Distribution of the Brittlestar *Amphiodia (Amphispina)* Species in the Southern California Bight in 1957-59

Between 1956 and 1959, scientists of the Allan Hancock Foundation, University of Southern California, conducted an extensive oceanographic, geological, and biological survey of the Southern California Bight. From Point Arguello to 4 km south of the U.S.-Mexico Border, 2,582 hydrographic stations were occupied and 862 biological and 900 sediment samples were taken (Jones 1969). To date, this is the only bight-wide survey of the benthos. The analyses of macroinvertebrate distributions and descriptions of infaunal communities that appeared in reports (Allan Hancock Foundation 1959, 1965; Stevenson 1961) and in published papers (Barnard and Hartman 1959, Barnard and Ziesenhenne 1960, Jones 1969) are the foundation of our knowledge of benthic communities in the bight.

One of the major findings of the survey (hereinafter called the State Survey) was that the red brittlestar *Amphiodia urtica* was the most abundant and widely distributed organism in the bight. In most areas in depths of 55 to 95 m, *Amphiodia urtica* was either a community

A successful benthic grab.

dominant or subdominant (Barnard and Ziesenhenne 1960, Jones 1969).

Recently, *Amphiodia urtica* has been a subject of study because it is rare or absent near municipal wastewater outfalls where it is the expected community dominant. Hence it is used as an indicator organism in monitoring programs. Alterations in benthic communities near outfalls are determined by comparing these areas to "reference" areas in similar depths. However, there has been some debate as to what constitutes a reference area.

The objective of this study was to use the State Survey data to help define reference conditions for *Amphiodia urtica*. While previous reports of the State Survey discussed the distribution of *Amphiodia urtica*, they did not specifically focus on the brittlestar, nor did they use all of the data. In this study, all the available data were used to determine the effect of latitude, depth, and sediment grain size on the abundance of *Amphiodia urtica* in the Southern California Bight.

Materials and Methods

The data were compiled from a computer database provided by EcoAnalysis, Inc. (Ojai, CA) and a hardcopy of the State Survey data (Allan Hancock Foundation 1965). Only samples with all echinoderms sorted and identified were included for a total of 537 samples (Figure 1).

Most of the samples were taken with a Hayward Orange Peel grab (OPG) with a rated capacity of 56.6 L. A modified van Veen grab was used for sampling in less than 10 m of water (a Campbell grab was used three times; however data from these samples were not included in the analyses). Samples taken with the OPG were screened through 1.0 mm mesh in the field, fixed in 10% formalin, and returned to the laboratory for sorting and identification. Samples taken with the van Veen were fixed whole and taken to the laboratory for screening, sorting, and identification (Jones 1961, 1969).

