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A SURVEY OF THE BENTHOS OFF SANTA BARBARA FOLLOWING THE JANUARY 1969 OIL SPILL

KRISTIN FAUCHALD
Department of Biological Sciences
University of Southern California
Los Angeles, California

The shelf off Santa Barbara is rather extensive and forms a large embayment open to the west. It is cut from the remainder of the southern California Borderland by the row of Channel Islands to the south and east. The deepest part of this bay, the Santa Barbara Basin is somewhat to the south of the middle of the bay, so that the shelf areas off Santa Barbara are considerably wider than the shelf of the Channel Islands. It is on this wide portion of the shelf that the oil drilling off Santa Barbara has been taking place. Platform A, which started leaking during the last days of January 1969, is roughly in the middle of the widest portion of the shelf.

A large-scale benthic survey was done off the southern California coast by the Allan Hancock Foundation during the years 1956–1960. (Allan Hancock Foundation, 1965) This survey, which was financed through the State of California, concentrated on mapping the different kinds of environments found along the coast. During this survey some very high values of standing crop of macroinvertebrates were reported from the Palos Verdes shelf off Los Angeles and from the shelf off Santa Barbara; up to 2,800 grams per square meter were present off Palos Verdes and better than 2,300 grams per square meter off Santa Barbara. These values are among the highest measured in the marine environment.

The present study, referred to below as the Pollution Study (Allan Hancock Foundation 1971) was patterned as much as possible on the State Survey to facilitate comparisons. We used a different, large grab than was used during the State Survey, but the

