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THE SEA BOTTOM OFF SANTA BARBARA, CALIFORNIA: BIOMASS AND COMMUNITY STRUCTURE

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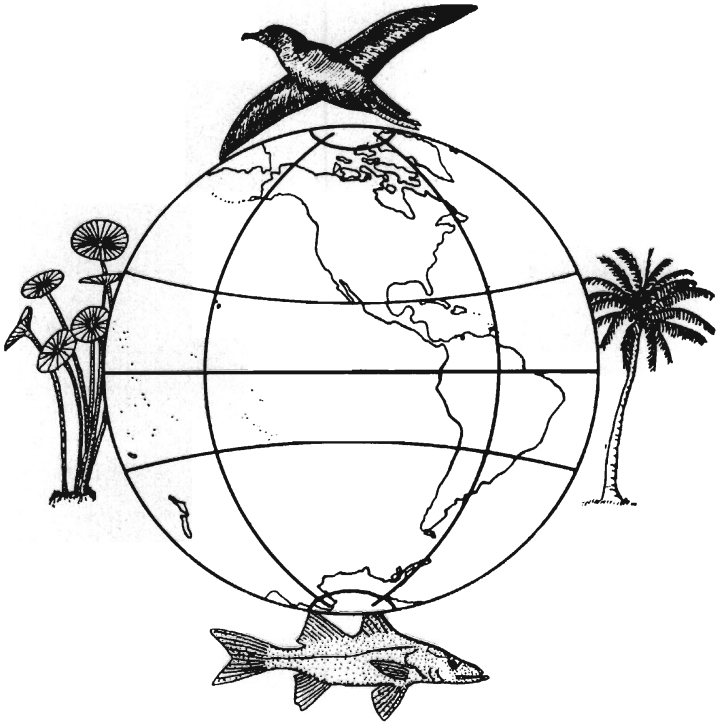

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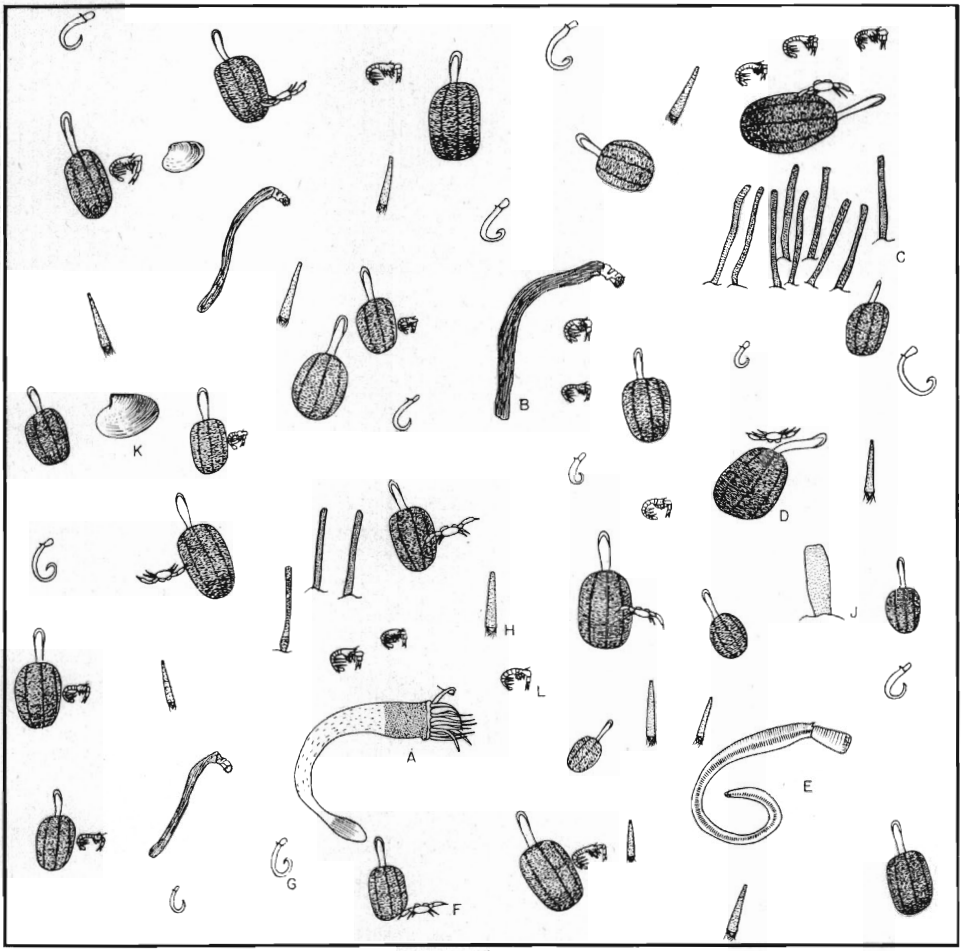

Fig. 1. Diagrammatic representation to the inhabitants of 0.25 m² of bottom soil collected from the middle of the *Listriolobus* bed. The larger animals are represented in their relative size proportions to the area. Many important smaller species are not included (see Table 1). The diagram represents an aggregate of averages from 7 stations

Symbols:

A, cerianthid anemone;
B, *Asychis lacera;*
C, *Phoronopsis* sp;
D, *Listriolobus pelodes;*
E, *Glycera robusta;*
F, *Pinnixa* spp.;
G, *Glycera capitata,*
H, *Pectinaria californiensis;*
J, *Pista disjuncta;*
K, *Compsomyax subdiaphana;*
L, *Callianassa* sp.

Note that in natural position *Listriolobus, Callianassa, Pinnixa, Glycera* and *Compsomyax* are buried in the sediment and not visible from the surface; only the upper ends of *Pectinaria, Phoronopsis* and perhaps *Pista* show on the surface. The cerianthid anemone lies encased in a vertical black slimy tube, and *Asychis* probably forms a conical surface mound. It is probable that sea-whips *(Stylatula,* not drawn) would be the most conspicuous organism in a photograph of the bottom; their frequency of occurrence is slightly less than one per 0.25 m².

