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A COMPARATIVE TRAWL SURVEY OF THREE AREAS OF HEAVY WASTE DISCHARGE

Edited by Alan J. Mearns
and Charles S. Greene

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
1500 East Imperial Highway, El Segundo, California 90245

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PREFACE

This publication represents one of a series of task reports to the Environmental Protection Agency in fulfillment of the requirements of Grant Number R-801152. Under this grant, the Coastal Water Research Project initiated a program to investigate demersal and benthic marine communities and to evaluate the sampling and analytical techniques used in characterizing these communities. The synoptic biological and hydrographic survey described here was the culmination of the first phase of this program.

ACKNOWLEDGMENTS

We are indebted to many individuals whose efforts contributed to the successful completion of this survey. Dr. John S. Stephens, Director of the Vantuna Consortium, Occidental College, and his students provided valuable assistance in planning and conducting the survey; we especially thank Catherine Cusick, John Helly, Steve Subber, and Susan Jelley. Kenneth Hudson and the crew of the R/V Vantuna were most helpful during the survey. In addition, Rusty Shields and Douglas Hotchkiss of the Los Angeles County Sanitation Districts were invaluable during sampling off the Palos Verdes coastal shelf, and Dr. Hal Puffer, Dilworth Chamberlain, and Laurie Phillips (University of Southern California) gave us special assistance during sampling off Orange County.

Contributing authors from the Project staff and their areas of expertise are M. James Allen, Marjorie Sherwood, and Robert Voglin (fisheries biology); Jack Word and Danuta Charwat (invertebrate biology); Thomas Sarason (sediments and benthic invertebrates); and Cindy Smith (oceanography). Jack Mardesich and Harold Stubbs provided assistance in field operations. Leslie Harris and Corey Dzitzer assisted in field collections and data processing.

We are grateful for the support of Dr. Richard Swartz of the Environmental Protection Agency in this research effort.

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INTRODUCTION AND SUMMARY

Many agencies have been using a variety of small otter trawls to survey nearshore fish and invertebrate populations in southern California. Because of the variation in gear and techniques, it has been very difficult to make firm conclusions about regional differences in the abundance and variety of this portion of the coastal fauna.

In September 1973, the Coastal Water Project conducted a 3-day synoptic trawl and water quality survey of three regions, using uniform sampling procedures. The purpose of the survey was to further define the extent of possible regional differences in in the abundance, health, and variety of demersal marine life. A second objective was to determine whether or not demersal fauna was distributed according to bottom water quality parameters.

The synoptic survey trawl samples contained approximately 35,000 individuals, representing 101 species of invertebrates and 68 species of fish. Catches were dominated by speckled sanddab (*Citharichthys sordidus*), stripetail rockfish (*Sebastes saxicola*), Dover sole (*Microstomus pacificus*), and several species of shrimp (*Sicyonia ingentis*, *Pandalus jordani*, *Crangon* spp.).

Of the three regions sampled, the largest catches, in terms of weight and number of individuals, were taken in Santa Monica Bay and on the Palos Verdes shelf. Each of these two regions produced a total number of species that was greater than that taken in San Pedro Bay. But individual catches in San Pedro Bay were generally more diverse than those in the other two regions.

In spite of these general trends, there were no statistically significant differences among the three coastal areas in terms of catch per haul, species per haul, biomass, and diversity. The faunal composition of the Palos Verdes shelf was different from that of either of the two bay areas, and a fin erosion disease was significantly more prevalent in benthic fishes from Palos Verdes than in those from the other two sites.

Much of the variability in fish and invertebrate catches appeared to be related to depth (and bottom water temperature and dissolved oxygen concentrations) rather than regional differences. Fish biomass and diversity was significantly higher in the deep off-shore samples (141 m) than inshore (26 m) and was related to decreasing temperature and low dissolved oxygen. The distribution of shrimp, the most abundant invertebrates (especially in Santa Monica Bay), was also related to depth.

These findings indicate that gear, gear use, depth, and bottom water quality (temperature and dissolved oxygen) all contribute to variations in yield and diversity of coastal organisms. It is concluded that a regional sampling approach would greatly increase the benefits of trawl sampling by reducing the variables of sampling methodology. This kind of survey should be repeated on a quarterly basis.

Table 1.
Description of stations, synoptic survey, September 1973.

Sta. No.	Alternate Sta. No.*	Time	Longitude**	Latitude	Depth (m)	Substrate †
SANTA MONICA BAY, 24 Sep						
5002	D-6	0803-0813	34° 01.60'	118° 37.40'	28	black sticky mud
5028	D-20	0858-0908	33° 59.75'	118° 37.60'	59	black-olive sticky mud
5095	-	1007-1017	33° 58.70'	118° 37.25'	138	No data
5004	H-6	1140-1150	34° 00.25'	118° 32.00'	25	dark olive sandy silt
5020	H-20	1230-1240	33° 58.60'	118° 34.40'	59	olive green sand/gravel
5096	-	1415-1425	33° 56.00'	118° 35.70'	142	No data
5007	B-6	1739-1749	33° 56.00'	118° 27.90'	20	gritty gray black mud w/pebbles
5022	S-20	1625-1635	33° 56.50'	118° 33.00'	64	dark gray-brown sandy gravel w/pebb.
5097	-	1525-1535	33° 56.70'	118° 34.50	136	No data
PALOS VERDES SHELF, 25 Sep						
6002	T1-75	0828-0838	33° 44.50'	118° 24.80'	27	brown sandy gravel with silt
6014	T1-200	0914-0924	33° 44.00'	118° 25.25'	63	brown sandy silt
6019	T1-450	1010-1020	33° 43.80'	118° 25.40'	146	light silty sand
6005	T3-75	1157-1207	33° 43.75'	118° 25.25'	26	light olive silty sand, H_2S
6012	T3-200	1245-1255	33° 43.00'	118° 22.50'	61	olive sandy silt
6022	T3-450	1343-1353	33° 42.80'	118° 22.50'	150	olive sandy silt
6007	T5-75	1702-1712	33° 42.20'	118° 18.50'	30	dark olive sandy silt, H_2S
6010	T5-200	1608-1618	33° 41.40'	118° 18.75'	60	dark olive silt with sand, H_2S
6025	T5-450	1507-1517	33° 41.00'	118° 19.00'	133	dark olive silt
SAN PEDRO BAY (ORANGE COUNTY), 26 Sep						
8008	4(Oxy)	0758-0808	33° 39.80'	118° 05.40'	24	black silt
8073	Oxy 2-3	0855-0905	33° 35.80'	118° 05.80'	66	olive black silt with clay
8023	T-5	0949-0959	33° 35.50'	118° 05.50'	143	olive green silt with mud
8067	-	1149-1159	33° 37.50'	118° 01.25'	25	grey olive green sandy silt
8068	-	1244-1254	33° 35.00'	118° 02.20'	62	No data
8069	-	1345-1355	33° 34.50'	118° 02.60'	143	olive green silt
8070	4(OrcoEd)	1720-1730	33° 36.40'	117° 59.40'	26	olive green clay
8071	near T-1	1625-1635	33° 34.00'	117° 59.80'	62	olive green silt
8072	-	1520-1530	33° 33.75'	117° 59.80'	145	olive green sandy silt

* Twenty-two stations sampled in the synoptic survey are presently used by other monitoring agencies; the station numbers assigned by these agencies are given in this column.

** Longitude and latitude readings were taken at the center of each trawl transect.

† Data on Palos Verdes sediments were extrapolated from data from a benthic grab survey conducted by Los Angeles County Sanitation Districts in January and February 1973.

All tows were 10 minutes in duration (time on bottom) and were made at a speed of 1.3 to 1.5 m/sec. Cable lengths out for each depth were 137 m at 26 m, 274 m at 61 m, and 426 m at 141 m. Tows were always made along bottom contours. At one station (5096), a second trawl haul was made because the net failed to open correctly during the first haul (only eight fish were collected).

The fishes and invertebrates from each collection were identified, counted, and measured onboard ship (invertebrates that we could not readily identify were preserved in formalin and examined again in the Coastal Water Project laboratory). Fish and identified invertebrates were weighed by species to the nearest 0.1 kg.

All specimens were examined for external signs of disease or anomalies as they were measured, and anomalous specimens were then preserved in buffered formalin. Specimens of flatfish, croakers, and black perch were packaged and frozen for analysis of trace chemicals (chlorinated hydrocarbons and metals).

The biological data was keypunched and summarized for diversity, species dominance, species associations, length frequencies, disease frequencies and other parameters, using data summarization programs recently developed by the Project. All analyses were completed on an IBM 3600 computer at the University of California, Los Angeles.

Water and Bathythermograph Samples

Following retrieval of each tow, we returned to the midpoint of the trawl transect and took water samples at the surface, at middepth (depth divided by 2), and within several meters of the bottom. Nansen bottles were used for the subsurface samples; these were attached to the cable 1 m above either a 61- or 137-m bathythermograph (BT). The BT was lowered to within 1 m of the bottom. Surface temperature was measured by a thermometer, and bottom temperature was taken as the lowest recording on the BT slide. Dissolved oxygen (D.O.) was measured at the surface, mid-depth, and bottom in duplicate, using the modified (azide) Winkler titration method. Conductivity was determined using an inductive salinometer at 17.9°C.

Secchi disk depth and wire angle was recorded following retrieval of the benthic grab samples (below).

Sediment Samples

A Shipek grab was used to sample benthic surface sediments at each station. Sediments were described by color and gross composition, and aliquots were taken for analysis of particle-size distribution and for benthic fauna retained on a 0.5-mm mesh screen.

Most of the Shipek grab samples were generally small and suitable only for description of the sediments obtained.

Additional Observations

We made incidental observations on birds, marine mammals, insects, and sea surface materials. Two drops of a green fluorescein dye were made 0.8 km off the Huntington Beach Pier to mark the ship location and ground-truth site for a NASA overflight, 26 September 1973.

Nine biological and hydrographic stations were completed each day by a technical staff of eleven to thirteen, the skipper, and two crew members.

OCEANOGRAPHIC OBSERVATIONS

Data from 27 bathythermograph and Secchi disk drops and 81 water samples were examined to describe both general oceanographic conditions and the characteristics of the bottom waters trawled during the biological survey. Data on clarity, mixed layer depths, salinity, temperature, D.O., and air and sea surface conditions are reported in Appendices A and B and summarized in the following paragraphs.

GENERAL OCEANOGRAPHIC CONDITIONS

The sea surface was calm at all sites during the survey. Offshore breezes occurred in the afternoon of the Santa Monica Bay and Palos Verdes surveys, and mild onshore (Santa Ana) wind conditions were noted during the cruise in San Pedro Bay.

Surface waters were warm, averaging 17.9°C off Palos Verdes and 18.4°C in Santa Monica and San Pedro Bays (Table 2). A seasonal thermocline was present at all sites, with mixed layer depths ranging from 7 to 10 m. The surface waters at all stations were saturated with D.O. (8.4 to 9.9 mg/L; 105 to 129 percent saturation), although the highest values were usually found inshore. Stations near the outfalls had both moderate and high D.O. values, and surface water D.O. seemed to be unaffected by the wastewater discharges.

The surface mixed layer was deeper off Palos Verdes (12.56 m) than in Santa Monica or San Pedro Bays (8.7 and 7.2 m, respectively) and was about the same order of depth as the Secchi disk readings for water clarity. The mixed layer was deepest at the two stations nearest shore on the middle Palos Verdes transect (Stations 6005 and 6012); visibility was low to moderate (5 to 9 m) at these sites. The clearest waters (visibility 10 to 14 m) were at offshore stations in Santa Monica and San Pedro Bays.

Below the mixed layer, temperature and D.O. decreased with increasing depth and distance offshore on all transects (Figures 2 through 4). In general, the thermocline (and the mixed layer) was shallower offshore than inshore, with most of the temperature gradient occurring in the upper 50 m. D.O. showed similar decreases with depth, but salinity generally increased with depth. None of these parameters, including D.O., showed significant deviations that could

Table 2. Surface temperature, dissolved oxygen, clarity, and salinity, synoptic survey, September 1973*

	Santa Monica Bay	Palos Verdes Shelf	San Pedro Bay
Temperature (^oC)			
Mean $\pm$ S.E.$_{\bar{x}}$	18.4 $\pm$ 0.13	17.9 $\pm$ 0.03	18.4 $\pm$ 0.14
Range	17.8-18.8	17.8-18.1	17.9-19.2
Salinity (^{o}/oo)			
Mean $\pm$ S.E.$_{\bar{x}}$	33.583 $\pm$ 0.013	no data	33.508 $\pm$ 0.018
Range	33.539-33.624		33.474-33.646
D.O. (mg/L)			
Mean $\pm$ S.E.$_{\bar{x}}$	8.67 $\pm$ 0.21	8.71 $\pm$ 0.09	8.77 $\pm$ 0.05
Range	8.1-9.4	8.4-9.1	8.5-9.0
D.O. Saturation (%)			
Mean $\pm$ S.E.$_{\bar{x}}$	113.33 $\pm$ 3.59	no data	114.11 $\pm$ 0.65
Range	105-129		112-117
Clarity (m)			
Mean $\pm$ S.E.$_{\bar{x}}$	11.13 $\pm$ 1.23	8.11 $\pm$ 0.99	9.69 $\pm$ 0.89
Range	5.0-14.0	7.5-9.5	5.8-12.8
Mixed Layer Depth (m)			
Mean $\pm$ S.E.$_{\bar{x}}$	8.67 $\pm$ 0.44	12.56 $\pm$ 4.12	7.22 $\pm$ 0.67
Range	7-10	7-25	7-9

* Values are based on data from 9 stations, with the following exceptions: Santa Monica Bay salinity and D.O. saturation, 6 samples; Santa Monica Bay clarity, 8 samples.

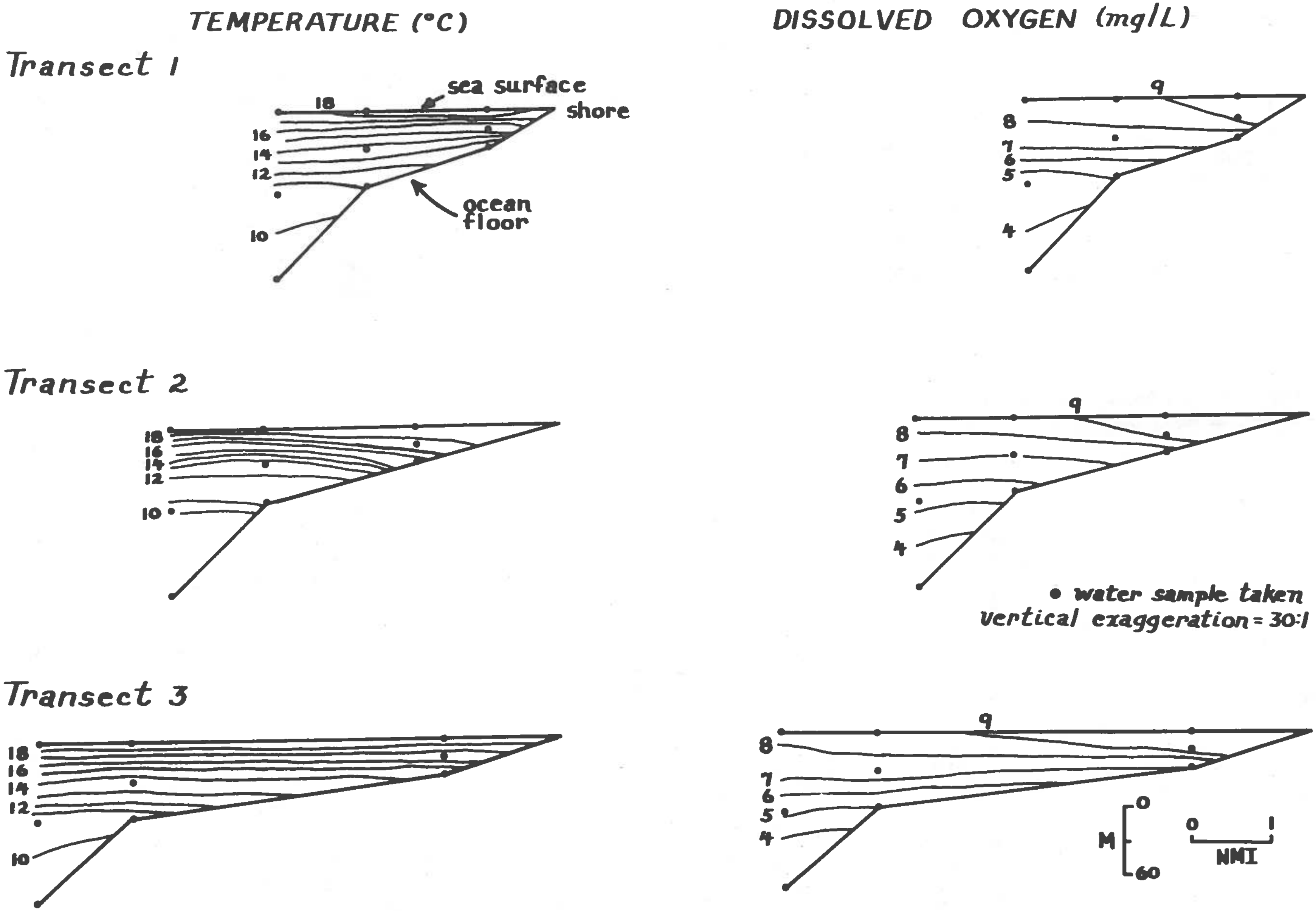

Figure 2. Temperature and dissolved oxygen with depth, Santa Monica Bay, 24 September 1973.

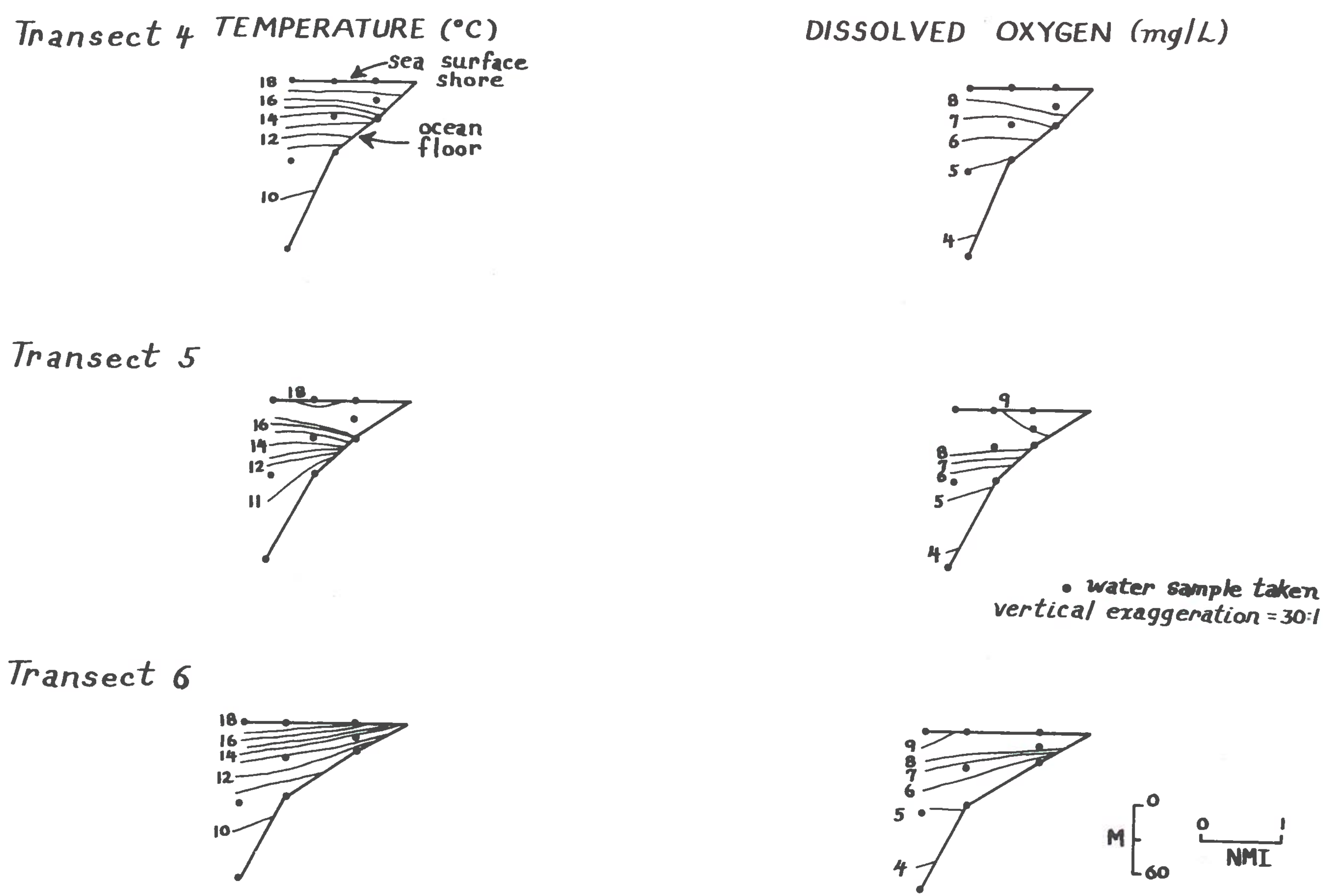

Figure 3. Temperature and dissolved oxygen with depth, Palos Verdes shelf, 25 September 1973.

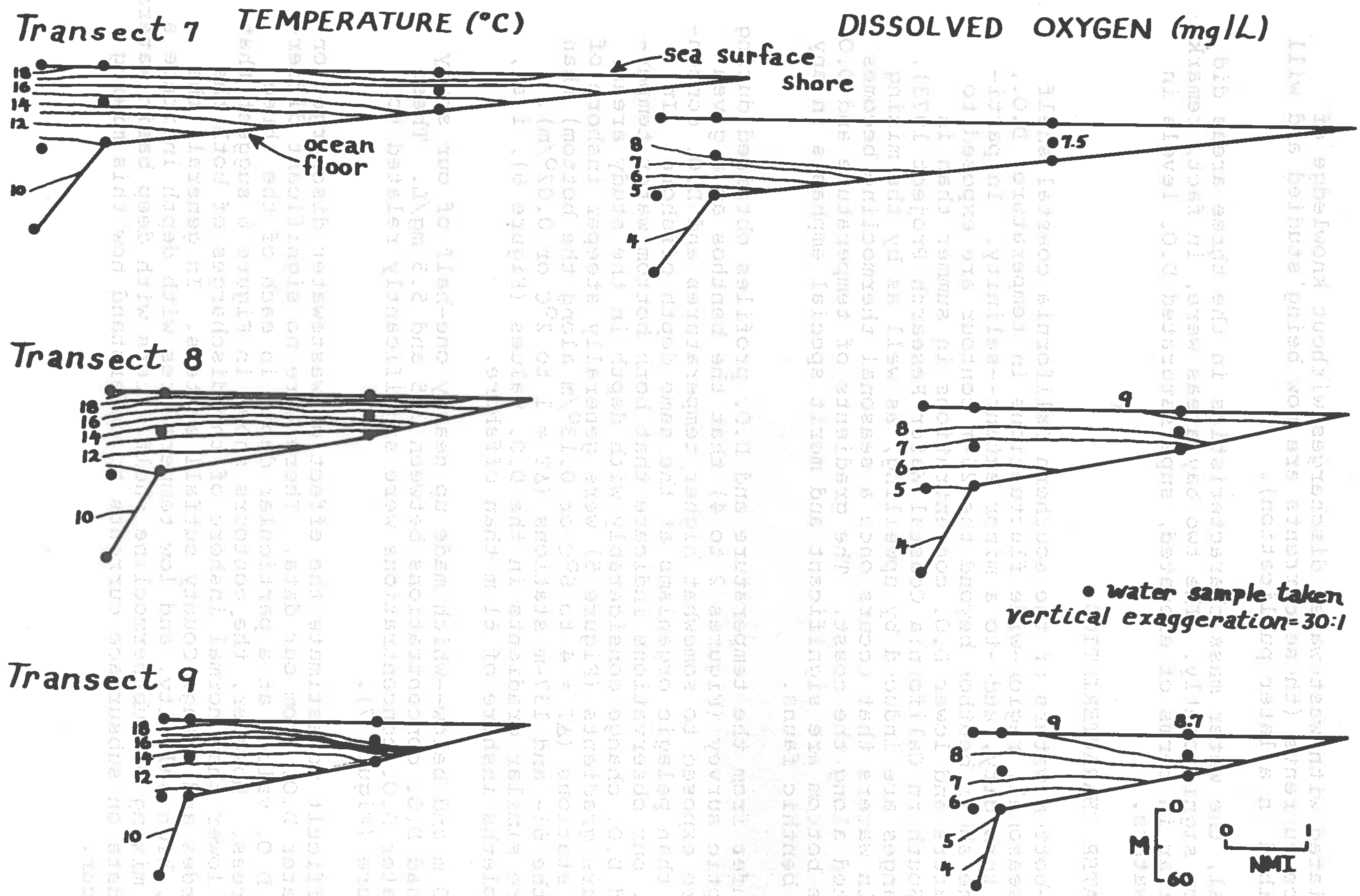

Figure 4. Temperature and dissolved oxygen with depth, San Pedro Bay, 26 September 1973.

be associated with wastewater discharges without knowledge of subsurface currents (these currents are now being studied and will be described in a later publication).

In general, the water mass characteristics in the three areas did not differ significantly. The two bay areas were, in fact, remarkably similar in terms of elevated, supersaturated D.O. levels in inshore waters.

