C-133

TM 229
June 1979

60-METER CONTROL SURVEY OFF SOUTHERN CALIFORNIA

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ERRATA

	Reads	Should Read
Page 2	INFAUNAL ORGANISMS No. of species/sq meter No. of individuals/sq meter	INFAUNAL ORGANISMS No. of species/0.1 sq meter No. of individuals/0.1 sq meter
Page 11 (Table column heading)	Limit (mg/g)	Limit (µg/g)
Page 21 (Table 8)	All references to (No./sq m) and (No. of .../sq m)	(No./0.1 sq m) and (No. of .../0.1 sq m)

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INTRODUCTION

All wastewater monitoring programs assess the environmental situation in the discharge area by comparing it to the situation where there is no discharge. Thus, the selection of the reference or control stations is of critical importance in evaluating effects: Control stations must be as similar as possible to the area being studied except that they are not exposed to outfall materials.

The Project has encountered the problem of selecting proper control sites in designing its surveys of southern California discharge areas. We considered using sites off the Channel Islands but rejected them because they are not oceanographically or biologically comparable to mainland sites. We also looked at data from the control sites used in the past by various dischargers and found that some of these were in areas influenced by the outfalls being investigated and consequently gave invalid reference information. In some monitoring surveys, a single reference station and a single set of measurements have been used as the basis for determining the natural or background conditions for an outfall site. Yet careful analysis of many samples reveals that chemical and biological conditions vary with water depth and type of bottom material and can differ by as much as a factor of 10, even in areas not influenced by man. Plainly, no single control station or set of measurements is valid for reference purposes.

Numerous benthic monitoring surveys, designed to assess the effects of existing or future discharges, have been taken on the southern California mainland shelf since 1956. While such surveys have provided much new information on the abundance and diversity of thousands of species of bottom organisms and fishes, and on the levels of pollutants in sediments around outfalls, few have provided a data base that would permit the identification of control sites, or areas where background conditions exist. An outstanding exception is the mainland shelf survey produced by the California State Water Resources Control Board and conducted some 20 years ago by the Allan Hancock Foundation, University of Southern California (California State Water Resources Control Board 1967; Jones 1969). That survey provided useful information on conditions at that time; however, we do not know if the results are representative today. Moreover, the previous survey did not provide data on sediment pollutant concentrations or trawl-caught fish and invertebrate populations--two types of information that are needed at present, particularly for rural areas of this coast.

Accordingly, in 1977, the Coastal Water Research Project sponsored a new survey of the mainland shelf from Point Conception to the United States/Mexico border. The goal of the survey was to identify possible control areas for contrasting with existing municipal wastewater discharge sites and to define the apparent normal variations in the chemistry and biology of the fine sediment areas covering much of the mainland shelf.

As a result of the survey, which is described here, we now believe we have identified 29 locations, the combined information from which can be used as control data for one depth--60 meters. We chose to limit this survey to the single depth because this is the depth of discharge of the largest municipal wastewater treatment plants along the coast and because discharged materials tend to drift along depth contours. Details on the methods and results of the survey are given in the following sections.

Values for several parameters measured at the control stations are summarized below:

	Mean	Range
ANALYSES OF BOTTOM SEDIMENTS (UPPER 2 CM)		
Percent volatile solids	2.8	1.8-3.8
Chemical oxygen demand (parts/ million, or ppm)	20,157	9,200-38,400
Nitrogen (ppm)	671	392-926
Acid volatile sulfides (ppm)	0.018	<0.003-0.069
Metals (ppm)		
Cadmium	0.39	0.1-1.4
Chromium	23	6.5-43
Copper	9.1	2.8-31
Lead	6.6	2.7-12
Nickel	12	1.6-35
Silver	0.38	0.06-1.7
Zinc	42	9.8-62
INFAUNAL ORGANISMS		
No. of species/sq meter	71	40-124
No. of individuals/sq meter	423	229-654
Infaunal Trophic Index value	90.3	69-98.3
TRAWL-CAUGHT ORGANISMS		
Invertebrates		
No. of species/trawl	11	5-24
No. of individuals/trawl	455	20-3,640
Fish		
No. of species/trawl	14	5-21
No. of individuals/trawl	347	11-1,294

MATERIALS AND METHODS

Between 28 April and 9 August 1977, 70 benthic grab samples and 53 trawl samples were taken at 71 stations between Point Conception and the U.S./Mexico border. The stations were located at intervals of approximately 10 km along the 360 km of coastline at depths of approximately 60 meters. In certain areas near the major municipal wastewater outfalls, stations were more closely spaced to delineate the expected outfall effects. Station locations are given in Table 1 and shown on Figure 1.

Position on station was determined through the combined use of dead reckoning, sightings off headlands, radar fixes, and depth measurements from a recording fathometer. We have estimated that the inaccuracy of positioning do not exceed 100 meters.

The vessels used during the survey are as follows:

1. M/V Marine Surveyor, Los Angeles City, John Keller, Skipper.
2. M/V Fury II, Orange County Department of Education, John Haas, Skipper.
3. M/V Monitor II, San Diego City, Susan Hamilton, director of collecting efforts.
4. M/V Enchanter IV, Fred Munson, Owner/Operator.
5. R/V Sea-S-Dee, Los Angeles County Sanitation Districts, Rusty Shields, Skipper.
6. R/V Van Tuna, Occidental College, Elden McAllicher, Operator.

Cruises are described in Table 2.

COLLECTION AND ANALYSIS OF BIOLOGICAL DATA

Infaunal Grab Samples

Two replicate grab samples were collected at each station, using a standardized 0.1-sq-meter Van Veen grab (Word et al. 1976; Word 1977). Sediment type, color, and odor and depth of grab penetration were recorded at sea. A sample was considered acceptable if the sampler had penetrated the bottom to a minimum of 10 cm, as penetration depths on this order have been shown to collect a minimum of 90 percent of the individuals and species typically found in southern California bottom sediments (Word et al. 1976; Word 1977).

The samples were sieved through a stacked set of screens with square mesh sizes of 2.5, 1.0, and 0.5 mm. The biological specimens and associated debris collected on each size of screen were fixed in borax-buffered formalin diluted to 10 percent concentration with seawater. The samples were retained in this

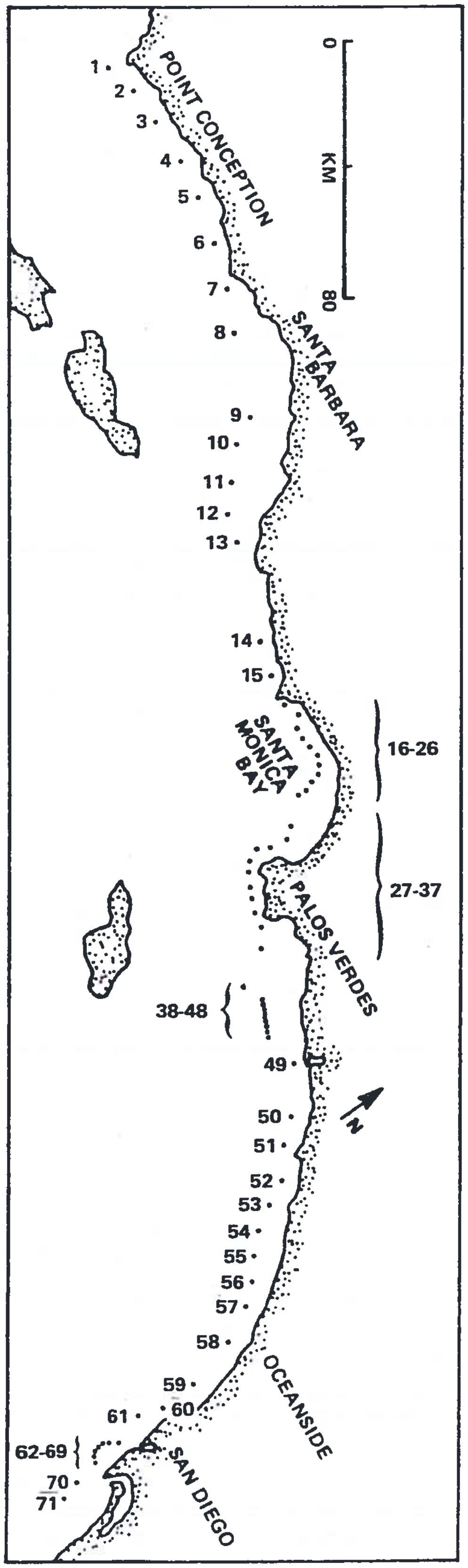


Figure 1. Station locations, control survey, 1977.

fixation solution for a period not exceeding 1 month; they were then rescreened through the next smaller mesh opening and preserved in a 70 percent ethanol/distilled water mixture for later analysis. The data in this report concern only the material collected on the 2.5- and 1.0-mm screens; the 0.5-mm samples have been archived for future research purposes.

The specimens were removed from the associated debris under a microscope at 10X power and sorted into five groups (Arthropoda, Mollusca, Echinodermata, Polychaeta, and other phyla). The specimens in each group were then identified to the lowest possible taxonomic unit, and the number of organisms in each unit was recorded. (Gastropod and bivalve mollusc shells were not counted unless they contained the animal.) The standing crop of organisms in each category was measured on an H-72 Mettler balance to the nearest 0.1 mg after the organisms had been air-dried on a paper towel for a period of exactly 5 minutes.

The samples were analyzed using a number of common statistical methods of measuring community structure. In addition, one new method--the Infaunal Trophic Index, which measures the relative abundance of organisms with certain feeding behaviors, or the function of the community (Word, in preparation)--was used. The Infaunal Trophic Index is a statistic indicating the relative abundance of organisms with one of four types of feeding behavior; the abundance of 47 select species is considered in arriving at the Index value, which is given by

$$ITI = 100 - \left[33\text{-}1/3\left(\frac{0n_1 + 1n_2 + 2n_3 + 3n_4}{n_1 + n_2 + n_3 + n_4}\right)\right]$$

where n_i is the number of individuals in Group i. Index values range from 0 to 100, with a value of 100 indicating that all individuals considered are suspension feeders (Group I) and a value of 0 indicating that all the individuals are subsurface detrital feeders (Group IV).

Thus the higher the Index number for a station, the greater the prevalence of

Table 1. Location and depths of control survey stations.

Station Number	Location	Depth (m)	Latitude North	Longitude West
1*	Pt. Conception	62	34°25'45"	120°26'45"
2*	Pt. Conception	59	34°25'05"	120°22'00"
3*	Sacate	59	34°26'28"	120°15'55"
4	Gaviota	81	34°25'40"	120°10'00"
5	Tajiguas	61	34°26'15"	120°04'02"
6*	Coal Oil Pt.	67	34°24'16"	119°56'48"
7*	Goleta Pt.	61	34°22'50"	119°46'55"
8	Santa Barbara	61	34°21'10"	119°41'15"
9*	Rincon Pt.	64	34°18'15"	119°30'00"
10*	Pitas Pt.	59	34°13'30"	119°27'29"
11	Ventura	58	34°09'50"	119°23'10"
12	Oxnard	53	34°07'15"	119°18'20"
13	Pt. Hueneme	65	34°03'50"	119°09'56"
14	Arroyo Sequit	58	34°01'40"	118°57'25"
15	Trancas Cyn.	58	34°00'45"	118°51'32"
16	Santa Monica Bay	59	33°59'55"	118°47'55"
17	Santa Monica Bay	57	33°59'33"	118°46'25"
18**	Santa Monica Bay	61	33°59'48"	118°43'56"
19**	Santa Monica Bay	61	34°00'00"	118°41'15"
20**	Santa Monica Bay	59	34°00'00"	118°38'33"
21**	Santa Monica Bay	59	33°59'33"	118°35'57"
22**	Santa Monica Bay	57	33°58'20"	118°33'53"
23**	Santa Monica Bay	59	33°56'36"	118°32'26"
24**	Santa Monica Bay	60	33°55'42"	118°32'25"
25**	Santa Monica Bay	60	33°54'36"	118°31'30"
26**	Santa Monica Bay	60	33°53'33"	118°31'30"
27**	Santa Monica Bay	60	33°52'20"	118°28'20"
28**	Santa Monica Bay	80	33°50'42"	118°26'36"
29**	Palos Verdes	59	33°48'15"	118°26'15"
30**	Palos Verdes	57	33°47'00"	118°27'00"
31**	Palos Verdes	59	33°43'54"	118°24'54"
32**	Palos Verdes	58	33°43'25"	118°22'57"
33**	Palos Verdes	59	33°42'48"	118°21'30"
34**	Palos Verdes	61	33°42'06"	118°20'18"
35**	Palos Verdes	55	33°41'18"	118°18'54"
36**	Palos Verdes	56	33°38'45"	118°15'51"
37**	Palos Verdes	55	33°36'20"	118°14'48"
38**	San Pedro Bay	60	33°34'36"	118°10'50"
39**	San Pedro Bay	58	33°35'48"	118°03'49"
40**	San Pedro Bay			
41**	San Pedro Bay	67	33°34'57"	118°02'05"
42**	San Pedro Bay	60	33°34'50"	118°01'30"
43**	San Pedro Bay	59	33°34'45"	118°00'50"
44**	San Pedro Bay	64	33°34'20"	118°00'40"
45**	San Pedro Bay	59	33°34'34"	118°00'32"
46**	San Pedro Bay	60	33°34'28"	117°59'49"
47**	San Pedro Bay	60	33°34'23"	117°59'35"
48**	San Pedro Bay	60	33°34'13"	117°58'57"
49**	Corona del Mar	59	33°35'10"	117°53'32"
50	Laguna Bch.	60	33°30'06"	117°46'30"
51	Dana Pt.	57	33°22'56"	117°44'00"
52	San Clemente	55	33°24'06"	117°39'30"
53	San Mateo Pt.	55	33°22'08"	117°38'09"
54	San Onofre	59	33°17'36"	117°33'30"
55	Aliso Cyn.	59	33°14'12"	117°29'45"
56	Oceanside	60	33°10'36"	117°25'48"
57	Carlsbad	60	33°07'36"	117°21'18"
58	Leucadia	60	33°03'12"	117°19'42"
59	Solana Bch.	60	32°58'30"	117°18'30"
60	Sorrento	62	32°53'45"	117°16'30"
61	La Jolla	64	32°49'30"	117°19'12"
62	Mission Bay	62	32°45'24"	117°18'24"
63	Pt. Loma	62	32°41'18"	117°17'18"
64	Pt. Loma	62	32°40'50"	117°17'09"
65**	Pt. Loma	62	32°40'35"	117°17'00"
66**	Pt. Loma	62	32°40'21"	117°16'59"
67**	Pt. Loma	62	32°40'10"	117°16'55"
68	Pt. Loma	62	32°39'50"	117°16'51"
69	Pt. Loma	62	32°39'20"	117°16'42"
70**	Chula Vista	60	32°36'00"	117°16'15"
71	Imperial Bch.	60	32°33'30"	117°15'54"

Table 2. 60-meter survey cruises,
28 April to 9 August 1977.

Cruise Date	Vessel	Stations Sampled Grabs	Trawls
28 Apr	Marine Surveyor	16-23	16, 18, 20, 22
2 May	R/V Van Tuna	-	39, 45, 48
10 May	Fury II	51, 52, 53	51, 52, 53
11, 12, 17-19 May	R/V Sea-S-Dee	-	29, 31-35, 37
1-3 Jun	Marine Surveyor	1-15	1-15
21-23 Jun	Fury II	54-61, 70, 71	54-61, 66, 70, 71
23 Jun	Monitor II	62-65, 67-69	-
6 Jul	Marine Surveyor	24-28	-
7-8 Jul	Enchanter IV	38, 49, 50	38, 49, 50
12, 14, 19 Jul	Enchanter IV	39-48	-
13 Jul	Marine Surveyor	29, 31-34	-
15 Jul	Marine Surveyor	30, 35-37	30, 36, 37
9 Aug	Marine Surveyor	-	24-28

suspension feeders, and the lower the number, the greater the prevalence of detrital feeders. The four groups of species are described in Table 3.

Trawl Samples

One otter trawl was taken at each of 53 of the 60-meter stations using single-warped, 7.6-meter (headrope length) otter trawls manufactured by Willis or Marinovich. The Willis net, which was used at the majority of the stations, is described in detail in Table 4.

At all but the Palos Verdes and Orange County stations, the trawl was deployed according to deck procedures described by Mearns and Allen (1978) and towed astern at a scope ratio (towing cable length vs. water depth) of 3 to 1 for 10 minutes on-bottom time. (The on-bottom time is the time between the full deployment of the cable and the initiation of net retrieval; in actual practice, the trawl actively captures fish on bottom for a somewhat longer time.) All tows were along the 60-meter isobath.

Stations off Palos Verdes were sampled for 10 minutes on-bottom time using Willis gear; the speed of the vessels was 2.5 knots, and the scope ratio was 3 to 1. Off Orange County, a Marinovich net was towed for 10 minutes on-bottom time at each station; the vessel speed was 2.5 knots, and the scope ratio was 3.3 to 1.

Previous studies (Mearns and Stubbs 1974) indicated that 7.8-meter trawls operate with door-to-door spreads ranging from

Table 3. Groups of species considered in calculating the Infaunal Trophic Index. The wastewater discharge factor affecting the abundance of each group appears to be the deposition or accumulation of organic particulate material.

Group and Description	Species	
I Suspension feeders primarily; dominant in control or background areas; decrease in abundance with increasing proximity to wastewater discharges; 19 species, 7 taxa	*Amphiodia (Amphispina) urtica* *Amphiodia (Amphispina) digitata* *Amphiodia psara* *Amphiodia occidentalis* *Amphiodia* spp. *Ampelisca pacifica* *Ampelisca hancocki* *Ampelisca brevisimulata* *Ampelisca macrocephala* *Ampelisca cristata*	*Paraphosux bicuspidatus* *Metaphoxus frequens* *Heterophoxus oculatus* *Ampelisca* sp. *Paraphoxus* sp. *Metaphoxus* sp. *Heterophoxus* sp. *Sthenelenella uniformis* *Phoronis* sp.
II Suspension and surface detritus feeders; may be abundant in control areas but are not dominant; increase in abundance in areas slightly affected by wastewater discharges; 14 species, 7 taxa	*Photis brevipes* *Photis californica* *Photis* spp. *Euphilomedes producta* *Euphilomedes carcharodonta* *Euphilomedes longiseta*	*Mediomastus* spp. *Myriochele gracilis* *Myriochele* sp. *Axinopsida serricata* *Mysella pedroana* *Mysella tumida*
III Surface detritus feeders primarily; often present but never abundant in control areas; most abundant in areas moderately affected by wastewater discharges; 4 species, 4 taxa	*Parvilucina tenuisculpta* *Macoma carlottensis* *Bittium* spp. *Spiochaetopterus costarum*	
IV Subsurface detritus feeders; rare at control sites; most abundant in areas heavily affected by wastewater discharges; 10 species, 8 taxa	*Armandia bioculata* *Schistomeringos longicornis* *Schistomeringos* sp. *Ophryotrocha* sp. Dorvelleidae, UI	*Capitella capitata* *Tubificidae*, UI *Solemya panamensis* *Solemya* sp. Stenothoidae, UI

Table 4. Characteristics and dimensions of the otter trawl used in the 60-meter survey.

Headrope length	7.62 meters (25 feet)
Footrope length	8.84 meters (29 feet)
Body mesh size (stretched)	4.13 cm (1-5/8 inches; #15 thread)
Cod-end mesh size (stretched)	5.08 cm (2 inches; #24 thread)
Cod-end liner size (stretched)	1.27 cm (1/2 inch; #3 thread)
Flotation	Sixteen 6-oz plastic floats, tested to 683 meters (2,240 feet)
Footrope chain	
Size of links	0.47 cm (3/16 inch)
Number of links	49.2
Weight of chain	6.55 kg (14.4 lb)
Length of chain	8.8 meters (29 feet)
Length of upper and lower leglines	1.22 meters (4 feet)
Otter boards	Two 2.54-cm thick mahogany boards
Width	76.2 cm (30 inches)
Height	50.8 cm (20 inches)
Weight	15.88 kg (35 lb)
Rigging	Four 1.27 cm-link chains
Front top chain	12 links
Front bottom chain	11 links
Back top chain	17 links
Back bottom chain	16 links
Leglines	Two chains with six 1.27-cm links each
Bridles	One pair of 22.9-meter (75-foot) lines
Door spread at 2.5 knots*	5.0-6.25 meters (16.5-20.5 feet)

*Measured with net in water, 16 Dec 75, from aboard the R/V Sea-S-Dee off Santa Catalina Island. Test by James Willis, Netmaker, Morro Bay, indicate net itself opens 4.9-5.2 meters (16-17 feet) with 3:1 bridles.

2 to 7.5 meters. Field measurements indicate that the Willis gear opened 5 to 6.2 meters, and the Marinovich gear opened 4.9 meters. Given these net spreads and the towing speed and on-bottom time used in this survey, each tow probably covered an area of about 3,700 sq meters.

All fish and invertebrates taken in each tow were identified, counted, weighed, and externally examined aboard ship. All fish were measured for board length; members of abundant species (more than 10 individuals) were measured to the nearest centimeter, and individuals representing less abundant species were measured to the nearest millimeter. The carapaces of all specimens of the larger crab species were measured to the nearest millimeter. Organisms showing signs of disease, parasitism, or abnormalities were preserved in 10 percent phosphate-buffered formalin and returned to the laboratory for further examination. Finally, numbers of newly recruited fishes were determined by inspecting the size class information and noting the asymmetric patterns that indicate the presence of individuals new to the population.

COLLECTION AND ANALYSIS OF CHEMICAL DATA

Tissue Samples

One of the objectives of this survey was to determine the levels of trace contaminants in the tissues of various organisms. Accordingly, specimens of nine species of fish and six species of invertebrates were collected from each of the trawls in which they occurred. The fish and most of the invertebrates were placed whole in plastic bags and rapidly frozen on dry ice. The sea cucumbers, *Parastichopus californicus*, were cut at both ends, slit longitudinally, and washed out with seawater to remove any sediments from the body that might contaminate the tissues to be analyzed. Our efforts in this portion of the study produced more than 600 individuals for tissue analysis, which is still in progress and will be reported at a later date.

Water Column Samples

At the center of each trawl transect, a hydrocast was made, and water on the surface and 2 meters above the bottom was collected with Van Dorn samplers. A temperature profile of the water column was also made with a 135-meter bathythermograph. Water clarity was measured with a Secchi disk, and the general oceanic conditions--wind direction, wind speed, swell height, and the presence of white caps, if any--were recorded.

The dissolved oxygen concentration of the water samples was measured using a modification of the Winkler iodometric techniques (Standard Methods 1976). All titrations were performed aboard ship.

Sediment Samples

A single Van Veen grab sample was collected at each station and subsampled aboard ship at depths of 2 and 5 cm for various physical and chemical analyses. Three subsamples were collected from each depth in plastic containers for later analysis of trace metals content, physical characteristics, and content of organic material. One subsample was taken in a foil-capped glass container at each depth for later analysis for chlorinated hydrocarbons. All samples were quickly frozen on dry ice at sea; they were then returned to the laboratory and stored in freezers until they could be analyzed.

The percent volatile solids in the upper 2 and 5 cm of sediments at a station was determined by analyzing well-mixed and pestle-ground sediments from a single subsample from each depth. Any large or conspicuous animal and shell fragments were removed from the samples prior to pestling. The values for the two depths were compared, and a decision was made to use the 2-cm samples for the remaining physical/chemical analyses.

All the remaining physical and chemical parameters, except chlorinated hydrocarbon content and sediment grain size, were determined by analysis of a single, well-mixed subsample with conspicuous animals and shell debris removed. This subsample came from one of the upper 2-cm samples from the grab. All the remaining subsamples were archived for future research.

Chlorinated hydrocarbons were measured on the 2-cm sample retained in a foil-capped glass container. The sediment grain size determinations were made on an aliquot of the samples taken prior to mixing and grinding.

Analytical procedures are described in the following subsections, which were written by the individuals responsible for the analyses.

Trace Metal Analysis (Tsu-Kai Jan). Sediment samples were analyzed for silver, cadmium, chromium, copper, nickel, lead, and zinc. A wet-acid method was used to digest the samples. This moderate digestion procedure extracts most of the metals usually considered to be biologically available, such as those associated with organic matter and sulfides and oxides and those adsorbed on the surface of solids. Metals associated with the silicate minerals (part of the lithogenous fraction) essentially are not biologically available and are not extracted by this procedure.

To prepare samples, approximately 0.5 to 2.0 grams of well-mixed sediment are weighed into a glass-covered, 150-ml beaker and dried in an electric oven at 75^{o}C for 48 hours. A nitric acid solution (20 ml of 1:1) is added to the dried samples, which are then digested on a hotplate until only about 3 ml of liquid remains; this procedure is then repeated. Then 20 ml of distilled deionized water and 2 ml of concentrated hydrochloric acid are added, and the mixture is boiled for 20 minutes. The mixture is then filtered through an acid-washed Whatman No. 40 filter paper (8-micron pore size), and the resulting filtrate is diluted with distilled, deionized water to 50 ml. Analytical blanks are prepared along with the sediment samples, using the same procedures and reagents.

Samples are analyzed on a Varian-Techtron atomic absorption spectrophotometer (Model AA-6) equipped with a simultaneous background corrector (Model BC-6), a premix type of burner, and a carbon-rod atomizer (Model 63). When a sample has a relatively high metals content, the diluted filtrate is aspirated into an air/acetylene flame. The concentrations of trace metals are then determined by comparing the results against known standards. A previous study of matrix interferences in flame atomic absorption revealed no significant interferences in detection of the seven elements in question, given a sample size of up to 2 grams. The detection limits for the metals using this method are as follows:

Metal	Limit (mg/g)	Metal	Limit (mg/g)
Silver	0.8	Nickel	1.8
Cadmium	0.4	Lead	3.0
Chromium	1.5	Zinc	0.3
Copper	1.4		

If a metal is present in concentrations below the flame detection limit, a flameless method must be used in the analysis; with the flameless procedure, 2.5 ml of treated solution are injected into a graphite furnace. The silver, cadmium, and lead concentrations in a small number of samples from this survey were determined using this method. Matrix interferences are checked, and compensations are made by running separate spiked samples. The detection limits for silver, cadmium, and lead with the flameless method are 7.0, 3.0, and 33 ng/gram, respectively. The conditions of the spectrophotometer during the analyses described here are given in Table 5.

All reagents are analytical reagent-grade, the water is deionized and distilled, and all standards are prepared by the dilution of 1,000-ppm stock solutions. The glassware and plastic containers are cleaned by being soaked in 6 percent nitric acid solution for more than 24 hours and then rinsed in distilled, deionized water.

Chlorinated Hydrocarbon Analysis (Theadore Heesen). Hexane extraction and Florisil column clean-up procedures were used during this study to produce samples for pesticide analysis; an additional saponification step was used to produce a sample for PCB analysis.