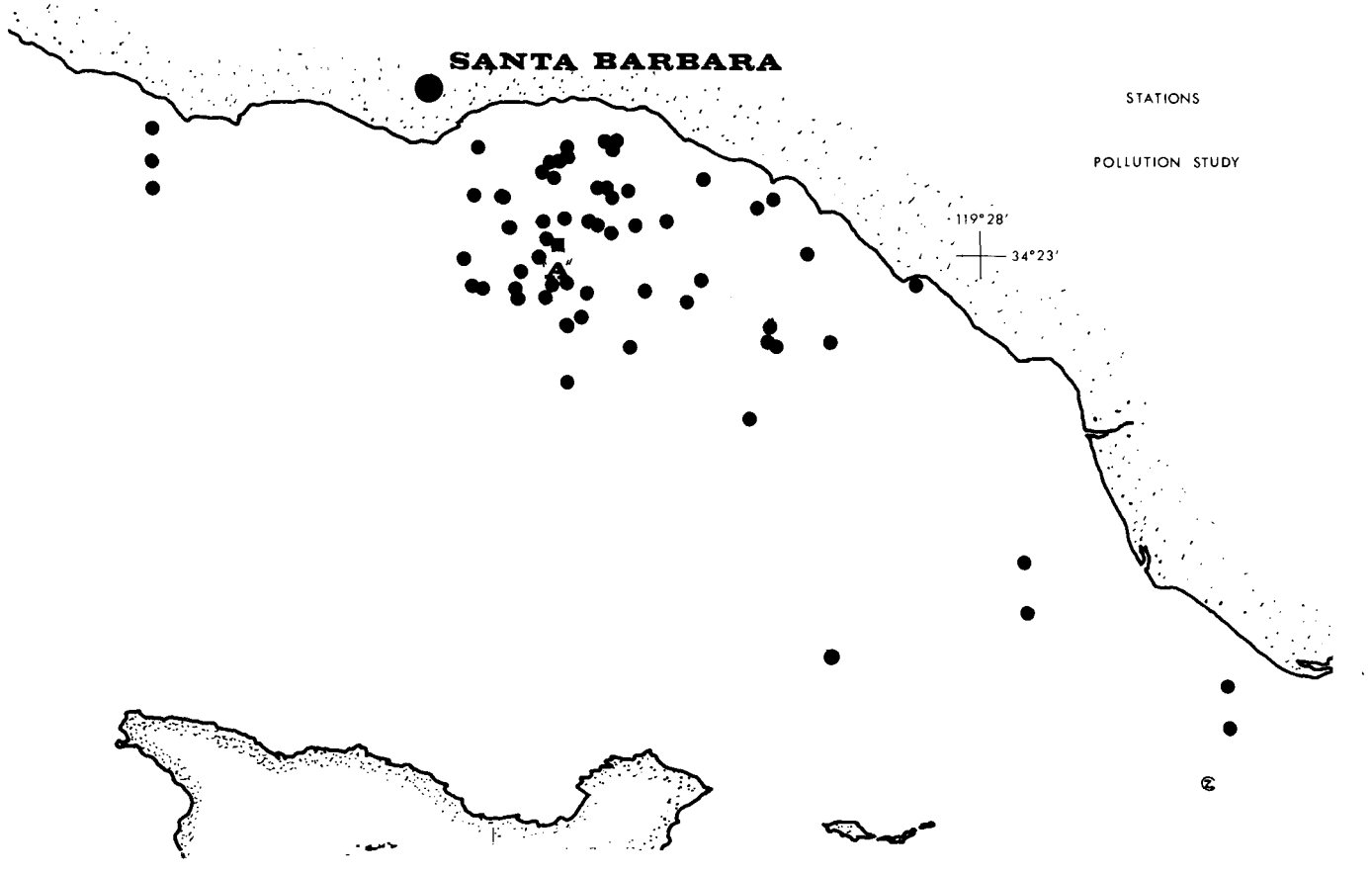


FIGURE 1. Stations, Pollution Study.

screening was done through screens of the same mesh-size and the lab-procedures were the same as much as possible.

It should be pointed out that neither study has been completed; both surveys were done only as far as the time and money permitted. During the State Survey at least some samples from all areas of the coast were as completely analyzed as possible; we had considerably shorter time to our disposal and had to analyze the samples as they came in. All samples in both surveys were analyzed for standing crop of macroinvertebrates. During both studies emphasis was placed on analyzing those groups that made up the largest fraction of the standing crop. In most samples analyzed, the groups actually identified is somewhere between 50 and 75% of the total standing crop.

The stations were taken in a pre-determined pattern (Fig. 1). In early March 1969 we took a series of samples scattered over the whole shelf area to see if we could identify any large-scale immediate effects of the oil spill. In May and June we repeat-sampled selected areas where the densest concentration of standing crop had been reported during the State Survey. Finally, in October, 1969 we re-sampled the whole area as much as possible. The areal distribution of samples during the Pollution Survey was approximately the same as during the State Survey in the same area, even if the number of samples was considerably higher during the latter study. As an example can be mentioned that during the State Survey we re-sampled the same area four times a year in an attempt to demonstrate temporal variations in the fauna; such an approach was impossible during the Pollution Study.

Perhaps the most striking differences between the results of the State Survey and those of the Pollution Study are in the records of standing crop. Figure 2 shows the standing crop in 1956–60. The population is described by contours, where points of similar standing crop have been connected to show the distribution of standing crop in the bottom. This method of showing standing crop has been criticized since it connects areas that have little or nothing to do with each other biologically, except that a similar amount of living macroinvertebrates is present in all areas connected. Nevertheless, the method gives a striking picture of what has been taking place off Santa Barbara in the ten years separating the two surveys (Figure 3). In general, the base-level of standing crop is similar in both surveys; it may have been re-

