Chapter 6. Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Marine fishes and 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. Assemblages of bottom dwelling (demersal) fishes and relatively large (megabenthic), mobile invertebrates that live on the surface of the seafloor 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, 2002, 2007). For the region surrounding the Point Loma Ocean Outfall (PLOO), the most common trawl-caught fishes include Pacific sanddab, longfin sanddab, Dover sole, hornyhead turbot, California tonguefish, plainfin midshipman, and yellowchin sculpin. Common trawl-caught invertebrates include various echinoderms (e.g., sea stars, sea urchins, sea cucumbers, and sand dollars), crustaceans (e.g., crabs and shrimp), molluscs (e.g., marine snails and octopuses), and other taxa.

Demersal fish and megabenthic invertebrate communities are inherently variable and may be influenced by both anthropogenic and natural factors. These organisms live in close proximity to the seafloor and are therefore exposed to contaminants of anthropogenic origin that may accumulate in the sediments via deposition from both point and non-point sources (e.g., discharges from ocean outfalls and storm drains, surface runoff from watersheds, outflows from rivers and bays, disposal of dredge materials). Natural factors that may affect these organisms include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperatures associated with large scale oceanographic events such as El Niño/La Niña oscillations (Karinen et al. 1985). These factors can affect migration patterns of adult fish or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations that affect species diversity and abundance of both fishes and invertebrates may also be due to the mobile nature of many species (e.g., fish schools, urchin aggregations).

The City of San Diego has been conducting trawl surveys in the area surrounding the present discharge site for the Point Loma Ocean Outfall (PLOO) since 1991. These surveys are designed to monitor the effects of wastewater discharge on the local marine biota by assessing the structure and stability of trawl-caught fish and invertebrate communities. This chapter presents analyses and interpretations of the demersal fish and megabenthic invertebrate data collected during 2008. A long-term analysis of changes in these communities from 1991 through 2008 is also presented.

Materials and Methods

Field Sampling

Trawl surveys were conducted at six fixed monitoring sites in the Point Loma region during 2008 (Figure 6.1). The six trawl stations, designated SD7, SD8, SD10, SD12, SD13, and SD14, are located along the 100-m depth contour, and encompass an area ranging from about 8 km north to 9 km south of the PLOO. A total of eight trawls were taken during two surveys in 2008. All six stations were sampled during the January (winter) survey, while sampling in July (summer) was limited to the two stations located nearest the outfall due to a resource exchange agreement to allow participation in the Bight'08 regional monitoring program (see Chapter 1). A single trawl was performed at each station during each survey using a 7.6-m Marinovich otter trawl fitted with a

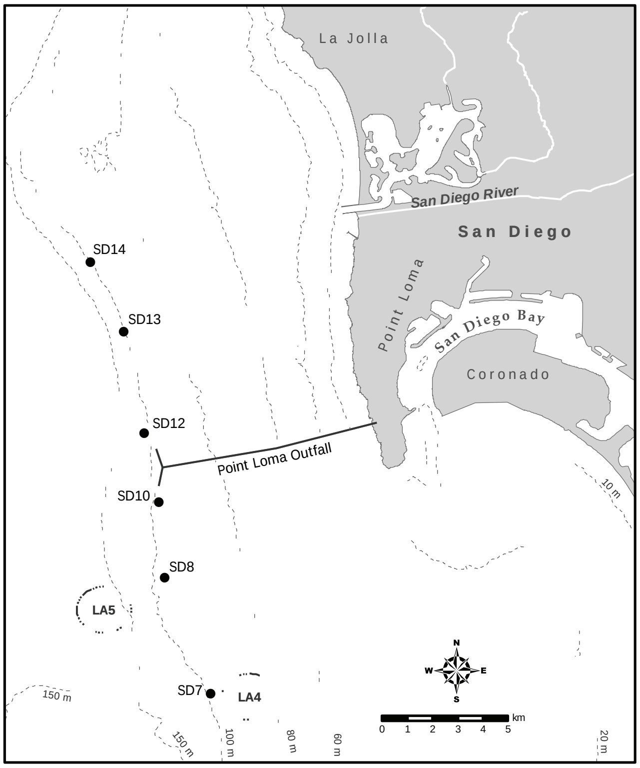

Figure 6.1
Otter trawl station locations, Point Loma Ocean Outfall Monitoring Program.

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.

The total catch from each trawl was brought onboard ship for sorting and inspection. All fish and invertebrates captured 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 (kg, wet weight) were recorded for each species. Additionally, each individual fish was inspected for physical anomalies or indicators of disease (e.g., tumors, fin erosion, discoloration) as well as the presence of external parasites, and then measured to the nearest centimeter size class (standard lengths). For invertebrates, the total number of individuals per species was recorded.

Data Analyses

Populations of each fish and invertebrate species were summarized as percent abundance, frequency of occurrence, mean abundance per haul, and mean abundance per occurrence. In addition, species richness (number of species), total abundance, total biomass, and Shannon diversity index (H') were calculated for each station. For historical comparisons, the data were grouped as “nearfield” stations (SD10, SD12), “south farfield” stations (SD7, SD8), and “north farfield” stations (SD13, SD14). The two nearfield stations were those located closest to the outfall (i.e., within 1000 m of the north or south diffuser legs).

A long-term multivariate analysis of demersal fish communities in the region was performed using data collected from 1991 through 2008. However, in order to eliminate noise due to natural seasonal variation in populations, this analysis was limited to data for the July surveys only over these 18 years. PRIMER software was used to examine spatio-temporal patterns in the overall similarity of fish assemblages in the region (see Clarke 1993, Warwick 1993, Clarke and Gorley 2006). 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 square root transformed and the Bray-Curtis measure of similarity was used as the basis for classification. Because species composition was sparse at some stations, a “dummy” species with a value of one was added to all samples prior to computing similarities (see Clarke and Gorley 2006). SIMPER analysis was subsequently used to identify the individual species that distinguished each cluster group.

