Jack Q. Word

THE INFAUNAL TROPHIC INDEX

A long-standing problem of marine biology is how to characterize communities of benthic infauna in a way that will reflect changes in their environment. After studying and working with a number of methods, we have come to believe that the majority of alterations in infaunal communities can be understood by examining the feeding strategies of community members. Two basic strategies (feeding on suspended material and feeding on deposited material) are of interest because changes in the dominance of organisms employing these strategies gives indication of changes in the amount of paniculate organic material present in the benthic environment. This paper contains a summary description of a method of numerically characterizing such changes.

Our project used the method—the Infaunal Trophic Index—throughout the past year to assess over 2,000 benthic samples, and we have compared the results from 200 of those samples with other measures of biological communities. We now feel confident that the Index provides a good characterization of benthic communities. The Index responds delicately to shifts in the species composition, and the numbers are convenient for charting areas of similar characteristics. It has been possible to compare recent samples with those taken in the past, even though the earlier data were collected by other scientists using different sampling equipment and techniques. We believe that this approach, with minor modifications in the species used, will be useful to ecologists surveying the benthos on large areas of the continental shelves.

BACKGROUND

A number of chemical and biological indicators have been used to identify changed and degraded environmental conditions, but the community of animals living in the muddy sea bottom probably gives the best indication of conditions. The infauna stay in the same location, have short life cycles, and respond rapidly to changes that may otherwise be undetectable. There have been numerous attempts to study these organisms in the past; some of the problems encountered were as follows:

- Several kinds of grab samplers have been used for bottom sampling. Some mix the sediment so that the upper surface cannot be recognized or subsampled; some seem to blow away the microcrustaceans on the bottom surface; others do not take an adequately large or deep sample.
- Various sizes of screens, ranging from 0.5 to 2.5 mm, have been used to separate the animals from the sediment, and varying percentages of the animals present in the sediment have been lost as a result.
- Samples have often been taken in replicate, the number ranging from 2 to 10 or more. A number of problems are inherent in taking replicates, one of these being that the ship from which the sampler is lowered may drift considerably between

samples. This means a far larger area is included in the grab pattern than was intended. If replicate grabs are really taken within a few meters of each other, there should be less variation.

- Over 4,500 species of animals live in or on the bottom in southern California coastal waters. A large number of these can be identified only by an expert taxonomist equipped with an extensive library. Even among taxonomists, there has been confusion because some animals have more than one name and many species are very similar to others in appearance. The Project's taxonomic intercalibration seminars and publications have done much to reduce the uncertainties and mistakes in local identifications. Even so, the proper identification of tiny, rare animals requires highly trained personnel and considerable time.
- The analysis of benthic data requires biological computer specialists, who produce cluster analyses, dendrograms, and ordination diagrams that compare samples with each other and with possible causes of change.
- These analyses help isolate factors that might be affecting the benthos, but they are not easily done in all laboratories. In developing the methods described here, one of our primary goals was to reduce the complexities and variations in data introduced by the factors described above.

APPROACH

Our approach to developing a "trophic" index for the infauna was stimulated by an "environmental quality index" for fresh-20 water oligochaete communities developed recently by Howmiller and Scott (1977). Using collective knowledge gained in many studies, these investigators grouped 26 organisms into three species-groups based on their sensitivity or tolerance to organic enrichment of bottom sediments. The total numbers of organisms in each group were then entered into a formula that produced a single number describing the overall trophic condition of the benthic community.

The Infaunal Trophic Index was developed using a similar strategy. It includes a more diverse suite of organisms (brittle stars, polychaetes, crustaceans, molluscs, and phoronids), which have been organized into four groups primarily on the basis of feeding strategy (some organisms were included in the groups on the basis of their known response to sources of organic material). The Index formula generates numerical values that indicate the trophic composition of soft-bottom benthic infaunal communities. Index values range from 0 to 100, with low numbers reflecting the presence of a community dominated by subsurface deposit-feeding organisms and high values indicating that the community is dominated by organisms that feed on material suspended in the water column. The development of the Index is described below. Criteria for Selection of Indicator Species In selecting species to be considered in the Index calculations, we examined data from many sources. However the selection was primarily based on data on benthic infauna collected in the Project's 60-meter survey (see Word and Mearns, this report). The following criteria were applied to that data:

- Species that occurred at only one or two stations or accounted for less than 5 percent of the infauna at those stations were eliminated. Approximately 50 percent (338 of 770) of the species collected were deleted from consideration on this basis.