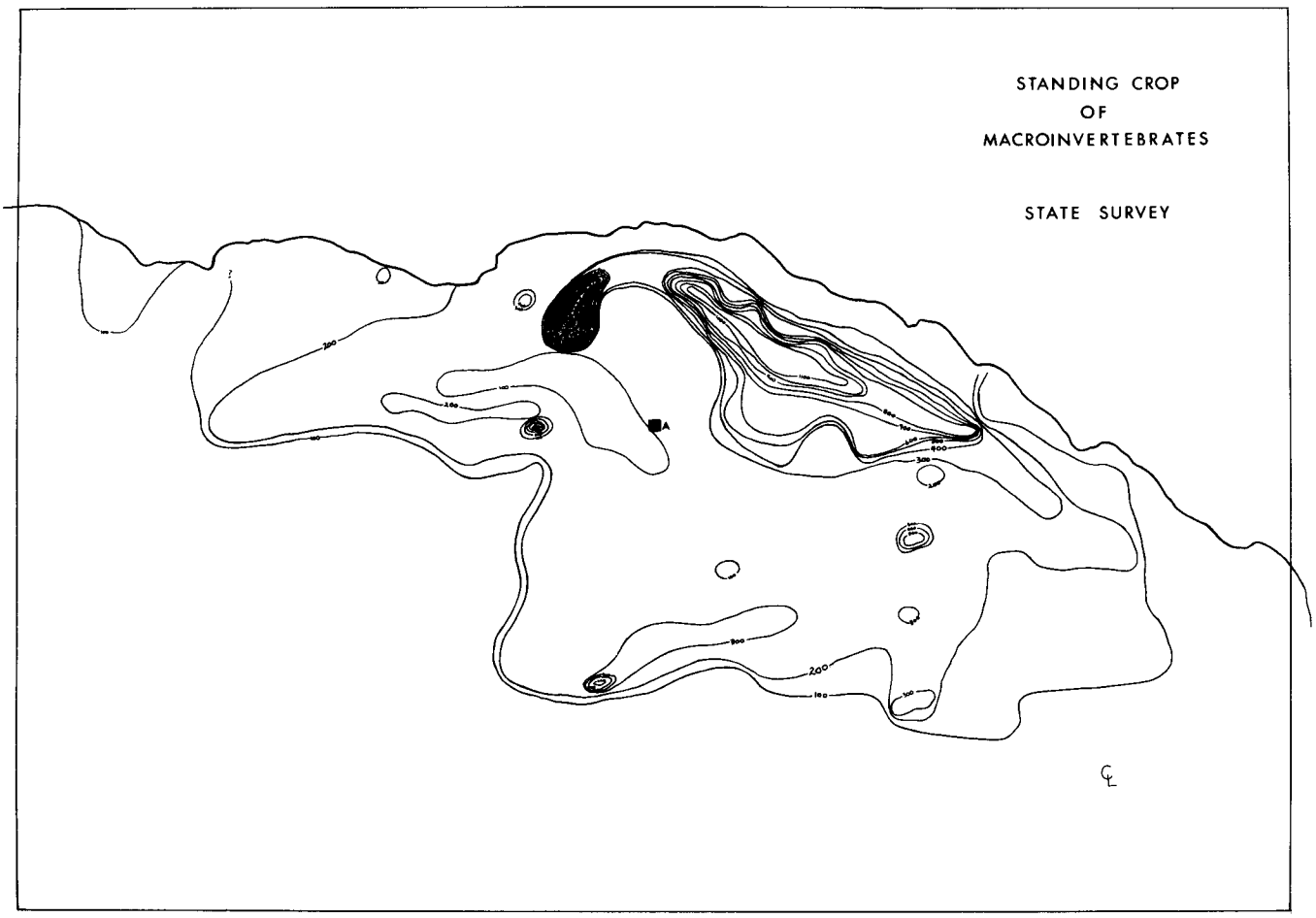
