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PARTIAL RECOVERY OF THE BENTHOS AT PALOS VERDES

One of the areas of southern California ocean bottom most seriously contaminated from the discharge of wastewater is the Palos Verdes shelf. The discharge of domestic and industrial wastes to these sediments began in 1937 and has continued to a present rate of approximately 341 mgd. Extensive monitoring of the animals and chemistry in these sediments has been carried out since 1971 by the County Sanitation Districts of Los Angeles County, with additional chemical and sediment analyses by the Coastal Water Research Project in 1973 and 1975.

The surveys have shown that, in addition to the high concentrations of pesticides (DDT and its derivatives) and trace metals present, the accumulation of organic material in these sediments had by 1973 resulted in a large area (16 sq km) of anaerobic sediments containing hydrogen sulfide (Figure 1). Data collected since 1973 show that the conditions in these sediments have changed: The most significant change has been the almost complete disappearance (to less than 2 sq km) of the hydrogen-sulfide-producing conditions of 1973.

The biological changes that accompany improved or modified conditions around deepwater outfalls, such as those on the Palos Verdes shelf, have not previously been reported. The purpose of this article is, therefore, to describe how basic biological parameters have changed in response to modifications in the physical/chemical environment. These parameters—the areal distributions of (1) the number and kinds of organisms and (2) the biomass (amount of biological material)—are known to change in response to the stresses of pollution and are, therefore, considered to be reliable indicators of the conditions that exist on this shelf.

To reduce the complexity of the existing data, comparisons will be restricted to the 10 sampling stations located along the 60-meter contour, where the impact of the outfalls is the greatest (Figure 1).

NUMBER OF ANIMALS

Excessive numerical dominance by one or a few species over all other species in a community is a widespread phenomenon typically associated with disturbed environments. Moderate to extreme examples of this phenomenon were present on the Palos Verdes shelf prior to 1975. The distributions of the number of individuals per station along the 60-meter depth contour for the summers of 1973, 1974, and 1975 are shown on Figure 2. Two peaks of abundance are apparent in these data. The species that account for the peak in Area A, which is located approximately 9 km downcurrent from the outfalls, are typically found around outfalls where there are moderate-to-high inputs of organic material and low-to-moderate concentrations of potential toxic substances in the sediments, such as pesticides or hydrogen sulfide. These "enriched" environmental conditions usually support a large number of species of which one or a few are often extremely abundant: In Area A, a small clam, *Parvilucina tenuisculpta*, accounted for no less than 80 percent of the animals in any one of the three survey years.

More extreme conditions existed around the outfalls (Area B on Figure 2). The species that account for the peaks of abundance in Area B are not usually found in undisturbed sediments on the open coast. Several of these species are typically found in the highly organic sediments of shallower bays and estuaries; others are characteristic of the low-oxygen environments of deeper waters. This group of species, especially when they are present in high abundance, are indicators of the low oxygen and often toxic conditions that can result from the accumulation of organic material in ocean sediments. The most characteristic members of this group of pollution-tolerant species are four polychaetous worms (*Shistomeringos longicornis*, *Capitella capitata*, *Armandia bioculata*, and an undescribed dorvillied) and a medium sized clam (*Solemya panamensis*). The sediment conditions that lead to the high abundances of this group normally support only a few other species in low abundance. An analogous terrestrial situation is often found following a severe forest fire, where the organisms that recolonize the area will be few in kind, many in number, and different from the normal fauna of the forest.

These two peaks are readily apparent in the 1973 and 1974 data as shown in Figure 2. It is equally apparent, however, that the peak of abundance associated with the extreme environmental conditions at the outfalls (Area B on Figure 2) is essentially absent in 1975. It is interesting to note that there is still a strong peak in Area A in 1975, and that this area of enhanced abundance seems to be moving toward the outfalls.

