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San Diego Regional Water Quality Control Board:
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November 1999, May 2000, November 2000

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INTRODUCTION

The State of California began its efforts to develop water quality biocriteria in 1993. Because water quality regulatory authority in California is divided into nine autonomous Regional Water Quality Control Boards, the State of California has taken a regional approach to biocriteria development instead of the statewide approach common in other states. The California Department of Fish and Game (DFG) has helped to coordinate this approach by developing and distributing standardized sampling, laboratory and quality assurance procedures for state bioassessment programs called the California Stream Bioassessment Procedure (CSBP). The CSBP is a regional adaptation of the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (Barbour et al. 1999) and is recognized by the EPA as California's standardized bioassessment procedure (Davis et al. 1996).

The CSBP is a cost-effective tool that utilizes measures of the stream's benthic macroinvertebrate (BMI) community and its physical/ habitat structure. BMI communities can be very complex, being composed of tens to hundreds of species. Individual species reside in streams for periods ranging from a month to several years. Because they are sensitive, in varying degrees, to temperature, dissolved oxygen, sedimentation, scouring, nutrient enrichment and chemical and organic pollution (Resh and Jackson 1993), BMIs can provide considerable information regarding the biological condition of water bodies. Together, biological and physical assessments integrate the effects of water quality over time, are sensitive to multiple aspects of water and habitat quality, and provide the public with more familiar expressions of ecological health (Gibson 1996, Yoder and Rankin 1998).

In 1997 and again in 1999, the San Diego Regional Water Quality Control Board (San Diego RWQCB) contracted DFG to help them incorporate bioassessment into their ambient water quality monitoring program. The initial sampling strategy was designed to gather a baseline of information to support several project goals:

- To include biological information in the San Diego RWQCB's ongoing water quality monitoring programs
- To create a species list of BMIs known from the region
- To establish a biological classification of different stream types in the region
- To identify potential reference sites for the San Diego regional bioassessments
- To determine the best index period for sampling BMI communities
- To select appropriate metrics for southern California stream bioassessments

A first report, delivered in April 2000 reported the results of bioassessments conducted on May, September and, November 1998 and May 1999 at 48 locations spread throughout the San Diego region. The sampling sites were chosen to supplement chemical data collected from long-term sampling locations.

Based on the results of the first round of sampling, several additional sites were selected to better represent less disturbed conditions in the San Diego region. New samples were collected at these and most of the original locations on three dates between November 1999 and November 2000. This document reports the results of these three sampling events.

In May 2001, a new set of sites were chosen and sampled to further establish reference conditions in the San Diego region. The results of this sampling event will be combined with the results of earlier sampling events to establish a preliminary Index of Biological Integrity (IBI) for the San Diego region. Karr (1981) first published the IBI as a consistent means of measuring the societal goal of biological integrity. Based on a combination of tested biological attributes of water resources, the IBI provides a cumulative site assessment as a single score value (Davis and Simon 1995) and is the end point of a multi-metric analytical approach recommended by the EPA for development of biocriteria (Davis and Simon 1995). In July 2002, a final report will present a working IBI for the San Diego region, which will be fortified with bioassessment results from selected reference and test sites sampled to date.

MATERIALS AND METHODS

Monitoring Reach Delineation

Sampling reaches were delineated according to the methods described in the CSBP (Harrington 1999). Reaches normally consisted of a five-riffle stretch of stream in which all riffles had similar gradient and substrate characteristics. Three of the five riffles within a reach were then randomly selected for sampling. Occasionally, it was not possible to find 5 contiguous riffles of similar characteristics at a site in which case fewer riffles (3 or 4) were used. Monitoring reach descriptions are summarized in Table 1 and a map of sampling locations is presented in Figure 1. Photographs of all sites are attached to this report as GIF files in Appendix I. Monitoring activities occurred during three sampling periods: November 9-16, 1999, May 22-25, 2000 and November 8-13, 2000.

BMI Sampling

Riffle length was measured for each of the three riffles, and a random number table was used to randomly establish a point along the upstream third of each riffle at which a transect was established perpendicular to stream flow. Starting with the riffle transect furthest downstream, the benthos within a 2 ft^2 area was sampled upstream of a 1 ft wide, 0.5 mm mesh D-frame kick-net. Sampling of the benthos was performed manually by rubbing cobble and boulder substrates in front of the net, followed by "kicking" the upper layers of substrate to dislodge any remaining invertebrates . The duration of sampling ranged from 60-120 seconds, depending on the amount of boulder and cobble-sized substrate that required rubbing by hand; more and larger substrates required more time to process. Three locations representing any habitat diversity along each transect were sampled and combined into a composite sample, representing a 6 ft^2 area for each transect and 18 ft^2 for the entire reach. Each composite sample was transferred into a 500 ml wide-mouth plastic jar containing approximately 200 ml of 95% ethanol. This technique was repeated for each of three riffles in each reach.

Table 1. Monitoring reach descriptions for benthic macroinvertebrate sampling locations in November 1999, May 2000 and November 2000.

WATERSHED NAME	LOCATION DESCRIPTION	SITE ID	LATITUDE/ LONGITUDE	Nov 99	May 00	Nov 00	REF.
San Juan Creek	Reach consisted of 3 riffles upstream of Pacific Park Drive	AC-PPD	N33E34' 30.6″ W117E 42' 53.9″	X			
San Juan Creek	Reach consisted of 5 riffles parallel to Country Club Road upstream of Hwy 1	AC-CCR	N33E30' 51.2″ W117E 44' 34.9″	X	X	X	
San Juan Creek	Arroyo Trabuco Creek: Reach consisted of 5 riffles downstream of Oso Parkway bridge crossing. Previously sampled at Avery Parkway.	ATC-AP	N33E35' 3.0″ W117E 38' 9.0″	X	X	X	
San Juan Creek	San Juan Creek: Reach consisted of f5 riffles upstream of 74 bridge crossing	SJC-74	N33E31' 9.0″ W117E 37' 25.4″		X	X	
Santa Margarita River	Murrietta Creek: Reach consisted of 5 riffles near USGS gauging station	MC-GS	N33E28' 36.8″ W117E 08' 25.5″		X	X	
Santa Margarita River	Temecula Creek: Reach consisted of 5 riffles immediately downstream of I-15	TC-I-15	N33E28' 27.9″ W117E 08' 16.8″	X	X	X	
Santa Margarita River	Rainbow Creek: Reach consisted of 3 riffles upstream of Willow Glen Road	RC-WGR	N33E24' 26.1″ W117E 11' 58.9″	X	X	X	
Santa Margarita River	DeLuz Creek: Reach consisted of 5 riffles downstream of DeLuz Rd.	DLC-DLR	N33°26’’27.9″ W117°19’’27.7″			X	
Santa Margarita River	Sandia Creek: Reach consisted of 5 riffles upstream of DeLuz Rd.	SC-DR	N33° 29′ 31.9″ W117° 14′ 47.1″		X	X	
Santa Margarita River	Sandia Creek: Reach consisted of 5 riffles along Sandia Creek Drive, 0.7 miles upstream of Rock Mountain Road	SC-SCR	N33E 25' 27.3″ W117E 14' 53.2″	X	X	X	
Santa Margarita River	Reach consisted of 5 riffles 2 miles upstream of Willow Glen Road	SMR-WGR	N33E25' 49.3″ W117E 11' 43.1″	X	X	X	
Santa Margarita River	Reach consisted of 5 riffles downstream of Sandia Road (near DeLuz/ Pico Road)	SMR-DP	N33E 24' 51.0″ W117E 14' 26.3″	X	X	X	
Santa Margarita River	Reach consisted of 5 riffles downstream of Santa Margarita Road, Camp Pendleton	SMR-CP	N33E20' 22.1″ W117E19' 51.9″	X	X	X	
San Luis Rey River	Pauma Creek: Site is located downstream of Doque Trail at Palomar Mtn. Park	PC-PMP	N33° 20′ 55.7″ W116° 54′ 48.2″			X	
San Luis Rey River	Reach consisted of 5 riffles upstream and downstream of Lilac Road	KC-LR	N33E17' 38.1″ W117E 05' 10.3″	X	X	X	
San Luis Rey River	Reach consisted of 5 riffles about 50 meters upstream of pullout opposite Outdoor Education School on Highway 76	SLRR-PG	N33E15' 44.5″ W116E 48' 29.5″	X	X	X	
San Luis Rey River	Reach consisted of 3 riffles downstream of old Hwy 395 and I-15	SLRR-395	N33E19' 27.8″ W117E 09' 28.2″	X	X		

