Chapter 5. Macrobenthic Communities

INTRODUCTION

Along the coastal shelf of southern California, benthic macroinvertebrates that live within or on the surface of the sediments (i.e., infauna and epifauna, respectively), represent a diverse faunal community (Fauchald and Jones 1979, Thompson et al. 1993a, Bergen et al. 2001). These animals are important members of the marine ecosystem, serving vital functions in wide ranging capacities. Some species decompose organic material as a crucial step in nutrient cycling, other species filter suspended particles from the water column, thus affecting water clarity. Many species of benthic macrofauna also are essential prey for fish and other organisms.

Human activities that impact the benthos can sometimes result in toxic contamination, low levels of oxygen, or other forms of environmental degradation. Certain macrofaunal species are highly sensitive to such changes and rarely occur in impacted areas. Others are opportunistic and can thrive under altered conditions. Since various species respond differently to environmental stress, macrobenthic assemblages have become valuable indicators of anthropogenic impact (Pearson and Rosenberg 1978, Warwick 1993, Smith et al. 2001). Consequently, the assessment of benthic community structure is a major component of many marine monitoring programs, which document both existing conditions and trends over time.

The structure of benthic communities is influenced by many factors including sediment conditions (e.g., particle size and sediment chemistry), water conditions (e.g., temperature, salinity, dissolved oxygen, and current velocity), and biological factors (e.g., food availability, competition, and predation). For example, benthic assemblages on the coastal shelf off San Diego typically vary along gradients in particle size and depth. However, both human activities and natural processes can influence the structure of invertebrate communities in marine sediments. Therefore, in order to determine whether changes in community structure are related to human impacts, it is necessary to have documentation of background or reference conditions for an area. Such information is available for the SBOO discharge area and the San Diego region in general (e.g., City of San Diego 1999, 2000).

This chapter presents analyses and interpretations of the macrofaunal data collected at fixed stations surrounding the SBOO during 2004. Included are descriptions and comparisons of soft-bottom macrofaunal assemblages in the area, and analysis of benthic community structure.

MATERIALS and METHODS

Collection and Processing of Samples

Benthic samples were collected during January and July, 2004 at 27 stations surrounding the SBOO (**Figure 5.1**). These stations range in depth from 18 to 60 m and are distributed along four main depth contours. Listed from north to south along each contour, these stations include: (1) 19-m contour: stations I35, I34, I31, I23, I18, I10, I4; (2) 28-m contour: stations I33, I30, I27, I22, I14, I16, I15, I12, I9, I6, I2, I3; (3) 38-m contour: stations I29, I21, I13, I8; (4) 55-m contour: stations I28, I20, I7, I1.

Samples for benthic community analysis were collected from two replicate 0.1-m^2 van Veen grabs per station during the January survey. During the July survey, two replicate grabs were collected for only eight stations (I1, I8, I9, I12, I13, I15, I28,

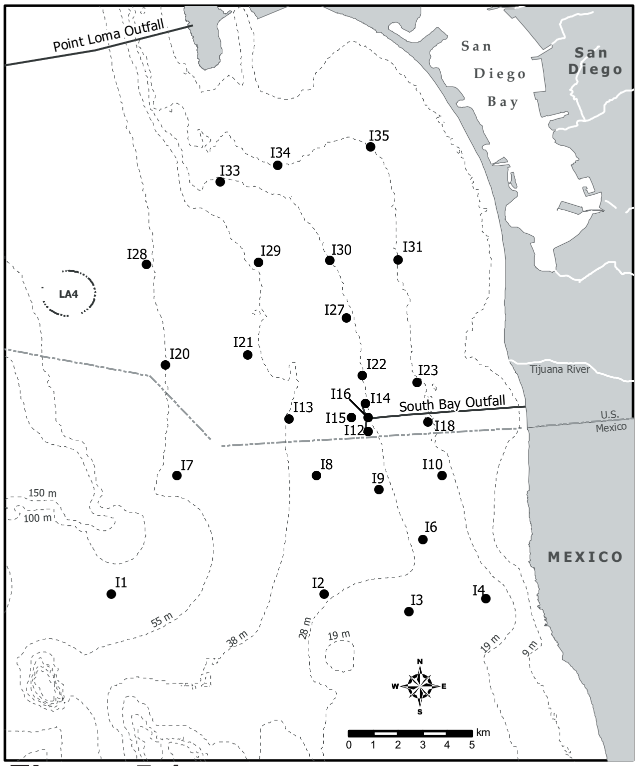


Figure 5.1
Macrobenthic station locations, South Bay Ocean Outfall Monitoring Program.

and I30) due to regulatory relief for a mandated sediment mapping study (see Chapter 1). One replicate grab was collected at the remaining 19 stations. A separate grab was collected at each station for analysis of sediment quality (see chapter 4). The criteria established by the United States Environmental Protection Agency (USEPA) to ensure consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0-mm mesh screen. Organisms retained on the screen were relaxed for 30 minutes in a magnesium sulfate solution and then fixed in buffered formalin (see City of San Diego 2004a). After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All organisms were sorted from the debris into major taxonomic groups by a subcontractor. Biomass was measured as the wet weight in grams per sample for each of the following taxonomic categories: Annelida (mostly polychaetes), Arthropoda (mostly crustaceans), Mollusca, Ophiuroidea, non-ophiuroid Echinodermata, and other miscellaneous phyla combined (e.g., Chordata, Cnidaria, Nemertea, Platyhelminthes, Phoronida, Sipuncula). Values for ophiuroids and all other echinoderms were later combined to give a total echinoderm biomass. After biomassing, all animals were identified to species or the lowest taxon possible and enumerated by City of San Diego marine biologists.