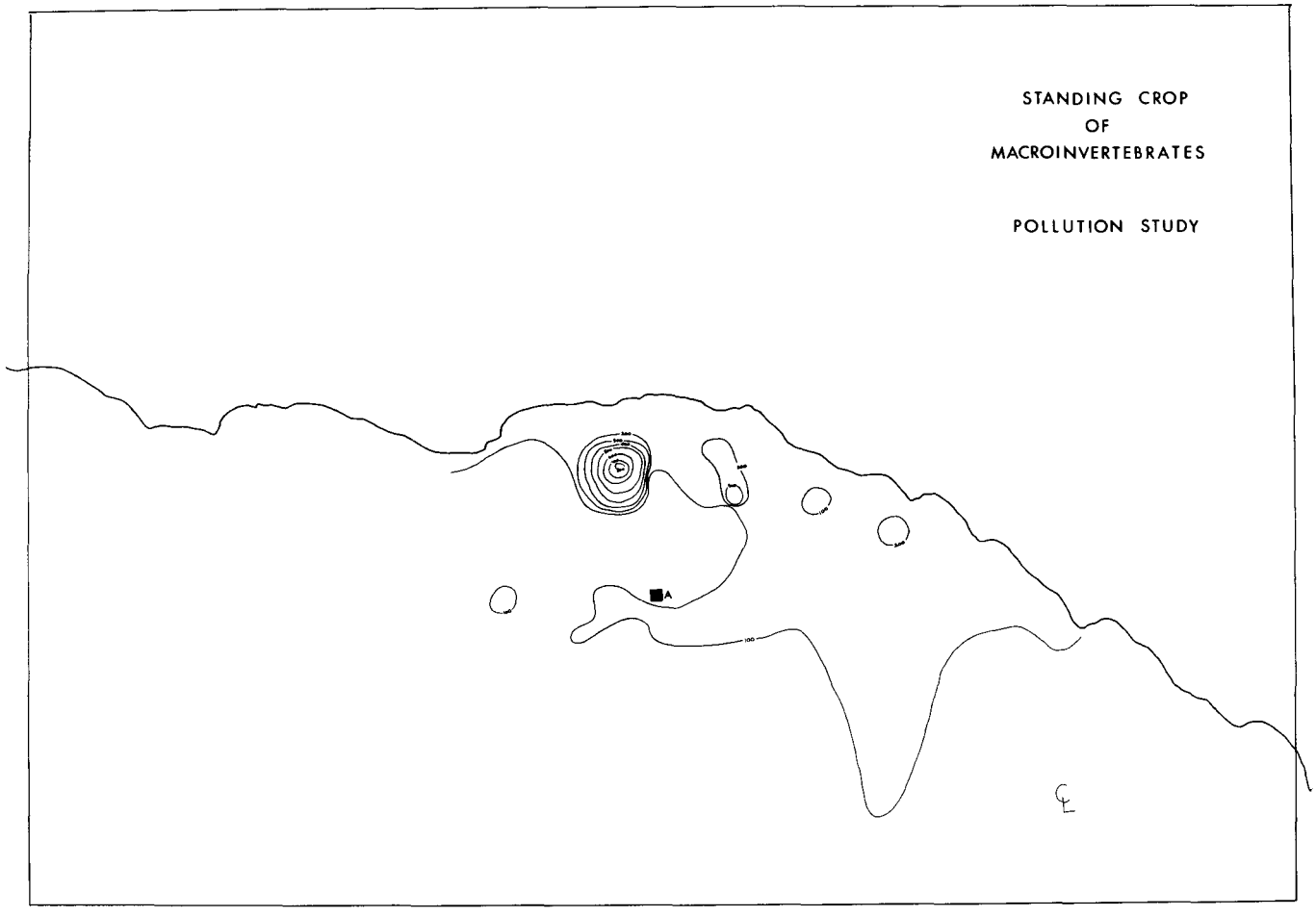


