1990 Reference Survey

Longspine combfish

We recently completed the third survey of chemical and biological conditions in reference areas on the mainland shelf off Southern California. Seven stations from the 60 m Survey (Word and Mearns 1979) and 1985 Reference Survey (Thompson *et al.* 1987) were sampled in July and August 1990. The objective was to provide estimates of sediment characteristics, contaminant levels, and biological conditions from the least impacted areas on the mainland shelf. A detailed account of sampling protocols, analytical methods, and the results are available as a SCCWRP Technical Report (Thompson *et al.* 1992).

Materials and Methods

Field Collections

Sediments, invertebrates, and fish were sampled at 30, 60, and 150 m at each of the seven stations; however, one 30 m station (R61 off La Jolla) had to be abandoned due to the presence of kelp. Water column salinity, temperature, and dissolved oxygen were measured at each station by hydrocast with a SeaBird CTD.

Sediment samples were collected with a 0.10 m^2 chain-rigged Van Veen grab sampler. Subsamples from the top 2 cm of the grab sample were taken with a 26 mm diameter syringe and immediately frozen for laboratory analyses. Macrobenthic infauna were collected from a separate Van Veen grab sample sieved through a 1.0 mm screen. The animals and debris were fixed in 10% borax buffered formalin in seawater, returned to the lab, and transferred to 70% ethanol. The samples were sorted to major taxa and identified to the lowest taxon practical. Megafaunal invertebrates and fish were collected at each station with a 7.6 m otter trawl towed for 10 min along an isobath at approximately 2 knots.

Laboratory Analyses

Total Organic Carbon and Nitrogen.

Sediments were analyzed for total organic carbon (TOC) and total nitrogen (TN) by high temperature (flash) combustion using a Carlo Erba EA1108 elemental analyzer (methods are detailed in *Total Organic Carbon and Total Nitrogen in Marine Sediments, Sediment Trap Particles, Municipal Effluents, and Surface Runoff* in this report).

Sand, Silt, Clay.

Sediment samples were homogenized, organic material was digested with 10% hydrogen peroxide, and the sample was wet sieved through a 63 µm stainless steel sieve. The sand fraction retained on the screen was dried and the sieving repeated. Particles that passed through the sieve were dried and added to the silt fraction. The sand fraction was weighed.

The silt/clay fraction that passed through the sieve was transferred to a 1000 ml graduated cylinder. After 24 hr, the water was decanted into 500 ml polypropylene bottles and centrifuged for 20 min at 1000 RPM. The water was siphoned from the centrifuge bottles and the residue was washed back into the graduated cylinder. Twenty-five ml of 1% Calgon solution were added to the silt/clay fraction to prevent flocculates and the sample was adjusted to 1000 ml with distilled H_2O and vigorously mixed. A 25 ml sample was drawn 20 cm from the top 20 sec after mixing (=silt fraction). The sample and pipet were rinsed with distilled water into an aluminum dish. A 25 ml sample was taken from a depth of 5 cm at the times tabulated by Plumb (1981) and transferred to an aluminum dish (=clay fraction). The samples were dried and weighed, and the weights were corrected for the addition of Calgon.

Trace Metals.

Sediments were analyzed for silver, cadmium, chromium, copper, nickel, lead, zinc, iron, and manganese by Global Geochemistry Corp. of Canoga Park, California. Wet sediment was digested in nitric acid and hydrogen peroxide. The digestate was then refluxed with either nitric acid or hydrochloric acid and then diluted to a volume of 50 ml (EPA procedure SW 846 3050). Percent moisture was determined on a separate sample. Digestates were analyzed on an inductively coupled plasma emission spectrometer (Baird simultaneous PST installed with 27 element channels). Concentrations were determined by comparison with standards. Samples were spiked after digestion and recoveries were used to correct data affected by the sample matrix.

Trace Organics.

Polynuclear aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons (CHCs) were analyzed by Global Geochemistry Corp. Extraction and clean up of sediment samples were conducted according to modified SCCWRP methods (Eganhouse *et al.* 1990). Wet sediment was extracted three times with methylene chloride by sonication for 30 min. The combined extracts were concentrated and cleaned up on a silica gel column. The PAHs were analyzed on an Incos 50 GC-MS by a modified EPA 8270 method. The CHCs were analyzed on a Varian 3700 GC with an ECD. The DDT compounds (o, p'-DDE, p,p'-DDE, o. p'-DDT, and p, p'-DDT) and the Arochlors (1242 and 1254) were quantified by the internal standard method with PCB congener 207 (Ballschmiter and Zell 1980). One peak was used for quantitation of 1242 and two peaks for 1254 (Eganhouse and Gossett 1991).