San Luis Rey River	Reach consisted of 3 riffles upstream of Mission Road	SLRR-MR	N33E15' 41.6″ W117E 14' 06.1″	**X**	**X**	**X**	
San Luis Rey River	Reach consisted of five riffles upstream of Fousat Rd crossing	SLRR-FR	N33° 13′ 34.3″ W117° 20′ 39.2″	**X**			
Carlsbad	Loma Alta Creek: Reach consisted of 5 riffles downstream of College Blvd.	LAC-CB	N33E12' 18.0″ W117E 17' 13.4″	**X**			
Carlsbad	Loma Alta Creek: Reach consisted of 5 riffles downstream of El Camino Real	LAC-ECR	N33E11' 57.6″ W117E 19' 48.2″		**X**	**X**	
Carlsbad	Buena Vista Creek: Reach consisted of 5 riffles downstream of Santa Fe Avenue	BVR-ED	N33E11' 57.9″ W117E 14' 35.1″	**X**			
Carlsbad	Buena Vista Creek: Reach consisted of 5 riffles upstream of South Vista Way	BVR-SVW	N33E10' 48.7″ W117E 19' 41.1″	**X**	**X**	**X**	
Carlsbad	Agua Hedionda Creek: Reach consisted of 5 riffles downstream of El Camino Real	AHC-ECR	N33E08' 57.0″ W117E 17' 46.9″	**X**	**X**	**X**	
Carlsbad	San Marcos Creek: Reach consisted of 5 riffles downstream of Santar Place	SMC-SP	N33E08' 37.0″ W117E 08' 54.2″	**X**			
Carlsbad	San Marcos Creek: Reach consisted of 5 riffles 50 m upstream of Mc Mahr Road intersection	SMC-M	N33E07' 47.8″ W117E 11' 29.0″	**X**	**X**	**X**	
Carlsbad	San Marcos Creek: Reach consisted of 5 riffles 50 m upstream of Mc Mahr Road intersection	SMC-RSFR	N33E06' 12.9″ W117E 13' 33.6″	**X**		**X**	
Carlsbad	San Marcos Creek: Reach consisted of 5 riffles downstream of Rancho Santa Fe Road	SMC-LCCC	N33E05' 18.7″ W117E 14' 43.6″	**X**	**X**	**X**	
Carlsbad	Encinitas Creek: Reach consisted of minimal riffle habitat, large pool was sampled using lentic procedures in May 2000	ENC-RSFR	N33° 04′ 4.2″ W117° 14′ 42.1″		**X**		
Carlsbad	Encinitas Creek: Reach consisted of 5 riffles downstream of Green Valley Rd	ENC-GVR	N33E04' 17.5″ W117E 15' 43.8″	**X**	**X**		
Carlsbad	Chicarita Creek: Site consisted of 5 riffles downstream of Evening Creek Road	CC-ECR	N32° 57′ 43.5″ W117° 05′ 36.2″		**X**	**X**	
Carlsbad	Reach consisted of 5 riffles downstream of Harmony Grove bridge	EC-HRB	N33E06' 31.6″ W117E 06' 41.2″	**X**	**?**		
Carlsbad	Reach consisted of 5 riffles downstream of Elfin Forest Resort	EC-EF	N33E04' 17.6″ W117E 09' 52.0″	**X**	**?**	**X**	
San Dieguito	Santa Ysabel Creek: Reach consisted of 5 riffles above/below HWY79 crossing	SYC-79	N33° 04′ 35.9″ W116° 24′ 26″		**X**	**X**	
San Dieguito	Kit Carson Creek: Reach consisted of 5 riffles above/below Sunset Drive crossing	KCC-SD	N33° 04′ 3.2″ W117° 03’′ 57.8″			**X**	
San Dieguito	Green Valley Creek: Reach consisted of 5 riffles just below West Bernardo Road	GVC-WB	N33° 02′ 38″ W117° 04′ 36.5″			**X**	
Los Peñasquitos Creek	Rattlesnake Creek: Reach consisted of 5 riffles adjacent to Hillary Park	RC-HP	N32E57' 36.0″ W117E 02' 31.2″		**X**		
Los Peñasquitos Creek	Reach consisted of 5 riffles upstream of Cobblestone Creek Road	LPC-CCR	N32E56' 55.9″ W117E 04' 06.6″	**X**			
Los Peñasquitos Creek	Reach consisted of 5 riffles upstream of Black Mountain Road	LPC-BMR	N32E56' 24.8 W117E 07' 36.5	**X**		**X**	