The sediment samples are first dried in an electric oven at 60°C for 24 hours. Then 20 to 40 grams of sediment are weighed into a cellulose Soxhlet thimble. The Soxhlet extraction apparatus is charged with 250 ml of hexane and mixed thoroughly for a period of 18 hours; the extract is then reduced in volume to about 25 ml using a rotary evaporator. Florisil (MCB FX284) that had been "activated" for 4 hours at 700°C and stored under hexane is used for clean-up purposes. A glass column (22 mm, IC) with a fritted glass plug is filled to a height of 7.6 cm with the Florisil slurry, and the slurry is covered with 1.3 cm of granular anhydrous sodium sulfate. About 40 ml of sample are then placed on the Florisil column and eluted with 45 ml of 6 percent (volume/volume) diethyl ether in hexane. At this point, a part of the

Table 5. General conditions of the spectrophotometer during trace metals analyses.

GENERAL INSTRUMENT PARAMETERS

Element	Wave Length (nm)	Lamp Current (mA)	Spectral Band Pass (nm)
Silver	328.1	3	1.0
Cadmium	228.8	6	0.5
Copper	357.9	5	0.5
Chromium	324.7	4	0.5
Nickel	232.0	5	0.2
Lead	217.0	8	1.0
Zinc	213.9	6	0.5

FLAME CONDITIONS

	Supply Pressure (PSI)	Flow Meter
Air	50	3.0 (≃9 liters/min)
Acetylene	10	2.0 (≃2 liters/min)

ATOMIZER SETTINGS

Element	Dry, 50 sec	Ash, 20 sec	Atomize, 2 sec	Nitrogen Gas (liters/min)
Silver	3.5	5.0	6.5	4
Cadmium	3.5	4.0	7.0	4
Lead	3.5	4.0	6.5	4

extract is set aside for pesticide analysis.

One-half of the sample extract is placed in an Erlenmeyer flask with 50 ml of a saponification mixture made by placing 5 grams of KOH dissolved in a slight amount of water and then diluting the mixture to 50 ml with ethanol. A three-ball Snyder condenser is placed on the flask, and the mixture is refluxed for 30 minutes on a steam table.

The mixture is then placed in a separatory funnel with 50 ml of hexane and 100 ml of deionized water and shaken for 5 minutes. The hexane portion is washed twice more with two separate 100-ml portions of deionized water. This extract is then analyzed for PCB's.

The sample extracts are injected into a Tracor MT 220 gas chromatograph equipped with nickel-63 detectors. The column is 2 mm, ID, by 1.8 meters and is packed with 1.5 percent OV-17 and 1.95 Percent QF-1 on Gas Chrom Q (Applied Science Laboratories, State College, Penn.). The standards (obtained from the U.S. Environmental Protection Agency, Research Triangle Park, N.C.) are injected into the gas chromatograph. Compounds are then identified by comparing retention times, and concentrations are derived by measuring peak heights.

All solvents are pesticide grade, and blanks are analyzed with each set of samples. All glassware is kiln-cleaned at 540°C for a period of 4 hours.

Biochemical Oxygen Demand Analysis (Henry Schafer). The biochemical oxygen demand (BOD) of sediments is the portion of organic material that is present and readily available to meet the metabolic needs of aerobic microorganisms. In this study, BOD was determined by measuring the amount of oxygen used over a set period of time by a population of microorganisms added to a certain quantity of sediment and maintained under controlled conditions. It is not a direct measure of the amount of oxygen that would be used in the field because it does not account for nor test the requirements of the typical fauna that would be present in the sediments.

A seeding solution (microorganism culture) is prepared by mixing marine sediments and digested sludge in 2 liters of oxygen-saturated seawater maintained at 20°C. This mixture is then aerated for a period of at least 1 week prior to being used.

A sediment sample (0.2 to 2 grams) is weighed and placed into a BOD bottle. Oxygen-saturated seawater is then siphoned into the bottle until it is full; care is taken not to introduce air bubbles or leave a space at the top of the bottle. Then 1 ml of the seed culture supernatant is added to the bottle, and it is capped with a ground glass stopper, creating a water seal. These same procedures are used to prepare blanks. The bottle are then agitated for 10 seconds, or until the sediment is completely suspended, and placed in a darkened area and maintained at 20°C. After an incubation period of 5 days, during which the bottles are agitated daily to resuspend sediments, the remaining concentration of dissolved oxygen in the blanks and test bottles is measured by the Azide Modification of the Winkler iodometric techniques for measuring dissolved oxygen (Standard Methods 1976).

The 5-day BOD (milligrams of oxygen used per kilogram of sediments) for each sample is then calculated, using the formula:

$$BOD_5 = \frac{(a - b)0.3}{c} \times 1,000,$$

where

a = the dissolved oxygen concentration of the blank,

b = the dissolved oxygen concentration in the test bottle, and

c = the grams of sediment added to the test bottle, 0.3 liters being the size of the bottle.

Chemical Oxygen Demand Analysis (Henry Schafer). The chemical oxygen demand (COD) of sediments is the portion of organic matter that is susceptible to a strong chemical oxidant. While most of the oxygen-demanding substances affected are immediately biologically available, (e.g., acetic acid), others (e.g., cellulose) are not part of the immediate biochemical load on the available oxygen.

To begin the COD analysis, an amount of sediment (0.1 to 2 grams, depending on its organic content) is weighed and placed in a 250-ml Erlenmeyer flask. Then 20 ml of 0.25 N potassium dichromate solution, 200 ng of mercuric sulfate, and 20 ml of a concentrated silver sulfate/sulfuric acid solution (22 grams of

$AgSO_4$ to a 9-pound (4.09 kg) bottle of H_2SO_4) are added; silver sulfate is added to the sulfuric acid as a catalyst for the oxidation of the straight chain (aliphatic) alcohols and acids. The chemicals are swirled in the flask until mixed; the flask is then attached to the condensers, and the mixture is gently boiled for 120 minutes. The condenser is then rinsed out and into the flask with deionized water. After the flask has been removed from the hotplate and allowed to cool, the sample is diluted with deionized water to 150 ml, and three drops of the ferroin indicator are added (1.485 grams 1,10-phenanthroline monohydrate and 695 mg $FeSO_4 \cdot 7H_2O$ diluted in deionized water to 100 ml). This final sample is then titrated with a ferrous ammonium sulfate solution (39 grams $Fe(NH_4)_2$-$(SO_4)_2 \cdot 6H_2O$ in deionized water and 20 ml of concentrated H_2SO_4, cooled and then diluted to 1,000 ml with deionized water) until a reddish-brown color first appears.

The COD (milligrams of oxygen used per kilogram of sediment) is then calculated as follows:

$$COD = \frac{(a - b)N}{c} \times 8{,}000,$$

where

N = ($0.25 \times K_2Cs_2O_7$) divided by the amount of ferrous ammonium sulfate (FAS) added to the sample,

a = the amount of FAS used by the blank,

b = the amount of FAS used to titrate the sample, and

c = the weight of the sample.

<u>Determination of Percent Volatile Solids (Henry Schafer)</u>. This is a method for determining, by weight, the amount of organic material present in sediments rather than the oxygen-demanding potential of those sediments. All materials that will combust at 550°C are defined as volatile. As even portions of crude oil will combust at this temperature, not all of the materials that combust are necessarily biological available organic foods.

The procedure consists of placing approximately 4 ml of sediment in a previously weighed beaker and determining the wet weight of the sediment. The sample is then placed in an electric drying oven at 105°C for 24 hours to drive off all liquids. The sample is retained in a desiccator until cooled, so that it will not rehydrate; its dry weight is then determined. The sample is then placed for 1 hour in a muffle furnace at 550°C. After the sample has cooled in the desiccator, the net ash-free weight is determined.

The formula for calculating percent volatile solids is as follows:

$$\%\ \text{volatile solids} = \frac{a - b}{a} \times 100,$$

where a is the dry weight of the sample and b is the ash weight.

Organic Nitrogen Analysis (Henry Schafer). In the presence of the digestion reagents (H_2SO_4, K_2SO_4, H_2O), the amino nitrogen compounds of many organic nitrogen-containing materials are converted to ammonium sulfate, which is then decomposed by sodium thiosulfate; the resulting ammonia is released by distillation from an alkaline medium and absorbed in boric acid. The ammonia in this liquid is then measured by titration, and the concentration of organic amino nitrogens in the sample is determined.

A sample of dried sediment (0.1 to 3 grams) is placed in an 800-ml Kjeldahl flask with 400 ml of distilled water neutralized to a pH of 7 with 1N NaOH or 1N H_2SO_4. To this solution, 24 ml of the phosphate buffer (14.3 grams KH_2PO_4, 68.8 grams K_2HPO_4, and 1 liter ammonia-free water at pH 7.4) and several boiling chips are added. This container is connected to one end of the distilling apparatus while a 500-ml Erlenmeyer flask containing 50 ml of the boric-acid-indicating solution (60 grams boric acid, 3 liters of ammonia-free distilled water, 20 ml methyl red solution (0.4 grams methyl red and 200 ml reagent alcohol), and 10 ml methylene blue solution (0.2 grams methylene blue and 100 ml reagent alcohol)) is placed on the receiving end of the condenser with its tip extending below the surface of the solution. Distillation is continued with this apparatus until 200 to 300 ml of the distillate is collected in the Erlenmeyer flask. The delivery tube is then removed from the distillate, but distillation is allowed to continue for a few moments to cleanse the condenser and delivery tube. A blank is also distilled using the same procedures. The samples are then titrated with 0.02 N H_2SO_4 until a pale lavender color is obtained. The amount of amino nitrogens contained in the sample is then determined by the calculation,

$$NH_3\text{-}N = \frac{(a - b)c \times 14{,}000}{d},$$

where

a = the amount of N H_2SO_4 added to the sample,

b = the amount of N H_2SO_4 added to the blank,

c = the normality of the H_2SO_4, and

d = The weight of the sample.

Hexane Extractable Material Analysis (Henry Schafer). By definition, this extraction procedure recovers materials called grease and oil, including lipids, chlorinated hydrocarbons, fatty acids, soaps, fats, waxes, and any other material that is soluble in hexane. All of these materials are fairly resistant to anaerobic digestion and, when discharged into the sea, often end up as films on the water surface. However, some of this material becomes associated with organic particles and is incorporated into the sediments. The amount of this material in a benthic sediment sample is therefore another indirect measure of the amount of organic particulates associated with the sediments.

To prepare the sample, 30 to 40 grams of sediment are dried at 105°C for 16 hours and then placed in an extraction thimble, which is then put into the extraction tube. Then, 200 ml of hexane (spectra grade) are placed in an Erlenmeyer flask, and the flask is connected to the condenser and extracting tube. The heating mantle is regulated so that the extraction cycle occurs once every 10 minutes for a period of 4 hours. At the end of the extraction, the hexane is removed using a rotary evaporator, and the remaining hexane is drained from the extraction/condenser apparatus into the Erlenmeyer flask. The material remaining in the flask, representing the hexane extractable material (HEM), is weighed after the flask is carefully wiped dry and placed in a desiccator. The amount of HEM is then determined as follows:

$$HEM = \frac{a - b}{c},$$

where

a = the weight of the flask and its contents,

b = the weight of the flask alone, and

c = the weight of the sample.

RESULTS

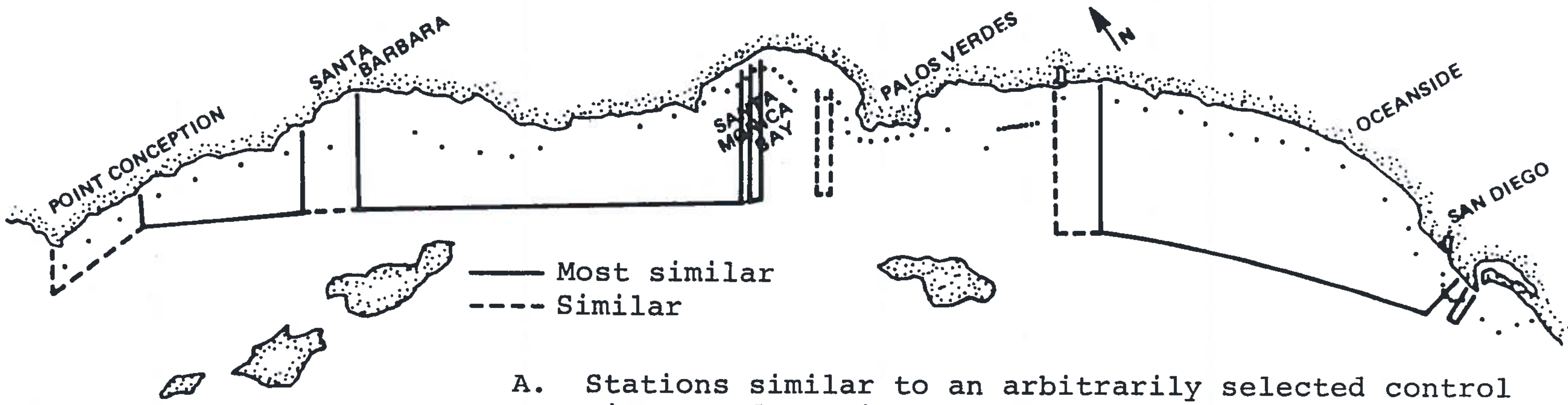
The physical, chemical, and biological data obtained in this survey are presented in Tables 6 through 19 and Figures 2 through 54. Lists of species taken during the survey are given in the appendices.

Control stations were originally chosen by examining the survey data and eliminating stations with obvious enhancements of metals, chlorinated hydrocarbons, and organics or with obviously low Infaunal Index values. This subjective technique was subsequently reinforced through the use of a more objective method of selection, the Bray-Curtis analysis of the abundances of infaunal species. Figure 2 shows the stations selected using the two procedures. The Bray-Curtis analysis of the abundances of infaunal tions; with our subjective technique, we selected 29 stations.

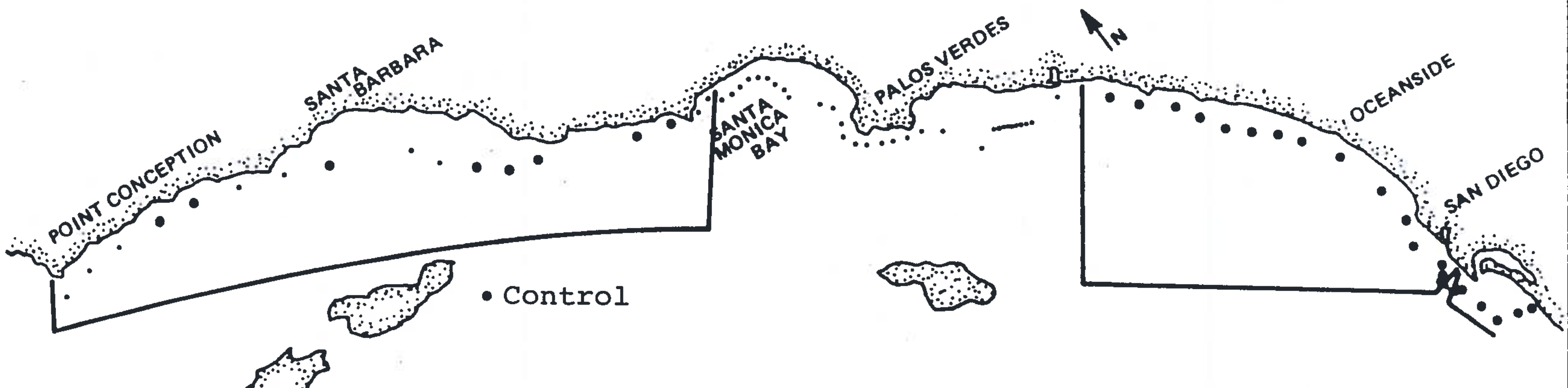
Reexamination of the data from the extra control stations selected in the Bray-Curtis analysis led us to the conclusion that the five stations still should be considered separately from the other control stations. The sediments from four of the stations had concentrations of black tar granules, which influenced the measurements of organic material. Although tar in the sediments is a natural occurrence in the area of an oil seep, we thought it best to keep information on such stations separate from that on the other control areas. Thus, two sets of control or natural values were calculated.

Tables 6 through 10 present the statistics on the mean, standard error, median, range, and 95 and 99 percent confidence limits for each measured parameter. Three sets of calculations are presented. The first set gives statistics for all stations surveyed, the second set is for control stations (those identified as not being affected by man), and the third set is for all control stations except those affected by natural oil seeps.

This technical memorandum is meant to be a complete compilation and graphic presentation of the data collected during the Project's control survey along the 60-meter isobath. The data, which have been and will continue to be used and analyzed for many purposes, give information on conditions on the southern California mainland shelf during one period of time. All of the samples and specimens of the infauna are retained in the museum at the Project, as are additional frozen samples of the sediments; hence, future measurements of parameters that become of interest are possible. We hope that this study can become a useful historical tool that can be applied in other ways, as needed.



A. Stations similar to an arbitrarily selected control site, as determined by the Bray-Curtis test.



B. Stations selected as controls through an examination of data.

Figure 2. Stations selected as controls, 60-meter survey, 1977.

Table 6. Summary statistics on trace metals (mg/dry kg) in surface sediments (2 cm), 60-meter control survey, 1977.

	Total	Control	Control Minus Oil Seep		Total	Control	Control Minus Oil Seep
SILVER				CADMIUM			
Mean	1.6	0.35	0.38	Mean	2.8	0.42	0.39
Std. Error	0.38	0.07	0.08	Std. Error	1.1	0.05	0.05
Median	0.41	0.15	0.20	Median	0.59	0.33	0.33
Range	0.04-18	0.04-1.7	0.06-1.7	Range	0.1-61	0.1-1.4	0.1-1.4
95% CL	0.83-2.4	0.21-0.49	0.22-0.54	95% CL	0.7-4.9	0.3-0.5	0.3-0.5
99% CL	0.6-2.6	0.16-0.54	0.16-0.60	99% CL	0-5.6	0.3-0.6	0.3-0.5
No. of sta.	69	35	28	No. of sta.	69	35	28
CHROMIUM				COPPER			
Mean	100	24	23	Mean	48	9.6	9.1
Std. Error	29	1.5	1.6	Std. Error	15	1.3	1.1
Median	32	22	22	Median	13	8.3	8.3
Range	6.5-1,300	6.5-43	6.5-43	Range	2.3-780	2.3-40	2.8-31
95% CL	44-110	21-27	20-26	95% CL	19-77	7-12	7-11
99% CL	25-180	23-26	19-28	99% CL	8.8-87	6-13	6-12
No. of sta.	69	35	28	No. of sta.	69	35	28
NICKEL				LEAD			
Mean	20	16	12	Mean	32	6.8	6.6
Std. Error	2.3	2.2	1.8	Std. Error	9.6	0.44	0.48
Median	12	11	9.7	Median	11	6.3	6.1
Range	1.6-110	1.6-51	1.6-35	Range	1.8-540	2.7-12	2.7-12
95% CL	16-25	12-21	8.6-16	95% CL	13-52	5.9-7.6	5.7-7.6
99% CL	14-26	10-22	7.3-17	99% CL	6.9-58	5.6-8.0	5.3-8.0
No. of sta.	69	35	28	No. of sta.	69	35	28
ZINC				% SAND			
Mean	130	45	42	Mean	48	42	40
Std. Error	36	3.3	2.5	Std. Error	2.9	4.1	4.0
Median	51	44	43	Median	49	38	38
Range	9.8-2,100	9.8-110	9.8-62	Range	5.2-90	5.2-87	7.6-84
95% CL	53-200	39-53	37-47	95% CL	42-53	34-50	32-48
99% CL	32-220	36-54	35-49	99% CL	40-55	31-53	29-51
No. of sta.	69	35	28	No. of sta.	69	35	28

Table 7. Summary statistics on measures of organic material and chlorinated hydrocarbons in surface sediments (2 cm), control survey, 1977. Units are mg/dry kg unless otherwise noted.

	Total	Control	Control Minus Oil Seep
BOD			
Mean	1,601	683	632
Std. Error	415	37.7	37.7
Median	734	667	636
Range	172-25,048	266-1,046	266-1,017
95% CL	772-2,430	606-760	554-709
99% CL	498-2,704	579-787	527-736
No. of sta.	69	35	28
VOLATILE SOLIDS (%, dry weight)			
Mean	4.3	3.3	2.8
Std. Error	0.53	0.25	0.11
Median	3.0	2.9	2.8
Range	1.8-27	1.8-9.5	1.8-3.8
95% CL	3.3-5.4	2.8-3.8	2.6-3.1
99% CL	2.9-5.8	2.6-4.0	1.9-3.1
No. of sta.	69	35	28
ACID VOLATILE SULFIDES			
Mean	0.098	0.019	0.018
Std. Error	0.03	0.003	0.004
Median	0.03	0.011	0.011
Range	<0.003-1.6	<0.003-0.069	<0.003-0.069
95% CL	0.04-0.16	0.006-0.025	0.0097-0.026
99% CL	0.02-0.18	0.011-0.027	0.007-0.029
No. of sta.	69	35	28
DDT			
Mean	7.4	0.03	0.02
Std. Error	4.4	0.003	0.008
Median	0.06	0.011	0.007
Range	<0.001-175	<0.003-0.07	<0.001-0.09
95% CL	0-16	<0.006-0.03	0-0.04
99% CL	0-19	0.01-0.03	0-0.07
No. of sta.	42	17	12
ARCHLOR 1254			
Mean	0.4	0.008	0.007
Std. Error	0.2	0.002	0.002
Median	0.02	0.005	0.003
Range	<0.001-6.6	<0.001-0.03	<0.001-0.025
95% CL	0-0.8	0.004-0.01	0.003-0.01
99% CL	0-0.94	0.002-0.01	0.0008-0.01
No. of sta.	42	17	12

	Total	Control	Control Minus Oil Seep
COD			
Mean	39,059	24,066	20,157
Std. Error	6,831	2,137	1,190
Median	24,100	22,100	20,700
Range	9,200-372,600	9,200-69,400	9,200-38,400
95% CL	25,397-52,721	19,802-28,530	17,715-22,599
99% CL	20,889-57,229	18,824-29,509	16,860-23,455
No. of sta.	69	35	28
KJELDAHL NITROGEN			
Mean	1,125	790	671
Std. Error	192	63	45
Median	769	752	741
Range	295-8,140	392-1,430	392-926
95% CL	736-1,513	658-922	575-768
99% CL	605-1,644	610-970	538-805
No. of sta.	50	22	16
HEXANE EXTRACTABLE MATERIAL			
Mean	1,566	1,536	243
Std. Error	676	263	44
Median	280	200	176
Range	0-39,400	0-39,400	0-1,130
95% CL	214-2,918	998-2,074	95-279
99% CL	0-3,364	812-2,260	63-311
No. of sta.	69	35	28
PCB			
Mean	0.6	0.01	0.01
Std. Error	0.3	0.003	0.004
Median	0.04	0.007	0.006
Range	<0.002-10.9	<0.002-0.04	<0.002-0.04
95% CL	0.01-1.2	0.006-0.02	0.002-0.02
99% CL	0-1.3	0.003-0.02	0.001-0.02
No. of sta.	42	17	12
RATIO, TOTAL DDT TO TOTAL PCB			
Mean	4.0	2.3	1.7
Std. Error	0.7	0.4	0.4
Median	2.1	2.1	1.7
Range	0.01-16	0.2-5.1	0.15-4.0
95% CL	2.7-5.4	1.4-3.2	0.8-2.7
99% CL	2.2-5.9	1.1-3.5	0.4-3.0
No. of sta.	42	17	12

Table 8. Summary statistics on infaunal organisms taken in control survey, 1977. Total number of stations was 70, control stations numbered 36, and number of stations minus oil-seep stations was 29.

	Total	Control	Control Minus Oil Seep
NUMBER OF SPECIES (No./sq m)			
Mean	72	72	71
Std. Error	2.9	3.7	3.5
Median	70	70	71
Range	32-167	32-135	40-124
95% CL	66-78	64-80	67-78
99% CL	64-80	62-82	61-81
ARTHROPODS (No. of species and No. of individuals/sq m*)			
Mean	18/74	21/66	21/61
Std. Error	1.0/6.9	1.4/6.7	1.5/5.5
Median	17/55	19/57	19/56
Range	2-43/2-271	8-41/19-222	8-34/19-124
95% CL	16-20/60-88	18-24/52-80	18-24/50-72
99% CL	15-21/56-92	17-25/48-84	17-25/46-76
ECHINODERMS (No. of species and No. of individuals/sq m*)			
Mean	4/76	5/123	5/141
Std. Error	0.3/10.7	0.3/15.9	0.4/18.3
Median	4/53	4/99	4/136
Range	0-10/0-365	2-10/9-365	2-9/9-365
95% CL	3-5/55-97	4-6/90-156	4-6/104-178
99% CL	3-5/48-104	4-6/79-167	4-6/90-192
MISCELLANEOUS PHYLA (No. of species and No. of individuals/sq m*)			
Mean	6/30	6/34	6/35
Std. Error	0.5/3.3	0.5/5.6	0.5/6.2
Median	6/23	6/24	6/23
Range	2-28/3-110	2-14/3-110	2-12/7-110
95% CL	5-7/23-37	5-7/23-45	5-7/22-48
99% CL	5-7/21-39	5-7/19-49	5-7/18-52
DOMINANCE**			
Mean	6.5	6.9	6.4
Std. Error	0.38	0.51	0.55
Median	6	6	6
Range	2-18	2-16	2-16
95% CL	6-7	7	5-8
99% CL	5-8	7	5-8

	Total	Control	Control Minus Oil Seep
NUMBER OF INDIVIDUALS (No./sq m)			
Mean	534	422	423
Std. Error	54	34	24
Median	447	408	440
Range	91-3,057	91-1,213	229-654
95% CL	426-642	353-491	375-471
99% CL	390-678	329-516	358-488
MOLLUSCS (No. of species and No. of individuals/sq m*)			
Mean	13/111	13/52	13/44
Std. Error	0.5/18.9	0.6/6.6	0.6/3.6
Median	13/56	13/39	13/41
Range	5-23/6-1,004	6-21/13-201	9-19/24-83
95% CL	12-14/73-149	12-14/38-65	12-14/37-51
99% CL	12-14/61-161	11-15/34-70	11-15/34-54
POLYCHAETES (No. of species and No. of individuals/sq m*)			
Mean	30/249	26/142	26/136
Std. Error	1.6/41.6	1.7/21.0	1.8/12.6
Median	26/132	24/111	24/119
Range	11-68/15-1,964	12-58/18-710	13-58/62-367
95% CL	27-33/166-332	22-30/99-185	22-30/110-162
99% CL	26-34/138-360	21-31/84-200	21-31/106-171
SHANNON-WEAVER DIVERSITY, H'			
Mean	3.0	3.12	3.05
Std. Error	0.06	0.08	0.08
Median	3.13	3.16	3.13
Range	1.34-4.16	2.19-3.98	2.19-3.98
95% CL	2.87-3.13	2.97-3.27	2.89-3.21
99% CL	2.82-3.17	2.91-3.32	2.84-3.26
RATIO, NO. OF INDIVIDUALS TO NO. OF SPECIES			
Mean	7.2	5.7	5.9
Std. Error	0.66	0.32	0.32
Median	5.7	5.3	5.7
Range	3.1-39.2	3.6-10.1	3.6-10.1
95% CL	5.9-8.5	5-6.3	5.3-6.6
99% CL	5.5-9.0	4.8-6.6	5.0-6.8

*Number preceding the slash is number of species; number following slash is number of individuals.
**Minimum number of species required to account for 60% of the individuals present in a sample.