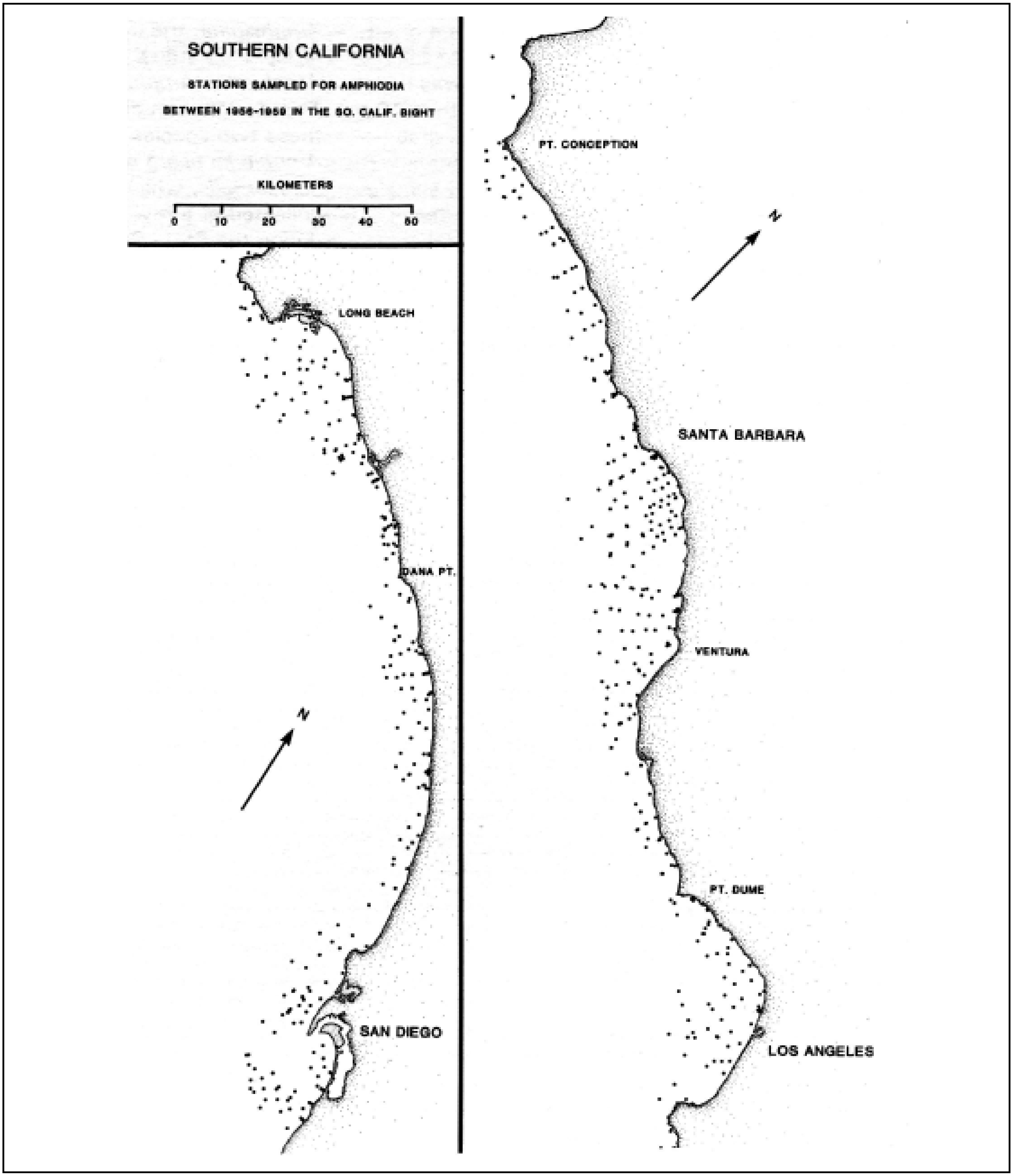
The echinoderms collected in the State Survey were identified by Mr. Fred Ziesenhenne of the Allan Hancock Foundation. Dr. Gordon Hendler of the Natural History Museum of Los Angeles County re-checked the identifications in 17 samples. He found that most of the *Amphiodia urtica* were correctly identified. There was some confusion in the identification of a closely related species, *Amphiodia digitata*. Since 80% of the all ophiuroids collected were identified as *Amphiodia urtica* and only 1% were identified as *Amphiodia digitata*, this taxonomic confusion does not materially affect the interpretation of the data. However, to resolve the taxonomic uncertainty, the data for *A. urtica* and *A. digitata* were combined. Since both species are members of the subgenus *Amphispina*, the combined group is identified as *Amphiodia (Amphispina)* spp. This designation differentiates these two species from *Amphiodia psara* and *A. occidentalis*, which were collected at a few stations during the State Survey.

While checking species identifications, Dr. Hendler also found that many specimens identified as *Amphiipholis squamata* were juvenile *Amphiodia urtica*. Specimens identified as *Amphipholis squamata* were not included in the data because it was impossible to determine which specimens had been misidentified. Thus the numbers for *Amphiodia urtica* were probably underestimated in our analyses; however, since only 10% of all ophiuroids collected were identified as *Amphipholis squamata*, the magnitude of the underestimate was probably small.

Prior to screening, approximately 0.5 L of sediment was taken from the grab for sediment grain size analysis. These samples were not refrigerated or preserved and often dried prior to analysis. Before processing, the sample was soaked in water and then wet-sieved through 0.062 mm mesh screen to remove the gravel and sand fraction. Percent sand and gravel was determined by settling (Emery

Figure 1.

