Rapid Stream Bioassessment

4.1 Background

MEC conducted stream bioassessment pursuant to RWQCB Order No. 2001-01 to assess the ecological health of the watershed units in San Diego County. The assessment was undertaken utilizing a protocol that samples and analyzes populations of benthic macroinvertebrates (BMIs). This program supplements the monitoring program conducted by the California Department of Fish and Game (CDFG) Water Pollution Control Laboratory from 1997 to May of 2001, under contract to the RWQCB. MEC followed the sampling and analysis protocols of the California Stream Bioassessment Procedure (CSBP) (Harrington 1999), a standardized procedure developed for California by CDFG and adapted from the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (Barbour et al. 1999). To further enhance data consistency and comparability, MEC sampled many of the same streams at similar locations as the previous CDFG surveys. CDFG selected the original sampling sites to complement the RWQCB's ongoing water quality monitoring programs.

The sampling protocol of the CSBP includes the collection of stream benthic macroinvertebrates and also assesses the quality and condition of the physical habitat. Utilizing species specific tolerance values and community species composition, numerical biometric indices are calculated, allowing for comparison of relative habitat health among streams in a region. Over time, this information is used to identify ecological trends and aid analyses of the appropriateness of water quality management programs (Yoder and Rankin 1998). Invertebrates reside in streams for periods ranging from a month to several years, and have varying sensitivities to the multiple stressors associated with urban runoff. By assessing the invertebrate community structure of a stream, a cumulative measure of stream habitat health and ecological response is obtained. This information may complement monitoring programs that test the chemical and physical water quality parameters and provide a measure of habitat conditions at the moment sampling occurs. The addition of bioassessment to chemical, bacterial, and toxicological approaches to watershed monitoring programs gives a comprehensive indication of water quality and the effects of ecological impacts.

This report presents the results from three stream bioassessment surveys, conducted in May 2002, October 2002, and May 2003. The data includes a taxonomic listing of all benthic macroinvertebrates identified in the surveys, and calculation of the biological metrics listed in the CSBP. Additionally, calculation of the Index of Biotic Integrity (IBI) for all monitoring reaches is included, following the most recent version developed by the CDFG Aquatic Bioassessment Laboratory for coastal southern California (Ode, Rehn, and May, unpublished data).


Benthic macroinvertebrate sampling

4.2 Materials and Methods

A general description of the methods incorporated in the sampling program is presented below. MEC personnel adhered to the protocols of the CSBP (Harrington 1999) as closely as practicable, and this document may be referenced for more detailed procedural information.

4.2.1 Monitoring Reaches

A minimum of 23 monitoring reaches were sampled in each survey, including three reference sites per survey. Descriptions of the locations are presented in Table 4-1 and a map illustrating these locations is shown in Figure 4-1. The primary goal for each survey was to sample 2 monitoring reaches in each of the 10 watershed management areas that have storm water mass loading stations. Of the two monitoring reaches, one was located as far downstream in the watershed as was practicable, and the other was located farther upstream in the watershed, but where it was still affected to some degree by urban development. Where possible, sites were located in the same stream reach that CDFG has previously sampled. Ongoing reconnaissance of the streams, with the goal of finding riffles with the highest quality in-stream habitats, has resulted in re-location of some of the monitoring reaches.

Reference sites have been designated by CDFG and the RWQCB based on upstream land use characteristics as determined by GIS datasets. When selecting reference monitoring sites for comparison with urban affected sites, statistical analyses by CDFG has indicated that in southern California, elevation is not a significant factor affecting benthic community quality (Ode et al. 2002). It may be noted that the physical habitat quality at the reference sites was superior to some of the test monitoring sites.

4.2.2 Monitoring Reach Delineation

The sampling points specified in the CSBP are located in a stream feature known as a riffle. An ideal riffle is an area of rapid flow with some surface disturbance and a complex and stable substrate. These areas provide increased colonization potential for benthic invertebrates. Riffles typically support the greatest diversity of organisms in a stream, and by selecting the optimal habitats available at each stream, comparability among streams is possible.

Under optimal conditions, five riffles constituted a monitoring reach, and three of these were randomly selected for sampling. In some cases, particularly in low gradient streams, only three riffles could be located within a reasonable reach length, and all three were sampled. Given sufficient riffle length, a sampling transect perpendicular to stream flow was selected randomly in the upper third of the riffle. In situations where the riffle was very short or narrow, the sample was taken to best represent available substrate types. Every monitoring reach was sampled from downstream to upstream. The locations and coordinates of the monitoring reaches are presented in Table 4-1, and a map of the locations is shown in Figure 4-1. Photographs were taken of every riffle sampled and one photograph representing each monitoring reach is presented in Appendix B.1.

Table 4-1. San Diego County: Stream Bioassessment Sampling Sites. May 2002, October 2002, May 2003.

Watershed Name	Receiving Water	Station Identification	Site Description	Station Coordinates
Santa Margarita River	Sandia Creek	REF-SC	Reach consisted of 5 riffles along Sandia Creek Drive	33 25.482' 117 14.942'
Santa Margarita River	De Luz Creek	REF-DLC	Reach consisted of 5 riffles downstream of De Luz Road	33 26.248' 117 19.434'
Santa Margarita River	De Luz Creek	REF-DLC3	Reach consisted of 5 riffles along De Luz-Murietta Road	33 27.574' 117 17.456'
San Luis Rey River	Keys Creek	REF-KC	Reach consisted of 5 riffles at Old Lilac Road	33 26.483' 117 19.434'
San Diego River	Cedar Creek	REF-CC	Reach consisted of 5 riffles upstream of Cedar Creek Road	33 01.514' 116 38.029'
Santa Margarita River	Santa Margarita River	SMR-WGR	Reach consisted of 5 riffles upstream of Willow Glen Road	33 25.614' 117 11.861'
Santa Margarita River	Santa Margarita River	SMR-DLR	Reach consisted of 5 riffles downstream of De Luz Road	33 23.844' 117 15.734'
Santa Margarita River	Santa Margarita River	SMR-CP	Reach consisted of 5 riffles downstream of Santa Margarita Road, Camp Pendleton	33 20.457' 117 19.897'
San Luis Rey River	San Luis Rey River	SLRR-BR	Reach consisted of 2 riffles near the USGS gauging station	33 13.095' 117 21.569'
San Luis Rey River	San Luis Rey River	SLRR-MR	Reach consisted of 3 riffles upstream of Mission Road	33 15.587' 117 14.176'
Carlsbad	Loma Alta Creek	LAC-ECR	Reach consisted of 3 riffles up and downstream of El Camino Real	33 11.995' 117 19.878'
Carlsbad	Loma Alta Creek	LAC-CB	Reach consisted of 5 riffles of College Blvd.	33 12.363' 117 17.087'
Carlsbad	Buena Vista Creek	BVR-ED	Reach consisted of 5 riffles downstream of Santa Fe Av.	33 10.840' 117 19.717'
Carlsbad	Buena Vista Creek	BVR-CB	Reach consisted of 5 riffles downstream of College Blvd.	33 10.809' 117 17.918'
Carlsbad	Agua Hedionda Creek	AHC-MR	Reach consisted of 5 riffles downstream of Melrose Road	33 09.132' 117 14.454'
Carlsbad	Agua Hedionda Creek	AHC-ECR	Reach consisted of 5 riffles downstream of El Camino Real	33 08.940' 117 17.830'
Carlsbad	San Marcos Creek	SMC-M	Reach consisted of 5 riffles upstream of McMahr Road	33 07.831' 117 11.575'
Carlsbad	San Marcos Creek	SMC-SP	Reach consisted of 5 riffles downstream of Santar Place	33 08.501' 117 08.740'
Carlsbad	San Marcos Creek	SMC-RSFR	Rreach consisted of 4 riffles downstream of Rancho Santa Fe Road	33 06.191' 117 13.609'
Carlsbad	San Marcos Creek	SMC-LCCC	Reach consisted of 5 riffles upstream of La Costa Country Club	33 05.466' 117 14.664'
Carlsbad	Encinitas Creek	ENC-GVR	Reach consisted of 3 riffles southwest of El Camino Real and La Costa Blvd	33 04.697' 117 16.000'
Carlsbad	Cottonwood Creek	CC-E	Cottonwood Creek. Reach consisted of 4 riffles downstream of Hwy 101	33 02.905' 117 17.629'
Escondido Creek	Escondido Creek	ESC-HRB	Reach consisted of 5 riffles downstream of Harmony Grove Bridge	33 06.550' 117 06.688'
Escondido Creek	Escondido Creek	ESC-CC	Reach consisted of 5 riffles downstream of Country Club Road	33 05.925 ' 117 07.836'