- For the purpose of developing the Index, the species that dominate samples were of greatest interest. Therefore, the dominant species in each sample were noted, and many of these were selected as Index organisms. Together, the animals selected accounted for an average of 58 percent (range: 40 to 89 percent) of the total number of individuals collected in each sample. The 47 species selected represent about 10 percent of the species not eliminated by application of the first criterion and about 5 percent of all species considered.
- Species distributions are generally strongly correlated with water depth: As depth increases or decreases, a particular species that has been dominant is frequently replaced by another, often of the same genus. To enlarge the scope of the Index applicability with respect to water depth, we considered each species individually to determine if we could use animals of that genus, or of some higher taxonomic category, as the indicator. If higher taxa employed the same feeding strategy as the species, the indicator list was altered to specify the highest taxon with that strategy; the final list contains 26 taxa above the level of species. In addition to expanding the depth range of the Index, these substitutions simplify the taxonomic identifications required in using the Index.

Once the indicator organisms were selected, they were placed in groups depending on their method of feeding and response to sources of organic material.

<u>Group I</u> is primarily dominated by suspension-feeding animals; Group II species are animals that can feed on suspended material or detritus on the sediment surface; Group III is dominated by surface detritus feeders; and Group IV animals feed on detritus beneath the sediment surface.

The animals in each group are listed in Table 1 and described in more detail in the following paragraphs. Group I. This group contains 19 species, representing 7 taxa, and is dominated by the suspension-feeding ophiuroid (brittle star), *Amphiodia urtica*. The species in the group feed by capturing suspended particles that drift into their mucous traps or filtration systems. These species dominate the control areas identified in the 60-meter survey, where sediment levels of BOD are relatively low. *A. uptica* is likely to be absent or greatly reduced in abundance near wastewater outfalls.

<u>Group II.</u> Group II species are also normally present in control communities. In some cases, the abundances of these species can increase by an order of magnitude, while the community as a whole is still dominated by Group I organisms. Representative members of this group are ostracods of the genus *Euphitomedes* and the polychaetes, *Tharyx* spp. and *Mediomastus* spp. These organisms feed both on suspended particles and surface detritus but are included together in Group II because of their similar responses to slight enhancements in the particulate load of near-bottom water. For example, male Euphil-*omedes* spp. are typically found in the water column feeding on suspended materials, and females are found on the sediments feeding on surface detritus. Polychaetes of the genus *Tharyx* use feeding palps to select certain sized particles from the sediment surface or water column. *Mediomastus* species probably feed by selecting settled particulates with their fleshy, papillated proboscises and thus are surface-deposit feeders.

All of the Group II species increase in abundance as sediment BOD levels increase. Where BOD is 30 percent above the natural level, their abundances may be an order of magnitude higher than in control areas.

Group III. Group III contains four species—three molluscs and one polychaete. All are surface-deposit feeders, and all are relatively uncommon along the control areas of the coastal shelf but become 100 times as abundant in areas where sediment BOD is 3 times background. The group is dominated by the clam, *Parvilucina tenutsculpta*; individuals of this species increase greatly in size as sediment BOD levels increase (Word et al. 1977).

Both Group III and Group II species increase in abundance with increasing proximity to wastewater outfalls; how-ever, at a certain point. Group II species begin to decrease in abundance, while Group III species continue to increase.