Results and Discussion

Fish Community

Thirty-four species of fish were collected in the area surrounding the PLOO in 2008 (Table 6.1, Appendix E.1). The total catch for the year was 1802 individuals, representing an average of about 225 fish per trawl. Pacific sanddabs were the dominant fish captured, occurring in every haul and accounting for 45% of the total number of fishes

Table 6.1

Demersal fish species collected in eight trawls in the PLOO region during 2008. PA=percent abundance; FO=frequency of occurrence; MAO=mean abundance per occurrence; MAH=mean abundance per haul.

Species	PA	FO	MAO	MAH	Species	PA	FO	MAO	MAH
Pacific sanddab	45	100	101	101	Blackbelly eelpout	<1	38	2	1
Yellowchin sculpin	11	88	29	25	Blackeye goby	<1	13	1	<1
Halfbanded rockfish	9	100	20	20	Blacktip poacher	<1	13	2	<1
Longspine combfish	6	100	14	14	Bluebanded ronquil	<1	25	2	<1
Plainfin midshipman	6	88	15	14	Bluespotted poacher	<1	13	1	<1
English sole	4	100	9	9	California lizardfish	<1	25	2	<1
Dover sole	4	100	9	9	California skate	<1	50	1	1
Shortspine combfish	3	100	7	7	California tonguefish	<1	38	2	1
Stripetail rockfish	3	63	10	6	Curlfin sole	<1	13	1	<1
Pink seaperch	1	75	4	3	Greenblotched rockfish	<1	63	1	1
Roughback sculpin	1	88	3	3	Longfin sanddab	<1	13	2	<1
California scorpionfish	1	63	3	2	Pink rockfish	<1	13	1	<1
Hornyhead turbot	1	75	3	2	Spotfin sculpin	<1	13	2	<1
Slender sole	1	50	4	2	Spotted cuskeel	<1	13	1	<1
Greenstriped rockfish	1	63	3	2	Spotted ratfish	<1	13	1	<1
Bigfin eelpout	<1	13	3	<1	Starry skate	<1	13	1	<1
Bigmouth sole	<1	38	3	1	White croaker	<1	13	2	<1

collected during the year. Halfbanded rockfish, longspine combfish, English sole, Dover sole, and shortspine combfish were also collected in every haul, but in much lower numbers. Other species collected frequently (≥75% of the trawls) included yellowchin sculpin, plainfin midshipman, pink seaperch, roughback sculpin, and hornyhead turbot. Pacific sanddabs averaged 101 fish per occurrence, while all other species averaged 29 or less with each contributing to no more than 11% of the total catch. The majority of species captured in the Point Loma region tended to be relatively small fish with an average length <20 cm (see Appendix E.1). Although larger species such as the California skate, starry skate, and spotted ratfish were also captured during the year, these skates and rays were relatively rare compared to species of bony fish.

During 2008, no more than 21 species of fish occurred in any one haul, and the corresponding diversity (H') values were all less than 2.2 (Table 6.2). Total abundance ranged from 100 to 438 fishes per haul; this variation tended to reflect differences in Pacific sanddab populations, which ranged between 43–247 fish per catch (Appendix E.2). Biomass varied widely from 4.7 to 13.5 kg per haul, with higher values coincident with either greater numbers of fishes or the large size of individual fish or fishes as expected. For example, the highest biomass measured during the year was 13.5 kg at station SD8 in January, which was due to both a large haul of Pacific sanddabs weighing 7 kg and two California skate with a combined weight of 2 kg (see Appendix E.3).

Large fluctuations in populations of a few dominant species have been the primary factor contributing to the high variation in fish community structure off Point Loma since 1991 (Figure 6.2, Figure 6.3). For example, species richness values for individual trawls performed within the PLOO region have ranged from 7 to 27 species, while total abundance per haul has varied from 44 to 2322 individuals/station/survey. These fluctuations in abundance have been greatest at stations SD10, SD12, SD13, and SD14 and generally reflect differences in populations of several dominant species. For example, the overall abundance has been low since January 2007 due to significantly fewer numbers of Pacific sanddabs, yellowchin sculpin, longspine combfish, Dover sole, and halfbanded rockfish captured during each survey at most stations.

Table 6.2

Summary of demersal fish community parameters for PLOO stations sampled during 2008. Data are included for species richness (number of species), abundance (number of individuals), diversity (H'), and biomass (kg, wet weight). ns=not sampled.

Station	Winter	Summer
Species Richness		
SD7	13	ns
SD8	19	ns
SD10	16	16
SD12	17	14
SD13	21	ns
SD14	18	ns
Survey Mean	17	15
Survey SD	3	1
Abundance		
SD7	156	ns
SD8	232	ns
SD10	200	196
SD12	100	188
SD13	292	ns
SD14	438	ns
Survey Mean	236	192
Survey SD	118	6
Diversity		
SD7	1.60	ns
SD8	1.96	ns
SD10	1.87	1.69
SD12	2.06	1.90
SD13	2.10	ns
SD14	1.57	ns
Survey Mean	1.86	1.79
Survey SD	0.23	0.15
Biomass		
SD7	6.4	ns
SD8	13.5	ns
SD10	5.1	4.8
SD12	4.7	5.2
SD13	10.1	ns
SD14	10.6	ns
Survey Mean	8.4	5.0
Survey SD	3.5	0.3

Moreover, patterns of change in the dominant species over time were generally similar among stations closest to the outfall and those at the northern sites. None of the observed changes appear to be associated with wastewater discharge.