BOTTOM WATER CHARACTERISTICS

The near-bottom waters of the southern California coastal shelf undergo seasonal, region-wide fluctuations in temperature, D.O., clarity, turbidity, and--to a minor extent--salinity. In particular, the shelf benthos beyond the 25-m contour are exposed to cooler waters and lower D.O. concentrations in summer than in winter (Southern California Coastal Water Research Project 1973). These changes are induced by upwelling, as well as by the mixing from basin waters that occurs once a seasonal thermocline becomes established along the coast. The gradients of temperature and D.O. along the bottom are significant and merit special emphasis in any study of benthic fauna.

We can infer from the temperature and D.O. profiles obtained during the synoptic survey (Figures 2 to 4) that the benthos at a given depth were exposed to somewhat higher temperatures and D.O. concentrations than pelagic organisms at the same depth offshore. In addition, our observations indicate that both bottom water temperature and D.O. change considerably with depth in the study areas. Temperature gradients (Figure 5) were generally steeper inshore of the 61-m stations (ΔT = 4 to 6^{o}C or 0.13^{o}/m along the bottom) than between the 61- and 137-m stations (ΔT = 1 to 2^{o}C or 0.02^{o}/m). There were similar gradients in the D.O. values (Figure 6), i.e., more isopleths inshore of 61 m than offshore.

Waters 50 m and below--which made up nearly one-half of our study region--had D.O. concentrations between 3.5 and 5.5 mg/L. These bottom water D.O. concentrations were significantly related to temperature (Figure 7).

It is difficult to estimate the effect of wastewater discharges on bottom water D.O. from our data. There were no significant differences in D.O. values at a particular depth in each of the three survey areas. However, the contours shown in Figure 6 suggest that D.O. was lower than normal inshore of the discharges of both the Palos Verdes and Orange County outfall systems. In general, the low D.O., high salinity, and low temperatures with depth indicate a regional mixing of subthermocline shelf waters with deep basin waters. We need data on subsurface currents to understand how this mixing might occur.

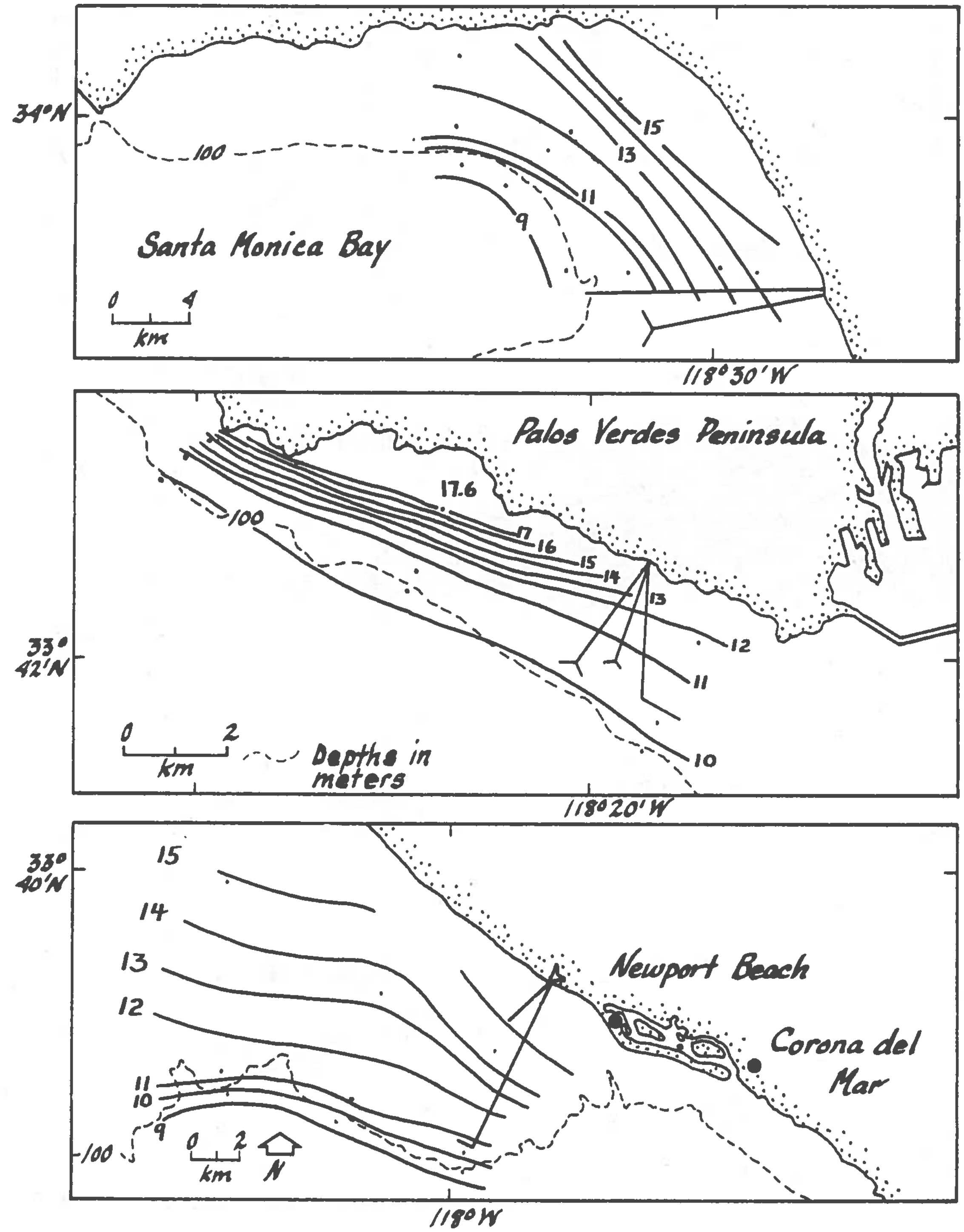

Figure 5. Bottom temperature isopleths (°C), synoptic survey, September 1973.

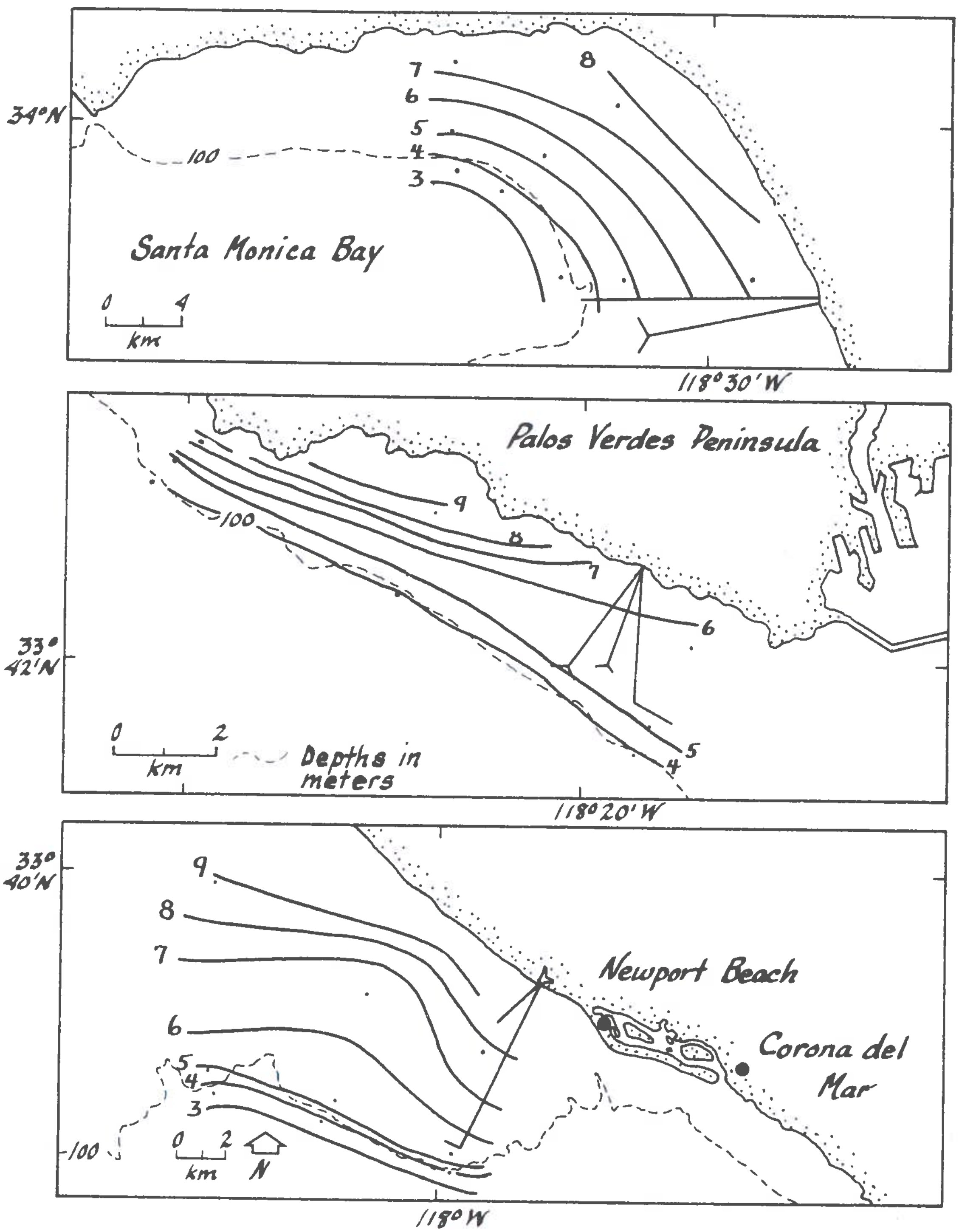

Figure 6. Bottom dissolved oxygen isopleths (percent saturation), synoptic survey, September 1973.

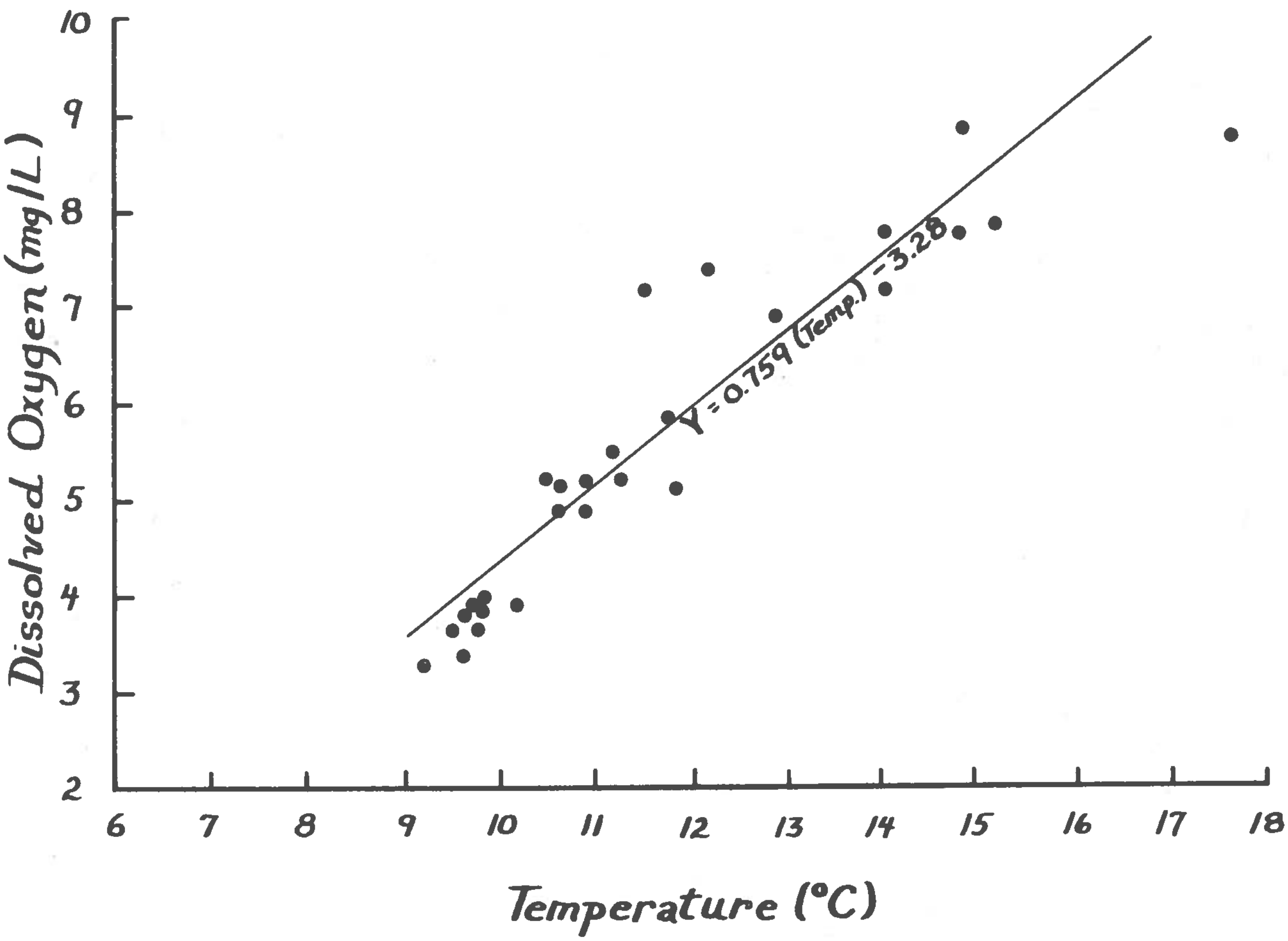

Figure 7. Bottom water temperature vs. dissolved oxygen, synoptic survey, September 1973. Linear correlation, $r = 0.934$ ($p < 0.001$).

BENTHIC SEDIMENTS

The composition of benthic sediments determines to a great extent the kind and variety of benthic organisms in an area and their availability as a food source for demersal fish and invertebrates. Sediments off Los Angeles and Orange County have been previously described by Jones (1969) and by the Coastal Water Project and Smith in the Project's 3-yr report (1973). The distribution of sediments contaminated by metals, chlorinated hydrocarbons, and hydrogen sulfide in southern California nearshore waters is also discussed in the Project's 3-yr report.

During the synoptic cruise, we took grab samples at the trawl stations in Santa Monica and San Pedro Bays. Data collected by the County Sanitation Districts of Los Angeles in early 1973 were used to identify sediment types at the trawl stations off Palos Verdes. Both the Project and District data are listed in Table 1; Figure 8 presents a simplified picture of the sediments encountered.

We obtained nine Shipek grab samples from Santa Monica Bay and nine from the Orange County outfall area during the survey. Five of the Santa Monica Bay samples had volumes of 0.5 to 1.11 liters, and the rest had volumes below 0.41.* Of the Orange County samples, one had a volume of 1.11, and the rest were below 0.41. The small size of the samples (many contained little or no sediment) may have been the result of highly compacted sediments, a mechanical malfunction of the grab, or a premature firing of the grab due to too rapid a descent. Because of the small number and size of the samples, we felt that faunal identification of these samples would not provide any useful data.

The two bay regions were dominated by sandy sediments, usually bearing some silt. In Santa Monica Bay, we found sticky black mud off Malibu and off Marina del Rey; near the sludge outfall, the sand was coarser and included gravel or pebbles. The sediments of southern San Pedro were less patchy in composition.

Off Palos Verdes, silty sand and sandy silt graded into silts approaching the outfalls. We noted some hydrogen sulfide odor in sediments from Station 6007 near the outfall system.

We did not find sludge or sludge-type material in any of the samples taken during the survey.

*Information for conversion of depth in Shipek bucket to sample volume was furnished by Hyperion Treatment Plant.

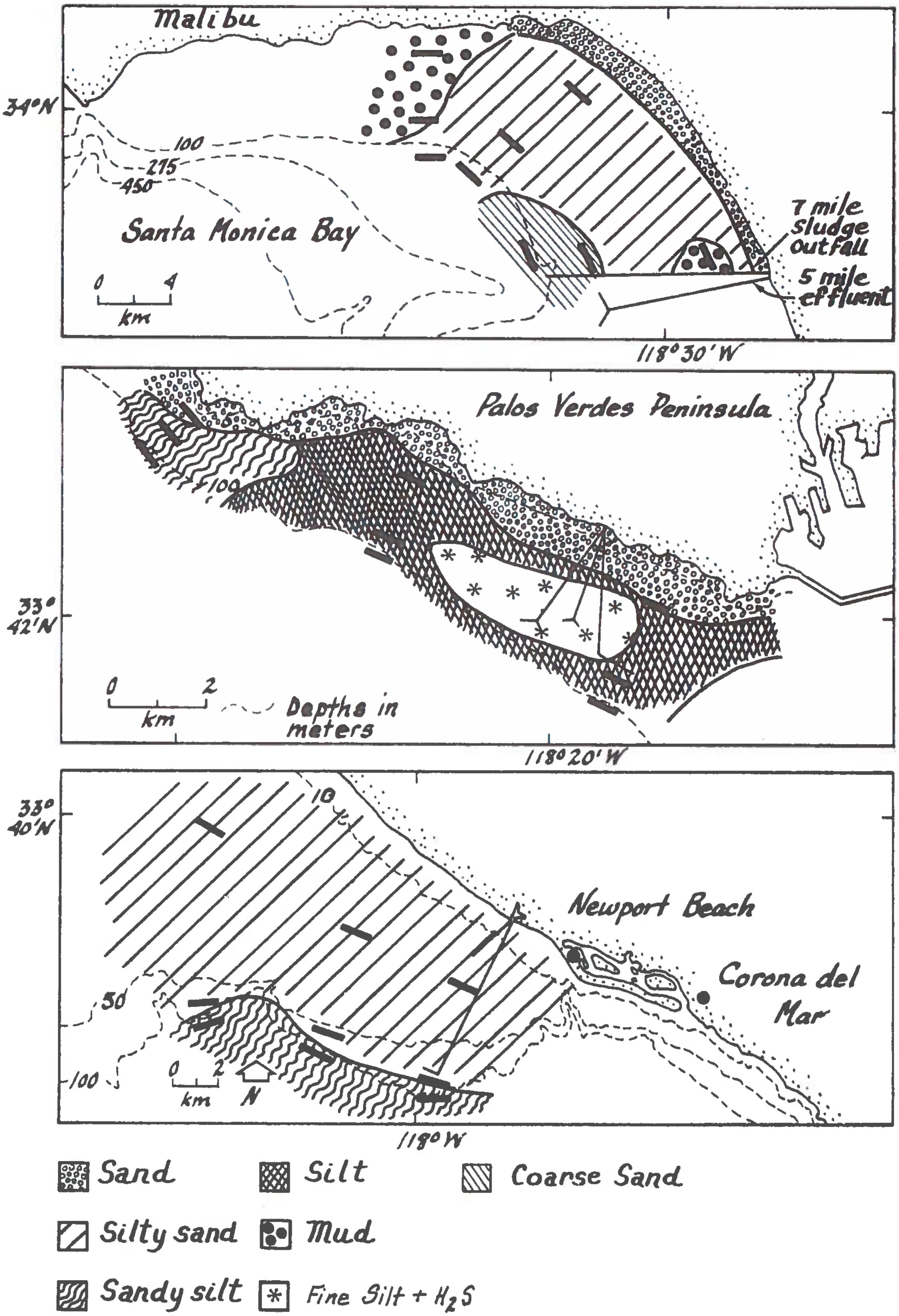

Figure 8. Sediment types, synoptic survey, September 1973. Palos Verdes shelf profile is based on data collected by the Los Angeles County Sanitation Districts, January-February 1973.

DEMERSAL POPULATIONS

The synoptic survey hauls produced approximately 35,000 specimens, representing 68 species of fish and 101 species of invertebrates (Table 3). The total weight of the catches was 635 kg (1,400 lb). Invertebrates made up about 70 percent of the species and 37 percent of the biomass.

Palos Verdes was the most productive region in terms of numbers of species of both fish (52 species) and invertebrates (60 species); San Pedro Bay was the least productive (41 fish species, 47 invertebrates). Palos Verdes and Santa Monica Bay trawls produced similar numbers of specimens (about 14,500 and 12,700, respectively), but the Palos Verdes catches had a much lower biomass of invertebrates. Conversely, San Pedro Bay samples were low in numbers of specimens and fish biomass but relatively high in invertebrate biomass (Table 3).

In general, then, the Palos Verdes and Santa Monica Bay samples indicated a more abundant and somewhat richer fauna than the San Pedro Bay samples. Detailed analyses of the fish and invertebrate catches are presented below.

DEMERSAL FISH

Species Abundance and Distribution

Common and scientific names of the 68 species of fish collected in the synoptic survey are listed in Table 4. The number of individuals per species in each sample is given in Appendices C through E. All but two species were found in earlier trawl surveys of these areas (Southern California Coastal Water Research Project 1973). Our specimens of lingcod (Ophiodon elongatus) from Santa Monica Bay (Station 5020, 59 m) are the first of this species from trawls off Los Angeles County. The three specimens were 170 to 185 mm standard length (SL) and were considered juveniles. A 117-mm lumptail searobin (Prionotus stephanophrys) was captured at Station 6007 (30 m) off Palos Verdes. This is the 27th known specimen from California waters. These fish are deposited in the Coastal Water Project museum collection.

Some benthic fishes generally thought to be common or abundant in southern California waters were relatively rare in the synoptic catches. The possible explanations for this vary with the species. Some probably were present but able to avoid the slow moving trawl

Table 3. Description of fish and invertebrate catches, synoptic survey, September 1973.

	Santa Monica Bay	Palos Verdes Shelf	San Pedro Bay	Combined
No. Samples	9	9	9	27
Total No. Species	105	112	88	169
Fish	51	52	41	68
Invertebrates	54	60	47	101
Total No. Specimens	13,795	13,760	6,103	33,658
Fish	5,455	5,813	3,019	14,287
Invertebrates	8,340	7,947	3,084	19,371
Total Biomass (kg)	227	215	189	631
Fish	126	174	95	395
Invertebrates	101	41	94	236

net (e.g., hake, Merluccius productus; petrale sole, Eopsetta jordani; sablefish, Anoplopoma fimbria); others are active primarily at night (e.g., spiny dogfish, Squalus acanthias; electric ray, Torpedo californica; ratfish, Hydrolagus colliei). Other common species were rare in our catches because they usually occupy shallower waters (C-O sole, Pleuronichthys coenosus), rocky subtidal habitats (ocean whitefish, Caulolatilus princeps; black perch Embiotoca jacksoni; lingcod, Ophiodon elongatus), or more southern, warmer waters (longfin sanddab, Citharichthys xanthostigma; lumptail searobin, Prionotus stephanophrys; stargazer, Kathetostoma averruncus). In some cases, our stations appeared to fall at the edge of the range of a species rather than in the center; thus, some common rockfishes (e.g., Sebastes dalli, S. eos, S. hopkinsi, S. goodei, S. macdonaldi, S. rosenblatti, S. rubrivinctus, S. vexillaris) and a thornyhead (Sebastolobus alascanus) were rare in the synoptic catches.

The species most abundant in the synoptic catches are listed in Table 5. There were notable differences in the species most abundant in each of the three survey areas (Figure 9). Stripetail rockfish, yellowchin sculpin, speckled sanddabs, and slender sole dominated different sites in Santa Monica Bay. Off Palos Verdes, speckled sanddabs, white croaker, stripetail rockfish, splitnose rockfish and Dover sole predominated. In San Pedro Bay, speckled sanddab and California tonguefish were dominant inshore, Pacific sanddab at 61 m, and slender sole at the deepest (137-m) stations.

The species that made up 90 percent of the specimens in each area are shown in Table 6. In Santa Monica Bay and off Palos Verdes, 10 and 11 species, respectively, accounted for 90 percent of the

Table 4. Common and scientific names of fish species taken off Los Angeles and Orange Counties, 24-26 September 1973.

Species	Common Name	Region*
Squalidae		
Squalus acanthias	Spiny dogfish	1 2
Torpedinidae		
Torpedo californica	Pacific electric ray	2
Chimaeridae		
Hydrolagus colliei	Ratfish	1
Argentinidae		
Argentina sialis	Pacific argentine	1 2
Synodontidae		
Synodus lucioceps	California lizardfish	1 2 3
Batrachoididae		
Porichthys myriaster	Specklefin midshipman	1 2
Porichthys notatus	Plainfin midshipman	1 2 3
Moridae		
Physiculus rastrelliger	Hundred-fathom codling	2
Merlucciidae		
Merluccius productus	Pacific hake	1 2 3
Ophidiidae		
Chilara taylori	Spotted cusk-eel	1 2 3
Zoarcidae		
Aprodon cortezianus	Bigfin eelpout	2 3
Lycodopsis pacifica	Blackbelly eelpout	1 2 3
Lyconema barbatum	Bearded eelpout	3
Scorpaenidae		
Scorpaena guttata	California scorpionfish	2 3
Sebastes crameri	Darkblotched rockfish	1 2
Sebastes dalli	Calico rockfish	1 3
Sebastes diploproa	Splitnose rockfish	1 2 3
Sebastes elongatus	Greenstriped rockfish	1 2 3
Sebastes eos	Pink rockfish	1
Sebastes goodei	Chilipepper	1 2 3
Sebastes hopkinsi	Squarespot rockfish	3
Sebastes jordani	Shortbelly rockfish	1 2 3
Sebastes levis	Cow rockfish	1 2
Sebastes macdonaldi	Mexican rockfish	2
Sebastes miniatus	Vermilion rockfish	1 2 3
Sebastes paucispinis	Bocaccio	1 2
Sebastes rosenblatti	Greenblotched rockfish	1 2 3
Sebastes rubrivinctus	Flag rockfish	3
Sebastes saxicola	Stripetail rockfish	1 2 3
Sebastes semicinctus	Halfbanded rockfish	1 2 3
Sebastes vexillaris	Whitebelly rockfish	3
Sebastolobus alascanus	Shortspine thornyhead	3
Triglidae		
Prionotus stephanophrys	Lumptail searobin	2

*1=Santa Monica Bay, 2=Palos Verdes Shelf, 3=San Pedro Bay.

