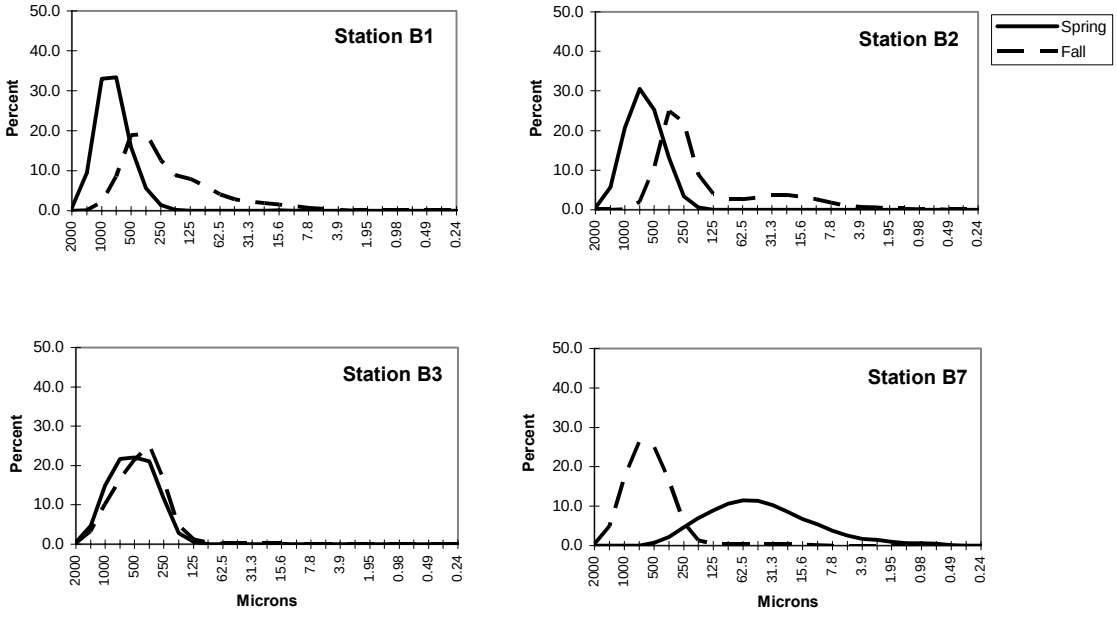
Table 3. Sediment particle size fractions (%), percentiles (16th, 50th & 84th) and sorting index values for stations located in the Santa Clara River Estuary during the spring and fall, 2004.

Station / Season	Particle Fraction Summary (%)				Percentile (microns)			Category [1.]	Percentile (phi)			Sorting Index [2.]	Sorting [2.]
	Sand	Silt	Clay	Fines	16%	50% [1.]	84%		16%	50%	84%		
May													
B1	99.9	0.1	0.0	0.1	428.2	661.4	940.5	course sand	1.2	0.6	0.1	0.6	moderately well sorted
B2	100.0	0.0	0.0	0.0	342.4	544.0	849.2	medium sand	1.5	0.9	0.2	0.7	moderately well sorted
B3	100.0	0.0	0.0	0.0	254.4	441.0	779.1	medium sand	2.0	1.2	0.3	0.8	moderately well sorted
B7	45.5	50.3	4.2	54.5	10.0	38.6	118.1	course silt	6.6	4.7	3.1	1.8	poorly sorted
October													
B1	88.6	11.4	0.0	11.4	64.3	242.4	454.3	fine sand	4.5	2.5	1.7	1.4	poorly sorted
B2	78.2	20.4	1.4	21.8	26.8	217.8	342.6	fine sand	5.5	2.9	1.9	1.8	poorly sorted
B3	99.4	0.6	0.0	0.6	214.6	364.5	677.6	medium sand	7.2	4.7	2.2	2.5	very poorly sorted
B7	98.4	1.6	0.0	1.6	283.9	490.2	807.1	medium sand	7.1	5.0	2.7	2.2	very poorly sorted

[1.] 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.

[2.] <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 2004 sampling surveys.



Macrobenthic Invertebrates

Summary

There were a combined total of 14,385 organisms collected from the four stations during the spring and fall bioassessment surveys (Table 4) (Appendix C, Tables 5 and 6). The numbers of organisms collected in the littoral sweeps during the spring (1,836) was far greater than in the fall (342). However, the numbers of taxa was similar in these samples during both seasons (7 and 8 respectively). The combined total number of organisms collected in the grab samples at all four stations was greater in the fall (7,225) compared to the spring (4,982). Abundances in the spring were similar at Stations B1, B2 and B7 and much lower at Station B3. In the fall abundances were greatest at Station B7 and B2, and were much lower at Stations B1 and B3.

A total of 18 unique species were collected during both surveys combined, with a total of 12 collected in the spring and 17 in the fall. The numbers of species collected in the littoral sweep samples during both surveys were nearly identical (7 and 8 respectively). In the spring the greatest number of species were collected at outfall Stations B1 and B2 (12 each). In the fall, the greatest numbers of species were collected at Stations B1 (12) and B7 (13).

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). Abundances in the littoral sweep samples collected at Station B1 in the effluent channel were much greater in the spring (1,836) than the fall (342). Of the grab samples, abundances were lowest at Station B3 during both seasons (400 and 411 respectively). The greatest abundances were found at Stations B2 (2,673) and B7 (3,614), both during the fall.

During the spring, abundances were significantly higher at Stations B2 compared to Stations B3 (ANOVA, $p < 0.05$). The drop in abundance at B3 was probably the result of its location in more open and less sheltered portions of the Estuary. 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 similar in the littoral sweep samples taken at Station B1 for both the spring and fall sampling events (7 and 9 respectively) (Table 4 and Figures 4 and 5; Appendix C, Tables 7 and 8). For the grab samples in the spring, taxa richness was significantly different among stations, decreasing from a high of 9 at Stations B1 and B2 to 5 at B7 (ANOVA, $p < 0.02$). There was no significant difference in taxa richness among stations in the fall. The average taxonomic richness was the same in the spring (7) and fall (7).

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.

Dominance was generally high across both seasons and stations regardless of sampling technique (Figures 4 and 5; Appendix C, Tables 7 and 8). For the littoral sweep samples, dominance was highest in the spring (89%) and lowest in the fall (62%). For the grab samples during the spring, dominance was lowest at Station B3 (79%), and higher at Stations B1 (85%), B2 (94%), and B7 (88%). During the fall dominance was significantly lower at Station B1 (63%) compared to B2 (89%), B3 (93%) and B7 (94%).

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 low across seasons and stations, not exceeding 1.2 at any site (Figures 4 and 5; Appendix C, Tables 7 and 8). The highest diversity measured in any sample was in the fall littoral sweep (1.18). Spring diversity in grab samples ranged from lowest at Station B2 (0.29) to highest at Station B3 (0.68). In the fall diversity was significantly greater at Station B1 (0.97) compared to B2 (0.39), B3 (0.29) and B7 (0.25). Average diversity in grab samples was very slightly greater in fall (0.62) compared to spring (0.50).