Locations of samples from the State Survey (1957-59) used in the present study.



1938). The silt/clay fraction was washed in acetone and filtered to remove salts and organic matter. Percent silt and clay was determined by pipette analysis (Rittenhouse 1939). Median grain size diameter was calculated by the method of Trask (Krumbein and Pettijohn 1938).

To make data from the OPG and van Veen grabs comparable, the number of animals per grab was converted to number per square meter. Since the area sampled by the van Veen grab is constant (0.1 m^2), the conversion involved multiplying the number of animals per grab by 10. However, the area sampled by the OPG varied with the depth of penetration of the grab. For this analysis, multiplication factors developed during the State Survey were used to convert the data (Jones 1969).

An effort was made to determine the reliability of the data. In addition to verifying species identifications, station data were checked against the original logs of the *R/V Velero IV* to determine the level of transcription error. On the whole, the data were judged reliable. However, given the semi-quantitative nature of the Hayward Orange Peel grab, limitations in navigational and depth-recording devices, and the handling of samples for sediment grain size analysis, interpretations of the data were limited to order of magnitude differences.

Results

Amphiodia spp. were most abundant in silty sediment (Figure 2). The range in median grain size in samples with *A. urtica* densities >1500/m^2 was 0.035 to 0.093 mm, which is coarse silt to very fine sand. If the one outlier (median grain size 0.093 mm) is excluded, the range in median grain size in samples with *A. urtica* densities >1500/m^2 was 0.035 to 0.073 mm. *Amphiodia* spp. were less abundant in sediments with smaller or larger median diameters.

The depth range for samples with *A. urtica* densities >1500/m^2 was 48 to 102 m (Figure 3). The maximum abundance of *Amphiodia* spp. generally decreased outside of this depth range. *Amphiodia* spp. were rarely collected in samples taken in less than 15 m or more than 185 m of water.

Since grain size is generally correlated with depth, it is

Figure 2.

Abundance of *Amphiodia (Amphispina)* spp. as a function of median grain size in the State survey, 1957-59. Part B is an expanded view of the data for samples with median grain size 0.10 mm.

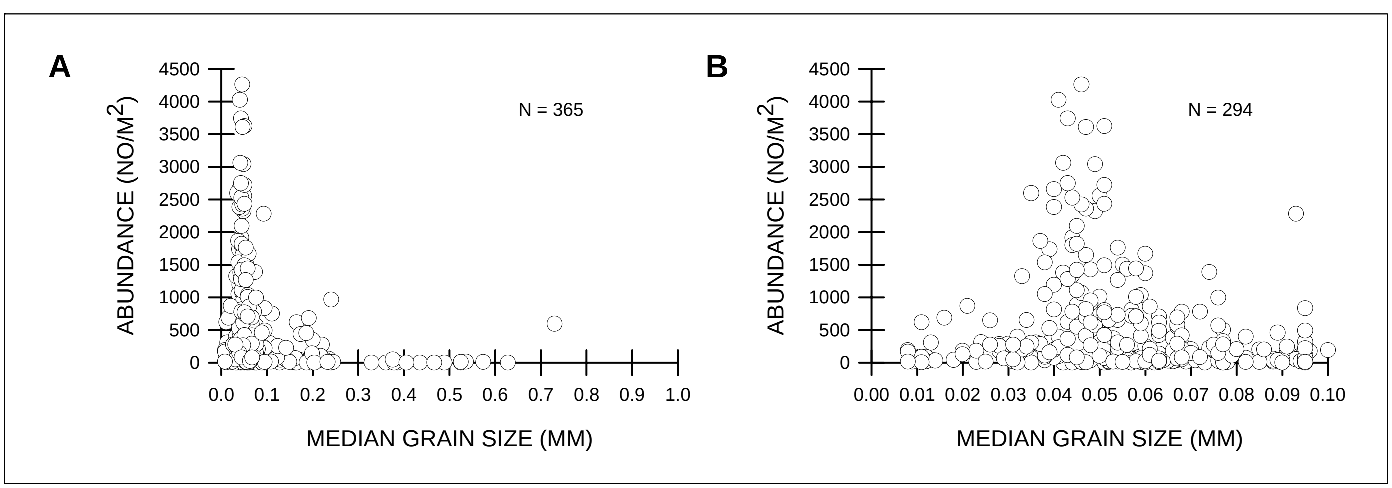


Figure 3.

