Chapter 6. Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Demersal fishes and megabenthic invertebrates are conspicuous components of soft-bottom habitats of the mainland shelves and slopes off southern California. More than 100 species of fish inhabit the Southern California Bight (SCB) (Allen 1982, Allen et al. 1998), while the megabenthic invertebrate fauna consists of more than 200 species (Allen et al. 1998). For the Point Loma region off San Diego, the most common trawl-caught fishes include Pacific sanddab, longfin sanddab, Dover sole, hornyhead turbot, California tonguefish, plainfin midshipman, and yellowchin sculpin. The common trawl-caught invertebrates include relatively large animals such as sea urchins and sea stars.

Communities of bottom dwelling fish and megabenthic invertebrates have become an important focus of monitoring programs throughout the world. For example, these organisms have been sampled extensively on the SCB mainland shelf for more than 30 years, primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). Although much is known about the condition of these types of assemblages (e.g., Allen et al. 1998), additional studies are useful in documenting community structure and stability, and may provide insight into the effects associated with anthropogenic and natural influences.

The City of San Diego Ocean Monitoring Program was designed to monitor the effects of the Point Loma Ocean Outfall (PLOO) on the local marine environment. This chapter presents analyses and interpretation of demersal fish and megabenthic invertebrate data collected under this program during 2004. A long-term analysis of changes in these communities from 1991 through 2004 is also presented.

MATERIALS AND METHODS

Field Sampling

A total of 12 trawls were performed during two surveys off Point Loma in 2004. The trawling area extends from about 8 km north to 9 km south of the outfall. Stations SD7–SD14 are located along the 100-m contour and were sampled during January and July (**Figure 6.1**). 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. Detailed methods for locating the stations and conducting trawls are described in the City of San Diego Quality Assurance Plan (City of San Diego in prep).

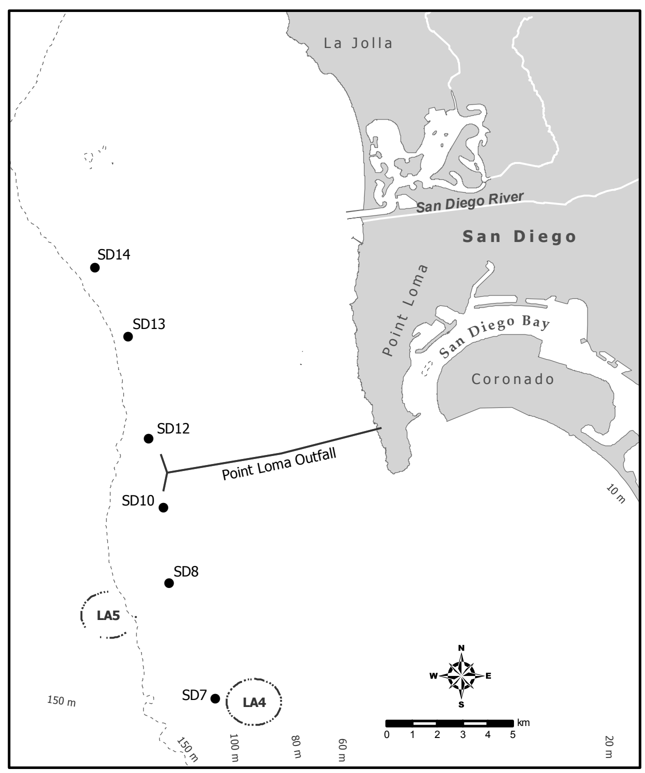

Figure 6.1
Otter trawl station locations, Point Loma Ocean Outfall Monitoring Program.

Table 6.1

Demersal fishes collected in 12 trawls off Point Loma, San Diego during 2004. Data for each species are expressed as percent abundance (PA), frequency of occurrence (FO), and mean abundance per occurence (MAO).