Data Analyses

The following community structure parameters were calculated for each station: species richness (mean number of species per 0.1-m^2 grab), annual total number of species per station, abundance (mean number of individuals per grab), biomass (mean grams per grab, wet weight), Shannon diversity index (mean H' per grab), Pielou's evenness index (mean J' per grab), Swartz dominance (mean minimum number of species accounting for 75% of the total abundance in each grab), Infaunal Trophic Index (mean ITI per grab) (see Word 1980), and Benthic Response Index (mean BRI per grab) (see Smith et al. 2001).

Multivariate analyses were performed using PRIMER v5 (Plymouth Routines in Multivariate Ecological Research) software to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region (see Clarke 1993, Warwick 1993). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking and ordination by non-metric multidimensional scaling (MDS). The macrofaunal abundance data were square-root transformed and the Bray-Curtis measure of similarity was used as the basis for both classification and ordination. Analyses were run on individual grab samples and on the mean of the two replicate grabs per station-survey. Differences in results were considered negligible; thus for clarity and simplicity, results presented herein are for mean abundances of replicate grabs per station-survey. Patterns in the distribution of macrofaunal assemblages were compared to environmental variables by overlaying the physico-chemical data onto MDS plots based on the biotic data (see Field et al. 1982).

Table 5.1

Benthic community parameters at SBOO stations sampled during 2004. Data are expressed as annual means for: species richness, no. species/0.1 m^2 (SR); total cumulative no. species for the year (Tot Spp); abundance/0.1 m^2 (Abun); biomass, g/0.1 m^2; diversity (H'); evenness (J'); Swartz dominance, no. species comprising 75% of a community by abundance (Dom); benthic response index (BRI); infaunal trophic index (ITI).

	N	SR	Tot spp	Abun	Biomass	H'	J'	Dom	BRI	ITI
19 m stations										
I-35	3	65	118	172	4.6	3.9	0.93	29	24	79
I-34	3	39	86	207	4.1	2.7	0.76	9	3	78
I-31	3	56	116	265	2.3	3.0	0.74	14	16	75
I-23	3	73	159	854	6.2	3.3	0.76	18	15	73
I-18	3	44	87	129	1.8	3.1	0.81	14	11	74
I-10	3	42	84	138	2.9	3.2	0.86	16	15	85
I-4	3	37	78	105	10.4	3.1	0.86	15	4	77
28 m stations										
I-33	3	78	154	233	2.3	3.9	0.90	31	22	82
I-30	4	54	125	136	1.0	3.5	0.88	22	22	80
I-27	3	64	131	176	1.8	3.7	0.90	26	23	79
I-22	3	51	108	174	3.8	3.1	0.80	17	20	76
I-14	3	61	113	200	1.6	3.4	0.82	20	21	78
I-16	3	72	158	213	10.9	3.4	0.81	26	20	79
I-15	4	51	115	215	3.2	2.5	0.64	12	16	73
I-12	4	69	154	273	2.4	3.2	0.76	20	20	77
I-9	4	83	181	365	3.0	3.2	0.73	20	25	78
I-6	3	42	78	201	9.4	2.8	0.75	11	11	73
I-2	3	47	90	235	1.8	2.4	0.63	10	12	71
I-3	3	48	93	228	12.9	2.9	0.74	12	10	72
38 m stations										
I-29	3	95	199	430	3.3	3.7	0.82	31	16	85
I-21	3	41	88	239	2.9	2.6	0.71	9	6	93
I-13	4	56	129	316	6.4	2.9	0.72	13	12	86
I-8	4	56	129	245	4.2	2.9	0.73	14	14	77
55 m stations										
I-28	4	135	270	405	4.4	4.3	0.89	52	9	80
I-20	3	63	121	251	5.4	3.4	0.84	20	12	87
I-7	3	67	136	270	2.8	3.5	0.84	20	8	87
I-1	4	52	133	160	1.0	3.1	0.80	18	15	75
All stations										
Mean		61	127	253	4.3	3.2	0.79	19	15	79
Min		37	78	105	1.0	2.4	0.63	9	3	71
Max		135	270	854	12.9	4.3	0.93	52	25	93

RESULTS and DISCUSSION

Community Parameters

Number of Species

A total of 719 macrobenthic taxa were identified during 2004. Of these, 30% represented rare or unidentifiable taxa that were recorded only once. The average number of taxa per 0.1 m^2 grab ranged from 37 to 135, and the cumulative number of taxa per station ranged from 78 to 270 (**Table 5.1**). This wide variation in species richness is consistent with previous years, and can probably be attributed to different habitat types in the area (see City of San Diego 2004b). Higher numbers of species, for example, are common at stations such as I28 and I29 where sediments are finer than most other SBOO sites (see Chapter 4). In addition, species richness varied between surveys, averaging about 17% higher in July than in January (see **Figure 5.2**). Although species richness varied both spatially and temporally, there were no apparent patterns relative to distance from the outfall.

Polychaete worms made up the greatest proportion of species, accounting for 34–55% of the taxa at various sites during 2004. Crustaceans composed 14–31% of the species, molluscs from 13 to 24%, echinoderms from 2 to 11%, and all other taxa combined about 5–18%. These percentages are generally similar to those observed during previous years, including prior to discharge (e.g., see City of San Diego 2000, 2004b).

Macrofaunal Abundance

Macrofaunal abundance ranged from a mean of 105 to 854 animals per grab in 2004 (Table 5.1). The greatest number of animals occurred at stations I9, I13, I23, I28, and I29, which were the only sites that averaged over 300 individuals per sample. Station I28 is typically characterized by high abundance, with a variety of different taxa accounting for the high numbers (see City of San Diego 2004b). In contrast, high abundances at station I23 primarily were due to large numbers of nematodes and several species of polychaetes (i.e., *Hesionura coineaui difficilis*, *Pisione remota*, and *Saccocirrus* sp) Overall, abundance values were within the range of historical variation (Figure 5.2), and there were no clear spatial patterns relative to the outfall.

