Chapter 6. Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Demersal fishes and megabenthic invertebrates are conspicuous members of continental shelf habitats, and assessment of their communities has become an important focus of ocean monitoring programs throughout the world. Such assemblages have been sampled extensively for more than 30 years on the mainland shelf of the Southern California Bight (SCB), primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). More than 100 species of demersal fish inhabit the SCB, while the megabenthic invertebrate fauna consists of more than 200 species (Allen 1982, Allen et al. 1998). For the region surrounding the South Bay Ocean Outfall (SBOO), the most common trawl-caught fishes include speckled sanddab, longfin sanddab, hornyhead turbot, California halibut, California lizardfish, and occasionally white croaker. Common trawl-caught invertebrates include relatively large taxa such as sea urchins and sand dollars.

The structure of these communities is inherently variable and may be influenced by both anthropogenic and natural factors. Demersal fishes and megabenthic invertebrates live in close proximity to sediments potentially altered by anthropogenic influences such as inputs from ocean outfalls and storm drain runoff. Natural factors that may affect these communities include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperature associated with large scale oceanographic events such as El Niños (Karinen et al. 1985). These factors can impact the migration of adult fish or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations that affect diversity and abundance may also be due to the mobile nature of many species (e.g., schools of fish or aggregations of urchins).

The City of San Diego has been conducting trawl surveys in the area surrounding the SBOO since 1995. These surveys are designed to monitor the effects of wastewater discharge on the local marine biota by assessing the structure and stability of the demersal fish and megabenthic invertebrate communities. This chapter presents analyses and interpretations of data collected during the 2006 trawl surveys.

MATERIALS AND METHODS

Field Sampling

Trawl surveys were conducted in January, April, July, and October 2006 at 7 fixed sites around the SBOO (**Figure 6.1**). These stations, SD15–SD21, are located along the 28-m isobath, and encompass an area south of Point Loma, California, USA to Punta Bandera, Baja California, Mexico. During

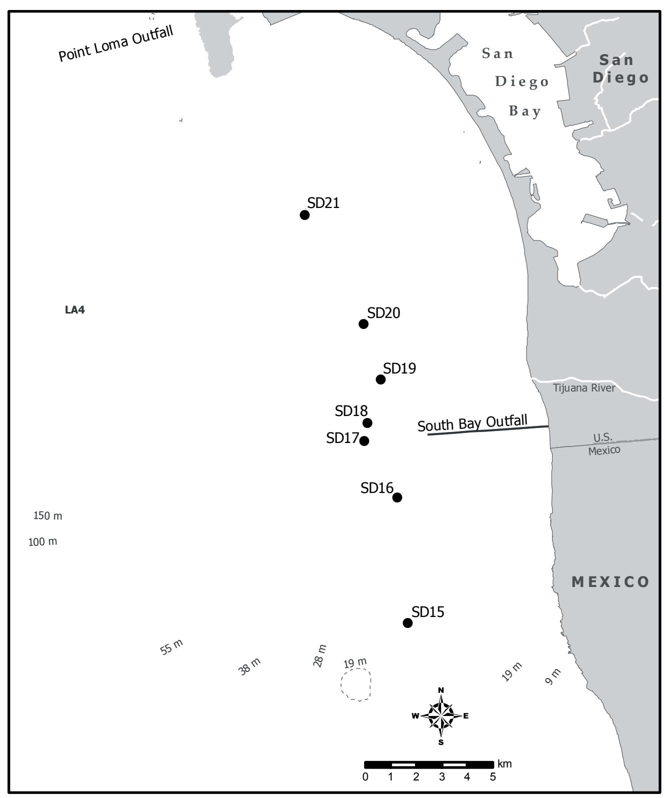


Figure 6.1
Otter trawl station locations, South Bay Ocean Outfall Monitoring Program (SD15–SD21).

each survey a single trawl was performed at each station using a 7.6-m Marinovich otter trawl fitted with a 1.3-cm cod-end mesh net. The net was towed for 10 minutes bottom time at a speed of about 2.5 knots along a predetermined heading.

Trawl catches were brought on board for sorting and inspection. All organisms were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. For fishes, the total number of individuals and total biomass (wet weight, kg) were recorded for each species. Additionally, each individual fish was inspected for external parasites or physical anomalies (e.g., tumors, fin erosion, discoloration) and measured to the nearest centimeter size class (standard lengths). For invertebrates, the total number of individuals was recorded per species. Due to the small size of most organisms, invertebrate biomass was typically measured as a composite wet weight (kg) of all species combined; however, large or exceptionally abundant species were weighed separately.

Data Analyses

Populations of each fish and invertebrate species were summarized as percent abundance, frequency of occurrence, and mean abundance per haul. In addition, species richness (number of species), total abundance, and Shannon diversity index (H') were calculated for both fish and invertebrate assemblages at each station. Total biomass was also calculated for each fish species by station.

Multivariate analyses were performed on 12 years of data from the July surveys of all 7 stations. PRIMER v6 (Plymouth Routines in Multivariate Ecological Research) software was used to examine spatio-temporal patterns in the overall similarity of fish 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 fish abundance data were limited to species that occurred in at least 10 hauls, or had a station abundance of 5 or greater. These data were square root transformed, and the Bray-Curtis measure of similarity was used as the basis for classification. Because the species composition was sparse at some stations, a dummy species with a value of 1 was added to all samples prior to computing similarities (see Clarke and Gorley 2006). The SIMPER ("similarity percentages") routine was used to describe inter- and intra-group species differences.

