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RESPONSE AND RECOVERY OF THE BENTHOS AT ORANGE COUNTY

In 1971, Orange County Sanitation Districts terminated the discharge of municipal wastewaters through a shallow, inshore submarine outfall and began discharging through a modern subthermocline diffuser. These two events provided a unique opportunity to study the progress of the "stress" and "recovery" that would most likely occur around these outfalls and to obtain an insight into the rates at which these processes progressed. The Project thus contributed to the support of the work of Dr. G. Smith (Scripps Institution of Oceanography), who recorded the changes, both biological and chemical, that occurred in the sediments at these outfalls between August 1970 and August 1972. Smith (1974) reported that recovery was rapid at the old outfall, with organic carbon and sulfide concentrations reaching background levels within 3 months and previously dominant invertebrate species becoming rare. Events at the new outfall were not as spectacular: There was little significant change in sediment chemistry or biological composition during the first 17 months following initiation of the discharge.

In 1975, the Project conducted two surveys of the sediments in the area of the outfalls—a preliminary survey in February and an extensive study in late July. Our primary goals were to evaluate the effects, if any, of the new outfall on the animals living in these sediments (benthic infauna) and to look for changes in the conditions at the old outfall. Samples were collected at 35 sampling sites (shown on Figure 1) using a 0.1-sq-m Van Veen benthic grab. Subsamples were taken for chemical analysis, and the animals retained on a 1.0-mm screen were preserved and later identified to species, whenever possible, and counted. Physical and chemical factors measured included grades of sediment coarseness and concentrations of potentially toxic trace metals, DDT, PCB, total volatile solids, and acid-volatile sulfides.

Although Smith sampled at six sites, three to the southeast of each outfall, he concentrated his biological work at the station nearest each outfall. Our sampling at these sites was done to correspond exactly with the procedures used by Smith.

RECOVERY AT THE OLD SHALLOW OUTFALL

Comparisons of our data from around the shallow outfall with those of Smith showed that conditions had changed since 1972. There have been sizable decreases in both the organic carbon and acid-volatile sulfide content of the sediments. Smith reported that, although the number of species remained essentially constant at the shallow outfall, the number of animals present, which was quite high prior to the termination of discharge, had decreased 'dramatically to background levels. Thus it was especially interesting to find that, in 1975, the values for both of these measures of biological activity were significantly lower than the "background" levels previously measured by Smith.

RECENT CONDITIONS NEAR THE NEW OUTFALL

A rather diverse fauna, representing 197 different taxa and comprising 22,870 individual organisms, was collected from the 35 sampling sites. The average biomass and number of species and individual organisms at sites along the 55-meter depth contour (diffuser depth) are shown in Figure 2; these biological parameters reveal a response to the presence of the outfall. The amount of biomass and the number of animals to the west of the diffuser were greatly enhanced. The distribution of species through these stations shows the opposite trend; there was a large decrease in the number of species present in the immediate area of the diffuser and a gradual increase with distance to the west. While currents on this shelf are variable, the patterns of distribution for both the animals and chemicals in these sediments indicate that prevailing currents had been to the west or northwest.

The average number of organisms at each site is contoured on Figure 1, as is a measure of species dominance. (A value for dominance is obtained by dividing the number of species that account for 90 percent of the organisms at a site by the total number of species at that site and subtracting from 1.0.) It is clear from the areal distributions shown on Figure 1 that the outfall has an offshore/onshore effect as well as the effect at diffuser depth. The same general areal patterns also apply for the number of species per site and biomass.

It is apparent from Figure 1 that the dominance of a few species over the remaining fauna is greatest at those sites where overall abundance is also the highest. A situation such as this, where high abundance coincides with high dominance, is often a good indication of a disturbed or stressed environment. The degree to which the environment is disturbed is often indicated by the kinds of species that are present, particularly those that are most dominant.

Two species dominate the infauna at sites to the west of the new diffuser—a small clam, *Parvilucina tenuisculpta*, a small crustacean (Ostracoda) , *Euphilomedes carcharodonta*. The former averaged about 3,300 animals/sq m and the latter about 2,500 animals/sq m at these sites, where the two species accounted for more than 68 percent of all animals collected. Under comparable natural conditions, these two species would account for far fewer animals (100 to 300) and a much smaller percent of the total fauna. Typically we find that *P. tenuiscutpta* reaches its highest densities around outfalls where there is a moderate to high flux of organic material to the sediments. Average densities of 6,000 animals/sq m, and a maximum of 17,000 animals/sq m, have been observed 9 km downcurrent from the outfalls on the Palos Verdes shelf. *E. carcharodonta*, on the other hand, seems to reach its greatest densities where there is a low to moderate flux of organic material. Of these two "indicator-like" organisms, *E. carcharodonta* is apparently much less tolerant of trace metals and chlorinated hydrocarbons (DDT and PCB) as indicated by its absence from areas on the Palos Verdes shelf where these substances are present in moderate concentrations and where *P. tenuiscutpta* reaches maximum densities.