Table 4-1. San Diego County: Stream Bioassessment Sampling Sites. May 2002, October 2002, May 2003.

Watershed Name	Receiving Water	Station Identification	Site Description	Station Coordinates
Escondido Creek	Escondido Creek	ESC-EF	Reach consisted of 5 riffles downstream of the old Elfin Forest Resort	33 04.417' 117 09.853'
Escondido Creek	Escondido Creek	ESC-VC	Reach consisted of 5 riffles in Vista Canyon	33 03.617' 117 10.802'
Escondido Creek	Escondido Creek	ESC-RSFR	Reach consisted of 3 riffles upstream of Rancho Santa Fe Road	33 02.365' 117 13.837'
San Dieguito River	Green Valley Creek	GVC-WB	Reach consisted of 5 riffles downstream of West Bernardo Drive	33 02.625' 117 04.567'
San Dieguito River	San Dieguito River	SD-DDH	Reach consisted of 5 riffles along Del Dios Highway downstream of Lake Hodges	33 02.459' 117 08.595'
Los Peñasquitos Creek	Los Peñasquitos Creek	LPC-CCR	Reach consisted of 5 riffles upstream of Cobblestone Creek Road	32 56.949' 117 04.214'
Los Peñasquitos Creek	Los Peñasquitos Creek	LPC-BMR	Reach consisted of 5 riffles downstream of Black Mountain Road	32 56.349' 117 07.864'
Los Peñasquitos Creek	Los Peñasquitos Creek	CCC-805	Reach consisted of 5 riffles downstream of I-805 at Sorrento Valley Road	32 53.403' 117 12.717'
Mission Bay	Rose Creek	MB-RC	Reach consisted of 5 riffles downstream of Highway 52	32 50.056' 117 13.887'
Mission Bay	Tecolote Creek	TC-TCNP	Reach consisted of 4 riffles downstream of Mt. Acadia Blvd	32 47.874' 117 11.339'
San Diego River	San Diego River	SDR-MT	Reach consisted of 5 riffles in Mission Trails Park	32 49.249' 117 03.866'
San Diego River	San Diego River	SDR-1	San Diego River. Reach consisted of 5 riffles downstream of Mission Valley Golf Course	32 45.736' 117 11.557'
San Diego Bay	Chollas Creek	CC-FB	Reach consisted of 5 riffles downstream of Federal Boulevard	32 43.606' 117 04.219'
Sweetwater River	Sweetwater River	SR-94	Sweetwater River. Reach consisted of 3 riffles at the Highway 94 crossing	32 43.962' 116 56.418'
Sweetwater River	Long Canyon Creek	SR-AD	Reach consisted of 5 riffles in Long Canyon Creek along Acacia Drive	32 39.394' 117 00.800'
Sweetwater River	Sweetwater River	SR-WS	Sweetwater River. Reach consisted of 5 riffles downstream of Bonita Road	32 39.436' 117 02.717'
Tijuana River	Tijuana River	TJ-DM	Tijuana River. Reach consisted of 5 riffles upstream of Dairy Mart Road	32 32.816' 117 03.741'

Figure 4-1. Stream Bioassessment Sites Sampled May 2002, October 2002, and May 2003.

4.2.3 Sample Collection

Once a sampling transect was established, benthic invertebrates were collected using a 1-ft-wide, 0.5-mm-mesh, D-frame kick-net. A 2-ft^2 area upstream of the net was sampled by disrupting the substrate and scrubbing the cobble and boulders, so that the organisms were dislodged and swept into the net by the current. The duration of the sampling generally ranged from 1 to 3 minutes, depending on substrate complexity. Three, 2-ft^2 areas were sampled along a transect and combined into a single composite sample representing 6 ft^2. The three sample points on the transect were selected to represent the diversity of habitat types present. This procedure was repeated for the next two riffles until three separate replicate samples were collected. Samples were transferred to one-quart jars, and preserved with 95% ethanol, and returned to MEC's laboratory for processing.

4.2.4 Physical Habitat Quality Assessment

For each monitoring reach sampled, the physical habitat of the stream and its adjacent banks were assessed using U.S. EPA Rapid Bioassessment Protocols. Habitat quality parameters were assessed to provide a record of the overall physical condition of the reach. Parameters such as substrate complexity, channel alteration, frequency of riffles, width of riparian zones, and vegetative cover help to provide a more comprehensive understanding of the condition of the stream. Additionally, specific characteristics of the sampled riffles were recorded, including riffle length, depth, gradient, velocity, and substrate composition.


Physical habitat assessment

Water quality measurements were taken at each of the monitoring sites using a YSI model 6600 environmental monitoring system. Measurements included water temperature, specific conductance, pH, dissolved oxygen, and chlorophyll. Chlorophyll was added to the water quality assessment in May 2003 to add information on phytoplankton productivity. Stream flow velocity was measured with a Marsh-McBirney Model 2000 portable flow meter, or was visually estimated.

4.2.5 Laboratory Processing and Analysis

At the laboratory, samples were poured over a No. 35 standard testing sieve (0.5-mm stainless steel mesh), and the ethanol was retained for re-use. The sample was gently rinsed with fresh water, and large debris, such as wood, leaves, or rocks was removed. The sample was transferred to a glass tray marked with grids 50-cm^2 in size. One grid was randomly selected, and the sample material contained within that grid was removed and processed. In cases where the animals appeared extremely abundant, a fraction of the grid may have been removed. The material from the grid was examined under a stereomicroscope, and all the invertebrates were removed, sorted into major taxonomic groups, and placed in vials containing 70% ethanol. If there were less than 300 animals in the grid, another grid was selected and processed. This process was repeated until 300 organisms were removed from the sample, or until the entire sample was sorted. Organisms from a grid in excess of the 300 were counted and placed in a separate vial labeled "remaining animals," so that a total abundance for the entire sample could be calculated. Terrestrial organisms, vertebrates, water-column associated organisms (e.g., copepods), and nematodes were not removed from the samples. Processed material from the sample was placed in a separate jar and labeled "sorted," and the unprocessed material was returned to the original sample container and archived. Sorted material was retained for quality assurance purposes.