Statistical Analyses

The contaminant concentrations and biological variables (species, individuals, and biomass) were tested for differences among groups of stations, depths, and surveys by one-way analysis of variance (ANOVA) and the HSD multiple comparisons test (Tukey 1951). The patterns in species composition among the stations were examined using classification analysis of species abundance data (Clifford and Stephenson 1975). Proportion data were arcsine transformed and abundance data were $\log_{10}$ transformed. A value of 0.5 times the detection limit was used to calculate sample statistics for contaminants with masses below detection limit.

Table 1.
Means and 95% confidence intervals (CI) of near-bottom water and sediment parameters by depth at the reference sites in July-August 1990.

	Stations					
	30 m (n=6)		60 m (n=7)		150 m (n=7)	
	mean	CI	mean	CI	mean	CI
Near-bottom water						
Temperature (°C)	13.2	(0.5)	11.8	(0.6)	10.1	(0.2)
Salinity (°/oo)	33.4	(0.1)	33.4	(0.1)	33.7	(0.1)
Dissolved oxygen (mg/L)	7.4	(1.9)	6.2	(1.6)	4.4	(1.2)
Sediment (% dry weight)						
Sand	65	(30)	48	(32)	38	(23)
Silt	32	(29)	47	(30)	52	(19)
Clay	3	(2)	6	(2)	10	(5)
Dry weight	69	(3)	65	(6)	60	(7)
Total organic carbon	0.47	(0.19)	0.57	(0.24)	0.82	(0.44)
Total nitrogen	0.04	(0.01)	0.04	(0.02)	0.07	(0.04)
Trace metals (ppm)						
Silver	0.10	(0.10)	0.25	(0.43)	0.05	(0.00)
Cadmium	0.26	(0.23)	0.24	(0.27)	0.37	(0.23)
Chromium	17	(4)	26	(14)	31	(10)
Copper	5.3	(2.3)	9.2	(5.5)	14	(5.6)
Nickel	8.0	(4.0)	11	(8.2)	14	(5.9)
Lead	4.4	(1.4)	6.9	(3.3)	8.2	(3.6)
Zinc	29	(11)	45	(21)	55	(18)
Iron	10,998	(3,667)	17,964	(7,746)	21,311	(6,037)
Manganese	99	(44)	133	(63)	156	(58)
Trace organics (ppb)						
Total PCB[1]	7	(4)	12	(11)	12	(10)
Total DDT[2]	5	(5)	13	(13)	15	(14)
Total PAH[3]	24	(20)	26	(14)	39	(20)

[1]Aroclor 1254 + Aroclor 1260
[2]o,p'-DDE + p,p'-DDE + p,p'-DDT + o,p'-DDT
[3]30 compounds

Results

Water column and sediments

Temperatures near the bottom ranged between 9.9° and 13.8°C. Salinities ranged between 33.2 and 33.8 ppt. The lowest salinities were measured at the head of the La Jolla submarine canyon. Dissolved oxygen concentrations ranged between 3.1 and 9.0 mg/L. Temperature and dissolved oxygen were generally lowest at the 150 m stations and highest at the 30 m stations.

Shelf sediments were predominantly sandy-silt. As water depth increased, the amount of sand in the sediments decreased and the amount of clay increased, except off Imperial Beach where sand increased in deep water. Total organic carbon (TOC) ranged from 0.15% to 1.52% and was highly correlated with clay content (r = 0.786).