FIGURE 2. Standing crop of macroinvertebrates, State Survey.

duced slightly in some areas, but this may be due to natural fluctuations in the bottoms. Generally, the values of standing crop over most parts of the shelf off Santa Barbara appear to be near 100 grams per square meter. Inshore of Platform A was found a very large patch with high values of standing crop; the peak values reported in the State Survey were near 2,300 grams per square meter. During the Pollution Study we found no value higher than 800 grams per square meter in the same area. Most of the repeat-sampling, both during the State Survey and the Pollution Study was done in this general area, so both sets of data are considered equally valid. Even more striking is the absence of the very dense areas stretching from Santa Barbara to Carpinteria as an eastwards extension of the major peak in biomass. This large area has dropped severely in standing crop in the ten years separating the two surveys.

This whole high-density area is essentially made up of a single species, the echiuroid worm *Listriolobus pelodes* Fisher. It was primarily thought that there had been a mass extinction of the worm in some areas, but the geographical distribution of *L. pelodes* in both surveys (Figs. 4–5) does not seem to have changed between the two surveys. The species is still present in roughly the same area it occupied ten–fifteen years ago, but has been drastically reduced in numbers in the intervening years. It should be remarked that in general communities that are dominated totally by one species tend to be rather unstable ecologically and the drop in numbers of *L. pelodes* in these beds may thus be a highly significant event in the biology of the sea-bed off Santa Barbara. Furthermore, these beds are, as far as known, the only beds formed by *L. pelodes* throughout its range, which presently is considered to be from Monterey to Isla Cedros in Mexico. Barnard and Hartman (1959) indicated that the presence of the beds off Santa Barbara might be due to the sedimentation pattern in the area and that the species is highly dependent on suitable sediment conditions. The biology of *L. pelodes* is otherwise unknown; McGinitie and McGinitie (1949) reported no luck in maintaining these animals alive in aquaria. Some specimens were maintained for nearly three weeks under highly abnormal conditions at the Santa Catalina Marine Biological Laboratory during the summer of 1969 and intensive studies of the biology of this animal are now being planned.

Other changes that have taken place in the ten years that separate the State Survey from the Pollution



Study include certain changes in the faunal composition, especially among the polychaetous annelids and the mollusks. The echinoderm fauna appears to be the same as it was ten years ago, both in terms of species composition and in numbers of specimens. Some of the apparent species replacements may be due to taxonomic difficulties, but in a number of instances the specimens taken in the two surveys were compared directly and found to differ.

We tried to analyze the factors that may have caused the observed changes in the benthos. During 1969 there was very heavy flooding in the area, with a corresponding high influx of terrestrially derived sediments. Hartman (1960) reported a local extinction of the marine fauna in the vicinity of the Ventura River following a flood in April, 1958; the numbers of *Listriolobus* in the beds off Santa Barbara, appear, however to have been unaffected by this flood. The floods in 1969 were considerably larger than those in 1958, so the factor cannot be excluded based on this prior example of flood effect in the same general area. Because of the general increase in human population in Santa Barbara and Ventura Counties, there has been an increased flow of sewage over the area. No matter how well sewage is treated, an increased flow is going to mean an increased load on the sea bottom. This factor cannot be excluded, but cannot, on the other hand, be indicted as responsible until we know the biology of the animals living in the area considerably better than we do today. If *L. pelodes* is in fact dependent on the exact composition of the sediments, the drilling for oil in the beds may in itself be enough to upset the balance in these ecologically precariously balanced beds. Finally, the oil spill cannot be excluded as a factor either. We found in October 1969 a small *L. pelodes* sitting in the middle of an inch-thick layer of oil only some 150 yards from Platform A; this may indicate that the effects of the crude oil are less than originally anticipated, but again, the long-term effects of large quantities of oil on the bottom cannot be assessed.

There are also possibilities that what we have seen in terms of numbers of specimens of *L. pelodes* may be due to natural fluctuations in the population, but this appears presently rather unlikely. Any of the factors mentioned may, singly or jointly, be responsible for the drop in standing crop of *L. pelodes* and the change of species of polychaetes and mullusks seen in the area, but at the present nothing can be said about this, since the biology of the different species remains unknown.