Similar to past years, polychaetes were the most abundant animals in the region, accounting for 38–77% of the different assemblages during 2004. Crustaceans averaged 3–33% of the animals at a station, molluscs from 3 to 26%, echinoderms from <1 to 13%, and all remaining taxa about 2–30% combined.

Biomass

Total biomass averaged from 1.0 to 12.9 grams per 0.1 m^2 (Table 5.1). High biomass values are often due to the collection of large motile organisms such as sand dollars, sea stars, crabs, and snails. For example, during 2004 a single specimen of the echinoid *Lovenia cordiformis* weighed 21.5 grams, accounting for over 60% of the annual biomass at station I3, and over 13% of the biomass for all stations during the July survey. Although these large animals introduced considerable variability, overall biomass at the SBOO stations during the year was similar to historical values (Figure 5.2).

Overall, polychaetes accounted for 4–77% of the biomass at a station, crustaceans 2–38%, molluscs 5–85%, echinoderms <1–80%, and all other taxa combined 1–37%. In the absence of large individual molluscs or echinoderms, polychaetes dominated most stations in terms of biomass.

Species Diversity and Dominance

Species diversity (H') varied during 2004, ranging from 2.4 at station I2 to 4.3 at I28 (Table 5.1). Average diversity in the region generally was similar to previous years (Figure 5.2), and no patterns relative to distance from the outfall were apparent. The relatively wide range of evenness values (0.63–0.93) also reflects the dominance of a few species at some of the SBOO stations. Most sites with evenness values below the mean (0.79) were dominated by polychaetes with the exception of I23, with the single most dominant taxa being nematodes (not identified beyond phylum). The spatial patterns in evenness were similar to those for diversity.

Species dominance was measured as the minimum number of species accounting for 75% of a community by abundance (see Swartz 1978). Consequently, dominance as discussed herein is inversely proportional to numerical dominance, such that low index values indicate communities dominated by few species. Values at individual stations varied widely, averaging from 9 to 52 species per station during the year (Table 5.1). Dominance values for 2004 were

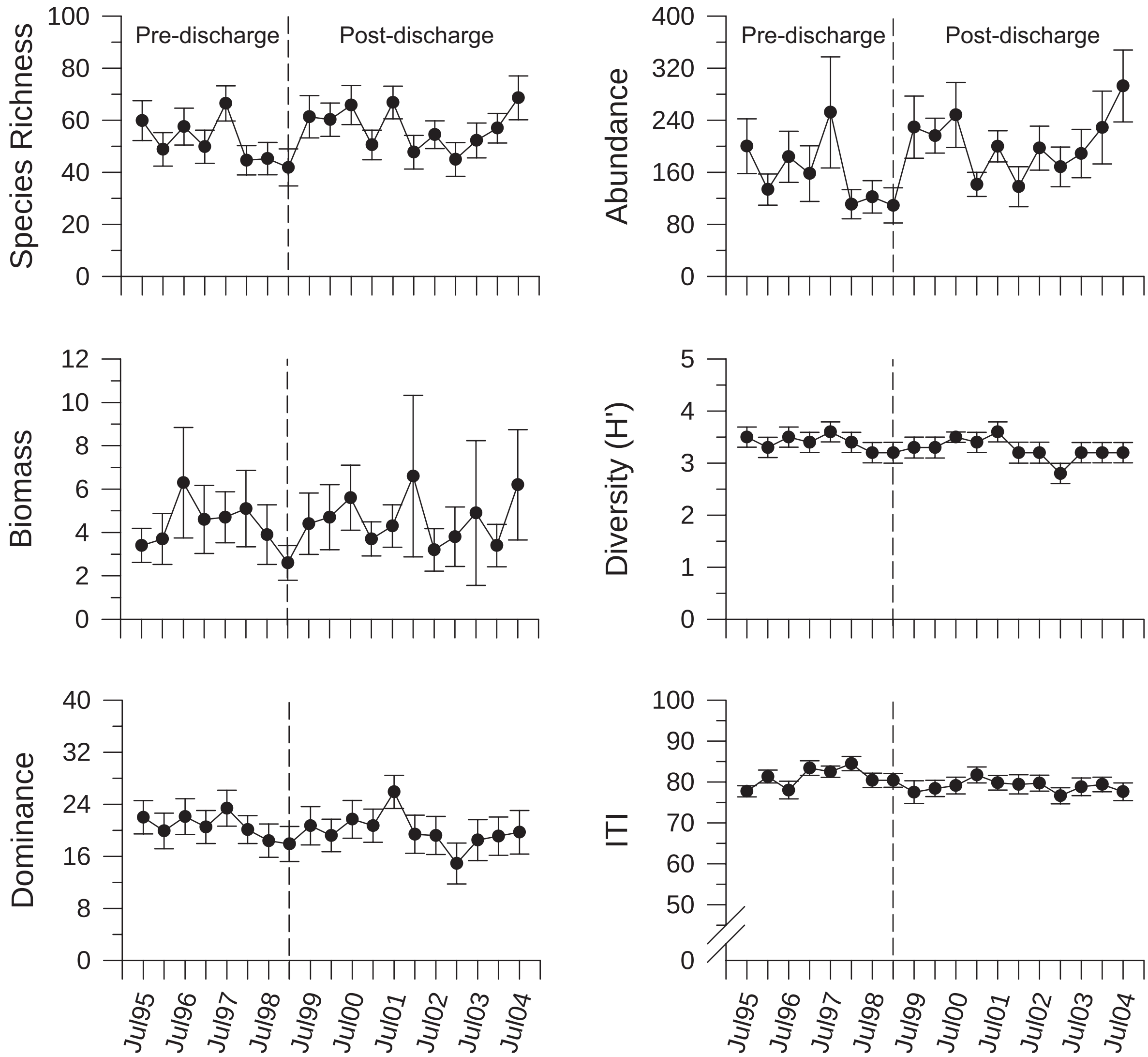


Figure 5.2

Summary of benthic community structure parameters surrounding the South Bay Ocean Outfall (1995–2004). Species Richness=number of species; Abundance=number of animals; Biomass=grams, wet weight; Diversity=Shannon diversity index (H'); Dominance=Swartz dominance index; ITI=infaunal trophic index. Data are expressed as means per $0.1m^2$ grab pooled over all stations for each survey (n=54). Error bars represent 95% confidence limits.

similar to historical values (Figure 5.2). No clear patterns relative to the outfall were evident in dominance values.