POLLUTION TOLERANT SPECIES

The distribution of the group of pollution-tolerant species along the 60-meter depth contour in 1973, 1974, and 1975 is shown on Figure 3. Comparisons of these peaks with those on Figure 2 (Area B) shows that they are essentially identical in form. The total number of animals found at Station 18 in 1973 and 1974 was 14,350 and 21,856 respectively. The pollution-tolerant species accounted for over 93 percent of these animals at Station 18, or 13,394 and 20,875, respectively. In 1975, there was no significant peak of abundance for these species around the outfalls. A small enhancement of this group of species does remain at Station 17, indicating that the conditions that favor this group have not completely disappeared.

BIOMASS

A second parameter that has been useful in revealing biological response to wastewater discharge on this and other shelf areas is the distribution of biomass relative to the outfalls. The distribution of biomass for the three summer surveys along the 60-meter depth contour is shown in Figure 4, where the total biomass is divided into two components: (1) Biomass contributed by *Listriotobus pelodes*, a relatively large worm-like echiuran, and (2) biomass contributed by all other species. *L. pelodes* first appeared in these samples in the summer of 1973 at the stations located on either side of Area B where the total abundance of animals was lowest. The populations of *L. pelodes* increased and were by 1974 the dominant component of the biomass.

The most significant feature of the distribution of these animals in 1973 and 1974 was their apparent inability to colonize the area occupied by the pollution-tolerant species. It seems reasonable to assume that L. pelodes could not tolerate the chemical and/or competitive conditions in these sediments during these years. Data from February 1975 (not presented) show that *L. pelodes* were still not present in the outfall area in significant numbers; however, it is apparent from Figure 4 that the factor or factors that inhibited their invasion of this area had disappeared by the summer of 1975. Total biomass reached peaks of 1,500 to 2,000 g/sq m off Palos Verdes; these are at least an order of magnitude higher than found in most other local coastal areas and are due almost exclusively to *L. pelodes*.

SUMMARY AND CONCLUSIONS

The improvements and changes in the physical/chemical nature of the sediments around the outfalls on the Palos Verdes shelf resulted in dramatic changes in the distributions and composition of the associations of animals living in these sediments. A group of species that has been associated with extremely stressful conditions around outfalls has become greatly reduced in numerical abundance, and species that would not or could not previously occupy these sediments are now present in high quantity (biomass). Although the chemical nature of these sediments is still far from natural (see Page 49), the observed biological events indicate that this environment has indeed improved as a biological habitat.

The exact cause of this improvement is not clear at this time. There have been improvements in the treatment of the effluent discharged off Palos Verdes that would contribute to the improved sediment conditions; however, changes in the sediments associated with the disappearance of the hydrogen sulfide conditions suggest that rather strong hydrological forces may also have contributed significantly to the changes by resuspending, mixing, and transporting quantities of the sediments (see also Page 63 and 197). The existing evidence suggests that the physical/chemical changes occurred over a relatively short period of time and the subsequent biological responses followed rather rapidly.

The impact of the outfalls on the numbers and kinds of animals at other depths (i.e., 30, 150, and 300 meters) is less than observed at 60 meters: The patterns of change have been similar to those described for 60 meters, but the degree of change has been correspondingly smaller.