Group IV. This last group contains species that have most often been called "indicators" of marine pollution. The majority are small marine worms (polychaetes and oligo-chaetes), which are subsurface-deposit feeders. They are generally not found in high abundance in areas where they must compete with other organisms. Their abundances are extremely low in control areas (only one individual from this group was found at the Project's 29 control sites), and they become extremely high in abundance as species in Groups II and III become rare. The species contained in Group IV are normally found together and dominate the most impacted areas around outfalls. Presumably, they are responding to enhanced levels of organic material in the sediment or to high concentrations of hydrogen sulfide, which have made the environment less desirable to other species.

CALCULATING AND USING THE INDEX

The Infaunal Trophic Index (ITI), a numerical description of the behavior of the groups in the environment, is calculated by the formula:

$$\text{ITI} = 100 - \left[33\text{-}1/3 \left(\frac{0n_1 + 1n_2 + 2n_3 + 3n_4}{n_1 + n_2 + n_3 + n_4} \right) \right]$$

where n_i is the number of individuals in Group i. The co-efficients in the numerator of the equation (0, 1, 2, 3) are simply scaling factors. Other numbers could be used; as long as the coefficients evenly increase (or decrease), they serve to generate a range of Index values that changes gradually and evenly as infauna feeding strategies change.

The values of the Infaunal Index range from 0 to 100. As shown in Figure 1, the dominance of each of the feeding groups is indicated by a range of Index values. Group I is dominant when values range from 78 to 100; Group II dominates when values range from 58 to 77; Group III, from 25 to 57; and Group IV, from 0 to 24. As shown in Figure 2, Index values less than 60 are inversely correlated with sediment BOD levels ($r > 0.9$).

Table 2 gives the average abundances of the organisms in each group in areas identified as control regions in the 60-meter survey. Species from each of the groups were found in the control areas, although Group IV species were rare. The range of abundance values for each group covers an order of magnitude.

We have compared Infaunal Index values with various other indices and sets of measurements to determine the relative effectiveness of each method in describing ecological conditions. In Figure 3, Index values for stations all along the southern California coast are compared with measurements of infaunal diversity, biomass, and number of individuals and with sediment levels of BOD at these same stations. Each set of measurements gives indications of the variations in conditions along the coast, but the Index is the most sensitive measure of changes in the structure of infaunal communities that reflect enhanced levels of organic material.

Changes are largest and most recognizable in wastewater outfall areas. In general, diversity decreases in these areas, biomass and abundance increase, and number of infaunal species is relatively low. However, there are exceptions to this general pattern. For example, in the 60-meter survey, the maximum number of species and the highest Shannon Weaver diversity values were found at stations near the center of San Pedro Bay, where the effects of Los Angeles/Long Beach harbors and two distant outfalls combine to create an altered situation. Highest abundance and biomass values and lowest Shannon Weaver diversity occurred approximately 5 km downcurrent from the largest outfall on the shelf, rather than in the immediate vicinity of the discharge. Low dominance values (dominance being the minimum number of species required to account for 60 percent of the individuals present) have been found in a remote area be-tween Dana Point and Oceanside as well as near the Palos Verdes outfall.

METHODOLOGY

Useful Index numbers result when care is taken in collecting samples, sorting and identifying animals, and recording data. The samples must also meet the following criteria:

- The station must have a fine sediment bottom (silty sand to clay); we have not yet developed control data for cobbled gravel or rocky areas (or small muddy areas amid a large area of rocks).
- The surface area considered must be at least 0.1 sq meter.
- The grab sampler must penetrate the bottom to a depth of at least 10 cm in fine sediment and 5 cm in coarse sand.
- The sample must reach the deck undisturbed and intact (samplers that leak or cause pressure waves are not acceptable).
- The sample must be screened through 1.0- or 0.7-mm mesh.

We use and recommend the modified Van Veen sampler. If the results from a survey are to be compared with our control data, the samples must be collected within the 20- to 200-meter depth range.