Ordination and classification analyses of fish abundance data from 1991 through 2008 distinguished between nine main cluster groups or assemblages (cluster groups A–I; see Figure 6.4). These results indicate that the demersal fish community off Point Loma remains dominated by Pacific sanddabs, with differences in the relative abundance of this or other common species discriminating between the different cluster groups (see Table 6.3, Appendix E.2). During 2008, assemblages at stations SD10 and SD12 were similar to those that occurred during 2006 and 2007 at all of the stations except SD7 (see description of group H below). There do not appear to be any spatial or temporal patterns that can be attributed to the outfall or the onset of wastewater discharge. Instead, most differences in local fish assemblages appear to be more closely related to large-scale oceanographic events (e.g., El Niño conditions in 1998) or the unique characteristics of a specific station location. For example, fish assemblages at stations SD7 and SD8 located south of the outfall and not far from the LA-4 and LA-5 disposal sites, respectively, often grouped apart from the remaining trawl stations. The composition and main characteristics of each cluster group are described in the paragraphs that follow.

Cluster groups A–E comprised five unique assemblages, each represented by one or two station/survey entities (i.e., trawl catches), and accounting overall for <7% of the total number of trawls (Table 6.3). Although most of these groups were dominated by Pacific sanddabs, they were unique compared to the other assemblages (i.e., cluster groups F–I) in terms of lower total abundance, fewer species, and/or relatively high numbers of less common species (e.g, midshipman, rockfish). Cluster group A represented the assemblage from station SD10 sampled in 1997, which was characterized by the fewest species and fewest number of fish of all hauls (i.e., 7 species, 44 fish). Cluster groups B and C each consisted of assemblages from only two trawls; group B represented the catch from stations SD7 and SD8 sampled in 2001, while group C was comprised of trawls from station SD8 in 1994 and station SD14

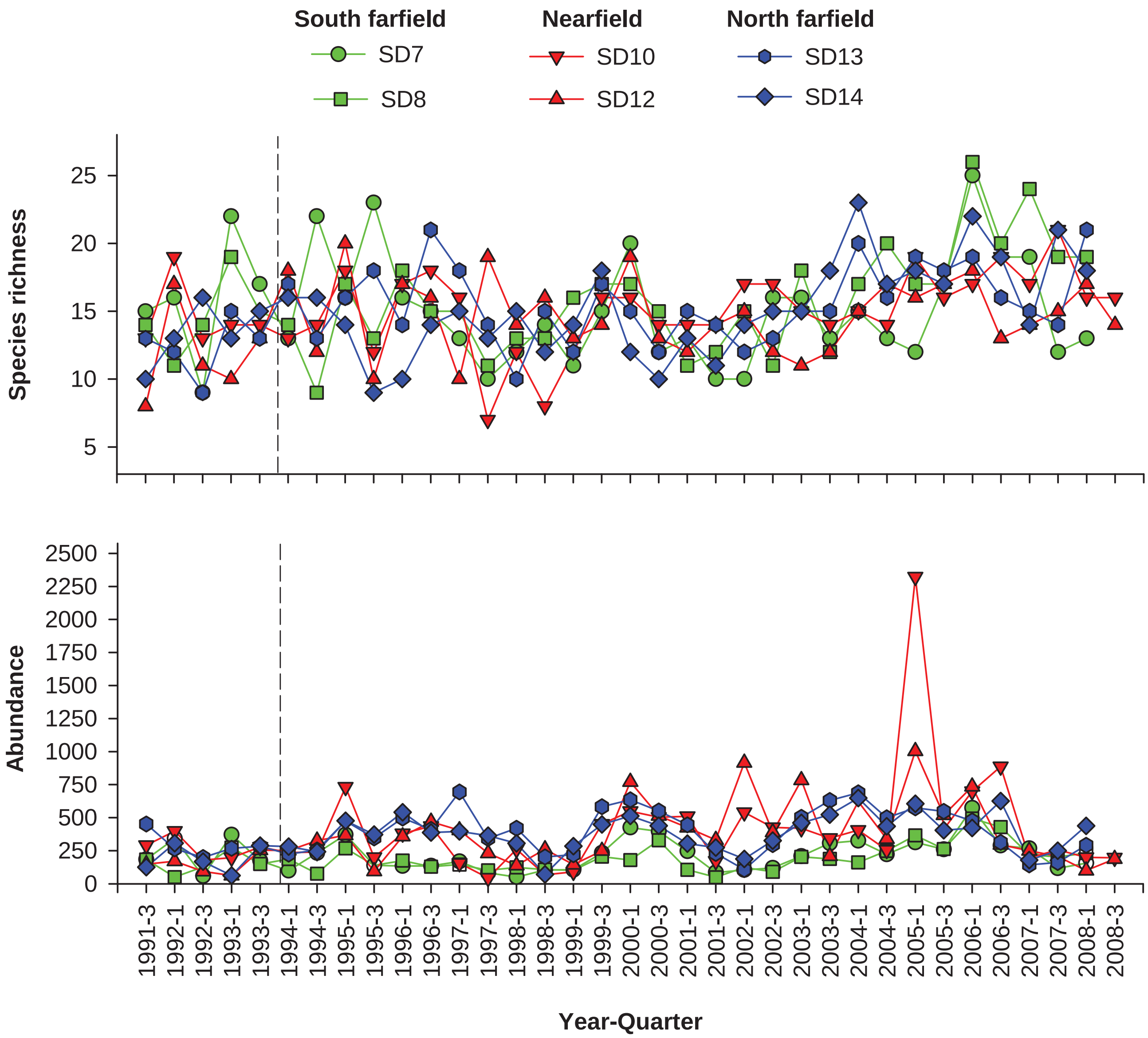

Figure 6.2

Species richness and abundance of demersal fish collected at each PLOO trawl station between 1991 and 2008. Data are total number of species and total number of individuals per haul, respectively. Dotted line represents initiation of wastewater discharge.

in 1998. These two assemblages were characterized by a few more species than group A (i.e., 11 species), and both also had low total abundances and relatively low numbers of Pacific sanddabs. Cluster group D represented the assemblage from station SD12 sampled in 1998. This assemblage was unique because it was dominated by a large population of plainfin midshipman. The second and third most abundant species comprising group D were Pacific sanddabs and Dover sole. Cluster group E represented the assemblage from station SD12 sampled in 1997, which had the highest number of species over all groups, and in addition to Pacific sanddabs was characterized by relatively high numbers of halfbanded rockfish and squarespot rockfish.