RESULTS AND DISCUSSION

Fish Community

Thirty-six species of fish were collected in the area surrounding the SBOO during 2006 (**Table 6.1**). The total catch for the year was 4244 individuals, representing an average of about 152 fish per trawl. Speckled sanddabs and California lizardfish comprised 49% and 18% of the total catch, respectively. No other species contributed more than 5% of the total catch. Speckled sanddabs were present in every haul, while California lizardfish occurred in 96% of the hauls. Other frequently occurring fishes were yellowchin sculpin, longfin sanddab, hornyhead turbot, California tonguefish, roughback sculpin, and English sole. Most of these common fishes, as well as the majority of other species collected, tended to be relatively small (average length <20 cm, see **Appendix D.1**). The largest species were relatively rare, and consisted primarily of sharks, skates, and rays (e.g., brown smoothhound, shovelnose guitarfish, California skate, bat ray).

During 2006, species richness and diversity (H') were relatively low across the survey area (**Table 6.2**). Species richness ranged from 2 to 18 during the year, but 27 of the 28 samples had fewer than 15 species. On average, the lowest species richness occurred at station SD15 (6 spp), while the highest number of species (18 spp) occurred at station SD18. Diversity (H') values can range from 0 to 5; average diversity values from the SBOO

Table 6.1

Demersal fish species collected in 28 trawls in the SBOO region during 2006. Data for each species are expressed as: percent abundance (PA); frequency of occurrence (FO); mean abundance per haul (MAH).

Species	PA	FO	MAH	Species	PA	FO	MAH
Speckled sanddab	49	100	74	California halibut	<1	36	1
California lizardfish	18	96	28	Calico rockfish	<1	29	<1
Yellowchin sculpin	5	61	7	Pygmy poacher	<1	21	<1
Longfin sanddab	5	54	7	Spotted turbot	<1	21	<1
White croaker	5	32	7	Basketweave cuskeel	<1	14	<1
Hornyhead turbot	5	82	7	Fantail sole	<1	18	<1
California tonguefish	3	82	4	Bigmouth sole	<1	18	<1
Roughback sculpin	2	64	4	California skate	<1	18	<1
Longspine combfish	2	25	3	Spotted cuskeel	<1	11	<1
English sole	1	54	2	California butterfly ray	<1	4	<1
Queenfish	1	21	1	Shovelnose guitarfish	<1	4	<1
Pacific pompano	1	7	1	Bat ray	<1	4	<1
California scorpionfish	<1	39	1	Bluespotted poacher	<1	4	<1
Northern anchovy	<1	18	1	Brown smoothhound	<1	4	<1
Plainfin midshipman	<1	39	1	Curlfin sole	<1	4	<1
Pacific sanddab	<1	14	1	Diamond turbot	<1	4	<1
Shiner perch	<1	25	1	Kelp pipefish	<1	4	<1
Specklefin midshipman	<1	32	1	Spotted ratfish	<1	4	<1

Table 6.2

Summary of demersal fish community parameters for SBOO stations sampled during 2006. Data are expressed as mean and standard deviation (SD) for species richness (number of species), abundance (number of individuals), diversity (H'), and biomass (kg, wet weight); n=4.

Station	Jan	Apr	Jul	Oct	Mean	SD	Station	Jan	Apr	Jul	Oct	Mean	SD
Species richness							*Abundance*						
SD15	2	10	4	7	6	4	SD15	62	106	84	115	92	24
SD16	9	11	7	12	10	2	SD16	49	127	295	230	175	109
SD17	13	14	9	11	12	2	SD17	113	115	302	169	175	89
SD18	18	12	14	10	14	3	SD18	187	150	354	215	227	89
SD19	6	12	13	10	10	3	SD19	67	65	175	176	121	63
SD20	9	14	14	11	12	2	SD20	55	131	195	186	142	64
SD21	9	14	11	12	12	2	SD21	43	129	197	152	130	65
Mean	9	12	10	10			Mean	82	118	229	178		
SD	5	2	4	2			SD	52	27	93	38		
Diversity							*Biomass*						
SD15	0.08	0.94	0.63	1.21	0.72	0.49	SD15	0.6	3.9	1.0	2.4	2.0	1.5
SD16	1.21	1.75	0.78	1.11	1.21	0.40	SD16	1.1	3.1	3.1	5.3	3.2	1.7
SD17	1.73	2.00	1.04	1.79	1.64	0.42	SD17	3.8	4.4	2.5	3.6	3.6	0.8
SD18	1.51	1.79	1.48	1.28	1.52	0.21	SD18	14.0	3.5	6.4	5.9	7.5	4.5
SD19	1.28	1.77	1.51	0.91	1.37	0.36	SD19	3.3	2.5	4.5	2.5	3.2	0.9
SD20	1.49	1.63	1.02	1.09	1.31	0.30	SD20	3.6	5.1	5.2	3.5	4.4	0.9
SD21	1.81	1.97	1.75	1.62	1.79	0.15	SD21	3.1	9.9	5.5	5.1	5.9	2.9
Mean	1.30	1.69	1.17	1.29			Mean	4.2	4.6	4.0	4.0		
SD	0.58	0.36	0.41	0.31			SD	4.5	2.5	1.9	1.4		