Table 4. Summary of total abundances by species and location during both spring and fall, 2004 bioassessment surveys of the Santa Clara River Estuary. Stations B1 thru B7 abundances are total counts, while littoral sweep samples are estimates.

Species	Tolerance Value (TV)	Functional Feeding Group	Spring 04						Fall 04					
			Littoral Sweep	Grabs				Total by Core	Littoral Sweep	Grabs				Total by Core
			B1	B1	B2	B3	B7		B1	B1	B2	B3	B7	
Berosus sp.	5	p	12	3	2	0	0	5	0	1	0	0	4	5
Chironominae	6	cg	6	43	4	1	26	74	213	104	83	6	17	210
Corisella sp.	8	p	30	0	11	4	0	16	0	0	0	0	2	2
Corxidae (imm)	8	p	0	0	0	0	0	0	0	0	1	3	52	56
Cyclopoida	8	cf	0	0	0	0	0	0	1	1	0	0	0	1
Cyprididae	8	cg	0	20	11	14	4	49	63	16	6	1	12	34
Daphnia sp	8	cf	0	0	1	0	0	1	5	2	0	0	0	2
Dolichopodidae	4	p	0	0	0	0	0	0	0	0	0	0	1	1
Eogammarus sp.	6	cg	0	0	0	0	0	0	0	0	0	0	1	1
Ephydra sp.	6	sh	0	0	0	0	0	0	0	0	0	21	2	22
Hyalella sp.	8	cg	6	4	0	0	0	4	38	8	0	0	0	8
Limnocythere sp.	8	cg	1638	1060	1744	325	1270	4399	10	382	2379	379	3507	6646
Limnodrilus sp.	10	cg	42	56	53	6	3	118	3	4	177	1	2	184
Orthocladiinae	5	cg	0	7	1	2	0	10	0	5	0	1	0	6
Physa/Physella sp.	8	sc	0	1	0	0	0	1	0	0	0	1	0	2
Pomatiopsis sp.	8	sc	0	0	1	0	0	1	0	2	22	0	0	25
Ramellogammarus sp.	6	cg	102	63	1	45	171	280	0	0	0	0	0	0
Tanypodinae	7	p	0	1	21	3	0	25	7	2	5	0	14	22
Total Average Abundance by Station			**1836**	**1257**	**1851**	**400**	**1474**	**4982**	**342**	**527**	**2673**	**411**	**3614**	**7225**
Average Numbers of Species			**7**	**12**	**12**	**8**	**6**	**13**	**8**	**12**	**9**	**8**	**13**	**17**

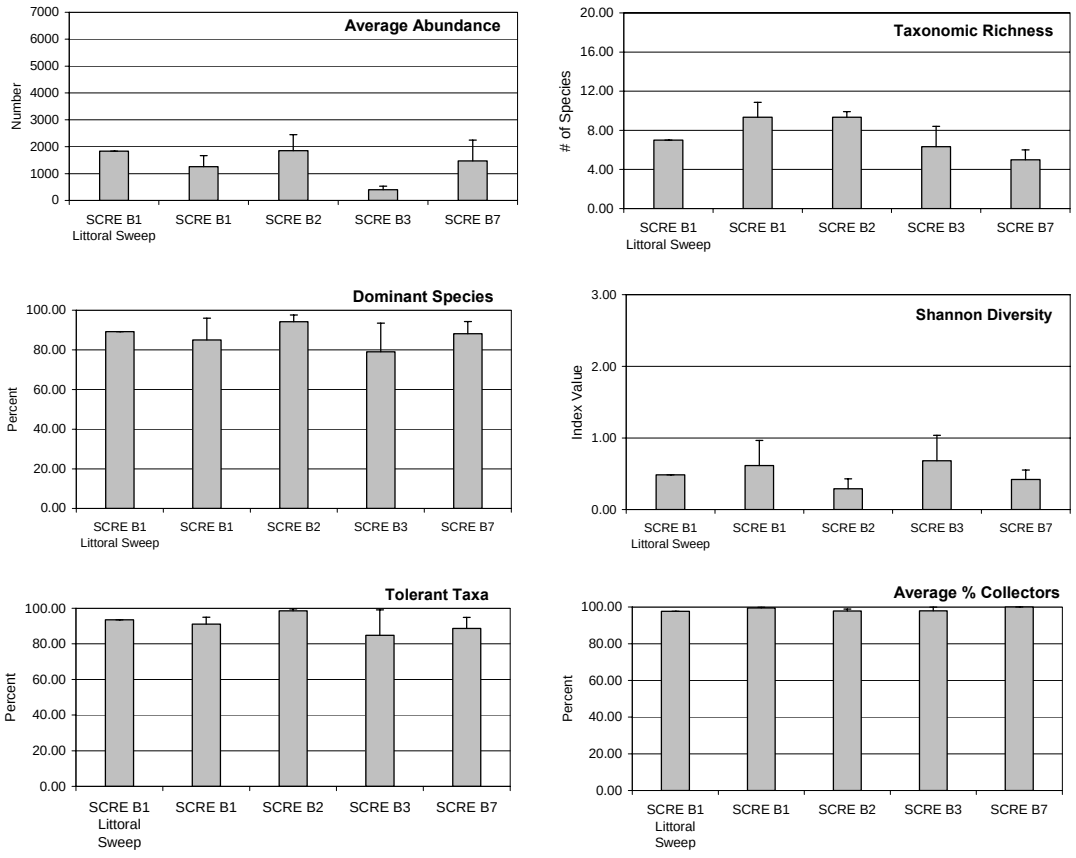


Figure 4. Bioassessment metrics calculated for populations collected from the Santa Clara River Estuary during the spring 2004.