Cluster group F consisted of assemblages from a total of 18 trawls, all but three of which were from

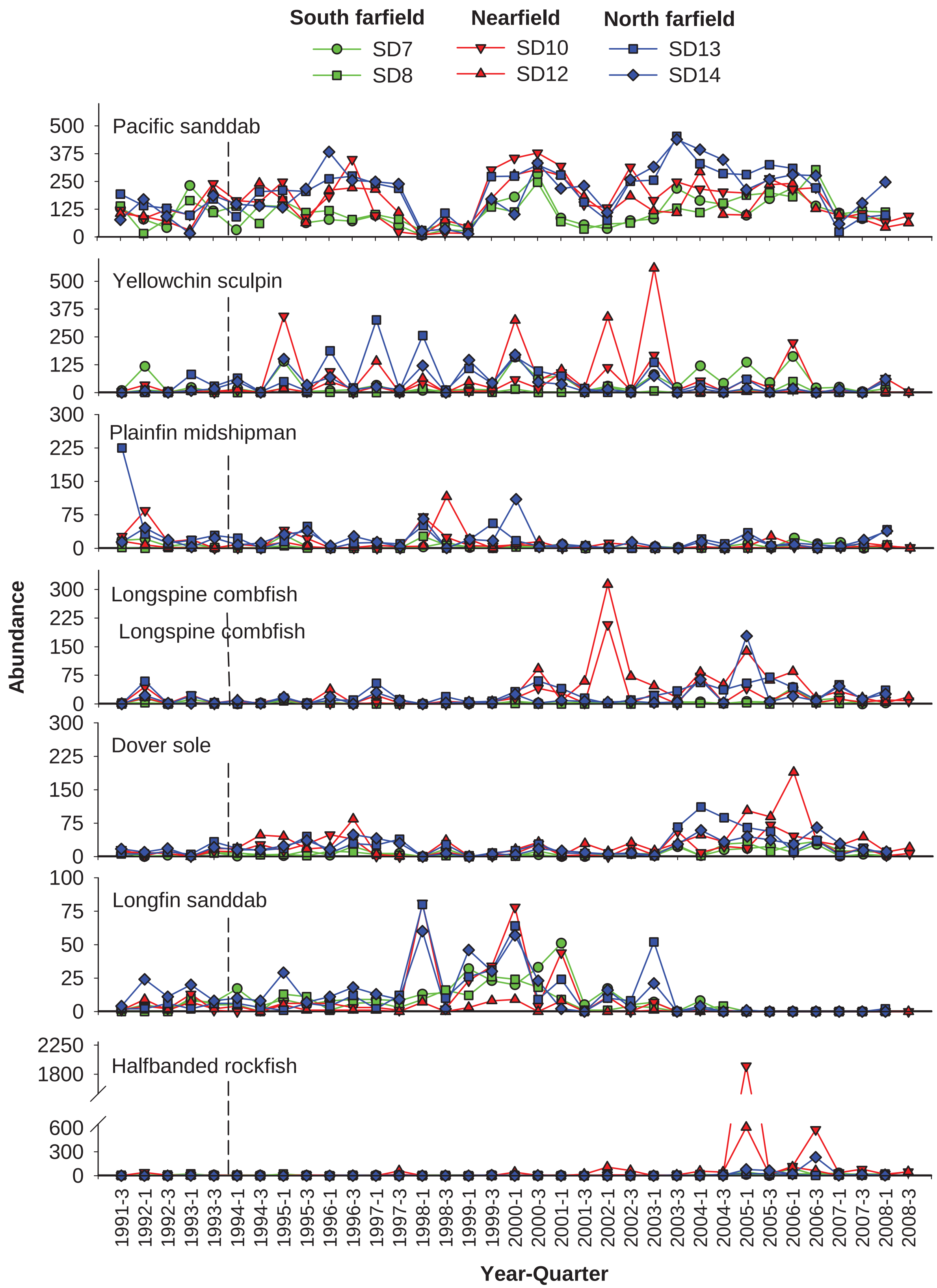

Figure 6.3
The seven most abundant fish species collected in the PLOO region from 1991 through 2008. Data are total number of individuals per haul. Dotted line represents initiation of wastewater discharge.