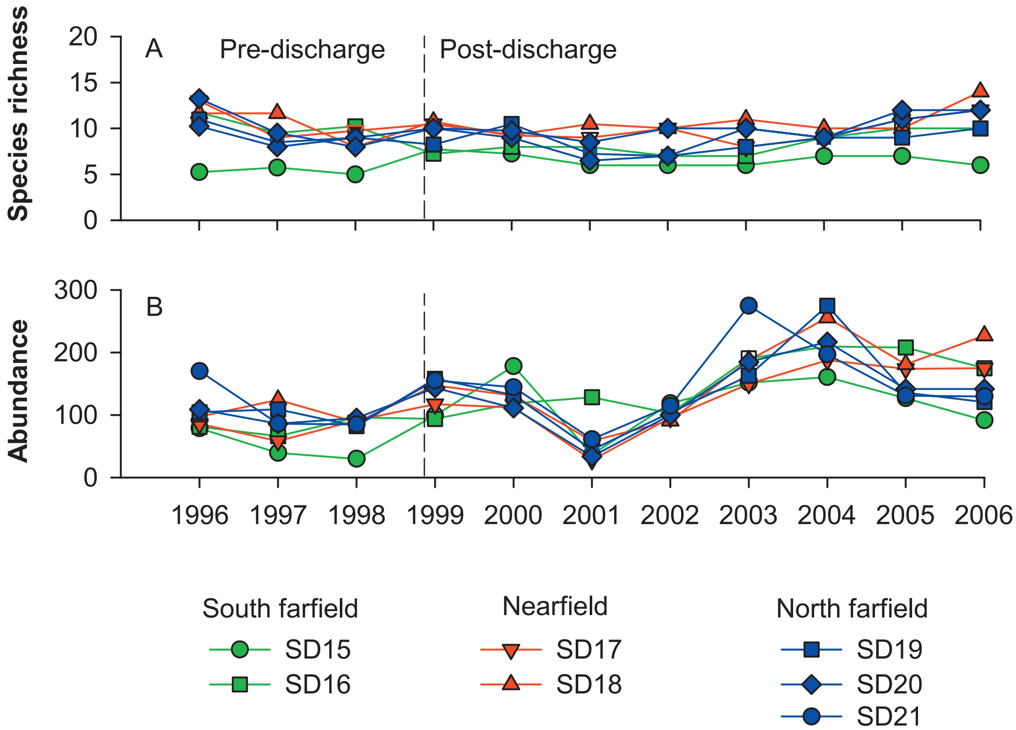
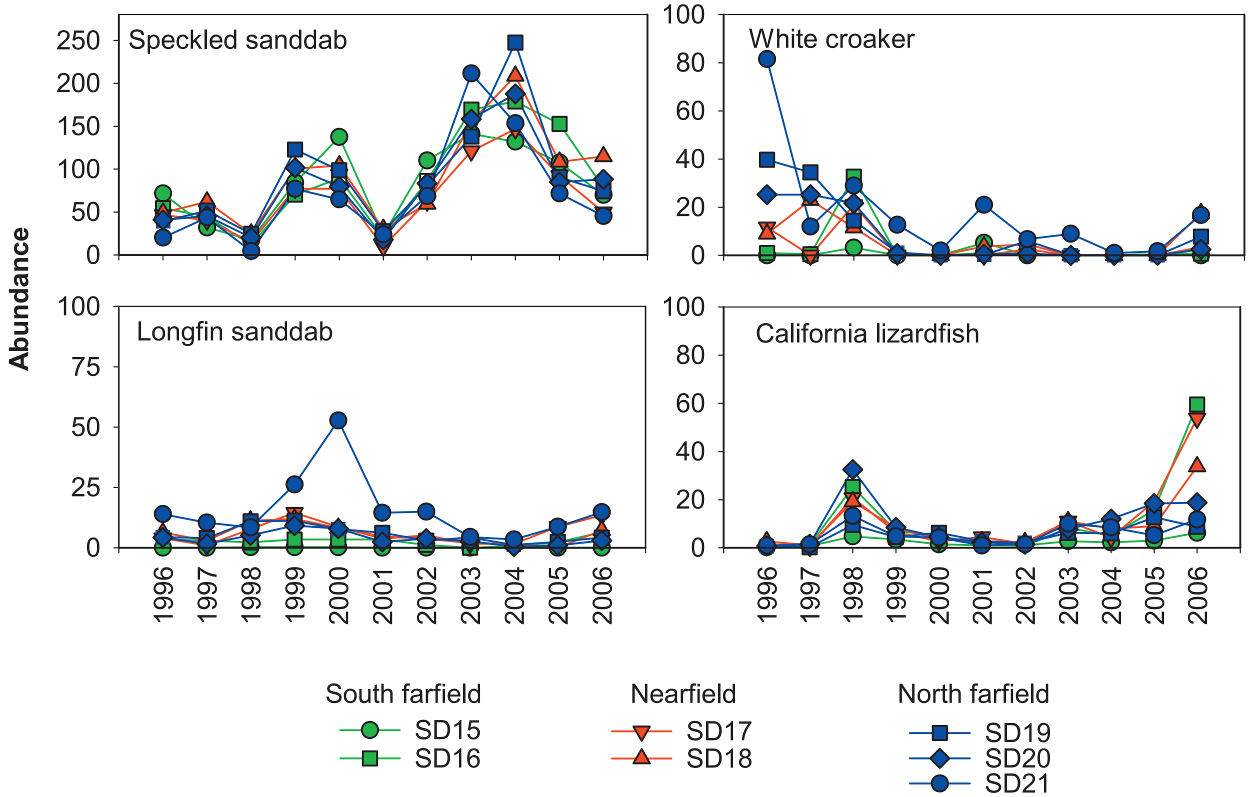