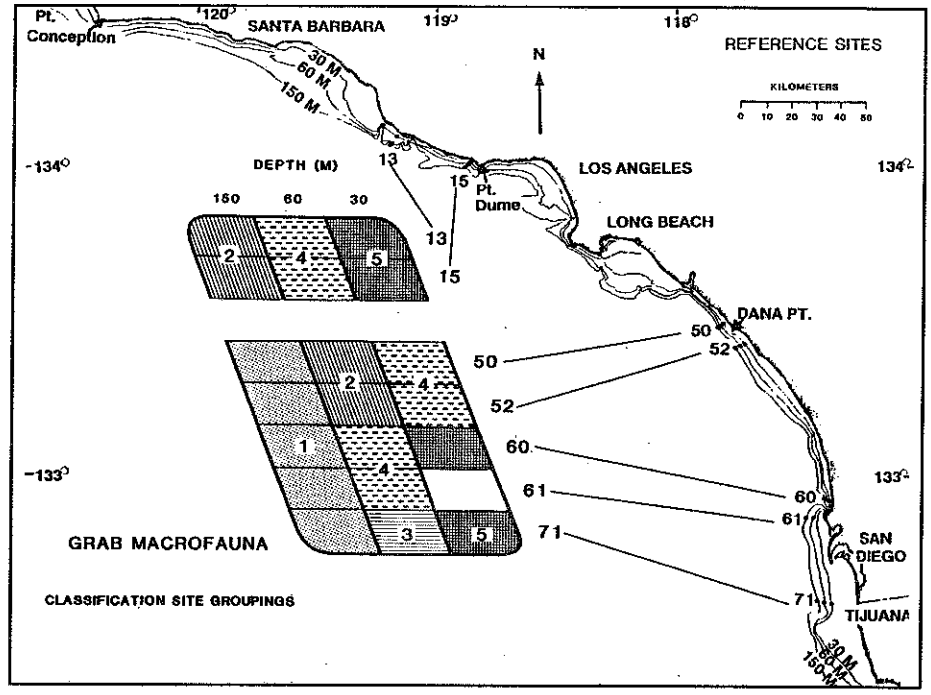
Sediment trace metal concentrations were generally low at all stations (Table 1) and were not significantly different among depths. Total DDT ranged between <0.5 to 39 ppb; concentrations were highest at the northern 60 and 150 m sites. Total PCBs ranged from <5 to 31 ppb; concentrations were highest off Point Dume and Dana Point. Total PAHs ranged from <0.09 to 69 ppb; concentrations were highest off Oxnard. The mean concentrations of trace organic contaminants were not significantly different among depths.

Macrobenthos

Classification analysis of the macrobenthos (>1 mm) identified five groups of stations (Figure 1; Table 2). Groups 1, 2, and 5 were variations of the *Amphiodia urtica-Spiophanes missionensis* assemblage (Group 4) that inhabits the entire Southern California mainland shelf. The benthos at station R71-60 formed a distinct assemblage. The number of species, number of individuals, and biomass were not significantly different among depths (Table 2).

Two species of amphipods, *Amphideutopus oculatus* and *Ampelisca brevisimulata,* dominated most of the grab samples collected at the 30 m stations. *Amphiodia urtica*, and to a lesser extent the polychaete, *Myriochele* sp. M., dominated samples collected at 60 m. The 150 m stations were dominated by the polychaetes, *Spiophanes fimbriata* and *Myriochele* sp. M, and *Amphiodia urtica.* The station in 60 m of water off Imperial Beach (R71) was dominated by the gastropod, *Micranellum crebricinctum,* and the ostracod, *Euphilomedes carcharodonta.*

Figure 1.
Distribution of benthic macrofaunal assemblages (site groups) determined by classification analysis of invertebrates collected in Van Veen grab samples.



Megabenthos

Classification analysis of the large, motile invertebrates (megabenthos) in otter trawl samples identified four groups of stations (Figure 2; Table 3). The asteroid, *Astropecten verrilli,* dominated trawl collections at 30 m, but decreased in abundance with increasing depth. The sea urchin, *Lytechinus pictus,* and the prawn, *Sicyonia ingentis* dominated collections at 60 m. The sea urchins, *Allocentrotus fragilis,* a common slope species, and *Lytechinus pictus* dominated the 150 m stations.

The number of species, indi-

viduals, and biomass per trawl were significantly higher at the 60 and 150 m stations compared to the 30 m stations (Table 3). The 60 m stations (Group 2) were inhabited by typical southern California mainland shelf megabenthos. The number of species was similar among the sites. Group 4a resulted from a small trawl catch at Station R52-30.

Demersal Fishes

Classification analysis of the demersal fishes identified three groups of stations (Figure 3; Table 4). The speckled sanddab *(Citharichthys stigmaeus)* and longfin sanddab *(Citharichthys xanthostigma)* dominated trawl catches at the 30 m stations. Pacific sanddab *(Citharichthys sordidus)* and longfin sanddab dominated trawl catches at the 60 m stations. Slender sole *(Eopsetta exilis)* and plainfin midshipman *(Porichthys notatus)* dominated trawl catches at the 150 m stations.

The number of fish species, individuals, and biomass increased with increasing depth

Table 2.

Mean abundance per 0.1 m² grab of the five most abundance macrofauna in each site group (determined by classification analysis) and the ten most common species. FO=frequency of occurrence (N=20); P=polychaete; Os=ostracod; Op=ophiuroid; Pe=pelecypod; G=gastropod; A=amphipod; Ph=phoronid.