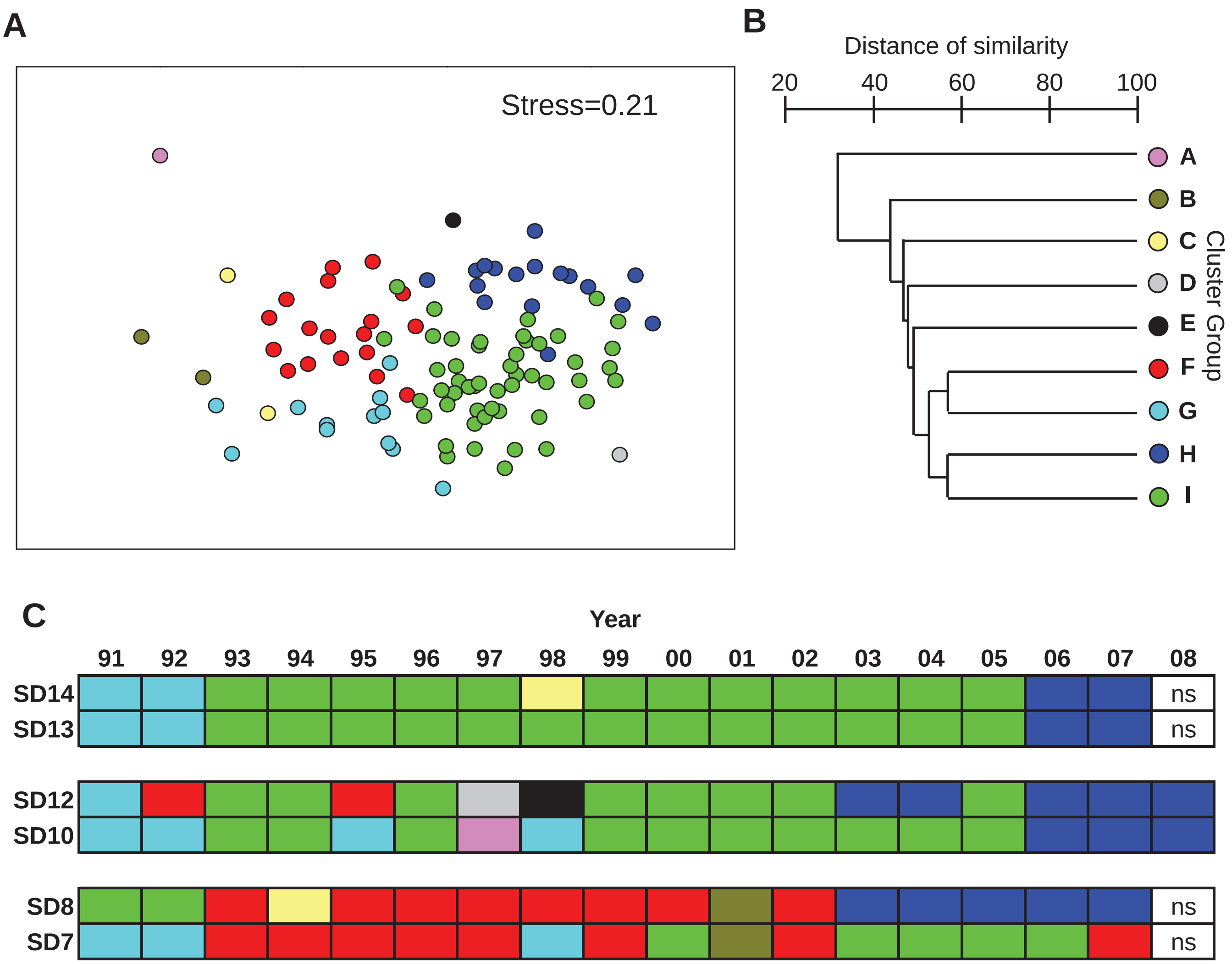

Figure 6.4

Results of classification analysis of demersal fish assemblages collected at PLOO stations SD7–SD14 between 1991 and 2008 (July surveys only). Data are presented as (A) MDS ordination, (B) a dendrogram of major cluster groups, and (C) a matrix showing distribution of cluster groups over time; ns=not sampled.

stations SD7 and SD8 between 1993 and 2002. Overall, this group was characterized by moderate numbers of fishes and different species. The Pacific sanddab was the dominant species in this group with an average of about 98 fish/haul, while the longfin sanddab and Dover sole were the next two most abundant species averaging ~8 fish/haul each. The relative abundances of the above two sanddab species, as well as halfbanded rockfish, shortspine combfish, California lizardfish, stripetail rockfish, plainfin midshipman, and squarespot rockfish distinguished this cluster group from all others (see Appendix E.4).

Cluster group G represented the assemblages from about 12% of all trawls. These included the trawl catches from station SD10 in 1995 and 1998, station SD7 in 1998, and almost all stations during 1991 and 1992. This group was characterized by relatively low species richness (~12 species/haul), moderate abundance (~185 fish/haul), and moderate numbers of Pacific sanddabs (~101 fish/haul). Also characteristic of this group were the plainfin midshipman and longfin sanddab, which averaged about 32 and 4 fish/haul, respectively. Other relatively abundant species included stripetail rockfish (~16 fish/haul) and Dover sole

Table 6.3

Description of cluster groups A–I defined in Figure 6.4. Data include number of hauls, mean species richness, mean total abundance, and mean abundance of the five most abundant species for each station group. Values that are underlined indicate species that were considered "characteristic" of that group according to SIMPER analyses (i.e., similarity/standard deviation ≥2.0).

	Cluster Groups								
	A	B	C	D	E	F	G	H	I
Number of hauls	1	2	2	1	1	18	12	17	50
Mean species richness	7	11	11	16	19	15	12	17	15
Mean abundance	44	68	74	261	231	149	185	310	360
Species	**Mean Abundance**								
Longfin sanddab	1.0	3.0	1.0			8.4	3.9	0.2	5.9
Pink seaperch	1.0	0.5	1.5	4.0	1.0	1.4	1.0	3.4	4.5
Gulf sanddab	1.0		1.0	5.0		0.2	0.3		0.7
Greenspotted rockfish	1.0				1.0	0.6	0.1		0.4
Spotfin sculpin	1.0		1.5			3.6		2.4	0.2
Halfbanded rockfish	16.0				60.0	2.3	0.5	69.5	7.2
Pacific sanddab	23.0	45.5	48.0	75.0	110.0	98.3	101.7	149.4	235.6
Dover sole		1.0	5.5	36.0	1.0	7.9	13.1	27.5	29.4
Yellowchin sculpin		5.0				3.8	2.9	0.6	17.0
Longspine combfish		2.5	2.0	7.0	2.0	0.6	1.2	11.0	14.1
Stripetail rockfish			7.5	1.0	5.0	2.7	16.5	2.3	13.0
Plainfin midshipman			1.5	116.0	4.0	1.6	32.3	3.9	9.3
Slender sole			0.5	2.0		1.0	0.5	6.8	5.4
Shortspine combfish					3.0	3.1	0.8	11.2	2.4
Greenblotched rockfish		0.5	1.5		8.0	0.7	0.3	0.5	1.3
California tonguefish		2.5			1.0	3.7	2.2	2.2	0.9
Bigmouth sole		2.5			1.0	1.2	0.4	0.6	0.8
California lizardfish		1.0				0.3	0.8	0.9	0.5
Roughback sculpin		1.5		2.0		0.3	0.3	0.2	0.4
Squarespot rockfish		0.5			23.0	0.1			
Vermilion rockfish					6.0				

(~13 fish/haul). The relative abundances of these four species distinguished this group from the others (Appendix E.4).