Figure 6.2
Annual mean species richness (number of species) and abundance (number of individuals) per SBOO station of demersal fish collected from 1996 through 2006.

region were ≤2.0 at all stations. These low values are typical of the southern region of the SCB, where median diversity was about 1.5 (Allen et al. 1998, Allen et al. 2002), and reflect the small number of species that comprise this community.

Abundance and biomass were highly variable across the survey area in 2006. The wide range in abundance (43–354 fish per haul) was due to population fluctuations of a few common species. For example, quarterly catches of California lizardfish and speckled sanddab ranged from 8 to 581 and 284 to 781, respectively. These fishes contributed to the highest abundance values at stations SD16–SD21 during July. The wide range of biomass values (0.6–14.0 kg per haul) reflect these population fluctuations and the size of individual fishes, such as the 2.5 kg bat ray collected at SD18 in January. The low species richness, diversity, abundance, and biomass values at station SD15 may be indicative of a different habitat at this location relative to the other stations (see Chapter 4).

Fish community structure in this region has varied in response to population fluctuations of a few dominant species since 1996 (**Figures 6.2, 6.3**). Although annual mean species richness has remained fairly consistent over the years (e.g., between 5 and 14 species per station), mean abundances have fluctuated between 28 and 275 individuals per station (Figure 6.2). Variability across stations primarily reflects changes in the populations of the dominant species. For example, the total catch for 2006 represents a decline of about 29% from the peak of 6010 individuals collected in 2004. This decline was due to a substantial drop in the total speckled sanddab catch at all stations from 2004 to 2006 (Figure 6.3). In contrast, inter-annual variability at individual stations is most often caused by large hauls of schooling species that occur infrequently. For example, large hauls of white croaker were responsible for the high abundance at SD21 in 1996, while a large haul of northern anchovy caused the relatively high abundance at SD16 in 2001. Overall, none of the observed changes appear to be associated with the South Bay outfall.



Ordination and classification analyses of fish data from July surveys between 1995 and 2006 resulted in 6 major cluster groups (station groups A–F) (see **Figure 6.4**). All of the assemblages were dominated by speckled sanddabs and were differentiated by relative abundances of this and other common species. No patterns of change in fish assemblages were associated with the SBOO. Instead, differences in the assemblages seem to be related to oceanographic events (e.g., El Niño conditions in 1998) or location (i.e., station). For example, station SD15 frequently grouped apart from the remaining stations. The composition of each station group and the species characteristic of each assemblage are described below (**Table 6.3**).

Station group A comprised the 2 northernmost stations (SD20–21) from 1995, and every station except SD15 during the 1998 El Niño. This assemblage had the second fewest individuals per haul, with an average of 9 species and 64 individuals. Station group A was characterized by the lowest abundance of speckled sanddabs, as well as relatively abundant longfin sanddabs and hornyhead turbot. The low number of speckled sanddabs separated this assemblage from those comprising groups C–F, while the relative number of longfin sanddabs separated group A from groups B and F.

Station group B comprised every station sampled during July 2001 except SD21, 3 southern and one northern station sampled in 1997, and station SD15 from 1998. The group had the fewest individuals per haul, averaging only 36 fishes representing 7 species. Like group A, station group B was also characterized by relatively low numbers of speckled sanddabs. The low number of speckled sanddabs separated this assemblage from all the others.

Station group C consisted of only 2 stations, SD16 and SD17, sampled in 2006. This assemblage was unique in that it contained large numbers of California