Los Peñasquitos Creek	Carroll Canyon Creek: Reach consisted of 5 riffles above/below railroad trestle at adjacent to 805 in Sorrento Valley	CCC-805	N32E53' 30.3″ W117E 12' 53.9″	**X**	**X**	**X**	
San Diego River	San Vicente Creek: Site consisted of 5 riffles just downstream of Wildcat Canyon road crossing	SV-WCR	N32° 59′ 46.9″ W116° 50′ 38.5″			**X**	
San Diego River	Reach consisted of 5 riffles upstream of Mission Dam	SDR-MD	N32E50' 25.8″ W117E 02' 20.7″	**X**			
San Diego River	Reach consisted of 5 riffles at the downstream boundary of Mission Trails Regional Park	SDR-MT	N32E49' 06.9 W117E 03' 55.1	**X**	**X**	**X**	
San Diego River	Reach consisted of 5 riffles adjacent to the River Valley golf course	SDR-1	N32E45' 53.9″ W117E 11' 28.9″	**X**			
San Diego River	Tecolote Creek: Reach consisted of 5 riffles upstream of cement apron.	TC-TCNP	N32° 46′ 32.3″ W117° 11′ 16.6″	**X**	**X**	**X**	
Sweetwater River	Reach consisted of 5 riffles downstream of Riverside Drive near I-8	SR-79	N32E50' 20.8″ W116E 36' 51.2″	**X**		**X**	
Sweetwater River	Reach consisted of 5 riffles upstream of Hwy 94	SR-94	N32E43' 59.9″ W117E 56' 19.0″	**X**		**X**	
Sweetwater River	Reach consisted of 5 riffles downstream of Sweetwater Road	SR-WS	N32E39' 29.1″ W117E 02' 36.4″	**X**			
Otay	Jamul Creek: site is located just upstream of Otay Lakes Road	JC-OLR	N32° 38′ 13.1″ W116° 53′ 3.7″			**X**	
Tijuana	Troy Canyon Creek: Reach located above Kitchen Creek Road, site at trail crossing.	TCC-TC	N32° 48′ 26.8″ W116° 26′ 25.2″		**X**	**X**	
Tijuana	Pine Creek: Reach consisted of 5 riffles just upstream of Old HWY 80 crossing.	PC-H80	N32° 50′ 13.9″ W116° 32′ 10.9″		**X**	**X**	
Tijuana	Cottonwood Creek: Reach consisted of 5 riffles downstream of Old HWY 80 crossing.	CC-H80	N32° 47′ 16.9″ W116° 29′ 51.4″		**X**	**X**	
Tijuana	La Posta Creek: Reach consisted of 5 riffles located in The Narrows between Cameron Truck Trail and Buckman Springs Road.	LPC-CTT	N32° 41′ 59.7″ W116° 28′ 44.9″			**X**	
Tijuana	Campo Creek: site is located just upstream of HWY 94 Gauging Station.	CC-H94	N32° 35′ 21.4″ W116° 31′ 04.7″			**X**	

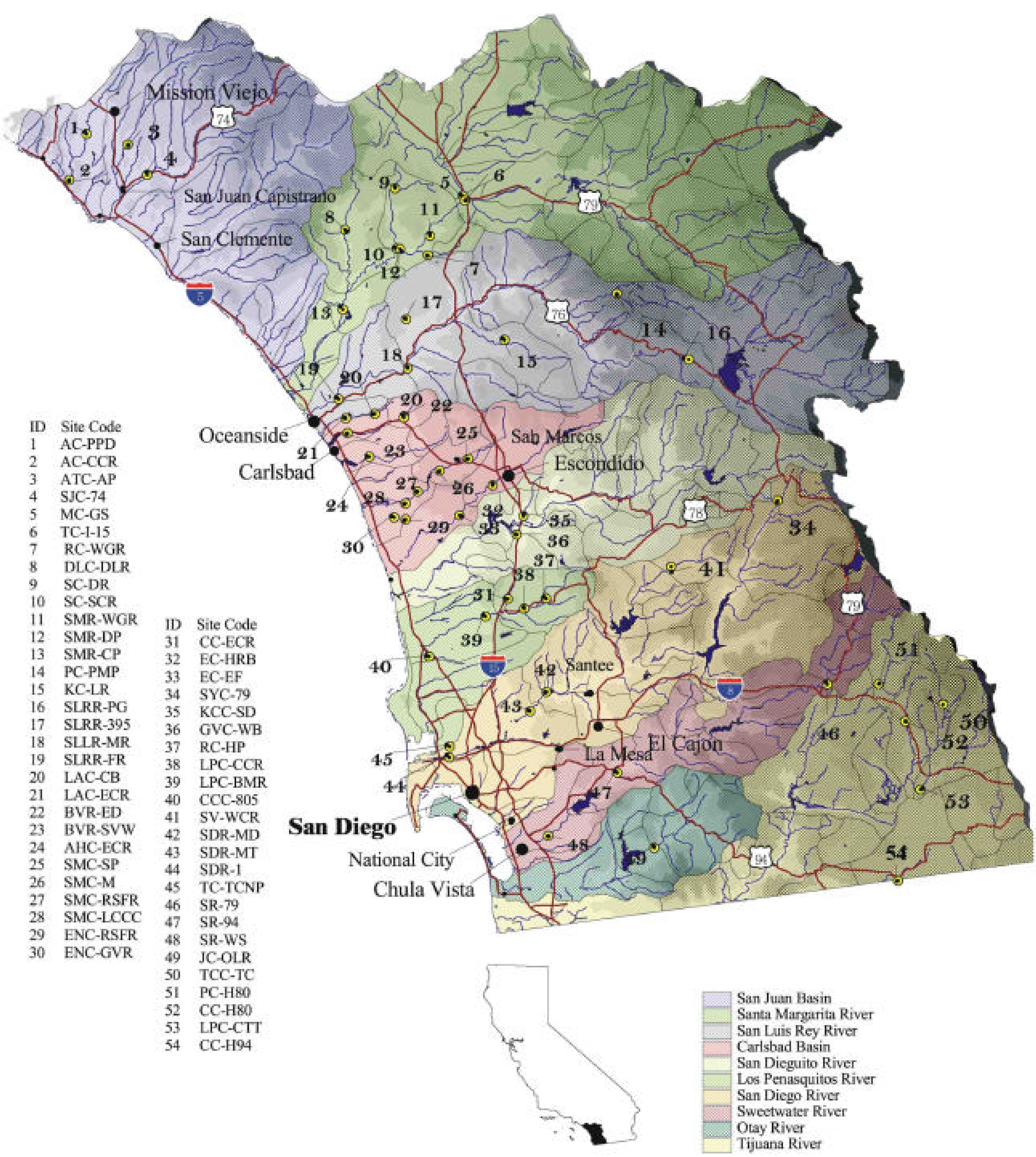

Figure 1. Locations of benthic macroinvertebrate locations sampled in November 1999, May 2000 and November 2000.

<u>Physical Habitat Quality Assessment</u>

Physical habitat quality was assessed for the monitoring reaches using U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (RBPs) (Barbour *et al*. 1999). Habitat quality assessments were recorded for each monitoring reach during each sampling event. Photographs were taken within each of the monitoring reaches to document overall riffle condition at the time of sampling. At a minimum, photographs were taken upstream and downstream through each reach sampled.