THE SEA BOTTOM OFF SANTA BARBARA, CALIFORNIA: BIOMASS AND COMMUNITY STRUCTURE

By J. Laurens Barnard[1] and Olga Hartman[2]

Introduction

Offshore benthic biology of the coast of California is poorly known. Studies on the kinds, numbers, sizes and quanitative distribution of animals have been in progress for a number of years and have been partly reported upon (Hartman, 1955, 1956, Hartman and Barnard, 1957).

Since 1956, the California State Water Pollution Control Board has supported investigation at the Allan Hancock Foundation of benthic shelf biology and the natural marine environments of southern California. A part of these studies has encompassed the shelf between Santa Barbara and Ventura (Fig. 2). This region is of considerable interest because of the discovery of large bottom areas of silt dominated by burrowing echiuroid worms, *Listriolobus pelodes* Fisher. The present paper is an appraisal of the gross structure of biomass and communities of the Santa Barbara shelf.

Methods

Benthic quantitative samples using an orange-peel grab (Hartman, 1955) of 0.25 m^2 capacity (88 liters volume) form the material used in this study. The samples have been analyzed for kinds and numbers of organisms, sizes and weights of individuals, and weights of groups of organisms. Biomass is measured as grams of wet drained animals preserved in formalin.

Description Of The Area

The Santa Barbara shelf, east to Port Hueneme lies on a west to east axis and is one of the broadest and gentlest sloping of the shelves of southern California (Fig. 2), most of which are steeper and narrower. The 50-fathom contour is used to define the seaward edge of the shelf; this varies in width from 4.5 to 9.5 nautical miles. The shoreward edge of the shelf, along the coastline, in depths of 10 fms. or less, is lined intermittently with kelp beds, usually a few hundred yards in width. Nearshore sediments generally are fine gray sands or silty sands (sediments are named according to classifications supplied by geologists). Those at the seaward edge, in 30 to 50 fms., are fine green sands or silty sands; those in moderate depths of 10 to 30 fms. are silts. At one place the silt beds are partially bisected by a perpendicular submerged sandy ridge.

The broad eastern end of the shelf, near Las Pitas Point, has silts which diminish and grade into silty sands and fine gray sands toward the Ventura-Hueneme coastline. In general, the gross community structure of the benthic fauna reflects the character of the bottom sediments.

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Benthic Communities

Several faunistic units have been identified on the Santa Barbara shelf. Some cover continuous areas of large extent and can be named for their dominant organisms. These associations may be called communities (Thorson, 1957). Other animal assemblages, of smaller extent and patchy in occurrence, represent intermediate or transitional fragments of communities still unnamed.

THE LISTRIOLOBUS COMMUNITY (Figs. 1, 3-7, Tables 1-3).—The concentrated occurence of echiuroids (tongue-worms) in large beds, occupying sediments in the open sea, has not previously been described. The location and extent of such a community in southern California is shown in fig. 3. The axis of greatest concentration occurs along the 20 fm. contour and extends 20 miles along the coast from Santa Barbara to a point east of Las Pitas. Here the individuals number about 100 to the square meter, and have a biomass of about 1100 grams to the square meter. The total weight of all animals retained in screens with a 1.0 mm. mesh, for the axial area reaches a mean of 1370 grams to a square meter. The fringes of the bed are characterized by lower biomass values and fewer numbers of individuals; the bed extends shoreward to the 10 fm. contour and seaward to the 30 fm. contour. The bed is continuous except for a

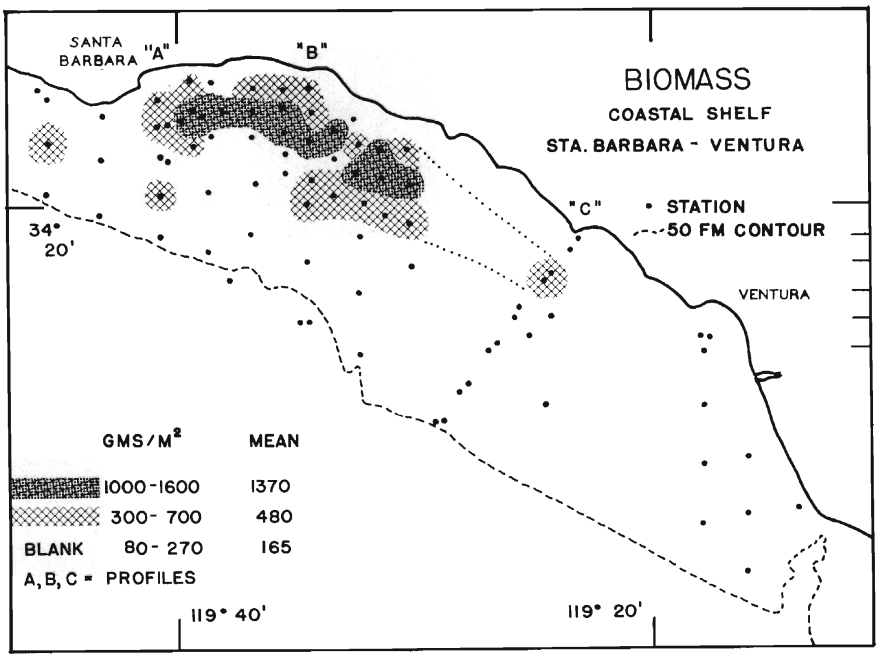

Fig. 2. Chart of Santa Barbara shelf, coast of California showing biomass distribution. Note that intermediate weights between levels are not represented.

submerged sandy ridge which bisects it (Fig. 3). The shoreward edge of the community meets a silty-sand fauna and flora; this consists of patches of numerous kinds of animals, some dominated by the polychaetous annelids (*Diopatra* and *Nothria*), of kelp beds, epifaunal animals on rocks or rubble, and of razor clams of the genus *Solen*.