Species	Common Name	Region*
Hexagrammidae		
Ophiodon elongatus	Lingcod	1
Zaniolepis frenata	Shortspine combfish	1 2 3
Zaniolepis latipinnis	Longspine combfish	1 2 3
Anoplopomatidae		
Anoplopoma fimbria	Sablefish	1 2
Cottidae		
Chitonotus pugetensis	Roughback sculpin	1 2 3
Icelinus quadriseriatus	Yellowchin sculpin	1 2 3
Radulinus asprellus	Slim sculpin	1 3
Agonidae		
Agonopsis sterletus	Southern spearnose poacher	1
Odontopyxis trispinosa	Pygmy poacher	1 2 3
Xeneretmus latifrons	Blacktip poacher	1 2 3
Branchiostegidae		
Caulolatilus princeps	Ocean whitefish	2
Sciaenidae		
Genyonemus lineatus	White croaker	2
Embiotocidae		
Cymatogaster aggregata	Shiner perch	1 2 3
Embiotoca jacksoni	Black perch	1
Phanerodon furcatus	White seaperch	2
Rhacochilus vacca	Pile perch	2
Zalembius rosaceus	Pink seaperch	1 2 3
Uranoscopidae		
Kathetostoma averruncus	Smooth stargazer	2
Stichaeidae		
Plectobranchus evides	Bluebarred prickleback	1
Gobiidae		
Lepidogobius lepidus	Bay goby	1 2
Stromateidae		
Peprilus simillimus	Pacific pompano	2
Bothidae		
Citharichthys sordidus	Pacific sanddab	1 2 3
Citharichthys stigmaeus	Speckled sanddab	1 2 3
Citharichthys xanthostigma	Longfin sanddab	1 3
Hippoglossina stomata	Bigmouth sole	1 2 3
Paralichthys californicus	California halibut	1
Pleuronectidae		
Eopsetta jordani	Petrale sole	1
Glyptocephalus zachirus	Rex sole	1 2 3
Lyopsetta exilis	Slender sole	1 2 3
Microstomus pacificus	Dover sole	1 2 3
Parophrys vetulus	English sole	1 2 3
Pleuronichthys coenosus	C-O sole	2
Pleuronichthys decurrens	Curlfin sole	1 2 3
Pleuronichthys verticalis	Hornyhead turbot	1 2 3
Cynoglossidae		
Symphurus atricauda	California tonguefish	1 2 3

*1=Santa Monica Bay, 2=Palos Verdes Shelf, 3=San Pedro Bay.

Table 5. Fishes most abundant in synoptic survey catches, September 1973.

Abundance Rank		No. of Individuals
1	Stripetail rockfish (Sebastes saxicola)	4,558
2	Speckled sanddab (Citharichthys stigmaeus)	2,461
3	Dover sole (Microstomus pacificus)	1,146
4	Yellowchin sculpin (Icelinus quadriseriatus)	1,059
5	Pacific sanddab (Citharichthys sordidus)	704
6	Slender sole (Lyopsetta exilis)	539
7	Splitnose rockfish (Sebastes diploproa)	476
8	California tonguefish (Symphurus atricauda)	360
9	Plainfin midshipman (Porichthys notatus)	330
10	Shiner perch (Cymatogaster aggregata)	234
11	English sole (Parophrys vetulus)	225
12	Curlfin sole (Pleuronichthys decurrens)	219
13	Longspine combfish (Zaniolepis latipinnis)	206
14	White croaker (Genyonemus lineatus)	195
15	Shortbelly rockfish (Sebastes jordani)	189
16	Rex sole (Glyptocephalus zachirus)	157
17	Pink seaperch (Zalembius rosaceus)	152
18	Blackbelly eelpout (Lycodopsis pacifica)	126
19	Blacktip poacher (Xeneretmus latifrons)	106
20	California lizardfish (Synodus lucioceps)	93

specimens and about 20 percent of the species captured. In contrast, 14 species accounted for 90 percent of the specimens, and 34 percent of the species, in the San Pedro Bay samples. This difference was, in part, the result of very high catches of several species off Palos Verdes and in Santa Monica Bay. San Pedro Bay catches were not heavily dominated by any single species and consequently had a higher diversity than catches from the other two regions.

Catch Statistics

Table 7 summarizes the number of species, number of specimens, biomass, and numerical diversities (Brillouin, H, and scaled Brillouin diversity, H(s))* of fish in each sample. Inspection of these data show a few important trends. First, all parameters varied greatly:

* The Brillouin measure of diversity is considered appropriate for this data, especially for the individual samples, because it evaluates each sample as a separate entity and not as a representative subsample from a much larger universe (the latter is a basic assumption for using the related Shannon-Weaver measure of species diversity). The scaled diversity, H(s), of Fager (1972) is considered to be a more precise measure of the evenness of distribution of individuals among species within a sample than the generally used measure, H/H_{max} (Greene 1973).

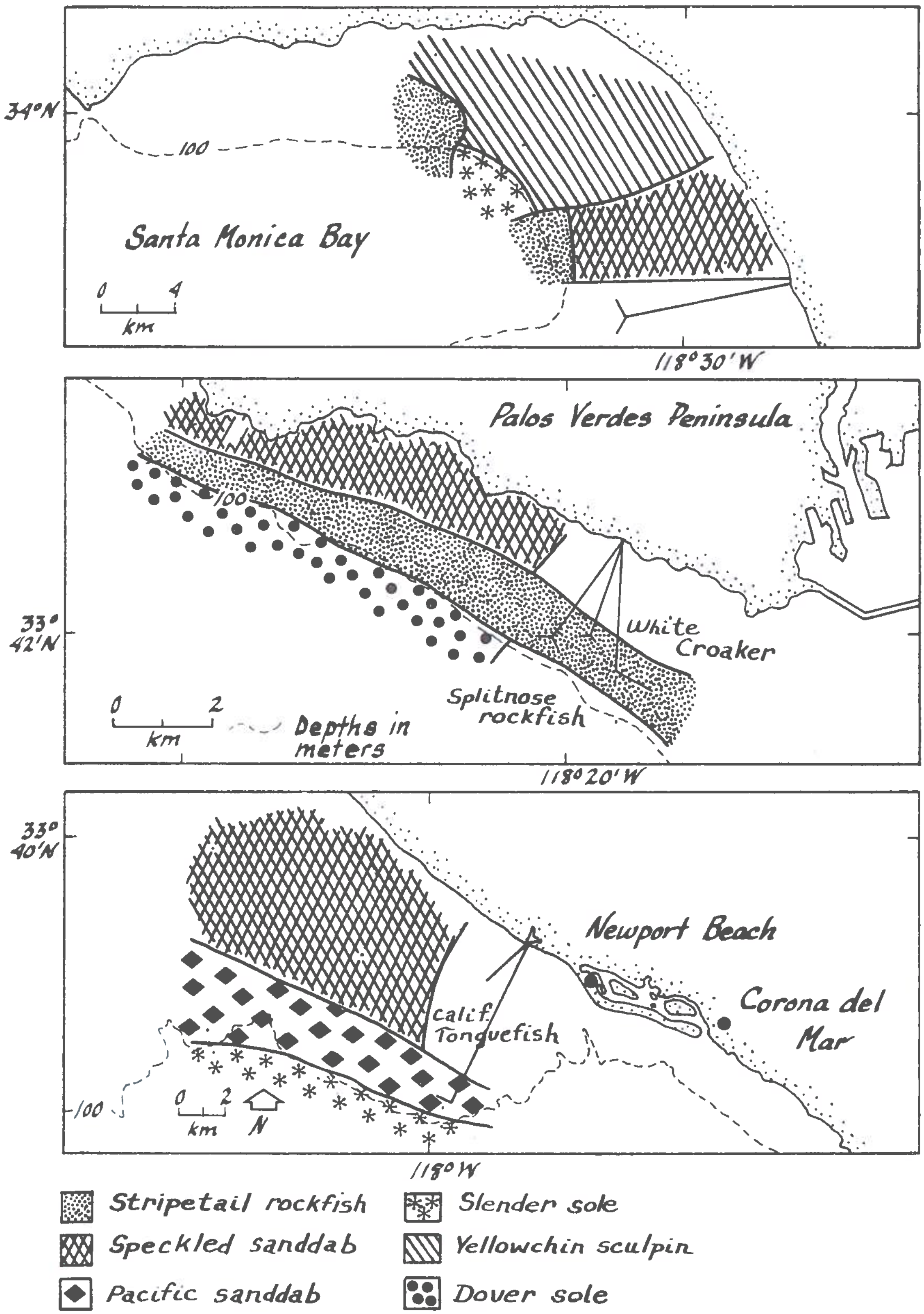

Figure 9. Distribution of dominant demersal fish, synoptic survey, September 1973.

Table 6. Abundance ranks of fishes comprising 90 percent of the specimens in each sampling area.

	SPECIES NAME	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL	CUMULATIVE PERCENT	SPECIES CUMULATIVE PERCENT
	SANTA MONICA BAY				
1	SEBASTES SAXICOLA	2433	44.54	44.54	1.96
2	ICELINUS QUADRISERIATUS	816	14.94	59.47	3.92
3	CITHARICHTHYS STIGMAEUS	422	7.72	67.20	5.88
4	CITHARICHTHYS SORDIDUS	264	4.83	72.03	7.84
5	MICROSTOMUS PACIFICUS	239	4.37	76.40	9.80
6	PORICHTHYS NOTATUS	209	3.83	80.23	11.76
7	LYOPSETTA EXILIS	198	3.62	83.85	13.73
8	ZANIOLEPIS LATIPINNIS	164	3.00	86.86	15.69
9	SEBASTES JORDANI	119	2.18	89.04	17.65
10	ZALEMBIUS ROSACEUS	64	1.17	90.21	19.61
	PALOS VERDES SHELF				
1	SEBASTES SAXICOLA	1858	31.96	31.96	1.92
2	CITHARICHTHYS STIGMAEUS	1567	26.96	58.92	3.85
3	MICROSTOMUS PACIFICUS	651	11.20	70.12	5.77
4	CYMATOGASTER AGGREGATA	219	3.77	73.89	7.69
5	PLEURONICHTHYS DECURRENS	208	3.58	77.46	9.62
6	GENYONEMUS LINEATUS	195	3.35	80.82	11.54
7	SEBASTES DIPLOPROA	171	2.94	83.76	13.46
8	FAROPHRYS VETULUS	159	2.74	86.50	15.38
9	ICELINUS QUADRISERIATUS	120	2.06	88.56	17.31
10	GLYPTOCEPHALUS ZACHIRUS	71	1.22	89.78	19.23
11	SEBASTES JORDANI	69	1.19	90.97	21.15
	SAN PEDRO BAY				
1	CITHARICHTHYS STIGMAEUS	472	15.63	15.63	2.44
2	CITHARICHTHYS SORDIDUS	378	12.52	28.15	4.88
3	LYOPSETTA EXILIS	321	10.63	38.79	7.32
4	SYMPHURUS ATRICAUDA	297	9.84	48.63	9.76
5	SEBASTES DIPLOPROA	288	9.54	58.16	12.20
6	SEBASTES SAXICOLA	268	8.88	67.04	14.63
7	MICROSTOMUS PACIFICUS	256	8.48	75.52	17.07
8	ICELINUS QUADRISERIATUS	124	4.11	79.63	19.51
9	PORICHTHYS NOTATUS	103	3.41	83.04	21.95
10	LYCODOPSIS PACIFICUS	97	3.21	86.25	24.39
11	PLEURONICHTHYS VERTICALIS	38	1.26	87.51	26.83
12	XENERETMUS LATIFRONS	37	1.23	88.74	29.27
13	SEBASTES SEMICINCTUS	36	1.19	89.93	31.71
14	FAROPHRYS VETULUS	35	1.16	91.09	34.15

Table 7. Catch data and diversity calculations for fish, synoptic survey, September 1973.

DATE MO DA YR	STA-SAMP	DEPTH (M)	BIOMASS (KG)	SPEC	INDI	BRILLOUIN DIVERSITY H	H(S)
SANTA MONICA BAY							
9/24/73	7.1	20	2.30	15	270	1.444	0.501
9/24/73	4.1	25	2.80	9	226	1.289	0.572
9/24/73	2.1	28	3.40	18	216	1.215	0.344
9/24/73	20.1	59	12.05	25	859	1.736	0.523
9/24/73	28.1	59	10.60	16	685	1.504	0.531
9/24/73	22.1	64	20.45	15	584	1.909	0.704
9/24/73	97.1	136	36.95	25	1919	0.680	0.189
9/24/73	95.1	138	25.50	18	409	1.891	0.647
9/24/73	96.2	142	12.51	17	287	1.701	0.579
SURVEY			126.20	51	5463	2.131	0.538
PALOS VERDES SHELF							
9/25/73	5.1	26	4.55	17	172	1.352	0.404
9/25/73	2.1	27	14.00	16	1671	0.888	0.306
9/25/73	7.1	30	33.05	20	719	1.725	0.563
9/25/73	10.1	60	10.50	15	278	1.245	0.418
9/25/73	12.1	61	16.95	19	303	1.545	0.487
9/25/73	14.1	63	28.60	20	1744	0.841	0.265
9/25/73	25.1	133	13.80	16	331	1.711	0.602
9/25/73	19.1	145	36.35	18	381	1.845	0.628
9/25/73	22.1	150	16.40	13	214	1.779	0.691
SURVEY			174.10	52	5813	2.197	0.551
SAN PEDRO BAY							
9/26/73	8.1	24	9.05	11	466	0.966	0.379
9/26/73	67.1	25	2.75	11	127	1.053	0.364
9/26/73	70.1	26	4.35	9	152	1.664	0.772
9/26/73	68.1	62	17.05	16	420	1.886	0.678
9/26/73	71.1	62	16.45	18	372	1.993	0.687
9/26/73	73.1	66	7.25	19	364	1.995	0.671
9/26/73	23.1	143	14.15	17	298	1.989	0.700
9/26/73	69.1	143	15.25	18	614	1.785	0.610
9/26/73	72.1	145	8.60	12	206	1.761	0.711
SURVEY			94.90	41	3019	2.673	0.719

The number of species per sample varied as much as threefold, even within a single survey area. Likewise, the number of fish per sample varied tenfold (127 to 1,919 fish per haul), biomass, tenfold (2.3 to 37 kg per sample), and Brillouin diversity (H), threefold (0.68 to 2.00 per sample). Second, catches generally increased with depth.

The statistical distributions are shown in Figure 10. These variables were compared by survey area and by depth using medians, ranges, and 95 and 80 percent confidence intervals about the medians. Figure 10 shows the skewness of these parameters. The calculations are shown graphically by survey area in Figure 11 and by depth in Figure 12.

There were no significant differences between samples from the three areas in terms of number of specimens and species per sample, biomass, and diversity, although there were some trends (Figure 10). Samples from Palos Verdes were slightly higher in biomass per sample than the samples from the two bays and slightly lower in individual sample diversity. San Pedro Bay samples had the lowest median species per sample and specimens per sample.

There were significant differences in catch patterns with depth (Figure 12). Diversity and biomass per sample were both significantly higher at the 137-m depths than inshore at the 22-m sites, with the differences occurring at the 95 percent level about median values. In contrast, catch per sample and species per sample did not increase significantly with depth. At a lower level of significance (80 percent), species per sample and total catch per sample still showed no significant increase with depth, but biomass and diversity were significantly higher at middepth stations than at the shallow depths. Overall, it appeared that total catch per haul and species per haul increased only slightly with depth while increases in biomass and diversity were considerably more significant.

Diseased and Anomalous Populations

We examined all of the fishes collected in the synoptic survey for external signs of disease and found approximately 2.5 percent to be obviously diseased or anomalous. The anomalies observed included fin erosion, tumors, color anomalies, external parasites, exopthalmia, and deformities. Fin erosion was the most common anomaly: Most of the fish affected with this condition came from the Palos Verdes catches (Tables 8 and 9). Prevalence of fin erosion was highest in the Dover sole as in previous surveys (Southern California Coastal Water Research Project 1973).

Although a number of white croaker (*Genyonemus lineatus*) were present in the catches off Palos Verdes, only 1.0 percent had eroded fins. Catches of white croaker in other locations, especially the Los Angeles-Long Beach Harbor, have had fin erosion

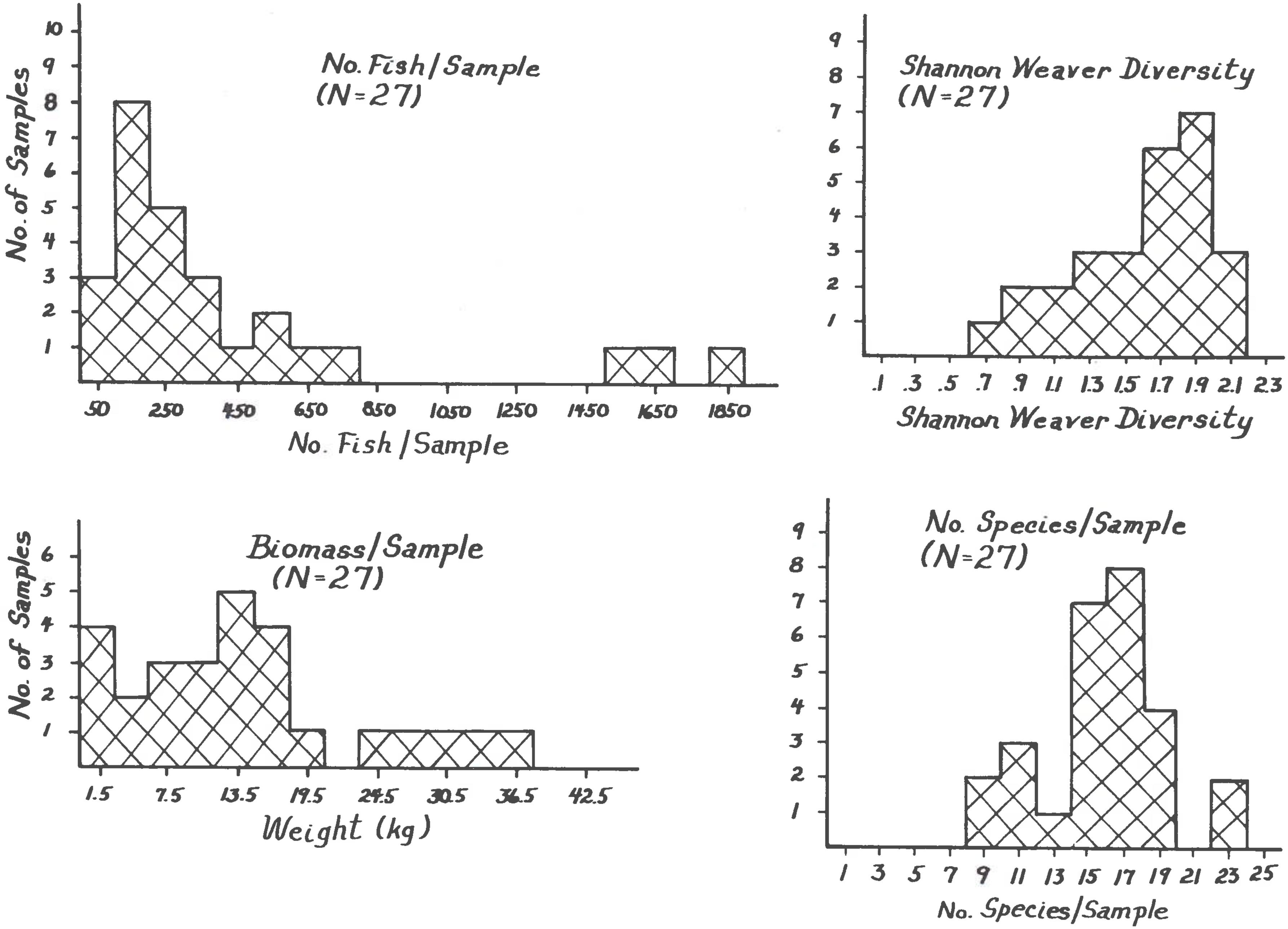

Figure 10. Fish catch statistics, synoptic survey, September 1973.

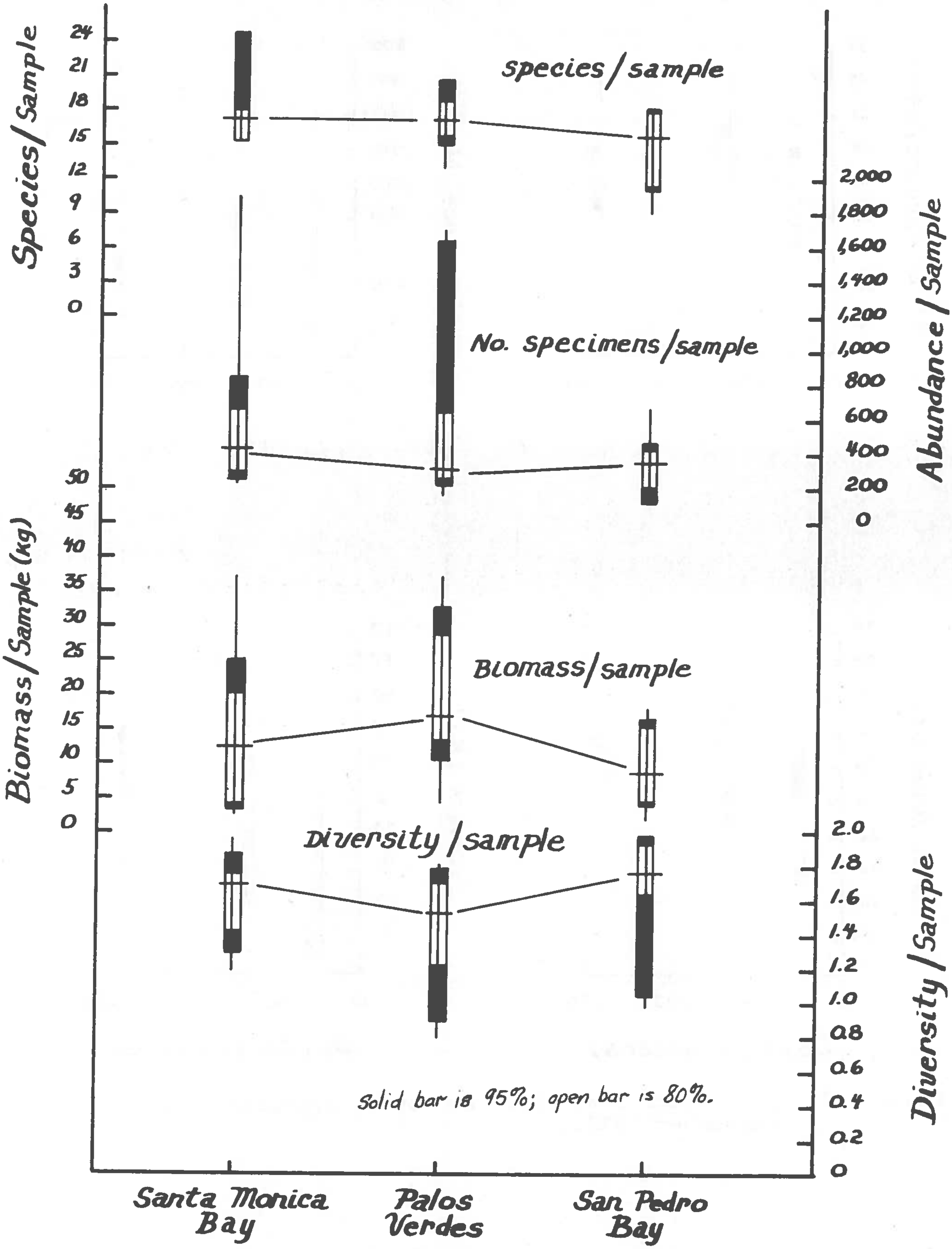

Figure 11. Fish catch statistics by survey area, synoptic survey, September 1973.

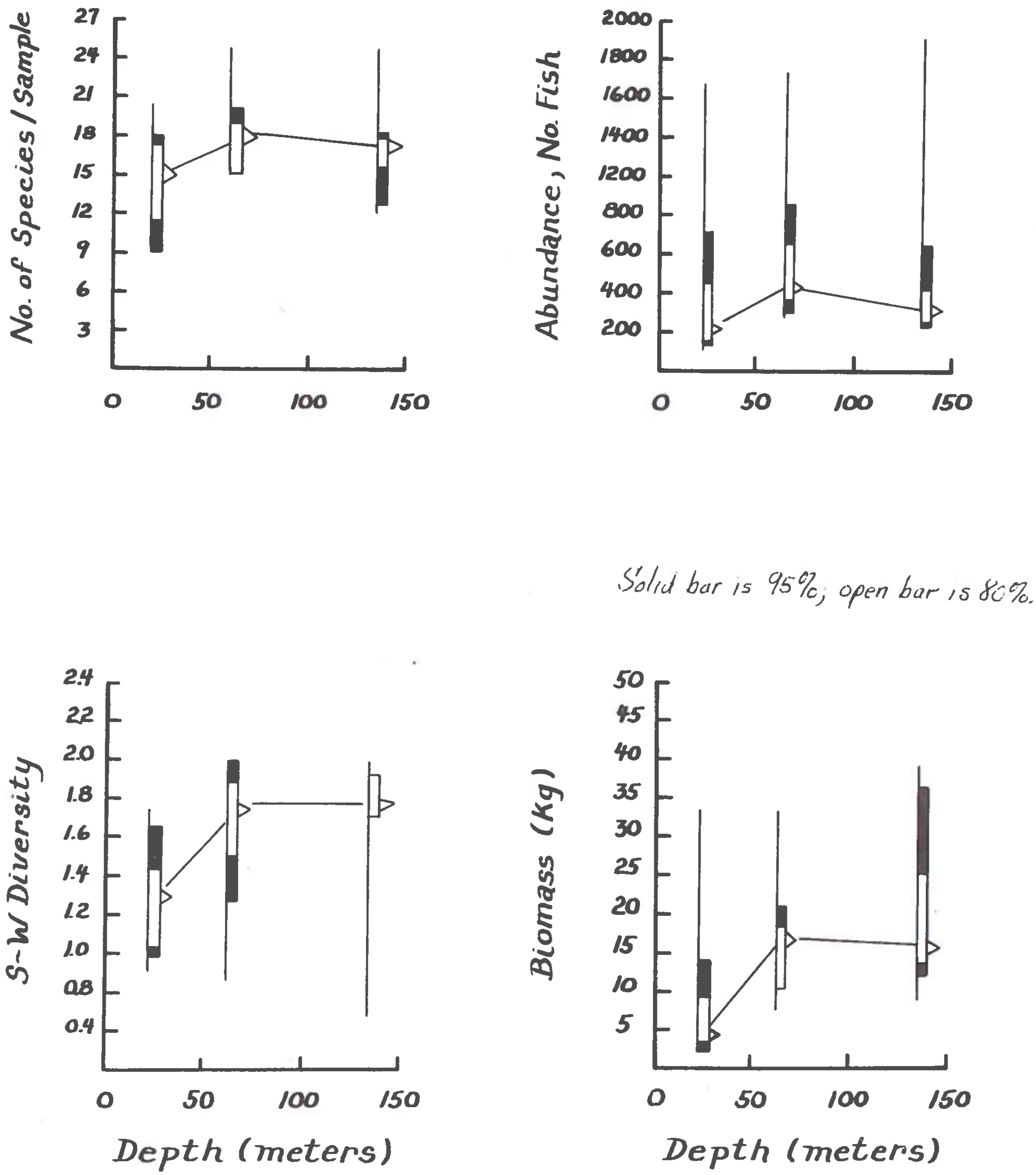

Figure 12. Fish catch statistics by depth, synoptic survey, September 1973.