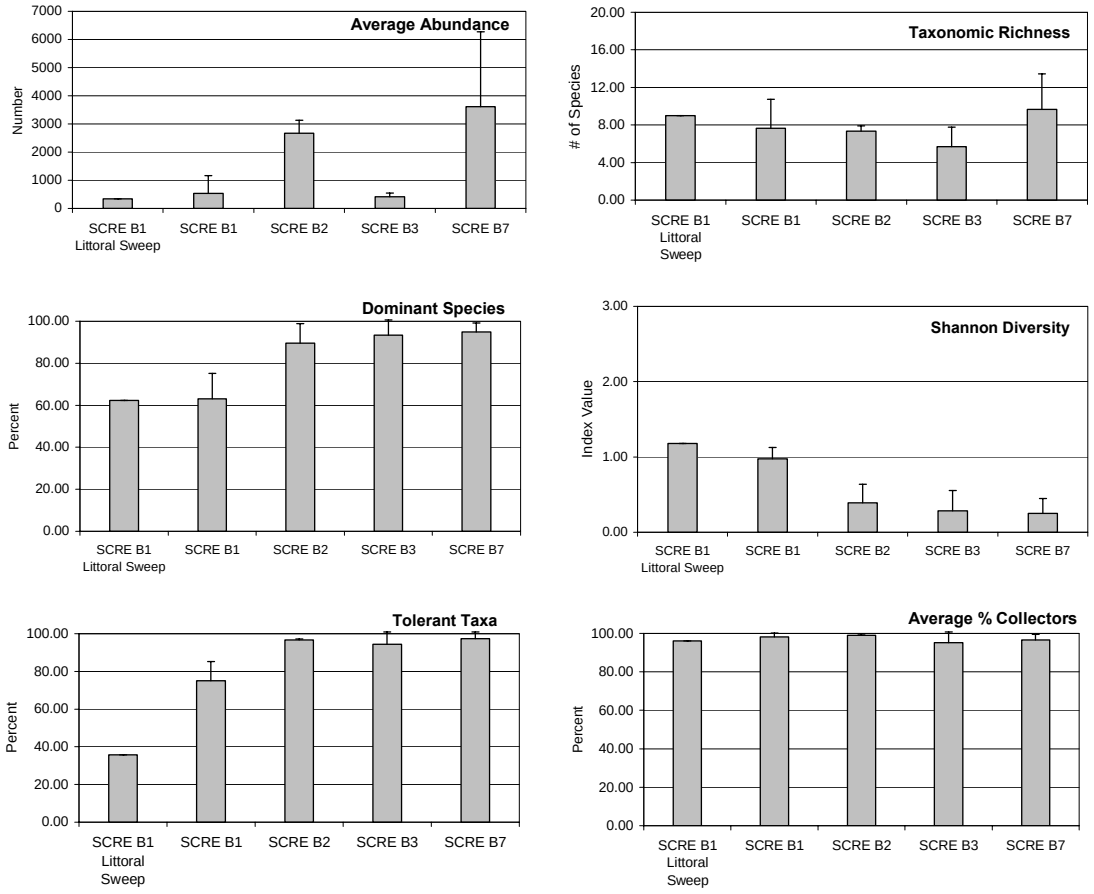


Figure 5. Bioassessment metrics calculated for populations collected from the Santa Clara River Estuary during the fall 2004.

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 high across seasons and stations in the Santa Clara River Estuary, ranging from 75 to 98% (Figures 4 and 5; Appendix C, Tables 7 and 8). The exception to this was the fall littoral sweep sample (35%). The percentage of tolerant organisms in the spring littoral sweep sample was much higher (93%). During the fall the percentage of tolerant organisms were significantly greater at Stations B2, B3 and B7 compared to outfall Station B1 (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 was high across both seasons and stations (Figures 4 and 5; Appendix C, Tables 7 and 8). The percentage of collectors exceeded 90% in all samples regardless of sample type, and during both seasons.

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 samples was dissimilar between the spring and fall sampling events. In the spring, the cypridid ostracod, *Limnocythere sp*., was the most dominant taxa accounting for 89% of the population. The next most abundant species included a gammarid amphipod (*Ramellogammarus sp.,* 5%), and the tubificid oligochaete, *Limnodrilus sp.* (2%). During the fall, the most abundant organisms were flies (Chironominae, 62%), followed by cypridid ostracods (18%), the amphipod, *Hyalella sp*. (11%) and *Limnocythere sp*. (3%).

The most common species collected by grab during both seasons and across all sites was the cypridid ostracod, *Limnocythere sp*. This species composed from 72% to 97% of the population at each of the sites and has a tolerance value of eight, indicating its ability to survive under stressful conditions. Other relatively abundant organisms found during the spring included *Ramellogammarus sp*. and *Limnodrilus sp*. During the fall, the next most abundant species included flies (Chironominae), cypridid ostracods, and *Limnodrilus sp*.

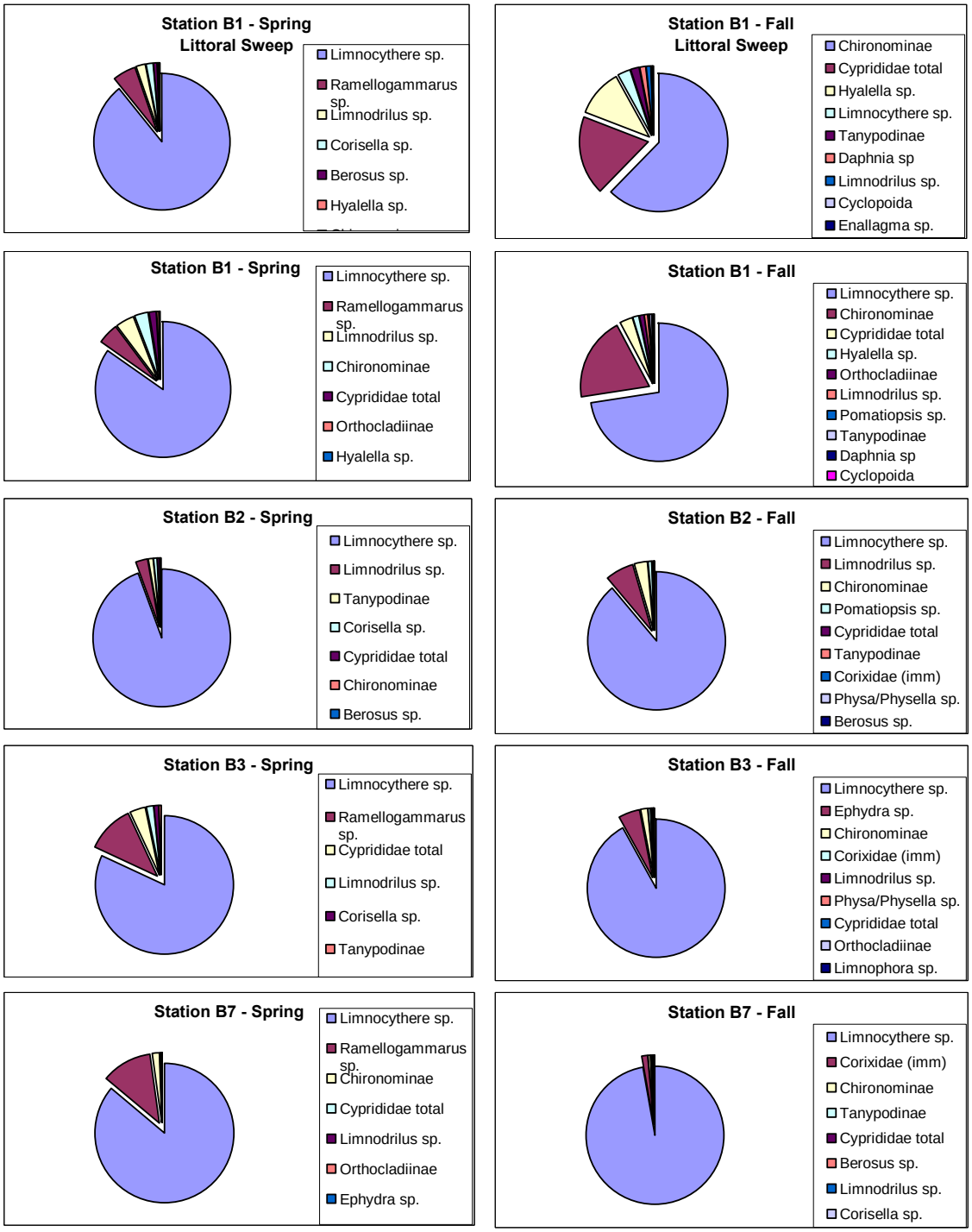
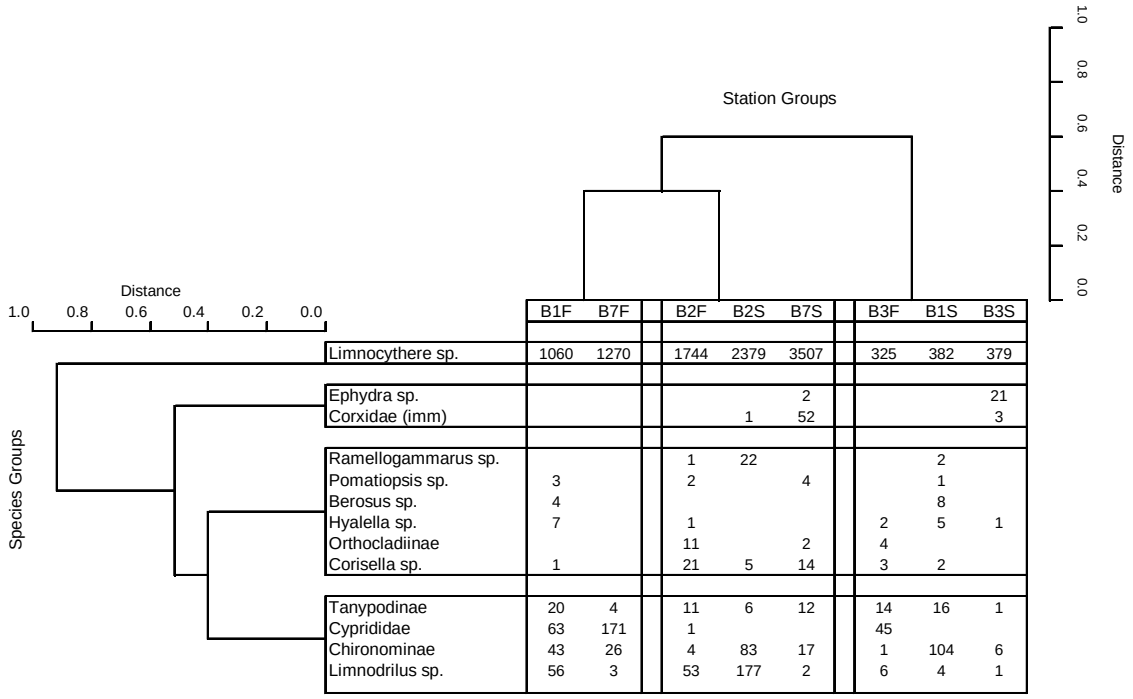