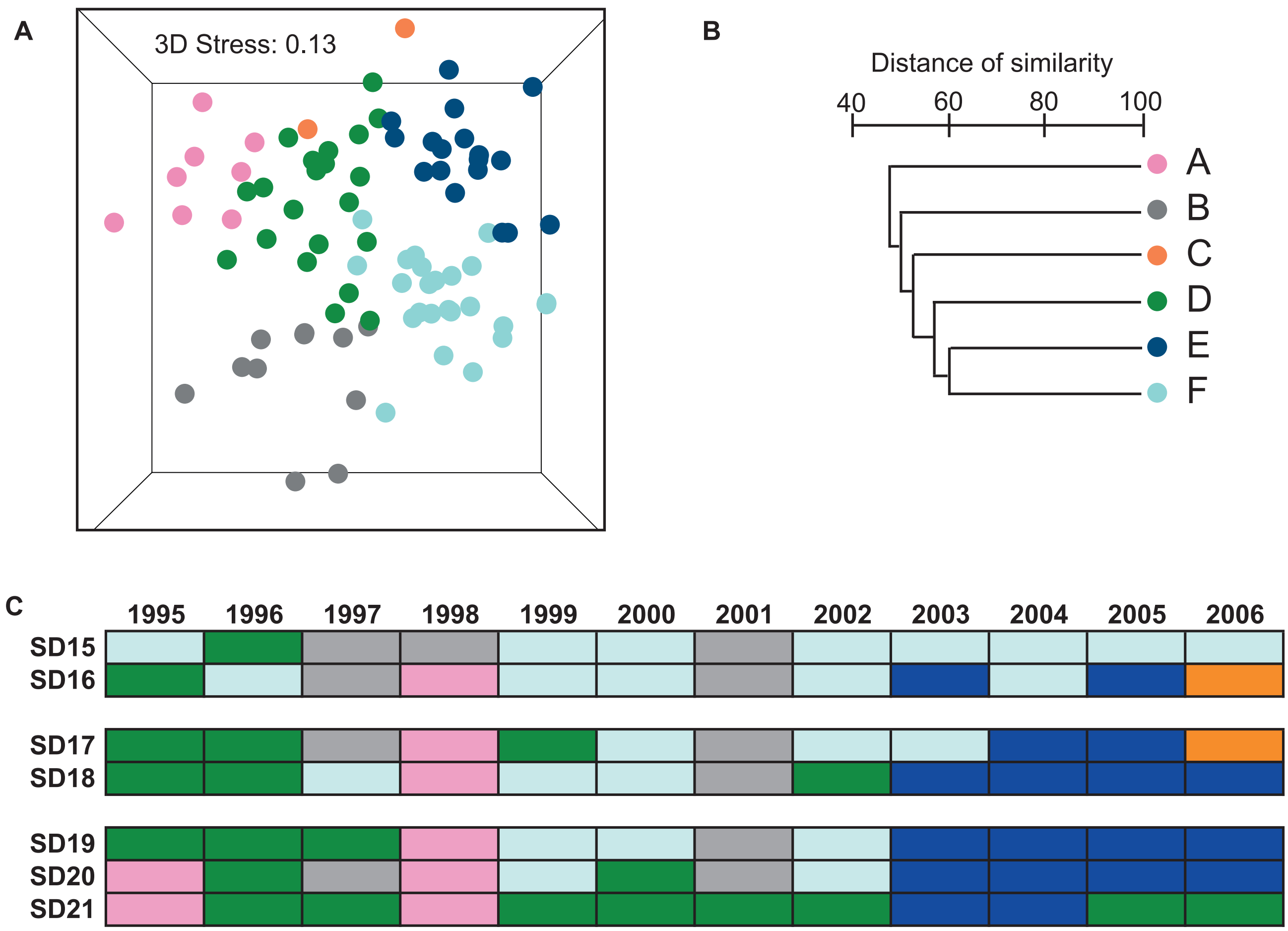


Figure 6.4
Results of classification analysis of demersal fish assemblages collected at SBOO stations SD15–SD21 between 1995 and 2006 (July surveys only). Data are presented as (A) MDS ordination, (B) a dendrogram of major station groups and (C) a matrix showing distribution over time.

lizardfish. Over 200 lizardfish were collected at each of these stations during July 2006, almost twice as many than any other haul included in these analyses.

Station group D encompassed 9 of the 12 surveys and included 10 of the 14 stations sampled in 1995 and 1996, 8 surveys at station SD21 (including 1996), and one trawl each from stations SD17—SD20 during various years from 1997 to 2002. Speckled sanddabs and hornyhead turbot were representative of this assemblage, although the numbers of English sole, California tonguefish, and longfin sanddabs distinguished it from the others.

Station group E comprised most stations sampled from 2003 to the present. This group averaged the highest number of species and the highest number of speckled sanddabs; it corresponds strongly to peak numbers of speckled sanddab numbers over the same years as depicted in Figure 6.3. The combination of relatively high numbers of speckled sanddabs and the presence of roughback sculpin distinguished this station group from all of the others.

Station group F comprised the largest number of trawls overall (n=24), and was represented in all but 2 surveys. This assemblage comprised most stations from 1999, 2000, and 2002, as well as several stations near the SBOO (SD17, SD18) and southward (SD15, SD16) during other years. The assemblage had the third highest overall abundance but the lowest species richness. It was dominated almost exclusively by speckled sanddabs and was unique in the absence of many species common to other

Table 6.3

Summary of the most abundant species comprising station groups A–F defined in Figure 6.4. Data include number of hauls, overall similarity within each group, mean species richness, and mean abundance for each station group, as well as the mean abundance of species that together account for 90% of the similarity (or 90% of total abundance for groups with n <2). Values in bold type indicate the species that are most representative of a station group (i.e., 3 species with highest similarity/SD values >2 for groups with n >2, or highest abundance for groups with n ≤2).

	Group A	Group B	Group C	Group D	Group E	Group F
Number of hauls	8	11	2	21	18	24
Average similarity	64	58	78	64	70	70
Mean species richness	9	7	7	9	10	6
Mean abundance	64	36	298	115	226	124
Species			**Mean abundance**			
Bigmouth sole				1		
California halibut		1				
California lizardfish	24	2	**212**	3	17	
California scorpionfish		2				
California tonguefish	2			5		
English sole	5			3	4	
Hornyhead turbot	**3**	3	**4**	**6**	5	4
Longfin sanddab	**12**			25	5	
Roughback sculpin					5	
Speckled sanddab	**12**	**23**	**56**	**60**	**165**	**111**
Spotted turbot		2				2
Yellowchin sculpin					18	

assemblages (e.g., California lizardfish, English sole, longfin sanddab, roughback sculpins).