Table 8. Species with fin erosion and tumors, synoptic survey, September 1973.

Species	Total No. of Indiv.	Indiv. with Fin Erosion No.	Indiv. with Fin Erosion %	Indiv. with Tumors No.	Indiv. with Tumors %
SANTA MONICA BAY					
Dover sole (*Microstomus pacificus*)	239	5	2.1	4	1.7
Slender sole (*Lyopsetta exilis*)	196	8	4.1		
Rex sole (*Glyptocephalus zachirus*)	57	1	1.8		
PALOS VERDES SHELF					
Dover sole (*Microstomus pacificus*)	651	238	37	4	0.6
Rex sole (*Glyptocephalus zachirus*)	71	24	34		
Curlfin sole (*Pleuronichthys decurrens*)	208	1	0.5		
Shortbelly rockfish (*Sebastes jordani*)	69	1	1.4		
White croaker (*Genyonemus lineatus*)	195	2	1.0		
SAN PEDRO BAY					
Dover sole (*Microstomus pacificus*)	256	4	1.5	4	1.6
California tonguefish (*Symphurus atricauda*)	297	1	0.3		
Plainfin midshipman (*Porichthys notatus*)	103	1	1.0		

Table 9. Specimens with anomalies other than fin erosion and tumors, synoptic survey, September 1973.

Species	Anomaly	No. of Individuals
SANTA MONICA BAY		
Dover sole (*Microstomus pacificus*)	unidentified lesion	1
English sole (*Parophrys vetulus*)	external parasitic isopod,	2
	structural deformity	1
California tonguefish (*Symphurus atricauda*)	ambicoloration	1
PALOS VERDES SHELF		
Pacific hake (*Merluccius productus*)	external parasitic isopod	1
Speckled sanddab (*Citharichthys stigmaeus*)	external parasite	6
Rex sole (*Glyptocephalus zachirus*)	bent fin rays	1
Dover sole (*Microstomus pacificus*)	bent fin rays	4
English sole (*Parophrys vetulus*)	ambicoloration	1
White croaker (*Genyonemus lineatus*)	external parasite,	1
	exopthalmia	20
SAN PEDRO BAY		
Pacific sanddab (*Citharichthys sordidus*)	external parasite	1
English sole (*Parophrys vetulus*)	external parasite	1
Hornyhead turbot (*Pleuronichthys verticalis*)	external parasitic leech	1
California tonguefish (*Symphurus atricauda*)	ambicoloration,	1
	unidentified lesion	1

frequencies as high as 30 percent (unpublished data). The low incidence in these Palos Verdes catches (in specimens in the size ranges affected in other areas) suggests that the factors that bring about the fin erosion diseases in the Dover sole and white croaker are different.

Of the three areas surveyed, Palos Verdes had the largest number of species with fin erosion; the frequencies of the disease in Dover sole and rex sole were also highest in this area (Table 8 and Figures 13 and 14). This pattern alone suggests that the fin erosion disease is location-dependent. Off Palos Verdes, the stations closest to the southernmost outfall had the highest incidences of diseased Dover sole and rex sole. The incidences of tumor-bearing Dover sole in the three areas, however, were fairly consistent (Figure 15).

Previous data (Mearns and Sherwood, in press) suggest that tumorigenesis in Dover sole occurs only in juvenile fish (55 to 125 mm, SL) during their first summer of benthic life. In the synoptic survey, tumor-bearing Dover sole ranged in size from 75 to 175 mm, but 10 of the 12 affected specimens were less than 125 mm. Incidence of tumor-bearing specimens in the catches of Dover sole 55 to 125 mm long in the three areas were Santa Monica Bay, 5.7 percent (N = 53), Palos Verdes shelf, 4.3 percent (N = 46), and San Pedro Bay, 13 percent (N = 30). These observations support our earlier conclusions that tumorigenesis in Dover sole is primarily a function of factors associated with juvenile life history.

Off Palos Verdes, where the incidence of Dover sole with fin erosion was high, affected individuals ranged in size from 70 to 240 mm, while apparently healthy individuals ranged from 40 to 280 mm (Figure 16). In Santa Monica Bay, Dover sole with fin erosion were in a more restricted size range (120 to 200 mm). Off Orange County, individuals with fin erosion were also restricted to larger size classes, generally greater than 160 mm. In contrast, tumor-bearing Dover sole were found predominately in the 70 to 130 mm size range in each survey area. Rex sole with fin erosion collected off the Palos Verdes Peninsula were in the 160 to 210 mm SL size range (Figure 17).

A comparison of Dover sole collected in June 1973 (Figure 18) and during the synoptic cruise (September 1973) at the same set of stations off Palos Verdes confirmed that the larger Dover sole move inshore for the summer and offshore for the winter. A similar pattern was seen in catches made in the vicinity of the Orange County outfall in San Pedro Bay. The prevalences of fin erosion in the June and September Palos Verdes Dover sole collections were approximately the same (34 and 37 percent, respectively). This indicates that diseased as well as apparently healthy fish participated in the seasonal migration.

The distribution patterns described above for fin erosion and tumor diseases confirm the conclusions reached in our earlier

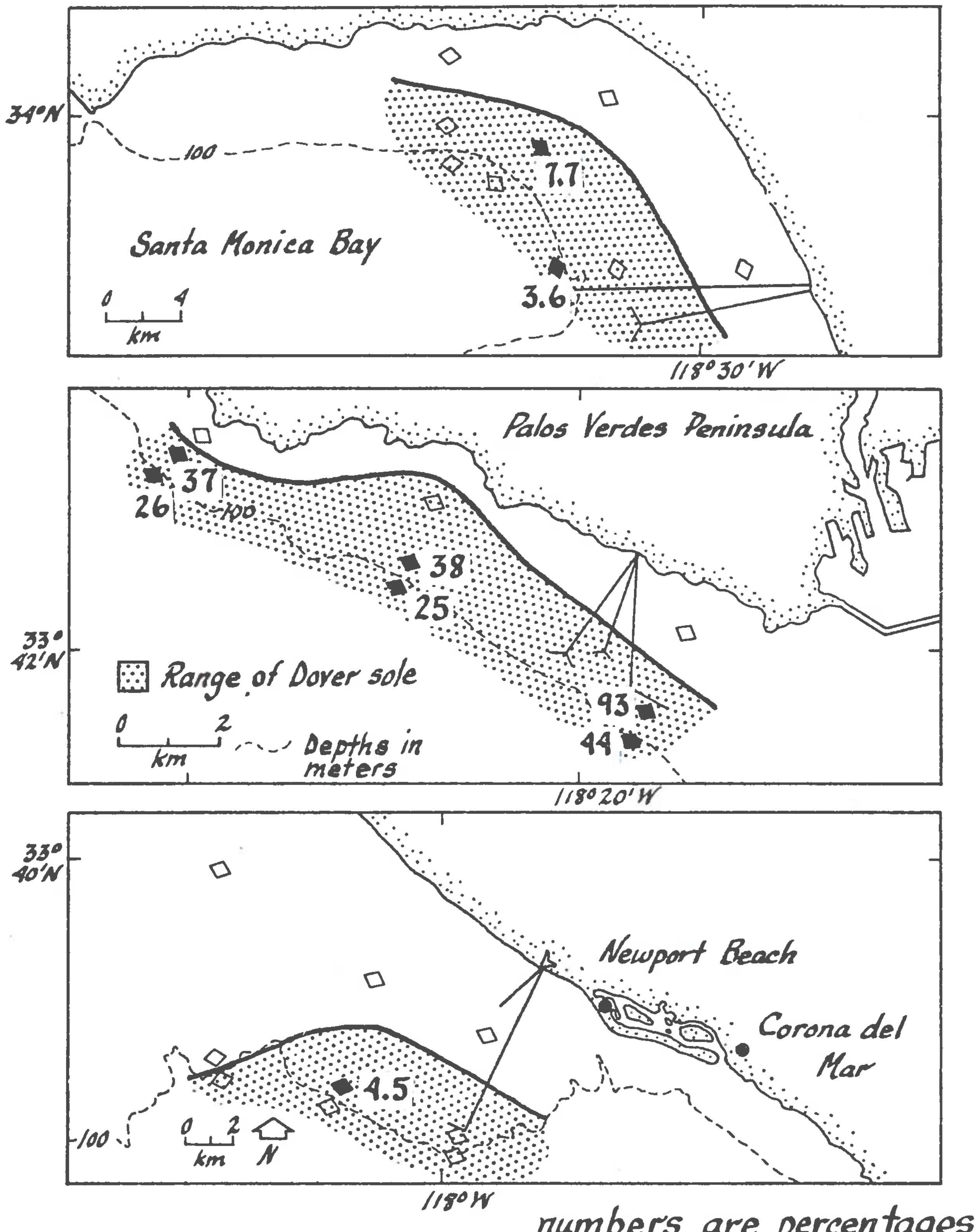

Figure 13. Distribution of fin erosion in Dover sole, synoptic survey, September 1973.

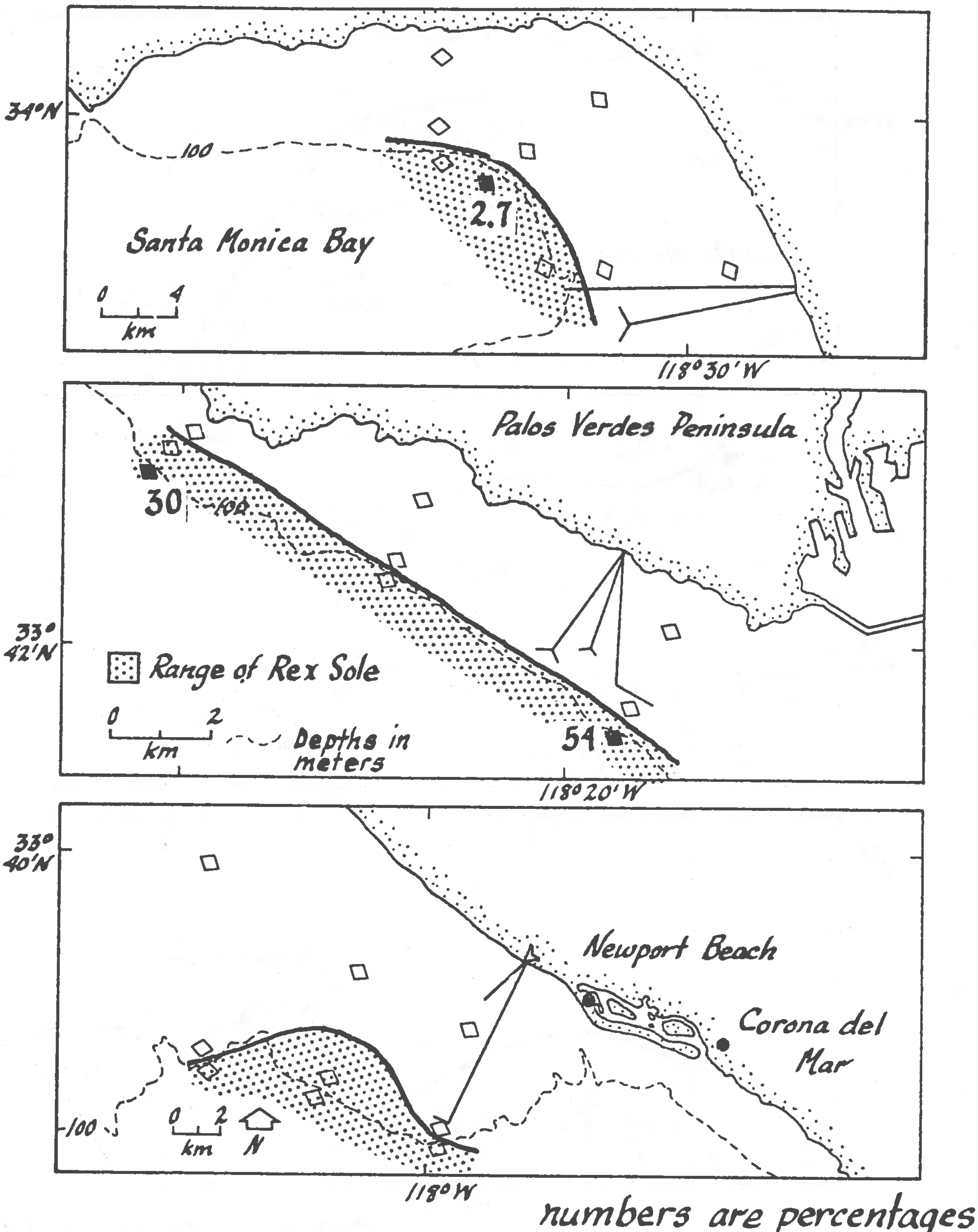

Figure 14. Distribution of fin erosion in rex sole, synoptic survey, September 1973.

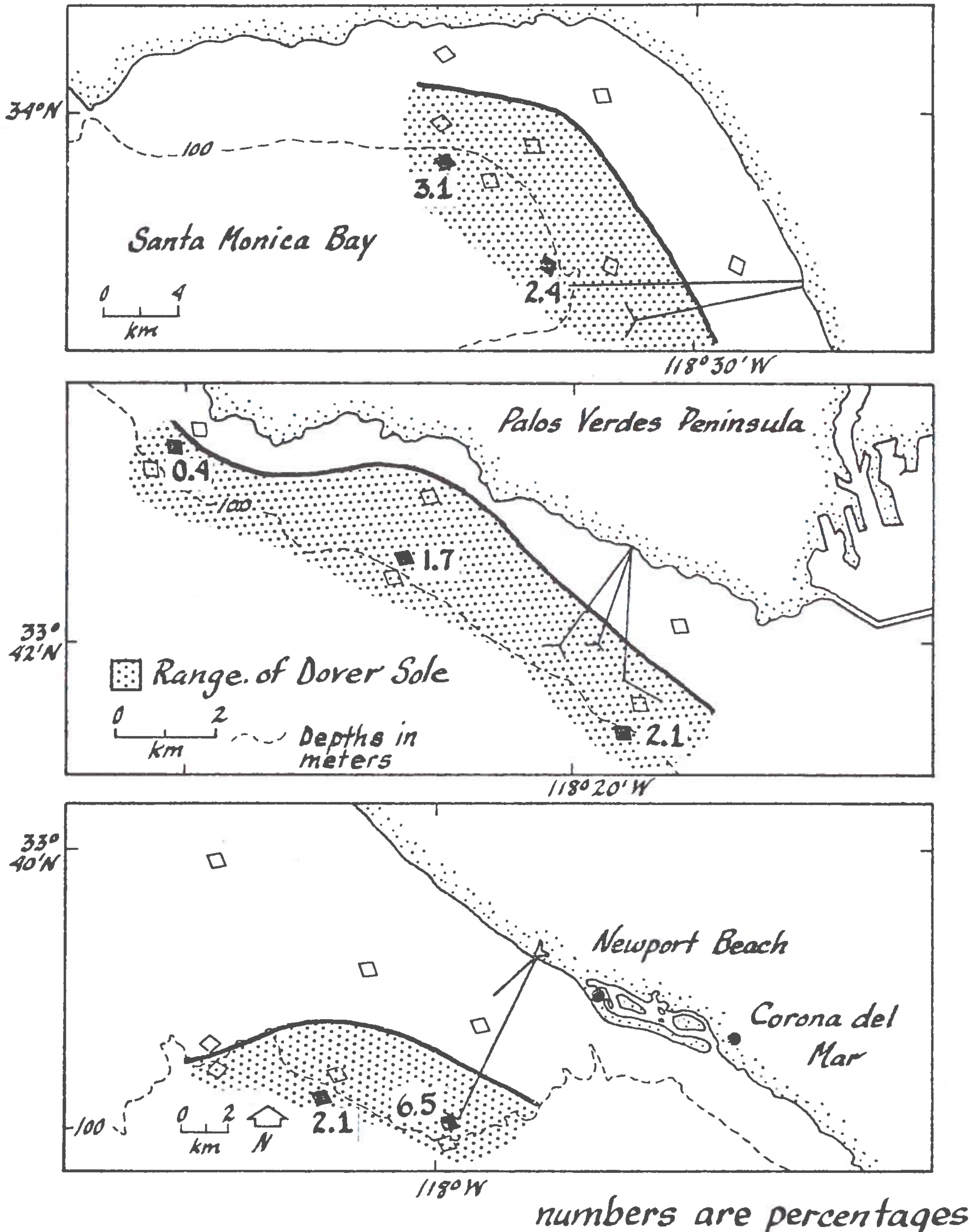

Figure 15. Distribution of tumors in Dover sole, synoptic survey, September 1973.

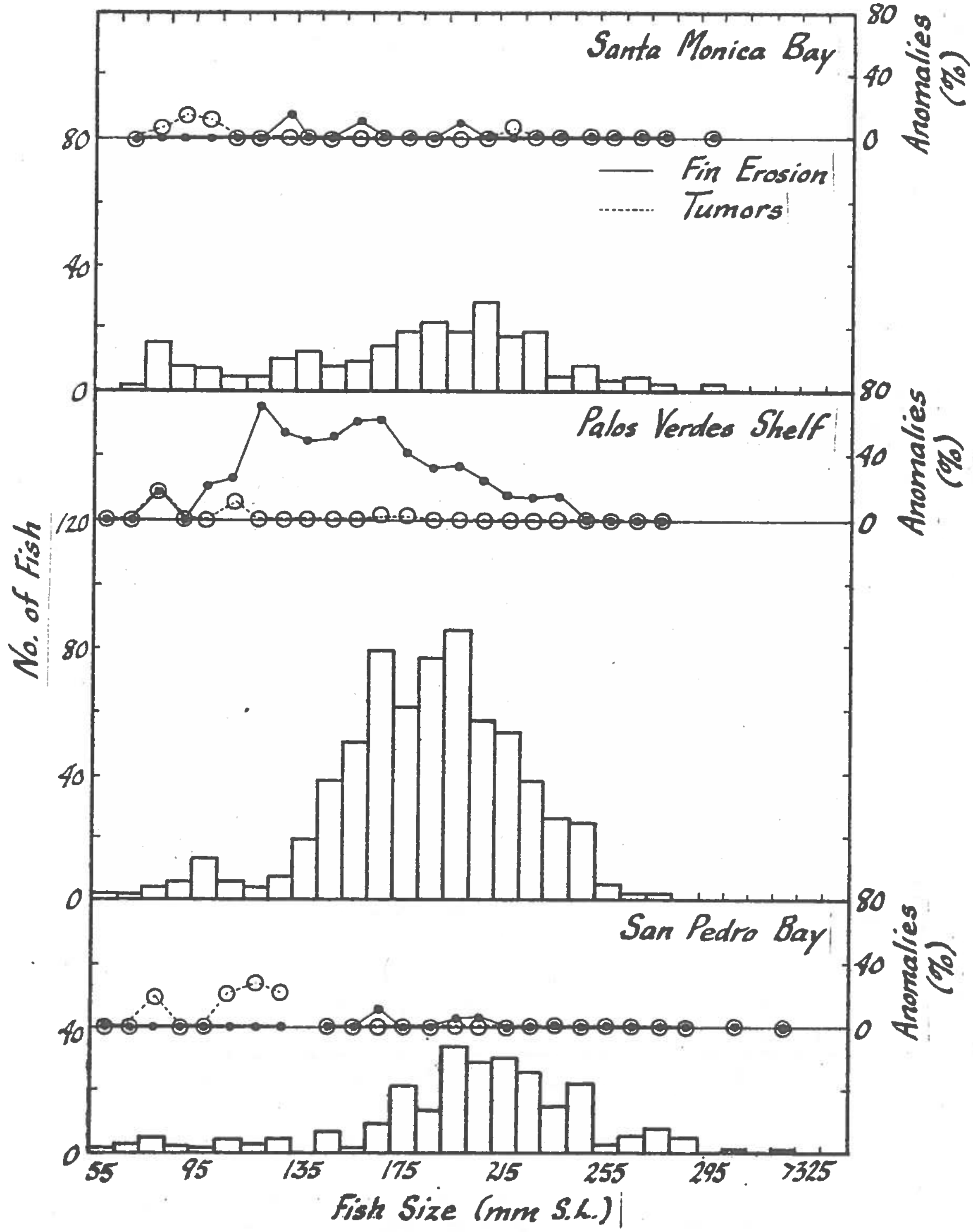

Figure 16. Size histogram of fin erosion in Dover sole, synoptic survey, September 1973

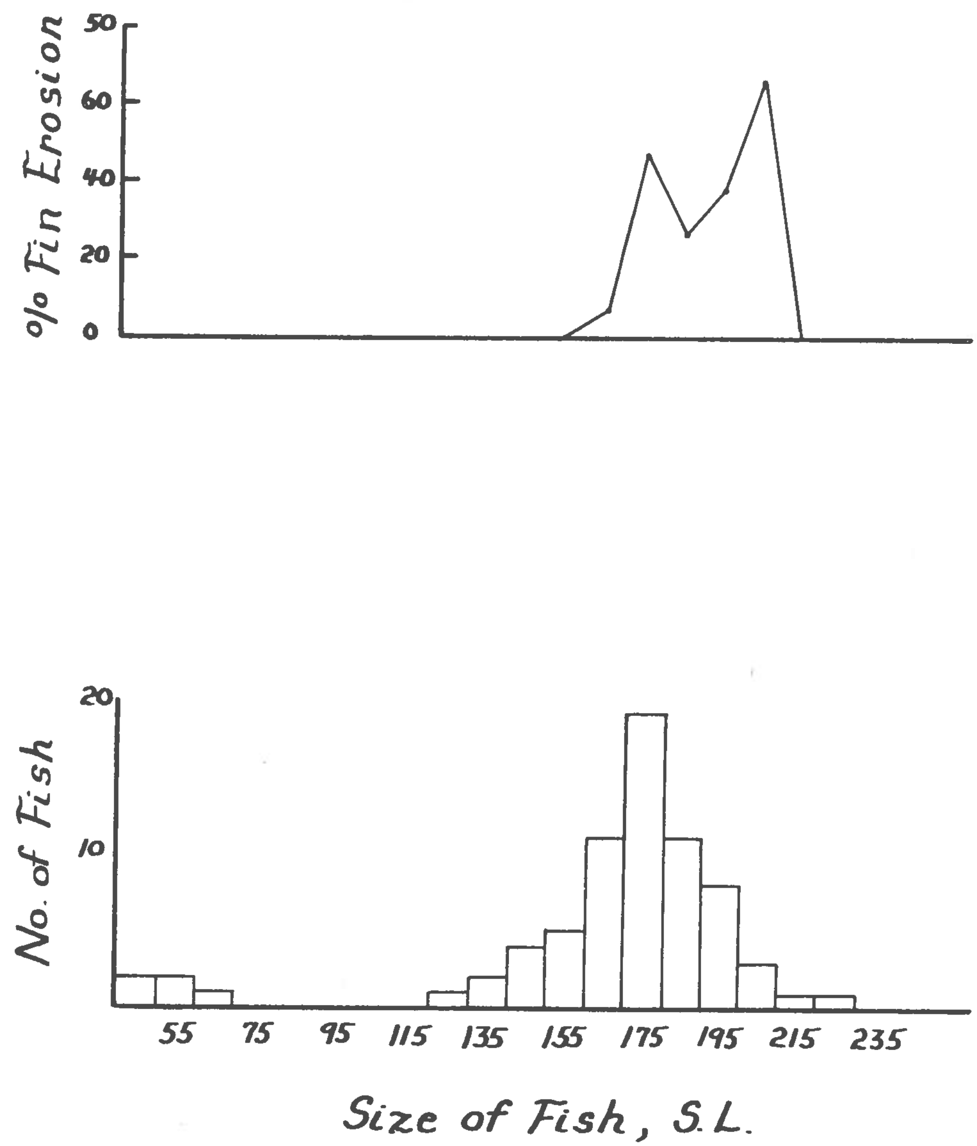

Figure 17. Fin erosion in rex sole taken off Palos Verdes, synoptic survey, September 1973.