Seaward, the *Listriolobus* community diminishes and is replaced by a benthic fauna dominated by an ophiuroid, *Amphiodia urtica*, and a clam, *Cardita ventricosa* (Table 4). The transistion may be abrupt, or partial, or replaced by a fauna of a completely different composition (possibly an ecotone).

Along the axis of greatest concentration, in depths between 15 and 25 fms., about 80% of the total biomass is composed of *Listriolobus pelodes*; this concentration is illustrated on biomass profiles, figs. 4 and 5. and as dark zones on fig. 3. Grab samples taken from the seaward edge of the community often have one or more large sea cucumbers, the holothurian *Molpadia intermedia*. Although this echinoderm is a burrower and presumably partly competitive with the echiuroid, the numbers of the latter do no diminish. This is shown in Table 3, where factors such as depth of bottom and kinds of sediment are considered more significant in the seaward depletion of the typical members of the *Listriolobus* community. *Molpadia* is found scattered throughout the *Amphiodia-Cardita*

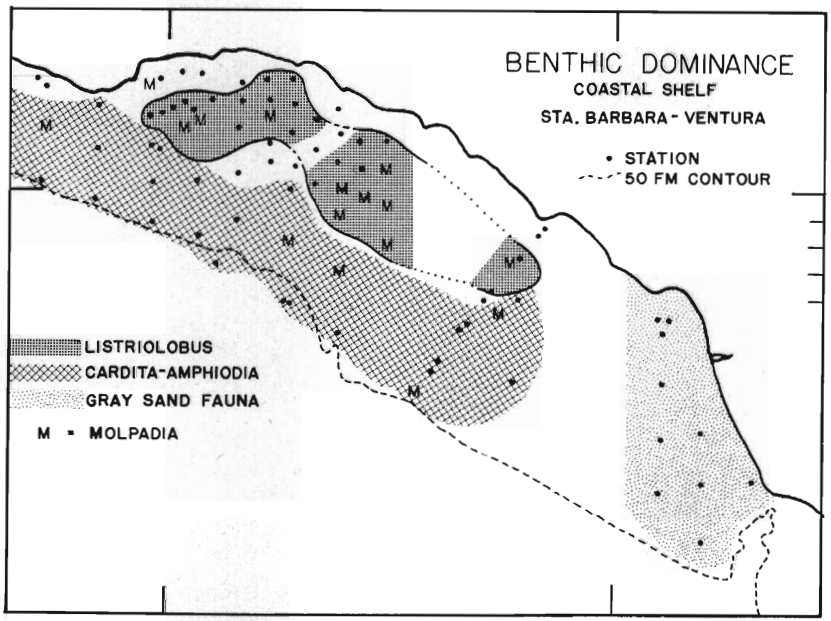

Fig. 3. Chart of Santa Barbara shelf, coast of California, showing dominance of bottoms by certain animal assemblages.

community (see below) but it may prove to have its greatest concentration in depths between the two communities.

When brought on shipboard in the grab the echiuroids are strongly contracted, smooth and turgid, resembling smooth cucumbers or striped watermelons. They are green, with flecks of black pigment on the posterior surface, and the intensity of the pigment tends to increase in larger individuals so that the posterior third of the animal is nearly black. Eight faintly visible longitudinal muscle bands show through the body wall. Maximum contracted size of specimens is 50 mm. long, but mature individuals are those measuring 25 mm. or longer. Fisher (1946) described a sexually mature specimen only 7 mm. long, but from a different locality.

TABLE 1

Silt bottoms dominated by mature *Listriolobus pelodes*. Other dominant animals are listed in approximate decreasing order. Additional large or conspicuous animals are listed below the horizontal line. Minor species are not listed. Each species is followed by a letter designating its common group name[3]. Asterisks denote species to be described elsewhere as new by Hartman.

Station Number of VELERO IV	*5404*	*5410*	*5166*	*5400*	*5413*	Average No. /m²
Depth in feet	112	115	126	126	164	—
Total Number of Species	72	49	126	73	81	—
Total Number of Specimens	485	257	1123	546	501	2330
Listriolobus pelodes E	31	20	27	27	11	92
Phoronopsis sp. R	20	6	2	30	1	48
Callianassa sp. S	9	15	45	7	4	64
Ceratocephala crosslandi americana P	6	—	4	35	52	76
Marphysa sp. * P	5	2	21	22	—	40
Pectinaria californiensis P	12	8	12	5	18	36
Hesperonoe sp. * P	23	10	1	31	6	56
Sternaspis fossor P	1	5	—	1	13	16
Pinnixa spp. or pea-crabs(p) C	2p	3	22	9	1	30
Amphiodia urtica O	10	39	32	11	31	98
Saxicavella pacifica M	48	4	11	40	13	93
Compsomyax subdiaphana M	1	1	9	1	1	
Glycera robusta or *G. americana*(a) P	1a	1	2	1	1	
Glycera capitata P	26	4	18	4	10	
Asychis lacera or *A. disparidentata*(d) P	—	7d	5	1	4	
Cerianthid anemone L	1	5	—	—	1	
Stylatula sp. L	1	1	—	3	2	
Pista disjuncta P	2	2	—	2	—	

[3]The following letters denote the common group names of the species listed in Tables 1 to 5.

A = cumacean crustacean
B = sea cucumber, holothurian echinoderm
C = crab, decapod crustacean
E = echiuroid worm, tongue worm (Phylum Echiurida)
G = snail, gastropod mollusk
H = tooth shell, scaphopod mollusk
L = coelenterate
M = clam, pelecypod mollusk
O = ophiuroid, brittle star, echinoderm
P = polychaetous annelid, segmented worm
R = phoronid worm (Phylum Phoronida)
S = shrimp, decapod crustacean

TABLE 2

Bottoms subdominated by small or immature *Listriolobus pelodes*. The species are arranged in the same order as those in Table 1. These stations are located at the eastern end of the *Listriolobus* bed where sediments are sandy silts or silty sands. Asterisks denote species to be described elsewhere as new by Hartman.