All organisms were identified to the standard taxonomic level described in the CAMLnet List of Californian Macroinvertebrate Taxa and Standard Taxonomic Effort, using standard taxonomic keys. Quality assurance of sample sorting was performed on a minimum of 10 percent of the samples to ensure at least a 90% removal rate of organisms. Taxonomic quality assurance was performed on 10% of the samples by taxonomists at the CDFG Aquatic Bioassay Laboratory in Rancho Cordova, CA.

4.2.6 Data and Statistical Analysis

A taxonomic list of BMIs identified from the samples was created using Microsoft Excel. Metric values based on the BMI community were calculated from the database. A list of these metric values and a brief description of what they signify are presented in Table 4-2.

For every monitoring reach, an Index of Biotic Integrity (IBI) was calculated utilizing the most recent method developed by CDFG (Ode, Rehn, and May, In Press). The IBI replaces the Benthic Macroinvertebrate Index (BMI) Ranking Score used in past analyses and is a significant improvement because it gives an absolute value to the benthic community quality based on the range of reference conditions in the region. The IBI can also be used to evaluate community conditions over time to monitor the effects of habitat degradation or the success of restoration efforts. The BMI ranking score was limited to a comparison of sites within a single survey, and the rankings were relative to the average quality of the sites sampled.

Additional analysis of the data included a comparison of IBI scores with habitat quality, and a cluster analysis to show the relationship between species associations and reach characteristics.

4.3 Results and Discussion

The results of the three surveys are discussed below. Each survey is summarized separately. Monitoring reaches are usually described by the stream name and the nearest cross street. For ease of interpretation in the discussion, the full name of each site is used; in the tables, the site initials are used.

4.3.1 Regional Benthic Community Structure

Appendix B.1 presents photographs that characterize each monitoring reach. A complete listing of the benthic invertebrates identified at all stations and replicates is presented systematically in Appendix B.2 and ranked total abundances for each species at all sampling sites combined are presented in Appendix B.3. Appendix B.4 lists the percent composition of the top five most abundant taxa for each monitoring reach. The systematic listing also shows the assigned tolerance value (TV) and functional feeding group (FFG) of each taxa. The FFG designations have been refined since the previous report with the addition of macrophyte herbivores (MH), piercer herbivores (PH), omnivores (OM), and xylophages (XY). There has also been a revision in the standard level of taxonomic effort. The primary changes have been to identify all Chironomidae at the family level and to identify all Oligochaetes at the class level. Additionally, beginning in October 2002, copepods and nematodes were no longer included in the data. With the exception of some beetles, nearly all of the insects identified in the program were in the larval and pupal stages of development, which metamorphose into an aerial adult form. Nearly all of the non-insect taxa are aquatic for their entire life cycle.

Table 4-2. Bioassessment Metrics Used to Characterize BMI Communities.

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
Dipteran Taxa	Number of taxa in the insect order (Diptera, "true flies")	Increase
Non-Insect Taxa	Number of non-insect taxa	Increase
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 Index	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 Dominant Taxa	Percent composition of the single most abundant taxon	Increase
Percent Chironomidae	Percent composition of the tolerant dipteran family Chironomidae	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
Functional Feeding Groups (FFG)		
Percent Collector-gatherers	Percent of macrobenthos that collect or gather fine particulate matter	Increase
Percent Collector-filterers	Percent of macrobenthos that filter fine particulate matter	Increase
Percent Scrapers	Percent of macrobenthos that graze upon periphyton	Variable
Percent Predators	Percent of macrobenthos that prey on other organisms	Variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	Decrease
Percent Others	Percent of macrobenthos that are parasites, macrophyte herbivores, piercer herbivores, omnivores, and xylophages	Variable
Abundance		
Estimated Abundance	Estimated number of BMIs in sample calculated by extrapolating from the proportion of organisms counted in the subsample	Variable

Source: SDRWQCB 1999

To gain better insight into benthic community structure and habitat associations, a cluster analysis was performed for each survey. This analysis illustrates relationships between species, and also associations between species and habitat types of the monitoring reaches. The analysis is based on a Bray-Curtis similarity index calculated on relative abundances of taxa by location. Monitoring sites with similar communities of taxa will cluster together; likewise, taxa that occur together at different locations will cluster together. The station clusters also show habitat type preferences by taxa. The cluster diagrams are shown in Appendix B.5.

For the three surveys discussed below, it may be noted that the winter of 2001-2002 was one of the driest on record. For the May and October 2002 surveys, some streams had very low flow, and after the winter rainy season of 2002-2003, many sites (including reference sites) had very thick growths of filamentous green algae on hard substrates. At some sites (e.g., Escondido Creek-Elfin Forest) where in past surveys the cobble had supported rich colonies of Hydropsychid caddisflies, the algae appeared to prohibit colonization. During the October 2003 survey, field biologists reported that the algae had died off and the Hydropsychid colonies had returned.

<u>May 2002</u>

Summing all stations in the program, a total of 95 taxa were identified from 27,424 individual organisms (Appendix B.3-1). The five most abundant taxa, in descending order were Chironomidae (non-biting midges), the black fly *Simulium* (Diptera: Simuliidae), the minnow mayfly *Baetis* (Ephemeroptera: Baetidae), Oligochaetes (earthworms), and *Hyalella* (Amphipoda: Hyalellidae). All of these taxa are at least moderately tolerant to habitat impairment. Chironomids were the dominant taxon at 16 of the sites (Appendix B.4-1).

Benthic macroinvertebrates, 6X

Diptera, the order of true flies, had 27 different taxa identified (Appendix B.2-1). Twelve taxa of Trichoptera (caddisflies) and eight taxa of Coleoptera (beetles) were identified, most of which occurred at the reference sites.

Cluster analysis of the taxa and monitoring reaches shows five major species clusters and four station clusters (Appendix B.5-1). Station cluster A may be characterized by sites that had fairly slow current with substrates of small cobble and gravel. The macroinvertebrates most associated with this habitat included many fly and non-insect taxa of species clusters 4 and 5, plus the ubiquitous taxa of species cluster 3. Station cluster B included the sites with the slowest currents, and many of these sites had low complexity substrates dominated by sands and fines. Macroinvertebrates characteristic of these sites included Corixids (water boatmen), Ephydrids (shore flies), and the crayfish *Pacifasticus lenuisculus* in species cluster 2, as well as the widely dispersed taxa of species clusters 3, 4, and 5. Most of the sites in station cluster C had swift current and a substrate of stable cobble and small boulder. The species best associated with these sites included very abundant taxa such as Baetid mayflies, *Simulium*, Chironimids, and *Hyalella*, of species cluster 3. The water mite *Sperchon* and Planariid flatworms, both predators, of species cluster 4 were also present at many of the sites in station cluster C. Station cluster D included the three reference sites, and the physical habitat at these sites had complex stable substrates with good current velocity. The species associated with this cluster included most of the Coleoptera, Trichoptera, and Plecoptera taxa collected in the region, as well as the predatory water mites *Atractides* and

Torrenticola. This station/species cluster association was the strongest of the survey. There was also a strong correlation to many of the species in cluster 4.