	Total	Control	Control Minus Oil Seep		Total	Control	Control Minus Oil Seep
PERCENT OF INFAUNAL INDEX ORGANISMS PRESENT THAT ARE GROUP I ORGANISMS				PERCENT OF INFAUNAL INDEX ORGANISMS PRESENT THAT ARE GROUP II ORGANISMS			
Mean	52	72	77	Mean	29	19	15
Std. Error	4.1	3.5	3.2	Std. Error	2.8	2.4	2.2
Median	57	76	83	Median	24	16	14
Range	0-99	30-96	42-96	Range	1-96	3-49	3-44
95% CL	44-60	64-79	71-84	95% CL	24-35	14-24	10-20
99% CL	41-63	62-81	68-86	99% CL	22-37	12-25	9-21
PERCENT OF INFAUNAL INDEX ORGANISMS PRESENT THAT ARE GROUP III ORGANISMS				PERCENT OF INFAUNAL INDEX ORGANISMS PRESENT THAT ARE GROUP IV ORGANISMS			
Mean	18	9	7	Mean	0.5	0.03	0.04
Std. Error	2.5	2.1	1.8	Std. Error	0.24	0.03	0.04
Median	10	5	5	Median	1	0.5	0.5
Range	0-72	0-49	1-36	Range	0-15	0-1	0-1
95% CL	13-23	5-14	4-11	95% CL	0.02-0.98	0.0-0.1	0-0.12
99% CL	11-24	4-15	2-13	99% CL	0-1.14	0.0-0.1	0-0.15
INFAUNAL TROPHIC INDEX *				BIOMASS (g/sq m)			
Mean	77.3	87.9	90.3	Mean	93.5	73.8	70.5
Std. Error	2.2	1.7	1.6	Std. Error	10.8	5.5	4.5
Median	79.9	91.2	93.5	Median	79	64	63
Range	21-99	59.9-98.3	69-98.3	Range	15-707	25-190	28-112
95% CL	73-82	84.4-91.4	87.1-93.5	95% CL	72-115	63-85	61-80
99% CL	71-83	83.1-92.7	86.0-94.7	99% CL	65-122	59-89	58-83

*Five additional stations were removed from the control-minus-oil-seep group because of anomalous but as yet unexplained physical, chemical, or biological values. The Infaunal Trophic Index statistics for the 24 remaining stations are as follows: Mean = 93.5; std. error = 0.9; median = 94.5; Range = 83.1-98.3; 95% CL = 91.6-95.4; and 99% CL = 90.9-96.5.

Table 9. Summary statistics on trawl-caught invertebrates taken in control survey, 1977.

	Total	Control	Control Minus Oil Seep
NUMBER OF SPECIES			
Mean	13	11	11
Std. Error	0.9	3.4	1.07
Median	11	9	9
Range	5-31	5-24	5-24
95% CL	11-15	4-17	8-13
99% CL	11-15	1-20	7-14
No. of sta.	53	29	22
GLEASON'S RICHNESS			
Mean	2.32	1.97	1.98
Std. Error	0.16	0.19	0.24
Median	2.07	1.78	1.77
Range	0.51-4.05	0.51-3.45	1.34-3.45
95% CL	2.00-2.64	1.58-2.36	1.48-2.48
99% CL	1.89-2.75	1.45-2.49	1.30-2.66
No. of sta.	53	29	22
BIOMASS (kg/sample)			
Mean	9.2	8.3	6.3
Std. Error	1.4	1.8	1.7
Median	5.3	5.0	2.6
Range	0.2-34	0.8-31	0.8-26
95% CL	6-12	4-12	3-10
99% CL	5-13	3-13	1-11
No. of sta.	41	20	17

	Total	Control	Control Minus Oil Seep
NUMBER OF INDIVIDUALS			
Mean	375	423	455
Std. Error	83	146	190
Median	200	188	166
Range	7-3,640	11-3,640	20-3,640
95% CL	208-543	124-722	61-849
99% CL	150-600	20-826	1-991
No. of sta.	53	29	22
SHANNON WEAVER DIVERSITY, H'			
Mean	1.15	1.08	1.07
Std. Error	0.09	0.12	0.15
Median	1.11	1.17	1.11
Range	0.01-2.56	0.41-2.45	1.17-2.45
95% CL	0.97-1.33	0.83-1.33	0.76-1.38
99% CL	0.91-1.39	0.75-1.41	0.65-1.49
No. of sta.	53	29	22

Table 10. Summary statistics on fishes taken in control survey, 1977.*

	Total	Control	Control Minus Oil Seep
NUMBER OF SPECIES			
Mean	14	14	14
Std. Error	0.7	0.8	0.8
Median	15	15	14
Range	2-29	2-22	5-21
95% CL	13-16	12-16	12-16
99% CL	12-16	11-16	12-16
NO. OF SPECIES WITHOUT RECRUITS			
Mean	14	14	14
Std. Error	0.7	0.8	0.9
Median	14	14	14
Range	2-29	2-22	5-21
95% CL	12-15	12-16	12-16
99% CL	12-16	12-16	11-16
GLEASON'S RICHNESS			
Mean	2.34	2.27	2.35
Std. Error	0.10	0.12	0.12
Median	2.34	2.17	2.17
Range	0.51-4.09	0.51-3.45	1.34-3.45
95% CL	2.14-2.54	2.02-2.52	2.10-2.60
99% CL	2.07-2.61	1.94-2.60	2.01-2.69
BIOMASS (kg/sample)			
Mean	6.2	6.7	5.8
Std. Error	0.8	1.2	1.1
Median	4.5	4.6	4.5
Range	0.3-22.0	0.3-22.0	0.6-20.2
95% CL	4.7-7.7	4.3-9	3.5-8.1
99% CL	4.1-8.3	3.4-9.9	2.6-9

	Total	Control	Control Minus Oil Seep
NUMBER OF INDIVIDUALS			
Mean	428	543	347
Std. Error	84	139	62
Median	234	307	253
Range	7-4,008	7-4,008	11-1,294
95% CL	259-598	259-827	220-475
99% CL	201-655	160-926	174-520
NO. OF INDIVIDUALS WITHOUT RECRUITS			
Mean	216	230	213
Std. Error	29	34	30
Median	177	189	193
Range	7-925	7-925	11-546
95% CL	157-276	159-300	151-275
99% CL	138-295	135-324	128-298
SHANNON WEAVER DIVERSITY, H'			
Mean	1.49	1.41	1.54
Std. Error	0.06	0.08	0.07
Median	1.55	1.41	1.46
Range	0.41-2.45	0.41-2.45	1.17-2.45
95% CL	1.37-1.61	1.25-1.57	1.39-1.69
99% CL	1.33-1.65	1.19-1.63	1.34-1.74

*Total number of stations was 53; control stations numbered 29; and 22 stations were considered in calculating control-minus-oil-seep values.

Table 11. Comparison of volatile solids (percent, dry weight) at two depths in surface sediments, control survey, 1977.

Station Number	Upper 2 cm	Upper 5 cm	Station Number	Upper 2 cm	Upper 5 cm
1*	2.6	2.7	36**	1.8	1.8
2*	4.3	3.0	37**	2.9	3.0
3*	9.5/8.0	5.4/10.0	38**	2.1	2.1
4	2.6	2.7	39**	2.2	2.4
5	3.0	2.8	40**	2.7	2.4
6*	3.4	3.2	41**	3.0	2.8
7*	5.0	4.8	42**	2.5	2.4
8	2.4	2.4	43**	2.7	2.6
9*	6.2	7.1	45**	2.6	2.6
10*	5.1	5.8	46**	2.1	2.3
11	2.8	2.9	47**	2.2	2.1
12	2.1	2.2	48**	1.9	1.9
13	1.8	1.9	49**	3.7	3.5
14	2.9	2.6	50	3.8	3.7
15	2.6	2.6	51	2.6	3.1
16	3.1	-	52	3.2	3.0
17	3.6	-	53	3.3	3.4
18**	4.2	-	54	2.9	2.8
19**	4.1	-	55	3.6	3.5
20**	3.8	-	56	3.8	9.6
21**	3.1	-	57	3.7	4.0
22**	2.8	-	58	2.7	2.6
23**	2.7	-	59	2.1	2.1
24**	3.9	3.1	60	2.3	2.3
25**	3.2	3.4	61	3.5	3.8
26**	4.8	4.9	62	2.5	2.6
27**	3.0	3.4	63	3.2	2.9
28**	2.4	3.0	64	2.4	2.7
29**	5.0	5.5	65**	3.1	3.2
30**		7.8	67**	3.3	2.9
31**	17.2	15.5	68	2.3	2.4
32**	16.0	3.9	69	2.3	2.3
33**	17.6	17.6	70**	4.7	4.1
34**	27	26.6	71	1.9	1.5
35**	10.8	9.9			

*Petroleum present in sediments.
**Station affected by man's activities (harbors, outfalls).

Table 12. Measures of organic material and percent sand and ratio of dry to wet material in surface sediments (2 cm), 60-meter control survey, 1977. A dash means "no data."

Station Number	BOD (mg/dry kg)	COD (mg/dry kg)	Volatile Solids (%, dry weight)	Total Organic Nitrogen (mg/dry kg)	Total Acid Volatile Sulfides (mg/dry kg)	Hexane Extractable Material (mg/dry kg)	Sand (%)	Ratio, Dry to Wet Material
1*	894	27,800	2.6	637	0.005	1,218	80.5	0.68
2*	722	14,600	4.3	-	0.005	329	86.8	0.67
3*	1,046	69,400	9.5	1,430	0.011	39,400	69.0	0.64
4	368	23,600	2.6	-	0.006	330	77.8	0.67
5	578	22,300	3.0	769	0.012	180	58.4	0.60
6*	1,041	32,600	3.4	886	0.029	705	57.5	0.65
7*	519	43,000	5.0	1,210	0.013	769	41.1	0.58
8	585	12,800	2.4	435	0.011	344	80.3	0.65
9*	964	43,800	6.2	1,360	0.058	4,410	5.2	0.50
10*	1,030	50,200	5.1	1,120	0.017	117	6.0	0.58
11	673	18,200	2.8	392	0.011	1,130	18.7	0.64
12	401	12,400	2.1	-	<0.003	40	35.8	0.66
13	266	11,600	1.8	-	<0.003	422	65.8	0.69
14	646	31,100	2.9	665	0.006	82	32.9	0.62
15	594	24,200	2.6	-	0.006	315	53.7	0.65
16	637	23,500	3.1	633	0.025	352	38.4	0.60
17	863	22,100	3.6	-	<0.003	122	18.4	0.61
18**	479	31,300	4.2	909	0.007	167	9.3	0.55
19**	800	33,300	4.1	-	0.078	1,213	8.5	0.58
20**	817	31,800	3.8	930	0.018	2,041	8.9	0.59
21**	486	28,600	3.1	-	0.029	244	36.2	0.65
22**	698	23,900	2.8	652	0.012	261	54.6	0.64
23**	1,009	29,400	2.7	880	0.035	732	78.8	0.66
24**	1,725	46,600	3.9	1,100	0.092	1,693	75.4	0.59
25**	1,390	37,900	4.8	1,120	0.203	1,007	23.7	0.61
26**	1,850	28,800	3.2	896	0.035	568	66.2	0.65
27**	541	27,600	3.0	769	0.011	489	30.0	0.63
28**	675	15,200	2.4	460	0.032	254	57.8	0.69
29**	943	39,300	5.0	1,080	0.026	340	21.3	0.59
30**	1,949	80,300	6.9	1,190	0.249	813	32.6	0.36
31**	7,781	178,200	17.3	4,500	0.379	6,656	54.0	0.34
32**	9,549	151,100	17.5	-	1.6	5,906	33.1	0.36
33**	10,289	245,300	18.6	5,000	0.67	-	48.3	0.35
34**	25,048	372,600	27	8,140	0.86	23,380	68.0	0.27
35**	5,816	109,800	10.8	3,160	0.741	144	49.0	0.42
36**	425	12,600	1.8	357	0.111	79	84.2	0.69
37**	474	16,700	2.9	581	0.003	160	72.9	0.67
38**	172	11,100	2.1	511	0.011	100	90.0	0.71
39**	927	13,600	2.2	512	0.039	144	71.4	0.66
40**	499	17,600	2.7	-	0.044	201	47.2	0.63
41**	609	24,600	3.0	-	0.053	404	47.1	0.57

*Petroleum present in sediments. **Station affected by man's activities (harbors, outfalls).

Station Number	BOD (mg/dry kg)	COD (mg/dry kg)	Volatile Solids (%, dry weight)	Total Organic Nitrogen (mg/dry kg)	Total Acid Volatile Sulfides (mg/dry kg)	Hexane Extractable Material (mg/dry kg)	Sand (%)	Ratio, Dry to Wet Material
42**	971	24,600	2.5	560	0.109	435	59.2	0.65
43**	1,367	23,700	2.7	712	0.023	598	68.8	0.65
45**	1,931	31,000	2.6	788	0.063	1,119	77.3	0.67
46**	1,208	16,600	2.1	546	0.033	212	75.7	0.70
47**	710	16.300	2.2	578	0.016	350	76.0	0.70
48**	734	17,200	1.9	486	0.011	294	80.2	0.71
49**	1,151	24,100	3.7	620	0.084	843	47.7	0.59
50	635	22,000	3.8	-	0.006	117	18.7	0.61
51	902	25,400	2.6	749	0.059	134	17.9	0.63
52	478	19,200	3.2	-	<0.003	69	7.6	0.61
53	667	21,100	3.3	820	0.006	73	9.6	0.57
54	809	20,300	2.9	-	0.012	59	14.7	0.62
55	492	16,600	3.6	725	0.006	-	27.7	0.61
56	692	38,400	3.8	755	0.059	35	30.1	0.58
57	1,017	22,600	3.7	893	0.041	456	22.3	0.57
58	361	14,400	2.7	498	0.018	95	49.1	0.62
59	421	17,500	2.1	-	0.006	200	49.9	0.64
60	730	12,800	2.3	505	0.031	555	49.4	0.61
61	573	16,300	3.5	741	0.004	237	46.2	0.63
62	750	16,500	2.5	-	0.069	416	51.6	0.65
63	509	23,300	3.2	926	0.025	172	36.6	0.57
64	913	18,500	2.4	-	0.03	347	38.3	0.59
65**	470	27,200	3.1	883	0.078	209	47.2	0.60
67**	888	25,400	3.3	-	0.027	254	48.8	0.56
68	967	24,300	2.3	870	0.03	255	49.7	0.63
69	757	24,200	2.3	-	0.016	92	38.1	0.64
70**	2,175	36,000	4.7	931	0.317	1,460	70.7	0.60
71	407	9,200	1.9	364	0.005	183	83.7	0.73

*Petroleum present in sediments. **Station affected by man's activities (harbors, outfalls).

Table 13. Trace metals (mg/dry kg) in surface sediments (2 cm), 60-meter control survey, 1977.

Station Number	Silver	Cadmium	Chromium	Copper	Nickel	Lead	Zinc
1*	0.04	0.94	19	2.3	20	3.6	23
2*	0.04	0.2	16	2.8	12	4.9	26
3*	0.06	0.32	22	5.4	38	5.4	34
4	0.06	0.48	28	3.5	16	2.7	35
5	0.1	0.46	28	4.2	22	4.1	38
6*	0.88	0.35	34	6.7	31	6.8	51
7*	0.12	0.6	42	8.9	37	7.8	71
8	0.07	0.25	18	2.8	6.3	3.0	31
9*	0.33	0.62	42	40	51	12	110
10*	0.21	0.73	27	16	36	9.8	84
11	0.13	0.35	23	8.3	21	5	54
12	0.05	0.5	17	5.5	15	4.1	40
13	0.84	0.21	16	3.0	12	4.1	36
14	0.35	0.31	32	8	32	6.1	44
15	0.37	0.7	37	7	26	6.1	41
16	1.7	1.4	43	11	30	11	52
17	0.98	0.58	43	12	35	11	61
18**	2.2	0.73	59	15	35	66	66
19**	1.7	0.65	69	20	41	20	77
20**	2.6	0.61	68	21	36	19	75
21**	1.5	0.45	56	17	27	14	63
22**	2.3	0.59	54	17	72	16	58
23**	6.1	3.4	97	57	19	28	107
24**	8.9	5.1	146	92	25	40	143
25**	7.3	3.6	146	7.7	18	22	121
26**	2.3	0.5	78	33	19	14	68
27**	1.9	0.64	74	22	13	13	62
28**	1.8	0.79	69	19	12	11	59
29**	2.0	1.2	86	33	15	25	67
30**	3.2	2.6	164	63	19	32	121
31**	9.8	19.2	680	289	50	162	526
32**	0.1	20.1	904	376	57	240	758
33**	12.8	32.5	1,098	479	61	298	1,188
34**	18.1	60.8	1,317	782	107	537	2,096
35**	5.8	11.2	499	230	37	132	494
36**	0.1	0.15	25	8.6	5.9	1.8	37
37**	0.47	0.25	44	16	9.6	22	53
38**	0.24	0.28	22	9	5.6	5.2	36
39**	0.26	0.4	33	18	10	17	43
40**	0.33	0.6	36	23	11	20	51
41**	0.45	0.8	42	29	11	22	44
42**	0.45	1.0	39	31	9.8	22	51
43**	0.57	1.4	42	34	11	24	53
45**	1.1	3.5	63	56	20	36	86
46**	0.45	1.0	37	27	9.5	24	46
47**	0.28	0.4	34	25	7.8	20	47
48**	0.35	0.4	31	21	7.8	15	39
49**	0.27	1.04	26	15	13	9.2	59
50	0.21	0.47	24	10	14	7.7	48
51	0.11	0.51	19	8.3	9.7	6.3	44
52	0.13	0.21	22	9.7	9.7	6.7	48
53	0.12	0.23	22	9.4	9.6	5.5	45
54	0.11	0.1	22	11	10	6.9	51
55	0.1	0.11	23	12	8.3	7.2	61
56	1.12	0.18	23	13	8.6	9.9	60
57	0.17	0.33	25	15	11	9.3	62
58	0.06	0.21	15	6.7	4.7	4.4	32
59	0.13	0.13	15	6.8	4.3	7.6	35
60	0.14	0.17	15	5.2	3.2	7.4	34
61	0.24	0.24	18	6.5	4.0	8.7	34
62	0.41	0.22	31	31	6.7	12	57
63	0.73	0.65	23	15	6.5	8.9	172
64	0.82	0.71	22	6.5	4.1	5.3	9.8
65**	0.96	0.97	28	5.9	7	19	57
66**	-	-	24	13	7.1	-	45
67**	0.88	0.66	24	13	7.1	11	45
68	0.75	0.59	18	10	5.7	5.4	35
69	0.37	0.5	19	9.3	5.0	5.8	38
70**	1.3	1.2	44	62	10	42.7	155
71	0.15	0.10	6.5	2.8	<1.6	3.7	12

*Petroleum present in sediments. **Station affected by man's activities (harbors, outfalls).

Table 14. Chlorinated hydrocarbons (mg/dry kg) in surface sediments (2 cm), 60 meter survey, 1977.

Station Number	Total DDT (ppm, dry weight)	Total PCB (ppm, dry weight)	PCB 1254 (ppm, dry weight)	Ratio, Total DDT to Total PCB
1*	0.023	0.011	0.005	2.1
3*	0.065	0.031	0.021	2.1
6*	0.046	0.009	0.006	5.1
7*	0.036	0.007	0.005	5.1
9*	0.039	0.010	0.008	3.9
11	0.013	0.005	0.004	2.6
13	0.026	0.009	0.006	2.89
15	0.057	0.016	0.012	3.56
17	0.085	0.031	0.025	2.74
19**	0.168	0.046	0.028	3.65
21**	0.172	0.125	0.108	1.38
22**	0.154	0.061	0.051	2.5
23**	0.218	0.256	0.188	0.85
24**	0.171	0.513	0.412	0.33
25**	0.174	0.119	0.103	1.5
26**	0.227	0.288	0.236	0.8
27**	0.474	0.069	0.061	6.9
28**	0.499	0.060	0.053	8.3
29**	1.296	0.109	0.090	11.9
30**	1.790	0.179	0.155	10
31**	25.008	2.075	1.684	12.1
32**	33.25	2.83	2.297	11.75
33**	48.516	3.857	2.913	12.6
34**	175.211	10.89	6.58	16
35**	23.852	1.931	1.431	12.4
36**	0.115	0.17	0.012	6.8
37**	<0.207	0.032	0.024	6.5
38**	0.032	0.014	0.010	2.29
39**	0.018	0.02	0.012	0.9
41**	0.019	0.063	0.031	0.3
45**	0.003	0.254	0.086	0.01
49**	0.036	0.020	0.015	1.8
51	0.012	0.007	0.005	1.71
53	0.008	<0.002	<0.001	4.0
55	0.006	0.004	0.002	1.5
57	0.004	0.005	0.003	0.8
59	0.002	0.005	0.003	0.4
61	0.001	0.004	0.003	0.25
62	0.006	0.040	0.021	0.15
65**	0.001	0.037	0.026	0.03
69	0.08	0.14	0.136	0.57
70**	<0.001	0.004	0.002	0.25

*Petroleum present in sediments. **Station affected by man's activities (harbors, outfalls).

Table 15. Data on infauna collected in control survey, 1977.

Station Number	No. of Species/ 0.1 sq m	No. of Indivi-duals/ 0.1 sq m	Domi-nance*	Shannon Weaver Diver-sity/ 0.1 sq m	Gleason's Richness/ 0.1 sq m	No. of Indivi-duals/ Species/ 0.1 sq m
1**	90	382	12	3.5	14.97	4.24
2**	133	1,213	9	3.65	18.87	8.99
3**	93	641	6	3.26	14.23	6.89
4	75	321	8	3.25	12.82	4.28
5	66	333	6	3.16	11.19	5.05
6**	69	232	12	3.52	12.49	3.55
7**	60	232	9	3.35	11.02	3.80
8	79	350	7	3.29	13.66	4.32
9**	32	91	6	2.89	6.87	2.84
10**	45	152	9	3.29	8.96	3.30
11	89	472	8	3.47	14.59	5.24
12	80	454	6	3.04	12.91	5.68
13	94	464	8	3.40	15.47	4.83
14	76	512	4	2.95	12.06	6.61
15	77	440	8	3.31	12.49	5.71
16	73	451	6	3.12	12.43	5.87
17	69	408	5	2.91	11.81	5.67
18˚	51	260	3	2.64	9.17	5.00
19˚	56	271	4	2.71	9.98	4.81
20˚	37	126	4	2.66	7.65	3.32
21˚	43	198	5	2.84	7.94	4.60
22˚	61	359	7	3.16	10.20	5.89
23˚	48	259	4	2.61	8.64	5.29
24˚	57	518	8	3.13	9.28	8.78
25˚	55	405	6	3.31	8.99	7.36
26˚	88	1,359	3	1.54	12.19	14.31
27˚	58	370	5	2.93	9.82	6.22
28˚	91	520	7	3.15	14.23	5.78
29˚	53	281	4	2.56	9.40	5.20
30˚	77	478	10	3.30	12.32	6.21
31˚	79	3,059	2	1.34	9.59	39.19
32˚	45	710	2	2.09	6.70	15.78
33˚	46	895	2	1.87	6.77	19.04
34˚	36	2,140	4	1.59	5.18	23.78
35˚	37	116	7	3.03	7.57	3.14
36˚	106	737	6	3.07	15.90	6.95
37˚	88	467	9	3.41	14.15	5.31
38˚	169	902	18	4.16	24.39	5.41
39˚	79	476	9	3.53	13.30	5.75
40˚	79	396	9	3.56	13.21	4.95
41˚	74	472	6	3.16	12.36	6.09
42˚	62	549	4	2.87	10.13	8.54
43˚	87	1,033	3	2.67	13.10	11.27
44˚	74	1,081	3	2.52	10.45	14.57
45˚	83	1,231	5	2.96	12.10	14.06
46˚	69	751	5	2.86	10.72	10.43
47˚	93	645	7	3.21	14.68	6.73
48˚	83	498	10	3.50	13.79	5.87
49˚	60	247	9	3.33	10.71	4.12
50	47	292	4	2.62	8.10	6.21
51	53	502	4	2.56	8.53	9.22
52	56	472	3	2.56	9.10	8.23
53	60	534	2	2.19	9.24	9.03
54	51	385	3	2.41	8.39	7.59
55	41	408	3	2.20	6.50	10.13
56	68	667	4	2.25	10.00	10.08
57	73	331	6	3.14	12.06	4.66
58	70	483	5	3.06	11.33	6.80
59	67	442	4	2.88	11.00	6.50
60	69	409	6	3.06	11.47	5.84
61	72	374	6	3.09	11.99	5.18
62	88	515	6	3.24	14.41	5.66
63	52	186	9	3.23	9.76	3.58
64	54	238	10	3.4	9.68	4.43
65˚	62	331	4	3.23	10.51	5.34
67˚	56	261	11	3.15	10.24	4.52
68	52	272	8	3.16	9.27	5.15
69	47	230	7	3.13	8.47	4.87
70˚	124	833	7	3.31	18.44	6.66
71	123	654	16	3.94	18.97	5.27

*Minimum number of species required to account for 60 percent of the number of individuals in sample. **Petroleum present in sediments. ˚Station affected by man's activities (harbors, outfalls).