Physical Habitat Characteristics

In addition to the physical habitat quality assessments for each entire reach, we recorded several additional measures of habitat characteristics within each riffle. The following measurements were taken in the vicinity of the BMI collection sites: GPS coordinates, elevation, riffle gradient, riffle width and depth, canopy cover, substrate complexity, substrate consolidation and the proportion of different substrate sizes (substrate composition). This data is available upon request from the ABL.

Ambient Water Chemistry Recording

Ambient water chemistry was recorded at each site using a Yellow Springs Instruments (YSI 3800 or YSI 85 water quality meter. Recorded measurements included water temperature, dissolved oxygen concentration, specific conductance, salinity and pH.

BMI Laboratory Analysis

At the laboratory, each sample was rinsed through a No. 35 standard testing sieve (0.5 mm brass mesh) and transferred into a tray marked with twenty, 25 cm^2 grids. All sample material was removed from one randomly selected grid at a time and placed in a petri dish for inspection under a stereomicroscope. All invertebrates from the grid were separated from the surrounding detritus and transferred to vials containing 70% ethanol and 5% glycerol. This process was continued until 300 organisms were removed from each sample. The material left from the processed grids was transferred into a jar with 70% ethanol and labeled as “remnant” material. Any remaining unprocessed sample from the tray was transferred back to the original sample container with 70% ethanol and archived. BMIs were then identified to a standard taxonomic level, typically genus level for insects and order or class for non-insects, using standard taxonomic keys (Brown 1972, Edmunds et al. 1976, Klemm 1985, Merritt and Cummins 1995, Pennak 1989, Stewart and Stark 1993, Surdick 1985, Thorp and Covich 1991, Usinger 1963, Wiederholm 1983, 1986, Wiggins 1996, Wold 1974).

Data Analysis

A taxonomic list of BMIs identified from the samples was entered into a Microsoft Excel® spreadsheet program. Excel® was used to calculate and summarize BMI community based metric values. A description of the metric values used to describe the community is shown in Table 2.

Table 2. Bioassessment metrics used to describe characteristics of the benthic macroinvertebrate (BMI) community at sampling reaches within the San Diego region.

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 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
Abundance		
Estimated Abundance	Estimated number of BMIs in sample calculated by extrapolating from	variable

	the proportion of organisms counted in the subsample	

Each of the monitoring reaches was given a relative BMI Ranking Score based on 6 of the BMI metric values selected as described above (Table 2; metrics 1,2,6, 7, 14 and 15). The scores were computed as follows:

$$Score = \sum (x_i - \overline{x}) / sem_i$$

where: x_i = site value for the *i*-th metric; x bar = overall mean for the *i*-th metric; sem_i = standard error of the mean for the *i*-th metric. An overall score of “0" is the average for all sites.

Selection of Appropriate Metrics

The metrics used to calculate the relative ranking scores were identical to those selected for the previous report with the exception of Percent Chironomidae. Percent Chironomidae was dropped in this analysis because a visual inspection of the data indicated a poor relationship between this metric and site quality.

RESULTS

Dominant BMI Taxa/ General Taxonomic Notes

November 1999- A total of 131 taxa were identified in the 35 sites sampled in November 1999. Most of these taxa were encountered in only a few sites. The benthic communities at most sites were numerically dominated by a few disturbance tolerant taxa, including the dipteran families Simuliidae, Chironomidae and Stratiomyidae, the baetid genera *Baetis* and *Fallceon*, hydropsychid caddisflies (especially *Hydropsyche*), oligochaete worms, planariid flatworms and ostracods. It is important to note that although these taxa are disturbance tolerant, their abundance at a site does not necessarily imply disturbance. They are ubiquitous in flowing waters throughout North America, and their adaptedness to stream environments allows them to flourish in a wide range of conditions. Thus, the benthic communities even in many of the targeted reference sites (see Appendix IIIa-c) were comprised largely of the aforementioned taxa. Notable exceptions were the KC-LR site, in which the caddisfly genus *Lepidostoma*, the damselfly genus *Argia* and the stonefly genus *Malenka* comprised three of the five most abundant taxa, and the SR-79 site in which the caddisfly genus *Micrasema*, the mayfly genus *Tricorythodes* and the dipteran genus *Dasyhelea* comprised three of the five most abundant taxa.

Other than the dominant dipteran families mentioned above, the families Empididae, Ceratopogonidae and

Tipulidae were frequently encountered, but rarely in great numbers. Hemiptera were uncommon in the November samples, with only 7 sites containing true bugs. *Argia* was the only odonate genus regularly encountered in the November samples, and occasionally ranked as one of the five most abundant taxa present. This result is not surprising in that most odonate genera inhabit depositional areas within streams, and thus are not frequently abundant in riffle samples. Beetles were uncommon in the November 1999 samples; 7 of the sites had only 1 or two beetle genera present, and 17 of the sites contained no beetles at all. Elmidae was the only beetle family ever encountered in numbers, and were relatively common in the Santa Margarita watershed. At the ATC-AP site in the San Juan Creek watershed, *Optioservus* was one of the five most abundant taxa.

May 2000- 148 taxa were identified in the 32 sites sampled during May 2000. The taxa that were most abundant at all sites were virtually identical to those most abundant during the November 1999 sampling event (see Appendix IIIa-c). The stonefly genus *Zapada* replaced *Malenka* (both Nemouridae) as an occasional abundant taxon. Again the dipteran families Empididae, Ceratopogonidae and Tipulidae, and this time Psychodidae, were frequently encountered, though never in great numbers. Hemiptera and Odonata (with the exception of *Argia*) were again uncommon, and Coleoptera were as uncommon in this data as in the November 1999 data (14 of the sites had no beetles at all), perhaps even more so as the abundance of Elmidae declined somewhat in the May 2000 samples.

November 2000- 159 taxa were identified in the 40 sites sampled during November 2000. In general, the most abundant taxa at each site in November 2000 were very similar to those in greatest abundance during the November 1999 and May 2000 sampling events (see above), with the following notable exceptions:1) the odonate genus *Argia* was one of the five most abundant taxa in 29 of the 40 sites. This is in contrast with previous sampling events in which *Argia*, though frequently encountered, rarely ranked as one of the five most abundant taxa. 2) The sensitive caddisfly genus *Micrasema* (Brachycentridae) was one of the five most abundant taxa in 7 of the 40 sites, and in 5 cases was the most abundant taxon. In the previous two sampling events the ubiquitous hydropsychids *Hydropsyche* and *Cheumatopsyche* were the only caddisflies to rank as the most abundant taxon at any given site.

BMI Community Metrics

TAXONOMIC RICHNESS

November 1999- Cumulative Taxonomic Richness (i.e., total taxa found within a reach) ranged from 16 to 54, with a mean richness of 31 taxa for all sites. 15 sites had taxonomic richness at or above the mean. The number of EPT taxa per site ranged from 0 to 15, with a mean of 5 EPT taxa per site; 16 sites had the number of EPT taxa at or above mean.