Figure 6. Cumulative percent abundance of most common species collected in the Santa Clara River Estuary from four sites during the spring and fall of 2004.

Cluster Analysis

The relative abundance of the cypridid ostracod, *Limnocythere sp*., at each station and during each season was the predominant factor driving the distribution of stations in the cluster analysis (Figure 7). Station Group 1 was formed by Stations B1 and B7 in the fall, which had moderate numbers of *Limnocythere sp*. compared to other sites and seasons. Station Group 2 was formed by Stations B2 in the spring and fall, and B7 in the fall, which had the greatest abundances of *Limnocythere sp*. Station Group 3 was formed by Stations B3 in the spring and fall, and B1 in the spring, which had the least *Limnocythere sp*. Except for the pattern driven by *Limnocythere sp*., there were no clear species group patterns.

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). Values associated with each cell are average (n = 3) species abundances for each station. Only the most frequently occurring organisms were used in the analysis (n ≥ 14) 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	B7F	B2F	B2S	B7S	B3F	B1S	B3S
Limnocythere sp.	1060	1270	1744	2379	3507	325	382	379
Ephydra sp.					2			21
Corxidae (imm)				1	52			3
Ramellogammarus sp.			1	22			2	
Pomatiopsis sp.	3		2		4		1	
Berosus sp.	4						8	
Hyalella sp.	7		1			2	5	1
Orthocladiinae			11		2	4		
Corisella sp.	1		21	5	14	3	2	
Tanypodinae	20	4	11	6	12	14	16	1
Cyprididae	63	171	1			45		
Chironominae	43	26	4	83	17	1	104	6
Limnodrilus sp.	56	3	53	177	2	6	4	1

DISCUSSION

The 2004 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 difficult to bring samples to the water surface since a good seal could not be formed. 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 and fall. The goal of this survey was to determine the effects, if any, the discharge from the Ventura Water Reclamation Facility has had on the biological communities in the Estuary.

River flow into the Estuary was typical of the past several years when drought conditions have prevailed. The only major storms of the year occurred in December and February. Rain events lead to removal of the sand berm at the mouth of the Estuary, thus allowing the Estuary to drain to the ocean. Even though sampling in May occurred after nearly three months of dry weather, the berm at the mouth of the Estuary had remained open. During the dry weather, season in the summer and fall, the berm redeveloped and the Estuary became inundated with water. As a result, the Estuary began a cycle of inundation due to flow from the Santa Clara River and the VWRF. This was combined with periodic partial draining as the sand berm was breached due to hydraulic and tidal pressure. Sampling in the fall occurred after the berm was partially breached and water levels in the Estuary were lower than during periods of complete inundation.

Water quality in the Estuary during 2004 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 20.5 to 23.2 °C. These findings were within the range of past studies (13.94 to 29.04, USFWS 1999). pH ranged from 7.14 at Station B7 during the spring to a high of 9.20 at the same station during the fall. Dissolved oxygen concentrations in the Estuary were highly variable ranging from 3.78 mg/L at Station B2 in fall to 8.97 mg/L during the fall at Station B3. 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) and 2003 (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 2004 survey, salinity during spring ranged from 0.0 ppt in the effluent channel to 5.2 ppt at Station B7 in the river channel. During the fall, salinity ranged from 0.0 ppt at Station B1 and B2 to 7.2 ppt at Station B3 and 6.4 ppt at Station B7. The slightly higher salinities measured at

Stations B3 and B7 were due to their location in the outer Estuary where the inflow of higher salinity water is more common. Salinity during the 2004 survey fell within the EPA's freshwater criterion (<1.0 ppt, 95% of the time) at Stations B1, B2 and B3, and below that of brackish water (5 to 10 ppt) at every station except B2 in the spring. 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 coarse sand at Station B1 in the effluent channel to coarse silt at Station B7 in the river channel. There was a shift toward finer particle sizes at effluent channel Stations B1 and B2 in the fall and in the spring at Station B7. The shifts, or lack thereof, in particle size distributions at Estuary stations between seasons were probably the result of their locations in the Estuary. The most dramatic difference between seasons at any site occurred at Station B7, which is located in the main river channel where sediments are constantly in flux. During the spring after a relatively dry winter season had ended, the sediments at this site were finer probably due to the lack of deposition of new upstream sediments. Why the sediment at this station became coarser during the summer and fall season is unclear. Particle sizes at Station B3, located in lower portion of the Estuary, remained relatively unchanged between sampling events. Both Stations B1 and B2 are located in a well protected side channel where the flow regime is fairly constant throughout the year. These sites are not subjected to heavy scouring except during very large storms.