Environmental Disturbance Indices

The benthic response index (BRI) during 2004 averaged from 3 to 25 at the various SBOO stations (Table 5.1). Index values below 25 (on a scale of 100) suggest undisturbed communities or "reference conditions," while those in the range of 25–33 represent "a minor deviation from reference condition," which may or may not reflect anthropogenic impact (Smith et al. 2001). Station I9 had the highest BRI, and was the only station at the upper limit for reference conditions. There were no patterns in BRI relative to distance from the outfall, and index values at sites nearest the discharge did not suggest significant environmental disturbance.

The infaunal trophic index (ITI) averaged from 71 to 93 at the various sites in 2004 (Table 5.1). There were no patterns with respect to the outfall, and all values at sites near the discharge were

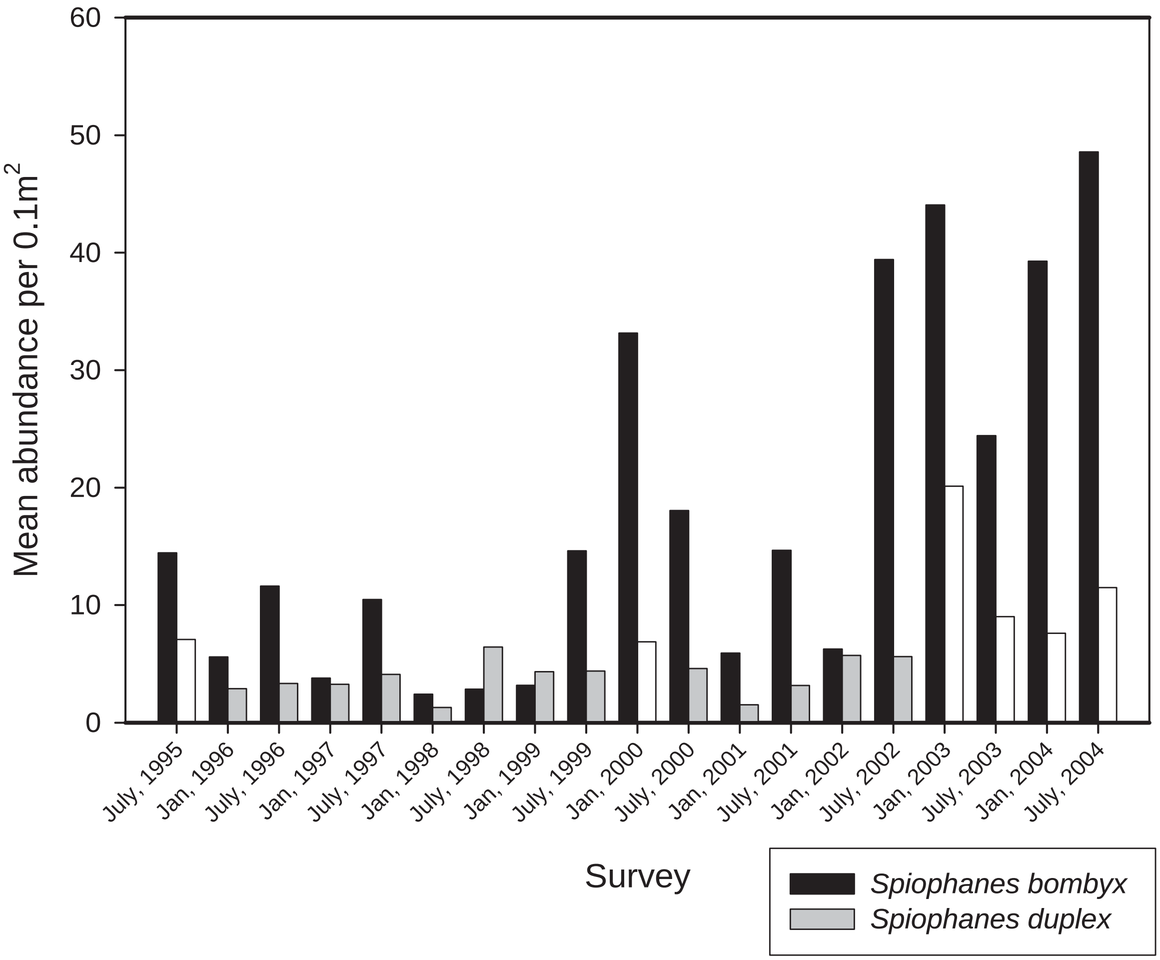


Figure 5.3
Mean abundance per 0.1 m^2 grab of the common polychaetes *Spiophanes bombyx* and *Spiophanes duplex*, for each survey at the SBOO benthic stations from July 1995 to July 2004.

characteristic of undisturbed sediments (i.e., ITI >60, Word 1980). In addition, average ITI over all sites has changed little since monitoring began (see Figure 5.2).

Dominant Species

Most assemblages in the SBOO region were dominated by polychaete worms. For example, the list of dominant fauna in **Table 5.2** includes 18 polychaetes, three crustaceans, one nemertean, and nematodes (not identified beyond phylum).

The spionid polychaete *Spiophanes bombyx* was the most numerous and the most ubiquitous species, averaging about 44 worms per sample and occurring in 100% of the samples. A closely related species, *S. duplex*, was fifth in total abundance. Together, these two species accounted for over 19% of all individuals collected during 2004. Both were found in higher numbers than some past years (**Figure 5.3**). The second most abundant taxa were nematode worms (not identified to species) and the third most abundant was the sabellid polychaete, *Euchone arenae*.