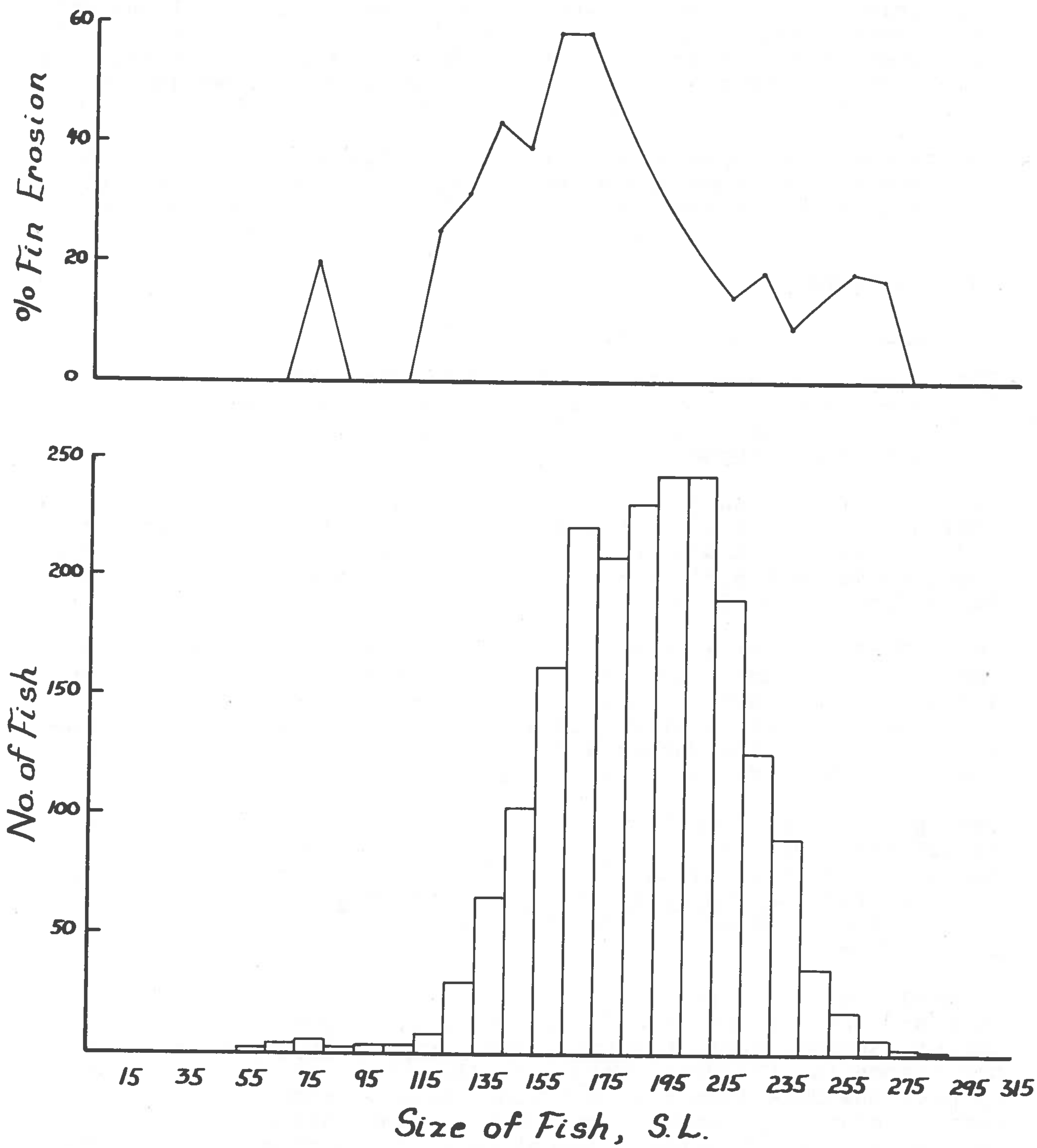

Figure 18. Fin erosion in Dover sole taken off Palos Verdes, June 1973.

reports (Southern California Coastal Water Research Project 1973; Mearns and Sherwood, in press): The diseases have different geographical distribution patterns and affect fish at different stages in their life cycles. The fin erosion disease in benthic fishes is clearly location-dependent and continues to occur in the vicinity of the Whites Point discharges. A seasonal pattern is present (Figure 19) in that prevalence of the disease is higher in winter catches than in summer. There also appears to have been a decrease in the prevalence of the disease in 1973 as compared to 1972. Continued monitoring is required to verify this trend.

In any case, it appears that previous sampling programs have been adequate to make comparisons of fin erosion disease distributions and frequencies in the three survey areas, despite difference in the gear and procedures used in monitoring each area.

INVERTEBRATES

Species Abundance and Distribution

The scientific names, common names, and distribution by area of the 101 invertebrate species taken in the synoptic survey are presented in Table 10. The number of individuals per species in each sample is presented in Appendices F through H.

The Palos Verdes samples produced the most species (60). Santa Monica Bay was the next richest area (54 species), and San Pedro Bay had the fewest species (47). Of the 19,371 invertebrate specimens collected, 8,340 were taken in Santa Monica Bay, 7,947 off Palos Verdes, and 3,084 in San Pedro Bay.

Only 17 of the 101 species collected were found in all three areas. The species compositions of the two bay areas were somewhat more similar to each other (28 species in common) than to that of the Palos Verdes shelf (Palos Verdes and Santa Monica Bay had 24 species in common and Palos Verdes and San Pedro Bay had 23 species in common). These faunal relationships are summarized in Figure 20.

Ten species out of the 101 collected accounted for 90.1 percent of all specimens (Table 11). Seven of these ten species were found in all three areas, but only four (Pandalus jordani, Spirontocaris bispinosa, Sicyonia ingentis, and Crangon zacae), all shrimp, ranked among the most dominant species occurring in each area (Table 12).

Several important trends in the spatial distribution of the dominant species are revealed in Table 11. Among the species of shrimp, Spirontocaris bispinosa and Sicyonia ingentis show a clear preference for the Palos Verdes shelf. This pattern is supported by previous data from the individual areas. Pandalus jordani was very abundant in samples from the bay areas (all but three specimens were recently settled juveniles). In contrast, adult forms

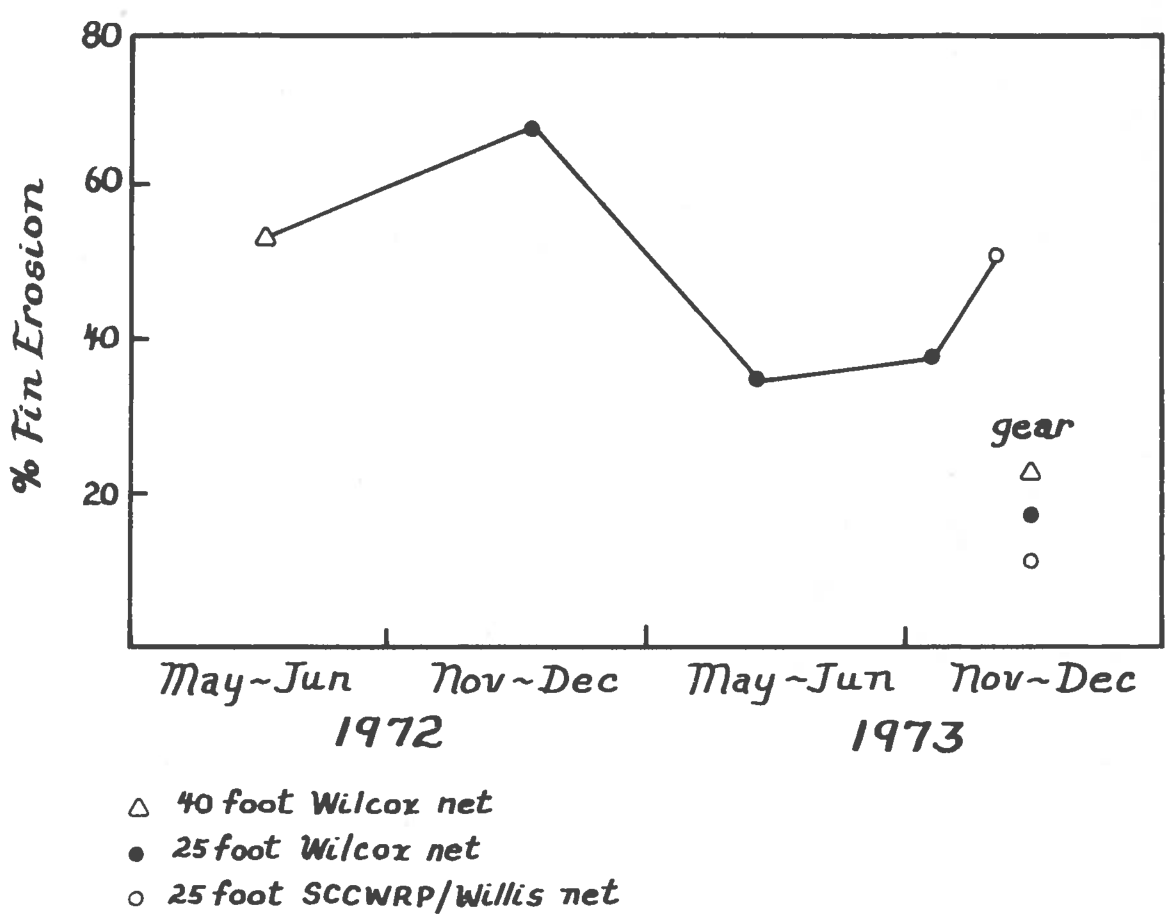

Figure 19. Prevalence of fin erosion in Dover sole taken at a set of stations on the Palos Verdes shelf, 1972-73.

Table 10. Scientific names of invertebrate species taken in synoptic survey, September 1973

Species	Santa Monica Bay	Palos Verdes	San Pedro Bay
Coelenterata			
Siphonophora			
Dromalia alexandri			X
Hydrozoa			
Aglaophenia			
Anthozoa			
Metridium sp.	X	X	
Stylatula sp.	X	X	
Ctenophora			
Pleurobrachia bachei		X	
Nemertinea			
Cerebratulus sp.	X		X
Echiuroidea			
Listriolobus pelodes	X	X	X
Echinodermata			
Asteroidea			
Astropecten verrilli	X	X	X
Astropecten braziliensis	X		
Mediaster aequalis	X		X
Pisaster brevispinus	X		X
Petalaster foliolatum	X		X
Patiria miniata		X	
Astrometis sertulifera		X	
Rathbunaster californicus			X
Echinoidea			
Lytechinus anamesus	X	X	
Allocentrotus fragilis	X	X	
Brisaster latifrons	X		
Ophiuroidea			
Ophiurans, UI	X		X
Holothuroidea			
Parastichopus californicus	X	X	X
Mollusca			
Gastropoda			
Prosobranchia			
Balcis sp.	X		
Calliostoma tricolor		X	
Collumbellidae, UI			
Conus californicus		X	
Crepidula nivea			X
Crepidula onyx		X	
Crucibulum spinosa	X		
Epitonium sp.	X		
Gastropod, UI	X	X	
Kelletia kelleti	X	X	
Lamellaria diegoensis	X		
Megasercula carpenteri			X
Nassarius insculptus		X	
Nassarius mendicus		X	X
Nassarius perpinguis		X	
Pteropurpura voxae		X	
Solamen sp.			

Table 10 (continued)

Species	Santa Monica Bay	Palos Verdes	San Pedro Bay
Opistobranchia			
Acanthadoris brunnea		X	X
Acanthadoris rhodocerus	X		X
Acteocina sp.			X
Armina californica	X		
Dendronotus sp.			X
Dirona picta	X		
Flabellinopsis iodinea	X		
Pleurobranchaea californica	X	X	X
Rictaxis punctocoelata		X	
Tritonia exsulans			X
Amphineura			
Lepidazona sp.		X	
Pelecypoda			
Acila castrensis	X		X
Lucina approximatus		X	
Macoma carlottensis	X	X	
Megacrenella sp.		X	
Pelecypod, UI	X	X	
Tapes sp.		X	
Tellina sp.		X	
Cephalopoda			
Octopus sp.	X	X	X
Rossia pacifica	X	X	X
Loligo opalescens			X
Annelida			
Polychaeta			
Chone sp.	X		
Eulalia sp.	X	X	
Glycera sp.	X		
Phyllochaetopterus sp.			
Pista elongata			X
Platynereis bicanaliculata		X	
Polychaete, UI	X		X
Hirudinea			
Leech, UI			
Arthropoda			
Crustacea			
Ostracoda			
Ostracod, UI	X		
Cirrepedia			
Balanus concavus pacificus			X
Scalpellum sp.	X		
Malacostraca			
Mysidacea			
Mysids, UI			
Cumacea			
Cumacean, UI		X	X

Table 10 (continued)

Species	Santa Monica Bay	Palos Verdes	San Pedro Bay
Isopoda			
Lironeca vulgaris	X	X	
Nerocila sp.		X	
Decapoda			
Peneides			
Peneidae			
Sicyonia ingentis	X	X	X
Sergestidae			
Sergestes similis		X	
Carides			
Pasiphaeidae			
Pasiphaea pacifica		X	
Pandalidae			
Pandalus jordani	X	X	X
Pandalus platyceros		X	
Hippolytidae			
Spirontocaris gracilis	X	X	
Spirontocaris sica		X	X
Spirontocaris sp. No. 1			
Spirontocaris nr. *dalli*		X	
Spirontocaris cristata	X	X	X
Spirontocaris bispinosa		X	
Spirontocaris sp. No. 2		X	
Crangonidae			
Crangon alaskensis elongata	X	X	X
Crangon nigromaculata	X	X	X
Crangon zacae	X	X	X
Crangon resima	X	X	X
Crangon spinosissima	X		X
Anomura			
Paguridae			
Pagurid, UI			
Isocheles sp.			
Anomuran, UI		X	X
Galatheidae			
Munida quadrispina		X	
Brachyura			
Majidae			
Majid, UI	X		
Calappidae			
Mursia gaudichaudii	X	X	X
Cancridae			
Cancer gracilis	X	X	X
Cancer anthonyi	X	X	X
Cancer productus		X	
Brachyuran, UI		X	
Chordata			
Urochordate, UI	X	X	X

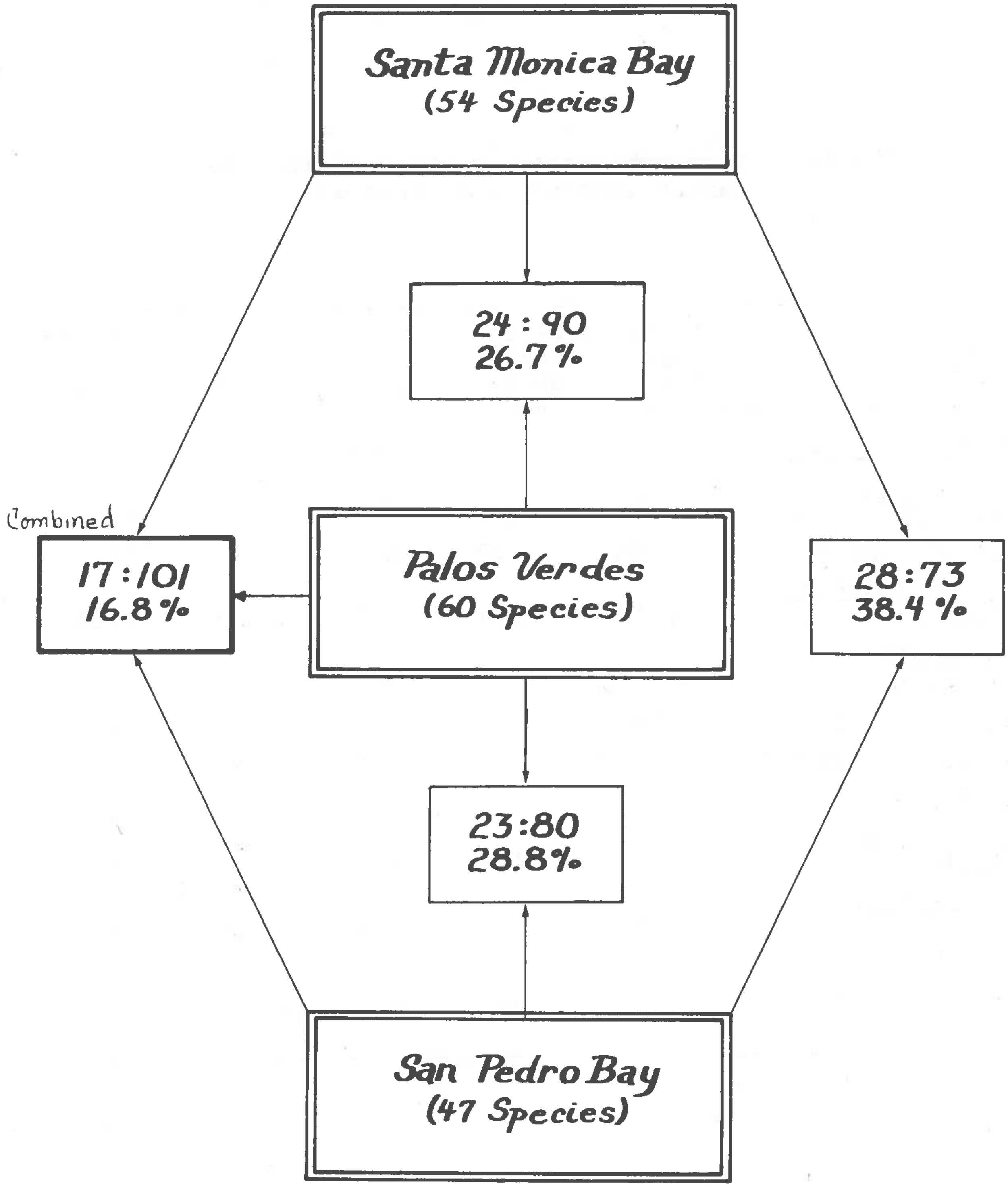

Figure 20. Degree of similarity of invertebrate fauna in Santa Monica Bay, on the Palos Verdes shelf, and in San Pedro Bay, synoptic survey, September 1973. Ratio of species in common to total number of species in regions, and percent similarity.

Table 11. Invertebrates most abundant in synoptic survey samples, September 1973.

Species	Santa Monica Bay	Palos Verdes Shelf	San Pedro Bay	Total	Cumulative Percent
Pandalus jordani	3,970	161	569	4,700	24.76
Spirontocaris bispinosa	298	2,499	713	3,510	42.41
Sicyonia ingentis	746	1,627	849	3,222	59.06
Crangon alaskensis elongata	22	1,577	19	1,618	67.42
Astropectin verrilli	1,132	7	243	1,382	74.56
Crangon zacae	489	363	175	1,027	79.86
Nassarius mendicus	-	707	1	708	83.52
Stylatula	500	15	-	515	86.18
Allocentrotus fragilis	351	118	-	469	88.60
Parastichopus californicus	252	11	141	404	90.70
Total	7,760	7,085	2,710	17,555	

Table 12. Dominant invertebrate species per area, synoptic survey, September 1973

	SPECIES NAME	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL	CUMULATIVE PERCENT	SPECIES CUMULATIVE PERCENT
	SANTA MONICA BAY				
1	PANDALUS JORDANI	3970	47.60	47.60	1.85
2	ASTROPECTEN VERRILLI	1132	13.57	61.18	3.70
3	SICYONIA INGENTIS	746	8.94	70.12	5.56
4	STYLATULA	500	6.00	76.12	7.41
5	CRANGON ZACAE	489	5.86	81.98	9.26
6	ALLOCENTROTUS FRAGILIS	351	4.21	86.19	11.11
7	SPIRONTOCARIS BISPINOSA	298	3.57	89.76	12.96
8	PARASTICHOPUS CALIFORNICUS	252	3.02	92.78	14.81
	PALOS VERDES SHELF				
1	SPIRONTOCARIS BISPINOSA	2499	31.45	31.45	1.67
2	SICYONIA INGENTIS	1627	20.47	51.92	3.33
3	CRANGON ALASKENSIS ELONGATA	1577	19.84	71.76	5.00
4	NASSARIUS MENDICUS	707	8.90	80.66	6.67
5	CRANGON ZACAE	363	4.57	85.23	8.33
6	MACOMA CARLOTTENSIS	265	3.33	88.56	10.00
7	PANDALUS JORDANI	161	2.03	90.59	11.67
	SAN PEDRO BAY				
1	SICYONIA INGENTIS	849	27.53	27.53	2.13
2	SPIRONTOCARIS BISPINOSA	713	23.12	50.65	4.26
3	PANDALUS JORDANI	569	18.45	69.10	6.38
4	ASTROPECTEN VERRILLI	243	7.88	76.98	8.51
5	CRANGON ZACAE	175	5.67	82.65	10.64
6	PARASTICHOPUS CALIFORNICUS	141	4.57	87.22	12.77
7	LYTECHINUS ANAMESUS	116	3.76	90.99	14.89

of the remaining two shrimp, Crangon alaskensis elongata and C. zacae, did not reveal distinct areal preferences during this survey. The large number of C. alaskensis elongata found on the Palos Verdes shelf consisted almost entirely of recently settled juveniles.

Among the dominant echinoderms, Astropectin verrilli (a sea star) and Parastichopus californicus (the sea cucumber) display distributional patterns that are similar to those observed in past surveys. Both species occurred in all three areas. They were present near the outfalls in the bays, but they were absent or rarely found near the outfalls on the Palos Verdes shelf (Figures 21 and 22). We did not find the sea urchin Allocentrotus fragilis in San Pedro Bay, although it has been found during previous surveys in parts of the bay adjacent to the sampling grid used in the synoptic survey.

Thirty-four (33.7 percent) of the species were collected from only one of the three survey areas. Most of these species are not considered unique to any one area and have been found elsewhere in previous surveys. However, several of the species collected do not typically occur at the depths sampled and are presently considered unusual if not rare to these regions. The shrimp Sergestes similis is reported to be a deepwater form and has not previously been found in shallower waters in this region. The small shrimp Pasiphaea pacifica is also a deep-water form typically found at depths greater than 300 m. The shrimp Spirontocaris cristata and S. nr. dalli are common to northern waters. The latter species, although not specifically identified, is very similar to an Alaskan form. Munida quadrispina, a galatheid, is a northern or deep (cold) water relative of the so-called pelagic red crab, Pleuroncodes planipes. All of these species, with the exception of S. cristata, were collected at Station 6022 (141 m) off Palos Verdes and may be an indication of upwelling.

The most unique invertebrate collected was a solid, pear-shaped animal supporting a small gas-filled sac at one end. The organism is a colonial coelenterate belonging to the Order Siphonophora and has been specifically identified as Dromalia alexandri. Two specimens were taken at Station 8069 in San Pedro Bay (143 m). Several similar organisms have been collected in this region and off of San Diego.

Catch Statistics

Table 13 summarizes the number of species, number of specimens, biomass, and numerical diversities (H and H(s)) of invertebrates in each sample. Inspection of these data reveals several general trends. First, the variability in all parameters is greater for invertebrates than for fishes, e.g., the number of species per sample ranged nearly sixfold (4 to 23), specimens per sample, 71-fold (37 to 2,637), biomass per sample, 70-fold (0.8 to 56.0),

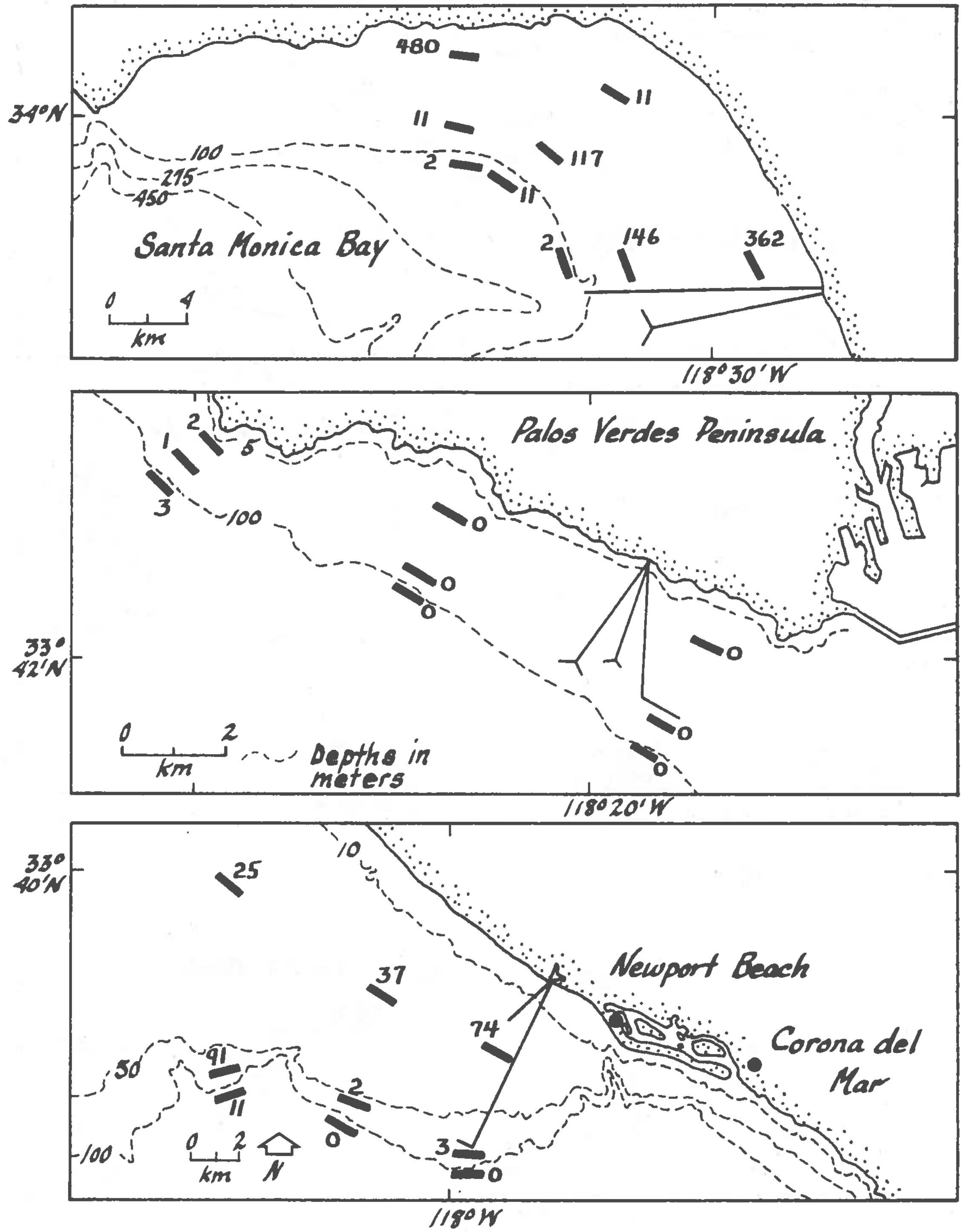

Figure 21. Distribution of Astropectin verrilli, synoptic survey, September 1973.