Abundance of *Amphiodia (Amphispina)* spp. as a function of depth in the State Survey, 1957-59. Part B is an expanded view of the data for samples in less than 40 m of water.

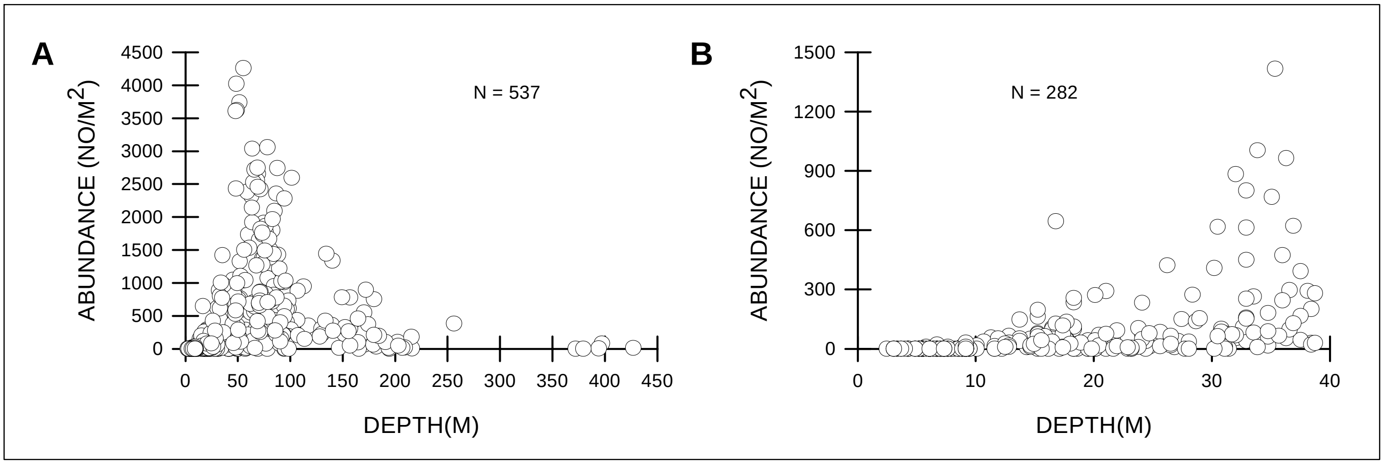
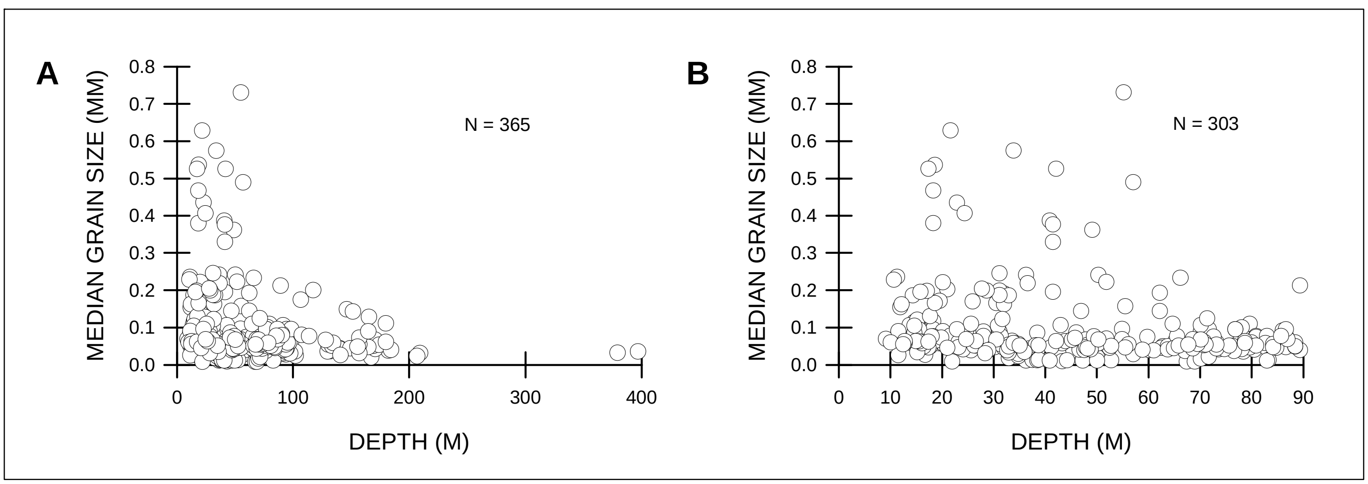