Two samples of undisturbed mud bottom, one for biological analyses and one for chemical, are obtained at each station. The biological sample is sieved through 1.0-mm screens, and the animals and debris retained are fixed in a 5 percent formalin/seawater solution buffered with borax. The second sample is carefully sectioned, and an aliquot of the upper 2 cm of sediment is removed, placed in appropriate containers and rapidly frozen on dry ice for later chemical analyses. The subsamples for analyses for organic material (e.g., BOD and volatile solids) and metals are retained in clean plastic containers; subsamples to be analyzed for chlorinated hydrocarbons are stored in foil-capped glass containers.

The screened organisms and debris are returned to the laboratory where the formalin is rinsed from the samples and they are rescreened. This material is then preserved in a 70 percent ethanol/distilled water solution.

The organisms are sorted from this mixture into seven classes of easily separated taxonomic units--polychaetes, molluscs, ophiuroids (discs and legs in separate vials), other echinoderms, arthropods, and all other phyla. Additional separations are made when warranted (if large in-vertebrates or fish, or abundant miscellaneous phyla are en-countered) . The ophiuroid discs are air-dried for easy identification and then rehydrated in alcohol for at least 24 hours before weighing; all of the other fractions are retained in alcohol.

The Infaunal Trophic Index species are then identified and counted. Finally, a total biomass determination is made. The organisms from each fraction are placed in a small plastic cylinder with a sieve of 0.5-mm mesh on one end. This container is placed on an absorbent paper towel for exactly 5 minutes and then weighed to the nearest 0.1 mg. The weight of the container is then subtracted from the total, and the result is recorded. The total weight of all fractions at a given station can then be determined.

EXAMPLES OF INFAUNAL TROPHIC INDEX USE

Changes in Benthic Communities over a 20-Year Period

In 1957-58, the Allan Hancock Foundation of the University of Southern California conducted a survey of the southern California mainland shelf. The survey covered stations close to those sampled in the Project's 60-meter survey, and the results were presented in detail (California Water Quality Control Board 1965). Thus, we were able to calculate Infaunal Index values for the earlier survey and compare them with our 1977 data. The results are presented in Figure 4.

The two sets of measurements, separated in time by 20 years, yielded similar Index values for the area between Point Conception and the center of Santa Monica Bay and the region between Newport Beach and Point Loma. These two areas generally coincide with those defined as having natural or control conditions in the 1977 survey. However, there were substantial differences in the Index values for other areas of the coast.

- Index values for several stations off Point Loma in 1967-58 were over 95; the values for these same stations in 1977 ranged from 65 to 89. Presumably, the decrease is related to the initiation of wastewater discharge off Point Loma in 1963. Index numbers for another area off San Diego (about 11 km south of Point Loma) were relatively low in 1957-58 (about 76) and even lower (about 65) in 1977. These values probably reflect the effects of harbor and ship discharges.

- •The Index values for an area in the center of Santa Monica Bay were about 90 in 1957-58 and about 48 in 1977. Municipal wastewater discharge into the Bay at 60-meter depths was initiated in 1959 and is probably responsible for this decrease in Index values.
- •Index numbers for the entire San Pedro Bay area in 1957-58 and 1977 were somewhat lower than control values, probably reflecting the effects of the urban activity on the coast of the Bay. A further decrease in Index values off Orange County in 1977 is centered about the site of a deepwater discharge there and is definitely related to it.
- •Index values were low in 1957-58 and 1977 off Palos Verdes, where wastes have been discharged into the sea since 1937. Comparison of the two sets of values indicates that the size of the area affected by this discharge has increased since 1957, and the effects of the outfall system appears to have spread into Santa Monica Bay.

Variations in Conditions Near a Wastewater Outfall

Infaunal Index values were calculated from data from 4 years of monitoring around the Orange County outfall; these are shown in Figure 5. The station closest to the end of the outfall diffuser consistently had the lowest Index values; the mean value for this station is 40. Index values in-crease rapidly with distance from this site--the mean value for stations within 1.5 to 2 km upcoast and downcoast is about 60.