Cluster group H comprised the assemblages from the only two stations sampled during July 2008 survey (i.e., SD10, SD12), as well as from all stations except SD7 in 2006 and 2007, SD12 during 2003–2004, and SD8 between 2003 and 2005. This group was characterized by relatively high numbers of Pacific sanddabs (~149 fish/haul), halfbanded rockfish (69 fish/haul), and Dover sole (~27 fish/haul). The higher abundances of these species helped distinguish this group from all of the others (Appendix E.4).

Cluster group I may represent "normal" or "background" conditions in the PLOO region, representing assemblages from almost half (i.e., 48%) of all trawls included in the analysis. Most of these assemblages were sampled at stations around or north of the PLOO between 1993 and 2005 (i.e., stations SD10–SD14). The main exceptions occurred during and after the 1998 El Niño (i.e., 1997–1999). This group was characterized by the highest average numbers of Pacific sanddabs (~235 fish/haul) and the second highest average numbers of Dover sole (~29 fish/haul). The next three most abundant species in this group were yellowchin sculpin (17 fish/haul),

Table 6.4

Species of megabenthic invertebrates collected in eight trawls in the PLOO region during 2008. PA=percent abundance; FO=frequency of occurrence; MAO=mean abundance per occurrence; MAH=mean abundance per haul.

Species	PA	FO	MAO	MAH	Species	PA	FO	MAO	MAH
Lytechinus pictus	97	100	2181	2181	*Rossia pacifica*	<1	25	1	<1
Acanthoptilum sp	2	75	68	51	*Philine alba*	<1	25	2	<1
Luidia foliolata	<1	75	6	4	*Metridium farcimen*	<1	25	1	<1
Parastichopus californicus	<1	63	5	3	*Antiplanes catalinae*	<1	25	1	<1
Ophiura luetkenii	<1	63	6	4	*Pleurobranchaea californica*	<1	13	1	<1
Octopus rubescens	<1	63	1	1	*Paguristes bakeri*	<1	13	2	<1
Strongylocentrotus fragilis	<1	63	2	2	*Neosimnia barbarensis*	<1	13	2	<1
Thesea sp B	<1	38	1	1	*Megasurcula carpenteriana*	<1	13	1	<1
Spatangus californicus	<1	38	2	1	*Cancellaria crawfordiana*	<1	13	1	<1
Platymera gaudichaudii	<1	38	1	<1	*Armina californica*	<1	13	1	<1
Astropecten verrilli	<1	38	4	2	*Arctonoe pulchra*	<1	13	1	<1
Sicyonia ingentis	<1	25	5	1					

longspine combfish (~14 fish/haul), and stripetail rockfish (13 fish/haul). The higher numbers of these five species, plus moderate numbers of longfin sanddab, plainfin midshipman and halfbanded rockfish, distinguished group I from the other assemblages.

Physical Abnormalities and Parasitism

Demersal fish populations appeared healthy in the PLOO region during 2008. There were no incidences of fin rot, discoloration, skin lesions, tumors, or any other indicators of disease among fishes collected during the year. Evidence of parasitism was also very low for trawl-caught fishes off Point Loma. Although the copepod *Phrixocephalus cincinnatus* infected <2% of the Pacific sanddabs collected during the year, this eye parasite was found on fish collected during each survey, and at least once from each station. In addition, a single slender sole with an eye parasite was reported from station SD12 during the winter survey.

Invertebrate Community

A total of 18,021 megabenthic invertebrates (~2253 per trawl) representing 23 taxa were collected during 2008 (Table 6.4, Appendix E.5). As in previous years, the sea urchin *Lytechinus pictus* was the most abundant and most frequently captured species, occurring in all trawls and accounting for 97% of the total invertebrate abundance. Other common species that occurred in more than half of the hauls included the sea pen *Acanthoptilum* sp, the sea star *Luidia foliolata*, the sea cucumber *Parastichopus californicus*, the brittle star *Ophiura luetkenii*, the octopus *Octopus rubescens*, and the sea urchin *Strongylocentrotus fragilis*.

Megabenthic invertebrate community structure varied among stations and between surveys during the year (Table 6.5). Species richness ranged from 5 to 13 species per haul, diversity (H') values ranged from 0.02 to 1.02 per haul, and total abundance ranged from 55 to 6012 individuals per haul. Patterns in total invertebrate abundance tended to mirror variation in *L. pictus* populations (Appendix E.6). For example, stations SD7, SD8, and SD10 had much higher invertebrate abundances than the other four stations due to relatively large catches of *L. pictus* (i.e., ≥2500/haul). The low diversity values (≤1.02) for the region were due to the numerical dominance of this sea urchin. Dominance of *L. pictus* is typical for these types of habitats throughout the SCB (e.g., Allen et al. 1998).