Correlation analyses showed that the physical and chemical factors measured in these sediments fall into two distinct groups:

- Group I: Sediment coarseness and total volatile solid and total DDT concentrations.
- Group II: Trace metal, total PCB, and acid-volatile sulfide concentrations.

It is especially interesting to note that the areal distributions of the acid-volatile sulfide and total volatile solids are not similar to one another as they often are around outfalls where organic material has accumulated and hydrogen sulfide is produced. This dissimilarity in areal pattern suggests that these sulfides exist primarily as metal sulfides.

The areal distributions of the two groups are illustrated in Figure 3 by their most typical member—mean sediment coarseness for Group I and copper for Group II. The pattern of the first group is only slightly related to the outfall, but the second group seems to be almost completely oriented to the outfall. Significant in these results is the association of volatile solids (a measure of organic matter) with the Group I factors. Not only is the distribution of organic material not related to the outfall, but the amounts that we found in the sediments were generally quite low for an outfall area.

We conducted additional analyses to try to identify potential cause and effect relationships between the concentrations of the chemical factors and the biological data. These analyses indicated that the altered faunal composition and enhanced abundance observed to the west of the outfall diffuser were in some way related to the Group II chemical factors, especially to the copper, cadmium, chromium, and PCB concentrations. Although the enhanced concentrations of these factors could possibly affect the composition of the fauna, it is highly unlikely that they would cause enhancement in the abundances of either *P. tenuiscutpta* or *E. carcharodonta*. This rather contradictory situation suggests that we did not or could not directly measure the factor(s) actually having the greatest effect on these animals.

It is reasonable and logical to assume that the enhanced abundances of animals immediately to the west of the outfall diffuser were the result of increased input of food material to these sediments. These materials would most likely be in the form of particulate organic matter originating from the outfall.

Observations and measurements of organic material in these sediments in July 1975 showed that the distribution of the small quantity of organic material present in the sediments was not related to the outfall. Similar measurements made on the preliminary survey in February 1975 (summarized in the Project's 1975 Annual Report) also revealed little organic material at the surface of the sediments; however, large quantities of a fibrous organic material from areas around each outfall were retained on the screens used for washing the animals from the sediment. This same material was present in Smith's samples from the new outfall in 1972, and it was also found as recently as early July 1975 in samples collected by the County Sanitation Districts of Orange County. The material, which resembles the organic material found around the terminus of the sludge line in Santa Monica Bay and the outfalls on the Palos Verdes shelf, was not present in our samples from late July 1975. These observations suggest that, between early and late July, the bottom sediments were subjected to strong mixing and scouring hydrological forces.

Samples from sediment traps that we had placed in the water just above the bottom around the new outfall in July 1975 contained large amounts of fine sand and organic material. This information supports the contention that the sediments had been recently mixed and finer materials resuspended and strongly suggests that the benthic infauna around this outfall were in fact responding to large fluxes of organic material to the sediments. The enhanced concentrations of the Group II chemicals also support this last contention. Most of these materials are transported to the sediments in association with particulate matter (Young et al. 1973). The animals ingest the organic material, and the chemicals that they do not retain are concentrated in their fecal pellets, which may then become incorporated into the sediments.

CONCLUSIONS

The almost complete absence of organic material in the sediments in late July 1975 compared to early in the same month suggests that the entire area had been recently scoured by strong wave-related forces. If this were the case, conditions in the area may have been better than usual at this time. Swells large enough to have a scouring effect at depths as great as 55-meters may not occur frequently (see article on Page 63) and it seems unlikely that eroding or resuspending forces as strong as those indicated by recent data are present annually. Scouring and mixing of bottom sediments would be expected to occur more frequently in shallower water and may be one reason why Smith observed a rapid recovery at the shallow-water outfall and why conditions at this outfall showed additional change in 1975.