Table 16. Phyla and biomass of infauna collected in control survey, 1977

Station Number	Arthro-pods	Molluscs	Echino-derms	Poly-chaetes	Miscella-neous	Biomass (g/ 0.1 sq m)
	No. of Species and No. of Individuals per 0.1 sq meter*					
1**	29/76	18/144	5/42	30/91	8/29	8.9
2**	41/222	21/126	10/45	49/710	12/110	12.1
3**	22/110	18/201	7/107	41/208	5/12	7.7
4	29/104	11/24	6/54	24/130	5/9	7.4
5	18/61	13/43	4/115	26/103	5/11	5.3
6**	17/46	12/29	4/68	29/64	7/25	6.8
7**	18/95	10/32	4/34	19/40	9/31	19.0
8	22/66	17/33	6/87	24/72	10/92	10.6
9**	8/22	6/13	2/33	12/18	4/5	3.9
10**	15/45	9/24	3/31	15/49	3/3	2.5
11	31/120	18/84	4/99	26/134	8/35	6.3
12	30/91	11/28	5/46	28/234	6/56	11.0
13	33/101	17/39	6/53	29/186	9/85	2.8
14	27/108	14/34	5/97	24/163	6/110	5.3
15	22/75	17/74	5/93	26/96	7/102	4.7
16	27/90	11/30	5/165	24/107	6/59	8.8
17	23/80	11/15	4/204	24/68	7/41	5.7
18•	17/36	6/14	6/151	18/50	4/9	5.6
19•	19/51	10/17	6/154	17/44	4/5	9.9
20•	14/31	5/6	2/66	11/15	5/8	1.5
21•	17/63	6/17	2/78	13/33	5/7	2.3
22•	19/52	9/23	2/118	25/131	6/35	4.9
23•	10/19	10/152	1/3	23/74	4/11	8.7
24•	7/29	7/117	0/0	32/335	11/37	13.5
25•	13/129	9/78	0/0	29/193	4/5	9.5
26•	17/178	20/305	3/4	45/806	3/66	11.8
27•	13/31	9/99	3/29	28/188	5/23	8.3
28•	26/142	13/91	5/12	43/254	4/21	6.7
29•	8/23	13/193	2/2	25/56	5/7	9.9
30•	19/75	17/160	2/2	36/217	3/24	21.0
31•	10/48	17/1,004	0/0	48/1,964	3/43	70.7
32•	2/2	12/235	0/0	24/424	7/49	22.9
33•	2/7	8/486	0/0	30/371	6/31	20.4
34•	2/5	10/310	0/0	22/1,795	2/30	-
35•	2/2	8/38	0/0	23/64	4/12	7.7
36•	24/54	10/15	4/4	59/614	9/50	3.0
37•	27/80	15/62	5/12	38/301	3/12	3.8
38•	42/233	22/136	5/24	62/407	28/102	8.7
39•	18/130	13/61	3/54	38/213	7/18	8.9
40•	15/75	14/53	1/24	41/213	8/31	7.6
41•	17/156	16/85	1/11	32/202	8/18	8.6
42•	16/163	13/185	1/1	26/183	6/17	8.8
43•	19/265	16/458	3/3	40/288	9/19	17.7
44•	16/271	15/504	2/3	32/231	9/72	-
45•	19/195	18/385	0/0	40/616	6/35	21.8
46•	15/59	17/325	1/5	31/333	5/29	13.5
47•	16/105	18/286	4/8	46/228	9/18	11.3
48•	10/30	18/185	3/4	43/241	9/38	8.4
49•	15/41	14/66	3/37	23/97	5/6	5.1
50	16/44	12/32	2/148	14/62	3/6	11.2
51	16/57	13/51	2/207	17/173	5/14	6.4
52	17/46	13/54	4/259	16/77	6/35	9.8
53	19/54	11/26	3/349	20/76	7/29	7.9
54	16/26	10/38	6/234	13/77	5/10	7.9
55	13/46	9/18	3/224	13/112	3/8	5.7
56	14/44	16/30	4/365	23/183	11/45	11.1
57	18/39	10/36	7/142	32/110	3/4	5.0
58	23/59	13/49	8/182	20/149	6/44	6.1
59	23/39	13/50	4/204	23/119	4/30	6.2
60	19/48	13/49	4/184	26/106	7/22	5.6
61	27/75	10/47	8/130	24/97	3/25	8.3
62	14/34	17/68	5/184	44/212	8/17	9.4
63	8/19	10/26	3/17	22/108	9/16	4.7
64	9/42	9/47	4/9	27/120	5/20	9.0
67•	11/27	19/58	4/6	17/146	5/24	4.4
68	10/24	13/81	3/17	20/131	6/19	6.1
69	8/20	10/65	3/57	22/71	4/17	4.3
70•	24/39	17/117	9/51	68/610	6/16	5.6
71	33/100	17/74	9/27	57/367	7/86	4.8

*Number of species precedes the slash, number of individuals follows it. **Petroleum present in sediments. •Station affected by man's activities (harbors, outfalls).

Table 17. Infaunal Trophic Index values for control survey, 1977. A dash means "no data."

Station Number	Infaunal Trophic Index Value/ 0.1 sq m	Relative Abundances of Infaunal Trophic Index Species (%) Group I	Group II	Group III	Group IV
1*	59.9	30	20	49	1
2*	72.7	36	47	17	1
3*	68.7	36	33	31	0
4	83.1	53	44	3	0
5	88.6	71	24	5	0
6*	88.8	72	22	6	0
7*	83.2	50	49	1	0
8	89.8	70	29	1	0
9*	94.7	84	16	0	0
10*	79.9	49	40	11	0
11	83.9	56	39	5	0
12	93.3	85	8	7	0
13	89.9	74	22	4	0
14	94.5	86	11	2	1
15	90.4	77	17	6	0
16	95.9	89	10	1	0
17	97.8	94	5	1	0
18**	98.7	96	4	0	0
19**	98.2	95	5	0	0
20**	99.1	99	1	0	0
21**	97.8	93	7	0	0
22**	93.6	85	11	4	0
23**	48.2	5	34	61	0
24**	57.7	1	71	27	1
25**	65.0	7	80	11	1
26**	63.1	10	69	21	0
27**	58.5	32	11	57	0
28**	60.9	14	54	31	<1
29**	46.6	11	17	72	0
30**	58.1	24	27	49	1
31**	54.8	<1	64	35	<1
32**	57.6	<1	72	27	<1
33**	64.4	0	96	1	3
34**	21.0	–	–	–	–
35**	51.0	0	57	39	4
36**	83.5	61	30	8	1
37**	72.8	33	54	10	2
38**	74.8	40	44	15	<1
39**	77.9	38	59	2	1
40**	79.4	47	44	9	0
41**	65.0	14	67	19	0
42**	55.6	6	54	40	0
43**	50.7	4	48	51	1
44**	47.9	3	39	57	1
45**	45.0	2	46	38	15
46**	44.0	4	25	69	2
47**	47.5	6	30	64	0
48**	53.6	20	21	59	0
49**	85.5	67	23	10	0
50	97.0	93	5	2	0
51	95.0	87	10	2	0
52	98.1	95	4	1	0
53	98.3	96	3	1	0
54	96.9	90	9	1	0
55	98.1	90	9	1	0
56	97.7	95	3	2	0
57	95.1	90	5	5	0
58	93.5	85	10	5	0
59	94.4	88	7	5	0
60	93.4	83	14	3	0
61	93.6	83	14	3	0
62	91.2	79	15	6	0
63	84.1	67	17	15	0
64	77.5	57	19	24	0
65**	79.6	48	42	10	0
67**	75.4	52	24	22	2
68	69.0	42	22	36	0
69	82.5	66	14	20	0
70**	69.7	38	35	26	1
71	72.1	45	28	27	1

*Petroleum present in sediments. **Station affected by man's activities (harbors, outfalls).

Table 18. Data on trawl-caught invertebrates, control survey, 1977. A dash means "no data."

Station Number	No. of Species/ Trawl	No. of Indivi-duals/ Trawl	Shannon-Weaver Diversity/ Trawl	Gleason's Richness/ Trawl	Biomass (kg/ trawl)
1*	6	31	1.34	1.46	-
2*	7	11	1.80	2.50	-
3*	17	180	1.48	3.08	-
4	13	26	2.34	3.68	-
5	16	421	0.51	2.48	-
6*	7	623	0.77	0.93	>12.1
7*	13	353	1.22	2.05	>30.5
8	16	166	1.54	2.93	>26.0
9*	14	671	0.44	2.00	>12.5
10*	11	351	0.80	1.71	>12.05
11	7	91	1.50	1.33	>12.7
12	15	57	1.88	3.46	>2.3
13	16	88	2.01	3.35	>15.06
14	10	80	1.54	2.05	>10.22
15	15	2,740	0.16	1.77	>9.62
16	24	106	2.26	4.93	>2.62
18**	11	486	0.91	1.62	>5.2
20**	19	645	1.11	2.78	>7.9
22**	17	223	1.13	2.96	>4.8
24**	8	582	0.16	1.10	>3.09
25**	19	493	0.94	2.90	>17.27
26**	15	226	0.77	2.58	>7.1
27**	11	554	0.60	1.58	>23.27
28**	12	241	1.05	2.01	>26.35
29**	9	621	0.44	1.10	>34.05
30**	10	25	1.95	2.80	-
31**	31	278	1.04	5.33	-
32**	11	49	2.01	2.57	-
33**	18	848	1.30	2.52	>19.36
34**	10	290	1.02	1.59	>5.06
35**	11	177	0.95	1.47	>0.4
36**	6	7	1.75	2.57	>1.09
37**	19	556	1.06	2.85	>0.2
38**	22	120	2.01	4.37	>5.6
39**	22	168	1.79	4.10	>5.35
45**	25	193	1.93	4.56	>2.1
48**	29	113	2.56	5.28	>16.7
49**	14	177	1.46	2.51	>22.0
50	16	201	1.53	2.83	>9.2
51	10	776	0.15	1.35	-
52	5	351	0.45	0.68	>2.5
53	8	199	0.74	1.32	-
54	8	29	1.62	2.08	>0.77
55	5	126	0.39	0.83	-
56	9	490	0.43	1.29	>2.1
57	6	253	0.27	0.90	>2.8
58	5	196	0.52	0.76	>1.7
59	6	20	1.54	1.67	>2.0
60	7	29	1.11	1.78	-
61	11	269	0.79	1.79	>0.8
62	9	110	1.33	1.70	>1.0
66**	12	191	1.17	2.09	>4.05
70**	16	312	0.68	2.61	>1.5
71	5	3,640	0.01	0.49	>5.0

*Petroleum present in sediments. **Station affected by man's activities (harbors, outfalls).

Table 19. Data on fishes collected in control survey, 1977.

Station Number	No. of Species: Total	No. of Species: Without Recruits	No. of Individuals: Total	No. of Individuals: Without Recruits	Biomass (kg/trawl)	Shannon Weaver Diver-sity	Gleason's Richness
1*	16	(same)	177	110	4.55	1.68	2.90
2*	2	(same)	7	(same)	0.30	0.41	0.51
3*	18	(same)	1,005	925	21.95	1.12	2.46
4	5	(same)	11	(same)	0.60	1.30	1.67
5	16	(same)	1,294	276	5.70	1.17	2.09
6*	11	(same)	871	173	4.40	1.11	1.48
7*	20	(same)	1,369	245	10.8	0.98	2.63
8	13	(same)	561	271	5.21	1.45	1.90
9*	19	(same)	4,008	294	17.5	0.63	2.17
10*	15	14	860	123	4.35	1.02	1.92
11	13	12	163	84	3.10	1.34	2.36
12	11	(same)	358	(same)	6.40	1.21	1.70
13	16	15	623	185	8.25	1.16	2.33
14	18	17	469	263	7.85	1.53	2.76
15	12	11	458	258	9.10	1.58	1.80
16	7	6	87	58	1.40	1.42	1.34
18**	11	(same)	225	(same)	3.2	1.57	1.85
20**	14	(same)	151	137	3.1	1.83	2.59
22**	18	(same)	293	198	5.0	2.08	2.99
24**	4	(same)	17	(same)	1.50	1.21	1.06
25**	17	(same)	247	239	14.75	1.82	2.58
26**	13	(same)	41	(same)	2.2	1.95	3.23
27**	23	(same)	391	170	5.2	1.92	3.69
28**	16	(same)	122	87	3.60	1.73	3.12
29**	15	14	185	153	4.9	0.83	1.34
30**	10	(same)	26	25	0.75	1.96	2.76
31**	10	9	56	46	0.80	1.91	2.24
32**	8	(same)	39	(same)	2.55	1.04	1.91
33**	10	8	111	96	3.1	1.71	1.91
34**	12	9	852	817	12.9	0.88	1.63
35**	7	6	33	30	2.45	0.71	0.86
36**	10	(same)	165	(same)	3.5	0.97	1.76
37**	19	18	950	801	17.5	1.56	2.63
38**	15	(same)	211	205	6.6	1.73	2.62
39**	16	14	523	482	2.5	1.02	2.40
45**	14	(same)	236	185	6.2	1.94	2.38
48**	16	(same)	916	830	14.8	1.87	2.20
49**	29	(same)	1,010	844	10.2	2.12	4.05
50	22	(same)	766	546	20.2	2.00	3.16
51	14	(same)	440	(same)	-	1.41	2.14
52	16	(same)	196	181	-	1.82	2.87
53	14	13	397	358	-	1.55	2.17
54	16	(same)	253	205	4.75	1.61	2.71
55	9	(same)	88	63	1.15	1.34	1.79
56	19	18	186	135	3.2	2.06	3.45
57	15	(same)	111	84	2.55	1.77	2.97

*Petroleum present in sediments. **Station affected by man's activities (harbors, outfalls).

Station Number	No. of Species Total	No. of Species Without Recruits	No. of Individuals Total	No. of Individuals Without Recruits	Biomass (kg/trawl)	Shannon Weaver Diver-sity	Gleason's Richness
58	12	(same)	183	100	4.0	1.26	2.11
59	11	(same)	158	120	2.85	1.31	1.98
60	13	(same)	256	212	5.2	1.46	2.16
61	16	(same)	220	193	4.2	1.55	2.79
62	21	(same)	593	499	16.5	2.20	3.27
66*	19	(same)	235	198	9.7	2.45	3.13
70*	17	(same)	234	217	6.25	1.63	2.94
71	14	(same)	114	(same)	3.95	1.73	2.75

*Station affected by man's activities (harbors, outfalls).

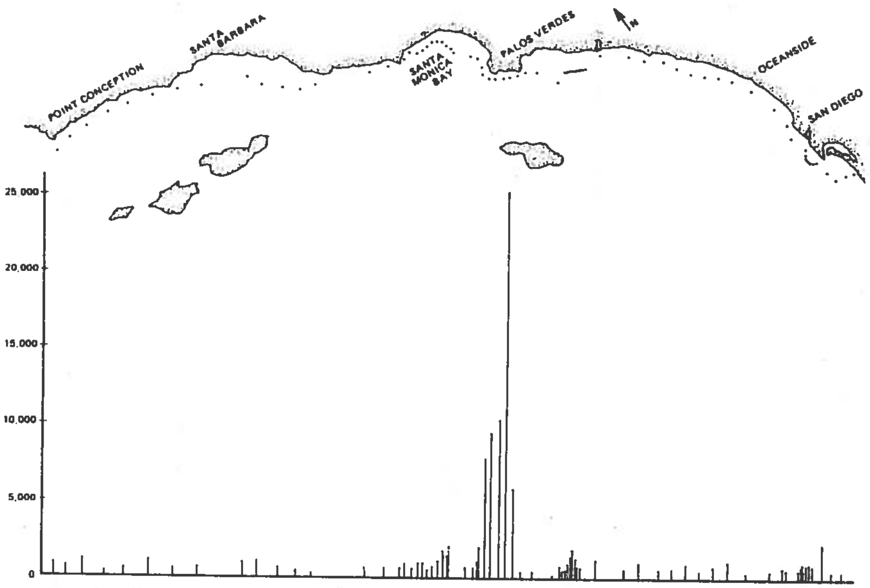


Figure 3. Biochemical oxygen demand at 2-cm depths in surface sediments, 60-meter survey, 1977.

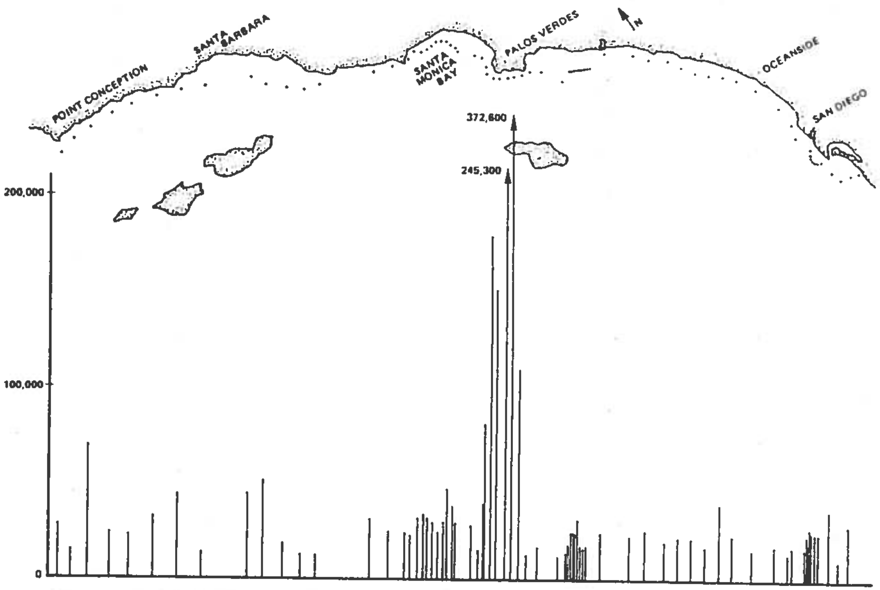


Figure 4. Chemical oxygen demand at 2-cm depths in surface sediments, 60-meter survey, 1977.

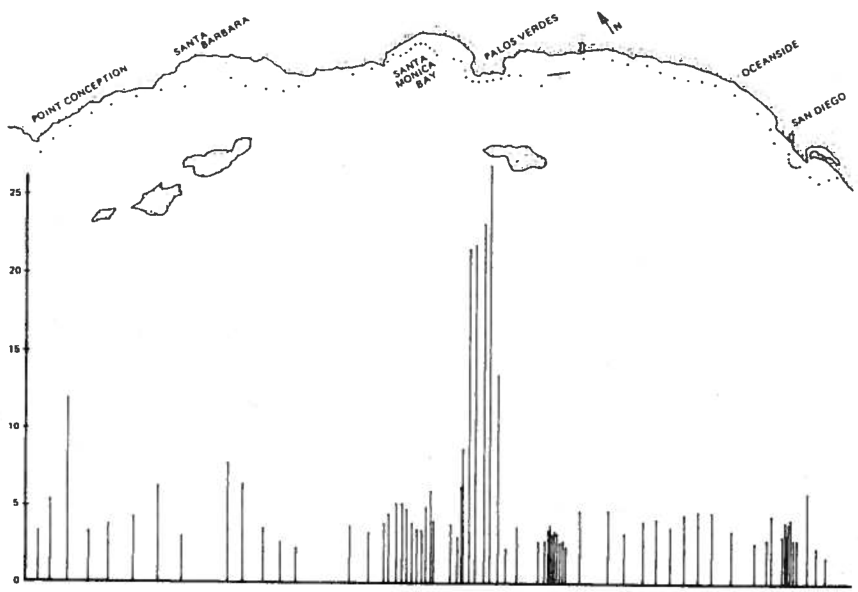


Figure 5. Volatile solids at 2 cm depths in surface sediments, 60-meter survey, 1977.

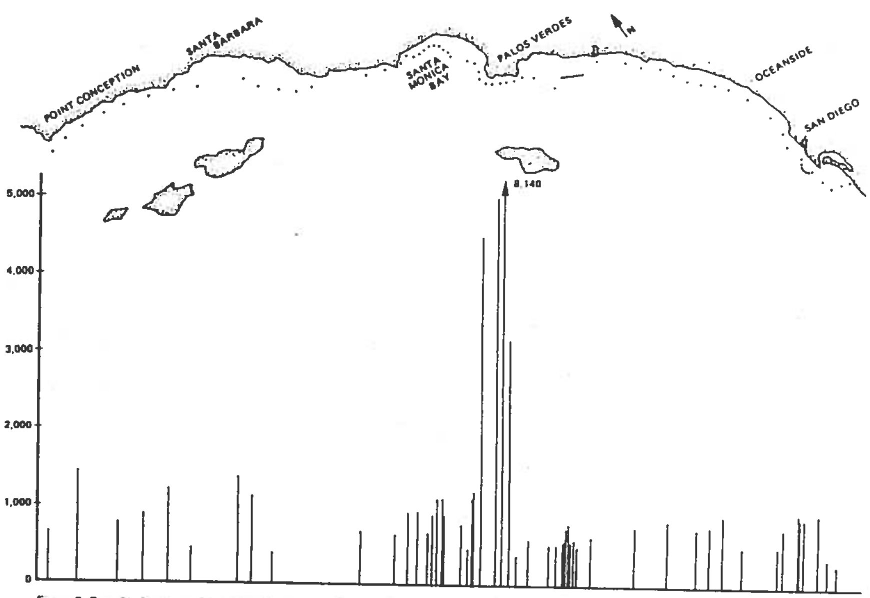


Figure 6. Organic nitrogen at 2 cm depths in surface sediments, 60-meter survey, 1977.

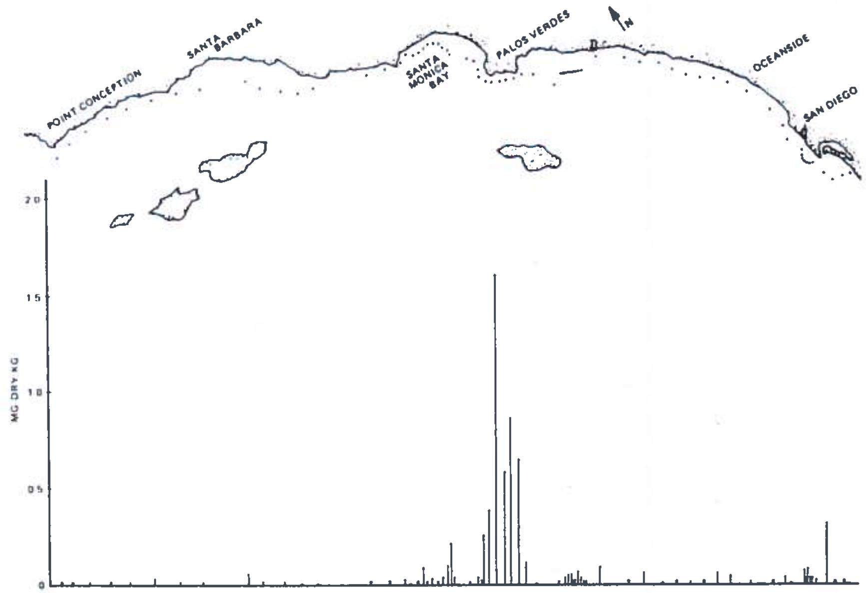


Figure 7. Acid volatile sulfides at 2 cm depths in surface sediments, 60-meter survey, 1977.

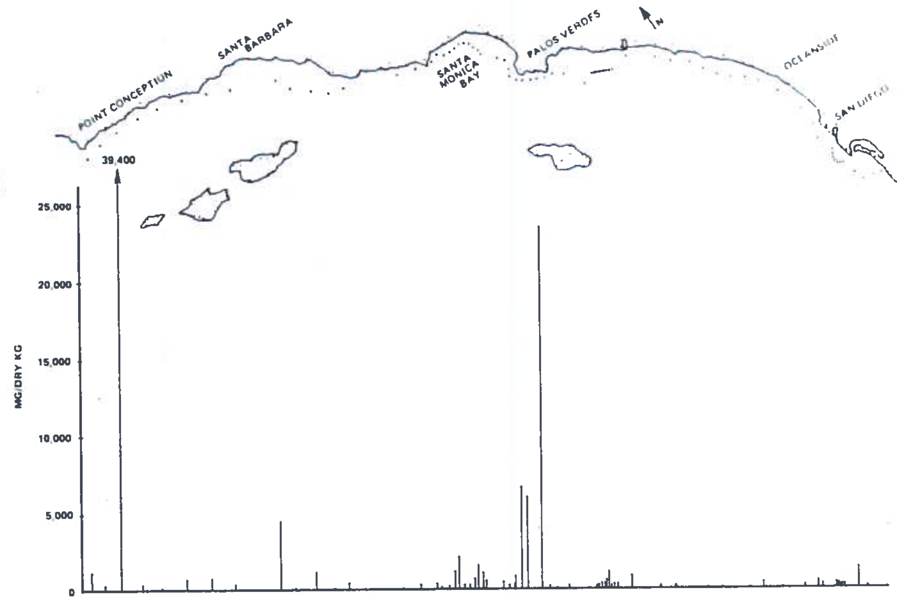


Figure 8. Hexane extractable material at 2-cm depths in surface sediments, 60-meter survey, 1977.

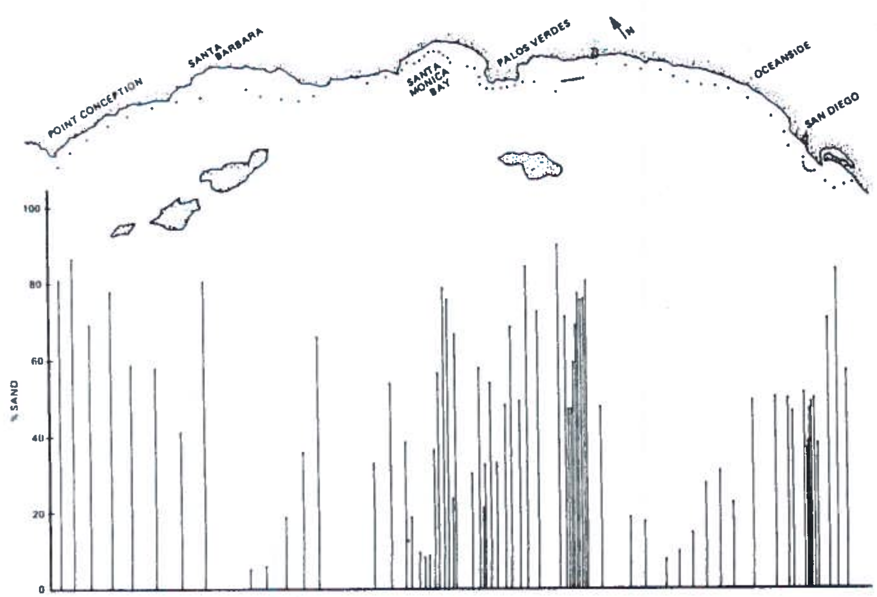


Figure 9. Percent sand in surface sediments (0 to 5 cm), 60-meter survey, 1977.

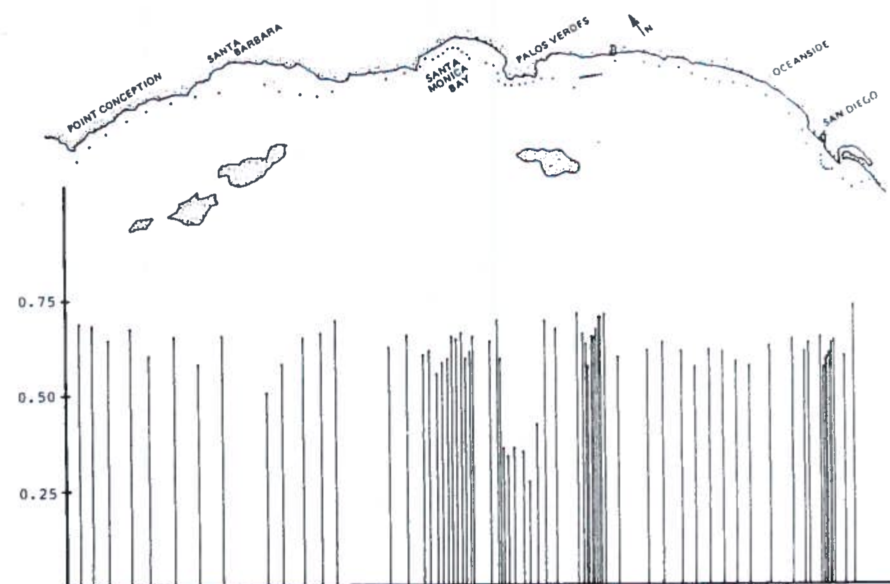


Figure 10. Ratio, dry to wet material in sediments, 60-meter survey, 1977.