Station Number of VELERO IV	*5262*	*5331*	*5330*	*5261*	Average No. /m²
Depth in feet	119	123	142	145	—
Total Number of Species	56	99	107	71	—
Total Number of Specimens	349	596	743	274	1962
Listriolobus pelodes E	15	1	15	5	36
Phoronopsis sp. R	8	20	23	3	54
Callianassa sp. S	31	44	37	34	146
Ceratocephala crosslandi americana P	1	—	1	5	7
Marphysa sp. *	1	6	9	10	26
Pectinaria californiensis P	7	8	4	—	19
Hesperonoe sp. *	2	1	1	3	7
Sternaspis fossor P	12	18	12	6	48
Pinnixa spp. C	6	14	2	8	30
Amphiodia urtica O	13	63	98	11	185
Saxicavella pacifica M	4	—	2	1	7
Compsomyax subdiaphana M	—	9	8	2	
Glycera robusta P	2	—	2	(5)	
Glycera capitata P	—	10	6	—	
Asychis lacera or *A. disparidentata*(d) P	—	2d	1	5	
Cerianthid anemone L	—	1	7	—	
Stylatula sp. L	20	1	1	3	
Pista disjuncta P	6	3	1	1	

TABLE 3

Four stations of various depths at which the large sea cucumber *Molpadia intermedia* was collected. The positive collection of this animal is marked by the letter "M" on Fig. 3. At station 5419 (below) *Molpadia* was collected in the *Listriolobus* bed: its presence did not noticeably depress the total number of the echiuroid. The most important effects of the decline of *Listriolobus* and its characteristic associated species (asterisks) are the increase with depth and the corresponding increase in distance from shore and coarsening of sediments, from silt to sandy silts and silty sands.

Station of VELERO IV	*5419*	*4826*	*5414*	*5421*
Depth in feet	127	142	173	221
Total Number of Species	58	42	47	52
Total Number of Specimens	434	89	304	301
Molpadia intermedia B	1	2	2	1
**Listriolobus pelodes* E	30	2	6	2
**Phoronopsis* sp. R	56	—	2	—
**Callianassa* sp. C	14	—	—	—
**Ceratocephala crosslandi americana* P	37	4	49	8
**Marphysa* sp. P	5	—	—	—
Pectinaria californiensis P	4	1	7	7
**Hesperonoe* sp. P	17	—	5	1
Sternaspis fossor P	4	—	—	3
**Pinnixa* spp. C	1	—	1	3
Amphiodia urtica O	7	3	21	47
**Saxicavella pacifica* M	64	1	8	2
Compsomyax subdiaphana M	—	1	2	—
Glycera robusta P	2	1	2	—
Glycera capitata P	16	1	6	8
Asychis lacera P	—	—	—	—
Cerianthid anemone L	1	—	1sm	2sm
sm = small				
Stylatula sp. L	—	—	—	—
Pista disjuncta P	—	—	—	—

BIOMASS VALUES.—The analysis of biomass values from other parts of the shelf of Southern California shows that, with the exception of a smaller area along the Palos Verdes Hills, in Los Angeles County, the weight of animals in the *Listriolobus* community (with a mean of 1370 grams to the square meter) is the largest in subalgal zones of southern California. Along the Palos Verdes shelf, a limited area is dominated by a *Chaetopterus-Lima* community in which biomass values attain 2400 grams to the square meter (excluding weights of *Chaetopterus* tubes but including shell weights of *Lima*). The cosmopolitan polychaete, *Chaetopterus variopedatus*, typically forms U-shaped parchment-like tubes which are largely embedded in the sediments except for the distal ends. At Palos Verdes the tubes are massed to produce thick clumps overlying the sediments. *Lima dehiscens*, a file-shell clam, constructs its nests under the massed *Chaetopterus* tubes. This community supports a great diversity of worm-like animals, but few other organisms; it differs in most of its specific units from those in the *Listriolobus* community.

The *Listriolobus* community is named for a single species since it is a strong dominant in terms of aggregate weight. Other animal species, characteristic of the community, may be considered subdominants. The next one, in terms of biomass is a phoronid, *Phoronopsis* sp., followed by three polychaetes, *Marphysa* sp., *Ceratocephala crosslandi americana* and *Hesperonoé* sp. These four reach their greatest concentrations in the

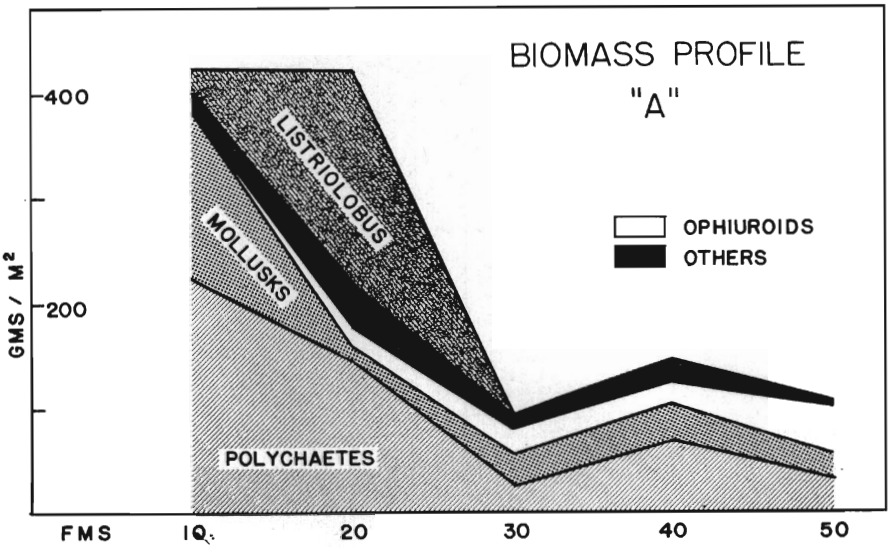

Fig. 4. Profile of biomass perpendicular to coastline at cross-section A denoted on figure 1. Weights are cumulative.