Physical Abnormalities and Parasitism

The overall absence of fin rot or other physical abnormalities among fishes collected for this survey suggest that fish populations in the area continue to appear healthy. No physical abnormalities and no external parasites were found attached to any fish collected during 2006. However, 2 known fish parasites, the ectoparasitic isopod *Elthusa vulgaris* and a leech (Annelida: Hirudinea), were observed in at least one trawl. Both types of parasites can become detached from their hosts during sorting, therefore it is unknown which fish were actually parasitized. Although *E. vulgaris* occurs on a wide variety of fish species in southern California, it is especially common on sanddabs and California lizardfish, where it may reach infestation rates of 3% and 80%, respectively (Brusca 1978, 1981).

Invertebrate Community

A total of 829 megabenthic invertebrates (~30 per trawl), representing 53 taxa, were collected during 2006 (**Appendix D.2**). The sea star *Astropecten verrilli* was the most abundant and most frequently captured species. This sea star was captured in almost all of the trawls and accounted for 62% of the total invertebrate abundance (**Table 6.4**). Another sea star, *Pisaster brevispinus*, occurred in 46% of the trawls but accounted for only 2% of the total abundance. The remaining taxa occurred infrequently, with only 7 occurring in 25% or more of the hauls. All of the taxa collected, with the exception of *A. verrilli*, had an average abundance per haul of 2 or less.

As with fish, invertebrate community measures varied among stations and between surveys during the year (**Table 6.5**). Species richness ranged from 4 to 12 species per haul and abundance values ranged from 8 to 98 individuals per haul. The biggest hauls

Table 6.4

Megabenthic invertebrate species collected in 28 trawls in the SBOO region during 2006. Data for each species are expressed as: percent abundance (PA); frequency of occurrence (FO); mean abundance per haul (MAH).

Species	PA	FO	MAH	Species	PA	FO	MAH
Astropecten verrilli	62	93	18	*Luidia armata*	<1	7	<1
Crangon nigromaculata	7	32	2	Majidae	<1	7	<1
Lytechinus pictus	6	29	2	*Pleurobranchaea californica*	<1	7	<1
Philine auriformis	3	11	1	*Pteropurpura festiva*	<1	7	<1
Cancer gracilis	2	32	1	*Sicyonia ingentis*	<1	7	<1
Kelletia kelletii	2	25	1	*Aphrodita armifera*	<1	4	<1
Pisaster brevispinus	2	46	1	*Aphrodita* sp	<1	4	<1
Heterocrypta occidentalis	2	29	<1	*Armina californica*	<1	4	<1
Dendraster terminalis	1	11	<1	*Cancer jordani*	<1	4	<1
Hemisquilla californiensis	1	18	<1	*Dendronotus frondosus*	<1	4	<1
Ophiothrix spiculata	1	25	<1	*Dendronotus iris*	<1	4	<1
Pagurus spilocarpus	1	29	<1	*Farfantepenaeus californiensis*	<1	4	<1
Randallia ornata	1	18	<1	*Flabellina pricei*	<1	4	<1
Platymera gaudichaudii	1	21	<1	*Florometra serratissima*	<1	4	<1
Crangon alba	1	7	<1	*Heptacarpus stimpsoni*	<1	4	<1
Octopus rubescens	1	11	<1	Hirudinea	<1	4	<1
Pyromaia tuberculata	1	21	<1	*Lamellaria diegoensis*	<1	4	<1
Loxorhynchus grandis	1	18	<1	*Loligo opalescens*	<1	4	<1
Cancer anthonyi	<1	4	<1	*Loxorhynchus* sp	<1	4	<1
Crossata californica	<1	14	<1	*Luidia foliolata*	<1	4	<1
Crangon alaskensis	<1	7	<1	*Megasurcula carpenteriana*	<1	4	<1
Elthusa vulgaris	<1	11	<1	*Paguristes bakeri*	<1	4	<1
Flabellina iodinea	<1	11	<1	*Paguristes turgidus*	<1	4	<1
Megastraea undosa	<1	7	<1	*Pagurus armatus*	<1	4	<1
Cancer sp	<1	7	<1	*Paracerceis cordata*	<1	4	<1
Dendronotus sp	<1	4	<1	*Sicyonia penicillata*	<1	4	<1

included large numbers of *A. verrilli*, particularly during April when their abundances ranged from 4 to 92 per haul. Although biomass was also somewhat variable, high values generally corresponded to the collection of large species such as the sea star *P. brevispinus* and cancer or sheep crabs.