Invertebrate species richness and abundances have varied over time (Figure 6.5). For example, species richness has ranged from 3 to 29 species per year since 1991, although patterns of change have been similar among stations. In contrast, changes in total abundance have differed greatly

Table 6.5

Summary of megabenthic invertebrate community parameters for PLOO stations sampled during 2008. Data are included for species richness (number of species), abundance (number of individuals), and diversity (H'). ns=not sampled.

Station	Winter	Summer
Species Richness		
SD7	6	ns
SD8	10	ns
SD10	9	11
SD12	5	13
SD13	6	ns
SD14	11	ns
Survey Mean	8	12
Survey SD	2	1
Abundance		
SD7	2516	ns
SD8	2524	ns
SD10	6012	4867
SD12	55	471
SD13	974	ns
SD14	602	ns
Survey Mean	2114	2669
Survey SD	2161	3108
Diversity		
SD7	0.05	ns
SD8	0.07	ns
SD10	0.02	0.05
SD12	0.43	1.02
SD13	0.37	ns
SD14	0.57	ns
Survey Mean	0.25	0.54
Survey SD	0.23	0.69

among the trawl stations. The average annual invertebrate catches have been consistently low at stations SD13 and SD14, while the remaining stations have demonstrated large fluctuations in abundance. These fluctuations typically reflect changes in *L. pictus* populations, as well as populations of *Acanthoptilum* sp, *S. fragilis*, the shrimp *Sicyonia ingentis*, and the sea star *Astropectin verrilli* (Figure 6.6). Additionally, abundances of *L. pictus* and *A. verrilli* are typically much lower at the two northern sites, which likely reflect differences in sediment composition (e.g., fine sands vs. mixed coarse/fine sediments, see Chapter 4). None of the observed variability in the trawl-caught invertebrate community appeared related to the discharge of wastewater from the PLOO.

Summary and Conclusions

Pacific sanddabs continued to dominate fish assemblages surrounding the Point Loma Ocean Outfall during 2008 as they have for many years. This species occurred at all stations and accounted for 45% of the total fish catch. Other characteristic, but less abundant species of fish included halfbanded rockfish, longspine combfish, English sole, Dover sole, shortspine combfish, yellowchin sculpin, plainfin midshipman, pink seaperch, roughback sculpin, and hornyhead turbot. 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, most differences were due to fluctuations in Pacific sanddab populations.

Assemblages of megabenthic invertebrates in the region were similarly dominated by a single species, the sea urchin *Lytechinus pictus*. Variations in overall community structure of the trawl-caught invertebrates generally reflect changes in the abundance of this urchin, as well as several other dominant species. These other species include the sea pen *Acanthoptilum* sp, the sea star *Luidia foliolata*, the sea cucumber *Parastichopus californicus*, the brittle star *Ophiura luetkenii*, the octopus *Octopus rubescens*, and the sea urchin *Strongylocentrotus fragilis*.

Overall, results of the 2008 trawl surveys provide no evidence that wastewater discharged through the PLOO has affected either demersal fish or megabenthic invertebrate communities in the region. Although highly variable, patterns in the abundance and distribution of trawl-caught fishes and invertebrates were similar at stations located near the outfall and farther away. These results are supported by the findings of another recent assessment of these communities off San Diego