May 2000- Cumulative Taxonomic Richness ranged from 18 to 62, with a mean richness of 31 taxa for all sites. 12 sites had taxonomic richness at or above the mean. The number of EPT taxa per site ranged from 0 to 19, with a mean of 8 EPT taxa per site; 15 sites had the number of EPT taxa at or above mean.

November 2000- Cumulative Taxonomic Richness ranged from 8 to 53, with a mean richness of 30 taxa for all sites. 21 sites had taxonomic richness at or above the mean. The number of EPT taxa per site ranged from 1 to 15, with a mean of 6 EPT taxa per site; 19 sites had the number of EPT taxa at or above mean.

COMPOSITION MEASURES

November 1999- Shannon Diversity ranged from 0.5 to 2.8, with a mean value of 1.98; 21 sites had a Shannon Diversity higher than the mean. The percent contribution of sensitive EPT taxa ranged from 0 to 25 percent, with a mean of 2.19 percent; only 5 sites had a higher than average percent contribution of sensitive EPT. The most abundant taxon comprised between 20 and 87 percent of BMI communities; the BMI communities at 7 sites were comprised of at least 50 percent of a single dominant taxon.

May 2000- Shannon Diversity ranged from 1.3 to 2.8, with a mean value of 2.04; 12 sites had a Shannon Diversity higher than the mean. The percent contribution of sensitive EPT taxa ranged from 0 to 31 percent, with a mean of 3.3 percent; only 8 sites had a higher than average percent contribution of sensitive EPT, and 22 sites had no sensitive EPT taxa.. Percent dominance by a single most abundant taxon was less pronounced in the May 2000 samples than in November 1999. The most abundant taxon comprised between 18 and 69 percent of BMI communities; the BMI communities at only 2 sites were comprised of at least 50 percent of a single dominant taxon.

November 2000- Shannon Diversity ranged from 0.63 to 2.5, with a mean value of 1.88; 21 sites had a Shannon Diversity higher than the mean. The percent contribution of sensitive EPT taxa ranged from 0 to 69 percent, with a mean of 17.4 percent; 20 sites had a higher than average percent contribution of sensitive EPT. The most abundant taxon comprised between 20 and 81 percent of BMI communities; the BMI communities at 11 sites were comprised of at least 50 percent of a single dominant taxon.

TOLERANCE VALUES

November 1999- Tolerance values indicated BMI communities moderately to greatly tolerant to disturbance (but see comments above regarding abundance of certain ubiquitous taxa). Average tolerance values per site ranged from 4.2 to 9.4, and only 5 sites had average tolerance values lower than 5. Most sites had no intolerant taxa, and only 3 sites had more than 10 percent of taxa present intolerant to disturbance.

May 2000- Tolerance values again indicated BMI communities moderately to greatly tolerant to disturbance. Average tolerance values per site ranged from 4.5 to 7.9 with 7 sites having average tolerance values less than 5. Twenty four of the 32 sites had no intolerant taxa present, and only 4 sites had more than 10 percent of taxa present intolerant to disturbance.

November 2000- In general tolerance values for BMI communities in this data set were similar to those in the previous two data sets, although one site (SC-SCR) had a much lower average tolerance value (2.7) than any site sampled in November 1999 or May 2000. Average tolerance values per site ranged from 2.7 to 8.3; 8 sites had average tolerance values lower than 5. Again, many sites had no intolerant taxa, but 8 sites (twice the number of sites compared to the previous two sampling events) had more than 10 percent of the taxa present intolerant to disturbance.

FUNCTIONAL FEEDING GROUPS

November 1999, May 2000, November 2000- All of the functional feeding groups were present in the entire project, but collectors and filterers comprised the bulk of the BMI communities at most sites sampled during each of the three sampling events summarized herein. However, the relative proportion of collectors to filterers varied considerably. Predators were sometimes relatively abundant, and comprised at least 15 percent of the BMI community in 39 percent of the samples collected during the three sampling events. Shredders were absent from most samples, and in only 4 cases did they comprise more than 10 percent of the BMI community. Grazers were also relatively uncommon in the samples, and comprised more than 10 percent of the BMI communitities in only ten cases in the November 1999 and May 2000 samples. Grazers were more frequently encountered in the November 2000 samples, and were more abundant within any given sample. They were present at all sites and comprised more than 10 percent of the BMI community in 12 cases, and in 7 cases comprised more than 20 percent of the BMI community.

Physical Habitat Quality Assessment

Total Physical Habitat scores are summarized in Table 3. Most sites sampled during the three sampling events reported herein scored in the "fair" or "good" range for all three sampling events. The factors most frequently responsible for physical habitat deterioration were sedimentation and consequently low substrate diversity, low channel flow status and impacted riparian area due to urbanization. Only four sites scored in the "excellent" range, *viz*. SMR-WGR, EC-EF, SDR-MT, and SDR-MD. Only two sites scored in the "poor" range, *viz*. BVR-SVW and AHC-ECR. BVR-SVW is a concrete lined drainage canal that flows through an urban area, while AHC-ECR is a highly impacted urban stream greatly impacted by sedimentation and recent bridge construction.

BMI Ranking Score

The BMI ranking scores were calculated independently for each sampling event and are presented in Figures 2a-c. Sites are grouped by major watershed unit. In each figure, the "mean" line (= 0) represents the average rank score of all sites. The rank scores are relative to each other and are comparable only within a sampling event and are not comparable between sampling events.

For the most part, relative rankings of sites were consistent across all sampling events, although completely consistent comparison is precluded by that fact that only 19 sites (out of a combined total of 54 sites) were sampled during all three sampling events. The majority of sites rank either slightly below or slightly above average. In general, the best sites are concentrated in the San Luis Rey, Santa Margarita and Tijuana watersheds. The sites that consistently rank well above average are: SR-79, PC-H80, SC-SCR, SC-DP and KC-LR. The lowest ranking sites are concentrated in the Carlsbad watershed (a grouping of several small watersheds) and Los Peòasquitos watershed.

Table 3. Physical habitat quality scores for sampling reaches within eight watersheds in the San Diego region in November 1999, May 2000 and November 2000. Scores for each habitat parameter range from 0 (poor) to 200 (excellent).