October 2002

Summing all stations in the program, a total of 99 taxa were identified from 19,347 individual organisms (Appendix B.3-2). The five most abundant taxa, in descending order were Chironomidae, *Simulium*, the caddisfly *Hydropsyche* (Trichoptera: Hydropsychidae), *Hyalella*, and *Baetis*. Dominance by a single taxon was not as pervasive as in other surveys, with Chironomids, *Hydropsyche*, and *Simulium* the dominant taxon at five, four, and three sites, respectively (Appendix B.4-2).

The order Diptera had the greatest number of different taxa with 29 taxa identified (Appendix B.2-2). Nine taxa of Trichoptera, seven taxa of Coleoptera, and seven taxa of Odonata (dragonflies and damselflies) were identified.

Cluster analysis of the taxa and monitoring reaches shows six species clusters and four station clusters (Appendix B.5-2). Station cluster A included sites that had moderate current velocity with substrates of gravel and sand. These sites were most associated with species clusters 4 and 5, which included the most abundant and widely distributed taxa. Taxa in these clusters included Chironomids, *Simulium*, and most of the non-insect taxa. Station cluster B had sites with high velocity currents and substrates dominated by stable cobble and boulder. Species cluster 1 was highly associated with these sites, characterized by the presence of the caddisflies *Cheumatopsyche*, *Hydropshche*, and *Tinodes*, the water mite *Sperchon*, and the aquatic caterpillar *Petrophila*. These taxa also associated the sites of cluster B with the sites of cluster C. Cluster C included the three reference sites plus Santa Margarita River-Willow Glen Road. The taxa of species clusters 1 and 2 were best associated with these sites, particularly species cluster 2. Species cluster 2 contained the Elmids (riffle beetles), the water penny beetle *Psephenus,* and many Trichopteran genera unique to the sites of cluster C. Station cluster D contained sites that mostly had fast current velocity with stable but variable substrates ranging from concrete to boulder to gravel. Species clusters 3 and 4 were associated with these sites, including the crayfish *Procambarus* and *Pacifasticus*, Ostracods, the snail *Physa/Physella*, and a variety of Dipteran (fly) taxa.

May 2003

Summing all stations in the program, a total of 95 taxa were identified from 21,226 individual organisms (Appendix B.3-3). The five most abundant taxa, in descending order were Chironomidae, *Simulium*, *Baetis*, *Fallceon quilleri*, and Oligochaeta. Chironomids were the dominant taxon at eight of the sites, and Simulium was the dominant taxon at 7 of the sites (Appendix B.4-3).

The order Diptera had the greatest number of different taxa with 27 taxa identified (Appendix B.2-3). There were 12 taxa of Coleoptera, and 11 taxa of Trichoptera identified.

Cluster analysis of the taxa and monitoring reaches shows four major species clusters and five station clusters (Appendix B.5-3). Station cluster A may be characterized by sites that had high velocity currents and substrate dominated by large cobble and boulder. These sites were best associated with species cluster 3, which contained many of the highly abundant species that were widely distributed across the study region. Station cluster B was characterized by sites with slow current velocity and substrates of gravel and cobble. Many taxa in species cluster 4 were associated with these sites, including several predators such as Argia, Hemerodromia, and Sciomyzids (marsh flies). Species cluster 3 also contained many taxa in station cluster B. Station cluster C contained sites with variable substrates ranging from large stable cobble to sand, but all had moderate to fast current velocity. These sites included taxa in all of the species clusters, but were most associated with species clusters 2 and 3. Species cluster 2 had several Crustacean taxa, Stratiomyids (soldier flies), and Corixids. Station cluster D consisted of two sites in the Tijuana River watershed. Both of these sites had very slow current with substrates dominated by fine particulate organic matter. Taxa that correlated these two sites included Dytiscids (predaceous diving beetles), Ephydrid shore flies, and the snail *Physa/Physella*. Station cluster E was the cluster of reference sites, which were characterized by high quality habitats supporting benthic invertebrates found only within this cluster. Elmids (riffle beetles), the stoneflies *Malenka* and *Isoperla,* and the dobsonfly *Neohermes* were some of the taxa characterizing this cluster.

4.3.2 Benthic Invertebrate Community Metrics

Benthic macroinvertebrate community mean metric values for each monitoring reach are presented in Appendix B.6 and are summarized below. A brief description of the metrics and what they signify about the composition of the benthic community are given in Table 4-2.

4.3.2.1 Taxa Richness

<u>May 2002</u>
Mean taxonomic richness ranged from a low of 5.7 taxa at Agua Hedionda Creek-Melrose Drive to 23.3 at Reference-Keys Creek (Appendix B.6-1). Total cumulative taxa per monitoring reach ranged from 9 at Agua Hedionda Creek-Melrose Drive to 44 at Reference-Keys Creek.

<u>October 2002</u>
Mean taxonomic richness ranged from a low of 8.3 taxa at San Diego River-1 to 22.7 at Reference-Sandia Creek (Appendix B.6-2). Total cumulative taxa per monitoring reach ranged from 14 at San Diego River-1 and San Luis Rey River-Mission Road to 32 at Reference-Sandia Creek.

<u>May 2003</u>
Mean taxonomic richness ranged from a low of 8.3 taxa at San Diego River-Mission Trails, San Luis Rey River-Benet Road, and Tijuana River-Dairy Mart Road to 21.0 at Reference-De Luz Creek (Appendix B.6-3). Total cumulative taxa per monitoring reach ranged from 12 at San Diego River-Mission Trails, San Luis Rey River-Benet Road, and Tijuana River-Dairy Mart Road to 32 at Reference De Luz Creek.

4.3.2.2 Species Diversity and Dominance

<u>May 2002</u>
Mean Shannon Diversity values ranged from 0.7 at Tecolote Creek to 2.0 at Reference De Luz Creek and Reference Sandia Creek (Appendix B.6-1). Dominance by a single taxon ranged from 28% Chironomids at Reference Keys Creek to 76% Chironomids at Tecolote Creek.

<u>October 2002</u>
Mean Shannon Diversity values ranged from 0.9 at San Diego River-1 to 2.2 at Reference Sandia Creek (Appendix B.6-2). Dominance by a single taxon ranged from 15% *Baetis* at San Marcos Creek-La Costa Country Club to 57% *Simulium* at San Diego River-1.

<u>May 2003</u>
Mean Shannon Diversity values ranged from 0.9 at Cottonwood Creek-Highway 94 to 1.9 at Agua Hedionda Creek-El Camino Real (Appendix B.6-3). Dominance by a single taxon ranged from 28% at Chollas Creek-Federal Blvd. and Reference-De Luz Creek to 75% at Campo Creek-Highway 94 and Reference Cedar Creek. Chironomids were the dominant taxon is each case.