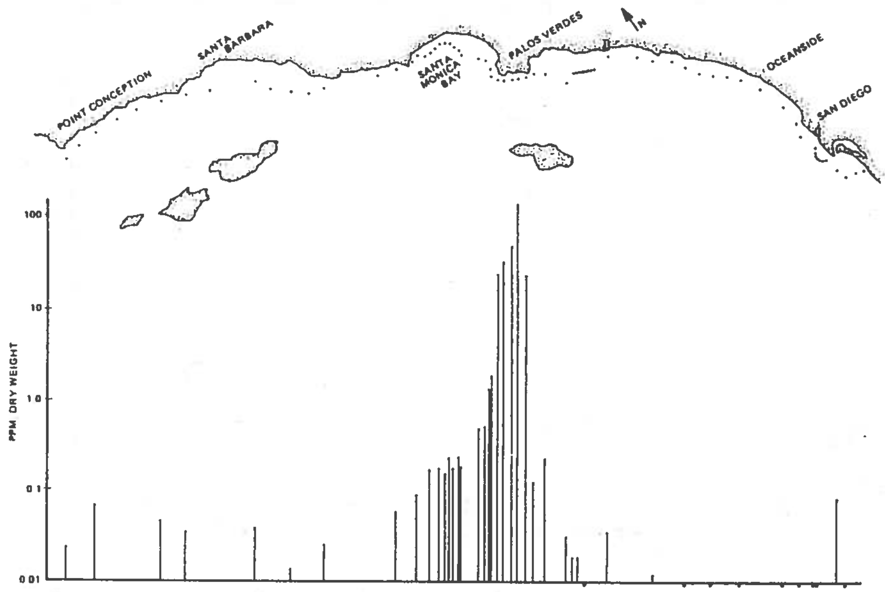


Figure 11. Total DDT at 2 cm depths in surface sediments, 60-meter survey, 1977.

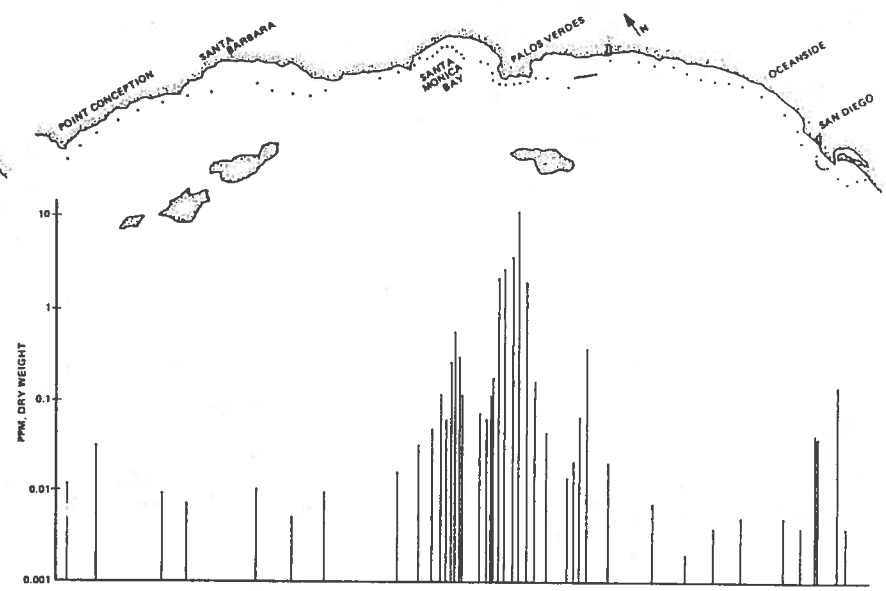


Figure 12. Total PCB at 2 cm depths in surface sediments, 60-meter survey, 1977.

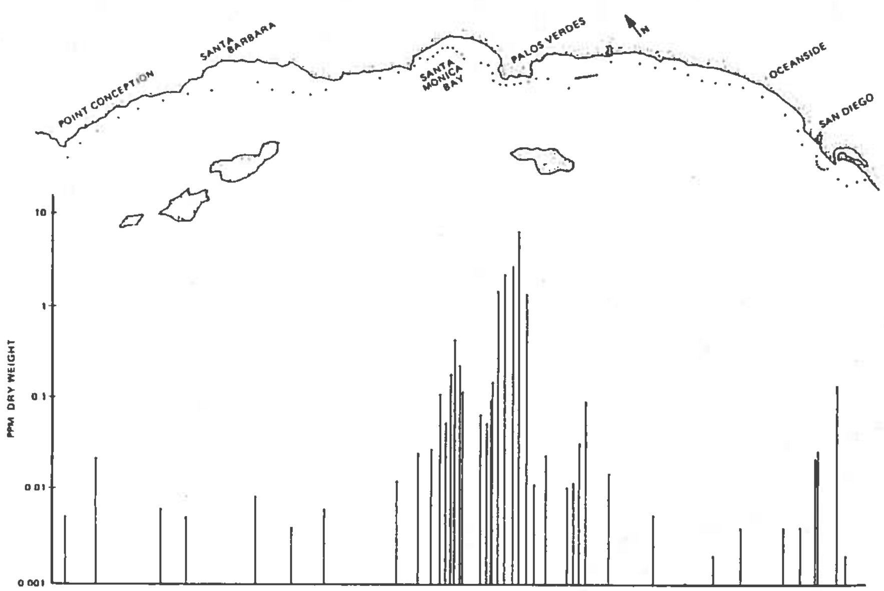


Figure 13. PCB 1254 at 2 cm depths in surface sediments, 60 meter survey, 1977.

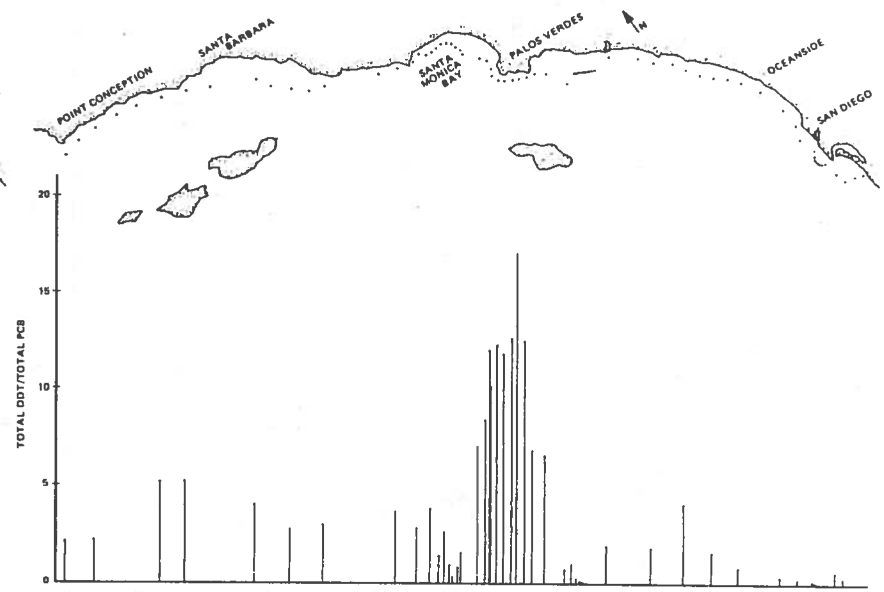


Figure 14. Ratio, total DDT to total PCB at 2 cm depths in surface sediments, 60 meter survey, 1977.

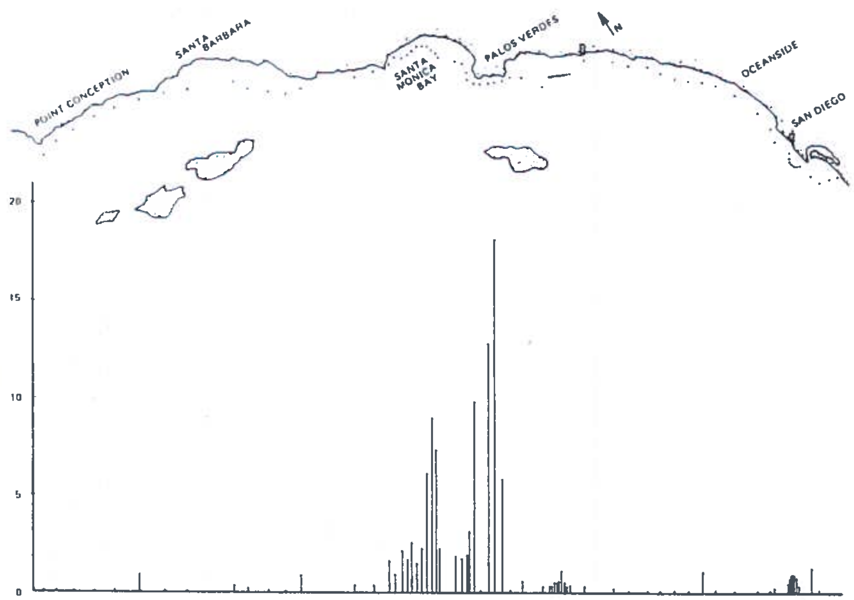


Figure 15. Silver at 2-cm depths in surface sediments, 60-meter survey, 1977.

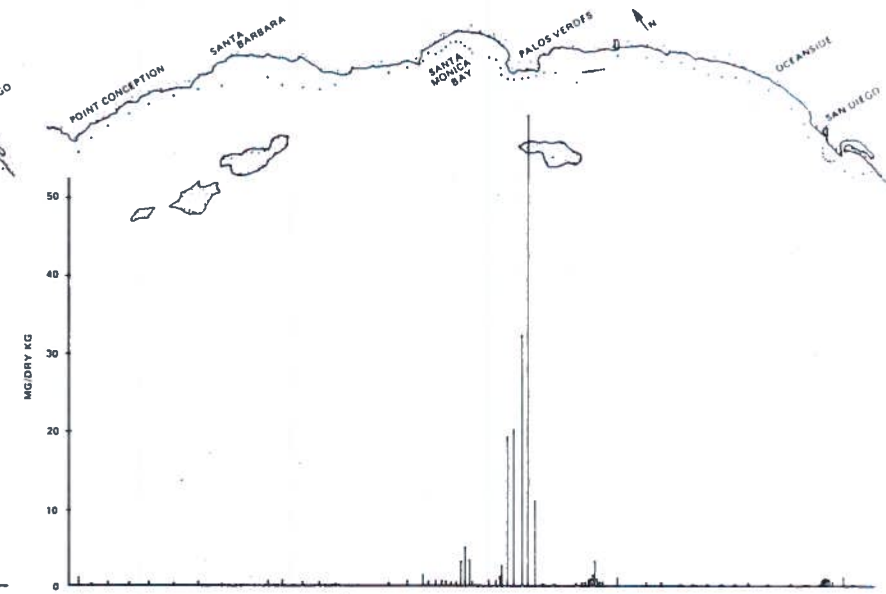


Figure 16. Cadmium at 2-cm depths in surface sediments, 60-meter survey, 1977.

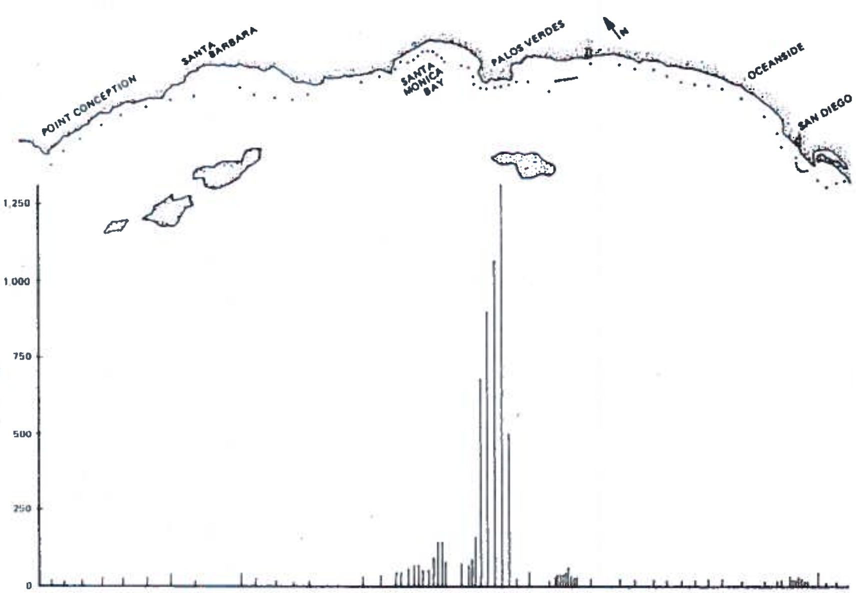


Figure 17. Chromium at 2-cm depths in surface sediments, 60-meter survey, 1977.

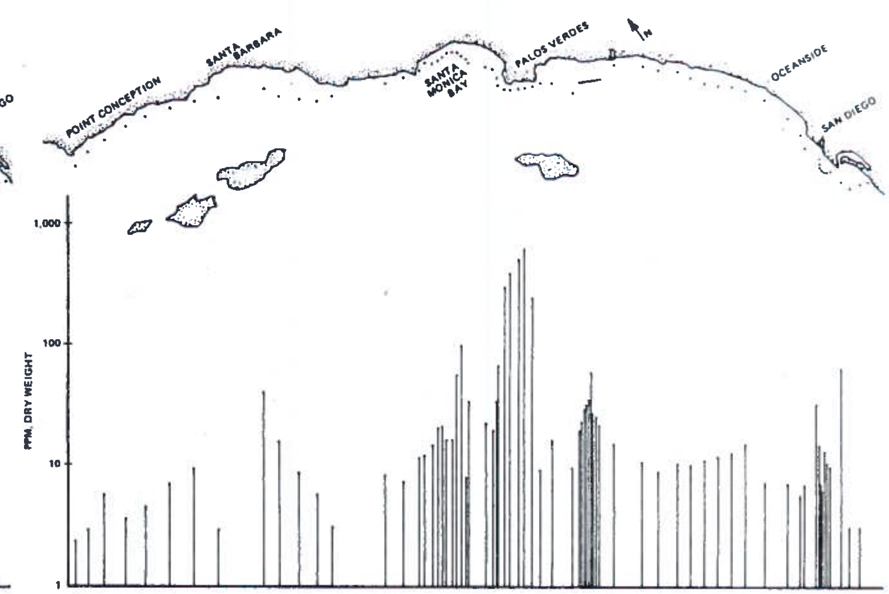


Figure 18. Copper at 2-cm depths in surface sediments, 60-meter survey, 1977.

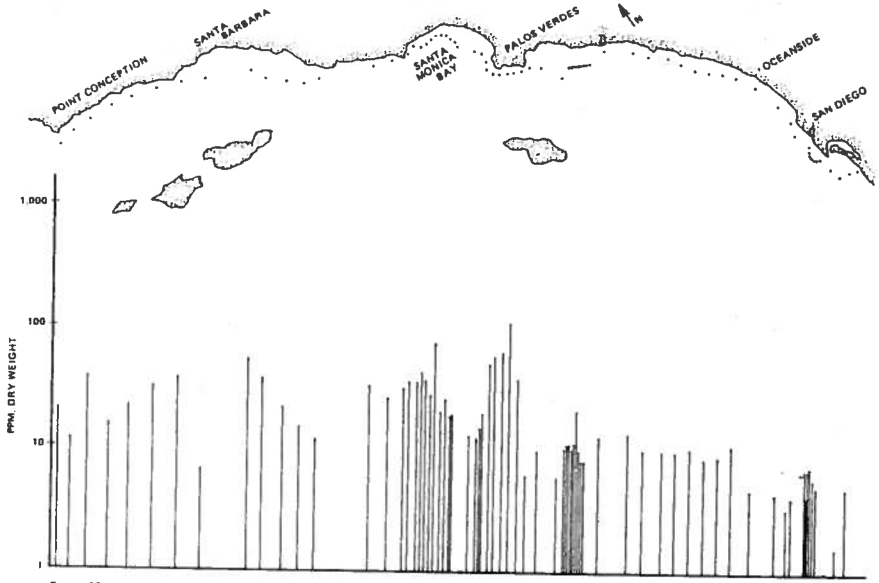


Figure 19. Nickel at 2-cm depths in surface sediments, 60-meter survey, 1977.

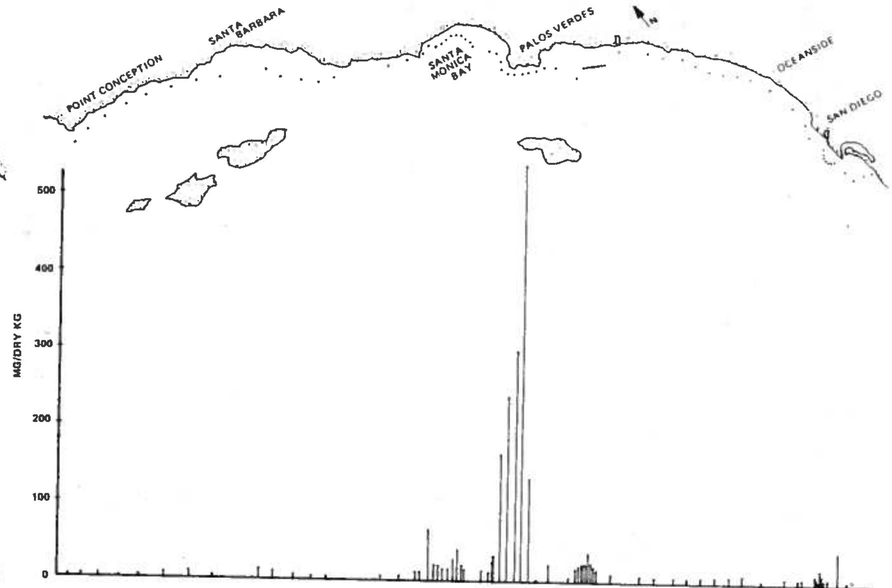


Figure 20. Lead at 2-cm depths in surface sediments, 60-meter survey, 1977.

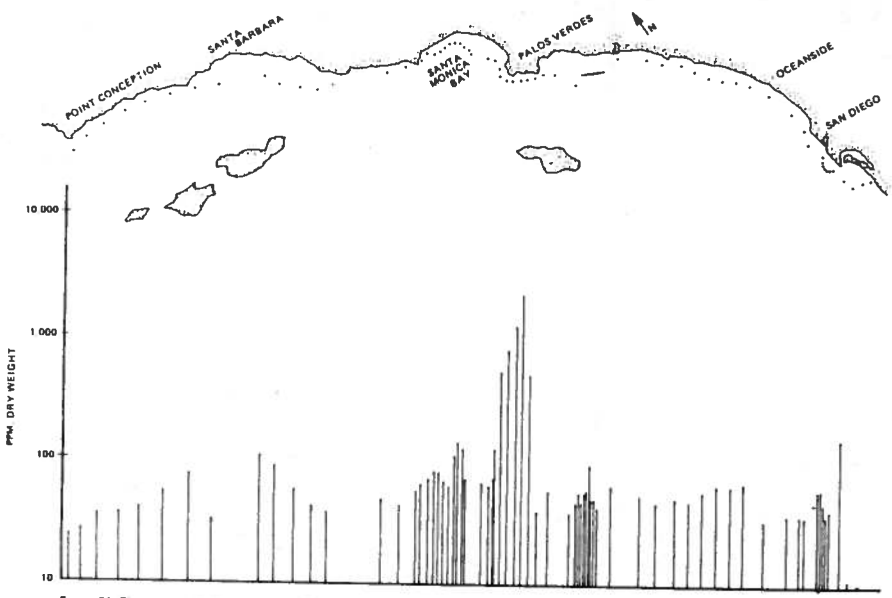


Figure 21. Zinc at 2-cm depths in surface sediments, 60-meter survey, 1977.

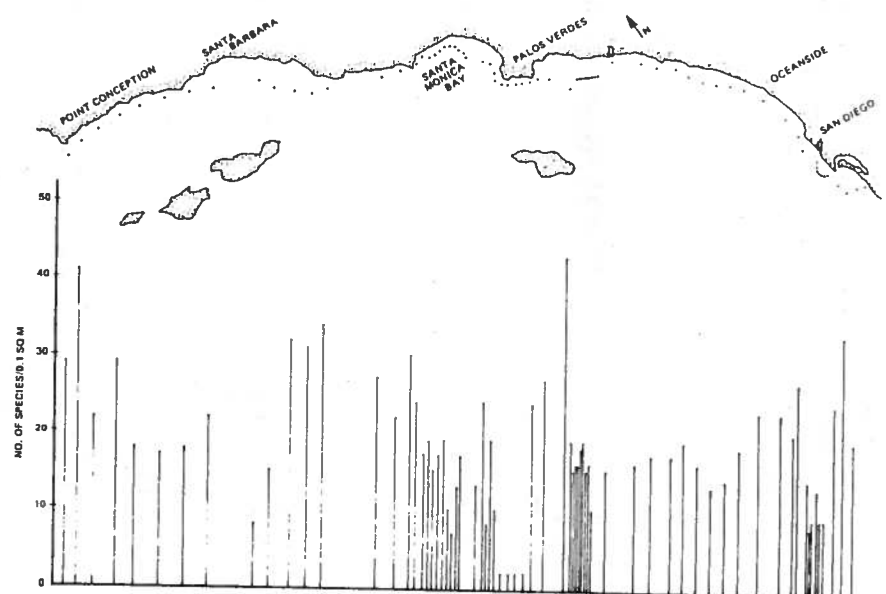


Figure 22. Numbers of arthropod species in grab samples, 60-meter survey, 1977.

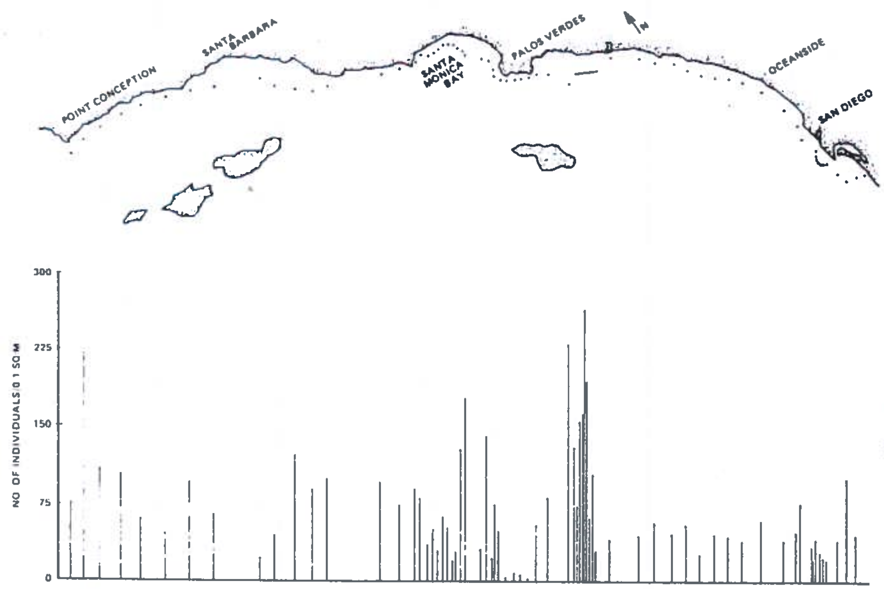


Figure 23. Numbers of arthropod individuals in grab samples, 60-meter survey, 1977.

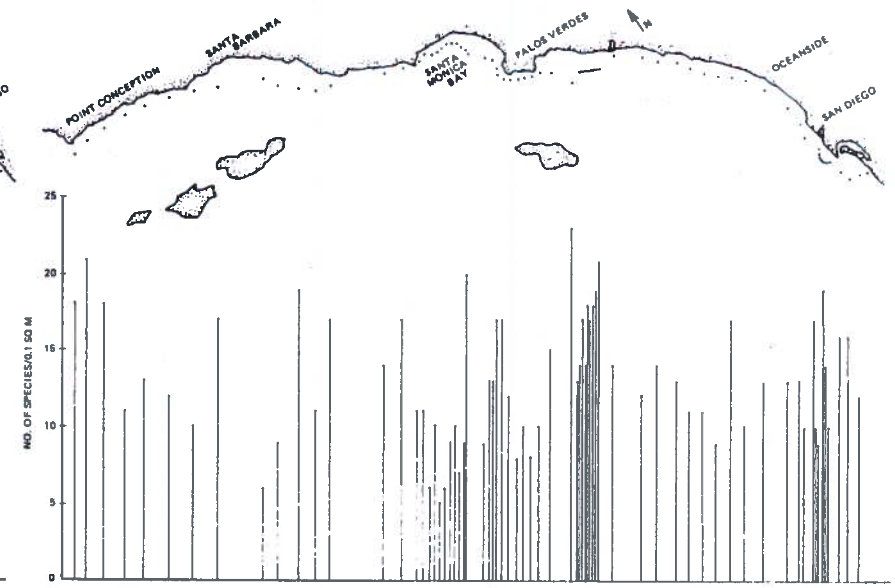


Figure 24. Numbers of mollusc species in grab samples, 60-meter survey, 1977.

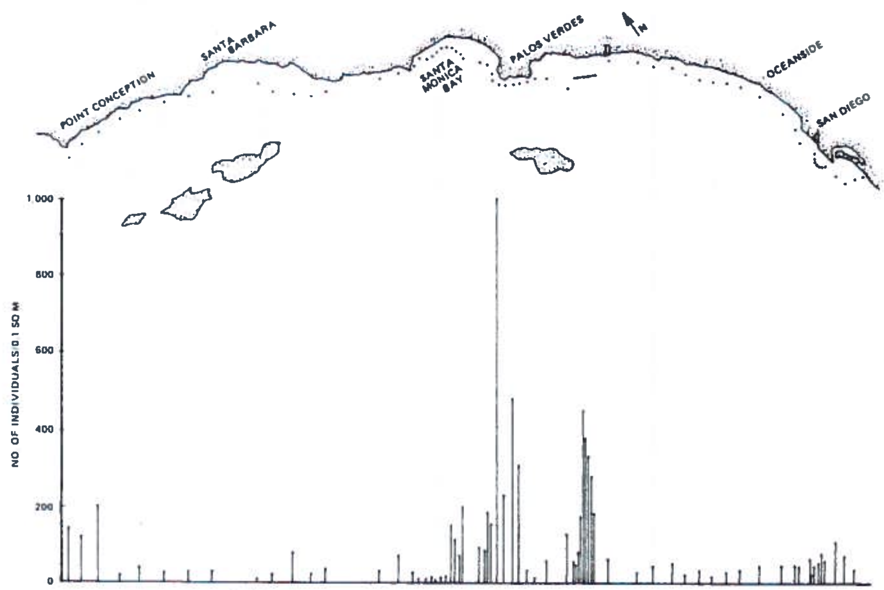


Figure 25. Numbers of mollusc individuals in grab samples, 60-meter survey, 1977.