It is apparent that, after 4.5 years of operation. Orange County's modern subthermocline diffuser system has had a measurable effect on the animals living in the sediments around it. This effect is manifested in the enhanced abundances of several "indicator-like" species in response to increased inputs of organic material. Because of the apparently scoured condition of these sediments when we took our samples, the enhanced levels of potentially toxic trace metals and PCB at the new outfall may normally be somewhat higher than we measured and, therefore, should be watched.

REFERENCES

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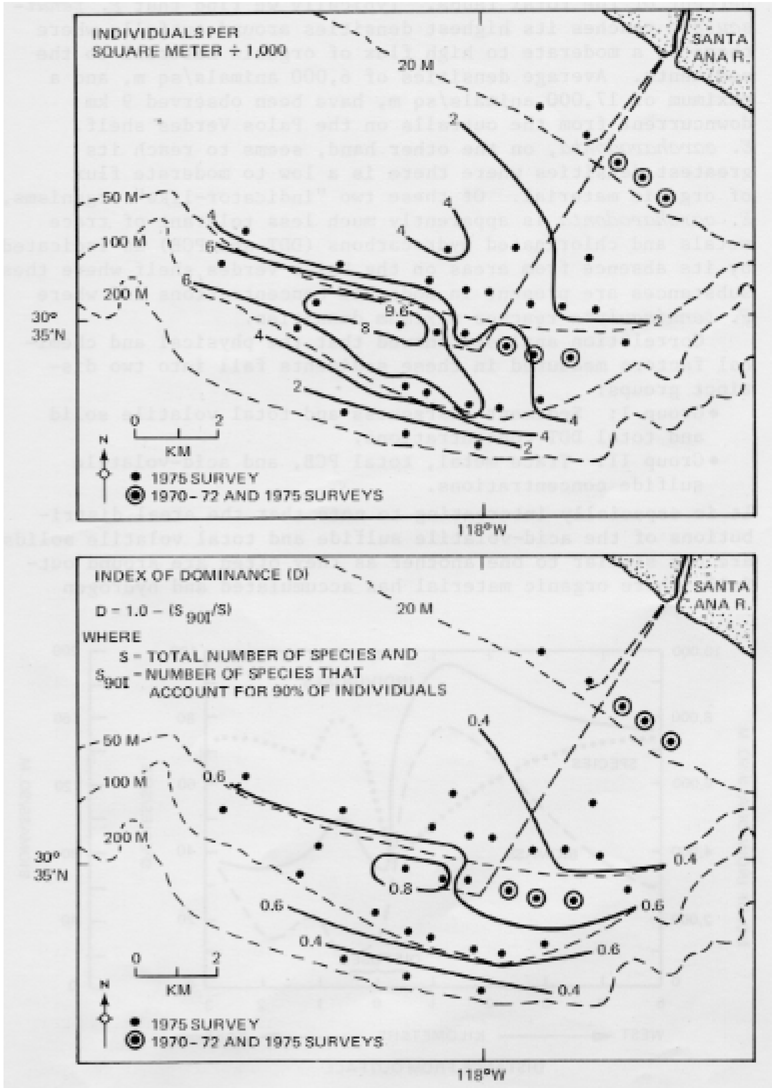

Figure 1. Abundance of invertebrates and dominance of species, Orange County outfall, July 1975.

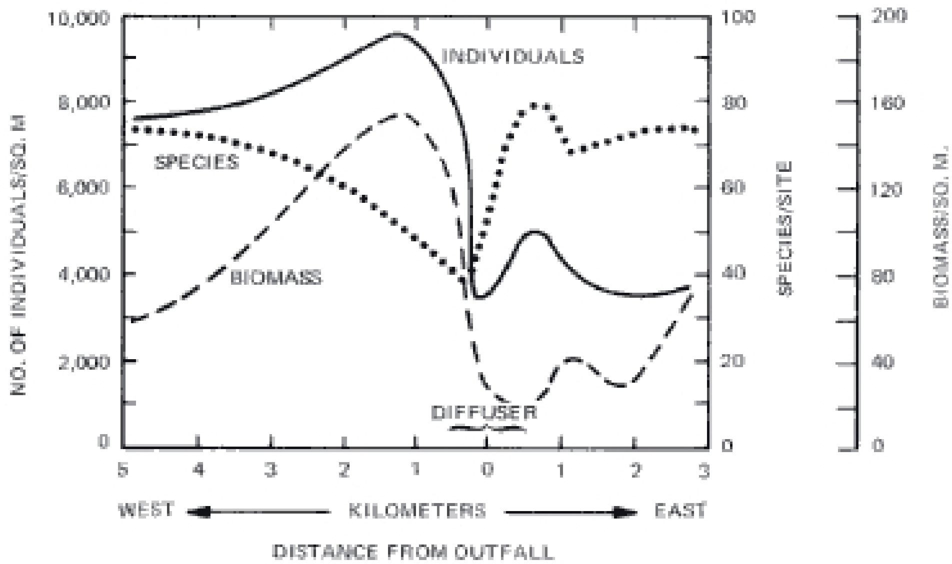

Figure 2. The distributions of individual organisms and biomass per square meter and species per site along the 55 – m (diffuser) depth contour.