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 2004 survey were those found in either freshwater or estuarine environments (USFWS 1999, ENTRIX 2003). The numbers of species collected at all stations by grab in the spring (13) were somewhat lower than in the fall (17). Normally, lower numbers of species might be expected during the spring due to scouring and deposition of upstream sediments during storm events. Since sampling occurred after several months of dry weather in the spring, it is probable that the BMI population remained more balanced during the year. The numbers of species collected in 2004 were similar to 2003 (Aquatic Bioassay 2004); though much less than during the 2002 survey, when taxa richness was highest during the fall closed estuary sampling (30) and lowest during the spring open estuary sampling (25) (ENTRIX (2003). During surveys conducted from 1997 to 1998 by Greenwald et al. (USFWS 1999) taxonomic richness averaged 24.

The average abundance of organisms collected by grab during the 2004 survey was similar between the spring (1,364) and fall (1,514). This was half the average numbers collected in 2003 in the spring (2,630) and the fall (2,963). It is possible that the drop in abundance in 2003 was a result of the equipment change from a coring device to a grab. However, the abundances measured in the littoral sweep

samples, for which the sampling technique had not changed, were also lower in 2004 (1,836 and 342 for spring and fall respectively) compared to 2003 (5,032 and 5,148 for spring and fall respectively). 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). Compared to this survey (2004), when a total of 14,385 organisms were collected, Greenwald et al. (USFWS 1999) collected far fewer organisms by 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 points out the highly dynamic nature of the Estuary environment.

By far the most abundant and ubiquitous species collected by grab from all sites combined was the cypridid ostracod, *Lymnocythere sp.* (>75% of the total population at all sites). This species has a tolerance value of eight indicating that it is capable of living under stressed conditions. Other relatively abundant organisms found during the 2004 spring survey included a gammarid amphipod (*Ramellogammarus sp*.) and a tubificid oligochaete (*Limnodrilus sp*.). During the fall the next most abundant species included flies (Chironominae), cypridid ostracods, and *Limnodrilus sp*. During the 2002 survey, *Limnodrilus sp*. was abundant and found at every site (ENTRIX 2003). Other abundant species collected by core during the 2003 survey included *Eogammarus sp*., isotomids, chironomids (flies), nematodes, *Pomatiopsis sp*. (gastropod), and Cyclopodia (copepod). Each of these was also found in relatively similar abundances across stations during the 2002 survey (ENTRIX 2003).

The results of sampling by littoral sweep were mixed. When compared with the grab sampling device, littoral sweep samples yielded higher abundances during the spring (1,836) and lower abundances during the fall (342). Additionally, the numbers of taxa collected by littoral sweep in 2004 were on the low end of the range compared to those collected by grab. The total number of taxa collected during both surveys and sampling techniques combined was 18. Of these, none were unique to the littoral sweep. This shows that the littoral sweep was likely less efficient in terms of total numbers of organisms and taxa collected.

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). 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 combine to make this a very difficult habitat to survive in.

The composition of the biological population found at SCRE stations during the 2004 survey appear to be most influenced by these factors. Differences between 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, along 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, 2004.

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	0.70	9.47	33.00	33.42	15.94	5.69	1.44	0.25	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B2	0.52	5.76	20.71	30.53	25.36	13.12	3.41	0.56	0.03	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
B3	0.50	4.71	14.95	21.72	22.08	21.10	11.59	2.78	0.57	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	0.04	0.70	2.16	4.59	6.95	8.95	10.64	11.49	11.31	10.25	8.59	6.73	5.33	3.75	2.61	1.69	1.42	0.99	0.66	0.59	0.47	0.10	0.00	0.00
October																											
B1	0.00	0.06	2.11	8.61	18.88	19.27	12.59	8.97	7.95	6.06	4.12	2.89	2.33	1.94	1.53	1.19	0.78	0.48	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B2	0.00	0.00	0.16	1.98	10.77	24.88	22.18	8.88	4.02	2.68	2.67	3.18	3.72	3.82	3.32	2.68	1.79	1.15	0.72	0.58	0.40	0.19	0.16	0.07	0.00	0.00	0.00
B3	0.28	3.36	10.18	16.53	21.41	25.15	16.05	4.66	1.23	0.43	0.17	0.14	0.15	0.15	0.12	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	0.31	4.93	17.18	26.13	24.98	16.50	5.76	1.35	0.54	0.36	0.37	0.41	0.42	0.38	0.31	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX C - MACROINVERTEBRATES

Table 5. Identified taxa for the Spring 2004 sampling event, by lifestage, by Station for Santa Clara River Estuary Stations.