Between July and September 1975, the mean Infaunal Index value for the station nearest the outfall dropped from about 40 to less than 10. In another study conducted in this area in July, this station was found to be in a region containing "sludge-type particles" (Greene and Mearns 1975; Greene 1976). The drop in the Infaunal Index value at the station could reflect the presence of these particles. When a more extensive sampling program was conducted less than 1 month later, the particles were not found; within 3 months, the Infaunal Index value for the station had returned to 40. If the presence of sludge-like particles is reflected in In-faunal Index values, the data for the 4-year period would indicate that the accumulation of such particles is not a regular occurrence.

Identification of Zone of Biological Enhancement of the Natural Community

Biomass and Infaunal Index values considered together some-times provide evidence of enhancement of natural benthic populations near a discharge site. This phenomenon can be seen in the data for the Point Loma area (Figure 6). The area affected by the outfall there (as indicated by Infaunal Index values) is about 20 sq km. Outside of this zone is a 45-sq-km area where Index values were indicative of back-ground or control conditions (values were 83 or higher), but biomass values exceeded the maximum control value of 112 grams/sq meter. More detailed examination of the data revealed that the high biomass values were not the result of increases in the numbers of individuals present but instead reflected increases in the size of individuals of the dominant species, *Amphiodia urtica*.

DISCUSSION

The Infaunal Trophic Index makes use of the concept of indicator species. The question that naturally arises is. Could the purposes of the Index be as well served by considering the distributions of only a few indicator species? The distributions of two such species around the Orange County outfall are shown in Figure 7, as are Infaunal Index values for the area. The worm, *Capitella capitata*, is known to be an indicator of changed or polluted benthic conditions in that it increases in abundance in areas where these conditions prevail; abundance for this species in control areas ranges from 0 to 1 individual/0.1 sq meter. The clam *Amphiodia urtica*, has a different pattern of response to changes in sediment conditions: This animal prefers clean sediments, and its abundance decreases with increasing proximity to a wastewater outfall.

The distribution of each of these species off Orange County gives useful information on conditions there, as shown in Figure 7. However, the Infaunal Index values for the same area provide a geographically continuous record of conditions, indicating that there are gradual changes in the sediments throughout a 54-sq-km area. *C. capitata* abundance data does not provide as sensitive a measure of change; the distribution of this animal shows outfall-related effects in an area of only 3.4 sq km. In contrast, the distribution of *A. urtica* gives information on a larger portion of the affected area, but it does not provide any indication of conditions in the immediate vicinity of the outfall.

Other numerical techniques, such as diversity indices, have been used to evaluate bottom conditions. A diversity index gives information about the relationship between the number of species in an area and the total abundance of organisms present. However, this relationship in itself does not necessarily indicate that a given set of environment conditions prevails. The Infaunal Index, being an indication of the feeding strategies of organisms, provides ranges of values that correspond to the amount of particulate material present in the sediments and in the water column.

A feature of the Index—the fact that only about 1 per-cent of the species that might be present in a sample are considered—raises another question: If all species are not considered, is not some information lost? It is evident that, even if all species are used in the determination of a single numerical index (e.g., as in diversity measurements), certain types of biological information associated with each species is also lost. One of the goals during the development of this index was to maximize the amount of biological information contained in a single numerical determination.

The Infaunal Index is a compromise. Ideally, the entire list of species present should be used in assigning an Index value to a station. We have found, however, that the addition of more species to the Infaunal Index list has only minimal effect on the resulting values, because the majority of individuals collected are already used in the calculation.

The Index does not include species that may occasional-ly colonize an area of study. There are at least two types of colonization that may occur. In the first, species that are similar in size to the Index species and respond to the same types of bottom conditions enter an area and feed in a similar manner to the Index species. These new organisms, when found in abundances great enough to alter Index values, could simply be added to the appropriate feeding category.