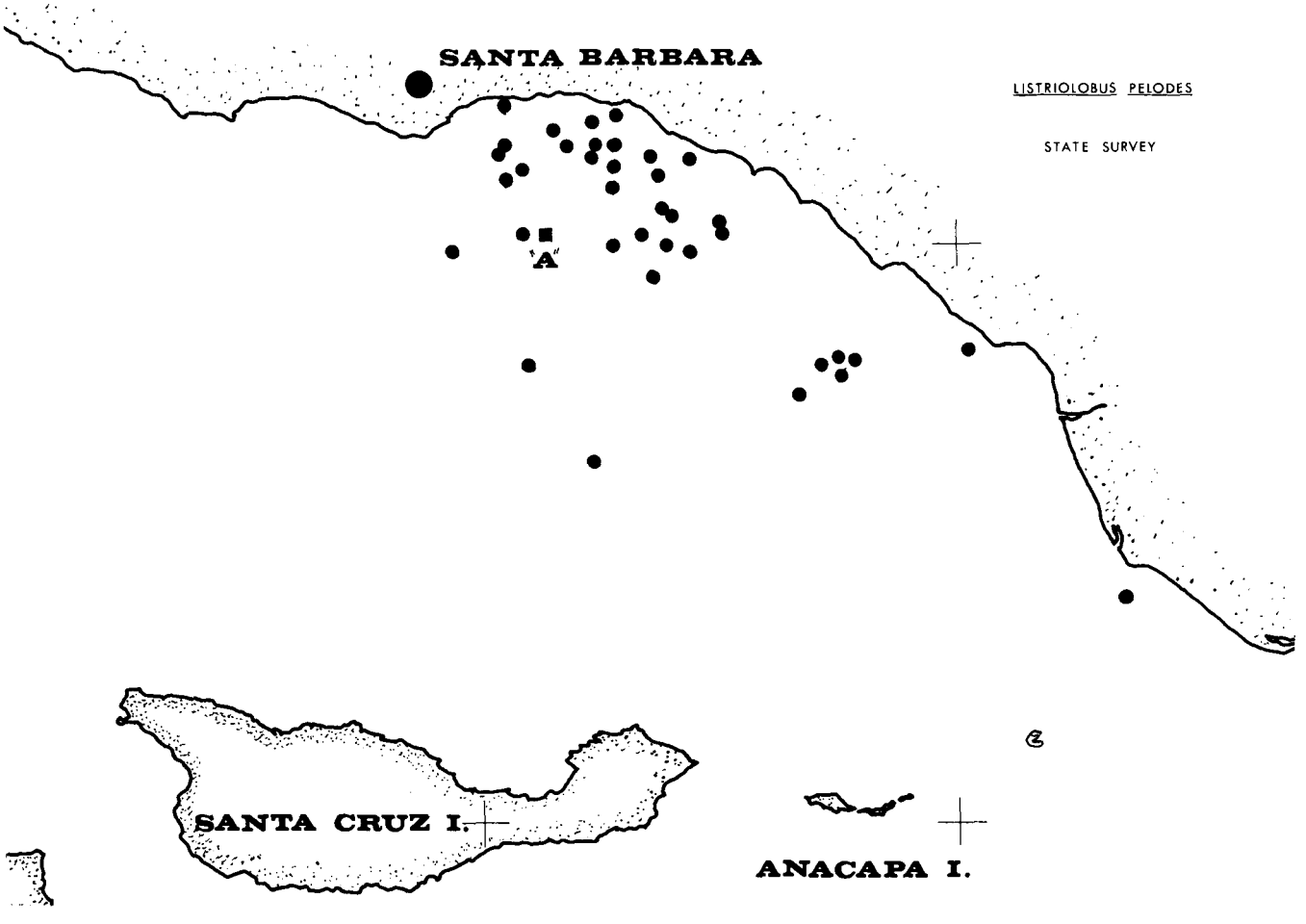


FIGURE 4. *Listriolobus pelodes*, State Survey.

The methodology used in the study may also have influenced our results. The survey method, using large grabs, counting the numbers of species present and their standing crop may be too insensitive to show the effects of pollution until it is too late. The brittle-star *Amphiodia urtica* is considered an indicator species for sandy bottoms in southern California and is common also elsewhere; in fact, it is so common just because it is rather insensitive to environmental changes as indicated by the range of conditions which it can be found in. To use such a species as an indicator of pollution, as we in fact did by using the survey method, will obviously underestimate the total effects of the pollutant in question. Smaller animals, such as small crustaceans, polychaetes and foraminiferans, may be more sensitive to environmental changes and may thus be better indicators of what is happening in the sea beds.

What is needed is at any rate a thorough, complete reworking of all the materials collected during the State Survey and the Pollution Survey so that we may get a comparatively firm base from which we can evaluate the kinds of studies that will be needed for each type of pollutant we pour into the area. I would furthermore recommend, that since we do not know what is happening in the area, we should be very careful not to upset the area further than has been done so far, provided of course that the changes we have observed are not due to natural fluctuations. It would be a shame if we should lose the *Listriolobus* beds off Santa Barbara, since they represent a unique natural resource. Since this environment is so precariously balanced, with nearly all the energy following through a single species, we may expect completely changed conditions in the sea bottom if this species should become extinct.