Habitat Parameter	Aliso Creek		San Juan Creek		Santa Margarita River								
	AC-PPD	AC-CCR	ATC-AP	SJC-74	MC-GS	TC-I15	RC-WGR	DLC-DLR	SC-DR	SC-SCR	SMR-WGR	SMR-DP	SMR-CP
November 1999	126	118	147	-	-	146	134	-	-	125	168	131	92
May 2000	-	93	127	122	99	105	118	-	150	135	154	139	110
November 2000	-	90	142	114	134	95	134	129	142	112	182	139	77

Habitat Parameter	San Luis Rey River						Carlsbad					
	PC-PMP	KC-LR	SLRR-PG	SLRR-395	SLRR-MR	SLRR-FR	LAC-CB	LAC-ECR	BVR-ED	BVR-SVW	AHC-ECR	SMC-SP
November 1999	-	141	139	103	107	98	88	-	102	90	81	142
May 2000	-	91	138	95	112	-	-	77	-	69	46	-
November 2000	147	80	99	-	125	-	-	58	-	25	35	-

Habitat Parameter	Carlsbad						Escondido Creek		San Dieguito		
	SMC-M	SMC-RSFR	SMC-LCCC	ENC-RSFR	ENC-GVR	CC-ECR	EC-HRB	EC-EF	SY-79	KCC-SD	GVC-WB
November 1999	143	120	135	-	78	-	135	154	-	-	-
May 2000	-	-	91	64	89	94	-	-	-	-	-
November 2000	113	126	81	-	-	117	-	146	112	82	129

Table 3 (continued). Physical habitat quality scores for sampling reaches within eight watersheds in the San Diego region in May 1998. Scores for each habitat parameter range from 0 (poor) to 20 (excellent).

Habitat Parameter	Los Penasquitos				San Diego River					Sweetwater River		
	RC-HP	LPC-CCR	LPC-BMR	CCC-805	SV-WCR	SDR-MD	SDR-MT	SDR-1	TC-TCNP	SR-79	SR-94	SR-WS
November 1999	-	150	129	143	-	151	165	140	133	139	98	118
May 2000	-	-	-	131	-	-	-	-	106	-	-	-
November 2000	-	-	117	122	135	-	133	-	120	97	78	-

Habitat Parameter	Otay	Tijuana				
	JC-OLR	TCC-TC	PC-H80	CC-H80	LPC-CTT	CC-H94
November 1999	-	-	-	-	-	-
May 2000	-	-	-	-	-	-
November 2000	137	82	131	110	99	80

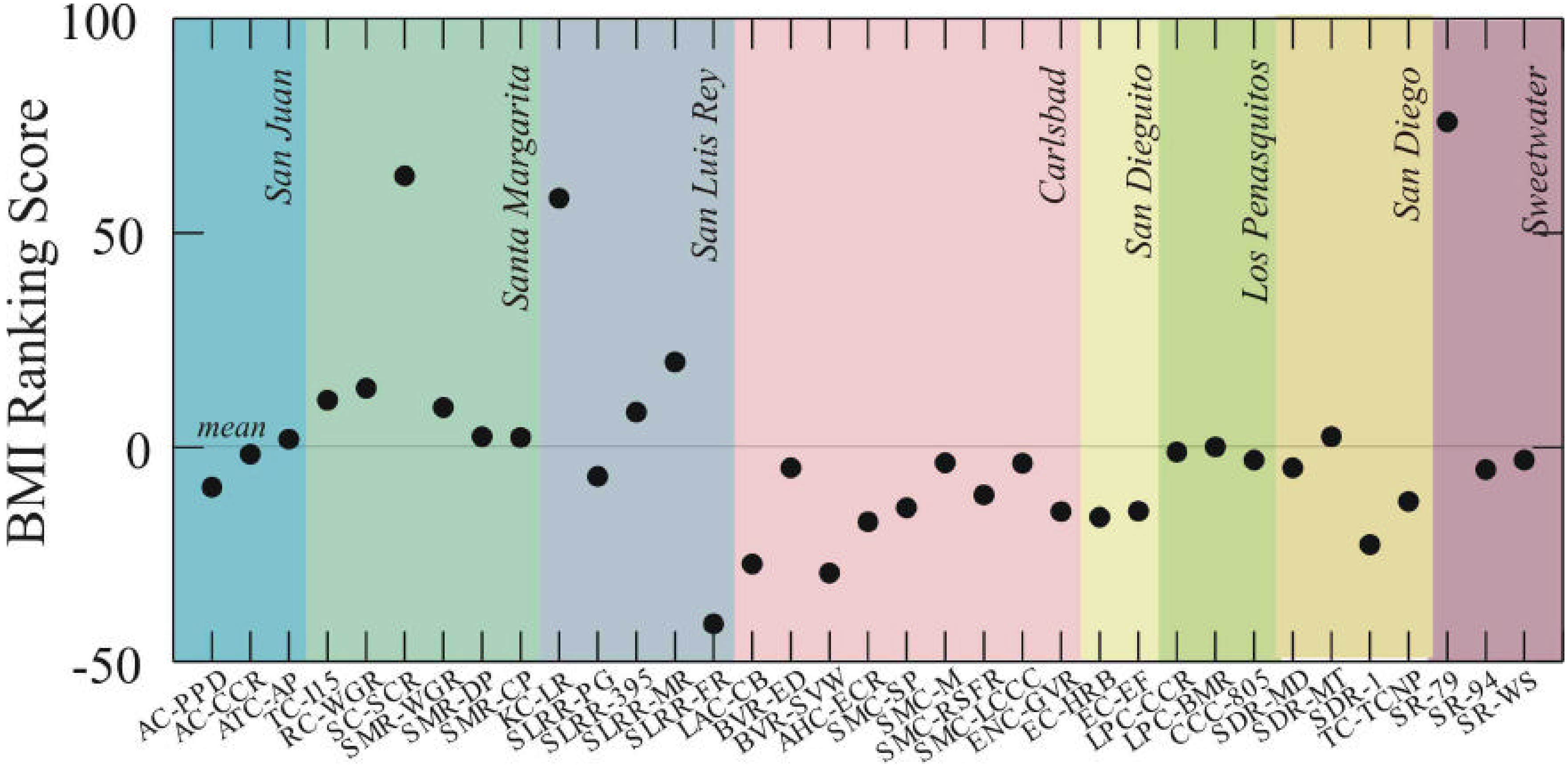

Figure 2a. BMI ranking scores for macroinvertebrate monitoring sites sampled in November 1999.