An example of a second type of colonization is the 1973 appearance of *Listriotobus pelodes* on the Palos Verdes shelf. Recent analyses of data from the area indicate that this animal not only responded to some condition in the sediments on the shelf by settling out in large numbers, but also temporarily altered the bottom conditions, creating conditions favorable for Group II species. *L. pelodes* could be considered either a Group III or Group IV organism, as it feeds both on the surface and in the sediments. The alterations it created appear to be a result of the dense populations of this large invertebrate churning the sediments and aerating them. Biomass values for this single species were as high as 2 kg/sq meter in areas where the normal biomass for all species is about 70 grams/sq meter.

Although *L. pelodes* altered the feeding structure of the communities, it did so without dramatically changing the amount of particulate organic material that was present and is required by other surface- and subsurface-deposit feeders that dominate the normal communities. This was demonstrated by the rather rapid return to earlier conditions when *L. pelodes* left the area.

The creation of conditions favoring Group II species would probably result from the recruitment of any large in-vertebrate species into an area, regardless of its feeding type. Therefore, the inclusion of large, abundant, and un- common species into the infaunal feeding groups without also considering their effect on the other species can give erroneous results and effectively hide the normal species relationships to the existing environmental conditions.

Effects of Replication, Screen Size, and Depth

The time and money expended in surveys of the benthic in-fauna rises considerably with increases in the number of samples taken at each station and the amount of surface area covered with each sample. Therefore, it is important to determine the number of replicates that must be taken and the amount of surface area that must be covered to adequately explain the differences between any two samples.

Determinations of Infaunal Trophic Index variations were made on replicate 0.1-sq-meter grab samples collected at 26 stations, representing a wide variety of bottom conditions. From two to five samples were taken at each station. The deviation from the mean index value at each station averaged ±5.7 percent (with a standard error of 0.96 percent). The low variability of the Index is probably related to two factors. First, the Index utilizes the relative percentages of types of organisms present rather than strict abundance values for various species. Although the abundances of a particular species in any two replicate samples may differ by as much as an order of magnitude, the relative abundance of that species to the others in each sample is much less variable. The second way that the Index calculations produce low variability is through combining species into groups. Although one species in a group may be patchily distributed and its abundance may fluctuate widely, the distribution and abundance of another species in that group often compensates for these fluctuations. Because of these limits on variability, there are usually small variations (standard errors) in the overall calculations of the Index values for each station.

The size of the juveniles settling into the infaunal community varies with species, and these differences can affect Infaunal Index values. For example, in one study, molluscs and ophiuroid juveniles present were larger than 0.7 mm and were retained on a screen of this size mesh; but numerous polychaete and microcrustacean juveniles in the same samples passed through this screen and were retained on a 0.5-mm sieve (Word et al. 1976). Only the organisms collected on the 0.7 mm screen were used to calculate the Index values: Since most of the molluscs and ophiuroids on the indicator list are in Groups I or III, and most polychaetes and microcrustaceans dominate Groups II and IV, this separation altered the Index values.

Generally, however, the use of sieve diameters of 1.0 and 0.7 mm made no difference in the calculation of the Index (Table 3). At three stations, the differences between 1.0, 0.7, and 0.5 mm made no difference; at the fourth station, the screen size accounted for a difference of 10 Index units. We intend to further investigate the effects of variations in screen size on Index values.

The Infaunal Trophic Index species inhabit the fine sediment areas of southern California's shelf at depth ranges of 20 to 200 m. These species are not generally found on rocky bottoms, in canyon areas, or in the basins. Therefore, it is inadvisable to apply this Index in its present form to these areas, or outside of the depth ranges indicated. The concept of the Infaunal Trophic Index should apply in these areas but other taxa will have to be identified for inclusion within the groupings and other control values are needed before the use of the Index can be expanded.

SUMMARY AND CONCLUSIONS

The Infaunal Trophic Index measures the feeding response of benthic infaunal organisms. It is applicable for fine sediment marine communities at depths ranging from 20 to 200 meters on the southern California mainland shelf. An Index number is precise, repeatable, and relatively easy and inexpensive to obtain.