			Mean number/grab by site group				
			1	2	3	4	5
			150m	60-150m	R71-60	30-60m	30m
Species	Taxon	FO	n=5	n=4	n=1	n=6	n=4
Euphilomedes producta	Os	9	8.4	20.8	0	1.2	.0
Spiophanes fimbriata	P	12	29.6	6.5	0	3.0	2.0
Maldane sarsi	P	15	11.8	1.0	1	1.3	1.5
Pectinaria californiensis	P	18	10.4	25.0	5	7.5	1.2
Amphiodia urtica	Op	16	19.4	120.2	0	77.3	4.2
Spiophanes berkeleyorum	P	16	6.8	2.5	0	6.0	1.8
Tellina carpenteri	Pe	17	2.0	2.2	0	5.7	2.0
Myriochele sp. M	P	6	0	386.5	1	6.8	0
Mediomastus sp.	P	19	9.2	5.2	4	7.0	2.8
Parvilucina tenuisculpta	Pe	19	13.2	1.2	8	5.2	2.8
Spiophanes missionensis	P	20	5.0	13.2	24	32.7	11.5
Rhepoxynius bicuspidatus	A	15	1.6	5.0	0	5.7	8.5
Prionospio sp. A	P	16	2.4	1.5	12	10.5	7.8
Paraprionospio pinnata	P	11	0.6	2.2	0	2.3	8.5
Chloeia pinnata	P	7	0.2	1.0	24	2.5	0
Micranellum crebricinctum	G	1	0	0	40	0	0
Euclymeninae sp. A	P	11	0.2	0.2	6	7.2	5.0
Euphilomedes carcharodonta	Os	13	0.2	2.8	40	4.8	5.2
Phoronis sp.	Ph	10	0	0.5	28	3.8	3.0
Ampelisca brevisimulata	A	11	0	1.5	0	3.8	12.5
Amphideutopus oculatus	A	7	0	0.2	0	0.3	16.8
Spiophanes bombyx	P	7	0	.0	10	0.3	9.5
Mean number species/grab			62.2	58.8	76.0	90.3	78
Mean number individivids/grab			247	691.5	356.0	375	273
Mean biomass (wet g)/grab			8.9	7.9	4.1	15	6.3

(Table 4). However, due to the variability among stations, there were no significant differences in species or biomass among the depths. The number of individuals was significantly greater at the 150 m stations compared to the 30 m sites.

Discussion

The mainland shelf (30-150 m) was composed primarily of sandy-silt sediments with an average TOC content of about 0.6%. The benthic invertebrates and demersal fishes collected at the 20 stations were typical of Southern California reference areas. Sediments at Station R71-60 contained about 94% sand and the macrofauna was distinct from the remaining stations (Table 2). Water depth and sediment type contribute to the differences among the assemblages identified by classification analysis.

The data from the 1977 60 m Survey (Word and Mearns 1979), the 1985 Reference Survey (Thompson *et al.* 1987), and the present study provide information about long-term temporal variation at reference sites. The chemical methods (sediment extraction and instrumental analysis) differed among the surveys. The number of DDT isomers and PAH compounds quantified changed between surveys. Nevertheless, silver was the only sediment characteristic measured that was significantly different among the three surveys (Table 5).

The same grab and trawl gear and methods were used in the 1977, 1985, and 1990 surveys. The assemblages of macrobenthic

Figure 2.
Distribution of benthic megafaunal assemblages (site groups) determined by classification analysis of invertebrates collected in trawl samples.