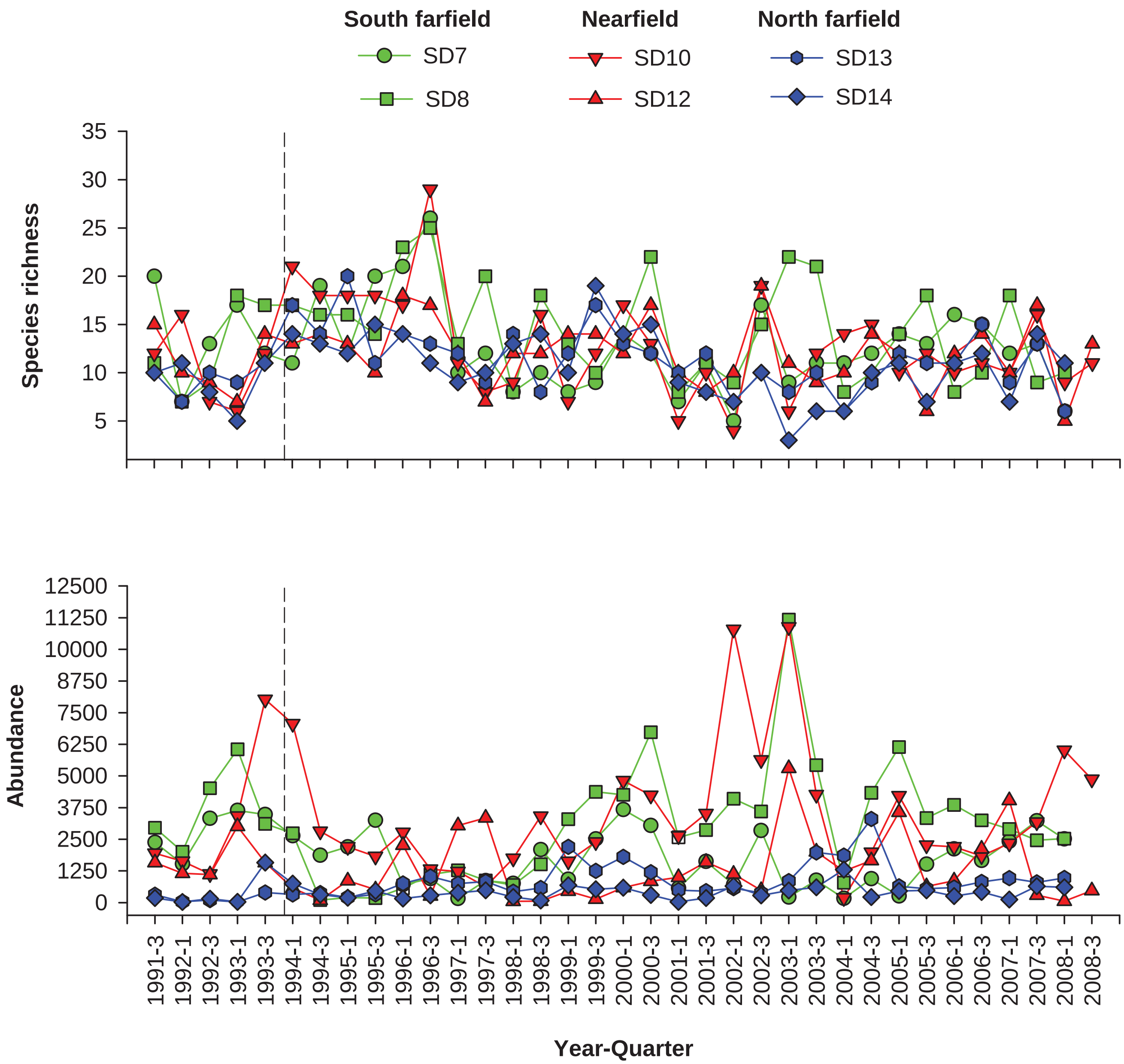

Figure 6.5
Species richness and abundance of megabenthic invertebrates collected at each PLOO trawl station between 1991 and 2008. Data are total number of species and total number of individuals per haul, respectively. Dotted line represents initiation of wastewater discharge.

(City of San Diego 2007). Significant changes in these communities appear most likely to be due to natural factors such as changes in ocean water temperatures associated with large-scale oceanographic events (e.g., El Niño or La Niña) or to the mobile nature of many of resident species. Finally, the absence of disease or other physical abnormalities in local fishes suggests that their populations continue to be healthy off Point Loma.

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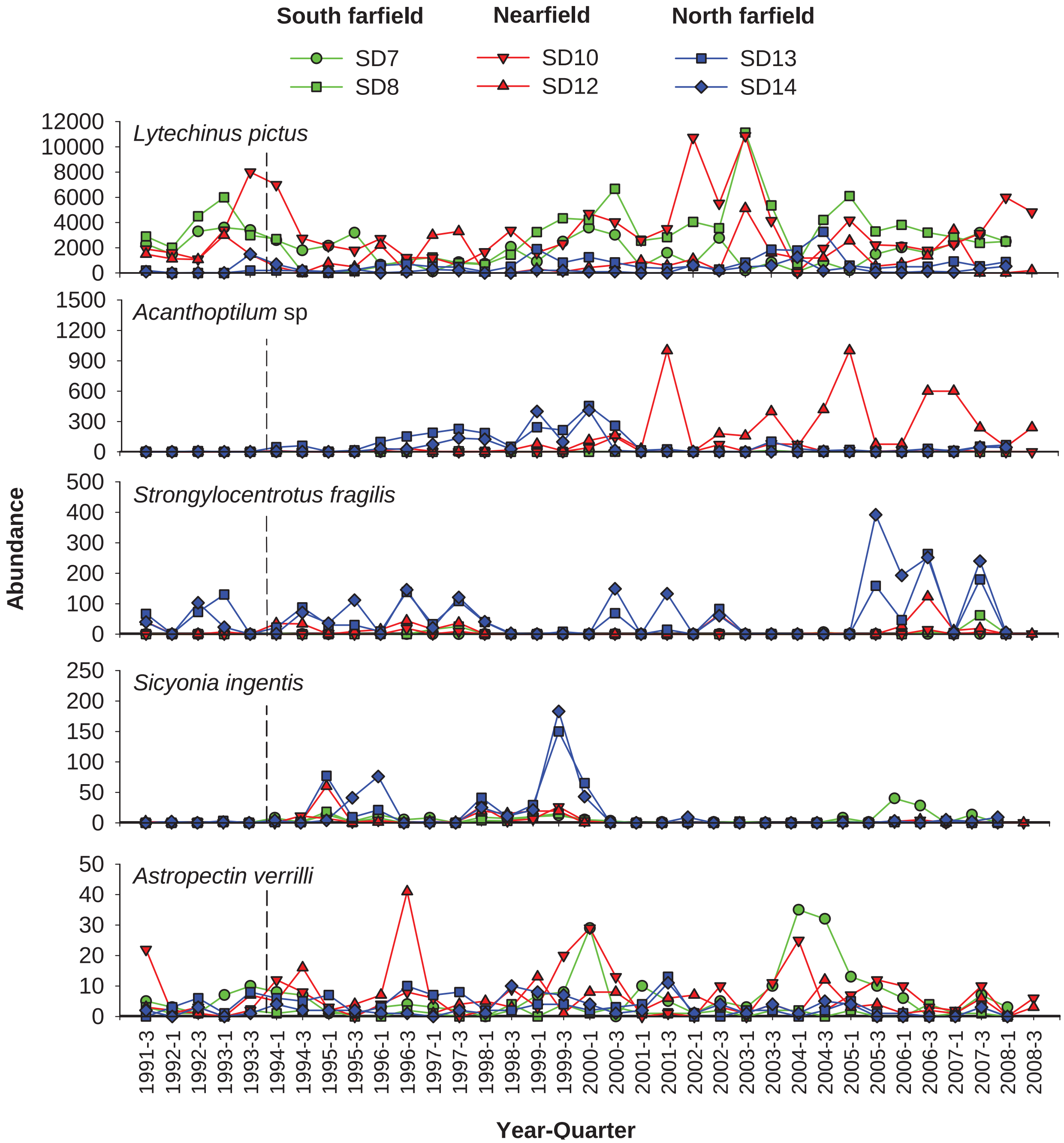

Figure 6.6
The five most abundant megabenthic species collected in the PLOO region from 1991 through 2008. Data are total number of individuals per haul. Dotted line represents initiation of wastewater discharge.

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