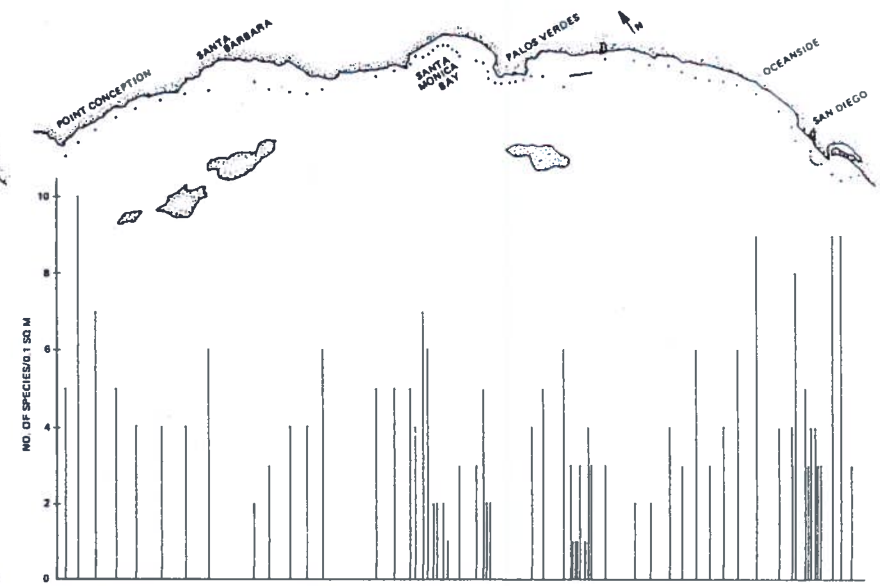


Figure 28. Numbers of echinoderm species in grab samples, 60-meter survey, 1977.

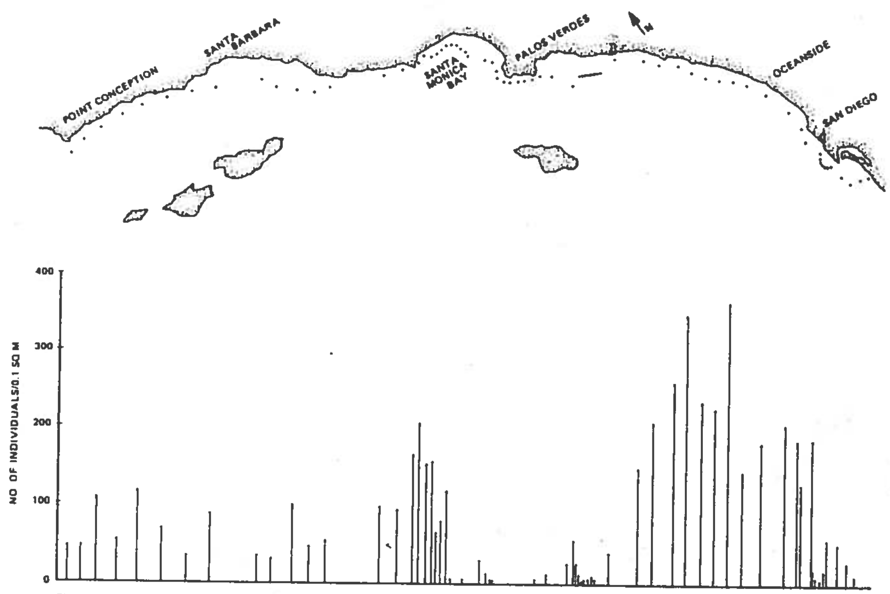


Figure 27. Numbers of echinoderm individuals in grab samples, 60-meter survey, 1977.

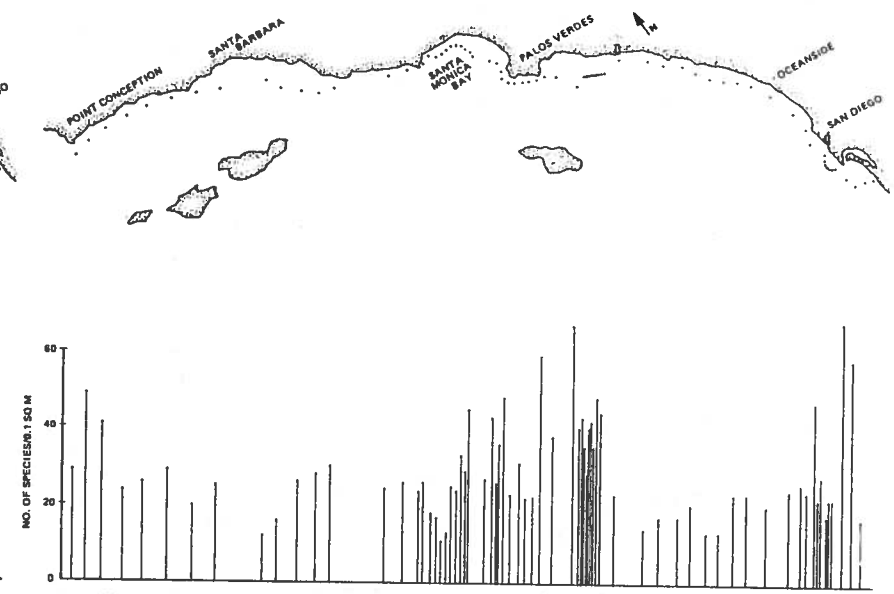


Figure 28. Numbers of polychaete species in grab samples, 60-meter survey, 1977.

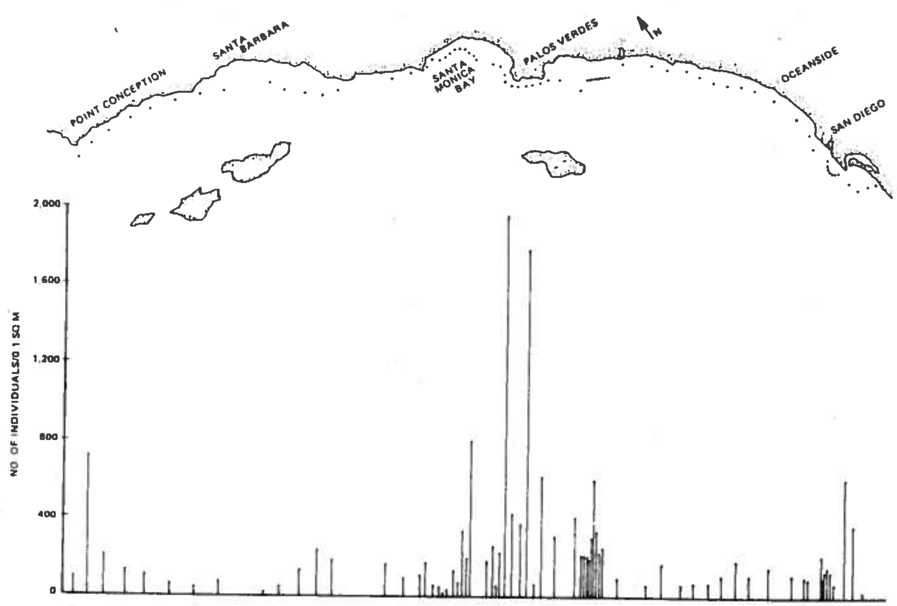


Figure 29. Numbers of polychaete individuals in grab samples, 60-meter survey, 1977.

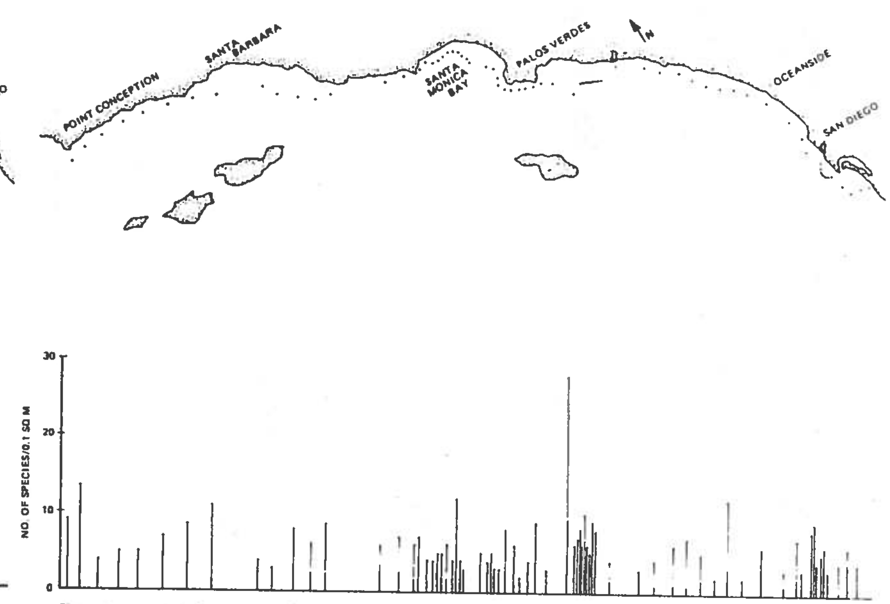


Figure 30. Numbers of miscellaneous species (other than arthropods, molluscs, echinoderms, and polychaetes) in grab samples, 60-meter survey, 1977.

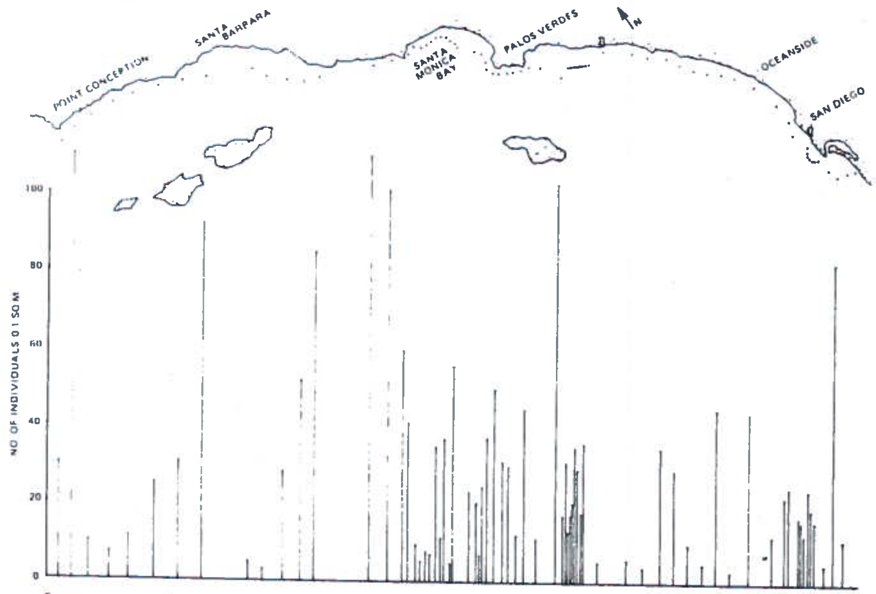


Figure 31. Numbers of individuals of miscellaneous species (other than arthropods, molluscs, echinoderms, and polychaetes) in grab samples, 60-meter survey, 1977.

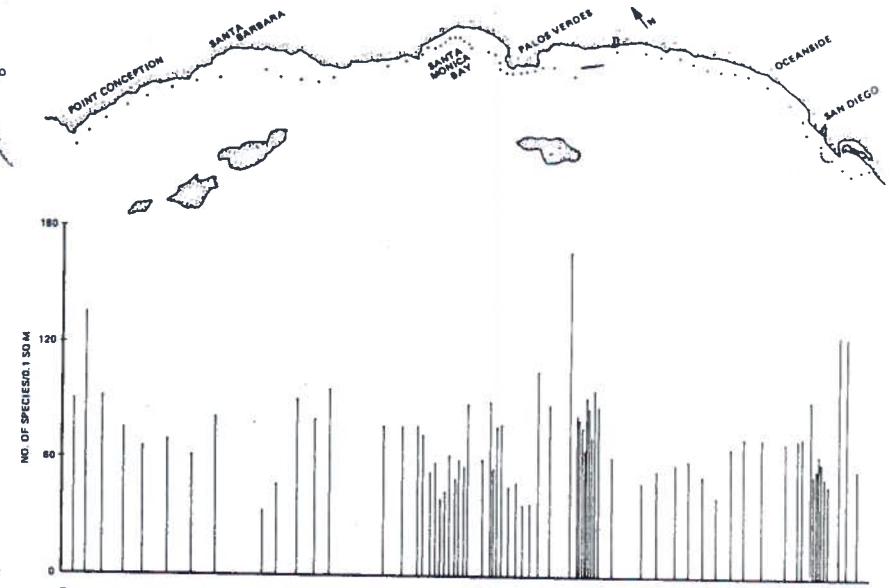


Figure 32. Total number of species in grab samples, 60-meter survey, 1977.

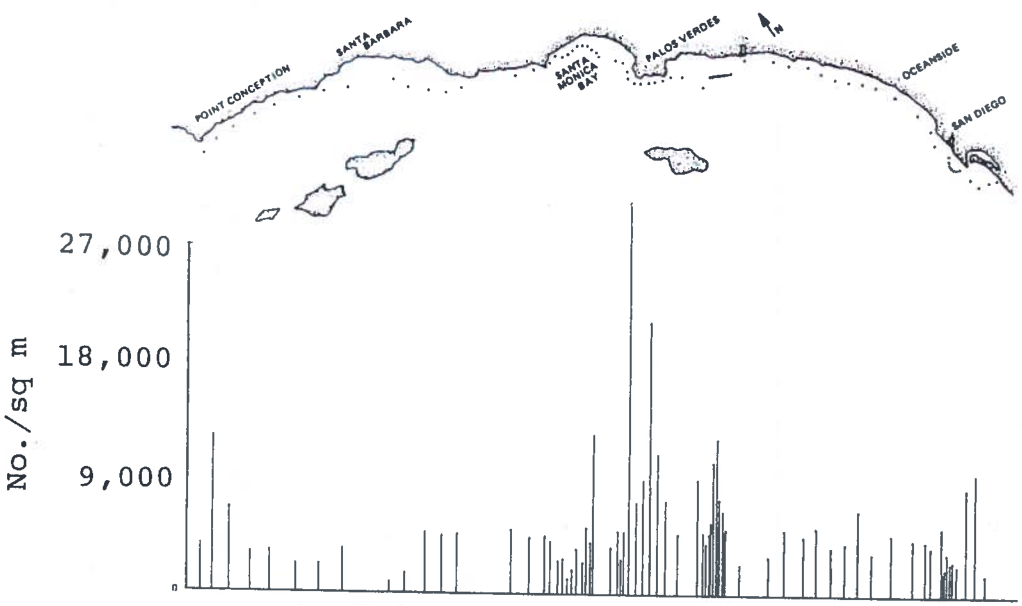


Figure 33. Total number of individuals in grab samples, 60-meter survey, 1977.

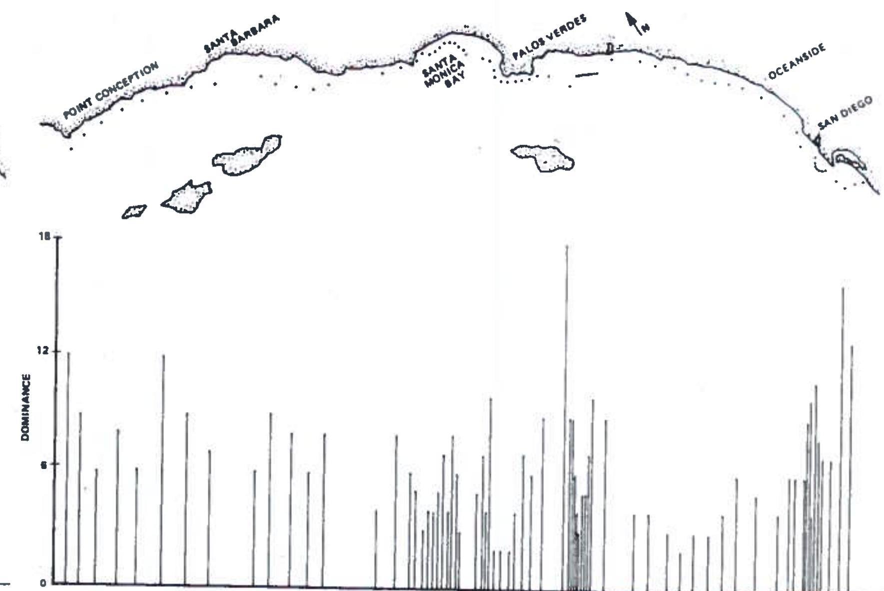


Figure 34. Dominance in grab-caught organisms, 60-meter survey, 1977. Dominance is defined here as the minimum number of species required to account for at least 80 percent of the individuals taken in a sample.

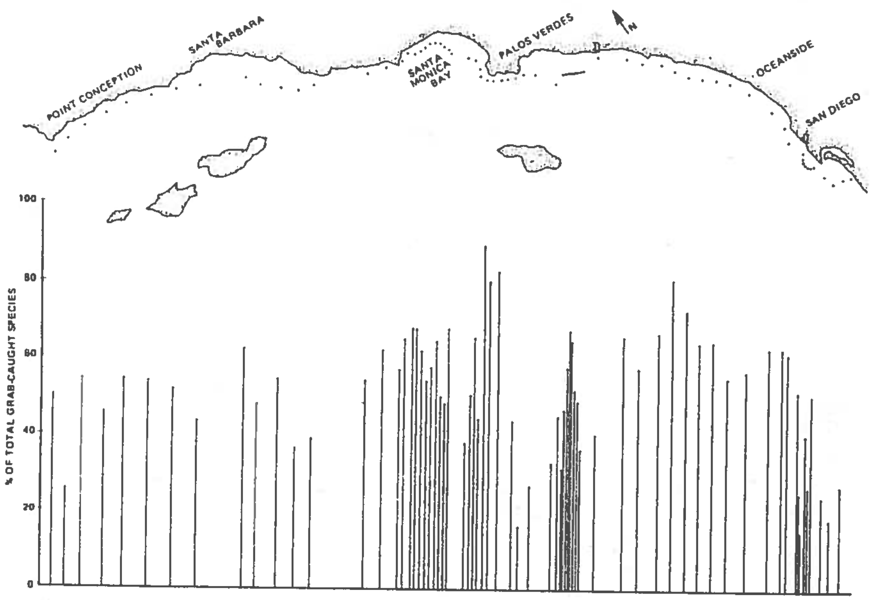


Figure 40. Percent of total grab-caught species that were among the 47 species used to obtain Infaunal Trophic Index values, 60-meter survey, 1977.

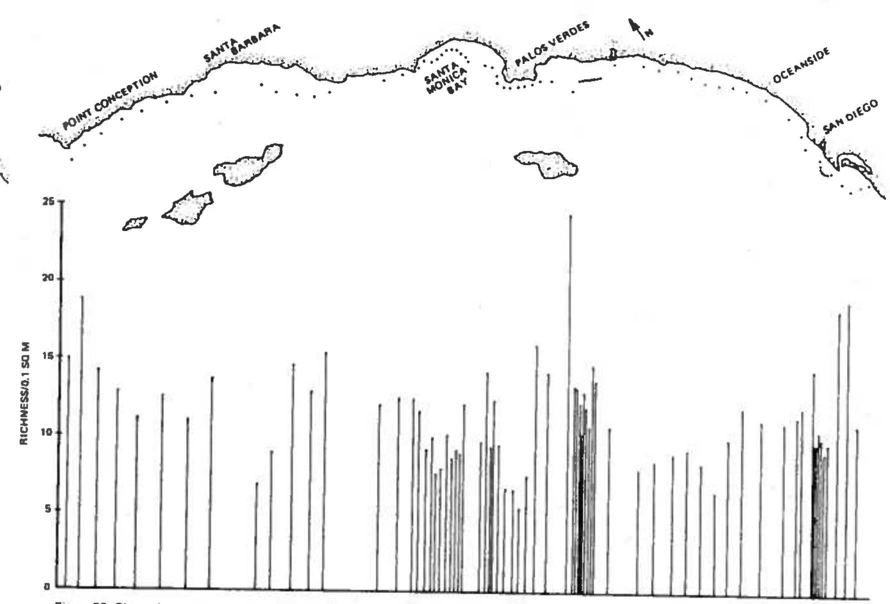


Figure 36. Gleason's richness in grab-caught organisms, 60-meter survey, 1977.

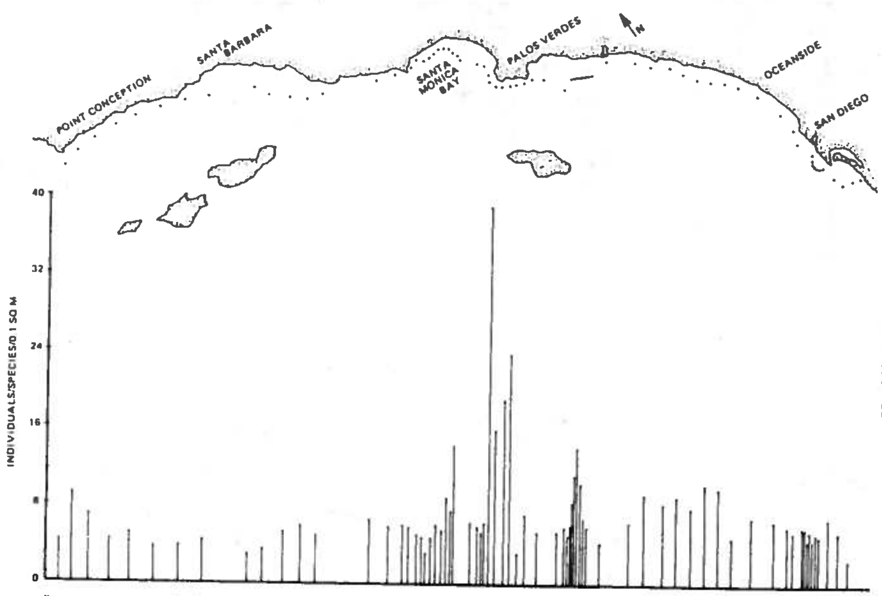


Figure 37. Numbers of individuals per numbers of species in grab samples, 60-meter survey, 1977.

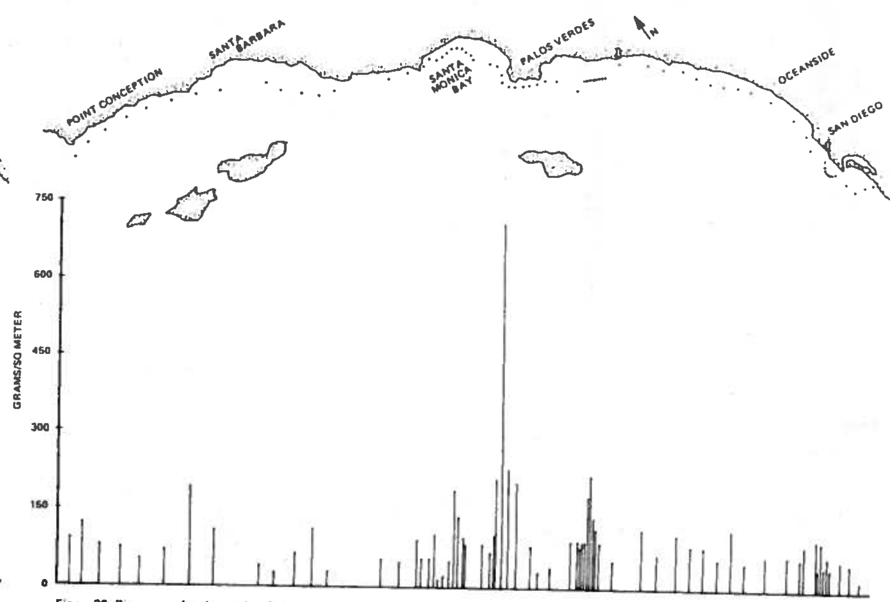


Figure 38. Biomasses of grab samples, 60-meter survey, 1977.

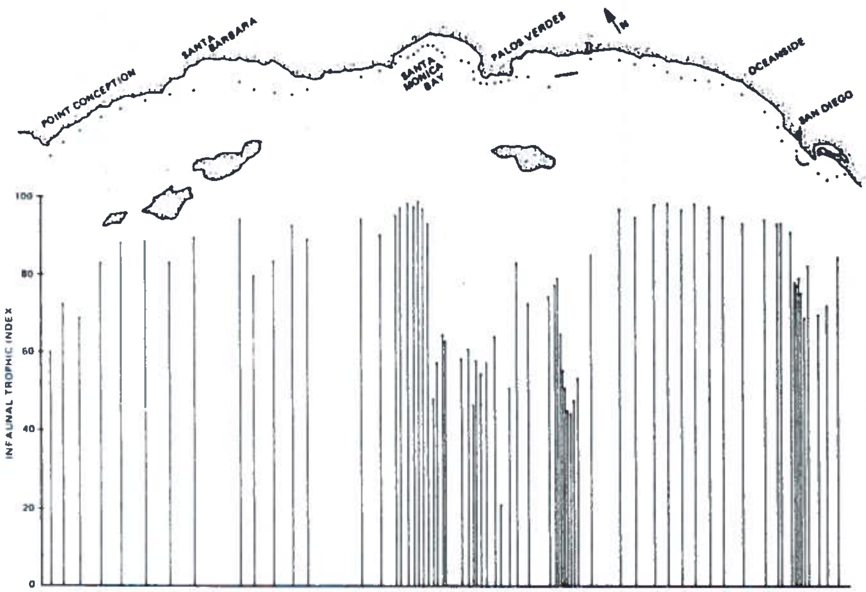


Figure 39. Infaunal Trophic Index values, 60-meter survey, 1977.