Figure 4.

Median grain size as a function of depth in the State Survey, 1957-59. Part B is an expanded view for samples taken in less than 90 m of water.



possible that the relationship between depth and abundance of *Amphiodia* spp. (Figure 3) was caused by the change in sediment texture rather than by depth. However, samples with median grain size between 0.035 and 0.073 occurred at all depths (Figure 4). The pattern of abundance versus depth for samples with median grain size between 0.035 and 0.073 (Figure 5) was similar to the pattern of abundance versus depth for all samples (Figure 3).

Amphiodia spp. were generally less abundant between Ventura and Point Conception (km 296-440) than elsewhere in the Southern California Bight (Figure 6). There were also areas with low abundance south of La Jolla (<km 33) and in San Pedro Bay (km 161-185). South of La Jolla and near Point Conception, there were areas between 48 and 102 m with coarse sediment (median

Figure 5.

Abundance of *Amphiodia (Amphispina)* spp. as a function of depth in samples with median grain size between 0.035 and 0.073 mm in the State Survey, 1957-59. Part B is an expanded view of the data for samples in less than 40 m of water.

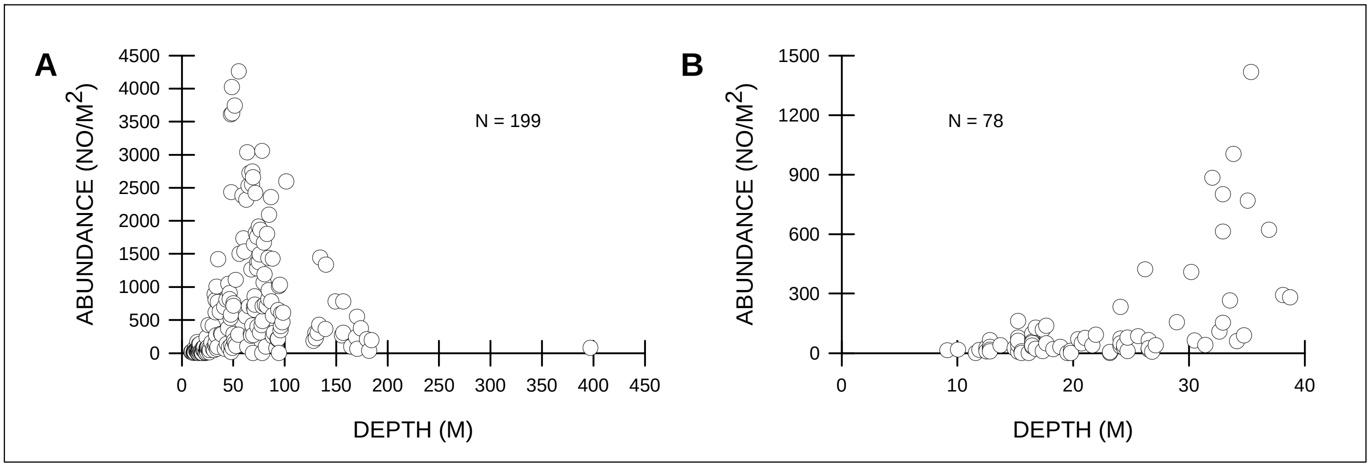
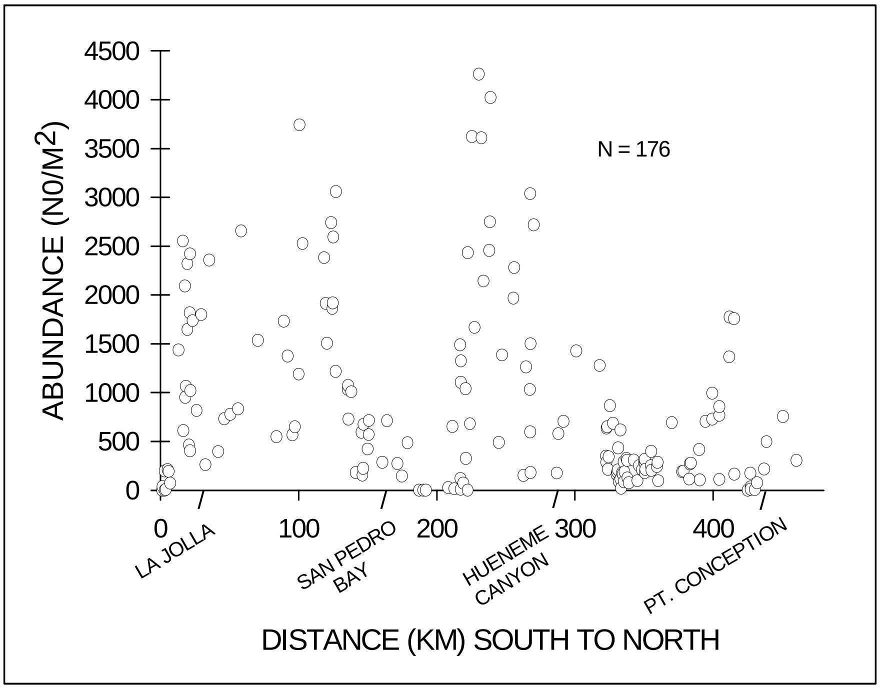