Listriolobus community and are sparsely present to absent in other areas. Other characteristic species, especially numerous small forms, comprise little weight but occur in numbers surpassing their occurence elsewhere; they include a small clam, *Saxicavella pacifica* (Table 1), several crustaceans, especially an unidentified ghost shrimp (*Callianassa* sp.), several liljeborgiid amphipods, cumaceans and ostracods. A bamboo-worm, *Asychis lacera*, is conspicuous in some samples; a large Ceriantharia (tubicolous anemone) regularly occurs, and a large white clam, *Compsomyax subdiaphana*, are other characteristic species in the *Listriolobus* community.

SIZE OF THE STANDING CROP.—The *Listriolobus* community is estimated to cover a partially discontinuous area of 46 square nautical miles. Thirty-four large grab samples have been taken to assess the area,

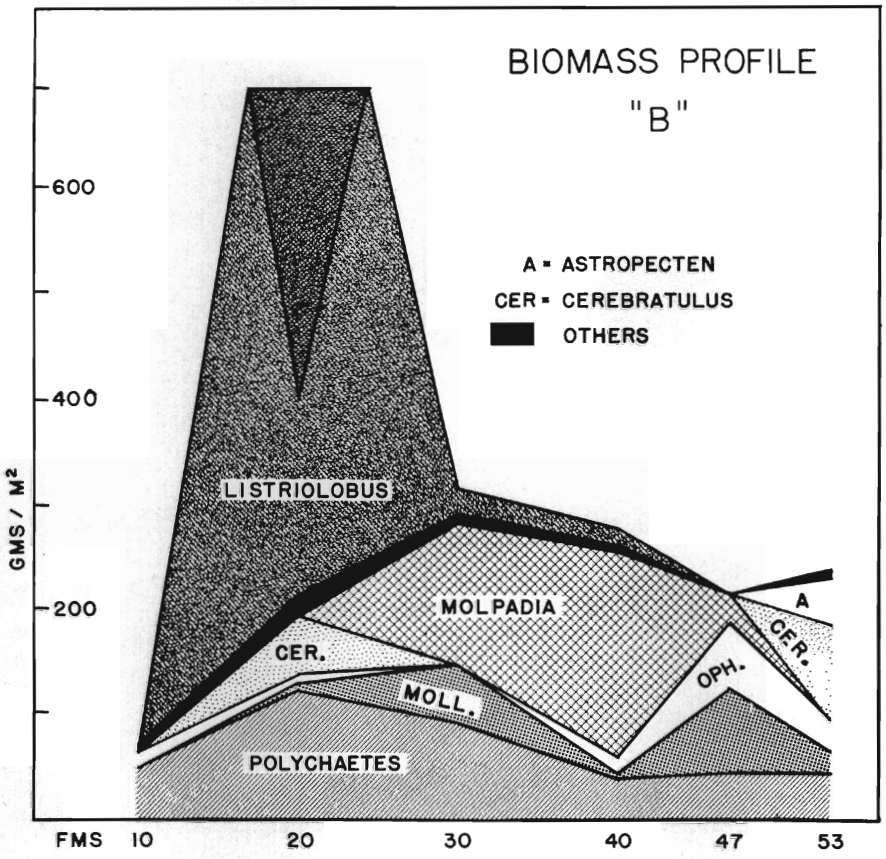

Fig. 5. Profile of biomass perpendicular to coastline at cross-section B denoted on figure 1. Weights are cumulative.

and the average weight of *Listriolobus* calculated at 480 grams per square meter. This represents a standing crop of 825,000 tons (avoirdupois) of the echiuroid in the bed for 1957. A small eastern part of this area has not been adequately sampled or weighted for this figure, but analysis of sediments in the area indicates a potentially diminished biomass. Considering this qualificaton, it is estimated that the total tonnage is more than 500,000 tons, or slightly more than the 1956 California fish landings (including extra-territorial tunas, California Department of Fish and Game, 1958).

THE AMPHIODIA-CARDITA COMMUNITY (Table 4).—This community occurs in bottoms covering a large part of the Santa Barbara shelf, in depths from the 30 to 60 fm. contours and along the upper slopes below the shelf. The lower depth limits have not been adequately defined. A small gastropod, *Bittium* sp., is particularly characteristic of this community; it does not occur as abundantly anywhere else. The fireworm, *Chloeia pinnata*, is also abundant and forms a heavy biomass, but this is common along many slopes of southern California where *Amphiodia urtica* and *Cardita ventricosa* do not occur. Other species of the community are listed in Table 4; the last four species listed permit comparative values with other tables.

Biomass values of this community range from 80 to 270 grams per square meter and are thus considerably lower than those of the *Listriolobus* community.