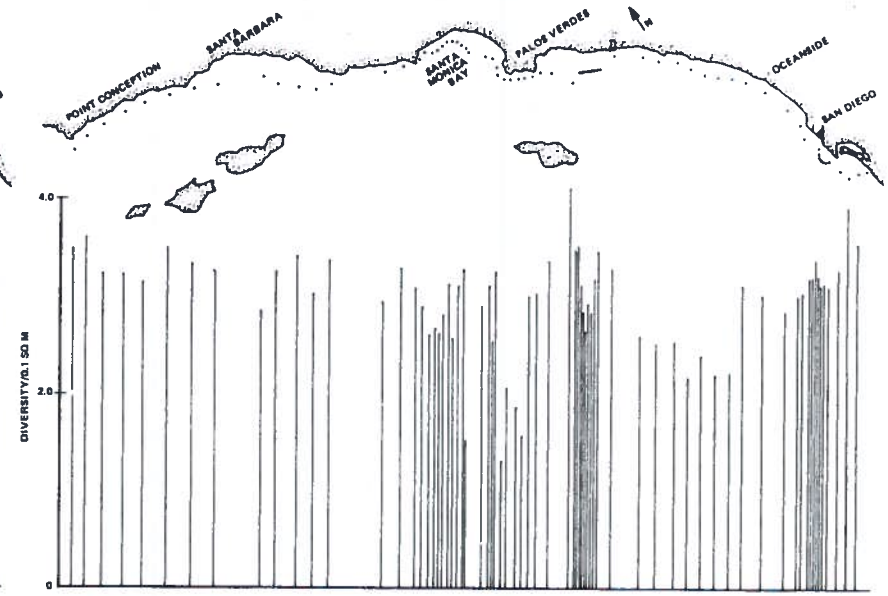


Figure 35. Shannon-Weaver diversity in grab-caught organisms, 60-meter survey, 1977.

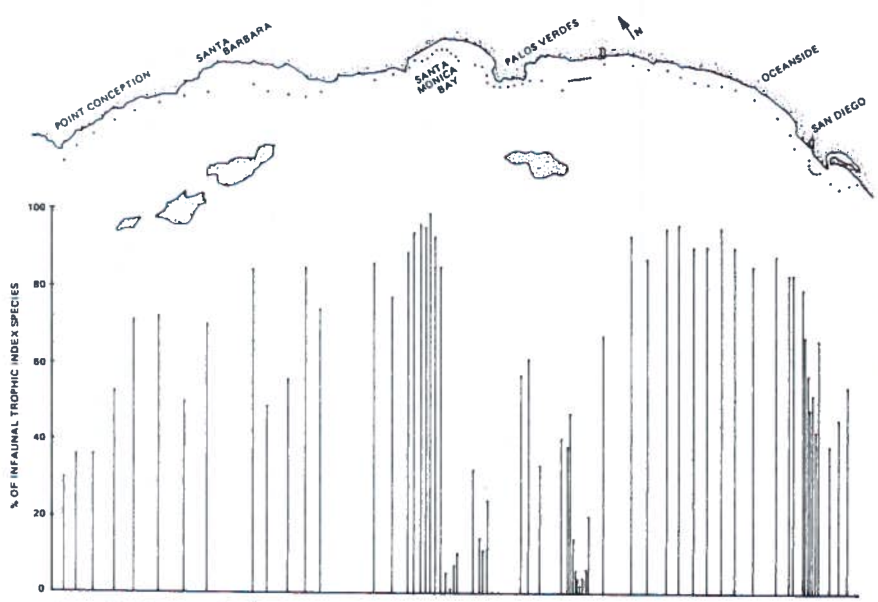


Figure 41. Percent of Infaunal Trophic Index species that were in Group I, 60-meter survey, 1977.

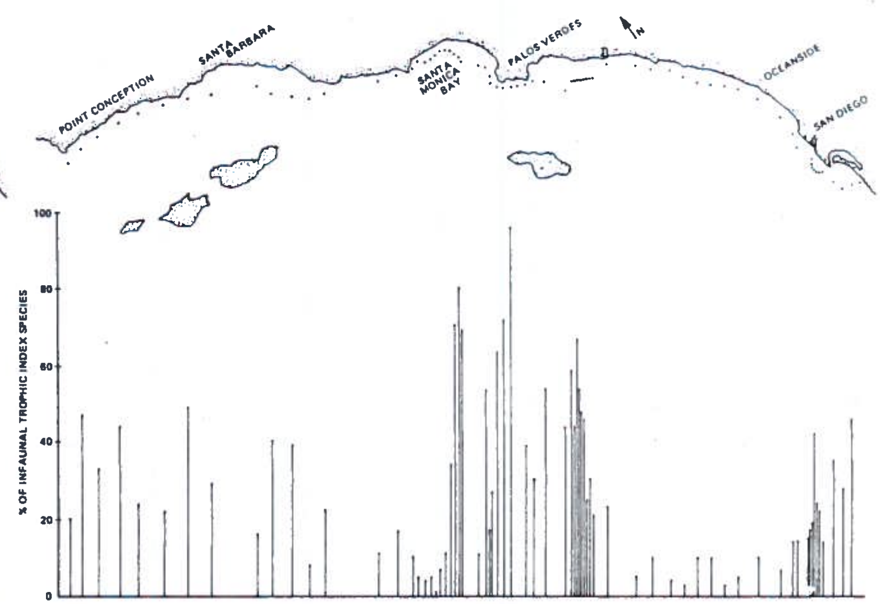


Figure 42. Percent of Infaunal Trophic Index species that were in Group II, 60-meter survey, 1977.

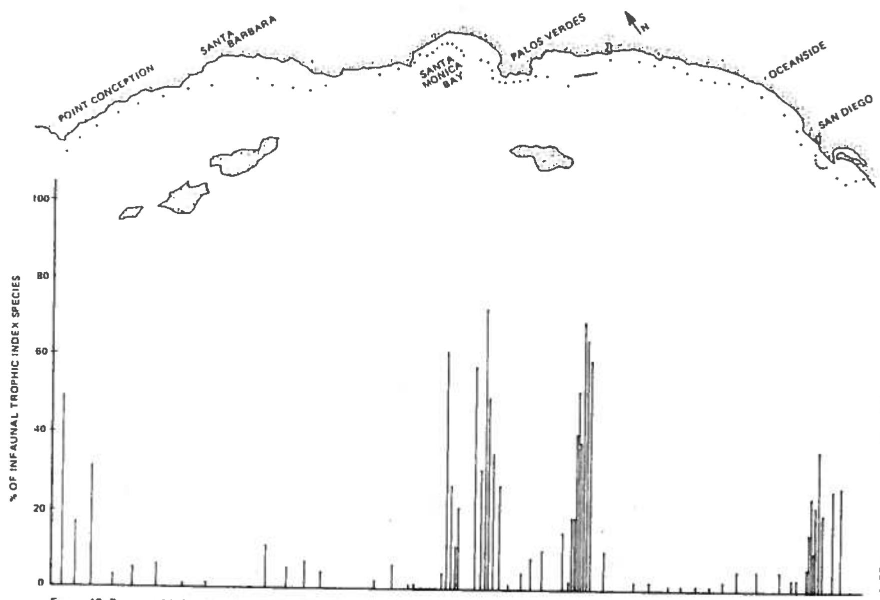


Figure 43. Percent of Infaunal Trophic Index species that were in Group III, 60-meter survey, 1977.

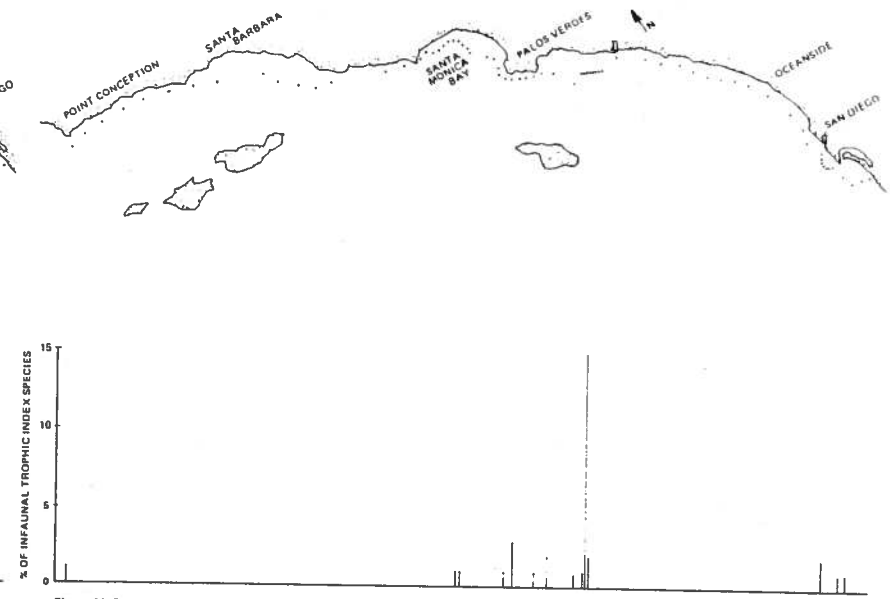


Figure 44. Percent of Infaunal Trophic Index species that were in Group IV, 60-meter survey, 1977.

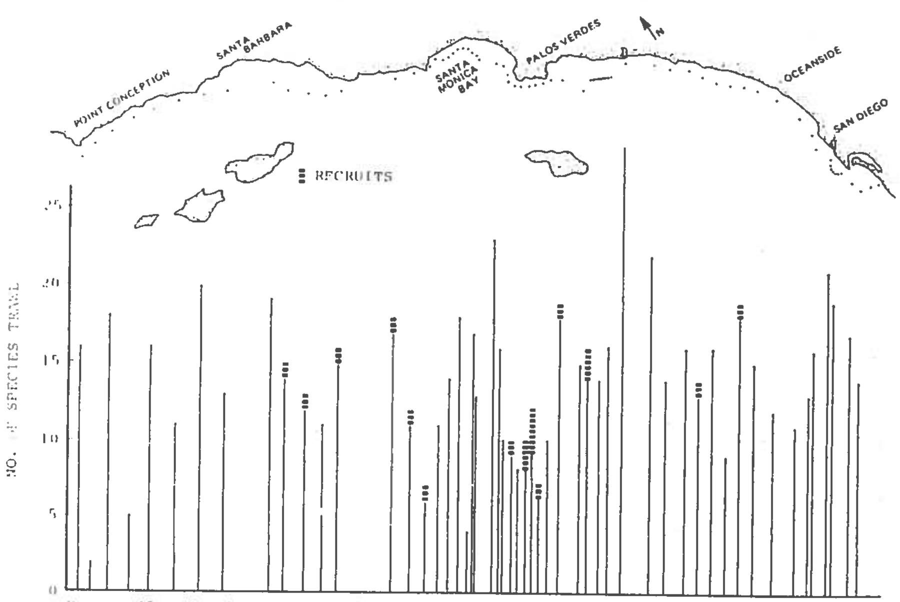


Figure 45. Total number of fish species, 60-meter survey, 1977.

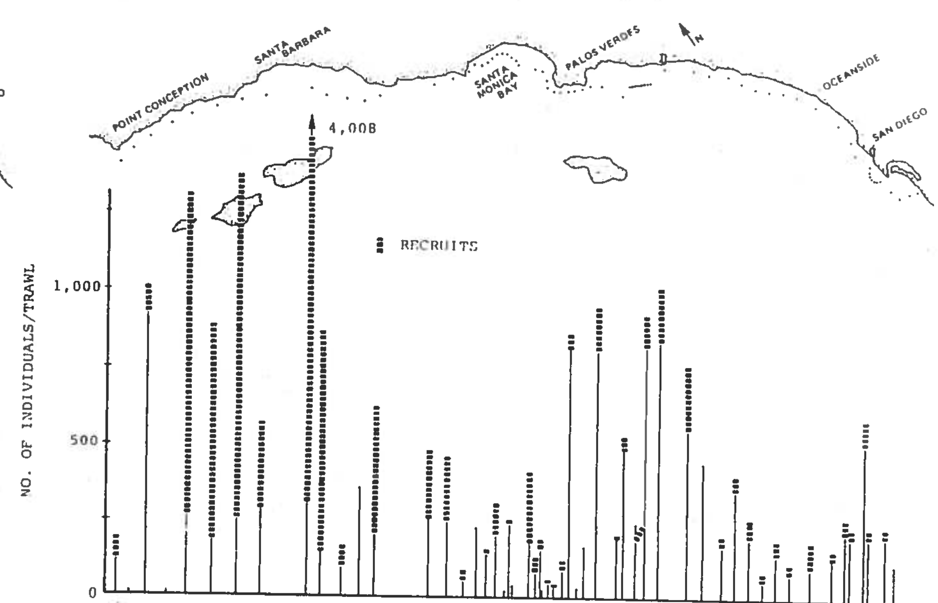


Figure 46. Total number of fish individuals, 60-meter survey, 1977.

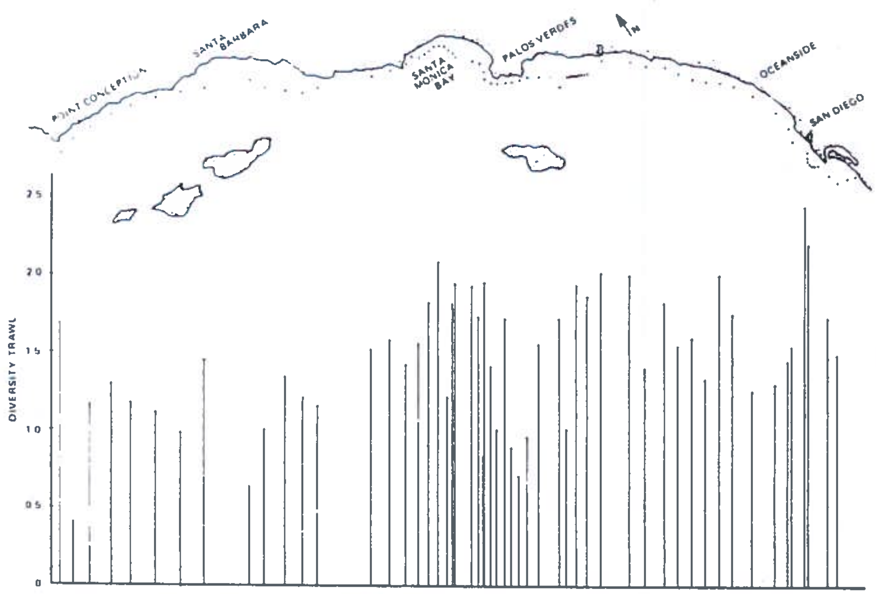


Figure 47. Shannon-Weaver Diversity, trawl-caught fish, 60-meter survey, 1977.

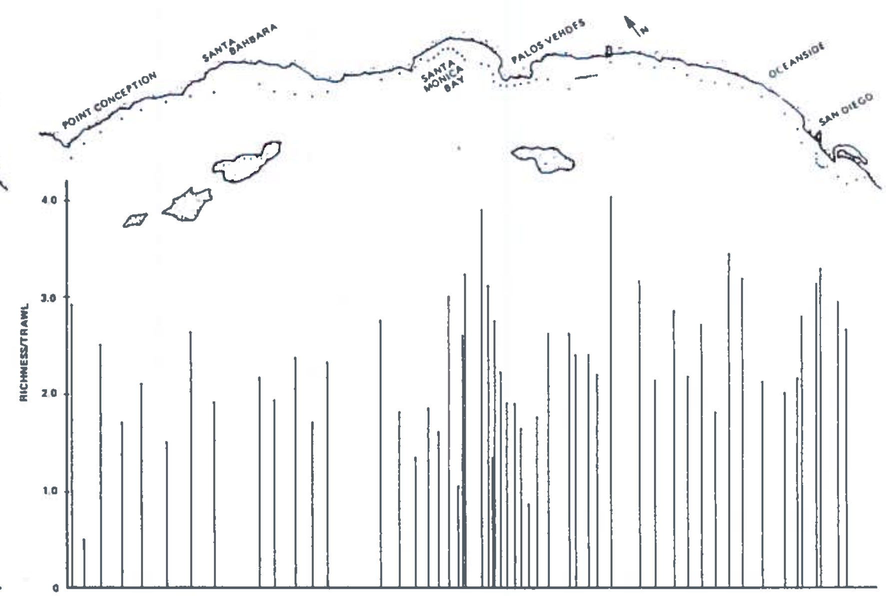


Figure 48. Gleason's Richness, trawl-caught fish, 60-meter survey, 1977.

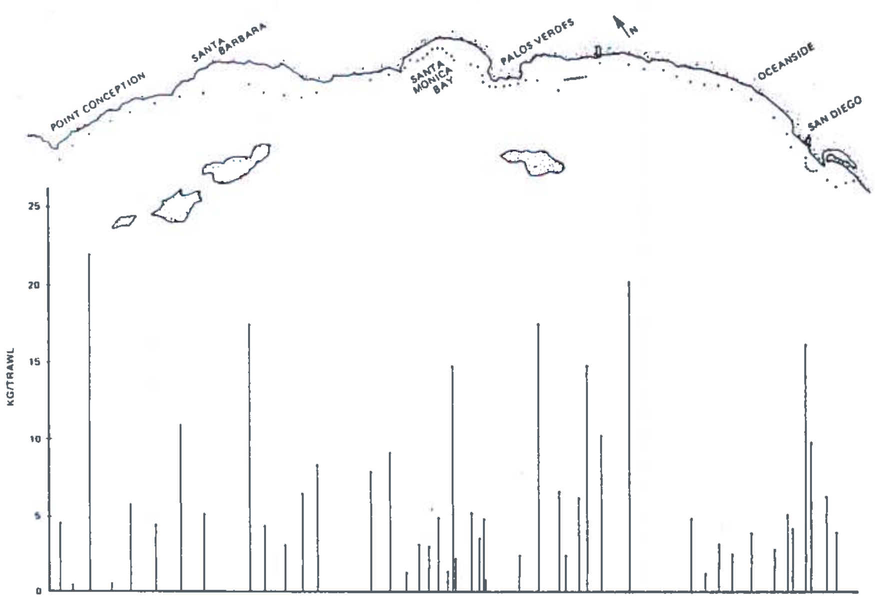


Figure 49. Fish biomasses, 60-meter survey, 1977.

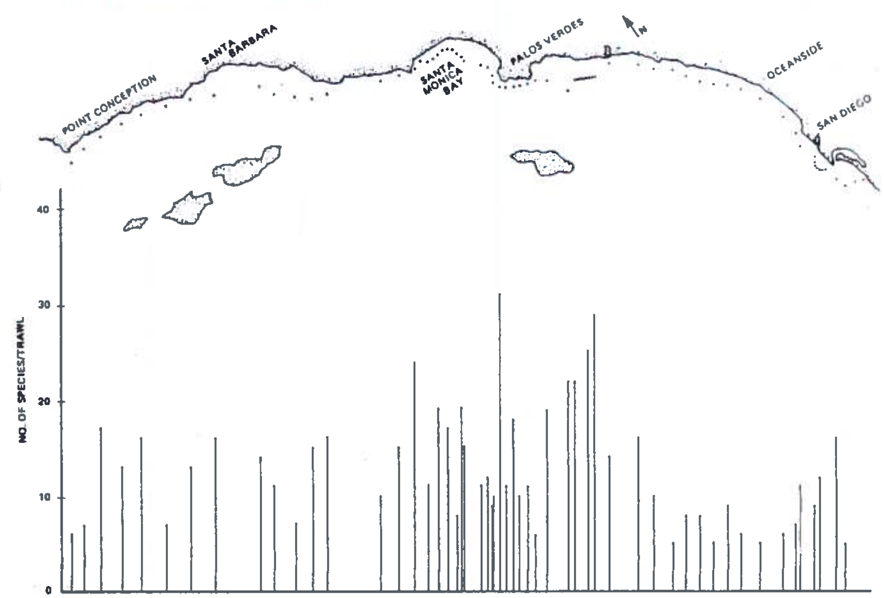


Figure 50. Total number of species, trawl-caught invertebrates, 60-meter survey, 1977.

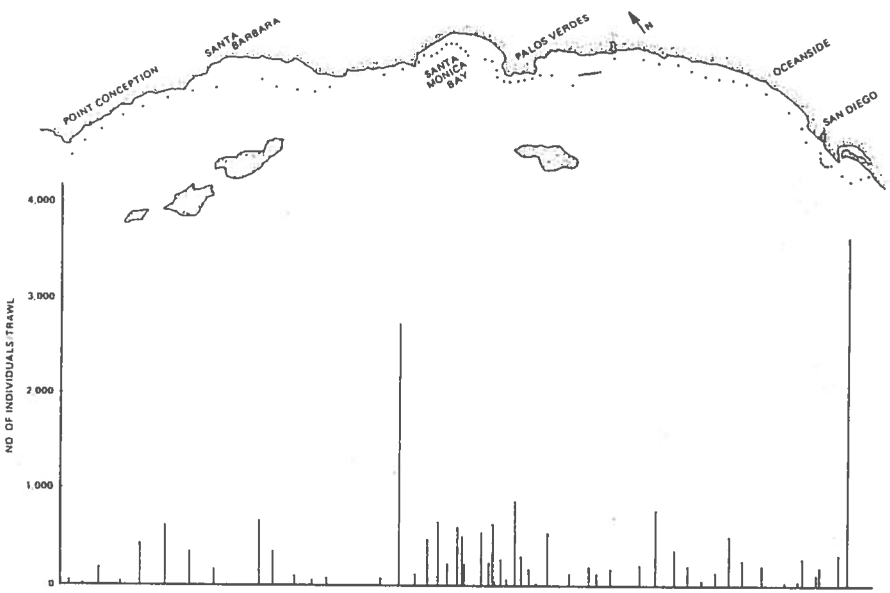


Figure 51. Total number of individuals, trawl-caught invertebrates, 60-meter survey, 1977.

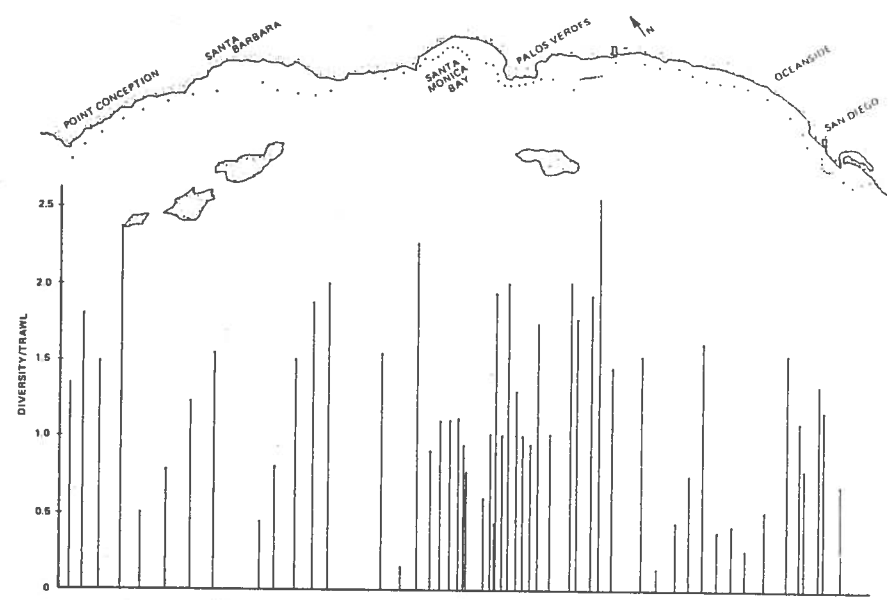


Figure 52. Shannon-Weaver Diversity, trawl-caught invertebrates, 60-meter survey, 1977.

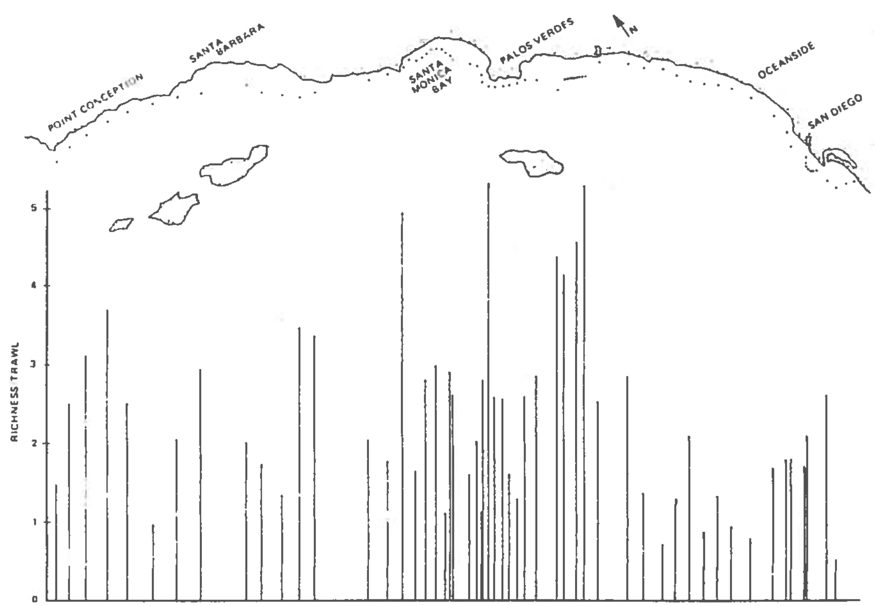


Figure 53. Gleason's Richness trawl caught invertebrates, 60-meter survey, 1977.

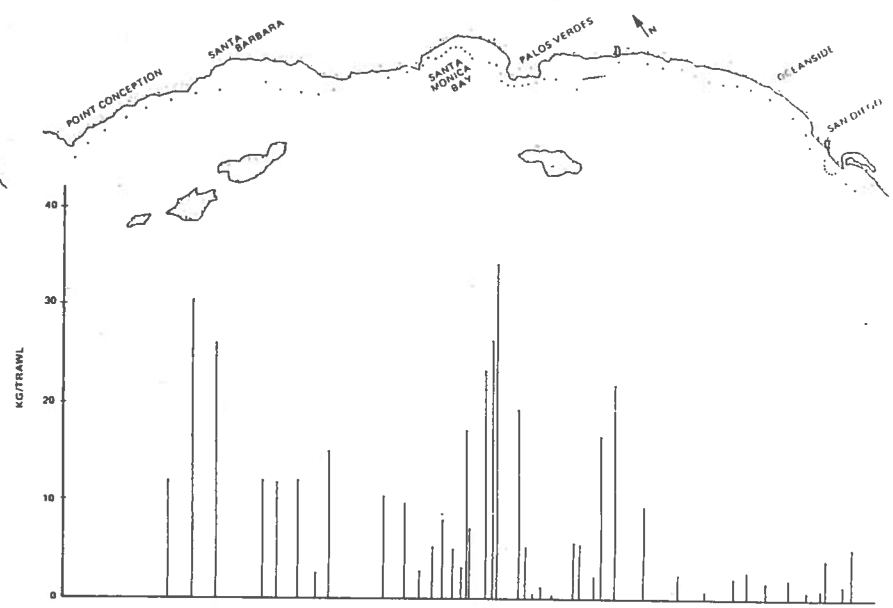


Figure 54. Biomasses of trawl-caught invertebrates, 60-meter survey, 1977.

ACKNOWLEDGMENTS

This survey was the result of a team effort on the part of individuals from a number of agencies. We especially thank Harold Stubbs, Marine Coordinator for the Coastal Water Research Project, who scheduled and directed all field work. Many Project staff members participated in sampling or laboratory analyses, and we appreciate the assistance of Michael Moore, Thomas MacDonald, Peter Striplin, Lance Horita, Michael Sanota, Richard Gossett, Patrick Hershelman, Leslie Harris, and Dr. David Young.