Figure 6.

Abundance of *Amphiodia (Amphispina)* spp. as a function of the approximate linear distance along the coast for samples collected between 48 and 102 m in the State Survey, 1957-59.



grain size >1.5 mm); near Ventura, there was an area with very fine sediment (median grain size <0.035 mm) (Figure 7). The pattern of abundance of *Amphiodia* spp. in samples with median grain size between 0.035 and 0.73 mm (Figure 8) was similar to the pattern of abundance of *Amphiodia* spp. in all samples (Figure 6). *Amphiodia* spp. were less abundant north of Ventura than elsewhere in the bight, and there were areas of low abundance south of La Jolla and in San Pedro Bay.

Discussion

The relationships between depth, sediment grain size, and Amphiodia spp. abundance had considerable scatter and were non-linear (Figures 2-5). Samples with the highest abundances occurred

Figure 7.

Median grain size as a function of the approximate linear distance along the coast for samples collected between 49 and 102 m in the State Survey, 1957-59.

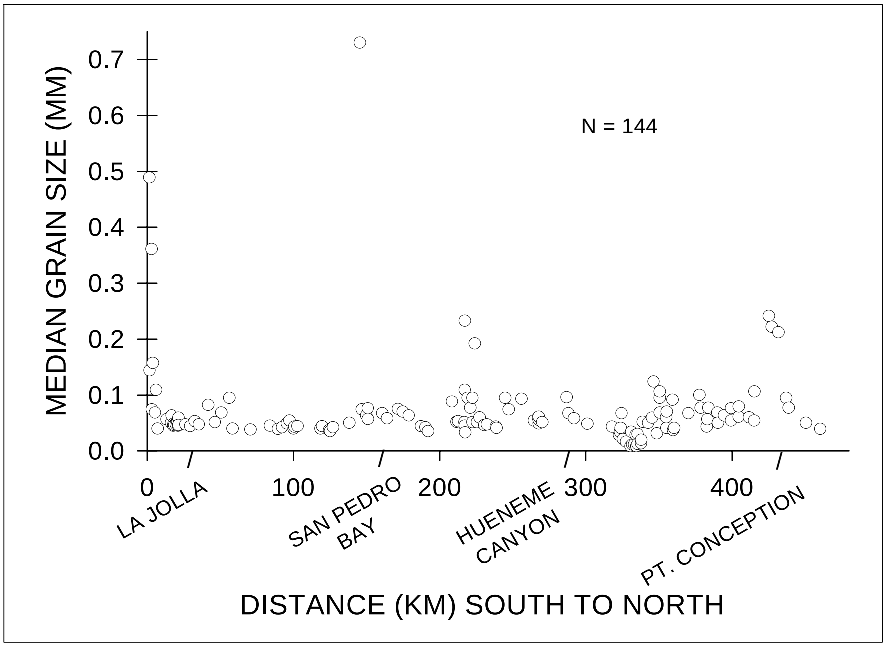
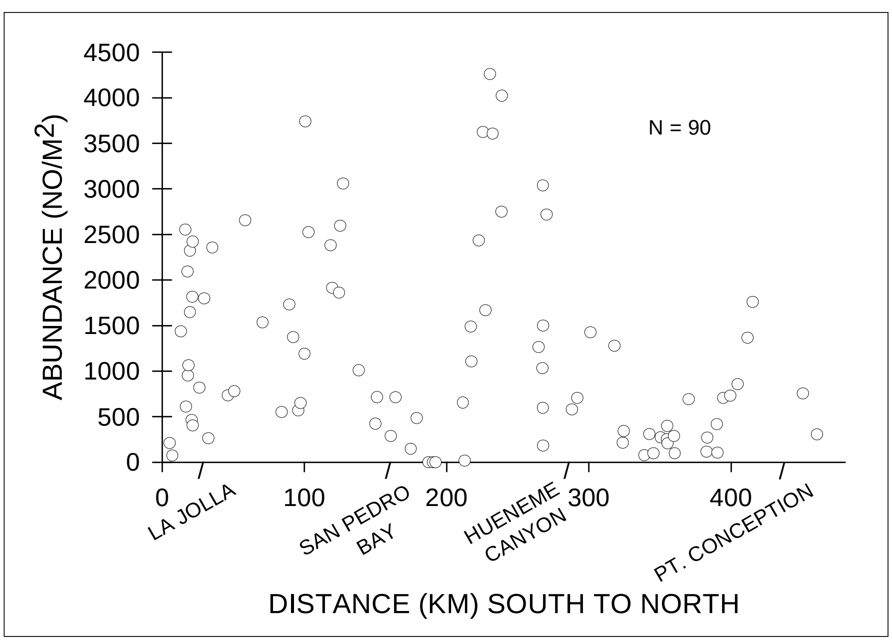


Figure 8.

Abundance of *Amphiodia (Amphispina)* spp. as a function of the approximate linear distance along the coast for samples collected between 48 and 102 m of water with median grain size from 0.036 to 0.073 mm in the State Survey, 1957-59.



over a limited range and there may have been a threshold beyond which abundances were always low. *Amphiodia* spp. were most abundant in water depths of 48 to 102 m in sediment with median grain size between 0.035 to 0.093 mm (coarse silt to very fine sand). They were rarely collected in less than 15 or more than 185 m of water.

Interestingly, the distribution of sediment grain size was independent of depth. While the number of samples with coarse sediment was higher in shallow than in deep water, samples with grain size between 0.035 and 0.073 mm were taken at all depths. However, in samples taken in less than 25 m or in more than 180 m of water, the abundance of *Amphiodia* spp. was low even when the sediment texture was presumably suitable. The effect of depth on the abundance of *Amphiodia* spp. was, in part, independent of grain size.

Amphiodia spp. were less abundant between Ventura and Point Conception than elsewhere in the bight, probably due to the presence of very fine and very coarse sediments. Southeast of Santa Barbara, there is a topographic high called the Carpinteria Shelf-Rise with sandy sediment (Wimberly 1961). To the east of the rise there is a large area of clayey-silts and silts that Wimberly (1961) called the Las Pitas Mud Deposit and the Santa

Clara Prodelta deposit. To the south of Point Conception, there is an area of fine sand probably caused by the refraction of waves around Point Conception.