Species	PA	FO	MAO	Species	PA	FO	MAO
Pacific sanddab	57	100	229	Bay goby	<1	42	1
Dover sole	9	100	38	California lizardfish	<1	25	2
Longspine combfish	8	100	32	Bluespotted poacher	<1	33	2
Yellowchin sculpin	6	83	29	Greenspotted rockfish	<1	25	2
Stripetail rockfish	6	83	29	Spotted cuskeel	<1	25	2
Halfbanded rockfish	3	92	14	Bigmouth sole	<1	42	1
Shortspine combfish	1	92	6	California skate	<1	33	1
Plainfin midshipman	1	83	6	Chilipepper rockfish	<1	17	2
California scorpionfish	1	42	11	Greenblotched rockfish	<1	8	2
Slender sole	1	50	9	Hornyhead turbot	<1	17	1
English sole	1	92	5	Pygmy poacher	<1	8	2
California tonguefish	1	67	6	Calico rockfish	<1	8	1
Pacific argentine	1	33	8	Sanddab unidentified	<1	8	1
Greenstriped rockfish	1	67	4	Cowcod	<1	8	1
Longfin sanddab	<1	58	3	Flag rockfish	<1	8	1
Blackbelly eelpout	<1	33	5	Flatfish unidentified	<1	8	1
Spotfin sculpin	<1	17	8	Gobiidae unidentified	<1	8	1
Rockfish unidentified	<1	58	2	Jack mackerel	<1	8	1
Pink seaperch	<1	67	2	Roughback sculpin	<1	8	1
Blacktip poacher	<1	17	6	Stripedfin ronquil	<1	8	1

Trawl catches were brought on board ship 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 fish, the total number of individuals and total biomass (wet weight, kg) were recorded for each species. Additionally, each individual fish was inspected for the presence of external parasites or physical anomalies (e.g., tumors, fin erosion, discoloration) and measured to the nearest centimeter according to standard protocols (see City of San Diego in prep). For invertebrates, the total number of individuals was recorded per species. When the white sea urchin, *Lytechinus pictus,* was collected in large numbers, its abundance was estimated by multiplying the total number of individuals per 1.0 kg subsample by the total urchin biomass.

Data Analyses

Populations of each fish and invertebrate species were summarized in terms of percent abundance (number of individuals/total of all individuals caught x 100), frequency of occurrence (number of occurrences/total number of trawls x 100) and mean abundance per occurrence (number of individuals/number of occurrences). In addition, species richness (number of species), total abundance, and Shannon diversity index (H') were calculated for both the fish and invertebrate assemblages at each station. Total biomass was also calculated for each fish species by station.

Multivariate analyses were performed on the six stations using PRIMER (Plymouth Routines in Multivariate Ecological Research) software

Table 6.2

Summary of demersal fish community parameters for 2004. Data are expressed as total number of species, mean number of species, mean abundance, mean diversity (H'), and mean biomass (BM) (kg, wet weight).

	No. of Species				
Station	Total	Mean	Abund	H'	BM
SD7	20	14	276	1.22	3.8
SD8	26	19	206	1.49	3.7
SD10	21	15	331	1.22	6.6
SD12	23	16	480	1.93	7.8
SD13	24	18	594	1.64	11.8
SD14	25	20	541	1.19	8.8

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 fish abundance data were square-root transformed and the Bray-Curtis measure of similarity was used as the basis for both classification and ordination.

RESULTS

Fish Community

At least 36 species of fish were collected in the area surrounding the PLOO during 2004 (**Table 6.1**). The total catch for the year was 4852 individuals, representing an average of about 404 fish per trawl. The Pacific sanddab comprised 57% of the total catch and occurred in every haul. Other frequently occurring fishes were Dover sole, longspine combfish, yellowchin sculpin, stripetail rockfish, halfbanded rockfish, shortspine combfish, plainfin midshipman, and English sole. These common species tended to be relatively small with an average length <20 cm (**Appendix C.1**).

Fish abundance and biomass were highly variable during 2004. For example, abundance averaged from 206 to 594 fish per haul (**Table 6.2**). Relatively large hauls were collected at both of the northern farfield stations (SD13 and SD14), which were nearly twice that of the southern stations (SD7 and SD8). This difference was primarily due to substantial numbers of Pacific sanddab present at stations SD13 and SD14 in January and July (**Appendix C.2**). The wide range in total fish biomass per haul (mean = 3.7 to 11.8 kg) was generally attributable to variation in the size of the catch or the occurrence of large individuals (e.g., California scorpionfish). For example, the greatest biomass occurred at station SD16 in April due to three relatively large California halibut that weighed approximately 7 kg combined (**Appendix C.3**).