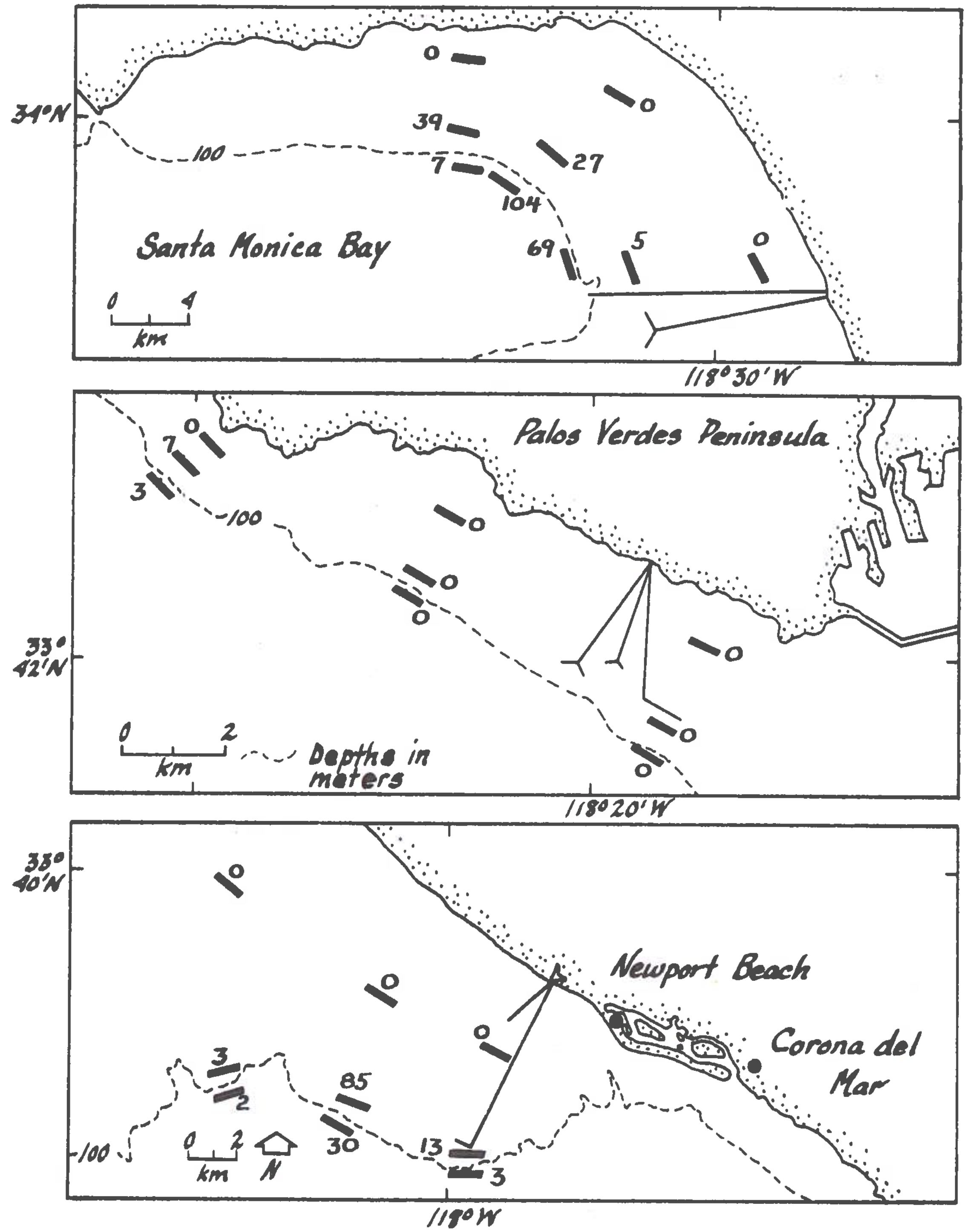

Figure 22. Distribution of *Parastichopus californicus*, synoptic survey, September 1973.

Table 13. Catch data and diversity calculations for invertebrates, synoptic survey, September 1973.

DATE MO DA YR	STA-SAMP	DEPTH (M)	BIOMASS (KG)	SPEC	INDI	BRILLOUIN DIVERSITY H	H(S)
SANTA MONICA BAY							
9/24/73	7.1	20	2.9	8	595	1.014	0.478
9/24/73	4.1	25	1.0	10	37	1.645	0.731
9/24/73	2.1	28	1.5	4	483	0.038	0.0
9/24/73	20.1	59	10.6	17	816	1.408	0.483
9/24/73	28.1	59	18.1	8	375	0.838	0.404
9/24/73	22.1	64	2.1	12	300	1.299	0.493
9/24/73	97.1	136	21.9	20	1026	1.259	0.401
9/24/73	95.1	138	5.4	20	2637	0.942	0.305
9/24/73	96.2	142	37.0	18	2036	1.305	0.444
SURVEY			100.5	54	8340	1.904	0.472
PALOS VERDES SHELF							
9/25/73	5.1	26	3.0	21	315	1.540	0.463
9/25/73	2.1	27	1.8	18	62	2.010	0.663
9/25/73	7.1	30	0.7	7	447	0.320	0.131
9/25/73	10.1	60	9.1	10	921	0.348	0.128
9/25/73	12.1	61	4.5	13	1767	0.727	0.272
9/25/73	14.1	63	8.1	10	545	0.443	0.159
9/25/73	25.1	133	1.0	14	535	1.096	0.391
9/25/73	19.1	146	11.1	16	766	1.059	0.359
9/25/73	22.1	150	2.0	23	2589	1.359	0.426
SURVEY			41.3	60	7947	2.050	0.495
SAN PEDRO BAY							
9/26/73	8.1	24	0.8	6	62	1.139	0.618
9/26/73	67.1	25	1.1	14	72	1.549	0.501
9/26/73	70.1	26	1.4	12	113	1.152	0.379
9/26/73	68.1	62	56.0	12	470	0.770	0.274
9/26/73	71.1	62	10.0	11	229	1.353	0.542
9/26/73	73.1	66	3.0	12	233	1.210	0.450
9/26/73	23.1	143	3.4	14	996	1.405	0.525
9/26/73	69.1	143	16.5	14	723	1.560	0.583
9/26/73	72.1	145	1.3	10	186	1.509	0.647
SURVEY			93.5	47	3084	2.072	0.529

and species diversity (H), almost 53-fold (0.038 to 2.010). Second, some of these parameters (number of species and number of specimens) increased significantly with depth.

Region, depth, and clumping are three sources of variability in faunal distribution that have been considered in our analysis of the synoptic survey data. Histograms of specimens, biomass, species, and diversity (H) for all samples through all areas are presented in Figure 23. It is apparent that specimens and biomass per sample are highly skewed to the right while species and diversity per sample approximate normal distributions. Because of these distributions, specimens and biomass per sample were analyzed in terms of the median, range, and 95 and 80 percent confidence intervals about their medians, and species and diversity (H) per sample were analyzed in terms of mean, range, and 95 and 80 percent confidence intervals about their means. Results of interregional comparisons are presented in Figure 24, and comparisons by depth are shown in Figure 25.

It is apparent from the data presented in Figure 24 that there are no significant differences between regions for any of the four variables at either the 95 or 80 percent confidence levels; however, several interesting trends and relationships occur. Palos Verdes samples produced the highest mean number of species per sample and the lowest mean diversity per sample. San Pedro Bay samples contained the lowest mean number of species and specimens per sample and the highest mean diversity per sample. Samples from San Pedro Bay also show less variability in these three parameters. Although biomass per sample was somewhat higher in Santa Monica Bay, the most striking aspect of the distribution of biomass is the extreme variability between samples. Most of this variability can be attributed to the patchy distributions of several relatively large echinoderms, primarily Parastichopus californicus, Allocentrotus fragilis, and Astropectin verrilli. Although these animals do not usually occur in great numbers, their large size has a pronounced effect in terms of biomass. This is especially true for the large sea cucumber, P. californicus, which was abundant at middepths in the bays and generally absent off Palos Verdes.

The most important result of these analyses is the apparent lack of significant differences among the regions. More intensive sampling would undoubtedly have altered the results to some degree, but we do not feel that a more comprehensive sampling program would have revealed significant differences among the survey areas in these comparisons.

The Brillouin information measure of species diversity (H) and its scaled version (H(s)) were determined for each sample in the survey and for the sums of the nine samples comprising each area (Table 13). These latter statistics (survey diversity in Table 13) have been included for two reasons: (1) while not accurate measures of the faunal diversity and evenness of each region, these indices provide a useful measure for comparing the total compositional diversity of

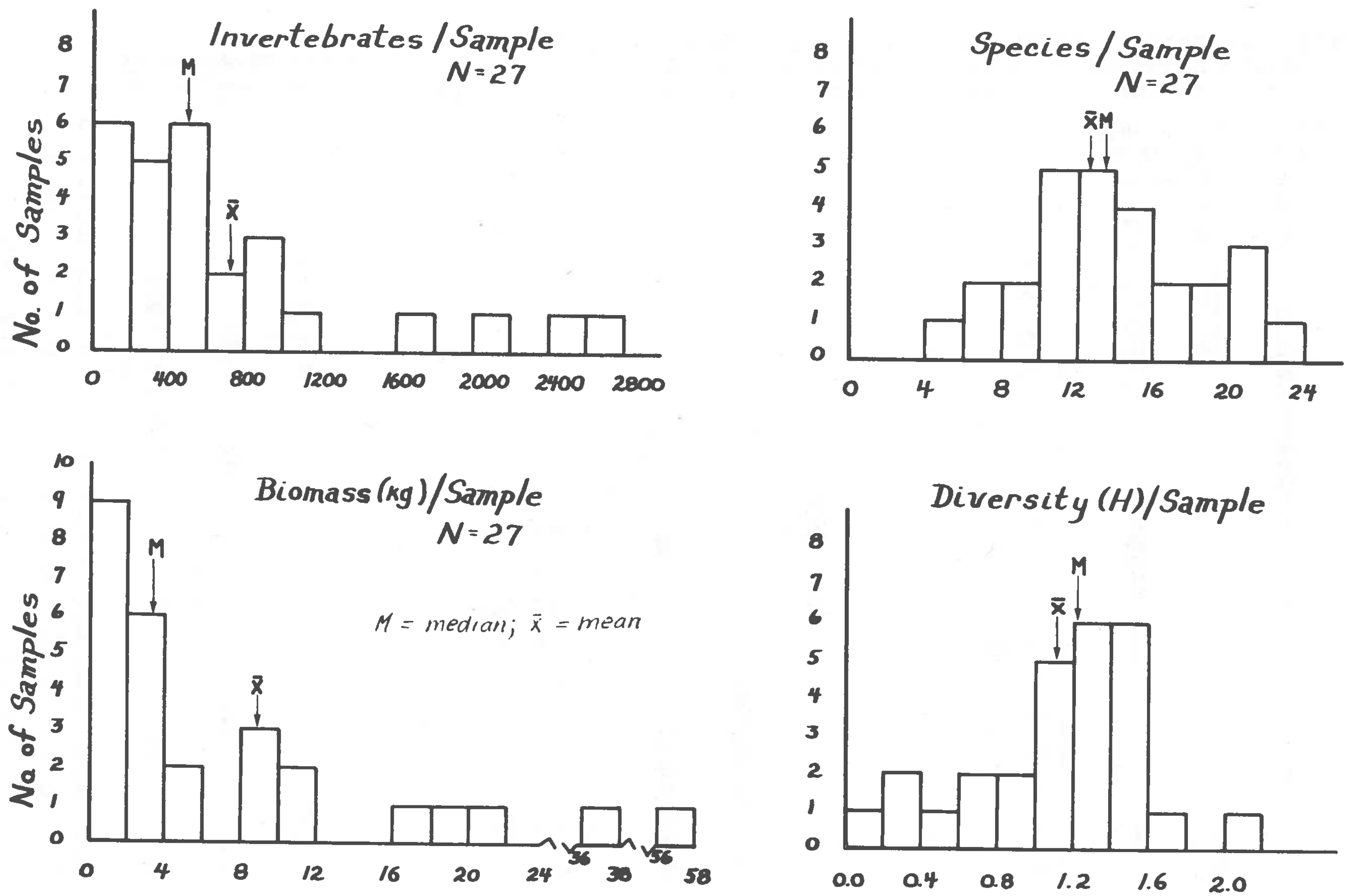

Figure 23. Invertebrate catch statistics, synoptic survey, September 1973.

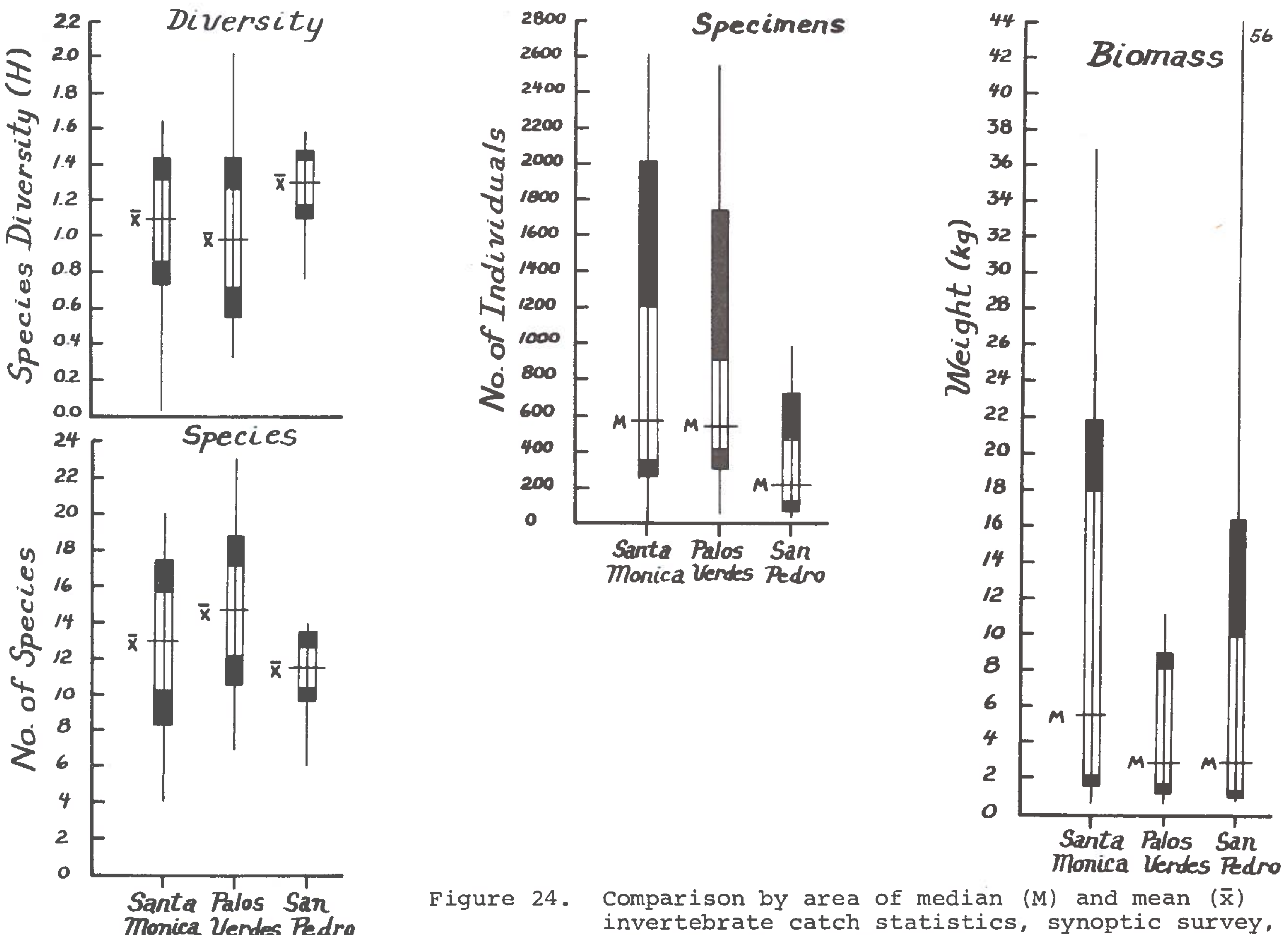

Figure 24. Comparison by area of median (M) and mean ($\bar{x}$) invertebrate catch statistics, synoptic survey, September 1973. Open bar is 80%, solid bar, 95%.

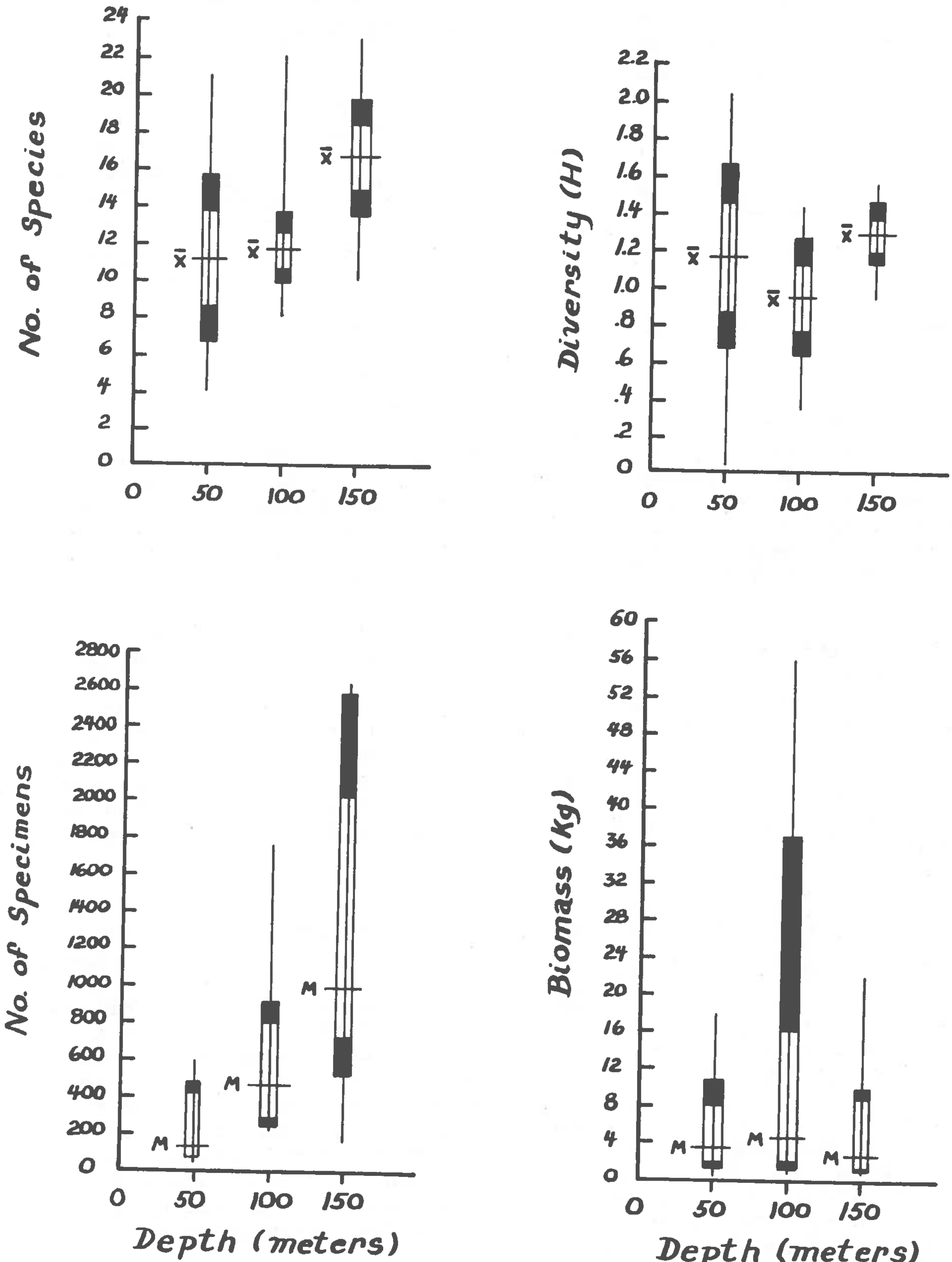

Figure 25. Comparison by depth of median (M) and mean ($\bar{x}$) invertebrate catch statistics, synoptic survey, September 1973. Open bar is 80%, solid bar, 95%.

Table 14. Brillouin index to diversity of benthic invertebrate samples, synoptic survey, September 1973.

Region	Diversity, H $\bar{x}$	Diversity, H S.D.	Scaled Diversity, H(s) $\bar{x}$	Scaled Diversity, H(s) S.D.	Diversity Differential
Santa Monica Bay	1.088	0.461	0.416	0.193	0.816
Palos Verdes Shelf	0.989	0.583	0.332	0.178	1.061
San Pedro Bay	1.294	0.255	0.502	0.118	0.778

the nine samples comprising each area, and (2) the difference between the total compositional diversity and the mean diversity of an area provides an index of the heterogeneity (patchiness) for the more dominant species occurring in the samples. This index has been called the Diversity Differential by Greene, and its logical evolution is presented in detail in his paper (1973).

Table 14 gives the means and standard deviations for H and H(s) and the diversity differential for each region. The diversity differential for each area is high, indicating that the distribution of species among samples was quite patchy. These high values of the index may in part be the product of the relatively great distance between sample sites, and thus reflect the spatial heterogeneity of the fauna. A comparison of the indices for each area indicates that the distribution of species among samples was more heterogeneous on the Palos Verdes shelf than in either of the two bays.

No parameter showed any significant differences with depth at the 95 percent confidence level (Figure 25). However, very strong trends are indicated by significant differences at the 80 percent confidence levels. For example, the number of species at deep stations (133 to 150 m) is significantly greater than at shallow (20 to 30 m) and intermediate (59 to 65 m) depths. There is also a trend of increasing numbers of species with increasing depth. Significantly fewer specimens were found at shallow stations than at deep stations, and there is a distinct trend toward increasing numbers of specimens with depth. There are no indications of differences in biomass through depths. However, the distribution of biomass from station to station is much more variable and more extremely skewed at intermediate depths than at the shallow and deep stations. This can be attributed to the prevalence of P. californicus in this depth range.

Diversity for each sample by depth is shown in Figure 26. Mean diversity for the samples taken at the shallow and deep stations shows a slight increase southward that coincides with the trend in total diversity for the regions. It is also apparent that the variability in species diversity among samples within and between areas decreases as depth increases. This is not altogether unexpected, because physical perturbations acting upon the system become more alike and predictable with depth.

Diversities for the three middepth samples off Palos Verdes were significantly lower than the diversities of comparable samples in either bay. Each of these samples was almost completely dominated by one of two species of shrimp: *Sicyonia ingentis*, which are characteristic of this depth range in all areas, and juvenile *Crangon alaskensis elongata*, which were extremely abundant at Station 6012.