								SCRE B1 Littoral Sweep	SCRE B1			SCRE B2			SCRE B3			SCRE B7		
Phylum	Class	Order	Family	Genus	Scientific Name	Tolerance Value (TV)	Functional Feeding Group (FFG)	1	1	2	3	1	2	3	1	2	3	1	2	3
Cnidaria		Actiniaria	Ophuroidea		**Ophuroidea (damaged)**	.	.													
Nematoda					**Nematoda**	5	.													
Mollusca	Gastropoda	Basommatiphora	Physidae	Physa/Physella	***Physa/Physella sp.***	8	sc				2									
			Lymanaeidae	*Fossaria*	***Fossaria sp.***	8	sc													
		Mesogastropoda	Hydrobiidae	*Pomatiopsis*	***Pomatiopsis sp.***	**8**	**sc**		1				1	1						
Annelida	Oligochaeta		Lumbriculidae		**Lumbriculidae**	5	cg													
			Tubificidae	*Limnodrilus*	***Limnodrilus sp.***	10	cg	42	149	14	5	103	15	41	2	4	13		2	7
Arthropoda	Branchiopoda	Diplostraca	Chydoridae		**Chydoridae**	.	**cf**	0												
			Daphniidae	*Daphnia*	***Daphnia sp***	**8**	**cf**	0				2								
	Malacostraca	Amphipoda	Gammaridae	*Ramellogammarus*	***Ramellogammarus sp.***	6	cg	102	62	91	35	2		1	50	69	15	84	46	384
			Talitridae	*Hyallela*	***Hyalella sp.***	8	cg	6	9	1	2		1							
		Decapoda	Astacidae	*Pacifastacus*	***Pacifasticus sp.***	6	om	0												
	Maxillipoda	Cycopoida			**Cyclopoida**	**8**	**cf**	0												
		Harpacticoida			**Harpacticoida**	**8**	**cf**	0												
	Ostracoda	Podocopina	Cyprididae		**Cypridídae type 1**	8	cg	0	5	12	5	27	2			5			6	6
					Cypridídae type 2	8	cg	0	30	4	1	1	1		37					
					Cypridídae type 3	8	cg	0	2				1							
					Cypridídae type 4	8	cg	0					1							
					Cypridídae total	8	cg	0												
			Limnocytheridae	*Limnocythere*	***Limnocythere sp.***	8	cg	1638	998	1443	739	1824	1128	2281	399	167	409	999	890	1920
	Insecta	Collembola	Isotomidae		**Isotomidae**	**5**	**cg**	0												
		Zygoptera	Coenagrionidae	*Enallagma sp*	***Enallagma sp.***	9	p	0	1											
		Hemiptera	Corixidae	*Corisella*	***Corisella sp.***	8	p	30	1			4	28	2	11	2				
		Coleoptera	Dryopidae	*Helichus*	***Helichus sp.*** **(A)**	5	sh	0												
				Hydroporus	***Hydroporus sp. (L)***	5	p	0												
			Hydrophilidae	*Berosus*	***Berosus sp.*** **(L)**	5	p	12	5	3		2		4						
		Diptera	Ceratopogonidae		**Ceratopogonidae (P)**	6	p	0												
				Dasyhelea	***Dasyhelea sp.***	6	cg	0												
					.	.	.	0												
			Chironomidae		**Chironominae**	6	cg	0												
					Chironomini	6	cg	0												
				Chironomus sp.	***Chironomus sp.***	10	cg	6	9	5	5		3			2		9	3	13
				Chironomus sp. (P)	***Chironomus sp.*** **(P)**	10	cg	0												2
				Dicrotendipes sp.	***Dicrotendipes sp.***	8	cg	0	33	2	1									
				Dicrotendipes sp. (P)	***Dicrotendipes sp. (P)***	8	cg	0												
				Phaenopsectra/Tribelos sp.	***Phaenopsectra/Tribelos sp.***	7	sc	0												
				Polypedilum sp.	***Polypedilum sp.***	6	sc	0												
					Tanytarsini	6	cg	0												
				Paratanytarsus sp.	***Paratanytarsus sp.***	6	cg	0	59	11	4	4		3	1			6	6	18
				Tanytarsus	***Tanytarsus***	6	cf	0	1			2					1	12		8
								0												
					Orthocladiinae	5	cg	0												
				Cricotopus	***Cricotopus sp.***	7	cg	0	9	5		1	1	2	3	2			1	
					Cricotopus sp. **(P)**	7	cg	0		1										
				Cricotopus Binctus Gr.	***Cricotopus Binctus Gr.***	7	cg	0												
				Eukiefferiella	***Eukiefferiella sp.***	8	cg	0	4											
				Orthocladius Complex	***Orthocladius Complex***	6	cg	0	1											
				Rheocricotopus	***Rheocricotopus sp.***	6	cg	0												
				Thienemanniella	***Thienemanniella sp.***	6	cg	0												
					Thienemanniella sp. **(P)**	6	cg	0												
								0												
					Tanypodinae	7	p	0												
					Pentaneurini	6	p	0												
				Apedilum	***Apedilum sp.***	6	p	0												
				Pentaneura	***Pentaneura sp.***	6	p	0												
				Tanypus	***Tanypus sp.***	10	p	0			2	43	4	14		8				
					Tanypus sp. (P)	10	p	0												
					Procladius sp.	9	p	0			1	1		1						
								0												
			Dolichopodidae		***Dolichopodidae*** **(L)**	4	p	0												
			Ephydridae	***Ephydra***	***Ephydra sp.*** **(L)**	6	sh	0										1		
				Hydrellia	***Hydrellia sp. (L)***	6	sh	0												
			Muscidae	***Limnophora***	***Limnophora sp.*** **(L)**	6	p	0												
			Sciomyzidae		**Sciomyzidae (P)**	6	p	0												
			Simuliidae	***Simulium***	***Simulium sp.*** **(L)**	6	cf													
					Total BMIs/sample			1836	1379	1592	802	2016	1186	2350	503	259	438	1111	954	2358

Table 5. Identified taxa for the Fall 2004 sampling event, by lifestage, by Station for Santa Clara River Estuary Stations.