In contrast to abundance and biomass, values for species richness and diversity (H') varied little and were relatively low in 2004 (Table 6.2). The average number of species was 20 or less at all stations over the year. Diversity values were less than 2 at all stations. These relatively low diversity values are due to the predominance of Pacific sanddabs.

Fluctuating populations of dominant species have been the primary factor contributing to variation in the structure of the fish community off Point Loma since 1992 (**Figure 6.2**). For example, species richness has remained fairly consistent over the years averaging from 10–20 species per station, while mean abundances have fluctuated substantially with mean values ranging from 93–690 individuals. These fluctuations in abundance have been greatest at stations SD10–SD14 and generally reflect differences in populations of several dominant species, especially the Pacific sanddab (**Figure 6.3**). Overall, none of the observed changes appear to be associated with the discharge of wastewater from the Point Loma outfall.

Ordination and classification of sites sampled during July between 1991 and 2004 resulted in seven major clusters (see **Figure 6.4**). These seven assemblages (station groups 1–7) differed mainly in terms of numbers of the more common species (**Table 6.3**). Station groups 1 through 4 consist of 1–2 trawls each characterized by low abundances of Pacific sanddabs and a variety of other species.

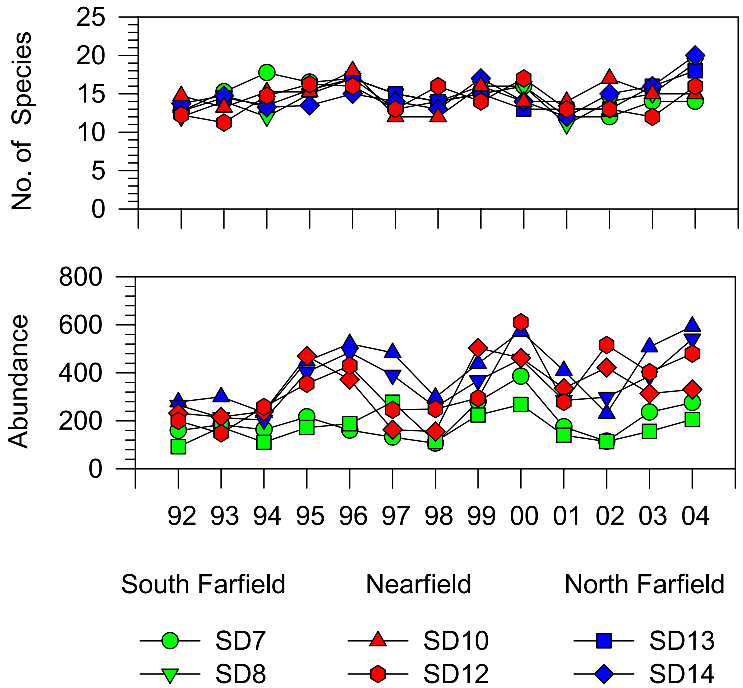

Figure 6.2
Number of species and total abundance of demersal fishes collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