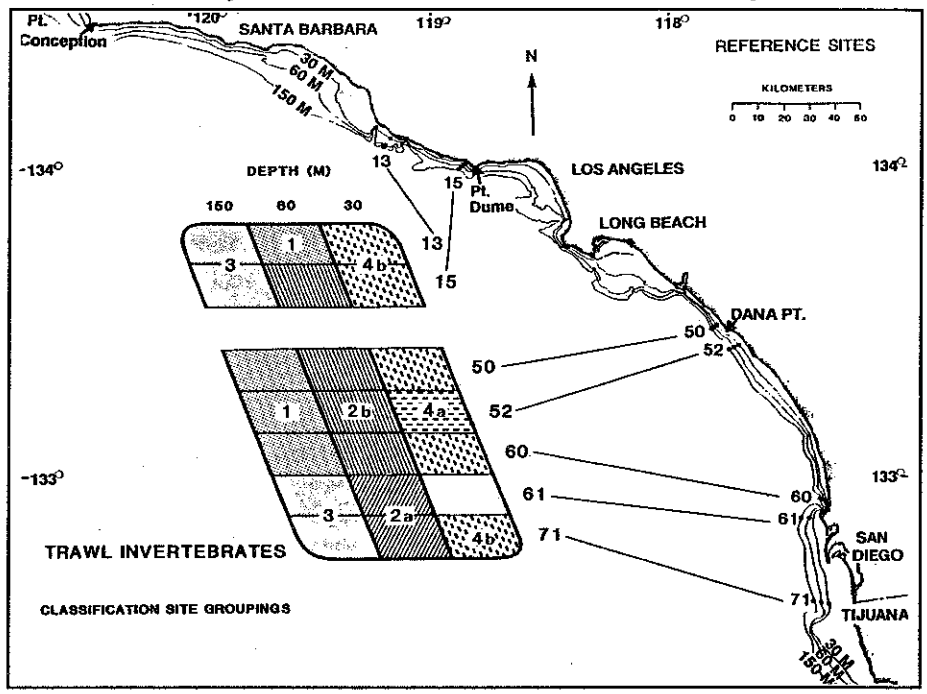
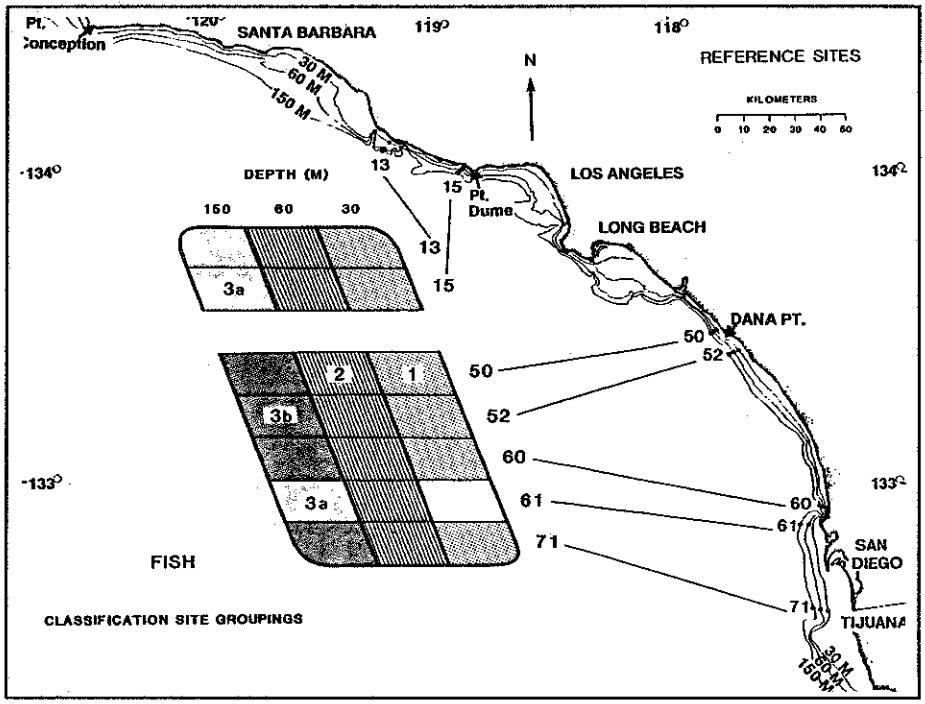


Figure 3.
Distribution of demersal fish assemblages (site groups) determined by classification analysis of fishes collected in trawl samples.



and megabenthic invertebrates sampled in 1990 were similar to the assemblages sampled in 1977 and 1985. The macrobenthic grab and megabenthic trawl statistics were highest in 1990, but there were no significant difference among surveys (Table 5). Megabenthic individuals were two orders of magnitude lower in 1985 than in 1977 and 1990. However, due to the large variation within years, the difference was not significant.

The assemblage of demersal fishes sampled in 1990 was similar to assemblages sampled in 1977 and 1985; seven of the ten most frequently occurring species were common to all three surveys. In contrast to the invertebrate data, fish trawl statistics were significantly lower in 1985 (Table 5). This may have resulted from altered environmental conditions following the 1982-83 El Niño and the severe storms in the winter of 1983.