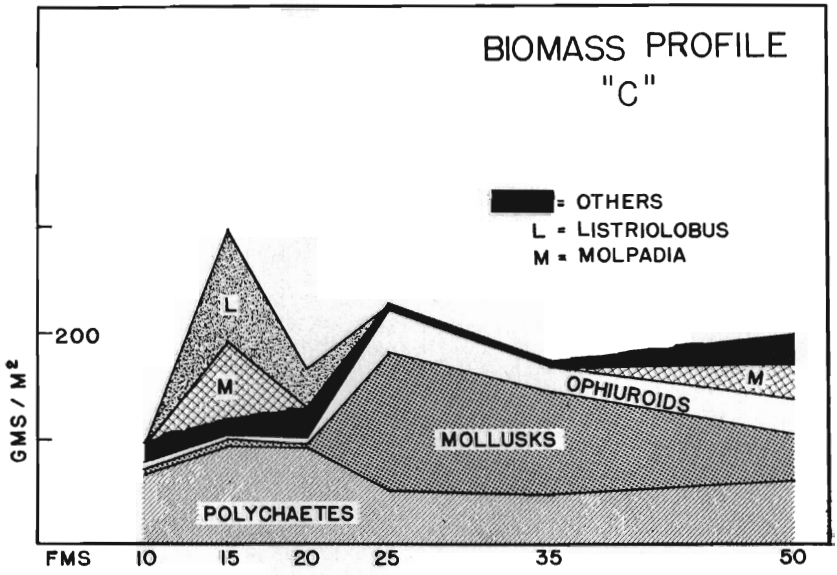

Fig. 6. Profile of biomass perpendicular to coastline at cross-section C denoted on figure 1. Weights are cumulative.

TABLE 4

Stations dominated by *Amphiodia urtica* and *Cardita ventricosa*. *Chloeia pinnata* and *Bittium* sp. are also abundant and especially characteristic of these bottoms in combination with the dominant species (asterisks). Names of these and other species are arranged in decreasing importance of total aggregate biomasses. Sediments are sandy silts or silty fine sands.

Station of VELERO IV	*5167*	*5168*	*5160*	*4828*	*4951*	*5173*	*5169*	*4783*
Depth in feet	176	221	253	268	291	308	312	335
Numbers of Species	114	99	132	53	98	92	72	53
Numbers of Specimens	892	1146	1680	164	737	445	526	247
**Amphiodia urtica* O	68	42	42	24	55	52	52	77
**Cardita ventricosa* M	3	35	57	17	14	13	10	19
**Chloeia pinnata* P	36	25	54	—	53	5	71	2
Pectinaria californiensis P	7	14	30	2	33	6	28	—
Travisia sp. P	1	8	1	2	11	1	5	2
**Bittium* sp. G	59	42	66	5	2	11	1	—
Nucula cardara or N. sp.(x) M	11	8	123	3	1	6x	—	2
Nuculana spp. M	2	3	6	2	—	1	—	—
Glycera capitata or G. sp.(x) P	14	6	11	—	14x	5	3	2x
Glycera americana or *G. robusta*(r) P	1	1r	—	—	1	—	—	—
Stylatula sp. L	—	—	1	1	—	—	1	—
Molpadia intermedia B	—	—	—	—	1	—	—	—

Gray Sand Faunas (Table 5)

The inshore areas of the Santa Barbara coastline between 7 and 12 fms. depth are characterized by fine gray sands, often mixed with silts. These bottoms are difficult to characterize with names of dominant animal species, for they are displayed as a patchwork of faunas existing in environments which vary for silt and food contents, proximity to kelp beds, and compactness of the substrate. The common denominators which indicate these bottoms are the four species of polychaetes listed in Table 5. Two onuphids (*Nothria elegans* and the very nearly related *N. iridescens*) construct characteristic tubes consisting of a thin, limp, mucoid sheath externally covered with a layer of fine sand. They most frequently occur in bottoms rich in detritus. Three kinds of *Prionospio* are characteristic; two (*P. pinnata* and *P.* nr. *malmgreni*) are frequently associated (the first attains larger size and extends to greater depths); a third (*P. cirrifera*) is usually exclusive of the other two and attains its maximum numbers in shallower depths (301 individuals in 9 fms. at Sta. 4782). It is probable that the razor clam, *Solen sicarius*, is more abundant and comprises a larger fraction of the biomass than figures indicate; as a deep burrower it is difficult to recover from the hard-packed sands. The three eastern samples on the Ventura shelf (Stas. 4839, 4841 and 4782) are additionally characterized by the scaphopod *Cadulus* sp. and the cumacean *Diastylopsis tenuis*. It is apparent from Table 5 that subdivisions of gray sand faunas occur and that considerable statistical exploration will be required to define the variations.

Diopatra ornata (polychaete) infrequently occurs on gray sands as limited herein, but is abundant and dominant on sands and rubble in depths shallower than 8 fms. It constructs thick, rigid tubes incorporating rubble fragments. It attaches and "farms" red algae on its tubes and thus is more abundant in the upper photic zones.

Ecology of *Listriolobus pelodes*

The habits of the echiuroid, *Listriolobus pelodes* Fisher, may closely resemble those of a well-known species, *Echiurus echiurus* (Pallas), as described by Gislén (1940); this occurs in mudflats of shallow seas along northwestern Europe. Individuals form U-shaped burrows with two, often partially plugged surface openings as much as three or four feet apart, and the burrow as much as three feet below the surface. *Listriolobus* has been taken in an orange-peel bucket which penetrates up to two feet into the sediments. Often the animals have been snagged by the bottom claws of the grab, indicating that they are deep burrowers and that possibly others, existing in deeper zones, have escaped the grabbing device.