4.3.2.3 EPT Taxa

EPT taxa refers to benthic macroinvertebrates in the orders Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies, respectively. These orders are considered separately in the analysis because they contain many taxa that are sensitive to disturbance and their presence usually indicates good stream habitat quality (note: a modified EPT index is sometimes considered, which eliminates the moderately tolerant EPT taxa such as Baetid mayflies and Hydropsychid caddisflies).

May 2002
The cumulative number of EPT taxa ranged from 0 at Loma Alta Creek-College Blvd., San Diego River-1, and Tecolote Creek to 16 at Reference Keys Creek (Appendix B.6-1). The Baetid mayflies (primarily *Baetis* and *Fallceon quilleri*) were by far the most abundant of the EPT taxa, and were present at 24 of the 30 monitoring sites, and were the dominant taxon at 5 of the sites. San Marcos Creek-La Costa Country Club and San Diego River-Mission Trails had the highest number of EPT taxa (7 and 5, respectively) of the non-reference sites. Escondido Creek-Vista Canyon had the highest overall EPT%, where they comprised 64% of the benthic community. Sensitive EPT taxa (tolerance value 0-3) were present only at the reference sites, although there were no sensitive mayflies caught at any of the sites. The caddisfly *Micrasema* was the most abundant sensitive EPT taxon (Appendix B.2-1).

October 2002
The cumulative number of EPT taxa ranged from 1 at Loma Alta Creek-El Camino Real., San Diego River-1, and Sweetwater River-Acacia Dr. to 8 at Reference De Luz Creek 3 (Appendix B.6-2). Baetid mayflies were again the most abundant of the EPT taxa, and were present at 19 of the monitoring sites (Appendix B.3-2). San Dieguito River-Del Dios Highway and Santa Margarita-De Luz Road had the highest number of EPT taxa (7 and 8 taxa, respectively) of the non-reference sites. Santa Margarita River-Willow Glen Road had the highest overall EPT%, where they comprised 78% of the benthic community. Sensitive EPT taxa (tolerance value 0-3) were present at all of the reference sites, plus three of the non-reference sites. The sensitive caddisfly *Tinodes* was present at San Dieguito River-Del Dios Highway, Santa Margarita-De Luz Road, and San Marcos Creek-La Costa Country Club (Appendix B.2-2).

May 2003
The cumulative number of EPT taxa ranged from 0 at Tijuana River-Dairy Mart Road to 12 at Reference De Luz Creek (Appendix B.6-3). Baetid mayflies were present at all of the monitoring sites except Tijuana River-Dairy Mart Road, and were the dominant taxon at 6 of the sites (Appendix B.4-3). Santa Margarita River had six different EPT taxa, the highest of the non-reference sites. Escondido Creek-Harmony Grove Bridge had the highest overall EPT%, where they comprised 76% of the benthic community. Sensitive EPT taxa (tolerance value 0-3) were present only at the reference sites. The caddisfly *Micrasema* was the most abundant sensitive EPT taxon (Appendix B.3-3).

4.3.2.4 Tolerance Measures

For most stream macroinvertebrates, a tolerance value has been determined for each taxon through prior experience with the animals' life history (e.g., Hilsenhoff 1987). Tolerance values range from 0 for animals highly sensitive to impairments, to 10 for animals that are highly tolerant to impairments. It should be noted that tolerance values of organisms identified to the family or genus level are a mean of the taxa within that taxonomic level. The presence of impairment tolerant animals does not always imply impairment (SDRWQCB 2001), but the presence of intolerant animals is unlikely when impairment has occurred.

May 2002
Mean tolerance values for all sites ranged from 4.8 at Reference-Sandia Creek to 7.4 at Loma Alta Creek-College Blvd. and San Diego River-1 (Appendix B.6-1). San Diego River-Mission Trails had the lowest mean tolerance value of the non-reference sites. Intolerant organisms (tolerance value 0-2) were present only at the reference sites, and were most prevalent at Reference-De Luz Creek, where they comprised 11% of the benthic community. Percent tolerant organisms (tolerance value 8-10) ranged from 72% at Loma Alta Creek-College Blvd. to 1% at Escondido Creek-Elfin Forest and Reference-Sandia Creek.

October 2002
Mean tolerance values for all sites ranged from 4.5 at Reference-Sandia Creek to 7.5 at Sweetwater River-Acacia Drive (Appendix B.6-2). Both of the Santa Margarita River sites had mean tolerance values within the range of the reference sites. Intolerant organisms (tolerance value 0-2) were present at all of the reference sites, and were most prevalent at Reference-De Luz Creek 3, where they comprised 8% of the benthic community. Both of the Santa Margarita sites, plus San Dieguito River-Del Dios Highway and San Marcos Creek-La Costa Country Club had some highly intolerant organisms present. Percent tolerant organisms (tolerance value 8-10) ranged from 69% at Agua Hedionda Creek-El Camino Real to 1% at both of the Santa Margarita River Sites.

May 2003
Mean tolerance values for all sites ranged from 4.8 at Escondido Creek-Harmony Grove Bridge to 7.2 at Sweetwater River-Bonita Road (Appendix B.6-3). Mean tolerance values of the reference sites ranged from 5.3 to 5.7. Intolerant organisms (tolerance value 0-2) were present at all of the reference sites, and were most prevalent at Reference-De Luz Creek 3, where they comprised 7% of the benthic community. Highly intolerant organisms were also present at Campo Creek-Highway 94 and at San Dieguito River-Del Dios Highway, where the fly *Dixella* was collected (Appendix B.2-3). Percent tolerant organisms (tolerance value 8-10) ranged from 61% at Sweetwater River-Bonita Road to 1% at Escondido Creek-Harmony Grove Bridge and Reference-Sandia Creek.

4.3.2.5 Functional Feeding Groups

As with tolerance values, functional feeding group (FFG) designations have been determined through prior life-history research of each genus or species. Making determinations of water quality based on feeding group composition can be problematic, but there are some generalizations that can be made. The collector-gatherer and collector-filterer feeding groups feed on fine particulate organic matter and will increase in response to impairment. The shredder feeding group feeds by shredding coarse particulate organic matter such as leaves, and predators prey on other stream organisms, and these two groups will usually decrease in response to impairment. The herbivore and omnivore feeding groups vary in their response to impairment.

May 2002
Benthic invertebrates in the collector-gatherer feeding group dominated most of the monitoring sites in the region (Appendix B.6-1). Collector-filterers were also abundant at some sites. The most abundant collector- gatherers included Chironomid midges, Baetid mayflies, Oligochaetes, and the Amphipod *Hyalella* (Appendix B.2-1). The most abundant collector-filterers were the black fly *Simulium* and the caddisfly *Hydropsyche*. Predators were present in high numbers at one site, San Diego River-Mission Trails, due to the presence of the water mite *Sperchon* and Planariid flatworms. Shredders, scrapers, and others were present in low numbers at all sites.