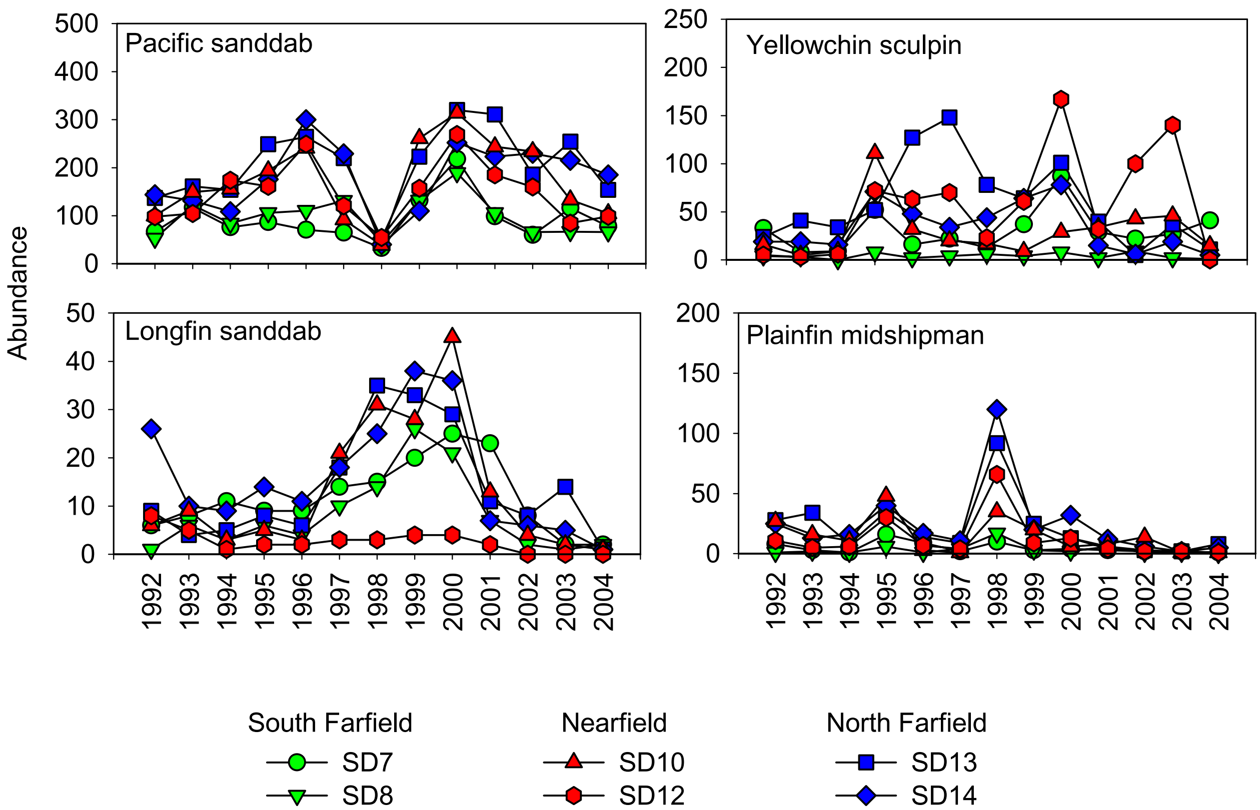

Figure 6.3
Number of individuals of each of the four most abundant species collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

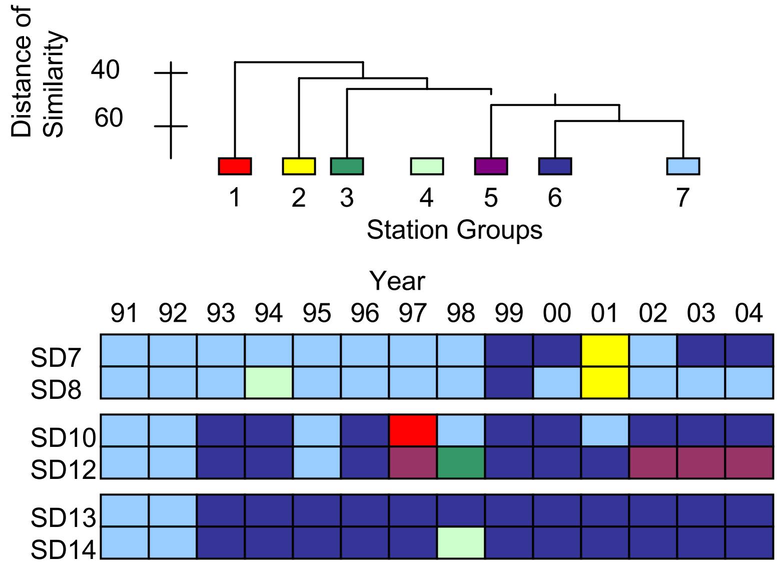

Figure 6.4
Classification analyses of demersal fish collected at PLOO stations from July 1991 through 2004. Data are presented as a dendrogram of major station groups and a matrix showing distribution over time.