Polychaetes comprised nine of the ten most abundant species per occurrence. Several polychaete species were found in high numbers at only a few stations (e.g., *Pareurythoe californica, Saccocirrus* sp, and *Eulalia levicornuta*). Few macrobenthic species were widely distributed, and of these only *Spiophanes bombyx*, *Ampelisca cristata cristata*, and *Sigalion spinosus* occurred in more than 80% of the samples. Only four of the most frequently

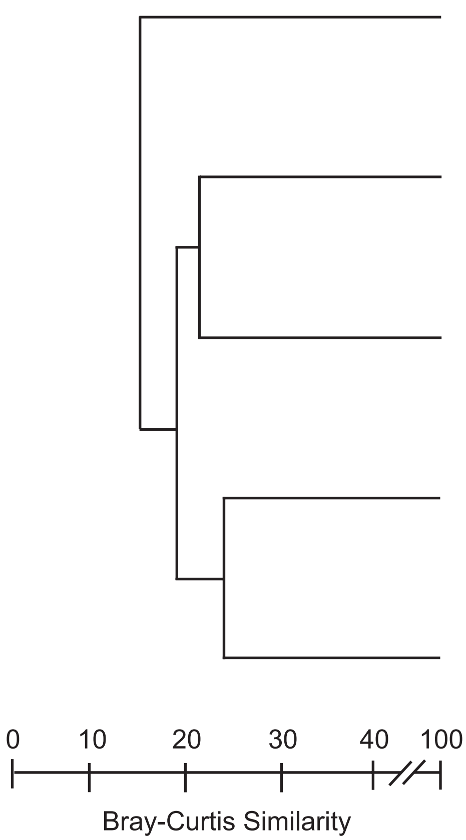
Table 5.2

Dominant macroinvertebrates at the SBOO benthic stations sampled during 2004. Included are the 10 most abundant species overall, the 10 most abundant per occurrence, and the 10 most frequently collected (or widely distributed) species. Abundance values are expressed as mean number of individuals per 0.1 m^2 grab sample. MAS=mean abundance per sample; MAO=mean abundance per occurrence; PA=percent of total abundance; FO=frequency of occurrence (%).

Species	Higher taxa	MAS	MAO	PA	FO
Most Abundant					
1. *Spiophanes bombyx*	Polychaeta: Spionidae	43.9	43.9	16.6	100
2. Nematoda	Nematoda	12.7	22.9	4.8	56
3. *Euchone arenae*	Polychaeta: Sabellidae	9.9	24.3	3.7	41
4. *Monticellina siblina*	Polychaeta: Cirratulidae	7.4	13.8	2.8	54
5. *Spiophanes duplex*	Polychaeta: Spionidae	7.2	9.5	2.7	76
6. Euclymeninae sp A	Polychaeta: Maldanidae	5.3	8.3	2.0	63
7. *Ampelisca cristata cristata*	Crustacea: Amphipoda	4.5	5.6	1.7	82
8. *Euphilomedes carcharodonta*	Crustacea: Ostracoda	4.0	6.8	1.5	59
9. *Lanassa venusta venusta*	Polychaeta: Terebellidae	3.7	16.7	1.4	22
10. *Mooreonuphis* sp SD 1	Polychaeta: Onuphidae	3.5	14.6	1.3	24
Most Abundant per Occurrence					
1. *Spiophanes bombyx*	Polychaeta: Spionidae	43.9	43.9	16.6	100
2. *Saccocirrus* sp	Polychaeta: Saccocirridae	2.4	43.7	0.9	6
3. *Pareurythoe californica*	Polychaeta: Amphinomidae	0.6	34.0	0.2	2
4. *Eulalia levicornuta*	Polychaeta: Phyllodocidae	1.0	26.5	0.4	4
5. *Euchone arenae*	Polychaeta: Sabellidae	9.9	24.3	3.7	41
6. Nematoda	Nematoda	12.7	22.9	4.8	56
7. *Hesionura coineaui difficilis*	Polychaeta: Phyllodocidae	3.0	20.1	1.1	15
8. *Pisione remota*	Polychaeta: Pisionidae	2.6	19.9	1.0	13
9. *Odontosyllis* sp SD 1	Polychaeta: Syllidae	0.7	19.0	0.3	4
10. *Chloeia pinnata*	Polychaeta: Amphinomidae	1.9	17.2	0.7	11
Most Frequently Collected					
1. *Spiophanes bombyx*	Polychaeta: Spionidae	43.9	43.9	16.6	100
2. *Ampelisca cristata cristata*	Crustacea: Amphipoda	4.5	5.6	1.7	82
3. *Sigalion spinosus*	Polychaeta: Sigalionidae	2.4	3.0	0.9	82
4. *Spiophanes duplex*	Polychaeta: Spionidae	7.2	9.5	2.7	76
5. *Spiochaetopterus costarum*	Polychaeta: Chaetopteridae	1.9	2.5	0.7	74
6. *Hemilamprops californicus*	Crustacea: Cumacea	2.2	3.1	0.8	72
7. Maldanidae †	Polychaeta: Maldanidae	2.0	3.1	0.8	67
8. *Glycinde armigera*	Polychaeta: Goniadidae	1.7	2.6	0.6	67
9. Euclymeninae sp A	Polychaeta: Maldanidae	5.3	8.3	2.0	63
10. *Carinoma mutabilis*	Nemertea: Anopla	2.5	3.9	0.9	63