October 2002
Benthic invertebrates in the collector-gatherer feeding group dominated most of the monitoring sites in the region (Appendix B.6-1). Collector-filterers were also dominant at some sites, including the reference sites and at Santa Margarita River and San Dieguito River. Composition of the collector-gatherer taxa was similar to the previous survey (Appendix B.2-1). The most abundant collector-filterers were the black fly *Simulium* and the caddisfly *Hydropsyche*. Predators were considerably more prevalent across the entire survey region in this survey than in both May surveys, primarily due to the increased abundance of *Sperchon,* Planariid flatworms, and the damselfly Argia.

May 2003
Functional feeding group compositions were similar to the May 2002 survey. Benthic invertebrates in the collector-gatherer feeding group dominated most of the monitoring sites in the region, and collector-filterers were most often the second most abundant group (Appendix B.6-1). Predators were present in low numbers throughout the study area, rarely accounting for more than 5% of the benthic community. Shredders, scrapers, and others were present in low numbers at all sites.

Dragonfly and Damselfly Naiads

4.3.2.6 Estimated Total Abundance

The estimated total abundance is the total number of animals estimated to be in the sample if the entire sample had been sorted. In rapid bioassessment programs, usually a fraction of the entire sample is processed and the percent volume of the fraction sorted is estimated. Then, a total abundance number is calculated for the entire sample. This represents an estimate of the number of animals living in 6 ft^2 of benthic habitat. The total abundance data is presented only as a general indicator of benthic community conditions. Response to moderate habitat impairment is often indicated by an increase in total abundance (by highly tolerant organisms) with a corresponding decrease in taxa richness and diversity; however, severe impairment can result in a catastrophic decrease in abundance.

May 2002
Mean estimated total abundance values ranged from 550 animals per sample at Sweetwater River-Highway 94 to 6,574 animals per sample at Cottonwood Creek-Encinitas Blvd (Appendix B.6-1). This range is quite moderate, and does not indicate severe habitat conditions at any of the sites.

October 2002
Mean estimated total abundance values ranged from 115 animals per sample at Agua Hedionda Creek-Melrose Drive to 5050 animals per sample at San Diego River-1 (Appendix B.6-2). Overall abundances across the survey region were much lower in the October survey than in the May surveys.

May 2003
Mean estimated total abundance values ranged from 783 animals per sample at San Luis Rey River-Benet Road to 11,556 animals per sample at Green Valley Creek-West Bernardo Road (Appendix B.6-3).

4.3.3 Physical Habitat Quality

Physical habitat quality scores for each monitoring reach are presented in Appendix B.6. The ten parameters are scored on a 0 to 20 scale, thus 200 is the highest possible score. The scores are assigned in a qualitative manner, so some variation among field biologists may be expected, and small differences in scores are not relevant. Large scale differences, however, are important when considering colonization potential by benthic macroinvertebrates.

May 2002

Total physical habitat quality scores ranged from 44 at Loma Alta Creek-College Blvd. to 171 at Reference-De Luz Creek (Appendix B.7-1). Several urban affected monitoring sites scored within the range of reference conditions, including Escondido Creek-Elfin Forest and Vista Canyon, San Diego River-Mission Trails, and San Marcos Creek-La Costa Country Club.

Water quality data is presented in Appendix B.8-1. pH measurements were mostly between 7.5 and 8.5, and the lowest reading occurred at Tecolote Creek with 7.0. Specific conductance, which can indicate the level of dissolved solids, was highest at Cottonwood Creek-Encinitas Blvd. (4.70 mS/cm), Tecolote Creek (4.50 mS/cm), and Encinitas Creek-Green Valley Road (4.30 mS/cm). Dissolved oxygen levels were moderate to high at all of the sites, and were the highest at Buena Vista River-So. Vista Way (18.24 mg/L) and San Marcos Creek-La Costa Country Club (18.04 mg/L). Both of these sites sustained thick growths of filamentous green algae. Average current velocities ranged from 0.6 ft/sec at Tecolote Creek to 3.0 ft/sec at Escondido Creek-Elfin Forest. Loma Alta Creek-El Camino Real, San Diego River-1, and Sweetwater River-Bonita Road had less than optimal current velocities (less than 1 ft/sec).

October 2002

Total physical habitat quality scores ranged from 64 at Sweetwater River-Acacia Drive to 175 at Santa Margarita River-Willow Glen Road (Appendix B.7-2).

San Marcos Creek in La Costa Canyon with heavy algae growth, May 2002

Water quality data is presented in Appendix B.8-2. pH values were somewhat higher than in the May surveys, as most sites were greater than 8.0. Specific conductance was highest at Tecolote Creek, Carroll Canyon Creek-805, and Sweetwater River-Acacia Drive, with values of 5.00 mS/cm, 3.63 mS/cm, and 3.60 mS/cm, respectively. Dissolved oxygen levels were mostly moderate, although both the San Diego River sites were quite low. Field biologists noted a considerable amount of dead filamentous algae at the San Diego River-Mission Trails site, and the flow level was very low. Current velocity was lowest at Tecolote Creek (0.7 ft/sec) and Agua Hedionda Creek-Melrose Drive (0.9 ft/sec).

May 2003

Total physical habitat quality scores ranged from 81 at Tijuana River-Dairy Mart Road to 178 at Reference De Luz Creek (Appendix B.7-3).

Water quality data is presented in Appendix B.8-3. pH values were all quite moderate, and the lowest reading occurred at Campo Creek-Highway 94 (7.3). Specific conductance was highest at Tecolote Creek and Chollas Creek-Federal Blvd., with values of 5.25 mS/cm and 4.95 mS/cm, respectively. For the May 2003 survey, in situ chlorophyll and turbidity readings were taken. Chlorophyll and turbidity were both substantially higher at Tijuana River-Dairy Mart Road than at all other sites. Dissolved oxygen values were moderate at most sites except Campo Creek-Highway 94, which had a dissolved oxygen reading of 1.5 mg/L. The substrate at this site was dominated by organic matter, and the riffles were shallow with low current velocity, which likely contributed to the low dissolved oxygen level in the water column.

4.3.4 Index of Biotic Integrity

During the last two years, the CDFG Aquatic Bioassessment Laboratory has been developing an Index of Biotic Integrity (IBI) applicable to a region extending from Monterey County to the Mexican Border, and inland to the borders of the Central Valley and the Mojave and Colorado Deserts. A preliminary IBI was published in December of 2002, and a revised IBI was developed in 2003. For this report, the revised IBI formula was used to calculate IBI scores for the monitoring reaches. The IBI is a multimetric index based on the cumulative value of seven biological metrics: percent collector-filterers plus collector-gatherers, percent non-insect taxa, percent tolerant taxa, cumulative Coleoptera taxa, cumulative predator taxa, percent tolerant individuals, and cumulative EPT taxa. These seven metrics were selected from sixty-one possible metrics based on responsiveness to disturbance and lack of correlation to other metrics (to avoid redundancy). In developing the revised IBI, analysis included data sets from a variety of studies, using collection protocols that differed somewhat in the level of sampling effort and habitat types sampled. To correlate samples collected according to the CSBP with other sampling protocols (on which the IBI scoring ranges are based) the 900 organism subsamples were reduced to 500 organisms by random elimination of taxa.