When washed from the silts the animals are strongly contracted and

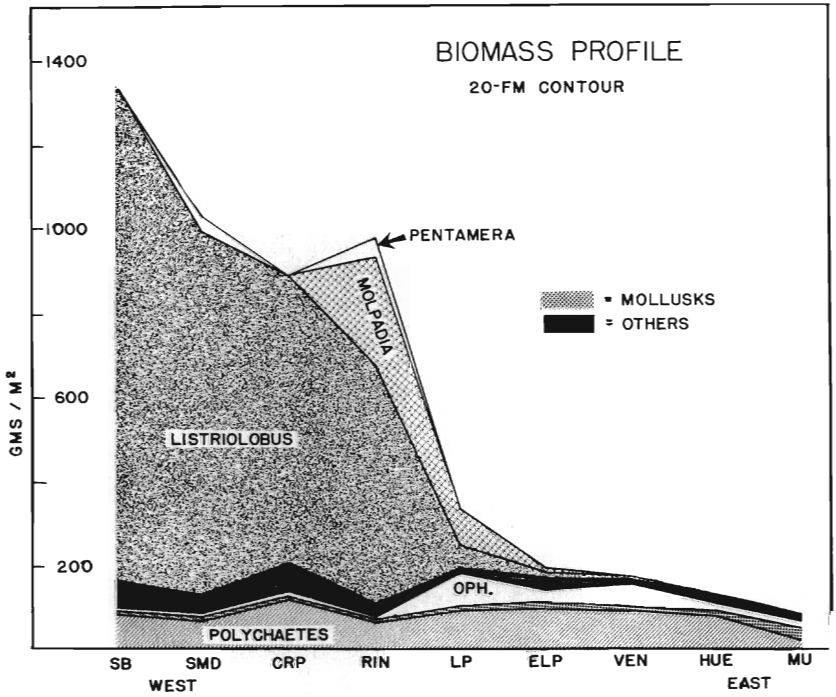

Fig. 7. Profile of biomass parallel to the coastline at the 20 fm depth contour. Weights are cumulative. Ordinal abbreviations running from west to east, left to right are: SB - Santa Barbara, SMD - Summerland, CRP - Carpinteria, RIN - Rincon Point, LP - Las Pitas Point, ELP - midway between Las Pitas Point and Ventura, VEN - Ventura, HUE - Hueneme, MU - Point Mugu.

TABLE 5

List of Stations characterized by faunas living on shallow gray sands. The stations are arranged from west to east, from Point Conception to Ventura. Note the changes within this assemblage, especially in the three eastern stations.

Station of VELERO IV	*4810*	*5583*	*5165*	*4956*	*5161*	*4839*	*4841*	*4782*
Depth in feet	47	51	39	55	67	68	60	54
Number of Species	43	91	78	101	125	86	77	70
Number of Specimens	134	612	411	1322	1000	620	673	755
Nothria elegans or *N. iridescens*(i) P	6	4	1	2i	16	14	38i	12
Prionospio spp. P	—	12	7	12	22	20	29	301
Pista disjuncta P	3	1	1	1	7	2	2	2
Magelona spp. P	3	3	50	9	5	105	9	17
Pinnixa spp. C	—	10	5	22	6	4	3	6
Solen sicarius M	2	—	4	3	17	1	—	—
Cadulus sp. H	—	—	—	—	17	11	24	1
Tellina sp. M	—	1	2	18	8	18	21	1
Macoma yoldiformis M	—	2	6	15	7	3	4	3
Pectinaria californiensis P	—	—	5	15	—	—	1	38
Diastylopsis tenuis A	—	2	—	—	1	20	33	1
Glycera capitata P	—	1	—	—	3	—	—	—
Amphiodia urtica O	—	3	18	26	11	8	6	16
Glycera americana or *G. robusta*(r) P	(3)	3	5	3	2	—	—	—
Diopatra ornata P	3	1	—	3	—	—	—	—

TABLE 6

Average weights of *Listriolobus pelodes* in grams, as preserved in formalin-seawater and drained. Measured lengths are arranged in size groups based on contracted animals. Gut contents are included in the weights. Measurements are based on all specimens from 22 stations, numbered from 5400 to 5421, located in the western part of the bed at its maximum development.

Number of Specimens Examined	Group Length Class in mm	Average Weight in grams
27	45	19.6
50	40	15.1
50	35	11.9
49	30	8.5
25	25	5.9
13	20	3.3
52	15	1.2
31	10	0.6
25	8	0.2
Totals 322	Average 26 mm Median 30 mm	Average 8.0 grams

TABLE 7

Populations of *Listriolobus pelodes*. Class A populations are well developed and occur in the western half of the bed along the 20 fm contour. Class B populations are composed of immature or stunted individuals; they occur either at the seaward or shoreward edges of the bed or at its eastern periphery. The frequency distribution is tabulated as the number of animals in each size group (length of contracted animal). Each population class is based on total number of specimens from four samples.

	Size groups in mm								Total Number	Biomass in
	10	*15*	*20*	*25*	*30*	*35*	*40*	*45*	of Specimens	g/m²
Class A	17	7	2	6	14	22	33	9	110	1120
Class B	36	17	3	2	2	1	—	—	61	74

remain so when preserved (see table 6 for sizes and average weights). Attempts to maintain the animals alive have failed although relaxation and movement occur for several hours until death (see Gislén, 1940, for behaviour).

The *Listriolobus* populations are not developed to the same extent throughout the Santa Barbara shelf; at the eastern end the animals are small, stunted or immature. This condition is believed to be related to the sediment composition which is less compact and subject to slumping which prevents the construction of discrete burrows. Because of the discontinuous distribution of our samples the eastern parts of the bed may be distinguished as supporting Class B or stunted populations; the frequency distribution of size groups is listed in Table 7. Intermediate populations occur between the large and small classes, especially at the seaward fringes of the western population.

The character of the sediments is believed to be the primary factor in restricting the populations of *Listriolobus* to the Santa Barbara shelf. In silts of the proper composition, food supply may be another important factor. Thus, in slope samples from depths greater than 60 fms. and consisting of compact sticky silts resembling those of the Santa Barbara shelf, there are no abundant populations of *Listriolobus;* instead, another echiuroid occurs, *?Arynchite* sp., usually singly in a sample. Other samples from depths as great as 70 fms. in near-shore submarine canyons, such as Hueneme, Mugu and Dume canyons, have yielded specimens of *Listriolobus* which are as well developed as those on the Santa Barbara shelf. The large supply of organic matter on the canyon floor may favor the development of *Listriolobus*.