Conclusions

The data collected during this survey complement the 1977 60 m Survey (Word and Mearns 1979) and the 1985 Reference Survey (Thompson *et al.* 1987). The seven reference areas (20 stations) sampled in 1990 were comparable to the major shelf habitats off Southern California and bracketed the major ocean municipal wastewater discharges. This is probably the minimum number of stations needed to describe reference conditions on the mainland shelf. With the renewed interest in bight-wide monitoring (National Research Council 1990), these reference stations could be incorporated into a regional monitoring program for the Southern California Bight. ■

Table 3.
Mean abundance of the megabenthos per 10-minute trawl in each site group (determined by classification analysis) and the ten most common species. FO=frequency of occurrence (N=20); C=crustacean; E=echinoderm; M=molluscan.

			Mean number/trawl by site group					
			1	2a	2b	3	4a	4b
Species	Taxon	FO	60-150m n=4	60m n=2	60m n=4	150m n=4	R52-30 n=1	30m n=5
Pandalus platyceros	C	3	29.8	0	0	0	0	0
Pleurobranchaea californica	M	7	2.8	0	0.2	1.4	0	0
Parastichopus californicus	E	11	25.8	13.0	12.8	0.6	0	0.4
Sicyonia ingentis	C	12	64.0	1.5	45.0	1.6	0	0
Luidia foliolata	E	15	29.8	4.0	2.2	13.4	0	2.8
Brissopsis pacifica	E	4	0.5	0	0	41.0	0	0
Allocentrotus fragilis	E	6	29.8	0	0	303.6	0	0
Octopus rubescens	M	6	0.2	3.0	0.5	1.2	0	0
Lytechinus pictus	E	13	23.2	11391.5	350.2	212.2	8	1.0
Luidia asthenosoma	E	1	0	6.0	0	0	0	0
Ophiothrix spiculata	E	7	0	6.0	3.0	0	0	0.2
Crangon alaskensis	C	3	0	0	6.5	0	0	0
Loxorhynchus grandis	C	8	0.5	0	2.2	0	0	0.2
Astropecten verrilli	E	17	0.8	40.0	11.2	8.8	9	110.4
Lovenia cordiformis	E	4	0	0	0	0.6	2	3.0
Heterocrypta occidentalis	C	3	0	0	0.2	0	0	1.0
Mean number species/trawl			16.8	14.5	10.8	11.0	5.0	7.2
Mean number individuals/trawl			249.5	11,478.0	440.0	739.3	21.0	122.
Mean biomass (wet kg)/trawl			17.4	21.1	8.4	17.0	0.2	1.2