Variations in megabenthic invertebrate community structure in the South Bay area generally reflect changes in species abundance (**Figures 6.5, 6.6**). Although species richness has varied little over the years (e.g., 4–14 species per station), annual abundance values have averaged between 7 and 273 individuals per station. These wide ranging abundance values are generally due to fluctuations in the populations of several dominant species, especially the echinoderms *A. verrilli*, *Lytechinus pictus*, and *Dendraster terminalis,* as well as the shrimp *Crangon nigromaculata* (Figure 6.6). For example, the high abundances recorded at SD17 in 1996 and SD15 in 1996 and 1997 were due to large hauls of *A. verrilli* and *L. pictus*. In contrast, the general decline in overall abundance values since 2004 is a result of declining numbers of *D. terminalis* and *A. verrilli.* None of the observed variability in the invertebrate communities can be attributed to the South Bay outfall.

SUMMARY AND CONCLUSIONS

As in previous years, speckled sanddabs continued to dominate fish assemblages surrounding the South Bay Ocean Outfall during 2006. Although the numbers of speckled sanddabs continued to decline markedly from their peak in 2004, this

Table 6.5

Summary of megabenthic invertebrate community parameters for SBOO stations sampled during 2006. Data are expressed as mean and standard deviation (SD) for species richness (number of species), abundance (number of individuals), diversity (H') and biomass (kg, wet weight); n=4.

Station	Jan	Apr	Jul	Oct	Mean	SD	Station	Jan	Apr	Jul	Oct	Mean	SD
Species richness							*Abundance*						
SD15	6	6	5	8	6	1	SD15	26	98	54	77	64	31
SD16	8	6	8	9	8	1	SD16	29	34	25	14	26	9
SD17	6	9	7	9	8	2	SD17	22	34	13	21	23	9
SD18	9	8	5	6	7	2	SD18	27	62	15	8	28	24
SD19	5	4	6	12	7	4	SD19	8	96	43	23	43	38
SD20	5	2	4	4	4	1	SD20	9	19	20	11	15	6
SD21	10	5	7	4	7	3	SD21	10	8	13	10	10	2
Mean	7	6	6	7			Mean	19	50	26	23		
SD	2	2	1	3			SD	9	36	16	24		
Diversity							*Biomass*						
SD15	1.14	0.66	0.74	0.88	0.86	0.21	SD15	0.1	0.3	0.3	2.9	0.9	1.3
SD16	1.25	0.96	1.37	2.11	1.42	0.49	SD16	1.8	0.5	0.7	1.3	1.1	0.6
SD17	1.28	1.12	1.69	1.63	1.43	0.27	SD17	0.7	0.2	0.3	0.2	0.4	0.2
SD18	1.58	0.72	1.23	1.67	1.30	0.43	SD18	1.7	0.7	0.4	0.3	0.8	0.6
SD19	1.39	0.22	0.83	2.22	1.17	0.85	SD19	1.2	0.1	0.3	0.3	0.5	0.5
SD20	1.43	0.21	0.59	1.34	0.89	0.59	SD20	1.0	0.1	0.5	0.8	0.6	0.4
SD21	2.30	1.39	1.69	0.94	1.58	0.57	SD21	2.6	0.1	1.0	0.1	1.0	1.2
Mean	1.48	0.75	1.16	1.54			Mean	1.3	0.3	0.5	0.8		
SD	0.39	0.44	0.45	0.52			SD	0.8	0.2	0.3	1.0		

species occurred at all stations and accounted for 49% of the total catch. Other characteristic, but less abundant species included the California lizardfish, yellowchin sculpin, longfin sanddab, hornyhead turbot, California tonguefish, roughback sculpin, and English sole. Most of these common fishes were relatively small, averaging less than 20 cm in length. Although the composition and structure of the fish assemblages varied among stations, these differences were mostly due to variations in speckled sanddab and California lizardfish populations.

Assemblages of relatively large (megabenthic) trawl-caught invertebrates were similarly dominated by one prominent species, the sea star *A. verrilli.* Although megabenthic community structure also varied between sites, these assemblages were generally characterized by low species richness, abundance, biomass, and diversity. As a result of declining numbers of *D. terminalis* and *A. verrilli,* there has been an overall decline in trawl-caught invertebrate abundance values since 2004.

The relatively low numbers and low species richness of fish and invertebrates found in the SBOO surveys are consistent with the depth and type of habitat in which the SBOO stations are located (see Allen et al. 1998). In contrast, trawl surveys for the Point Loma Ocean Outfall region include stations located farther offshore on the mainland shelf containing finer sediments, and result in higher species richness and abundance in each trawl. The mean number of fish species collected per haul off Point Loma often reaches 23 species per station with mean abundances up to 1368 individuals per station (e.g., City of San Diego 2006).

Overall, results of the 2006 trawl surveys provide no evidence that the discharge of wastewater from the South Bay Ocean Outfall has affected either the fish or megabenthic invertebrate communities in the region. Although highly variable, patterns in the abundance and distribution of species were similar at stations located near the outfall and farther away, indicating a lack of anthropogenic influence. Changes in the communities appeared