The natural southern California infaunal communities are dominated by suspension-feeding organisms; Infaunal Index values greater than 78 reflect their presence. Other suspension-dominated communities occur, as indicated by Index values ranging from 58 to 77. Index values between 25 and 57 indicate the presence of infaunal communities dominated by surface-deposit feeders; and values less than 24 reflect domination by subsurface-deposit feeding types. Infaunal Index values lower than 60 are inversely correlated to sediment biochemical oxygen demand.

In developing the Infaunal Trophic Index, we have tried to minimize nonenvironmental sources of error (grab device and screen size used, number of replicates taken, species identification, etc.). We believe that the principle of using a feeding index to characterize communities and their environment is valid world wide and can be applied in any area, given a data base adequate to allow identification of groups of organisms with similar feeding strategies.

The Infaunal Trophic Index is not in itself a pollution index. It does not measure the degree of pollution nor is it a measure of "good" or "bad" conditions. It does not intentionally measure the effects of toxic pollutants on the infauna. It is simply a scale of values. However, when sufficient other data are available, as described in later papers, Infaunal Trophic Index values can be used to delineate areas of pollution.

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Table 1. Species in Infaunal Trophic Index groups.

GROUP I
Dominated by suspension feeders

Ophiuroidea
- *Amphiodia (Amphispina) urtica*
- *Amphiodia (Amphispina) digitata*
- *Amphiodia psara*
- *Amphiodia occidentalis*
- *Amphiodia* spp.

Amphipoda
- *Ampelisca pacifica*
- *Ampelisca hancochi*
- *Ampelisca brevisimulata*
- *Ampelisca macrocephala*
- *Ampelisca cristata*
- *Paraphoxus bicuspidatus*
- *Metaphoxus frequens*
- *Heterophoxus oculatus*
- *Ampelisca* sp.
- *Paraphoxus* sp.
- *Metaphoxus* sp.
- *Heterophoxus* sp.

Polychaeta
- *Sthenelanella uniformis*

Phoronida
- *Phoronis* sp.

19 species, 7 taxa

GROUP II
Dominated by a combination of suspension and surface-detritus feeders

Amphipod
- *Photis brevipes*
- *Photis californica*
- *Photis* spp.

Ostracoda
- *Euphilomedes producta*
- *Euphilomedes carcharodonta*
- *Euphilomedes longiseta*

Polychaeta
- *Tharyx* spp.
- *Mediomastus* spp.
- *Myriochele gracilis*
- *Myriochele* sp.

Pelecypoda
- *Axinopsida serricata*
- *Mysella pedroana*
- *Mysella tumida*
- *Mysella* spp.

14 or more species, 7 taxa

GROUP III
Dominated by surface deposit feeders

Mollusca
- Pelecypod
  - *Parvilucina tenuisculpta*
  - *Macoma carlottensis*
- Gastropoda
  - *Bittium* spp.

Polychaeta
- *Spiochaetopterus costarum*

4 species, 4 taxa

GROUP IV
Dominated by subsurface detritus feeders

Polychaeta
- *Armandia bioculata*
- *Shistomeringos longicornis*
- *Shistomeringos* sp.
- *Ophryotrocha* sp.
- Dorvelleidae, UI
- *Capitella capitata*

Oligochaeta
- Tubificidae, UI

Pelecypoda
- *Solemya panamensis*
- *Solemya* sp.

Amphipoda
- Stenothoidae, UI

10 species, 8 taxa

Table 2. Average abundances (number of individuals/sq meter) of Infaunal Trophic Index groups at control stations. Note the presence of individuals from each species-group, although Group IV species are rare.

Group	Mean Abundance	Standard Error	Range
I	2,160	175	780-4,100
II	317	49	90-1,020
III	73	10	10-160
IV	0.09	0.06	0-10

Table 3. Variations in Infaunal Trophic Index values with changes in the size of the screens through which samples are sieved. Note that (1) use of 2.0 and 0.7-mm screens resulted in no significant differences in values and (2) use of 1.0- and 0.5-mm screens resulted in no significant differences in values for three of the four stations.