We were greatly assisted by Joe Nagaro (City of Los Angeles), Joe Meistrell and Dr. Irwin Haydock (Los Angeles County Sanitation Districts), Greg Pamson, Michael Heinz, and Thomas Pesich (Orange County Sanitation Districts), Bill Conn and Susan Hamilton (City of San Diego), Donald Cadien (Marine Biological Consultants, Inc.), and Brad Myers, formerly with the Project.

We appreciate the interest and untiring efforts of Willard Bascom, who continually encouraged us and helped see the study to its completion. We thank Robin Simpson for editing and producing this report.

The individuals responsible for the identification of organisms are listed below. We thank those from other agencies who assisted in this effort.

ARTHROPODS
- Bruce Benedict, Marine Biological Consultants, Inc.
- Ann Martin, Orange County Sanitation Districts
- Brad Myers, Coastal Water Research Project
- Jack Q. Word, Coastal Water Research Project

ECHINODERMS
- Leslie H. Harris, Coastal Water Research Project
- Jack Q. Word, Coastal Water Research Project

MOLLUSCS
- Don Cadien, Marine Biological Consultants, Inc.
- Phil Chang, Hyperion Treatment Plant
- Ron Cressey, Hyperion Treatment Plant
- Peter Striplin, Coastal Water Research Project
- Jack Q. Word, Coastal Water Research Project

OPHIUROIDS
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- Michael Martin, Hyperion Treatment Plant
- Dave Montagne, Los Angeles County Sanitation Districts

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- Jan Stull, Los Angeles County Sanitation Districts
- Jack Q. Word, Coastal Water Research Project

MISCELLANEOUS

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- F.G. Hochberg, Jr., Santa Barbara Museum of Natural History
- John Ljubenkov, Allan Hancock Foundation
- Brad Myers, Coastal Water Research Project
- Leslie H. Harris, Coastal Water Research Project
- Jack Q. Word, Coastal Water Research Project

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Appendix A. Infaunal species taken in control survey, 1977.

Annelida
- Acesta catherinae
- Acesta sp.
- Aedicirra sp.
- Aglaophamus sp.
- Aglaophamus dicirrus
- Allia antennata
- Allia nolani
- Allia ramosa
- Amaeana occidentalis
- Amage sp.
- Amage anops
- Amage arieticornis
- Amage perfecta
- Ampharete acutifrons
- Ampharete arctica
- Ampharete goesi
- Ampharete labrops
- Ampharete sp.
- Ampharetidoe
- Amphicteis glabra
- Amphicteis scaphobranchiata
- Amphicteis sp.
- Amphisamytha bioculata
- Anaitides sp.
- Anaitides groenlandica
- Anaitides medipapillata
- Anaitides papillosa
- Anaitides sp. 2
- Anaitides sp. 4
- Anobothrus sp.
- Apoprionospio pygmaeus
- Arabellidae
- Apomatus sp.
- Aricidea sp.
- Armandia bioculata
- Artacama coniferi
- Artacamella hancocki
- Asabellides lineata
- Asychis sp.
- Asychis disparidentata
- Axiothella rubrocincta
- Axiothella sp.
- Boccardia basilaria
- Boccardia hamata
- Brada sp.
- Capitella capitata
- Capitellidae
- Caulleriella alata
- Caulleriella gracilis
- Caulleriella hamata
- Ceratocephale crosslandi americana
- Chaetopteridae
- Chaetozone armata
- Chaetozone setosa
- Chloeia entypa
- Chone ecaudata
- Chone gracilis
- Chone mollis
- Chone veleronis
- Chone sp.
- Cirriformia spirabranchia
- Cirratulidae
- Cistena californiensis
- Clymenura gracilis
- Cossura brunnea
- "Decamastus gracilis"
- Decamastus sp.
- Diopatra ornata
- Diopatra splendissima
- Diopatra sp.
- Dorvilleidae sp. 1
- Drilonereis falcata
- Drilonereis sp.
- Drilonereis mexicana
- Drilonereis nuda
- Ehlersia (=Langerhansia) heterochaeta
- Eteone dilatae
- Eteone sp.
- Euchone arenae
- Euchone incolor
- Euchone limnicola
- Euchone sp.
- Euclymene companula
- Eulalia sp.
- Eumida "sanguinea"
- Eumida sp. 1
- Eumida sp. 2
- Eumida sp.
- Eunice americana
- Eunice sp.
- Eunicidae
- Eunoe sp.
- Eusyllis transecta
- Exogone gemmifera
- Exogone lourei
- Exogone sp.
- Fabricia berkeleyi
- Fabricia sabella
- Flabelligeridae
- Genetyllis castanea
- Glycera sp.
- Glycera americana
- Glycera branchiopoda
- Glycera convoluta
- Glycinde armigera
- Glycinde polygnatha
- Glycinde wireni
- Goniada brunnea
- Goniada littorea
- Goniada sp.
- Goniadidae
- Gyptis brevipalpa
- Haploscoloplos elongatus
- Harmothoe crassicirrata
- Harmothoe imbricata
- Harmothoe "lunulata"
- Harmothoe priops
- Harmothoe scriptoria
- Harmothoe sp.
- Hesionidae
- Hesperonoe laevis
- Heteromastus filobranchus
- Heteromastus sp.
- Hyalonoecia juvenalis
- Hyalonoecia stricta
- Hyalonoecia sp.
- Lanassa gracilis
- Lanice conchilega
- Lanice sp.
- Laonice apelloefi
- Laonice cirrata
- Laonice sacculata
- Laonice sp.
- Lepidasthenia interrupta
- Loimia medusa
- Lumbrineriidae
- Lumbrineris californiensis
- Lumbrineris cruzensis
- Lumbrineris index
- Lumbrineris japonica
- Lumbrineris lagunae
- Lumbrineris "latreilli"
- Lumbrineris limicola
- Lumbrineris pallida
- Lumbrineris tetraura
- Lumbrineris sp.
- Lysippe annectans
- Magelona pacifica
- Magelona sp.
- Magelona pitelkai
- Magelona sacculata
- Maldane cristata
- Maldane sarsi
- Maldane sp.
- Maldanidae
- Marphysa belli oculata
- Marphysa disjuncta
- Marphysa sp.
- Mediomastus sp.
- Megalomma pigmentum
- Megalomma sp.
- Melinna heterodonta
- Melinna oculata
- Mesochaetopterus taylori
- Micropodarke dubia
- Microspio sp.
- Microspio pigmentata
- Minuspio cirrifera
- Myriochele sp.
- Myriochele gracilis
- Naineris sp.
- Neanthes sp.
- Nephtys assignis
- Nephtys caecoides
- Nephtys californiensis
- Nephtys cornuta franciscana
- Nephtys ferruginea
- Nephtys parva
- Nephtys sp.
- Nereis sp.
- Nereidae
- Ninoe chilensis
- Ninoe gemmea
- Ninoe sp.
- Nothria elegans
- Nothria iridescens
- Nothria sp.
- Notocirrus californiensis
- Notomastus hemipodus
- Notomastus magnus
- "Notomastus tenuis"
- Notomastus sp.
- Notoproctus pacificus
- Odontosyllis sp.
- Odontosyllis phophorea
- Onuphidae
- Onuphis eremita
- Onuphis littoralis
- Onuphis nebulosa
- Onuphis parva
- Onuphis sp.
- Ophelina acuminata (=Ammotrypane aulogaster)
- Ophelina pallida (=Ammotrypane pallida)
- Owenia collaris
- Paleanotus bellis
- Panthalis pacifica
- Paranaitis polynoides
- Parandalia ocularis
- Paraonidae
- Paraprionospio pinnata

Annelida (continued)
Petaloproctus tenuis borealis
Pherusa capulata
Pherusa papillata
Pherusa sp.
Pholoe glabra
Pholoides (=Peisidice) aspera
Phyllochaetopterus limicolus
Phyllochaetopterus prolifera
Phyllodoce ferruginea
Phyllodoce hartmanae
Phyllodoce sp.
Phyllodocidea
Pilargidae
Pilargis berkeleyi
Pilargis maculata
Pista brevibranchiata
Pista cristata
Pista disjuncta
Pista fasciata
Pista moorei
Pista sp.
Platynereis bicanaliculata
Podarke pugettensis
Poecilochaetus johnsoni
Polycirrus sp.
Polydora caulleryi
Polydora citrona
Polydora convexa
Polydora giardi
Polydora limicola
Polydora nuchalis
Polydora socialis
Polydora websteri
Polydora sp.
Praxillella affinis pacifica
Praxillella sp.
Praxillella maculata
Prionospio steenstrupi
Prionospio sp.
Pseudomalacoceros (=Nerinides) maculata
Pseudomalacoceros pigmentata
Pseudopolydora kempi
Raricirrus maculata
Rhamphobranchium longisetosum
Rhodine bitorquata
Rhynchospio sp.
Sabellaria cementarium
Sabellaria sp.
Sabellidae
Scaleworm fragments
Scalibregma inflatum
Schistocomus hiltoni
Schistocomus sp. 1
Schistomeringos caeca
Schistomeringos longicornis
Schistomeringos sp.
Serpulidae
Sigalionidae
Sigambra tentaculata
Sphaerosyllis californiensis
Spio punctata
Spiochaetopterus costarum
Spionidae
Spiophanes berkeleyorum
Spiophanes bombyx
Spiophanes cirrata
Spiophanes kroyeri (=fimbriata)
Spiophanes ?missionensis
Spiophanes pallidus
Spiophanes sp.
Steggoa californiensis
Sternaspis fossor
Sthenelais tertiaglabra
Sthenelais verruculosa
Sthenelais sp.
Sthenelanella uniformis
Streblosoma crassibranchia
Subadyte mexicana
Syllidae
Tauberia gracilis
Tauberia oculata
Tauberia (=Paraonis) sp.
Terebellidae
Terebellides stroemii
Thalanessa spinosa
Tharyx sp.
Thelepus sp.
Thelepus setosus
Travisia brevis
Travisia foetida
Travisia gigas
Travisia sp.
Trochochaeta multisetosa
Typosyllis "aciculata"
Typosyllis heterochaeta
Typosyllis sp.
Hirudinea
Oligochaete, UI
?Peloscolex gabriellae
Peloscolex sp. 2
Tubificid type 1

Mollusca
Gastropoda
Acteocina culcitella
Acteocina exima
Acteocina harpa
Acteocina sp.
Acteon painei
Aegires albopunctatus
Aglaja ocelligera
Alia carinata
Amphissa undata
Amphissa versicolor
Austrotrophon catalinensis
Balcis sp.
Bittium larum
Bittium sp.
Caecum crebricinctum
Calyptraea contorta
Calpytraea sp.
Cancellaria crawfordiana
Cancellaria (=Admete) rhyssa
Cephalaspidea
Cerithiopsis sp.
Crepidula onyx
Cylichna sp.
Cylichna diegensis
Epitonium sp.
Gastropod, UI
Gastropteron pacificum
Haminoea virescens
Haminoea sp.
Kelletia kelletii
Kurtzia arteaga
Kurtziella beta
Kylix halocydne (Mangellinae) = Turridae
Megasurcula carpenteriana
Micranellum crebricinctum
Nassarius insculptus
Nassarius mendicus
Natica sp.
Neverita alta
Neverita reclusiana
Odostomia sp.
Olivella baetica
Olivella biplicata
Olivella sp.
Ophiodermella cancellata
Pleurobranchaea californiana
Polinices draconis
Rictaxis punctocaelatus
Sinum scopolosum
Spiculata barbarensis
Sulcoretusa sp.
Tricolia pulloides
Turbonilla sp. J
Turbonilla sp.
Turritella cooperi
Volvuella cylindrica
Volvuella panamica
Volvuella sp.

Pelecypoda
Acila castrensis
Adontorhina sp.
Amygdalum pallidum
Amygdalum sp.
Asthenothaerus villosior
Axinopsida serricata
Cardiomya californica
Carditidae
Chamidae
Compsomyax subdiaphana
Cooperella subdiaphana
Crenella divaricata
Crenella sp.
Cumingia sp.
Cyclocardia ventricosa
Cyclocardia sp.
Entodesma sp.
Gregariella chenui
Hiatella arctica
Irus lamellifer
Leptopecten latiauratus
Lucinoma acutilineata
Lyonsia californica
Lyonsia diegensis
Lyonsia sp.
Macoma acolasta
Macoma carlottensis
Macoma yoldiformis
Macoma sp.
Megacrenella sp.
Megacrenella columbiana
Modiolus neglectus
Modiolus sp.
Musculus sp.
Mysella sp. F
Mysella sp.
Mysella pedroana = M. tumida

Mollusca (continued)
Mytilidae
Nemocardium centifilosum
Nucula tenuis
Nucula sp.
Nuculana hamata
Nuculana taphria
Nuculana sp.
Pandora filosa
Pandora sp.
Paramya sp. A
Parvilucina tenuis-culpta
Pectinidae, UI
Pelecypod, UI
Periploma discus
Poromya sp.
Psephidia sp.
Pseudochama exogyra
Saxicavella sp.
Saxicavella pacifica
Solemya panamensis
Solemya sp.
Solen sp.
Tellina carpenteri
Tellina idae
Tellina modesta
Tellina pristiphora
Tellina sp.
Tellinidae
Thracia trapezoides
Thracia sp.
Thyasira barbarensis
Thyasira flexulosa
Thyasira sp.
Tomburchus redondoensis
Transenella tantilla
Verticordia ornata
Scaphopoda, UI
Cadulus sp.
Dentalium neohexagonum
Dentalium sp.
Gadila fusiformis
Siphonodentalium sp.
Aplacophora, UI
Polyplacophora, UI
Hanleya hanleyi
Leptochiton sp.
Arthropoda
Acidostoma hancocki
Ampelisca agassizi
Ampelisca brevisimulata
Ampelisca cristata
Ampelisca hancocki
Ampelisca indentata
Ampelisca macrocephale
Ampelisca milleri
Ampelisca pacifica
Ampelisca pugetica
Ampelisca romigi
Ampelisca shoemakeri
Ampelisca sp.
Ampeliscaphotis podop-thalma
Amphideutopsis oculatus
Amphipod, UI
Anomuran, UI
Anonyx sp.
Anoplodactylus erectus
Anoplodactylus sp.
Anthuridae
Aora sp.
Aoridae
Aoroides columbiae
Arcturidae, UI
Argissa hamatipes
Argulidae
Astropella sp. S
Atylus tridens
Balanus sp.
Bathyleberis californica
Bathyleberis garthi
Bathyleberis sp. C
Bathymedon pumilus
Bathymedon sp.
Byblis veleronis
Byblis sp.
Callianassa sp.
Callianassidae
Campylaspis canaliculata
Campylaspis hartae
Campylaspis rubromaculata
Campylaspis sp. M
Campylaspis sp.
Cancer sp.
Cancer branneri
Cancer jordani
Caprella sp.
Cerapus tubularis
Clythroceros planipes
Copepod, UI
Copepod, Calanoid, UI
Crangon alaskensis elongata
Cylindroleberdinae
Decapod, UI
Diastylis californica
Diastylis sp. A
Diastylis sp.
Diastylidae
Epinebalian, UI
Epinebalia pugettensis
Erichthonius braziliensis
Erileptus spinosus
Eudorella pacifica
Eudorellopsis longirostris
Eudorellopsis sp.
Euphausiacea, UI
Euphilomedes carcharodonta
Euphilomedes producta
Gammaropsis sp.
Gammaropsis thompsoni
Gnathia crenulatifrons
Gnathia sp.
Hemilamprops californica
Hemiproto sp. H
Heptacarpus stimpsoni
Heptacarpus sp.
Heterocrypta occidentalis
Heterophoxus bicuspidatus
Heterophoxus oculatus
Hippolytidae, UI
Hippomedon denticulatus
Hippomedon sp.
Idarcturus alellomorphus
Idarcturus sp.
Isopod, UI
Jaeropsis dubia
Lamprops carinata
Lamprops sp. A
Lembos audbettius
Lembos sp.
Lepidepecreum gurjanovae
Lepidepecreum sp.
Leptochelia sp.
Leptognathia sp.
Leptostylis sp. A
Leptostylis sp.
Leucon subnasica
Listrella albinia
Listriella diffusa
Listrella goleta
Listriella melanica
Lophopanopeus sp.
Lysianassa oculata
Lysianassa sp.
Lysianassidae
Majiidae
Mayerella banksi
Megaluropus sp.
Mesolamprops bispinosa
Metaphoxus frequens
Monoculodes hartmanae
Monoculodes sp.
Munna sp.
Mursia gaudichaudii
Mysidacean, UI
Natantia, UI
Neastacilla californica
Neomysis kadiakensis
Nicippe tumida
Nymphon pixallae
Opisa tridentata
Oradarea sp.
Oropallene sp.
Orthopagurus minimus
Oxyurostylis pacifica
Paguridae, UI
Pagurus sp.
Palaemonidae
Parapagurodes laurentae
Paraphoxus abronius
Paraphoxus bicuspidata
Paraphoxus epistomus
Paraphoxus floridanus
Paraphoxus jonesi
Paraphoxus lucubrans
Paraphoxus obtusidens
Paraphoxus robustus
Paraphoxus similis
Paraphoxus spinosus
Paraphoxus stenodes
Paraphoxus sp.
Parasterope sp.
Pardisynopiae synopiae
Photis brevipes
Photis californica
Photis lacia
Photis macrotica
Photis sp.
Phoxocephalidae
Phtisicinae (Caprellidae)
Pinnixa barnhardti
Pinnixa franciscana
Pinnixa occidentalis
Pinnixa tubicola
Pinnixa sp.
Pinnotheridae
Pleusymptes subglaber
Podochela hemphilli
Podochela lobifrons
Podochela sp.
Pontogeneia sp.
Porcellanidae
Prachynella lodo
Protomedia articulata
Pycnogonid, UI

Arthropoda (continued)

- Pycnogonum stearnsi
- Pyromaia tuberculata
- Rhachotropis sp.
- Rutiderma sp.
- Sarsiella sp. B
- Scalpellum sp.
- Scalpellum californicum
- Scleroconcha trituberculata
- Scleroplax sp.
- Sicyonia ingentis
- Silophasma (=Haliophasma) geminata
- Socarnoides illudens
- Stenothoidae
- Sthenothoides bicoma
- Synchelidium sp.
- Synidotea calcarea
- Synidotea magnifica
- Tanaid, UI
- Tanystylum sp.
- Tiron biocellata
- Tritella pilimana
- Tritella sp.
- Upogebia pugettensis
- Urothoe varvarina
- Vargula tsujii
- Westwoodilla caecula
- Westwoodilla sp.

Echinodermata

- Amphichondrius granulosus
- Amphiodia (Amphispina) sp.
- Amphiodia (Amphispina) digitata
- Amphiodia psara
- Amphiodia (Amphispina) urtica
- Amphiodia sp.
- Amphipholis pugetana
- Amphipholis squamata
- Amphioplus sp.
- Amphiura arcystata
- Amphiuridae
- Asteroidea, UI
- Astropecten sp.
- Astropecten verrilli
- Brisaster latifrons
- Cucumaria sp.
- Cucumariidae
- Dougaloplus amphacantha
- Echinoidea, UI
- Holothuroidea, UI
- Leptosynapta sp.
- Luidia sp.
- Lytechinus anamesus
- Lytechinus sp.
- Ophiopholis sp.
- Ophiopsila californica
- Ophiura lutkeni
- Ophiuroconis bispinosa
- Ophiuroidea, UI
- Pentamera populifera
- Synaptidae
- Taeniogyra sp.

Miscellaneous Phyla

- Ammodiscus sp.
- Cornuspira sp.
- Dentalina sp.
- Discorbis sp.
- Foraminifera, UI
- Frondicularia gigas
- Frondicularia sp.
- Haplophragmoides sp.
- Nonionidae
- Rhabdammina sp.
- Rheophax sp.
- Robulus sp.
- Protozoa, UI
- Textularia sp.
- Acanthoptilum gracile
- Acanthoptilum sp.
- Anemone, UI
- Anthozoa, UI
- Burrowing anemone, UI
- Cerianthidae
- Coenocyathus bowersi
- Corymorpha sp.
- Edwardsia sp. A.
- Edwardsiidae
- Filigella mitzukurii
- Gorgonian, UI
- Halcampoides sp.
- Halecidae
- Hydroid, UI
- Isoedwardsia sp. A
- Pennatulacea, UI
- Perigonimus sp.
- Plumularia sp.
- Sea pen, UI
- Stylatula elongata
- Virgulariinae
- Platyhelminthes, UI
- Nematode, UI
- Nemertea, UI
- Brown-striped nemertean, UI
- Cerebratulus californiensis
- Cerebratulus sp.
- Purple-banded nemertean, UI
- Bryozoan, UI
- Buskia sp.
- (Cupuladria sp./Discoporella sp.) = Lunulariidae
- Filicrisia sp.
- Ectoproct, UI
- Glottidia albida
- Phoronis sp.
- Phoronopsis sp.
- Sipuncula, UI
- Golfingia sp.
- Listriolobus pelodes
- Chaetognath, UI
- Sagitta sp.
- Ascidian, UI
- Mogula sp.
- Styela sp.
- Hemichordate, UI

Appendix B. Species taken by trawl in control survey, 1977.

FISHES

Agonopsis emmelane
Anoplopoma fimbria
Aprodon cortezianus
Argentina sialis
Cephaloscyllium ventriosum
Chilara taylori
Chitonotus pugetensis
Citharichthys fragilis
Citharichthys sordidus
Citharichthys stigmaeus
Citharichthys xanthostigma
Coryphopterus nicholsi
Cymatogaster aggregata
Eopsetta jordani
Genyonemus lineatus
Hippoglossina stomata
Hydrolagus colliei
Icelinus tenuis
Lepidogobius lepidus
Lycodopsis pacifica
Lyopsetta exilis
Microstomus pacificus
Odontopyxis trispinosa
Ophiodon elongatus
Paralichthys californica
Parophrys vetulus
Peprilus simillimus
Pleuronichthys decurrens
Pleuronichthys verticalis
Porichthys notatus
Rathbunella spp.
Raja ornata
Raja binoculata
Scorpaena guttata
Sebastes sp.
Sebastes chlorostictus
Sebastes crameri
Sebastes dalli
Sebastes diploproa
Sebastes elongatus
Sebastes goodei
Sebastes hopkinsi
Sebastes jordani
Sebastes levis
Sebastes miniatus
Sebastes mystinus
Sebastes paucispinis
Sebastes rosenblatti
Sebastes saxicola
Sebastes semicinctus
Sebastes serranoides
Sebastes vexillaris/ caurinus
Symphurus atricauda
Synodus lucioceps
Torpedo californica
Xeneretmus latifrons
Xeneretmus triacanthus
Zalembius rosaceus
Zaniolepis frenata
Zaniolepis latipinnis

INVERTEBRATES

Annelida
Polychaeta
Chaetopterus variopedatus
Diopatra sp.
Diopatra ornata
Hyalinoecia juvenalis
Phyllochaetopterus sp.
Scaleworm
Mollusca
Acanthodoris brunnea
Acteocina sp.
Aplysia californica
Armina californica
Bittium sp.
Bursa californica
Calinaticina oldroydi
Calliostoma sp.
Calliostoma tricolor
Calliostoma turbinum
Cancellaria cooperi
Chama pellucida
Chelidonura inermis
Compsomyax sp.
Corolla spectabilis
Cyclocardia ventricosa
Diodora aspera
Dirona picta
Dorid, UI
Doriopsilla albopunctata
Epitonium (Nitidiscala) sp.
Flabellinopsis iodinea
Hermissenda crassicornis
Heteropod, UI
Hiatella arctica
Hinnites giganteus
Kelletia kelletii
Lamellaria sp.
Lima hemphilli
Loligo opalescens
Megasurcula carpenteriana
Mytilus edulis
Nassarius insculptus
Nassarius mendicus
Nassarius perpinguis
Nemocardium centifilosum
Neverita altus
Neverita recluzianus
Octopus californicus
Octopus rubescens
Pecten diegensis
Philine alba
Pleurobranchaea californica
Pleurobranchus californicus
Pododesmus macrochisma
Polinices lewisii
Pteropod, UI
Rossia pacifica
Spiculata barbarensis
Tritonia diomedeae
Arthropoda
Alphaeopsis equidactylus
Alpheus sp.
Alpheus clamator
Ampelisca sp.
Balanus concavus pacificus
Balanus galetus
Balanus tintinnabulum calif.
Balanus sp.
Cancer anthonyi
Cancer gracilis
Cancer jordani
Caprella californica
Crangon alaskensis elongata
Chthamalus sp.
Cymadusa uncinata
Decapod, UI
Erileptus spinosus
Eualus herdmani
Hemisquilla stylifera
Heptacarpus brevirostris
Heterocrypta occidentalis
Lironeca vulgaris
Lophopanopeus sp.
Loxorhynchus crispatus
Loxorhynchus grandis
Lysmata californicus
Majidae, UI
Melita appendiculata
Mimulus foliatus
Mursia gaudichaudii
Mysidacean, UI
Nymphon pixallae
Orthopagurus minimus
Pachygrapsus crassipes
Paguridae, UI
Paguristes bakeri
Pagurus armatus
Pagurus sp. 4
Pandalus danae
Pandalus platyceros
Photis sp.
Podochela hemphilli
Portunus xantusii
Pyromaia tuberculata
Randallia ornata
Scalpellum sp.
Scalpellum californicum
Sicyonia ingentis
Synalpheus lockingtoni
Echinodermata
Allocentrotus fragilis
Astropecten verrilli
Caudina sp.
Cucumariidae
Florometra perplexa
Henricia leviuscula
Luidia asthenosoma
Luidia foliolata
Luidia ludwigi
Lytechinus anamesus
Mediaster aequalis
Molpadia sp.
Ophiopteris papillosa
Ophiothrix spiculata
Ophiura lutkeni
Parastichopus californicus
Pycnopodia helianthoides
Rathbunaster californicus
Sclerasterias heteropaes
Solaster dawsoni
Strongylocentrotus franciscanus
Strongylocentrotus purpuratus
Other Phyla
Acanthoptilum sp.
Austrobdella californica
Bryozoan, UI
Coenocyathus bowersi
Corynactis californica
Ctenophore, UI
Epizoanthus induratum
Eugorgia sp.
Eugyra arenosa
Filigella mitzukurii
Hexactinellidae, UI
Listriolobus pelodes
Lophogorgia chilensis
Metridium senile

Nemertean, UI
Paracyathus stearnsi
Pegea confoederata
Pennatulacean, UI
Platyhelminthes, UI
Pleurobrachia bachei
Poriferan, UI
Pyrosoma sp.
Salpidae, UI
Styela gibbsi
Stylatula elongata
Thalamoporella sp.
Tunicate, UI
Urochordate, UI