Station group 5 also represents an infrequently occurring assemblage. This assemblage occurred at SD12 in just four of 14 years and consisted of moderate numbers of Pacific sandabs, and relatively high numbers of halfbanded rockfish and longspine combfish. By contrast, station groups 6 and 7 reflect hauls that were more typical for the region. Station group 6 occurred in 12 of the past 14 years and represented 50% of the sampled stations. This relatively consistent assemblage contained high numbers of Pacific sanddabs, Dover sole, yellowchin sculpin, and stripetail rockfish, and is typical of the cold water conditions that predominate in deep waters off Point Loma. The fish assemblage comprising station group 7 is representative of the southern stations SD7 and SD8 and becomes more widespread during warmer water years (i.e., 1991–1992, 1995, 1998). This assemblage was characterized by lower abundances of the colder water species listed for station group 6, especially Pacific sanddabs. These changes in fish assemblages appear to be unrelated to the discharge of wastewater from the PLOO.

Physical Abnormalities and Parasitism

The occurrences of fin rot and other physical abnormalities were generally low in fish populations off Point Loma during 2004. For example, only ten Dover soles (approximately 2% of the Dover population) collected at stations near and far away from the outfall were found to have tumors. According to Dr. J. Allen of the Southern California Coastal Water Research Project (personal communication), these tumors are likely from a Dover specific infection and have not been associated with degraded environments. The copepod eye parasite *Phrixocephalus cincinnatus* occurred on 2% of the Pacific sanddabs collected and was present at all stations during all surveys. The ectoparasitic isopod, *Elthusa vulgaris*, also occurred in two trawls (**Appendix C.4**). However, the host fishes are unknown since this isopod becomes detached from the host during sorting. Although *E. vulgaris* occurs on a wide variety of fish species off 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 17,977 megabenthic invertebrates, representing 38 species, were collected during 2004 (**Table 6.4**, Appendix C.4). The white sea urchin *Lytechinus pictus* was the most abundant and most frequently captured species. It was present in all of the

Table 6.3

Summary of the demersal fish assemblages for the seven main station cluster groups defined in Figure 6.4. Data include number of hauls, mean number of species, mean number of individuals, as well as the distribution of abundant and frequently occurring fish species in each group. Most abundant species in bold.

	SG1	SG2	SG3	SG4	SG5	SG6	SG7
Number of hauls	1	2	1	2	4	42	32
Mean no. of species per haul	7	11	16	11	15	15	13
Mean no. of individuals per haul	44	25	261	74	292	364	163
Species	**Mean Abundance**						
Pacific sanddab	**23**	**46**	**75**	**48**	**126**	**243**	**100**
Plainfin midshipman			**116**	2		9	**14**
Dover sole		1	36	6	24	**27**	12
Halfbanded rockfish	**16**				**44**		2
Longspine combfish		3	7	2	35	11	
Stripetail rockfish				**8**	6	16	7
Yellowchin sculpin		**5**				18	3
Slender sole					18	4	
Longfin sanddab	1	3				8	5
Shortspine combfish					9		3
Pink seaperch	1		4	2		5	
Gulf sanddab	1		5	1			
Squarespot rockfish					6		
Greenstriped rockfish				1	5		
California tonguefish		3					3
Spotfin sculpin	1			2			3
Blackfin eelpout			4				
Bay goby		1				3	
Blackbelly eelpout					4		
Roughback sculpin		2	2				
English sole			3				
Bigmouth sole		3					
California scorponfish			2				
Greenblotched rockfish				2			
California lizardfish		1					
Greenspotted rockfish	1						

trawls and accounted for 94% of the total invertebrate catch. Other species that occurred in at least half of the hauls included the sea pen *Acanthoptilum* sp, the sea stars *Astropecten verrilli* and *Luidia foliolata*, the brittle star *Ophiura luetkenii,* and the sea cucumber *Parastichopus californicus*.

As with the fishes, numbers of invertebrates varied among stations and between surveys during the year, while species richness and diversity were relatively uniform (**Table 6.5, Appendix C.5**). For example, the mean number of species per station ranged from 8 to 15, while abundance per station averaged from 555 to 2578 individuals. The largest hauls (in terms of abundance) occurred at stations SD8 and SD13, primarily due to large numbers of the urchin *L. pictus*. Diversity values were also extremely low (<1) for the entire area due to the numeric dominance of this urchin. The numeric dominance of *L. pictus* is typical of similar habitats throughout the SCB.