A related concept is the potential, periodic slumping of canyon floors which provides fresh surfaces for available settling of larvae. In some cases the successful larvae are *Listriolobus;* others are polychaetes, especially *Heteromastus filobranchus, Spiophanes missionensis, Nothria pallida, Haploscoloplos elongatus* and *Pectinaria californica,* and the clam, *Saxicavella pacifica.* In each case the canyon samples are dominated by large numbers of one or two of the settling species, suggesting the exclusion of others. Thus, repopulation in canyons may depend on happenstance, according to the species of larvae which are available after slumping has occurred.

Summary

Three large areas of the Santa Barbara coastal shelf are characterized by: (a) a complex gray sand fauna between depths of 7 to 12 fms., indicated by four species of polychaetes, and especially well developed at the eastern portion of the shelf; (b) a large silt bed at depths of 15 to 25 fms. dominated by an echiuroid worm, *Listriolobus pelodes;* (c) muddy bottoms between 30 and 60 fms. depth, largely dominated by the ophiuroid, *Amphiodia urtica,* and the clam, *Cardita ventricosa.*

The large bed of *Listriolobus* dominates the Santa Barbara shelf; its

biomass is reflected in profiles of the area, averaging 480 grams of echiuroids to the square meter, with some areas as great as 1100 grams to the square meter.

Substrate characteristics and food supply are considered the major factors in the development of the *Listriolobus* bed.

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Literature Cited

Calif. Dept. of Fish and Game.
1958. The Marine fish catch of California for the years 1955 and 1956. Fish Bull. (105): 104 pp.

Fisher, Walter Kenrick.
1946. Echiuroid worms of the North Pacific Ocean. U.S. Nat. Mus., Proc., 96: 215-292, pls. 20-37, textfigs. 10-19.

Gislén, Torsten.
1940. Investigations on the ecology of *Echiurus*. Lunds Univ. Arssk. N.F., Avd. 2, 36(10): 1-39, pls. I-VI.

Hartman, Olga.
1955. Quantitative survey of the benthos of San Pedro Basin, Southern California. Allan Hancock Pac. Exped., 19: 1-187, pls. 1-7.
1956. Contributions to a biological survey of Santa Monica Bay, California. Multilith Rept. to Hyperion Engineers Inc. by Geology Dept., Univ. So. Calif., 161 pp.

Hartman, Olga and J. Laurens Barnard.
1957. Summary of results of a biological survey of the shallow offshore ocean bottom from Point Arguello, California to the Mexican border. Multilith Rept. to State of California, Water Pollution Control Board. by Allan Hancock Foundation, Univ. So. Calif., pp. 37-87.

Thorson, Gunnar.
1957. Bottom communities (sublittoral or shallow shelf). Chapter 17, pp. 461-534, 20 figs. In, Treatise on Marine Ecology and Paleoecology, ed. Joel W. Hedgpeth, Geol. Soc. Amer. Mem. 67.

Station Data[4]

Station	Date	Lat. N	Long. W	Depth, fms.	Sediment[5]
4782	Dec. 17, 1956	34-15-16	119-17-45	9	blk silt
4783	Dec. 18, 1956	34-17-20	119-37-45	56	gn sdy silt
4810	Jan. 15, 1957	34-24-00	119-30-45	8	gy crs cd, grvl
4826	Jan. 17, 1957	34-22-30	119-38-20	24	gn silty sd
4828	Jan. 17, 1957	34-18-20	119-38-20	45	gn silty sd
4839	Feb. 6, 1957	34-10-50	119-17-50	11	gn f sd
4841	Feb. 6, 1957	34-15-00	119-17-50	10	gy sd
4951	Apr. 10, 1957	34-19-40	119-43-10	49	gn silty sd, sh
4956	Apr. 10, 1957	34-24-28	119-39-10	9	gn-blk f sd
5160	Jul. 2, 1957	34-23-00	119-54-00	42	gn sdy silt
5161	Jul. 2, 1957	34-24-35	119-54-00	11	
5165	Jul. 3, 1957	34-24-30	119-40-30	7	gy sdy silt
5166	Jul. 3, 1957	34-23-05	119-40-40	21	gn m sd
5167	Jul. 3, 1957	34-21-40	119-40-40	29	gn m sd
5168	Jul. 3, 1958	34-20-20	119-40-40	37	gn m sd
5169	Jul. 3, 1957	34-18-58	119-40-45	52	gn silt, sh
5173	Jul. 3, 1957	34-14-50	119-32-25	51	gn silt
5261	Sep. 18, 1957	34-16-00	119-25-55	24	gn sdy silt
5262	Sep. 18, 1957	34-17-15	119-24-40	20	gn sdy silt
5330	Oct. 17, 1957	34-15-28	119-25-12	24	gn sdy silt
5331	Oct. 17, 1957	34-16-17	119-24-20	21	gn sdy silt
5400	Nov. 21, 1957	34-23-21	119-38-17	21	gn sdy silt
5404	Nov. 21, 1957	34-23-30	119-35-10	19	gn sdy silt
5410	Nov. 22, 1957	34-22-15	119-32-28	19	gn sdy silt
5413	Nov. 22, 1957	34-20-25	119-33-28	27	gn sdy silt
5414	Nov. 22, 1957	34-20-00	119-32-20	29	gn sdy silt
5419	Nov. 22, 1957	34-20-45	119-30-17	21	gn sdy silt
5421	Nov. 22, 1957	34-17-58	119-30-15	37	gn sdy silt
5583	Jan. 30, 1958	34-23-15	119-32-25	9	vf gy sd

[4]The grid of stations 5400 to 5421 is bounded by the extreme positions 34-17-58 N to 34-23-30 N and 119-30-15 W to 119-38-17 W.

[5]Abbreviations: blk = black, gn = green, gy = gray, crs = coarse, m = medium, f = fine, vf = very fine, sd = sand, sdy = sandy, sh = shells