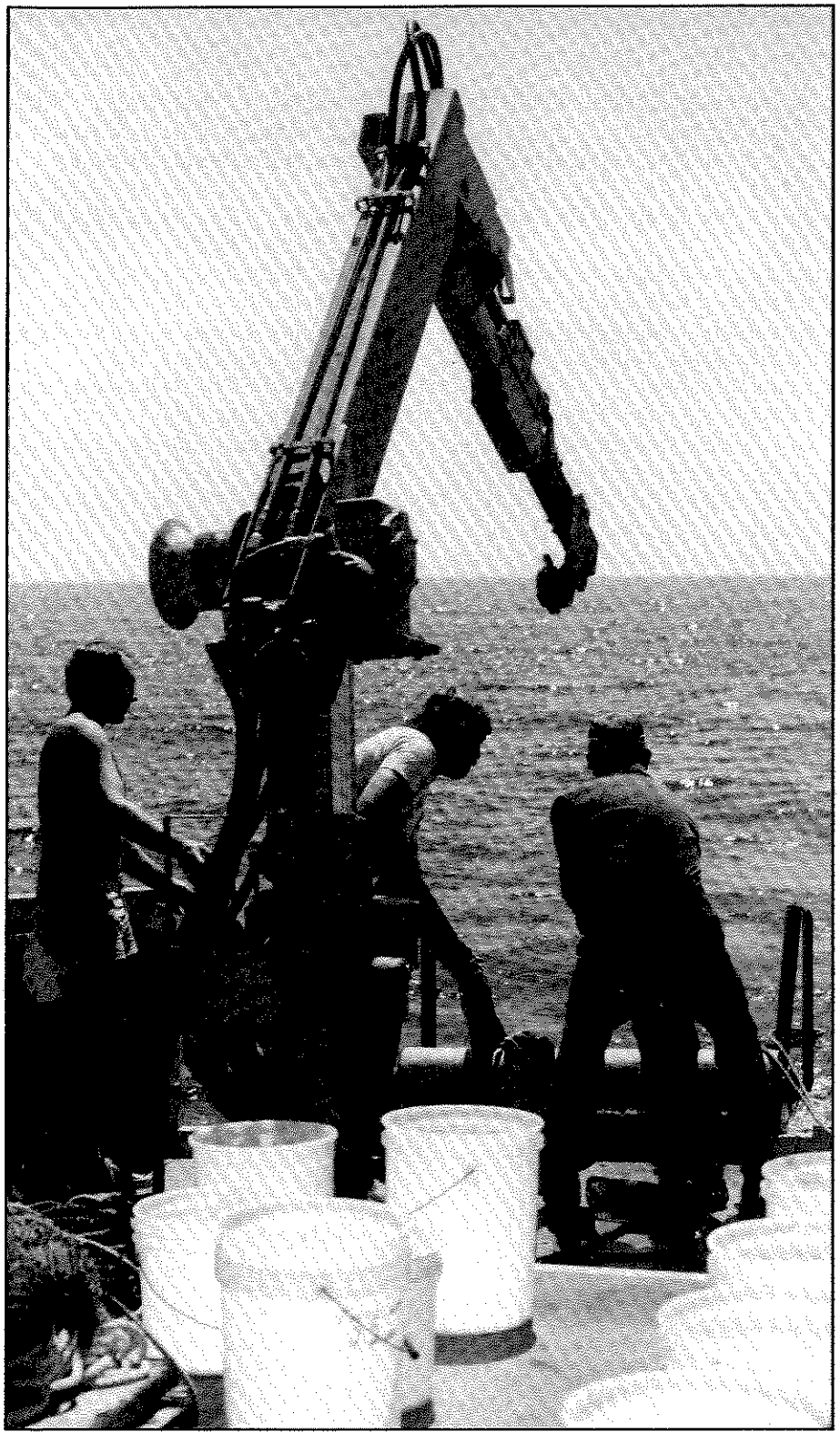
References

- Ballschmiter, K. and M. Zell. 1980. Analysis of polychlorinated biphenyls (PCB) by glass capillary chromatography. *Fresen. Z. Anal. Chem.* 302:20-31.
- Clifford, H.T. and W. Stephenson. 1975. An introduction to numerical classification. Academic Press, New York. 229 pp.
- Eganhouse, R., R.W. Gossett, and G.P. Hershelman. 1990. Congener-specific characterization and source identification of PCB input to Los Angeles Harbor. Final report to the California Regional Water Quality Control Board - Los Angeles Region. September 1990. 34 pp.
- Eganhouse, R. and R.W. Gossett. 1991 Sources and Magnitude of Bias Associated with Determination of Polychlorinated Biphenyls in environmental Samples. *Anal. Chem.* (In Press).
- National Research Council. 1990. Monitoring Southern California's coastal waters. National Academy Press, Washington, D.C. 154 pp.
- Plumb, R. 1981. Procedures for handling and chemical analysis of sediment and water samples. Tech. Rept. EPA/CE-81-1. U.S. Army Corps of Engineers. Vicksburg, MI.
- Thompson, B.E., J. Laughlin, and D. Tsukada. 1987. 1985 reference site survey. Technical Report 221. Southern California Coastal Water Research Project, Long Beach. 50 pp.
- Thompson, B.E., D. Tsukada, and D. O'Donohue. 1992. 1990 Reference Survey. Technical Report 355. Southern California Coastal Water Research Project, Long Beach. 58 pp.
- Tukey, J.W. 1951.

Table 4.

Mean abundance of five most abundant species of demersal fish per 10-minute trawl in each site group (determined by classification analysis) and the ten most common species. FO=frequency of occurrence (N=20).

		Mean number/trawl by site group			
		1	2	3a	3b
		30m	60m	150m	150m
Species	FO	n=6	n=7	n=3	n=4
Speckled sanddab	6	52.2	1.7	0	0
Hornyhead turbot	13	9.7	6.1	0	0
California lizardfish	14	4.7	2.4	0.3	0.8
Longfin sanddab	13	32.7	73.0	0	0.2
California tonguefish	10	0.7	12.6	0	0.2
Yellowchin sculpin	10	0.3	46.6	0.3	0.2
Longspine combfish	6	0.3	19.7	0.3	0
Bigmouth sole	16	6.0	3.3	0.3	4.2
Pink surfperch	9	0	4.0	0	4.8
Pacific sanddab	16	10.2	91.0	99.3	40.5
Slender sole	7	0	0	18.7	188.2
Dover sole	9	0	1.1	8.7	57.0
Stripetail rockfish	9	0	1.7	41.7	38.2
Plainfin midshipman	10	0	1.0	40.7	115.8
Gulf sanddab	7	0	0.4	81.0	16.5
Mean number species/trawl		11.2	14.1	10.7	18.8
Mean number individuals/trawl		129.7	278.9	296.7	553.8
Mean biomass (wet kg)/trawl		8.0	8.2	10.9	18.7



Hauling the net aboard

Quick and dirty methods in statistics. pp. 189-197, *In:* Simple analysis for standard designs. Part II. Proc. 5th Ann. Conv. Amer. Soc. Qty. Ctrl.