Invertebrate species richness and abundance has varied over time (**Figure 6.5**). The annual species richness has averaged from 5 to 20 species between 1992 and 2004, although the patterns of change have been similar among stations. In contrast, changes

Table 6.4

Megabenthic invertebrate species collected in 12 trawls off Point Loma, San Diego during 2004. Data for each species are expressed as percent abundance (PA), frequency of occurrence (FO), and mean abundance per occurence (MAO).

Species	PA	FO	MAO
Lytechinus pictus	94	100	1406
Acanthoptilum sp	3	67	76
Astropecten verrilli	1	83	12
Platymera gaudichaudii	1	42	20
Luidia foliolata	1	75	10
Parastichopus californicus	<1	83	5
Ophiura luetkenii	<1	75	3
Crangon alaskensis	<1	33	5
Luidia asthenosoma	<1	33	4
Allocentrotus fragilis	<1	33	3
Philine auriformis	<1	17	5
Megasurcula carpenteriana	<1	25	2
Octopus rubescens	<1	42	1
Pleurobranchaea californica	<1	25	2
Thesea sp B	<1	33	2
Nymphon pixellae	<1	25	2
Rossia pacifica	<1	25	1
Tritonia diomedea	<1	17	2
Astropecten ornatissimus	<1	17	1
Elthusa vulgaris	<1	17	1
Loligo opalescens	<1	17	1
Metridium farcimen	<1	17	1
Ophiopholis bakeri	<1	17	1
Amphiodia urtica	<1	8	1
Armina californica	<1	8	1
Cancellaria crawfordiana	<1	8	1
Florometra serratissima	<1	8	1
Fusinus barbarensis	<1	8	1
Loxorhynchus grandis	<1	8	1
Luidia armata	<1	8	1
Mediaster aequalis	<1	8	1
Nassarius insculptus	<1	8	1
Neosimnia barbarensis	<1	8	1
Paguristes turgidus	<1	8	1
Podochela hemphillii	<1	8	1
Spatangus californicus	<1	8	1
Telesto californica	<1	8	1
Virgularia agassizi	<1	8	1

in abundance have differed among stations. For example, the average annual invertebrate catches were consistently low at stations SD13 and SD14, while the remaining stations demonstrated large peaks in abundance at various times. These fluctuations typically reflect changes in several dominant echinoderm populations, especially that of *L. pictus* and another

Table 6.5

Summary of megabenthic invertebrate community parameters off Point Loma for 2004. Data are expressed as total number of species, mean number of species, mean abundance, and mean diversity (H').

	No. of Species			
Station	Total	Mean	Abund	H'
SD7	15	12	555	0.83
SD8	15	9	2560	0.12
SD10	22	15	1084	0.85
SD12	18	12	1453	0.45
SD13	11	8	2578	0.11
SD14	12	8	750	0.44

urchin, *Allocentrotus fragilis* (see **Figure 6.6**). None of the observed variability in the invertebrate community could be attributed to the discharge of wastewater from the Point Loma outfall.

SUMMARY AND CONCLUSIONS

Pacific sanddabs once again dominated the demersal fish assemblages surrounding the Point Loma Ocean Outfall during 2004. Other fish, such as the Dover sole, longspine combfish, yellowchin sculpin, stripetail rockfish, halfbanded rockfish, shortspine combfish, plainfin midshipman, and English sole were also collected frequently. The megabenthic invertebrate assemblages were also dominated by a few, prominent species. The white sea urchin *Lytechinus pictus* was the most abundant species, while the sea pen *Acanthoptilum* sp, the sea stars *Astropecten verrilli* and *Luidia foliolata*, the brittle star *Ophiura luetkenii,* and the sea cucumber *Parastichopus californicus* were also common.

As in previous years, variation among stations and between surveys in both fish and invertebrate communities in the region was generally due to population fluctuations of the dominant species mentioned above. Fluctuations in fish abundance have been greatest at stations SD10–SD14, and generally reflect differences in the populations of the Pacific sanddab and several other dominant species. Invertebrate abundances were largely