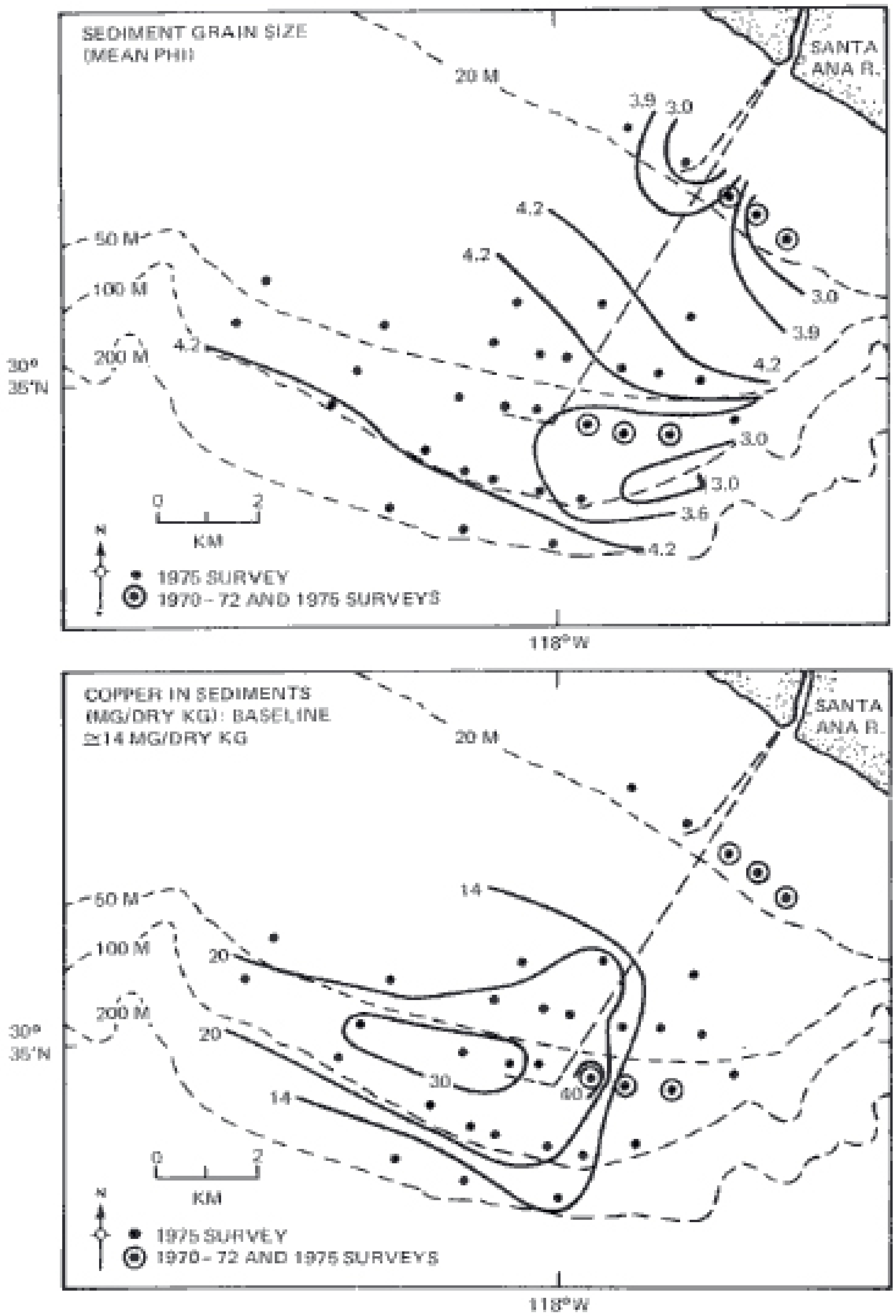

Figure 3. Sediment grain size and copper concentration, Orange County outfall, July 1975.