						Tolerance Value (TV)	*Functional Feeding Group (FFG)*	SCRE B1 Littoral Sweep	SCRE B1			SCRE B2			SCRE B3			SCRE B7		
Phylum	**Class**	**Order**	**Family**	**Genus**	**Scientific Name**			1	1	2	3	1	2	3	1	2	3	1	2	3
Cnidaria		Actiniaria	Ophuroidea		**Ophuroidea (damaged)**	.	.													
Nematoda					**Nematoda**	5	.													
Mollusca	Gastropoda	Basommatiphora	Physidae	Physa/Physella	***Physa/Physella sp.***	8	sc				1	1					2	1		
			Lymanaeidae	*Fossaria*	***Fossaria sp.***	8	sc													
		Mesogastropoda	Hydrobiidae	*Pomatiopsis*	***Pomatiopsis sp.***	**8**	**sc**		7			28	35	4						
Annelida	Oligochaeta		Lumbriculidae		**Lumbriculidae**	5	cg													
			Tubificidae	*Limnodrilus*	***Limnodrilus sp.***	10	cg	3	9	3		36	482	12	1	2		4	2	
Arthropoda	Branchiopoda	Diplostraca	Chydoridae		**Chydoridae**	**.**	**cf**													
			Daphniidae	*Daphnia*	***Daphnia sp***	**8**	**cf**	4	2		4									
	Malacostraca	Amphipoda	Gammaridae	*Ramellogammarus*	***Ramellogammarus sp.***	6	cg											3		
			Talitridae	*Hyallela*	***Hyalella sp.***	8	cg	33	22	2								1		
		Decapoda	Astacidae	*Pacifastacus*	***Pacifasticus sp.***	6	om													
	Maxillipoda	Cycopoida			**Cyclopoida**	**8**	**cf**	1	3		1									
		Harpacticoida			**Harpacticoida**	**8**	**cf**													
	Ostracoda	Podocopina	Cypridiidae		**Cypridiidae type 1**	8	cg	55	10	26	11	8	4	5		2		20	6	9
					Cypridiidae type 2	8	cg													
					Cypridiidae type 3	8	cg													
					Cypridiidae type 4	8	cg													
					Cypridiidae total	8	cg													
			Limnocytheridae	*Limnocythere*	***Limnocythere sp.***	8	cg	9	968	86	92	2754	2319	2063	279	459	398	3249	6324	948
	Insecta	Collembola	Isotomidae		**Isotomidae**	**5**	**cg**													
		Zygoptera	Coenagrionidae	*Enallagma sp*	***Enallagma sp.***	9	p	1												
					Coenagrionidae (imm)	9	p				1									
		Hemiptera	Corixidae	*Corisella*	***Corisella sp.***	8	p											2	1	2
					Corixidae (imm)	8	p					1	1			7	1	145	4	8
		Coleoptera	Dryopidae	*Helichus*	***Helichus sp.* (A)**	5	sh													
				Hydroporus	***Hydroporus sp. (L)***	5	p													
			Hydrophilidae	*Berosus*	***Berosus sp.* (L)**	5	p		2					1				5	2	5
		Diptera	Ceratopogonidae		**Ceratopogonidae (P)**	6	p													
				Dasyhelea	***Dasyhelea sp.***	6	cg											1		
						.	.													
			Chironomidae		**Chironominae**	6	cg													
					Chironomini	6	cg													
				Chironomus sp.	***Chironomus sp.***	10	cg	154	111	16	35	9	7	19						2
				***Chironomus sp.* (P)**	***Chironomus sp.* (P)**	10	cg	1	10	2	2			1						
				Dicrotendipes sp.	***Dicrotendipes sp.***	8	cg	5	12		2									
				Dicrotendipes sp. (P)	***Dicrotendipes sp. (P)***	8	cg													
				Phaenopsectra/Tribelos sp.	***Phaenopsectra/Tribelos sp.***	7	sc													
				Polypedilum sp.	***Polypedilum sp.***	6	sc													
					Tanytarsini	6	cg													
				Paratanytarsus sp.	***Paratanytarsus sp.***	6	cg	3	27	2	9	1	3							
				Tanytarsus	***Tanytarsus***	6	cf	22	60	7	16	98	73	38		16	3	27		21
					Orthocladiinae	5	cg													
				Cricotopus	***Cricotopus sp.***	7	cg		8						1	1				
					***Cricotopus sp.* (P)**	7	cg		7											
				Cricotopus Binctus Gr.	***Cricotopus Binctus Gr.***	7	cg													
				Eukiefferiella	***Eukiefferiella sp.***	8	cg													
				Orthocladius Complex	***Orthocladius Complex***	6	cg													
				Rheocricotopus	***Rheocricotopus sp.***	6	cg													
				Thienemanniella	***Thienemanniella sp.***	6	cg													
					***Thienemanniella sp.* (P)**	6	cg													
					Tanypodinae	7	p													
					Pentaneurini	6	p													
				Apedilum	***Apedilum sp.***	6	p	4	7			1	8							
				Pentaneura	***Pentaneura sp.***	6	p													
				Tanypus	***Tanypus sp.***	10	p	2				1	2	3				1		42
					Tanypus sp. (P)	10	p													
					Procladius sp.	9	p													
			Dolichopodidae		***Dolichopodidae* (L)**	4	p												3	
			Ephydridae	***Ephydra***	***Ephydra sp.* (L)**	6	sh								1	51	10	3	2	
				Hydrellia	***Hydrellia sp. (L)***	6	sh													
			Muscidae	***Limnophora***	***Limnophora sp.* (L)**	6	p									1		1		
			Sciomyzidae		**Sciomyzidae (P)**	6	p													
			Simuliidae	***Simulium***	***Simulium sp.* (L)**	6	cf													
					Total BMIs/sample			297	1265	144	174	2938	2934	2146	282	539	414	3463	6344	1037

Table 7. Bioassessment metrics calculated for each station during the spring 2004 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.

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	1836	1258	1851	400	1474	1364	4.00**	0.05	B2 > B3
	st. dev.	N/A	408	599	126	769	476			
	cv	N/A	32	32	32	52	37			
Taxonomic richness	mean	7.00	9.33	9.33	6.33	5.00	7.40	6.09**	0.02	B1, B2 > B7
	st. dev.	N/A	1.53	0.58	2.08	1.00	1.30			
	cv	N/A	16.37	6.19	32.87	20.00	18.86			
Shannon Diversity	mean	0.49	0.61	0.29	0.68	0.42	0.50	1.33	0.33	
	st. dev.	N/A	0.35	0.14	0.35	0.13	0.24			
	cv	N/A	57.15	46.77	51.94	31.53	46.85			
% dominant taxa	mean	89.22	85.01	94.22	79.06	88.21	87.14	1.27	0.34	
	st. dev.	N/A	10.97	3.38	14.45	6.11	8.73			
	cv	N/A	12.90	3.59	18.28	6.93	10.43			
Percent Chironomidae	mean	0.33	3.85	1.35	1.89	1.74	1.83	0.65	0.60	
	st. dev.	N/A	3.95	1.02	2.40	0.69	2.02			
	cv	N/A	102.82	75.75	127.09	39.73	86.35			
Tolerance Value	mean	7.91	7.67	7.94	7.64	7.94	7.82	1.88	0.21	
	st. dev.	0.00	0.20	0.04	0.40	0.52	0.23			
	cv	0.00	2.55	0.52	5.22	6.54	2.97			
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	0.00	0.00			
	cv	0.00	0.00	0.00	0.00	0.00	0.00			
Percent Tolerance Value (8-10)	mean	93.46	91.07	98.51	84.78	88.68	91.30	1.55	0.27	
	st. dev.	N/A	3.82	1.09	14.35	6.17	6.36			
	cv	N/A	4.19	1.11	16.92	6.96	7.30			
Percent Collectors	mean	97.71	99.49	97.90	97.98	99.97	98.61	2.73	0.11	
	st. dev.	N/A	0.29	1.01	1.94	0.05	0.82			
	cv	N/A	0.29	1.03	1.98	0.05	0.84			
Percent Filterers	mean	0.00	0.00	0.03	0.00	0.00	0.01	N/A	N/A	
	st. dev.	0.00	0.00	0.06	0.00	0.00	0.01			
	cv	N/A	N/A	173.21	N/A	N/A	173.21			
Percent Grazers	mean	0.00	0.11	0.04	0.00	0.00	0.03	2.00	0.19	
	st. dev.	0.00	0.13	0.04	0.00	0.00	0.03			
	cv	N/A	119.51	99.69	N/A	N/A	109.60			
Percent Predators	mean	2.29	0.36	2.02	2.02	0.00	1.34	2.90	0.10	
	st. dev.	0.00	0.16	0.98	1.94	0.00	0.62			
	cv	0.00	44.95	48.66	96.04	N/A	47.41			
Percent Shredders	mean	0.00	0.00	0.00	0.00	0.03	0.01	N/A	N/A	
	st. dev.	0.00	0.00	0.00	0.00	0.05	0.01			
	cv	N/A	0.00	0.00	0.00	173.21	43.30			

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 2004 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.