Each metric value was given a score from zero to ten based on the range of reference conditions in the region. The scores were summed and the total index score was categorized into qualitative ratings of Very Good, Good, Fair, Poor, and Very Poor. The revised IBI is more sensitive than the preliminary IBI, and reference sites in San Diego County rarely score in the Very Good range. The metrics and scoring ranges are shown in Table 4-3. Total IBI scores are shown in Figure 4-2, and include the IBI scores for June and October of 2001. This gives the IBI scores for up to five surveys conducted by MEC. A complete list of the IBI parameter values and scores for each monitoring reach are listed in Appendix B.9. Figure 4-3 shows the relationship between IBI scores and physical habitat quality for all three surveys.

To add perspective to the effects of randomly reducing the taxa list from 900 to 500 organisms, five separate reductions were performed and the range and average IBI scores are shown in Appendix B.10. It is interesting to note that for some monitoring reaches, the IBI score varied by up to 10 points, depending on the results of the random organism elimination step. This analysis indirectly illustrates the degree to which biological variability can affect the results of the analysis. It also shows that when a data reduction procedure, such as the IBI, is performed, interpretation of the results should not be limited to a single value. The researchers on this program noticed a few instances where the IBI score for a site was either higher or lower than expected based on overall knowledge of the benthic community composition.

Table 4-3. Index of Biotic Integrity Parameters and Scoring Ranges.

Parameter	% CF+CG	% Non-Insect Taxa	% Tolerant Taxa	Coleoptera Taxa	Predator Taxa	% Intolerant Individuals	EPT Taxa
Metric Score							
10	0-51	0-7	0-6	>5	>13	30-100	>19
9	52-55	8-12	7-9		12,13	27-29	17-19
8	56-60	13-16	10-12	5	11	24-26	15-16
7	61-66	17-20	13-16	4	10	21-23	13-14
6	67-71	21-25	17-19		9	18-20	11-12
5	72-76	26-29	20-22	3	8	15-17	9-10
4	77-81	30-33	23-26	2	7	12-14	7-8
3	82-86	34-38	27-29		6	9-11	5-6
2	87-91	39-42	30-32	1	5	6-8	3-4
1	92-95	43-46	33-35		4	3-5	1-2
0	96-100	47-100	36-100	0	0-3	0-2	0

Total IBI Scoring Ranges	0-13 Very Poor	14-26 Poor	27-40 Good	41-55 Good	56-70 Very Good

Source: Ode , Rehn, and May, Unpubl. Data

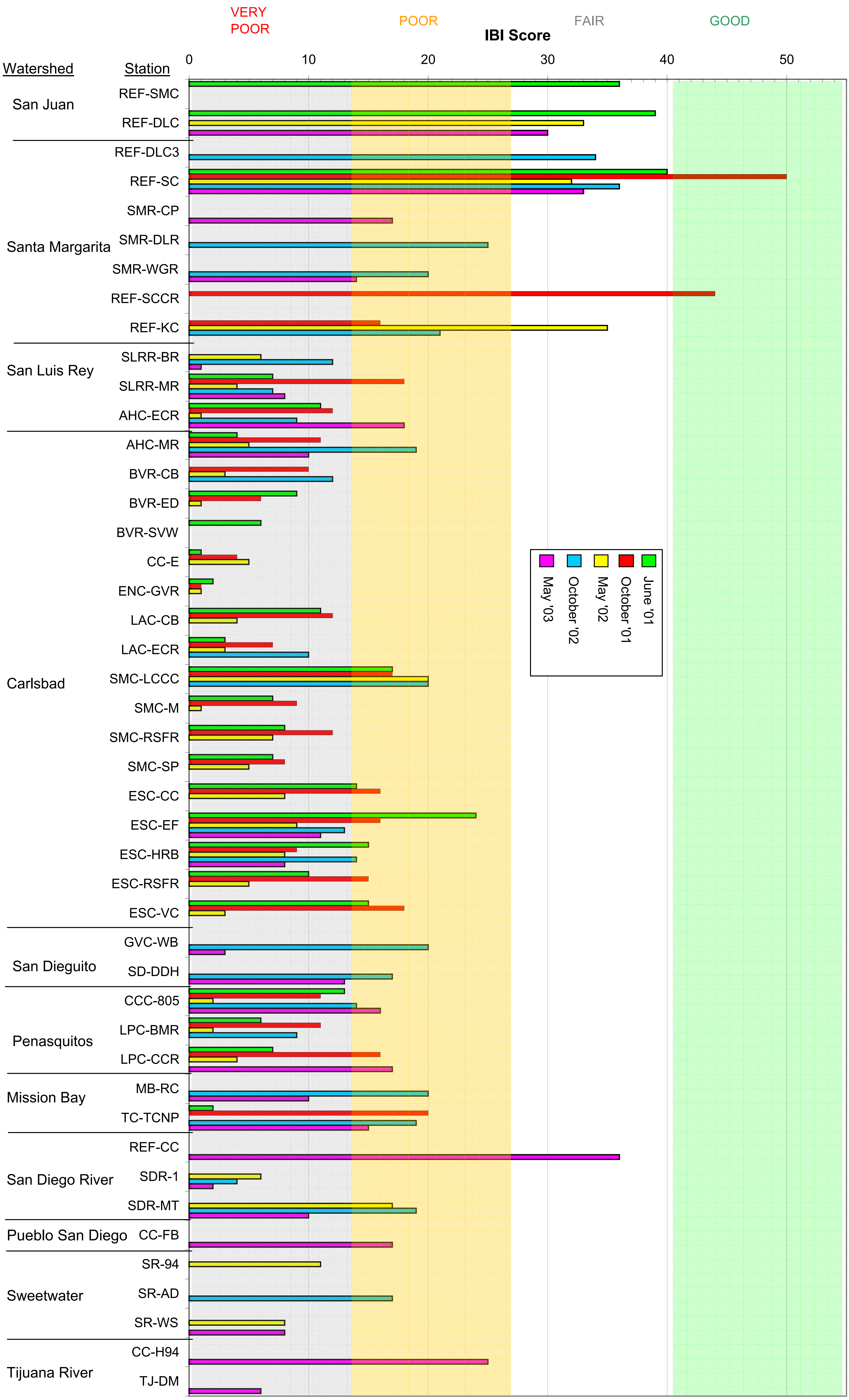

Figure 4-2. Final IBI Scores for Surveys June 2001 through May 2003.