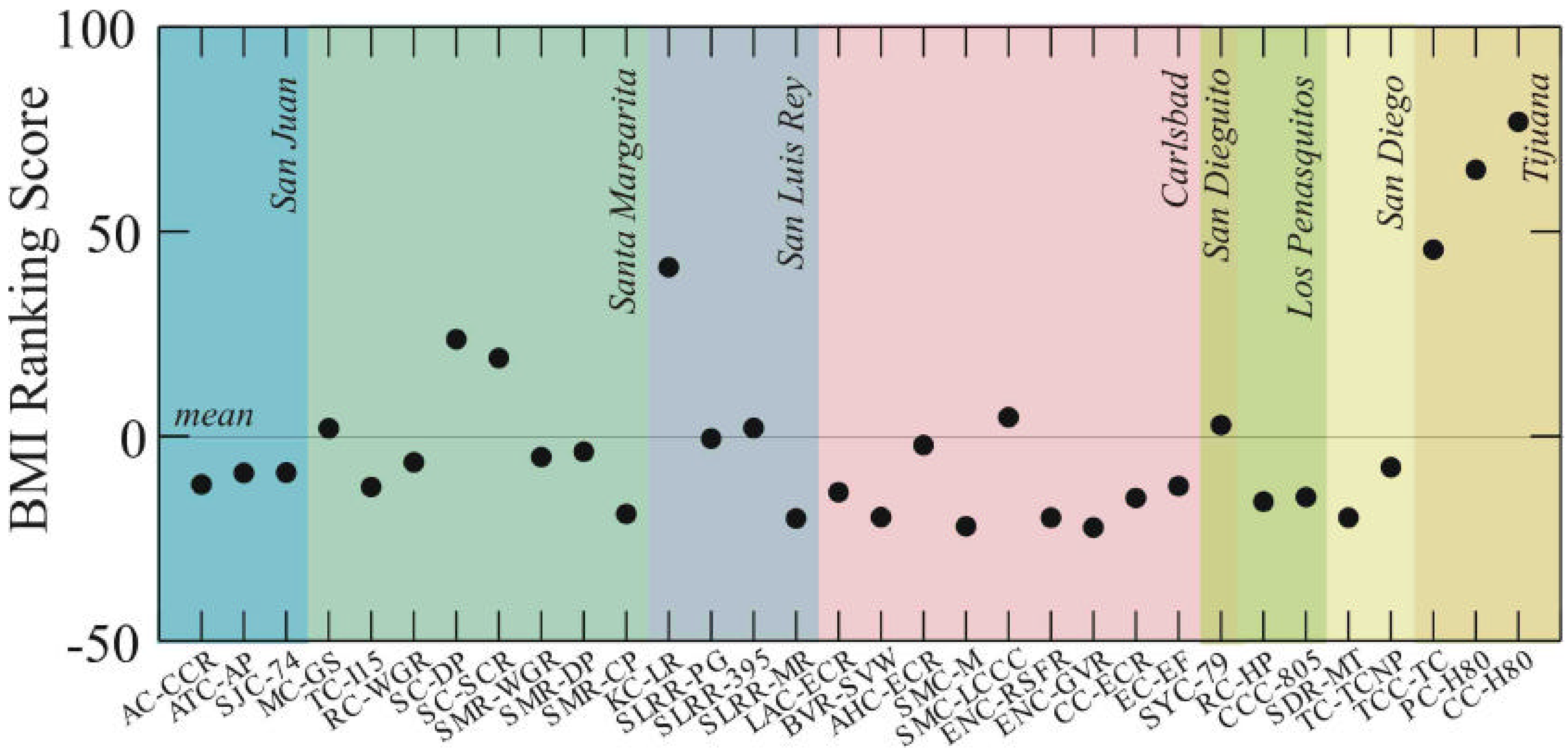

Figure 2b. BMI ranking scores for macroinvertebrate monitoring sites sampled in May 2000.

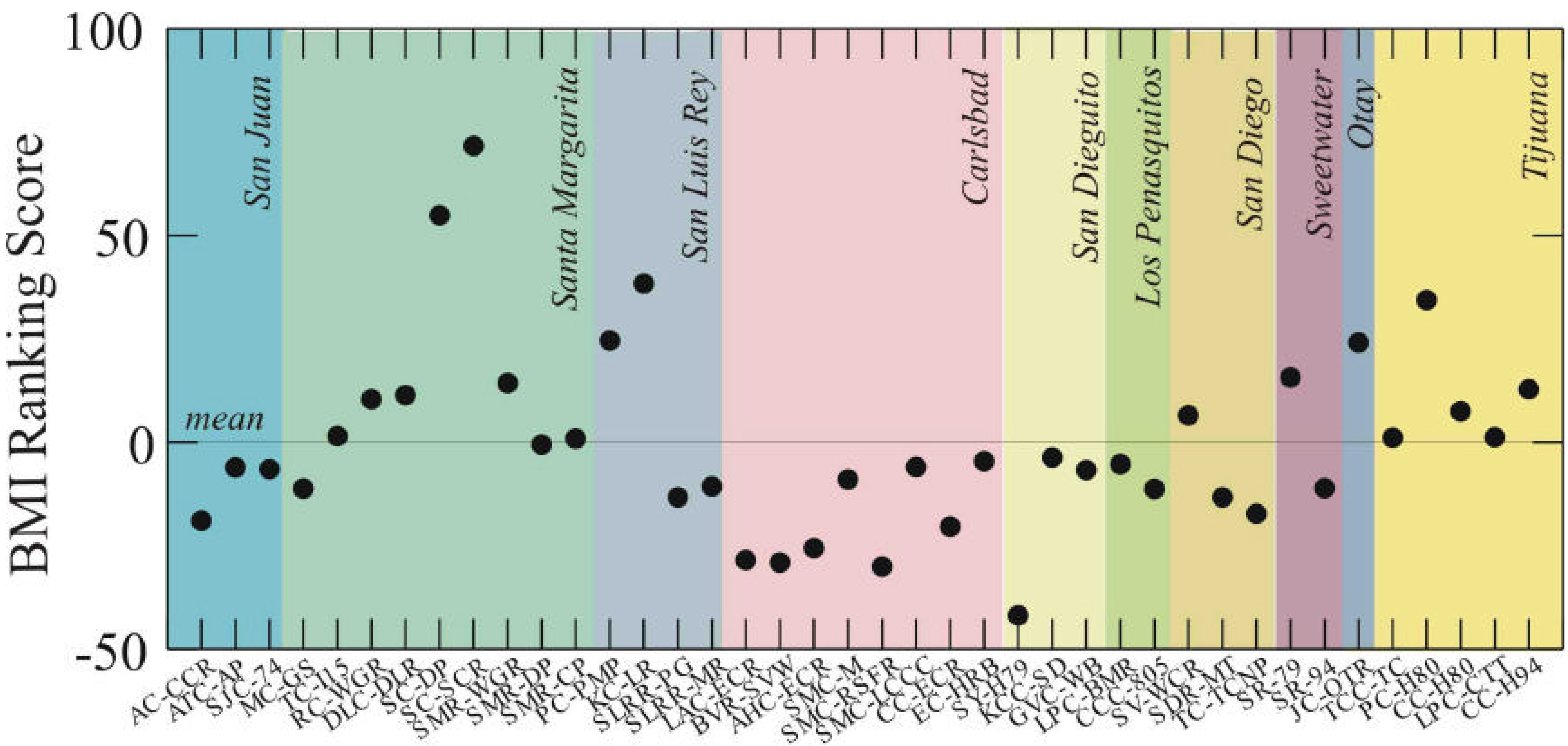

Figure 2c. BMI ranking scores for macroinvertebrate monitoring sites sampled in November 2000.