† = unidentified juveniles and/or damaged specimens

A



CG	SR	ABUN	% Fines	Top Three Taxa
A (n=2)	73 (71-77)	854 (155-1576)	10.1 (9.4-10.9)	Nematoda; *Hesionura coineaui difficilis*; *Saccocirrus* sp
B (n=4)	93 (34-152)	283 (74-532)	17.5 (7.9-27.3)	*Spiophanes duplex*; *Spiophanes bombyx*; *Chloeia pinnata*
C (n=23)	64 (36-95)	213 (105-401)	12.9 (1.2-35.0)	*Spiophanes bombyx*; *Monticellina siblina*; Euclymeninae sp A
D (n=8)	60 (35-98)	325 (163-766)	4.6 (0.0-27.3)	*Euchone arenae*; *Spiophanes bombyx*; *Lanassa venusta venusta*
E (n=17)	49 (27-107)	207 (91-427)	4.0 (0.0-15.7)	*Spiophanes bombyx*; *Dendraster terminalis*; *Caecum crebricinctum*

B

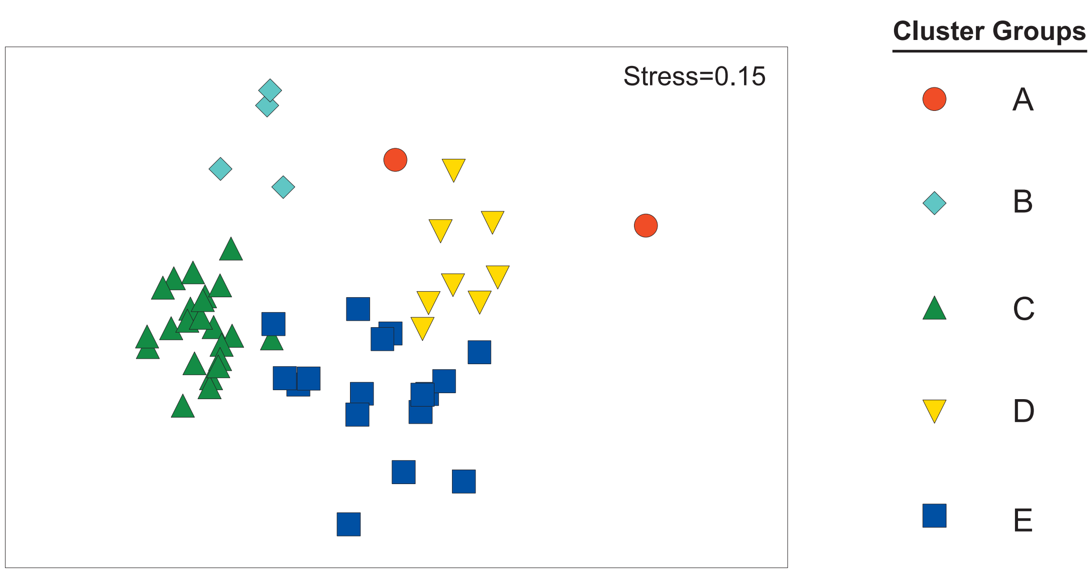


Figure 5.4

(A) Cluster results of macrofaunal abundance data for the SBOO benthic stations sampled during 2004. CG=cluster group; SR=mean number of species; ABUN=mean number of individuals. Ranges in parentheses are for individual grab samples. **(B)** MDS ordination of SBOO benthic stations sampled during 2004. Plot based on square-root transformed macrofaunal abundance data for each station/survey entity. Cluster groups superimposed on station/surveys illustrate a clear distinction between faunal assemblages.

collected species were also among the top ten taxa in terms of abundance (i.e., *S. bombyx*, *Ampelisca cristata cristata*, *S. duplex*, and *Euclymeninae* sp A).

Multivariate Analyses

Classification analysis discriminated between five habitat-related benthic assemblages (cluster groups A–E) during 2004 (**Figure 5.4A**). These assemblages differed in terms of their species composition, including the specific taxa present and their relative abundances. The dominant species composing each group are listed in **Table 5.3**. A MDS ordination of the station/survey entities confirmed the validity of cluster groups A–E (Figure 5.4B). These analyses identified no significant patterns regarding proximity to the discharge (**Figure 5.5**).

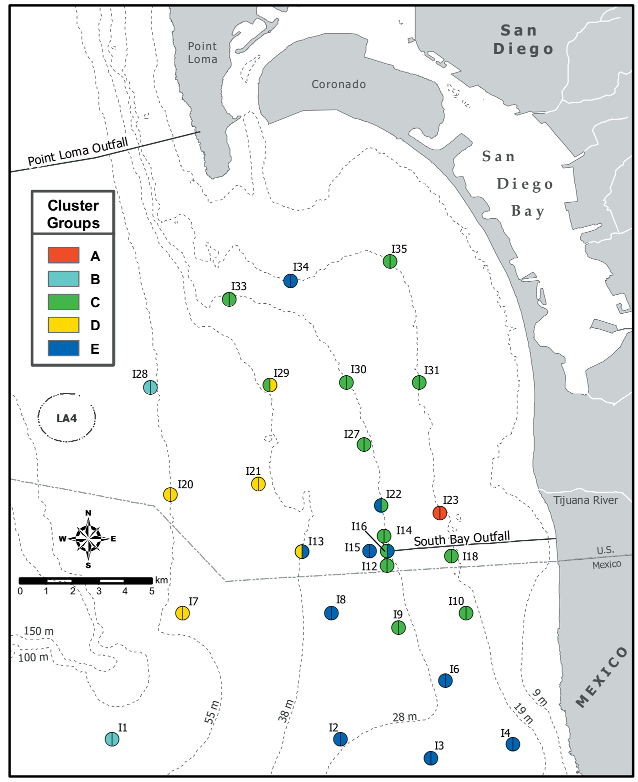


Figure 5.5
SBOO benthic stations sampled during January and July 2004, color-coded to represent affiliation with benthic cluster groups. Left half of circle represents cluster group affiliation for the January survey; right half represents the July survey.