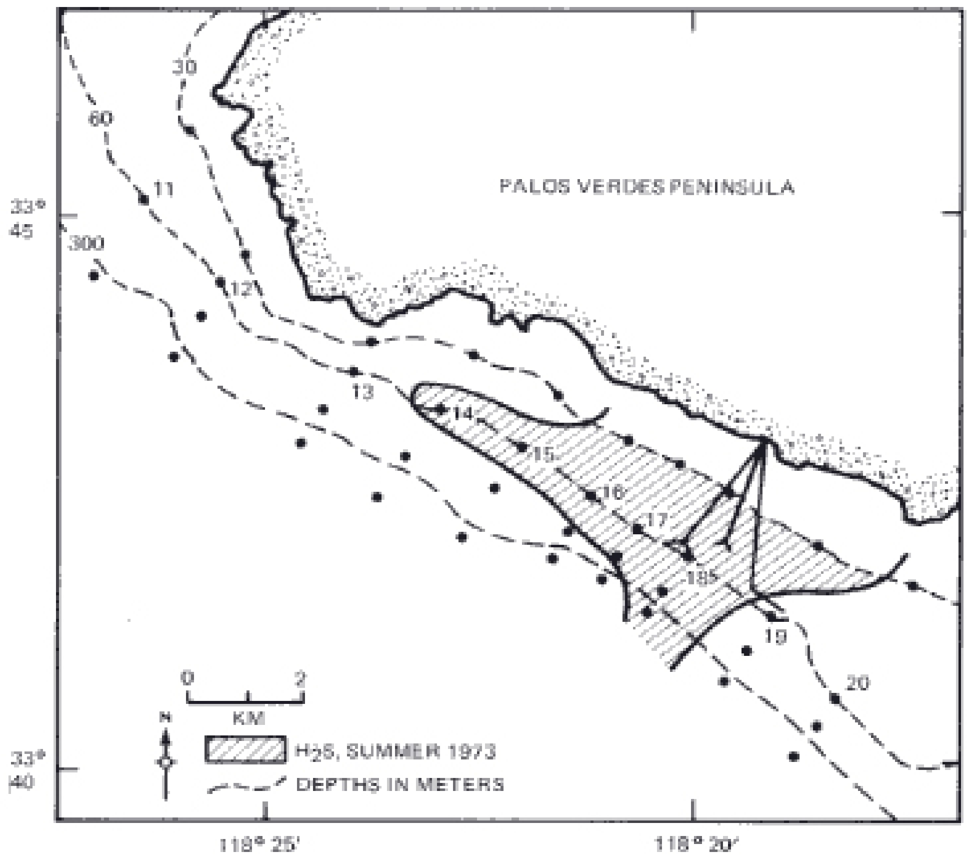

Figure 1. Benthic sampling stations on the Palos Verdes shelf and slope. Stations 11 through 20 were used in the present study.