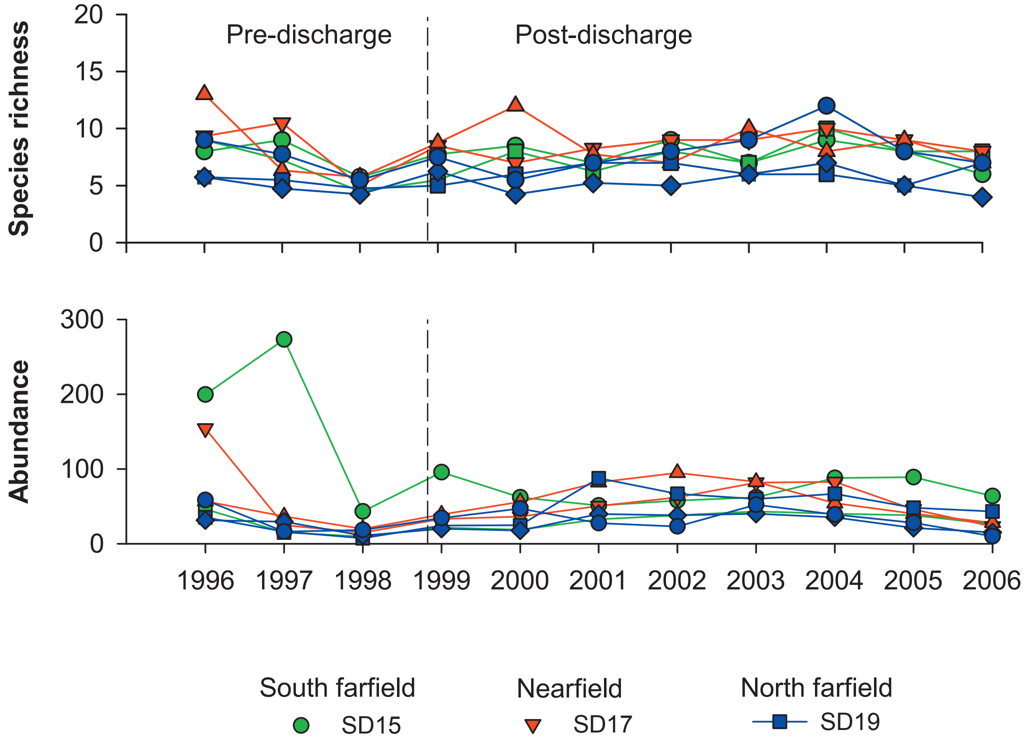
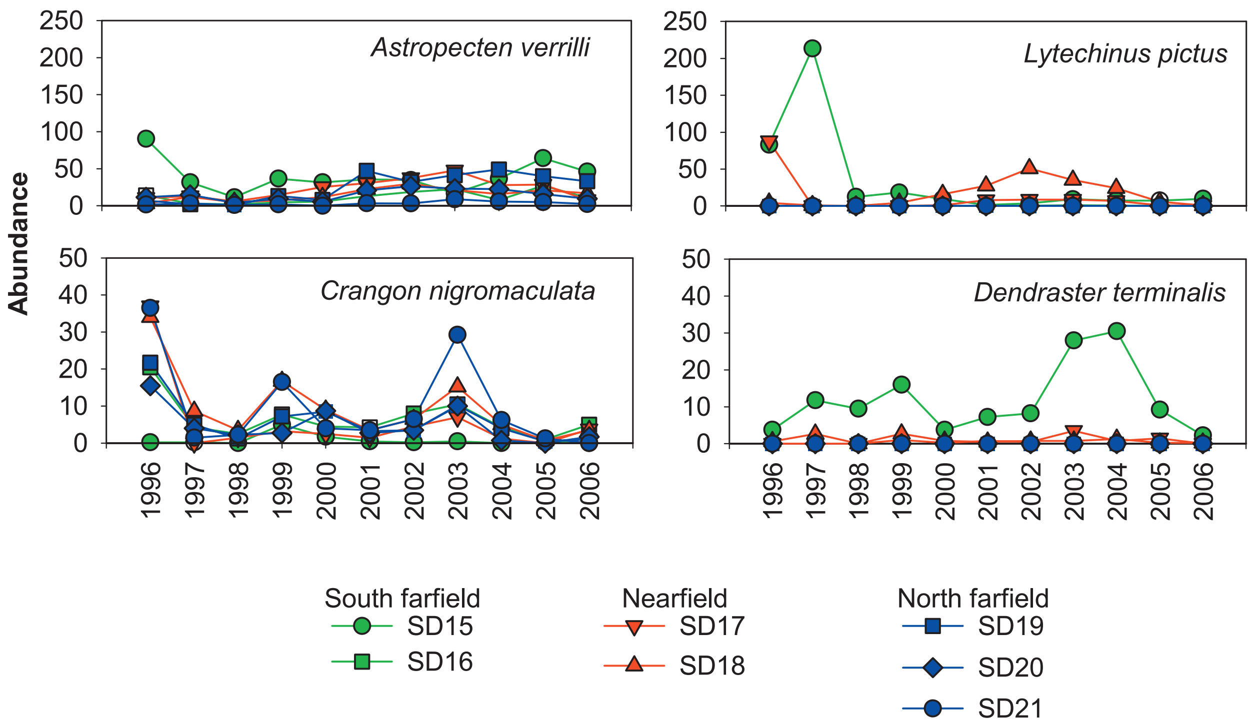


Figure 6.5
Annual mean species richness (number of species) and abundance (number of individuals) per SBOO station of megabenthic invertebrates collected from 1996 through 2006.



to be more likely due to natural factors such as changes in water temperature associated with large scale oceanographic events (e.g., El Niño) and the mobile nature of many of the species collected. Finally, the absence of disease or other physical abnormalities in local fishes suggests that populations in the area continue to be healthy.

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