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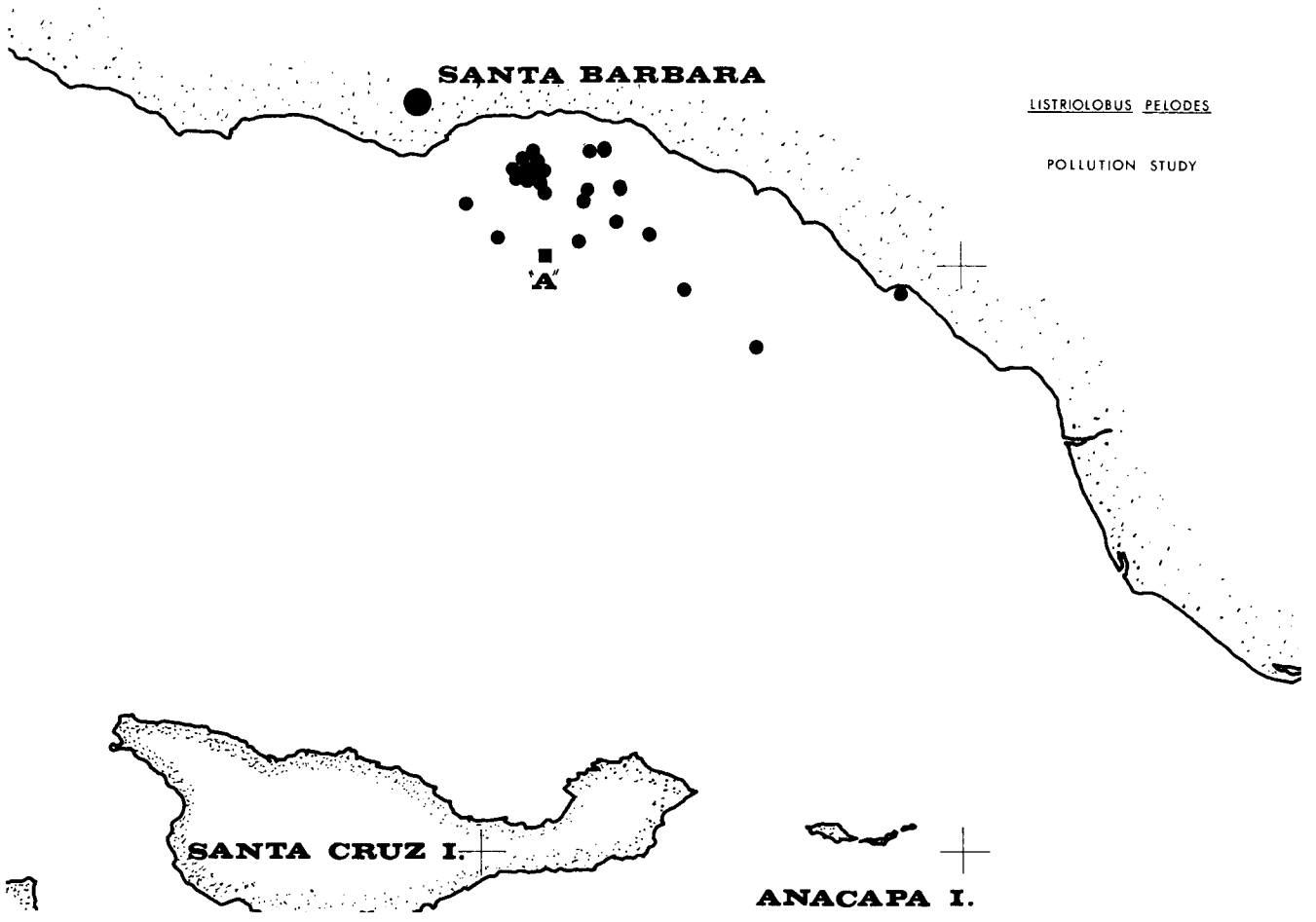

FIGURE 5. *Listriolobus pelodes*, Pollution Study.