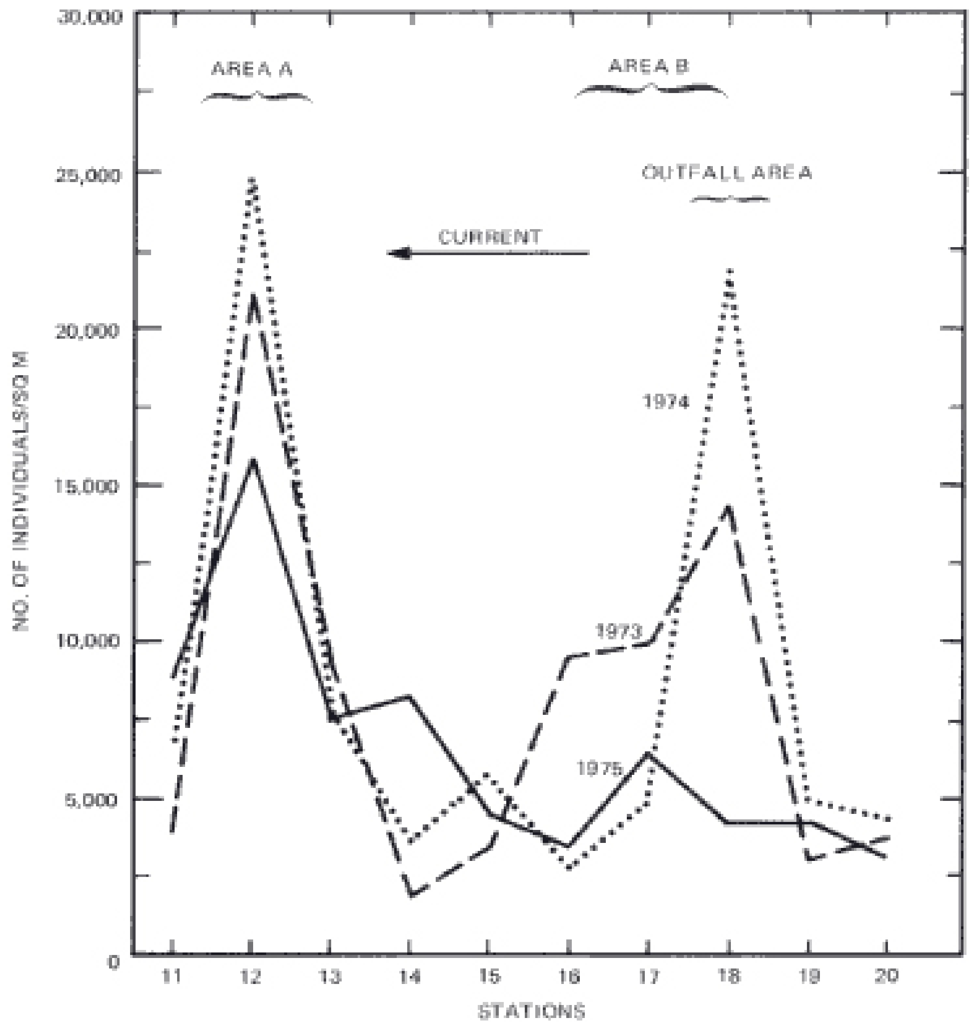

Figure 2. Distributions of the number of organisms along the 60-meter depth contour for the summers of 1973, 1974 and 1975.

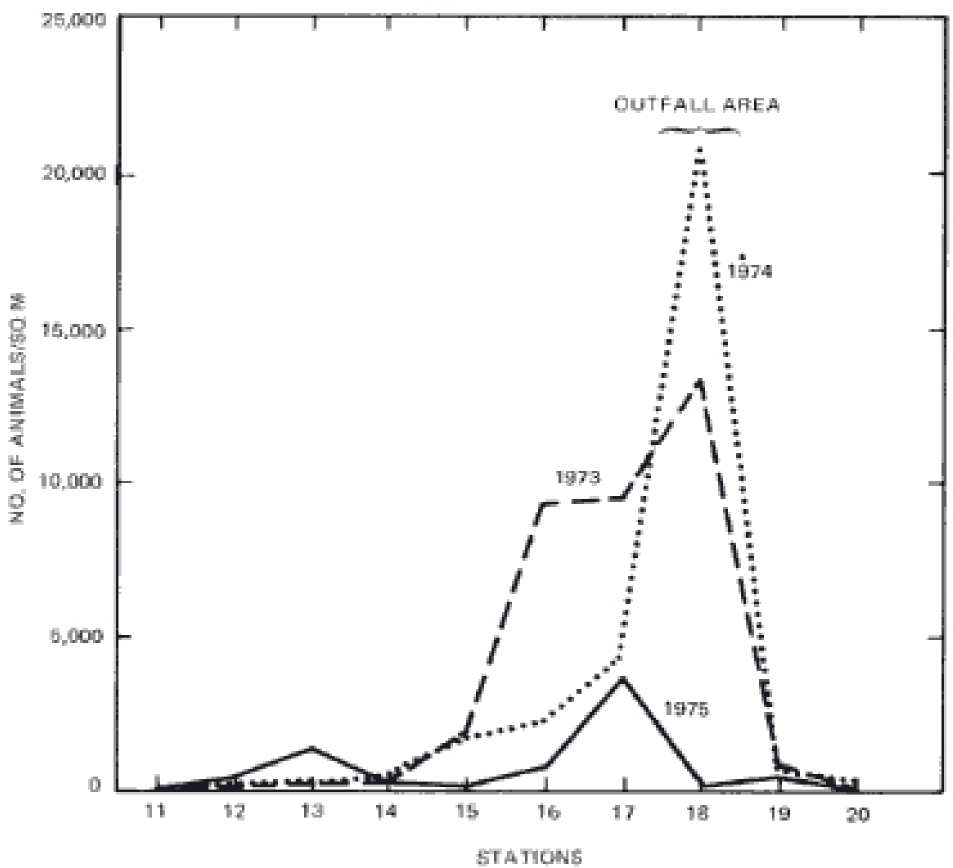

Figure 3. Distribution of the pollution indicator species-group along the 60-meter depth contour for the summers of 1973, 1974 and 1975.