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	343	528	2673	412	3615	1514	7.51[1.]	0.05	
	st. dev.	N/A	639	456	129	2657	970			
	cv	N/A	121	17	31	73	61			
Taxonomic richness	mean	9.00	7.67	7.33	5.67	9.67	7.87	0.68	0.58	
	st. dev.	N/A	3.06	0.58	2.08	3.79	2.38			
	cv	N/A	39.85	7.87	36.74	39.16	30.91			
Shannon Diversity	mean	1.18	0.97	0.39	0.29	0.25	0.62	7.03**	0.01	B1 > B2, B3, B7
	st. dev.	N/A	0.15	0.24	0.27	0.20	0.22			
	cv	N/A	15.73	62.10	93.24	80.14	62.80			
% dominant taxa	mean	62.29	63.04	89.64	93.41	94.97	80.67	8.86**	0.001	B2, B3, B7 > B1
	st. dev.	N/A	12.17	9.26	7.28	4.25	8.24			
	cv	N/A	19.30	10.33	7.80	4.48	10.48			
Percent Chironomidae	mean	64.31	24.89	3.25	1.41	2.36	19.24	7.11[1.]	0.06	
	st. dev.	N/A	10.30	0.46	1.52	3.41	3.92			
	cv	N/A	41.40	14.03	107.77	144.54	76.93			
Tolerance Value	mean	6.76	7.52	8.06	7.89	7.96	7.64	7.02**	0.01	B2, B3, B7 > B1
	st. dev.	N/A	0.22	0.18	0.13	0.05	0.14			
	cv	N/A	2.93	2.27	1.60	0.64	1.86			
Percent Intolerance Value (0-2)	mean	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	
	st. dev.	N/A	0.00	0.00	0.00	0.00	0.00			
	cv	N/A	0.00	0.00	0.00	0.00	0.00			
Percent Tolerance Value (8-10)	mean	35.69	75.06	96.73	94.45	97.32	79.85	8.47**	0.01	B2, B3, B7 > B1
	st. dev.	N/A	10.26	0.44	6.40	3.56	5.16			
	cv	N/A	13.67	0.45	6.77	3.66	6.14			
Percent Collectors	mean	95.96	98.11	98.99	95.19	96.58	96.97	0.79	0.53	
	st. dev.	N/A	2.02	0.60	5.49	2.83	2.74			
	cv	N/A	2.06	0.61	5.77	2.93	2.84			
Percent Filterers	mean	1.68	1.09	0.00	0.00	0.00	0.55	2.77	0.42	
	st. dev.	N/A	1.56	0.00	0.00	0.00	0.39			
	cv	N/A	142.95	0.00	0.00	0.00	35.74			
Percent Grazers	mean	0.00	0.38	0.79	0.16	0.01	0.27	2.99	0.09	
	st. dev.	N/A	0.33	0.53	0.28	0.02	0.29			
	cv	N/A	86.65	67.41	173.21	173.21	125.12			
Percent Predators	mean	2.36	0.43	0.22	0.58	3.37	1.39	2.67[1.]	0.44	
	st. dev.	N/A	0.38	0.14	0.80	2.83	1.04			
	cv	N/A	88.06	63.16	138.44	84.01	93.42			
Percent Shredders	mean	0.00	0.00	0.00	4.08	0.04	0.82	9.31[1.]	0.02	B3 > B1, B2
	st. dev.	N/A	0.00	0.00	4.78	0.04	1.20			
	cv	N/A	0.00	0.00	117.13	111.33	57.11			

[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 2004.

SCRE Littoral Sweep B1		SCRE B1		SCRE B2		SCRE B3		SCRE B7	
Taxa	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**
Limnocythere sp.	*89.2*	*Limnocythere sp.*	*84.3*	*Limnocythere sp.*	*94.3*	*Limnocythere sp.*	*81.3*	*Limnocythere sp.*	*86.1*
Ramellogammarus sp.	*5.6*	*Ramellogammarus sp.*	*5.0*	*Limnodrilus sp.*	*2.9*	*Ramellogammarus sp.*	*11.2*	*Ramellogammarus sp.*	*11.6*
Limnodrilus sp.	*2.3*	*Limnodrilus sp.*	*4.5*	Tanypodinae	*1.1*	Cyprididae total	*3.5*	Chironominae	*1.7*
Corisella sp.	*1.6*	Chironominae	*3.4*	*Corisella sp.*	*0.6*	*Limnodrilus sp.*	*1.6*	Cyprididae total	*0.3*
Berosus sp.	*0.7*	Cyprididae total	*1.6*	Cyprididae total	*0.6*	*Corisella sp.*	*1.1*	*Limnodrilus sp.*	*0.2*
Hyalella sp.	*0.3*	Orthocladiinae	*0.5*	Chironominae	*0.2*	Tanypodinae	*0.7*	Orthocladiinae	*0.02*
Chironominae	*0.3*	*Hyalella sp.*	*0.3*	*Berosus sp.*	*0.1*	Orthocladiinae	*0.4*	*Ephydra sp.*	*0.02*
		Berosus sp.	*0.2*	Orthocladiinae	*0.1*	Chironominae	*0.3*		
		Tanypodinae	*0.1*	*Ramellogammarus sp.*	*0.1*				
		Physa/Physella sp.	*0.1*	*Pomatiopsis sp.*	*0.04*				

Table 10. Ten most abundant species collected from each sampling site (reps = 3) in Santa Clara River Estuary during the fall 2004.

SCRE Littoral Sweep B1		SCRE B1		SCRE B2		SCRE B3		SCRE B7	
Taxa	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**
Chironominae	*62.3*	*Limnocythere sp.*	*72.4*	*Limnocythere sp.*	*89.0*	*Limnocythere sp.*	*92.0*	*Limnocythere sp.*	*97.0*
Cyprididae total	*18.5*	Chironominae	*19.6*	*Limnodrilus sp.*	*6.6*	*Ephydra sp.*	*5.0*	Corixidae (imm)	*1.4*
Hyalella sp.	*11.1*	Cyprididae total	*3.0*	Chironominae	*3.1*	Chironominae	*1.5*	Chironominae	*0.5*
Limnocythere sp.	*3.0*	*Hyalella sp.*	*1.5*	*Pomatiopsis sp.*	*0.8*	Corixidae (imm)	*0.6*	Tanypodinae	*0.4*
Tanypodinae	*2.0*	Orthocladiinae	*0.9*	Cyprididae total	*0.21*	*Limnodrilus sp.*	*0.24*	Cyprididae total	*0.3*
Daphnia sp	*1.3*	*Limnodrilus sp.*	*0.8*	Tanypodinae	*0.19*	*Physa/Physella sp.*	*0.16*	*Berosus sp.*	*0.11*
Limnodrilus sp.	*1.0*	*Pomatiopsis sp.*	*0.44*	Corixidae (imm)	*0.02*	Cyprididae total	*0.16*	*Limnodrilus sp.*	*0.06*
Cyclopoida	*0.34*	Tanypodinae	*0.44*	*Physa/Physella sp.*	*0.01*	Orthocladiinae	*0.16*	*Corisella sp.*	*0.05*
Enallagma sp.	*0.34*	*Daphnia sp*	*0.38*	*Berosus sp.*	*0.01*	*Limnophora sp.*	*0.08*	*Ephydra sp.*	*0.05*
		Cyclopoida	*0.25*					*Ramellogammarus sp.*	*0.03*