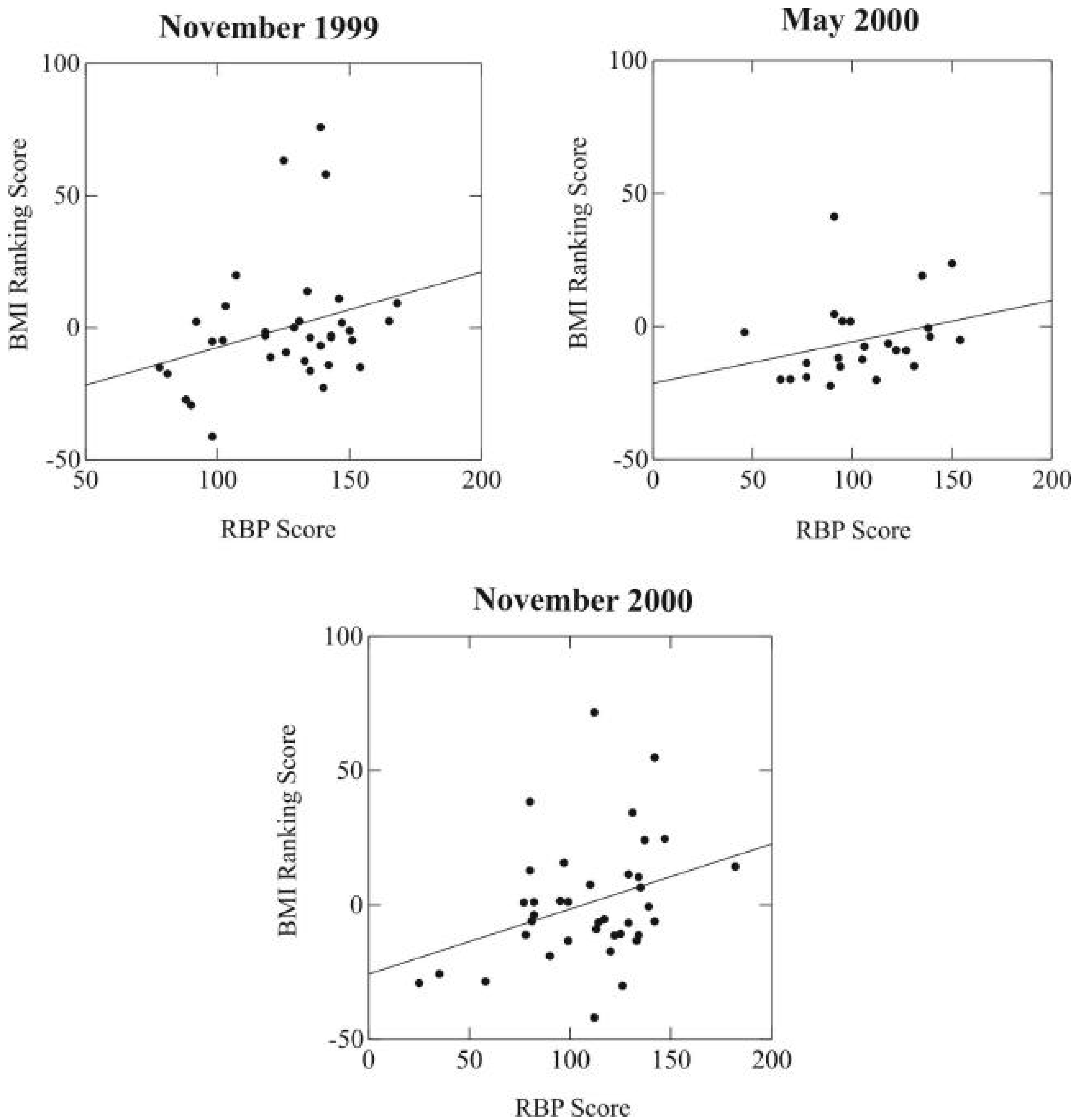

Figure 3. Scatterplots of the relationship between physical habitat scores (RBP) and benthic macroinvertebrate ranking scores for sites sampled in November 1999, May 2000 and November 2000.

DISCUSSION

The primary objectives of this project were to continue to collect biological information for the San Diego RWQCB's ambient monitoring program and to provide baseline data on the BMI community in regional streams. Together with the results of the first round of biological sampling (May 1998 to May 1999) and the reference site sampling event of May 2001, we will use the data presented here to:

1) classify similar streams and stream reaches within San Diego region watersheds, including possible reference sites,

2) determine the best time of year or index period for continued sampling of BMIs in watersheds of the San Diego region, and

3) determine the most appropriate set of biological metrics to use for describing BMI communities in watersheds of the San Diego region.

These objectives will lead to the production of a workable IBI using a modified approach outlined by the EPA (Barbour et al. 1999) and Karr and Chu (1999) and ultimately provide the foundation for the use of biocriteria in the San Diego region. The IBI is the end point of a multi-metric analytical approach recommended by the EPA for development of biocriteria (Davis and Simon 1995).

Site Classification and Selection of Reference Sites

Since our last report, we have sampled several sites that were specifically chosen for their potential as reference sites. All of these sites scored at least as high as the average ranks (note that the average rank was higher than in previous sampling events because we dropped several of the lowest scoring sites from the dataset), and several scored among the highest in each sampling event. Several of the sites noted in our earlier report

However, more work needs to be done to survey additional parts of the region for additional reference sites, particularly in the upper regions of watersheds like the Santa Margarita, San Luis Rey and Sweetwater Rivers, as well as other watersheds such as the San Dieguito River, the Otay River and the Tijuana River, which were not sampled in this study. The U.S. EPA's Western Environmental Monitoring and Assessment Project (EMAP) is currently underway and includes many additional sites within the region covered by the San Diego RWQCB. Bioassessment projects managed by the City of San Diego should also be included in future coordination efforts.

Index Period

The strong seasonal component to biological metrics that we noted in our previous report was not as apparent as it was in the earlier sampling events. However, there were fewer sampling locations in common and the different sampling periods may have been more affected by inter-annual variation in precipitation.

The interpretation of biological condition in this region appears to be very much influenced by seasonality and sampling timing.

RECOMMENDATIONS AND FUTURE WORK

1. We will continue to investigate the influence of sampling timing and make recommendations about this aspect of bioassessment in the region in our upcoming report.

2. On the basis of the first two sets of sampling events, the San Luis Rey River and Tijuana River watershed and parts of the Santa Margarita River and Sweetwater River watersheds are good candidates to provide reference conditions for this region.

3. We recommend further testing of additional metrics upon the addition of future datasets to improve the effectiveness of regional bioassessments.

4. The ranking scores described in this report are based on a multi-metric approach to bioassessment. We recommend the development of a multivariate IBI to be used to complement the strengths of the multi-metric approach.

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