Cluster group A represented the January and July survey from a single station (I23) located on the 19-m depth contour. Sediments at this site were characterized by a relatively low percentage of fine particles. The group A assemblage was somewhat unique for the region; it was dominated by nematode worms and some relatively abundant uncommon polychaete species. Many of the dominant polychaetes from this group were absent from, or occurred in much lower numbers at the other SBOO stations (e.g., *Hesionura coineaui difficilis*, *Saccocirrus* sp, *Pisione remota*).

Cluster group B comprised two stations located along the 55-m depth contour. Sediments at these deepwater sites contained a relatively high percentage of fine particles (**Figure 5.6**). The group B assemblage was characterized by high species richness and abundance, averaging 93 taxa and 283 individuals per grab (Figure 5.4A). The three most abundant species were the spionid polychaetes *Spiophanes bombyx* and *S. duplex* and the amphinomid polychaete *Chloeia pinnata*. The following polychaetes were also characteristic of this assemblage, but relatively uncommon in other groups: the oweniid *Myriochele gracilis*, the paraonid *Aricidea (Acmira) simplex*, and the sigalionid *Sthenelanella uniformis* (Table 5.3). The ophiuroid *Amphiodia urtica*, typically found at this depth, also was abundant in this assemblage.

Cluster group C included sites primarily located along the 19 and 28-m depth contours, and where sediments also contained relatively high amounts of fine particles. This assemblage averaged 64 taxa and 213 individuals per 0.1 m^2. The dominant species in this group were *Spiophanes bombyx* and *S. duplex*, the cirratulid *Monticellina siblina*, and the maldanid *Euclymeninae* sp A.

Cluster group D comprised two stations characterized by coarse relict red sand sediments located along the 55-m depth contour and three stations along the 38-m contour. In contrast to the other deeper-water assemblage described above (group B), this group had fewer taxa but more individual organisms per grab. The polychaetes

Table 5.3

Summary of the most abundant taxa composing cluster groups A–E from the 2004 survey of SBOO benthic stations. Data are expressed as mean abundance per sample (no./0.1m^2) and represent the ten most abundant taxa in each group. Values for the three most abundant species in each cluster group are in bold. n=number of station/survey entities per cluster group

		Cluster Group				
		A	B	C	D	E
Species/Taxa	Taxa	(n=2)	(n=4)	(n=23)	(n=8)	(n=17)
Ampelisca cristata cristata	Crustacea	1.5	1.1	5.3	6.8	3.6
Amphiodia urtica	Echinodermata	—	4.6	0.1	0.1	0.5
Apionsoma misakianum	Sipuncula	3.0	3.9	—	8.9	0.1
Aricidea (*Acmira*) *simplex*	Polychaeta	—	4.5	0.1	0.7	—
Axiothella rubrocincta	Polychaeta	0.3	—	1.7	1.4	4.3
Cadulus aberrans	Mollusca	—	2.0	3.2	0.1	0.5
Caecum crebricinctum	Mollusca	0.3	0.1	—	2.9	**4.8**
Carinoma mutabilis	Nemertea	0.8	0.4	2.4	0.1	4.4
Chloeia pinnata	Polychaeta	11.0	**11.1**	—	4.5	0.1
Chone veleronis	Polychaeta	0.3	0.1	5.0	—	0.6
Cirriformia sp SD2	Polychaeta	20.0	—	0.1	0.5	0.1
Dendraster terminalis	Echinodermata	0.8	—	—	0.7	**4.9**
Euchone arenae	Polychaeta	55.3	0.6	0.1	**46.8**	2.8
Euclymeninae sp A	Polychaeta	5.0	1.3	**11.1**	0.2	0.7
Eulalia levicornuta	Polychaeta	26.5	—	—	—	—
Euphilomedes carcharodonta	Crustacea	0.5	7.3	5.0	0.3	4.2
Eusyllis sp SD2	Polychaeta	0.8	—	—	7.0	0.3
Hesionura coineaui difficilis	Polychaeta	**74.8**	—	0.1	0.8	0.3
Lanassa venusta venusta	Polychaeta	—	0.3	0.1	**24.8**	0.1
Leptochelia dubia	Crustacea	0.8	5.3	0.9	3.1	3.4
Monticellina siblina	Polychaeta	—	3.8	**16.3**	0.2	0.6
Mooreonuphis sp	Polychaeta	—	—	0.1	10.1	2.9
Mooreonuphis sp SD1	Polychaeta	—	—	—	21.2	1.2
Myriochele gracilis	Polychaeta	—	6.5	—	—	0.1
Nematoda	Nematoda	**221.8**	3.8	0.5	22.9	1.9
Odontosyllis sp SD1	Polychaeta	19.0	—	—	—	—
Onuphidae	Polychaeta	—	0.5	0.2	9.0	1.7
Ophelia pulchella	Polychaeta	0.3	—	—	0.9	3.6
Photis californica	Crustacea	—	5.0	—	0.5	—
Pisione remota	Polychaeta	58.8	—	0.1	2.6	—
Protodorvillea gracilis	Polychaeta	19.5	—	0.1	1.9	3.4
Saccocirrus sp	Polychaeta	**65.3**	—	—	0.1	—
Sigalion spinosus	Polychaeta	3.8	1.3	3.5	2.6	1.1
Solamen columbianum	Mollusca	—	1.9	—	2.0	3.4
Spiophanes bombyx	Polychaeta	4.5	**18.5**	**33.8**	**33.2**	**73.4**
Spiophanes duplex	Polychaeta	1.0	**31.3**	10.0	2.5	0.7
Sthenelanella uniformis	Polychaeta	—	9.8	0.6	—	0.1
Syllis (*Typosyllis*) sp SD1	Polychaeta	6.3	—	—	11.4	0.1
Syllis (*Typosyllis*) sp SD2	Polychaeta	20.5	—	0.1	0.4	0.6
Tellina modesta	Mollusca	1.0	—	3.9	0.1	0.6