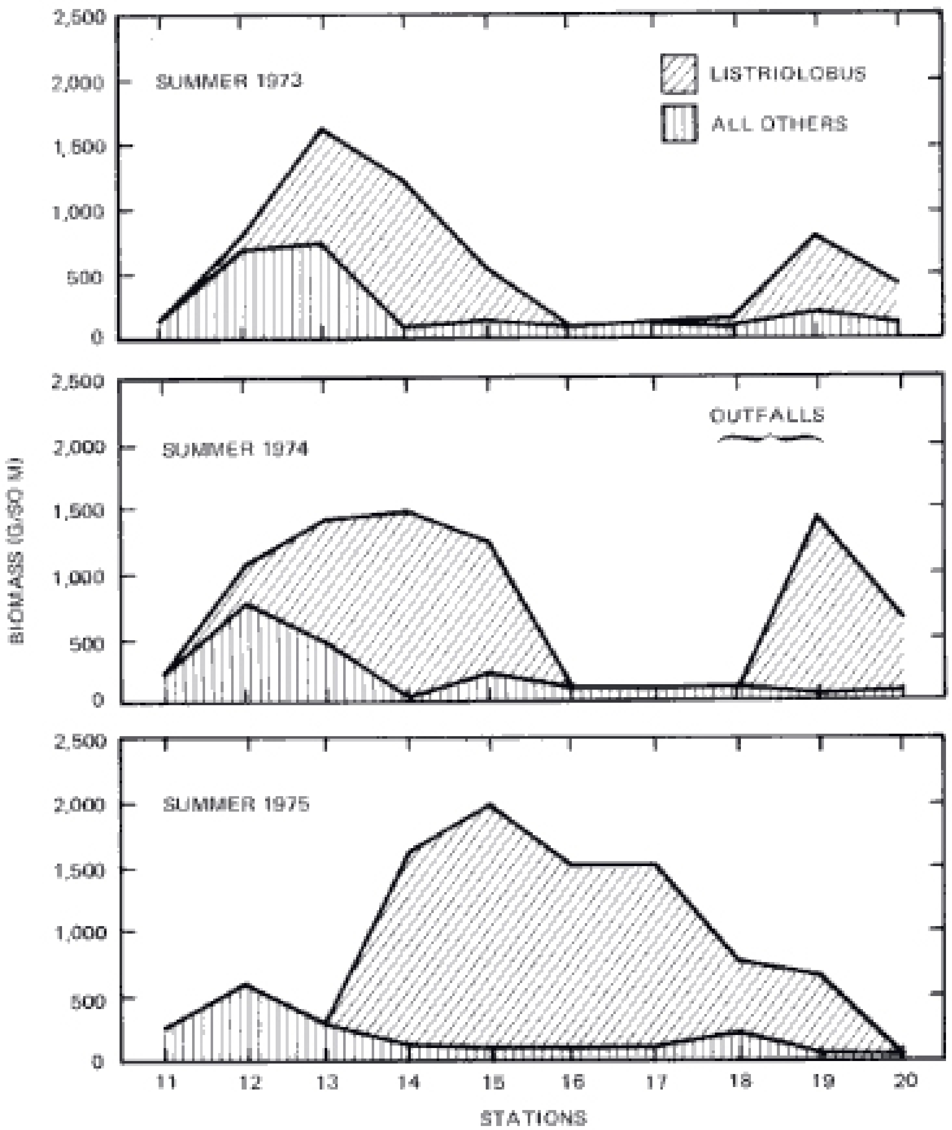

Figure 4. Distribution of biomass along the 60-meter depth contour for the summers of 1973, 1974 and 1975.