Even when the differences in sediment texture were taken into account, the abundance of *Amphiodia* spp. was lower north of Ventura than elsewhere in the bight. Barnard and Ziesenhenne (1960) described a faunal break at Hueneme Canyon. North of the canyon, the benthic assemblage in 60 to 92 m (the *Amphiodia urtica-Cardita ventricosa* community) mollusks, particularly the clam *Cyclocardia* (=*Cardita*) *ventricosa*, were abundant. Barnard and Ziesenhenne postulated that the northward flowing countercurrent moves offshore at Hueneme Canyon so that the area north of the canyon is generally colder than the area south of the canyon.

The abundance of *Amphiodia* spp. was also lower south of La Jolla and in San Pedro Bay and was associated with sediment texture. The sediment in most of the samples taken south of La Jolla was a coarse red sand was dominated by polychaetes and called the *Nothria stigmatus-Spiophanes bombyx* association (Jones 1969). Wimberly (1961) suggested that this sand was deposited during the ice age when the sea level was approximately 90 m lower than at present. Sediment in two of the samples collected in this area, however, was a fine green sand. The abundance of *Amphiodia* spp. was relatively low in these samples even though grain size and water depth were within the suitable range. One of these samples was dominated by mollusks; organisms in the other sample were not completely identified.

In San Pedro Bay, the grain size of the sediment was within the range that was suitable for *Amphiodia* spp. However, Barnard and Ziesenhenne (1960) suggested that even though the median grain size was similar, the sediment in San Pedro Bay was slightly coarser than the sediment in other areas of the bight that supported *Amphiodia urtica* communities. Barnard and Ziesenhenne included the benthos in San Pedro Bay in the *Amphioplus hexacanthus* community, which was similar to the *Amphiodia urtica* community, except that *Amphiodia urtica* was less abundant and the brittlestar *Amphioplus hexacanthus*, the brachiopod *Glottida albida*, and several species of polychaetes were more abundant.

It is apparent that some, but not all, of the geographical distribution of *Amphiodia* spp. is attributable to the geographical distribution of sediment types. If more or better measures of sediment texture were available, it is possible that more of the *Amphiodia* spp. distribution could be explained by sediment type. However, other factors, including food availability, competition, and predation, may affect its distribution.

Because of the major El Niño in 1957-1959 (e.g., Reid 1988), there is a question of how representative the State Survey data are of current conditions in the bight. During the last decade, the abundance of *Amphiodia urtica* has ranged from about 500 to 4500/m^2 at control stations in the municipal wastewater monitoring programs in Santa Monica Bay, off Orange County, and off Point Loma (personal observation). This is within the range of abundance measured in the State Survey.

Available information suggests that benthic communities may have changed since the State Survey. In 1977, SCCWRP sampled 71 stations between Point Conception and the Mexican Border (Word and Mearns 1979); 13 stations were north of Ventura. The abundance of *Amphiodia* spp. in these samples ranged from 300 to 1130/m^2, comparable to the range in abundance in the State Survey. However, the clam *Cyclocardia ventricosa* was collected at only two of the 13 stations and its abundance was 60 to 70/m^2. In the State Survey, *C. ventricosa* was collected at 12 out of 16 stations between 50 and 70 m north of Ventura and its abundance ranged from 4 to 388/m^2; its abundance at seven stations was greater than 330/m^2. These data suggest that the abundance of *Cyclocardia ventricosa* decreased between 1959 and 1977, and that the clam no longer dominates the community with *Amphiodia urtica*. However, a systematic, bight-wide survey is required to determine if the community types described by Barnard and Ziesenhenne (1969) and Jones (1969) are still applicable.

Conclusions

Brittlestars *Amphiodia (Amphispina)* spp. were most abundant in water depths of 48 to 102 m in sediments with median grain size between 0.035 and 0.093 mm, a diameter classified as coarse silt to very fine sand. *Amphiodia* spp. were rarely collected in less than 15 or more than 185 m of water.

The abundance of *Amphiodia (Amphispina)* spp. was generally lower north of Ventura than elsewhere in the bight. The difference in abundance can be attributed, in part, to the character of the sediment. Large areas of silty and sandy sediments north of Ventura would not be expected to support abundant populations of *Amphiodia* spp. However, even in areas north of Ventura with apparently suitable sediment, the abundance of *Amphiodia (Amphispina)* spp. was relatively low. The reason for this is unknown.

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