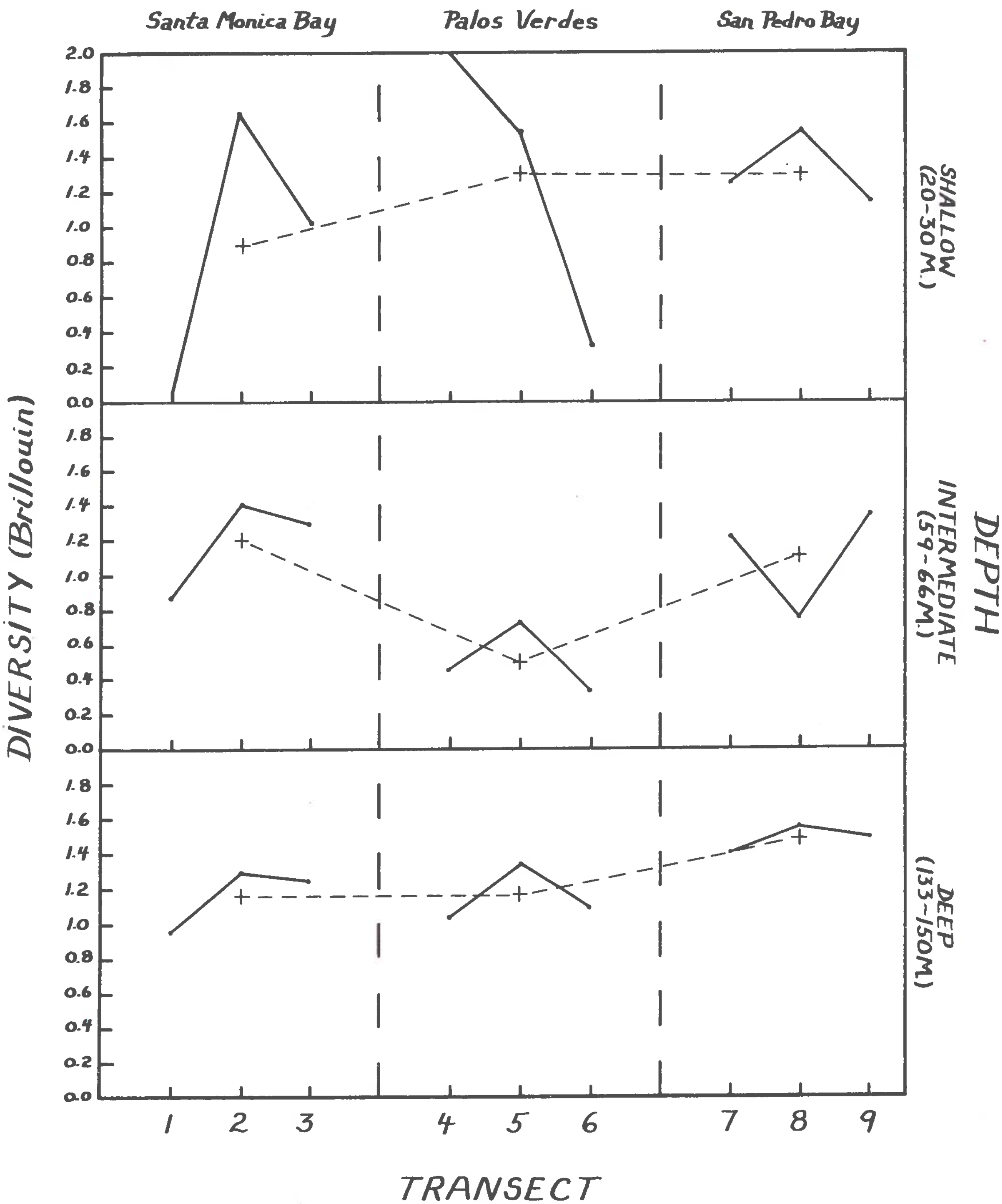

Figure 26. Invertebrate diversity by depth, synoptic survey, September 1973.

DISCUSSION

COMPARISON OF FISH AND INVERTEBRATE CATCH STATISTICS

The synoptic survey data show some general trends in fish and invertebrate distributions in the three survey areas. First, both the number of species and the diversity per sample were substantially higher for fish than for invertebrates. Second, the variability of all catch parameters (species, specimens, biomass, and diversity) was substantially higher for invertebrates than for fish. Finally, fish are more evenly distributed (in terms of numbers of species and numbers of specimens) through the three depths surveyed than are invertebrates.

REGIONAL COMPARISONS

Between 1969 and 1972, several agencies conducted individual trawling surveys in the three regions of concern to us here. Each agency worked only in specific areas; although all collected samples with otter trawls, there were differences in the vessels, nets, and procedures used, as well as in the depths trawled and the seasons of the year during which the individual surveys were conducted.

In trying to obtain an overall view of the conditions in the three areas, the Project compared the data from the different surveys in its 3-year report (1973: Table 7-5). The comparison suggested that Santa Monica Bay was relatively low in numbers and kinds of epibenthic fauna in comparison to San Pedro Bay or other southern California coastal areas, and that the Palos Verdes shelf fell somewhere in between. Other researchers, such as Fay (1972), have supported this view.

The data from the synoptic survey, however, suggest that differences in the abundance and distribution of epibenthic fauna in the three areas is not as great as we previously supposed. Moreover, the data also show that during this survey, Santa Monica Bay was more productive than the other two areas. Finally, our original findings of fish diseases were reconfirmed by the synoptic survey results: Fin erosion, the disease most prevalent in southern California benthic fishes, is concentrated off Palos Verdes (and also appears to a small extent in Santa Monica Bay) and affects a large portion of the abundant bottomfish fauna.

A direct attempt to compare the present data with previous reports is difficult without allowing for the differences in sampling procedures and the seasonality of catches (most apparent in a 4-year trawling program off Orange County). In addition, in previous surveys, biomass (weight of organisms) of fish and abundances and weights of trawl-caught invertebrates were not reported. It is, however, interesting to compare our present observations with previous data on benthic fish catches for two parameters--median number of specimens per sample and mean number of species per sample (Table 15).

Each survey represents samples taken on an approximately equal-effort per depth basis, spanning depths from 18 to about 180 m. The most complete sampling for all areas occurred in 1971, and it is clear from the data in Table 15 that the San Pedro Bay samples produced the highest catch per unit effort: Catches were on the order of three times higher there than in Santa Monica Bay or Palos Verdes at any given season. Average number of species per haul, a much less variable parameter, also appeared to be significantly higher in the San Pedro Bay samples than in those from Santa Monica Bay or Palos Verdes. The trend was also toward lower May-July catches in Santa Monica Bay and Palos Verdes than in San Pedro Bay. However, the results for Palos Verdes in November-December 1972 were very similar to those from San Pedro Bay (494 and 414 fish/haul, and 15,3 and 15.6 species/haul, respectively). These shifts in catch appear to be associated with gear changes noted in Table 15.

Obviously, the temporal and spatial variations in these parameters make it impossible to come to firm conclusions about the effects of sampling procedures on trawl results. The only way these effects can be evaluated with certainty is by sampling the areas concurrently using the procedures and gear used in previous surveys. The gear and procedures used to obtain the present data were identical to those used by Marine Biological Consultants in sampling the San Pedro Bay area between 1971-73. Samples were recently collected by this agency, and a comparison of these data will be undertaken.

The most obvious deviation from our present results is with the Santa Monica Bay data collected by the Hyperion Treatment Plant, City of Los Angeles, using gear and procedures similar to those of Carlisle (1969). The range of values for abundance per sample are remarkably similar. The design of the gear used was not distinctly different than that presently in use by other agencies, but trawling speed differences (1.5 knots vs. 2.5-3.0 knots used by the Project, Marine Biological Consultants, and County Sanitation District of Los Angeles County) and effective net openings may be key factors in producing comparatively low yields (Mearns, 1974). The distance covered at the slower speed is about two-thirds that at a speed of 2.5 knots (402.3 meters vs. 671 meters) and one half that at 3 knots (402.3 meters vs. 804.6 meters). In addition,

Table 15. Number of fish and species per sample, trawling surveys, February 1971 to September 1973. Sample sizes in parentheses.

Year	Quarter	Santa Monica Bay	Palos Verdes	San Pedro Bay
NUMBER OF INDIVIDUALS PER 10-MINUTE TRAWL (MEDIANS)				
1971	Feb-Apr	169 (15)[1]	164 (13)[2]	373[4]
	May-July	108 (6)[1]	-	880[4]
	Aug-Oct	132 (28)[1]	82 (28)[2]	598[4]
	Nov-Jan	-	102 (11)[2]	454[4]
1972	Feb-Apr	-	-	470[4]
	May-July	98 (31)[1]	214 (25)[2]	512[4]
	Aug-Oct	-	-	394[4]
	Nov-Jan	-	494 (26)[3]	414[4]
1973	Feb-Apr	-	297 (19)[3] 167 (18)[2]	303[4]
	May-July	-	684 (21)[3]	588[4]
	Aug-Oct	-	-	216[4]
	Synoptic	400 (9)[5]	331 (9)[5]	364 (9)[5]
NUMBER OF SPECIES PER 10-MINUTE TRAWL (MEANS ± $S.E._{\bar{x}}$)				
1971	Feb-Apr	9.4 ± 0.5	8.9 ± 1.3	15.9 ± 1.4
	May-July	8.3 ± 0.8	-	17.4 ± 1.3
	Aug-Oct	10.4 ± 0.7	10.0 ± 0.8	20.2 ± 1.6
	Nov-Jan	-	12.5 ± 2.2	17.4 ± 1.3
1972	Feb-Apr	-	-	16.8 ± 0.7
	May-July	9.6 ± 0.8	11.7 ± 0.7	20.8 ± 1.2
	Aug-Oct	-	-	18.3 ± 1.8
	Nov-Jan	-	15.3 ± 0.9	15.6 ± 1.7
1973	Feb-Apr	-	14.0 ± 0.5 12.1 ± 1.0	17.6 ± 1.1
	May-July	-	15.3 ± 1.2	20.3 ± 2.1
	Aug-Oct	-	-	16.5 ± 1.1
	Synoptic	17.6 ± 1.7	16.7 ± 0.9	15.7 ± 1.1

1. Hyperion Treatment Plant; 24-ft Wilcox trawl, 1-1/2 kn, median = 120.
2. Los Angeles County Sanitation Districts; 40-ft Wilcox trawl with 35-ft leglines, 2.7 kn, median = 164.
3. Los Angeles County Sanitation Districts; 24-ft Wilcox trawl, 2.7 kn, median = 494.
4. Marine Biological Consultants; 25-ft Marinovich trawl, 2.5 to 3.0 kn, 8 standardized stations trawled quarterly, median = 462.
5. Coastal Water Project synoptic; 25-ft Marinovich trawl, 2.5 to 3.0 kn, median = 364.

the Hyperion nets have been opening only about half the width of other nets with similar headrope length (Mearns, 1974). These factors would be sufficient to account for relatively low catches in past data from Santa Monica Bay. Tests are underway to check this hypothesis.

ENVIRONMENTAL GRADIENTS

Previous data (Southern California Coastal Water Research Project 1973) have shown that sediments contaminated by metals, organic material and pesticides from wastewater discharges show strong environmental gradients, radiating from the discharge sites. Benthic infauna are particularly sensitive to these gradients and reflect them at all major outfall sites studied to date (Hyperion, Whites Point, Orange County (San Pedro Bay), and Point Loma (San Diego)).

The present data demonstrate another set of environmental gradients that have a significant relation to the distribution of epibenthic fauna. During our sampling period, some faunal characteristics (especially fish biomass and diversity) were distributed according to depth and temperature and, to some degree, according to dissolved oxygen, as summarized in Figure 27.

Stephens (unpublished data on file at the Project) feels that the increase in fish catches with depth is in part attributable to longer actual on-bottom fishing time (ranging from 20 to 25 minutes at depths of 100 to 200 m). Correcting for this, he found highest fish abundance at the 66 m depth, with abundance decreasing inshore and offshore. This is consistent with his observation that the most productive trawling depths are in the range of 30 to 100 m. It seems noteworthy that all of the major marine wastewater discharges fall within this depth range.

Considering that the middepths of the coastal shelf are probably most productive for fish and some invertebrates, we can now examine possible depth-related environmental factors. Inshore, it is unlikely that well oxygenated water would limit biomass of demersal organisms; therefore, temperature, depth, light, or other factors such as food (benthic infauna) must be limiting. Overall, the greatest abundance and biomass of shelf epibenthic fauna occurred at the 61- and 137-m depths in cool water (9 to 11.5°C), with relatively low dissolved oxygen concentrations (3.5 to 5.5 mg/L). Since sampling occurred over a short period and reflected only a single point in a long-term fluctuation of seasonal events, it is possible that, over a long period, the deeper forms are limited by chronically low dissolved oxygen, perhaps making them less tolerant of the effects of toxic materials. If they are not limited by depth, temperature, or food, one would expect avoidance of low dissolved oxygen concentrations resulting in inshore movement of this fauna. Some evidence for this was presented (Southern California Coastal Water Research Project 1973) but in terms of numbers of

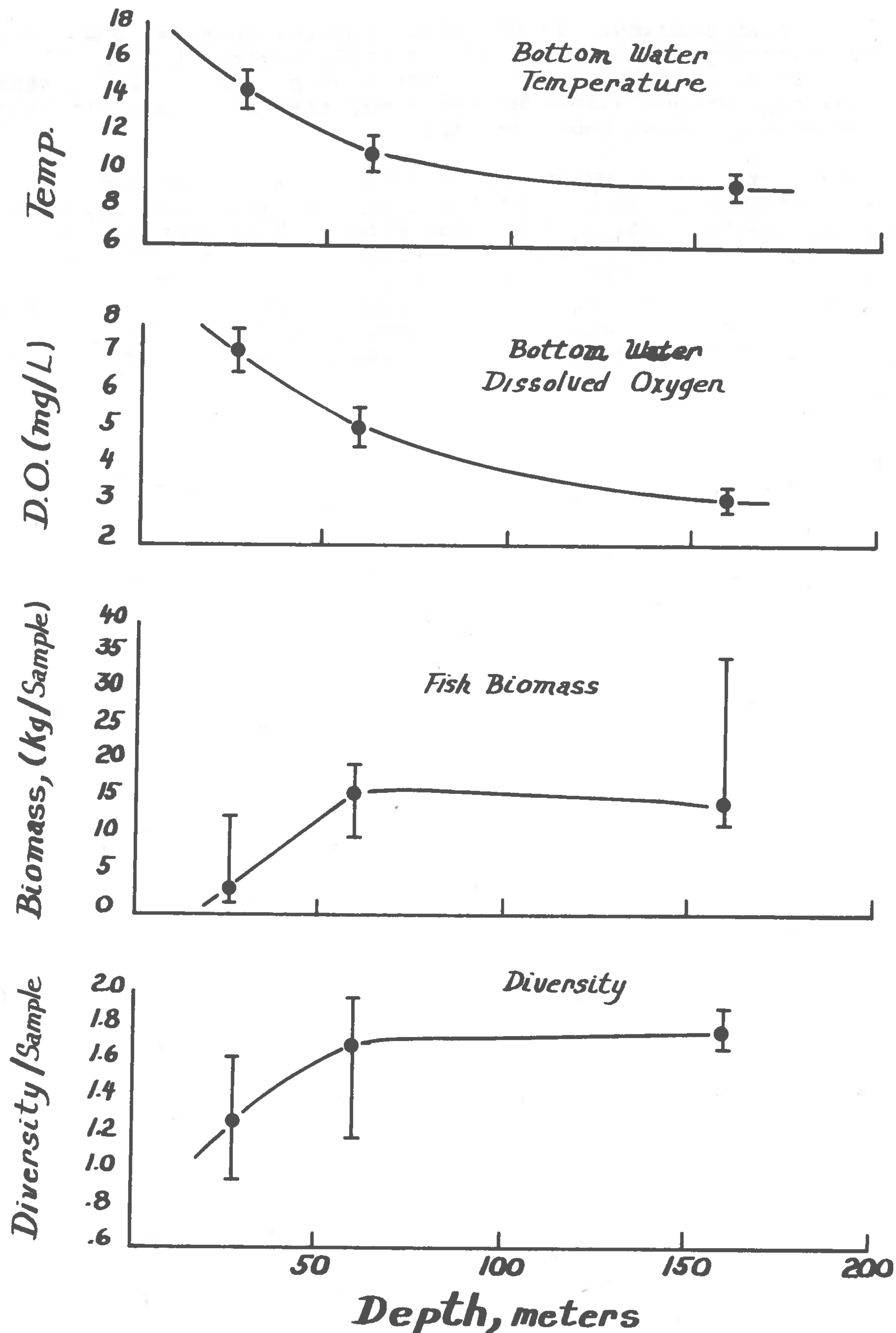

Figure 27. Bottom water quality, depth, and fish catch statistics, synoptic survey, September 1973.

fish rather than biomass. In any case, coastal demersal fauna biomass and diversity appear to be considerably higher at 50 m than inshore of this depth contour during late summer. Warm water inshore and low oxygen concentrations offshore may play important limiting roles toward regulating those factors.

With proper sampling of bottom water parameters (temperature, benthic biomass, dissolved oxygen), these factors regulating the distribution of shelf epibenthic fauna can be understood in the near future. There is already evidence (to be described in a future Project publication) that competition among ecologically similar species plays a significant role in affecting community; the work to date gives promise that the role of both natural and pollution-related gradients can be ascertained at the population and community level.

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APPENDICES

Appendix A. Weather, water clarity, and bathythermograph data synoptic survey, September 1973.

STATION	TIME	WIND (knts)	CLARITY* (m)	MLD** (m)	THERMOCLINE STRENGTH ($\Delta T/\Delta D$ = °C/m)	THERMOCLINE TYPE
Santa Monica Bay, 24 September 1973						
5002	0803-0813	0	-	7	5.8/21 = .27	NORMAL
5028	0858-0908	0	10	7	4.3/23 = .19	NORMAL
5095	1007-1017	1-2	14	8	5.7/26 = .22	NORMAL
5004	1140-1150	1-2	7	6	4.0/22 = .18	NORMAL
5020	1230-1240	2	12	9	4.7/15 = .31	NORMAL
5096-2	1415-1425	4	14	10	5.8/23 = .25	NORMAL
5007	1739-1749	4-5	5	7	4.6/17 = .27	NORMAL
5022	1625-1635	4-5	13	7	4.3/16 = .27	NORMAL
5097	1525-1535	4-5	14	9	6.8/31 = .22	NORMAL
Palos Verdes, 25 September 1973						
6002	0828-0830	1	8.5	10	3.0/16 .19	NORMAL
6014	0914-0924	1	9.5	14	2.2/4; 2.9/7 = .50; .41	DOUBLE T.C.
6019	1010-1020	1	9.5	12	6.1/27 .23	NORMAL
6005	1157-1207	2	6.5	25	0.5/25 .02	HOMOTHERMAL
6012	1245-1255	4-6	7.5	25	5.2/19 .27	NORMAL
6022	1343-1353	4-8	8.5	18	5.4/26 .21	NORMAL
6007	1702-1712	8	7.5	7	5.4/9 .60	NORMAL
6010	1608-1618	8	8.0	9	4.6/9 .51	NORMAL
6025	1507-1517	8	7.5	12	5.9/26 .23	NORMAL
San Pedro Bay, 26 September 1973						
8008	0758-0808	2	5	7	3.8/16 .24	NORMAL
8073	0855-0905	0	11	7	5.0/10 .50	NORMAL
8023	0949-0959	1	10	7	5.7/31 .18	NORMAL
8067	1149-1159	10	5.8	7	5.1/14 .36	NORMAL
8068	1244-1254	10	10.4	4	4.5/13 .35	NORMAL
8069	1345-1355	2	10.7	8	5.9/21 .28	NORMAL
8070	1720-1730	2	9.3	8	5.0/15 .33	NORMAL
8071	1625-1635	5	12.8	13	4.5/6 .75	NORMAL
8072	1520-1530	7	12.2	6	7.1/20 .36	NORMAL

*Secchi disk reading.

**Mixed layer depth.

Appendix B. Surface, middepth, and bottom water hydrographic data, synoptic survey, September 1973.

STATION	TIME	SURFACE TEMP. (°C)	SURFACE S. (‰)	SURFACE D.O. (mg/ℓ)	SURFACE % Sat.	MID-DEPTH DEPTH (m)	MID-DEPTH TEMP. (°C)	MID-DEPTH S. (‰)	MID-DEPTH D.O. (mg/ℓ)	MID-DEPTH % SAT.	BOTTOM MEAN DEPTH (m)	BOTTOM TEMP. (°C)	BOTTOM S. (‰)	BOTTOM D.O. (mg/ℓ)	BOTTOM %Sat
Santa Monica Bay, 24 September 1973															
5002	0803-0813	18.0	-	9.4		14	15.7	33.556	9.4	116	28	12.2	33.475	7.3	90
5028	0858-0908	18.2	-	8.4		30	13.2	33.476	7.5	88	59	11.8	33.558	5.1	57
5095	1007-1017	17.8	-	8.1		73	10.3	33.592	4.8	52	138	9.7	33.898	3.6	39
5004	1140-1150	18.8	33.553	9.0	118	13	17.2	33.529	9.0	115	25	15.1	33.457	7.8	96
5020	1230-1240	18.2	33.579	8.3	108	31	12.2	33.450	7.0	80	59	11.2	33.508	5.5	63
5096-2	1415-1425	18.3	33.610	8.1	105	73	10.0	33.630	5.1	56	142	9.2	33.885	3.4	37
5007	1739-1749	18.8	33.539	9.9	129	14	16.9	33.480	9.6	122	20	14.0	33.449	7.2	86
5022	1625-1635	18.8	33.592	8.4	110	31	13.1	33.462	7.5	88	64	10.6	33.594	4.9	55
5097	1525-1535	18.8	33.624	8.4	110	74	10.6	33.531	–	90	136	9.6	33.917	3.4	38
Palos Verdes, 25 September 1973															
6002	0828-0830	17.9	-	8.5		14	16.9	34.320	8.4	106	27	14.0	34.195	7.7	92
6014	0914-0924	17.9	-	8.4		31	13.2	34.224	6.7	79	63	10.9	34.201	4.9	56
6019	1010-1020	18.0	-	8.4		74	10.6	34.307	5.0	56	146	9.6	34.636	3.7	40
6005	1157-1207	17.9	-	9.0		14	17.8	33.224	9.1	117	26	17.6	34.220	8.8	113
6012	1245-1255	18.1	-	8.9		31	14.8	34.184	8.4	102	61	10.6	34.150	5.1	57
6022	1343-1353	17.8	-	8.8		74	11.6	34.257	5.5	63	150	10.2	34.571	3.9	43
6007	1702-1712	17.9	-	8.8		14	13.8	34.356	8.1	97	30	11.7	34.597	5.8	67
6010	1608-1618	17.9	-	8.5		31	12.0	34.176	6.4	73	60	10.5	34.146	5.2	58
6025	1507-1517	18.0	-	9.1		72	10.5	34.196	5.0	55	133	9.8	34.026	3.8	42
San Pedro Bay, 26 September 1973															
8008	0758-0808	18.2	33.507	8.7	113	13	16.8	33.402	7.5	95	24	14.9	33.431	8.9	108
8073	0855-0905	17.9	33.474	8.9	115	13	14.8	33.383	8.4		66	11.5	33.355	7.2	
8023	0949-0959	18.0	33.482	8.7	112	74	10.3	33.584	4.9	54	143	9.7	33.781	3.8	41
8067	1149-1159	18.3	33.508	9.0	117	14	15.2	33.439	8.8	107	25	12.9	33.341	6.9	80
8068	1244-1254	18.5	33.464	8.8	115	31	13.2	33.325	6.7	78	62	11.2	33.394	5.2	46
8069	1345-1355	19.2	33.646	8.9	117	74	10.6	33.601	5.0	55	143	9.5	33.793	3.6	39
8070	1720-1730	18.3	33.496	8.7	113	14	18.8	33.480	9.1	119	26	14.8	33.359	7.7	93
8071	1625-1635	18.6	33.488	8.7	113	31	13.4	33.355	7.5	89	62	10.9	33.425	5.2	58
8072	1520-1530	19.0	33.507	8.5	112	72	10.8	33.507	5.9	66	145	9.7	33.750	3.8	41

Appendix C. Fish catch per species per haul, Santa Monica Bay, 24 September 1973.

STATION-SAMPLE	7.1	4.1	2.1	20.1	28.1	22.1	97.1	95.1	96.2	
DEPTH(M.)	20	25	28	59	59	64	136	138	142	
DAY OF YEAR	268	268	268	268	268	268	268	268	268	TOTAL
SQUALUS ACANTHIAS	–	–	–	–	–	–	1	–	1	2
TORPEDO CALIFORNICA	–	–	–	–	–	–	–	1	–	1
HYDROLAGUS COLLIEI	–	–	–	–	–	–	1	–	–	1
ARGENTINA SIALIS	–	–	–	–	–	–	–	2	6	8
SYNODUS LUCIOCEPS	11	6	12	1	2	–	–	–	–	32
MERLUCCIUS PRODUCTUS	–	–	–	–	–	–	2	–	1	3
CITHARICHTHYS SORDIDUS	–	–	2	118	111	22	1	9	1	264
CITHARICHTHYS STIGMAEUS	129	78	10	25	1	179	–	–	–	422
CITHARICHTHYS XANTHOSTIGMA	–	–	1	–	1	–	–	–	–	2
HIPPOGLOSSINA STOMATA	1	1	4	3	–	1	1	–	–	11
PARALICHTHYS CALIFORNICUS	–	–	1	–	–	–	–	–	–	1
EOPSETTA JORDANI	–	–	–	–	–	–	1	–	–	1
GLYPTOCEPHALUS ZACHIRUS	–	–	–	–	–	–	2	18	37	59
LYOPSETTA EXILIS	–	–	–	–	–	1	9	47	139	198
MICROSTOMUS PACIFICUS	–	–	–	26	4	51	83	65	10	239
PAROPHRYS VETULUS	–	–	–	3	–	19	7	–	2	31
PLEURONICHTHYS DECURRENS	–	–	–	7	–	–	–	–	–	7
PLEURONICHTHYS VERTICALIS	5	17	4	3	4	1	–	–	–	34
SYMPHURUS ATRICAUDA	10	7	8	16	14	–	1	–	–	56
CYMATOGASTER AGGREGATA	4	–	–	–	–	3	–	–	–	7
EMBIOTOCA JACKSONI	–	–	1	–	–	–	–	–	–	1
ZALEMBIUS ROSACEUS	–	–	1	1	6	38	16	2	–	64
SEBASTES CRAMERI	–	–	–	–	–	–	12	3	2	18
SEBASTES DALLI	–	–	–	1	–	–	–	–	–	1
SEBASTES DIPLOPROA	–	–	–	–	–	–	1	–	16	18
SEBASTES ELONGATUS	–	–	–	1	–	–	–	4	–	5
SEBASTES EOS	–	–	–	–	–	–	1	–	–	1
SEBASTES GOODEI	–	–	–	12	1	4	–	–	–	17
SEBASTES JORDANI	–	–	–	–	–	–	77	42	–	119
SEBASTES LEVIS	–	–	–	1	1	–	16	–	–	18
SEBASTES MINIATUS	–	–	–	16	–	–	–	–	–	16
SEBASTES PAUCISPINIS	–	–	–	2	1	–	4	–	–	7
SEBASTES ROSENBLATTI	–	–	–	–	–	–	6	5	1	12
SEBASTES SAXICOLA	2	–	4	153	344	78	1653	167	31	2433
SEBASTES SEMICINCTUS	–	–	–	9	–	–	–	–	–	9
ANOPLOPOMA FIMBRIA	–	–	–	–	–	–	2	–	1	3
OPHIODON ELONGATUS	–	–	–	3	–	–	–	–	–	3
ZANIOLEPIS FRENATA	–	–	–	–	–	–	5	13	3	21
ZANIOLEPIS LATIPINNIS	2	2	6	10	21	123	–	–	–	164
CHITONOTUS PUGETENSIS	4	–	1	–	–	–	–	–	–	5
ICELINUS QUADRISERIATUS	85	104	153	413	56	4	–	–	–	816
RADULINUS ASPRELLUS	–	–	–	–	–	–	–	7	–	7
AGONOPSIS STERLETUS	1	–	1	–	–	–	–	–	–	2
ODONTOPYXIS TRISPINOSA	4	–	4	5	–	–	–	–	–	13
XENERETMUS LATIFRONS	–	–	–	–	–	–	12	15	17	44
LEPIDOGOBIUS LEPIDUS	6	1	1	2	8	–	–	–	–	18
PORICHTHYS MYRIASTER	4	–	–	–	–	–	–	–	–	4
PORICHTHYS NOTATUS	2	10	2	25	110	59	–	–	1	209
PLECTOBRANCHUS EVIDES	–	–	–	–	–	–	–	2	–	2
LYCODOPSIS PACIFICUS	–	–	–	–	–	1	2	6	18	27
CHILARA TAYLORI	–	–	–	3	–	–	3	1	–	7
TOTAL	270	226	216	859	685	584	1919	409	287	5463
TOTAL SPECIES	15	9	18	25	16	15	25	18	17	51

Appendix D. Fish catch per species per haul, Palos Verdes shelf, 25 September 1973.