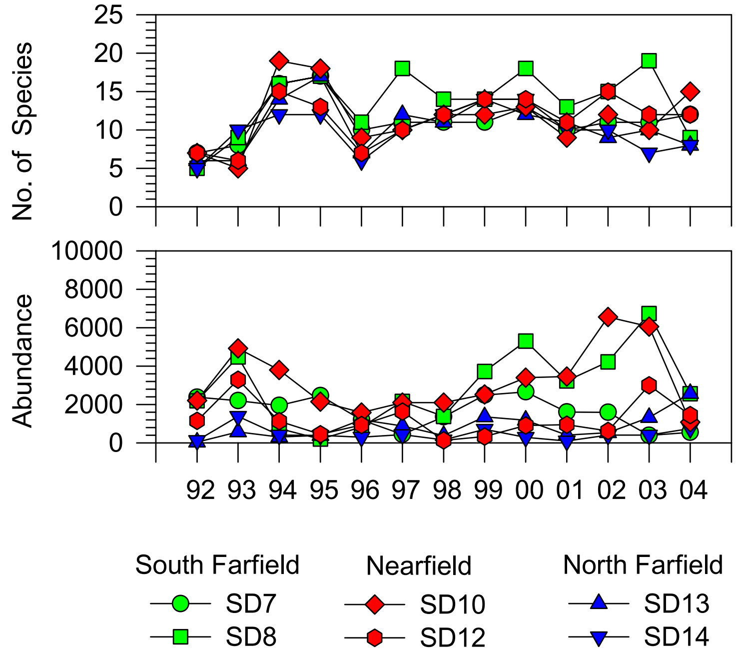

Figure 6.5
Number of species and total abundance of megabenthic invertebrates collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

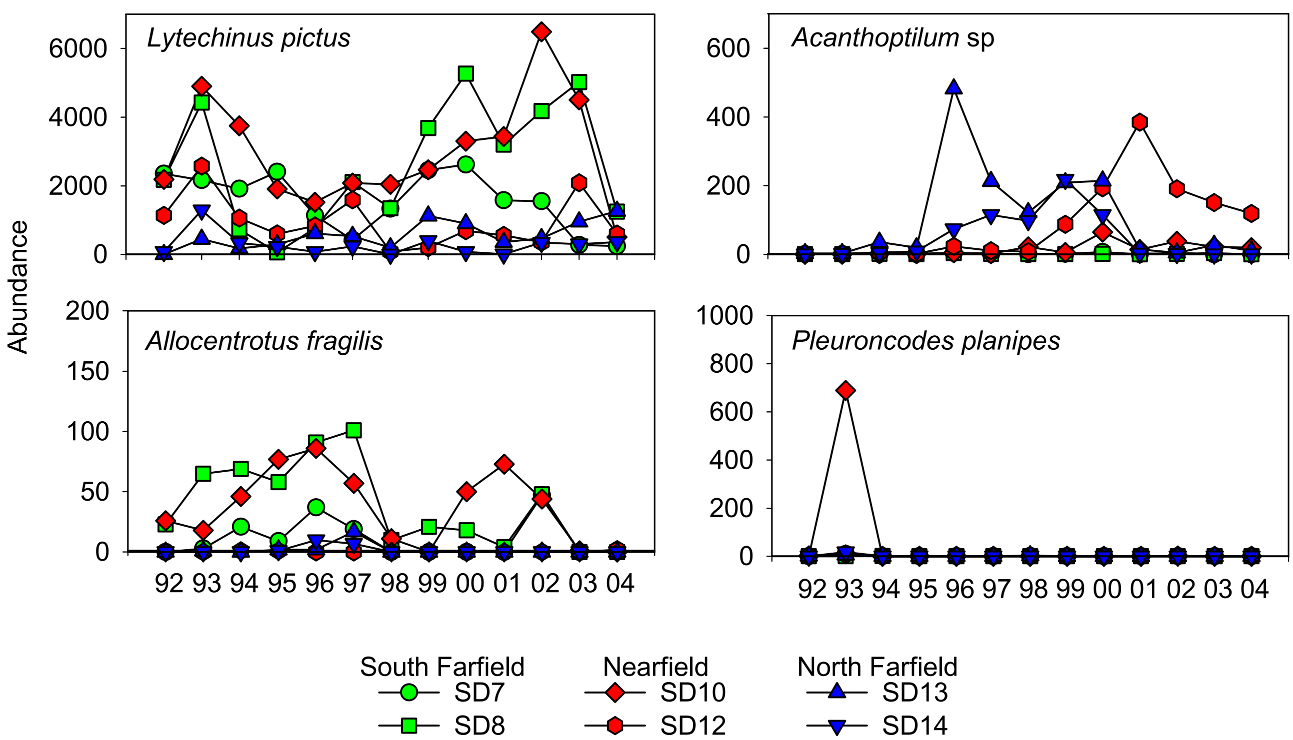

Figure 6.6
Number of individuals of each of the four most abundant species of megabenthic invertebrates collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

affected by changes in three echinoderms, *Lytechinus pictus, Astropectin verrilli*, and *Luidia foliolata,* especially at stations SD7–SD10.