- Word, J. and A. Mearns. 1979. 60 meter control survey off Southern California. Technical Report 229. Southern California Coastal Water Research Project, Long Beach. 58 pp.

Acknowledgements

Author Bruce Thompson thanks the City of Los Angeles, County Sanitation Districts of Los Angeles County, and the City of San Diego for providing ship time, and the captains and crews of the R/V *La Mer,* R/V *Ocean Sentinel,* and R/V *Monitor III* for their assistance. Global Geochemistry (Canoga Park, CA) performed the sediment trace metal and organic hydrocarbon analyses. Dr. Robert Smith (EcoAnalysis, Ojai, CA) performed the classification analyses. Harold Stubbs (SCCWRP) directed the field collections and was ably assisted by David Tsukada, Diane O'Donohue, Andrew Jirik, Dario Diehl, Azra Khan, Marilyn Castillo, Larry Cooper, and Valerie Raco (SCCWRP).

Table 5.

Sediment and biological variables measured in the 60 m Survey (Word and Mearns 1977), the 1985 Reference Survey (Thompson et al. 1986), and the 1990 Reference Survey (Thompson et al. 1992). Means and confidence limits 95% CI (in parentheses) were calculated from the seven 60 m sites common to each survey. Total DDT and total PCB were only measured at three sites in 1977 common to the 1985 and 1990 surveys. Total PAH was not measured in 1977. ANOVA = one-way analysis of variance; P = probability.

	1977		1985		1990		ANOVA
	mean	95% CI	mean	95% CI	mean	95% CI	P
Sediments							
TOC (%)	0.53[1]	(0.15)	0.57	(0.36)	0.57	(0.24)	0.982
TVS (%)	2.7	(0.8)	3.3	(1.8)	2.9[1]	(1.3)	0.888
Sand (%)	46.4	(26.1)	49.7	(38.2)	47.8	(32.4)	0.984
Silver (ppm)	0.30	(0.25)	0.04	(0.05)	0.25	(0.43)	0.001**
Cadium (ppm)	0.30	(0.21)	0.13	(0.11)	0.24	(0.27)	0.165
Chromium (ppm)	19.8	(9.4)	21.8	(11.1)	25.6	(13.8)	0.753
Copper (ppm)	6.3	(2.9)	11.0	(6.4)	9.2	(5.5)	0.538
Nickle (ppm)	10.1	(8.4)	11.6	(8.7)	11.4	(8.2)	0.870
Lead (ppm)	6.3	(1.9)	5.4	(3.4)	6.9	(3.3)	0.412
Zinc (ppm)	36.1	(12.2)	44.5	(25.7)	45.1	(21.2)	0.913
ΣPCB (ppb)	9.7	(13.6)	18.9	(11.3)	10.6	(11.0)	0.235
ΣDDT (ppb)	28.0	(63.2)	23.5	(35.5)	12.6	(12.7)	NT[2]
ΣPAH (ppb)	—		26.3	(44.7)	25.9	(14.0)	NT[2]
Biology							
Infaunal species (no/grab)	68	(23)	56	(19)	83	(21)	0.070
Infaunal individuals (no/grab)	418	(88)	332	(138)	626	(573)	0.136
Infaunal biomass (no/grab)	6.7	(3.1)	10.0	(6.4)	15.2	(15.4)	0.354
Megafaunal species[3] (no/trawl)	10.7	(5.0)	11.8	(6.0)	13.3	(4.0)	0.495
Megafaunal individuals (no/trawl)	1043	(1490)	85	(45)	3556	(5627)	0.078[4]
Megafaunal biomass (no/trawl)	7.0	(6.1)	3.5	(4.4)	12.4	(10.2)	0.075[4]
Fish species[3] (no/trawl)	15.6	(3.2)	11.4	(3.8)	14.1	(3.0)	0.087
Fish individuals (no/trawl)	375	(246)	146	(73)	279	(118)	0.026*
Fish biomass (no/trawl)	8.4	(7.1)	3.9	(1.5)	8.2	(3.9)	0.029*

*significant at 0.05

**significant at 0.01

[1]Value calculated from regression of TOC on TVS

[2]Not tested because different components were measured in different years.

[3]Names of organisms not standardized among surveys

[4]Variances heterogeneous