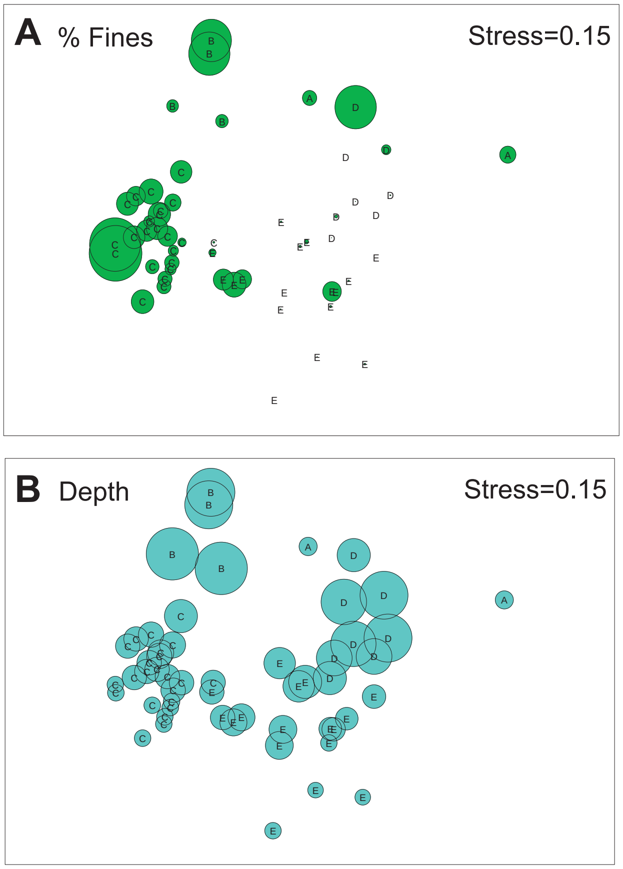


Figure 5.6
MDS ordination of SBOO benthic stations sampled during January and July 2004. Cluster groups A–E are superimposed on station/surveys. Percentage of fine particles in the sediments **(A)** and station depth **(B)** are further superimposed as circles that vary in size according to the magnitude of each value. Plots indicate associations of benthic assemblages with habitats that differ in sediment grain size and depth.

Euchone arenae and *Spiophanes bombyx* dominated this group, followed by the terebellid polychaete *Lanassa venusta venusta.*

Cluster group E comprised sites that were located on or near the 28-m depth contour. These sites averaged a low percentage of fines, with some stations containing relict red sands. The group E assemblage averaged 49 taxa and 207 individuals per grab, the lowest among all cluster groups. *Spiophanes bombyx* was numerically dominant in this group, followed by the echinoderm *Dendraster terminalis,* and the gastropod *Caecum crebricinctum.*

SUMMARY and CONCLUSIONS

Benthic macrofaunal assemblages surrounding the South Bay Ocean Outfall were similar in 2004 to those that occurred during previous years (City of San Diego 2000, 2004). In addition, these assemblages were generally typical of those occurring in other sandy, shallow-water habitats throughout the Southern California Bight (SCB) (e.g., Thompson et al. 1987, 1993b, City of San Diego 1999, Bergen et al. 2001). For example, the two assemblages found at the majority of stations (e.g., groups C and E) contained high numbers of the spionid polychaete *Spiophanes bombyx*, a species characteristic of shallow-water environments in the SCB (see Bergen et al. 2001). These two groups represented sub-assemblages of the shallow SCB benthos that differed in the relative abundances of dominant and co-dominant species. Such differences probably reflect variation in microhabitat structure, such as the presence of a fine sediment component (i.e., group C), or coarse, relict red sands (i.e., group E). In contrast, the group B assemblage occurs in mid-depth shelf habitats that probably represent a transition between the shallow sandy sediments common in the area and the finer mid-depth sediments characteristic of much of the SCB mainland shelf (see Barnard and Ziesenhenne 1961, Jones 1969, Fauchald and Jones 1979, Thompson et al. 1987, 1993a, b, EcoAnalysis et al. 1993, Zmarzly et al. 1994, Diener and Fuller 1995, Bergen et al. 2001). A second deeper-water assemblage (group D) occurred where relict red sands were present. Polychaetes dominated group D, including the ubiquitous spionid polychaete *S. bombyx.* Finally, the group A assemblage characteristic of station I23 was quite dissimilar from assemblages found at any other station. Nematode worms and various abundant polychaete species in these samples were not common elsewhere in the region. This assemblage is similar to that sampled previously at I23 during July 2003. Analysis of the sediment chemistry data provided no evidence to explain the occurrence of this assemblage, and the presence of these animals may reflect particular components of the sediments such as variation in microhabitats or types and amounts of shell hash or algal detritus.

Multivariate analyses revealed no clear spatial patterns relative to the outfall. Comparisons of the biotic data to the physico-chemical data indicated that macrofaunal distribution and abundance in the region varied primarily along gradients of sediment type and depth. Relatively high numbers of the spionid polychaetes *Spiophanes bombyx* and *S. duplex* were collected during 2004. However, temporal fluctuations in the populations of these taxa are similar in magnitude to those that occur elsewhere in the region and that often correspond to large-scale oceanographic conditions (see Zmarzly et al. 1994). Overall, temporal patterns suggest that the benthic community has not been significantly impacted by wastewater discharge via the SBOO. For example, the range of values for species richness and abundance during 2004 was similar to that seen in previous years (see City of San Diego 2000, 2004b). In addition, environmental disturbance indices such as the BRI and the ITI were generally characteristic of assemblages from undisturbed sediments.

Anthropogenic impacts have spatial and temporal dimensions that can vary depending on a range of biological and physical factors. Such impacts can be difficult to detect, and specific effects of the SBOO discharge could not be identified during 2004. Furthermore, benthic invertebrate populations exhibit substantial spatial and temporal variability that may mask the effects of any disturbance event (Morrisey et al. 1992a, b, Otway 1995). Although some changes have likely occurred near the SBOO, benthic assemblages in the area remain similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf.

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