Demersal fish and megabenthic invertebrate communities are inherently variable, and the observed changes in community structure may be influenced by both anthropogenic and natural factors. Anthropogenic influences include inputs from such things as ocean outfalls and storm drain runoff. None of the observed variability in the trawl-caught fish or invertebrate communities off Point Loma can be attributed to such influences. Natural factors may 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 Niño (Karinen et al. 1985). In general, the observed variability in the PLOO assemblages was more likely due to such natural factors that can impact the migration of adult fish or the recruitment of juveniles into an area (see Murawski 1993). Population fluctuations that affect diversity and abundance may also be due to the mobile nature of many species (e.g., aggregations of urchins).

Overall, there was no evidence that wastewater discharge from the Point Loma Ocean Outfall in 2004 affected either demersal fish or megabenthic invertebrate communities in the region. Despite the variable structure of these assemblages, patterns of species diversity, abundance, and biomass at stations near the outfall were similar to sites located further away. In addition, no changes have been found in these assemblages that can be attributed to over 11 years of waste water discharge. Furthermore, the low incidences of physical abnormalities on local fishes suggest that populations in the area are healthy.

LITERATURE CITED

Allen, M.J. (1982). Functional structure of soft-bottom fish communities of the southern California shelf. Ph.D. dissertation. University of California, San Diego. La Jolla, CA. 577 pp.

Allen, M.J., S.L. Moore, K.C. Schiff, S.B. Weisberg, D. Diener, J.K. Stull, A. Groce, J. Mubarak, C.L. Tang, and R. Gartman. (1998). Southern California Bight 1994 Pilot Project: Chapter V. Demersal Fishes and Megabenthic Invertebrates. Southern California Coastal Water Research Project, Westminister, CA. 324 pp.

Brusca, R.C. (1978). Studies on the cymothoid fish symbionts of the eastern Pacific (Crustacea: Cymothoidae). II. Systematics and biology of *Livoneca vulgaris* Stimpson 1857. Occ. Pap. Allan Hancock Fdn. (New Ser.), 2: 1–19.

Brusca, R.C. (1981). A monograph on the Isopoda Cymothoidae (Crustacea) of the eastern Pacific. Zool. J. Linn. Soc., 73: 117–199.

City of San Diego. (in prep). EMTS Division Laboratory Quality Assurance Project Plan. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

Clarke, K.R. (1993). Non-parametric multivariate analyses of changes in community structure. Aust. J. Ecol., 18: 117–143.

Cross, J.N., and L.G. Allen. (1993). Chapter 9. Fishes. In: Dailey, M.D., D.J. Reish, and J.W. Anderson, eds. Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA. p. 459–540.

Cross, J.N., J.N. Roney, and G.S. Kleppel. (1985). Fish food habitats along a pollution gradient. California Fish and Game, 71: 28–39.

Helvey, M., and R.W. Smith. (1985). Influence of habitat structure on the fish assemblages associated with two cooling-water intakestructures in southern California. Bull. Mar. Sci., 37: 189–199.

Karinen, J.B., B.L. Wing, and R.R. Straty. (1985). Records and sightings of fish and invertebrates in the eastern Gulf of Alaska and oceanic phenomena related to the 1983 El Niño event. In: Wooster, W.S. and D.L. Fluharty, eds. El Niño North: El Niño Effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant Program. p. 253–267.

Murawski, S.A. (1993). Climate change and marine fish distribution: forecasting from historical analogy. Trans. Amer. Fish. Soc., 122: 647–658.

Warwick, R.M. (1993). Environmental impact studies on marine communities: pragmatical considerations. Aust. J. Ecol., 18: 63–80.