STATION-SAMPLE	5.1	2.1	7.1	10.1	12.1	14.1	25.1	19.1	22.1	
DEPTH(M.)	26	27	30	60	61	63	133	146	150	
DAY OF YEAR	269	269	269	269	269	269	269	269	269	
										TOTAL
SQUALUS ACANTHIAS	–	–	–	–	1	–	–	–	–	1
TORPEDO CALIFORNICA	–	–	–	1	2	–	–	–	–	3
HYDROLAGUS COLLIEI	–	–	–	–	–	–	–	8	–	8
SYNODUS LUCIOCEPS	8	18	2	1	–	–	–	–	–	29
PHYSICULUS RASTRELLIGER	–	–	–	–	–	–	–	–	7	7
MERLUCCIUS PRODUCTUS	–	–	–	–	–	–	2	3	1	6
CITHARICHTHYS SORDIDUS	1	–	1	4	17	38	1	–	–	62
CITHARICHTHYS STIGMAEUS	106	1305	153	–	1	2	–	–	–	1567
HIPPOGLOSSINA STOMATA	–	1	–	–	–	–	–	–	–	1
GLYPTOCEPHALUS ZACHIRUS	–	–	–	–	–	5	22	40	4	71
LYOPSETTA EXILIS	–	–	–	–	–	–	14	1	7	22
MICROSTOMUS PACIFICUS	1	–	–	29	58	223	96	152	92	651
PAROPHRYS VETULUS	6	16	124	2	3	6	–	2	–	159
PLEURONICHTHYS COENOSUS	–	6	–	–	–	–	–	–	–	6
PLEURONICHTHYS DECURRENS	27	148	26	5	2	–	–	–	–	208
PLEURONICHTHYS VERTICALIS	4	5	1	1	–	–	–	–	–	11
SYMPHURUS ATRICAUDA	1	6	–	–	–	–	–	–	–	7
PEPRILUS SIMILLIMUS	–	–	1	–	–	–	–	–	–	1
GENYONEMUS LINEATUS	–	–	192	–	2	1	–	–	–	195
CAULOLATILUS PRINCEPS	–	1	–	–	–	–	–	–	–	1
CYMATOGASTER AGGREGATA	1	–	179	8	24	7	–	–	–	219
PHANERODON FURCATUS	–	–	7	–	–	–	–	–	–	7
RHACOCHILUS VACCA	–	–	3	–	–	–	–	–	–	3
ZALEMBIUS ROSACEUS	–	–	–	40	11	8	–	–	–	59
SCORPAENA GUTTATA	–	–	11	–	–	–	–	–	–	11
SEBASTES CRAMERI	–	–	–	–	1	1	8	–	1	11
SEBASTES DIPLOPROA	–	–	–	–	–	–	104	60	7	171
SEBASTES ELONGATUS	–	–	–	–	–	–	3	7	–	10
SEBASTES GOODEI	–	–	–	–	3	12	–	–	–	15
SEBASTES JORDANI	–	–	–	–	2	43	–	14	10	69
SEBASTES LEVIS	–	–	–	2	1	3	1	1	–	8
SEBASTES MACDONALDI	–	–	–	–	–	–	1	1	–	2
SEBASTES MINIATUS	2	10	–	–	1	–	–	–	–	13
SEBASTES PAUCISPINIS	–	–	8	1	–	1	1	2	–	13
SEBASTES ROSENELATTI	–	–	–	–	–	–	1	2	–	3
SEBASTES SAXICOLA	1	11	2	176	161	1368	60	46	33	1858
SEBASTES SEMICINCTUS	–	–	–	4	–	2	–	–	–	6
ANOPLOPOMA FIMBRIA	–	–	–	–	–	–	–	2	3	5
ZANIOLEPIS FRENATA	–	–	–	–	–	–	13	–	25	38
ZANIOLEPIS LATIPINNIS	–	–	–	3	4	8	–	–	–	15
CHITONOTUS PUGETENSIS	2	20	1	–	–	–	–	–	–	23
ICELINUS QUADRISERIATUS	4	114	1	–	–	1	–	–	–	120
PRIONOTUS STEPHANOPHRYS	–	–	1	–	–	–	–	–	–	1
ODONTOPYXIS TRISPINOSA	3	5	–	–	–	–	–	–	–	8
XENEPETMUS LATIFRONS	–	–	–	–	–	–	3	6	16	25
LEPIDOGOBIUS LEPIDUS	2	–	–	–	4	1	–	–	–	7
KATHETOSTOMA AVERRUNCUS	–	–	–	–	–	–	1	–	–	1
PORICHTHYS MYRIASTER	2	3	1	–	–	–	–	–	–	6
PORICHTHYS NOTATUS	–	–	1	–	5	12	–	–	–	18
APRODON CORTEZIANUS	–	–	–	–	–	–	–	32	8	40
LYCODOPSIS PACIFICUS	–	–	–	–	–	2	–	–	–	2
CHILARA TAYLORI	1	2	4	1	–	–	–	2	–	10
TOTAL	172	1671	719	278	303	1744	331	381	214	5813
TOTAL SPECIES	17	16	20	15	19	20	16	18	13	52

Appendix E. Fish catch per species per haul, San Pedro Bay, 26 September 1973.

STATION-SAMPLE	8.1	67.1	70.1	68.1	71.1	73.1	23.1	69.1	72.1	
DEPTH(M.)	24	25	26	62	62	66	143	143	145	
DAY OF YEAR	270	270	270	270	270	270	270	270	270	
										TOTAL
SYNODUS LUCIOCEPS	6	7	17	-	-	2	-	-	-	32
MERLUCCIUS PRODUCTUS	-	-	-	-	-	-	1	-	-	1
CITHARICHTHYS SORDIDUS	-	-	-	106	134	130	-	8	-	378
CITHARICHTHYS STIGMAEUS	291	87	31	-	-	63	-	-	-	472
CITHARICHTHYS XANTHOSTIGMA	-	-	-	1	1	-	-	-	-	2
HIPPOGLOSSINA STOMATA	1	2	2	-	3	5	-	-	-	13
GLYPTOCEPHALUS ZACHIRUS	-	-	-	2	-	-	15	9	3	29
LYOPSETTA EXILIS	-	-	-	2	-	-	78	180	61	321
MICROSTOMUS PACIFICUS	-	-	-	89	46	-	53	48	20	256
PAROPHRYS VETULUS	1	-	-	-	29	-	1	1	3	35
PLEURONICHTHYS DECURRENS	1	2	-	-	-	1	-	-	-	4
PLEURONICHTHYS VERTICALIS	29	4	-	1	1	3	-	-	-	38
SYMPHURUS ATRICAUDA	130	19	40	45	35	26	2	-	-	297
CYMATOGASTER AGGREGATA	-	-	-	1	-	7	-	-	-	8
ZALEMBIUS ROSACEUS	-	-	-	15	7	5	-	-	2	29
SCORPAENA GUTTATA	1	1	3	-	-	-	-	-	-	5
SEBASTES DALLI	-	-	-	-	3	9	-	-	-	12
SEBASTES DIPLOPROA	-	-	-	-	-	-	62	180	46	288
SEBASTES ELONGATUS	-	-	-	-	-	-	2	1	-	3
SEBASTES GOODEI	-	-	-	1	-	-	-	-	-	1
SEBASTES HOPKINSI	-	-	-	-	-	1	-	-	-	1
SEBASTES JORDANI	-	-	-	-	1	-	-	-	-	1
SEBASTES MINIATUS	-	-	-	-	-	18	-	-	-	18
SEBASTES ROSENBLATTI	-	-	-	-	-	-	-	1	-	1
SEBASTES RUBRIVINCTUS	-	-	-	-	-	1	-	-	-	1
SEBASTES SAXICOLA	-	-	-	77	38	3	22	83	45	268
SEBASTES SEMICINCTUS	-	-	-	1	4	31	-	-	-	36
SEBASTES VEXILLARIS	-	-	-	-	-	1	-	-	-	1
SEBASTOLOBUS ALASCANUS	-	-	-	-	-	-	3	1	-	4
ZANIOLEPIS FRENATA	-	-	-	1	2	-	5	7	10	25
ZANIOLEPIS LATIPINNIS	-	-	-	17	10	-	-	-	-	27
CHITONOTUS PUGETENSIS	1	1	1	-	1	13	-	-	-	17
ICELINUS QUADRISERIATUS	1	1	39	8	31	42	1	1	-	124
RADULINUS ASPRELLUS	-	-	-	-	-	-	-	6	-	6
ODONTOPYXIS TRISPINOSA	-	1	4	-	1	-	-	-	-	6
XENERETMUS LATIFRONS	-	-	-	-	-	-	26	5	6	37
PORICHTHYS NOTATUS	4	2	15	53	25	3	1	-	-	103
APRODON CORTEZIANUS	-	-	-	-	-	-	5	5	-	10
LYCODOPSIS PACIFICUS	-	-	-	-	-	-	18	72	7	97
LYCONEMA BARBATUM	-	-	-	-	-	-	3	5	2	10
CHILARA TAYLORI	-	-	-	-	-	-	-	1	1	2
TOTAL	466	127	152	420	372	364	298	614	206	3019
TOTAL SPECIES	11	11	9	16	18	19	17	18	12	41

Appendix F. Invertebrate catch per species per haul, Santa Monica Bay, 24 September 1973

STATION-SAMPLE	7.1	4.1	2.1	20.1	28.1	22.1	97.1	95.1	96.2	TOTAL
DEPTH(M.)	20	25	28	59	59	64	136	138	142	
DAY OF YEAR	268	268	268	268	268	268	268	268	268	
POLYCHAETE , UNIDENT.	-	-	-	1	-	-	-	1	-	2
EULALIA SP.	-	-	-	-	-	-	1	-	-	1
GLYCERA	-	-	-	-	-	-	1	-	-	1
CHONE	-	-	-	1	-	-	-	-	-	1
GASTROPOD , UNIDENT.	-	-	-	-	-	-	-	1	-	1
BALCIS	-	-	-	1	-	-	-	-	-	1
EPITONIUM	-	-	-	-	-	-	-	1	-	1
CRUCIBULUM CF. SPINOSUM	-	-	-	1	-	-	-	-	-	1
LAMELLARIA DIEGOENSIS	-	-	-	1	-	-	-	-	-	1
KELLETIA KELLETTII	4	-	-	-	-	-	-	-	-	4
COLUMBELLIDAE	-	-	-	-	-	-	1	-	-	1
PLEUROBRANCHAEA CALIFORNICA	-	-	-	2	1	-	-	-	-	3
ACANTHODORIS RHODOCERUS	-	-	1	-	-	-	-	-	-	1
ARMINA CALIFORNICA	-	-	-	-	-	-	1	-	-	1
DIRONA PICTA	-	-	1	-	-	-	-	-	-	1
FLABELLINOPSIS IODINEA	-	-	1	-	-	-	-	-	-	1
PELECYPOD , UNIDENT.	-	-	-	-	-	-	-	8	-	8
ACILA CASTRENSIS	-	-	-	1	-	1	-	46	14	62
MACOMA CARLOTTENSIS	-	-	-	-	-	-	3	16	5	24
OCTOPUS	2	-	-	38	11	1	8	16	39	117
ROSSIA PACIFICA	-	1	-	-	-	-	1	15	9	26
OSTRACOD , UNIDENT.	-	-	-	3	-	-	-	-	-	3
SCALPELLUM	-	-	-	-	-	1	-	-	-	1
LIRONECA VULGARIS	-	-	-	-	-	2	-	-	-	2
BOPYRIDAE	-	-	-	-	-	-	1	13	11	25
EUSICYONIA	-	-	-	264	285	10	-	35	148	746
PANDALUS JORDANI	-	9	-	-	-	10	559	2059	1310	3970
SPIRONTOCARIS BISPINOSA	-	-	-	-	-	-	21	124	153	298
SPIRONTOCARIS GRACILIS	-	-	-	-	-	-	3	-	-	3
CRANGON NIGROMACULATA	121	3	-	-	-	-	-	-	-	124
CRANGON ALASKENSIS ELONGATA	-	-	-	-	2	18	2	-	-	22
CRANGON ZACAE	-	-	-	5	-	5	39	233	207	489
CRANGON RESIMA	-	-	-	-	-	-	6	36	26	68
CRANGON SPINOSISSIMA	-	-	-	-	-	-	-	3	-	3
MURSIA GAUDICHAUDII	-	-	-	-	-	-	4	-	3	7
MAJIIDAE (= INACHIDAE)	-	-	-	1	-	-	-	-	-	1
CANCER ANTHONYI	-	1	-	-	-	1	-	-	1	3
CANCER GRACILIS	2	-	-	-	-	-	-	-	-	2
STYLATULA	100	-	-	-	-	100	300	-	-	500
METRIDIUM	-	-	-	-	-	-	3	-	1	4
CEREBRATULUS	-	1	-	-	-	-	-	-	1	2
HIRUDINEA	-	3	-	-	-	-	-	-	-	3
LISTRIOLOBUS	-	4	-	-	-	-	-	-	-	4
ASTROPECTEN BRASILIENSIS	2	-	-	-	-	-	-	-	-	2
ASTROPECTEN VERRILLI	362	11	480	117	11	146	2	2	-	1132
PETALASTER FOLIALATA	-	-	-	4	8	-	1	-	1	14
MEDIASTER AEQUALIS	-	-	-	4	-	-	-	-	-	4
PISASTER BREVISPINUS	2	-	-	-	-	-	-	-	-	2
LYTECHINUS ANAMESUS	-	-	-	-	18	-	-	3	2	27
ALLOCENTROTUS FRAGILIS	-	-	-	345	-	-	-	6	-	351
BRIASTER LATIFRONS	-	-	-	-	-	-	-	-	1	1
OPHIUROID , UNIDENT.	-	2	-	-	-	-	-	12	-	14
PARASTICHOPUS CALIFORNICUS	-	-	-	27	39	5	69	7	104	252
UROCHORDATE , UNIDENT.	-	2	-	-	-	-	-	-	-	2
TOTAL	595	37	483	816	375	300	1026	2637	2036	8340
TOTAL SPECIES	8	10	4	17	8	12	20	20	18	54

Appendix G. Invertebrate catch per species per haul, Palos Verdes shelf, 25 September 1973.

STATION-SAMPLE	5.1	2.1	7.1	10.1	12.1	14.1	25.1	19.1	22.1	
DEPTH(M.)	26	27	30	60	61	63	133	146	150	
DAY OF YEAR	269	269	269	269	269	269	269	269	269	
										TOTAL
EULALIA SP.	1	-	-	-	1	-	-	-	-	2
PLATYNEREIS BICANALICULATA	1	-	-	1	-	-	-	-	-	2
GASTROPOD , UNIDENT.	-	-	-	-	-	-	-	-	2	2
CALLIOSTOMA TRICOLOR	-	1	-	-	-	-	-	-	-	1
CREPIDULA ONYX	-	18	4	-	-	-	-	1	-	23
CREPIDULA FORNICATA	6	-	-	-	-	-	-	-	-	6
PTEROPURPURA VOXAF	-	1	-	-	-	-	-	-	-	1
KELLETIA KELLETTII	-	11	-	-	-	-	-	-	-	11
NASSARIUS INSCULPTUS	-	1	-	-	-	-	-	-	77	78
NASSARIUS MENDICUS	178	4	418	21	21	-	-	1	64	707
NASSARIUS PERPINGUIS	-	-	-	-	-	-	-	-	1	1
CONUS CALIFORNICUS	20	2	5	-	-	-	-	-	-	27
RICTAXIS PUNCTOCAELATUS	-	2	-	-	-	-	-	-	-	2
PLEUROBRANCHAEA CALIFORNICA	-	-	-	-	2	1	-	-	-	3
ACANTHODORIS BRUNNEA	-	1	-	2	-	-	1	-	9	13
PELECYPOD , UNIDENT.	1	-	-	-	-	1	-	-	-	2
MEGACRENELLA	-	-	-	-	-	-	1	-	-	1
LUCINA APPROXIMATA	1	-	-	10	9	-	-	2	20	42
TAPES	1	-	-	-	-	-	-	-	-	1
TELLINA	1	-	-	-	-	-	-	-	-	1
MACOMA CARLOTTENSIS	-	-	-	-	2	-	15	-	248	265
LEPIDOZONA	-	2	-	-	-	-	-	-	-	2
OCTOPUS	-	2	-	-	2	4	3	-	1	12
ROSSIA PACIFICA	-	-	-	-	-	-	1	-	-	1
CUMACEAN , UNIDENT.	-	-	-	-	-	1	-	-	-	1
NEROCILA	3	-	-	1	-	-	-	-	-	4
LIRONECA VULGARIS	1	-	-	-	-	-	-	-	-	1
SERGESTES SIMILIS	-	-	-	-	-	-	-	-	2	2
FUSICYONIA	-	-	-	859	236	493	32	7	-	1627
PASIPHAEA PACIFICA	-	-	-	-	-	-	-	-	2	2
PANDALUS JORDANI	-	-	1	-	-	-	68	89	3	161
PANDALUS PLATYCEROS	-	-	-	-	1	-	16	5	4	26
SPIRONTOCARIS	1	-	-	-	-	-	-	-	-	1
SPIRONTOCARIS BISPINOSA	-	-	-	-	1	-	372	516	1610	2499
SPIRONTOCARIS SICA	-	-	-	-	-	-	2	1	7	10
SPIRONTOCARIS SP.	-	-	-	-	-	-	-	1	-	1
SPIRONTOCARIS GRACILIS	-	-	-	-	-	-	1	8	12	21
SPIRONTOCARIS NR. DALLI	-	-	-	-	-	-	-	-	1	1
CRANGON NIGROMACULATA	13	-	9	-	-	-	-	-	-	22
CRANGON ALASKENSIS ELONGATA	-	-	-	11	1402	25	-	-	139	1577
CRANGON ZACAE	-	-	-	-	-	-	21	9	333	363
CRANGON PESIMA	-	-	-	-	-	-	-	1	43	44
ANOMURA , UNIDENT.	11	1	-	-	-	-	-	-	-	12
MUNIDA QUADRISPINA	-	-	-	-	-	-	-	-	3	3
BRACHYURA , UNIDENT.	-	-	-	-	-	-	-	-	1	1
MURSIA GAUDICHAUDII	1	7	9	-	8	4	1	1	6	37
CANCER SP.	25	-	-	-	-	-	-	-	-	25
CANCER PRODUCTUS	3	-	-	-	-	-	-	-	-	3
CANCER ANTHONYI	4	-	-	-	-	-	-	-	-	4
CANCER GRACILIS	1	4	-	-	1	-	-	-	-	6
STYLATULA	1	-	1	13	-	-	-	-	-	15
METRIDIUM	-	1	-	2	-	-	-	-	-	3
PLEUROBRANCHIA BACHEI	-	-	-	-	-	-	-	-	1	1
LISTRIOLOBUS PELODES	41	-	-	-	81	-	-	-	-	122
ASTROPECTEN VERRILLI	-	2	-	1	-	1	-	3	-	7
PATIRIA MINIATA	-	1	-	-	-	-	-	-	-	1
ASTROMETIS SERTULIFERA	-	1	-	-	-	-	-	-	-	1
ALLOCENTROTUS FRAGILIS	-	-	-	-	-	-	-	118	-	118
PARASTICHOPUS CALIFORNICUS	-	-	-	-	-	7	1	3	-	11
UROCHORDATE , UNIDENT.	-	-	-	-	-	8	-	-	-	8
TOTAL	315	62	447	921	1767	545	535	766	2589	7947
TOTAL SPECIES	21	18	7	10	13	10	14	16	23	60

Appendix H. Invertebrate catch per species per haul, San Pedro Bay, 26 September 1973.

STATION-SAMPLE	8.1	67.1	70.1	68.1	71.1	73.1	23.1	69.1	72.1	
DEPTH(M.)	24	25	26	62	62	66	143	143	145	
DAY OF YEAR	270	270	270	270	270	270	270	270	270	
										TOTAL
POLYCHAETE , UNIDENT.	-	-	-	1	-	-	-	-	-	1
PISTA ELONGATA	1	-	-	-	-	-	-	-	-	1
CREPIDULA NIVEA	-	-	5	-	-	-	-	-	-	5
NASSARIUS MENDICUS	-	-	-	1	-	-	-	-	-	1
MEGASURCULA CARPENTERIANA	-	-	-	-	-	1	-	-	-	1
ACTEOCINA	-	-	-	-	-	-	-	1	-	1
PLEUROBRANCHAEA CALIFORNICA	-	2	-	-	1	-	-	-	-	3
ACANTHODORIS BRUNNEA	-	3	-	-	-	-	-	-	-	3
ACANTHODORIS RHODOCERUS	-	1	-	-	-	-	-	-	-	1
DENDRONOTUS SP.	-	2	-	-	-	-	-	-	-	2
TRITONIA EXSULANS	-	1	-	-	-	-	-	-	-	1
ACILA CASTRENSIS	-	-	-	-	-	-	1	1	-	2
OCTOPUS	-	-	2	9	6	11	7	-	6	41
LOLIGO OPALESCENS	-	-	-	-	-	2	-	-	-	2
ROSSIA PACIFICA	-	-	-	-	-	-	5	15	2	22
BALANUS CONCAVUS PACIFICUS	-	-	-	-	-	4	-	-	-	4
CUMACEAN , UNIDENT.	-	-	-	1	-	-	-	-	-	1
BOPYRIDAE	-	-	-	-	-	-	1	-	-	1
EUSICYONIA	-	-	-	356	82	109	131	169	2	849
PANDALUS JORDANI	-	3	-	-	-	-	381	140	45	569
SPIRONTOCARIS BISPINOSA	-	-	2	-	2	-	367	292	50	713
SPIRONTOCARIS SICA	-	-	-	-	-	-	-	5	1	6
SPIRONTOCARIS CRISTATA	-	1	-	-	-	-	-	-	-	1
CRANGON NIGROMACULATA	26	9	18	-	-	-	-	-	-	53
CRANGON ALASKENSIS ELONGATA	-	-	-	10	9	-	-	-	-	19
CRANGON ZACAE	-	-	-	-	-	-	57	55	63	175
CRANGON RESIMA	-	-	-	-	-	-	30	7	12	49
CRANGON SPINOSISSIMA	-	-	-	-	-	-	1	-	-	1
ISOCHELES SP.	-	-	1	-	-	-	-	-	-	1
ANOMURA , UNIDENT.	-	-	1	-	-	-	-	-	-	1
MURSIA GAUDICHAUDII	-	1	2	2	2	3	1	1	2	14
CANCER ANTHONYI	-	1	-	-	-	-	-	-	-	1
CANCER GRACILIS	4	-	-	-	-	1	-	-	-	5
ALCYONARIA , UNIDENT.	-	-	-	-	-	-	-	2	-	2
PLEUROBRANCHIA BACHEI	-	-	-	-	-	2	-	-	-	2
CEREBRATULUS	-	1	-	-	-	-	-	-	-	1
HIRUDINEA	4	-	-	-	-	-	-	-	-	4
LISTRIOLOBUS PELODES	-	3	3	-	-	-	-	-	-	6
ASTROPECTEN VERRILLI	25	37	74	2	3	91	11	-	-	243
PETALASTER FOLIALATA	-	-	1	1	-	-	1	4	-	7
MEDIASTER AEQUALIS	-	-	-	-	-	1	-	-	-	1
RATHEUNASTER CALIFORNICUS	-	-	-	1	4	-	-	-	-	5
PISASTER BREVISPINUS	-	-	1	-	-	-	-	-	-	1
LYTECHINUS ANAMESUS	-	7	3	-	100	5	-	1	-	116
OPHIUROID , UNIDENT.	-	-	-	1	2	-	-	-	-	3
PARASTICHOPUS CALIFORNICUS	-	-	-	85	18	3	2	30	3	141
UROCHORDATE , UNIDENT.	2	-	-	-	-	-	-	-	-	2
TOTAL	62	72	113	470	229	233	996	723	186	3084
TOTAL SPECIES	6	14	12	12	11	12	14	14	10	47