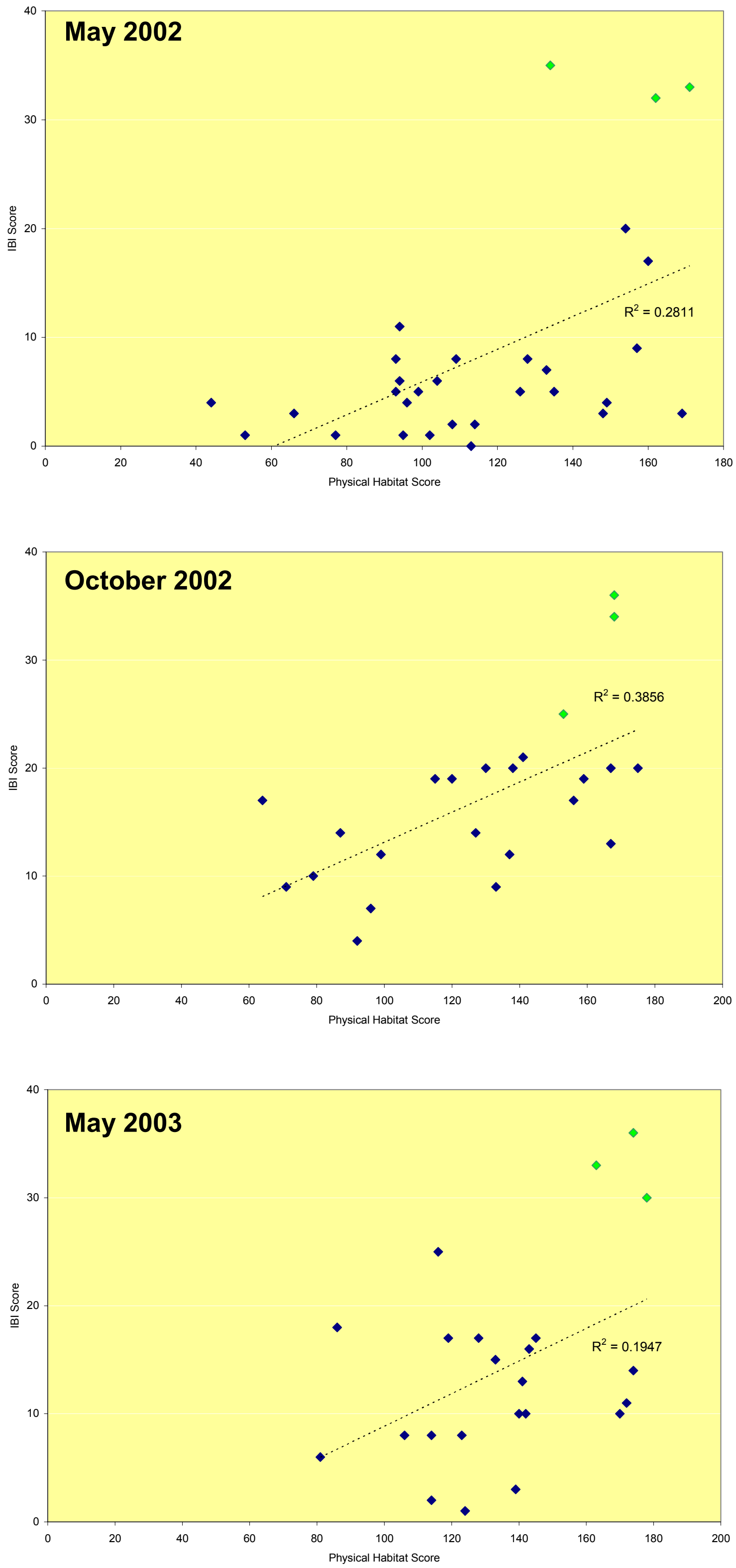

Figure 4-3. Relationship Between Physical Habitat Scores and IBI Scores for San Diego County Bioassessment Sites.

May 2002

IBI scores of the monitoring reaches ranged from 0 at Tecolote Creek to 35 at Reference Keys Creek (Figure 4-2, Appendix B.9-1). Twenty-five of the 30 sites were rated Very Poor, two of the sites rated Poor, and the three reference sites rated Fair. Overall, the scores for this survey were the lowest of the five surveys. San Marcos Creek-La Costa Country Club had the highest IBI score of the non-reference sites.

The relationship between IBI scores and habitat quality had a correlation coefficient (R^2) of 0.28, indicating a low correlation between the two (Figure 4-3). Several sites with very good physical habitat quality had low IBI scores, such as Escondido Creek-Vista Canyon and Buena Vista River-College Boulevard. This indicates that water quality is likely a greater factor in invertebrate community composition than the physical habitat features of the urban affected streams.

October 2002

IBI scores of the monitoring reaches ranged from 4 at San Diego River-1 to 36 at Reference Sandia Creek (Figure 4-2, Appendix B.9-2). Eight of the sites were rated Very Poor and 13 of the sites were rated Poor. Two of the reference sites were rated Fair and one was rated Poor. Santa Margarita River-De Luz Road was the highest scoring non-reference site, and was rated above Reference Keys Creek.

The relationship between IBI scores and habitat quality had a correlation coefficient of 0.39 (Figure 4-3). This R^2 value is higher than the other two May surveys, and reflects the overall higher IBI scores that were calculated for the October survey. Sites with good physical habitats but low IBI scores included Escondido Creek-Elfin Forest and Los Peñasquitos Creek-Black Mountain Road.

May 2003

IBI scores of the monitoring reaches ranged from 1 at San Luis Rey River-Benet Road to 36 at Reference Cedar Creek (Figure 4-2, Appendix B.9-3). Twelve of the sites were rated Very Poor and eight of the sites were rated Poor. The three reference sites were rated Fair. Campo Creek-Highway 94 was the highest scoring non-reference site.

The relationship between IBI scores and habitat quality had a correlation coefficient of 0.19, indicating a very low correlation between IBI scores and physical habitat quality (Figure 4-3). San Diego River-Mission Trails, Green Valley Creek-West Bernardo Drive, and San Luis Rey River-Benet Road had the lowest IBI scores in relation to physical habitat quality.

4.4 Summary and Conclusions

A total of 41 different stream monitoring reaches were assessed in San Diego County in the surveys of May 2002, October 2002, and May 2003. Five of these sites were considered to represent reference conditions.

Taxonomic identification of samples collected May 2002 produced 95 taxa of benthic invertebrates from 27,424 individual organisms. October 2002 samples produced 99 taxa from 19,347 individuals. May 2003 samples produced 95 taxa from 21,226 individuals.

The habitat types present in the monitoring reaches of the region can be roughly divided into four categories based on current velocity, substrate composition, and substrate complexity. Benthic invertebrate correlations with the different habitat types show that some organisms are quite ubiquitous, and are capable of colonizing a wide range of habitat conditions, while other organisms have more specific habitat preferences.

For all three surveys, the most abundant organisms in the study region were non-biting midges (Diptera: Chironomidae) and the black fly *Simulium* (Diptera: Simuliidae). The majority of organisms from the urban affected sites were moderately or highly tolerant to stream impairments. Organisms highly intolerant to impairments were encountered infrequently at the urban affected sites, but their presence even in low numbers is significant. Sites that supported highly intolerant organisms included Campo Creek-Highway 94, San Dieguito River-Del Dios Highway, Santa Margarita River-De Luz Road, Santa Margarita River-Willow Glen Road, and San Marcos Creek-La Costa Country Club.

The Index of Biotic Integrity ratings of the monitoring sites ranged from Good to Very Poor. IBI scores for the reference sites were nearly always higher than for the urban affected sites. The May 2002 survey produced consistently lower IBI scores across the entire region than in the other surveys. Although the specific causes for this trend are not known, this survey did occur at the end of severe drought conditions in San Diego County. Comparison of IBI scores with physical habitat scores of the monitoring reaches indicated a poor correlation between habitat quality and benthic community quality.