Grab Station*	1.0 mm screen	0.7 mm screen	0.5 mm screen
1	72.4	71.8	72.3
2	65.9	66.7	67.5
3	0.82	0.57	0.44
4	46.5	46.5	36.4

*All stations were in Santa Monica Bay.

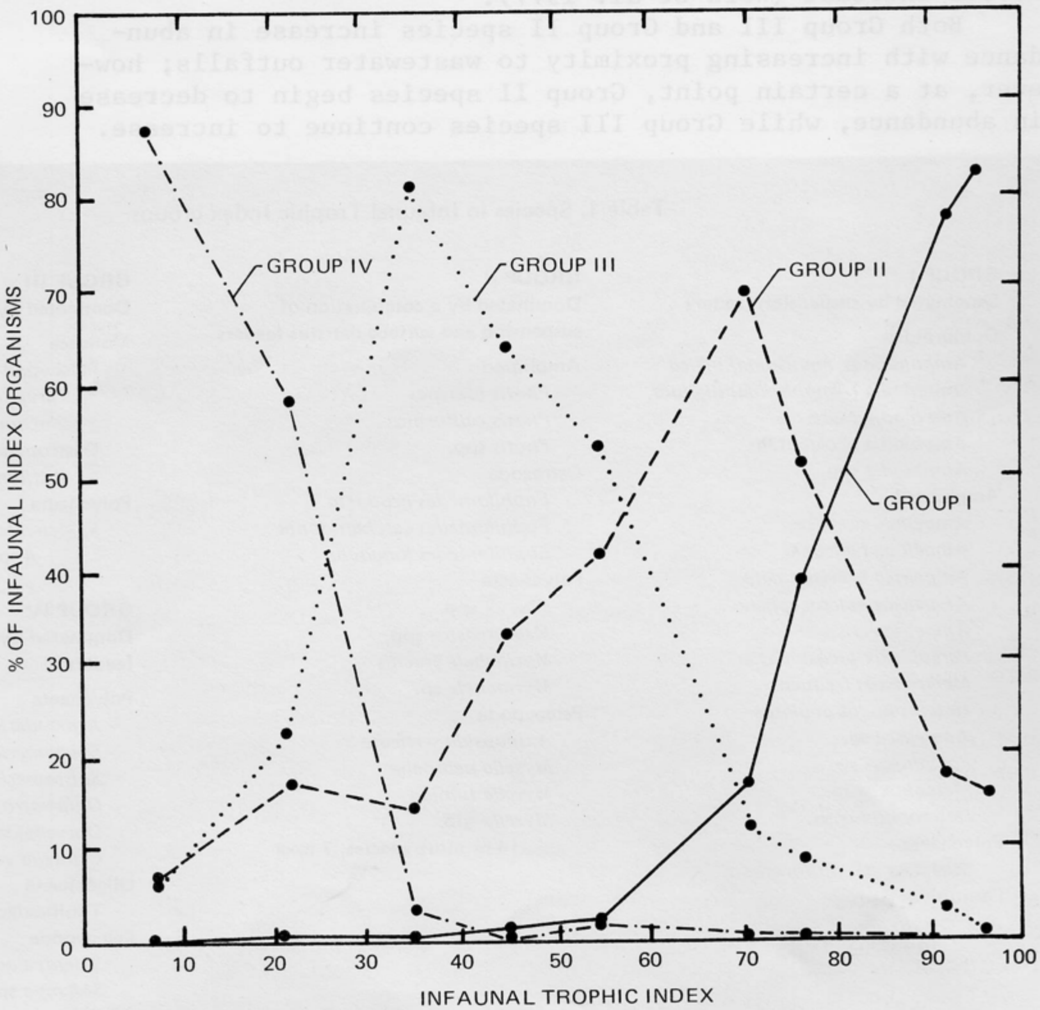

Figure 1. Dominance of Infaunal Index Groups in 300 samples from southern California stations 20 to 200 meters in depth. Although individuals from all groups are present over the range of Infaunal Index values, each group dominates a specific interval of values.

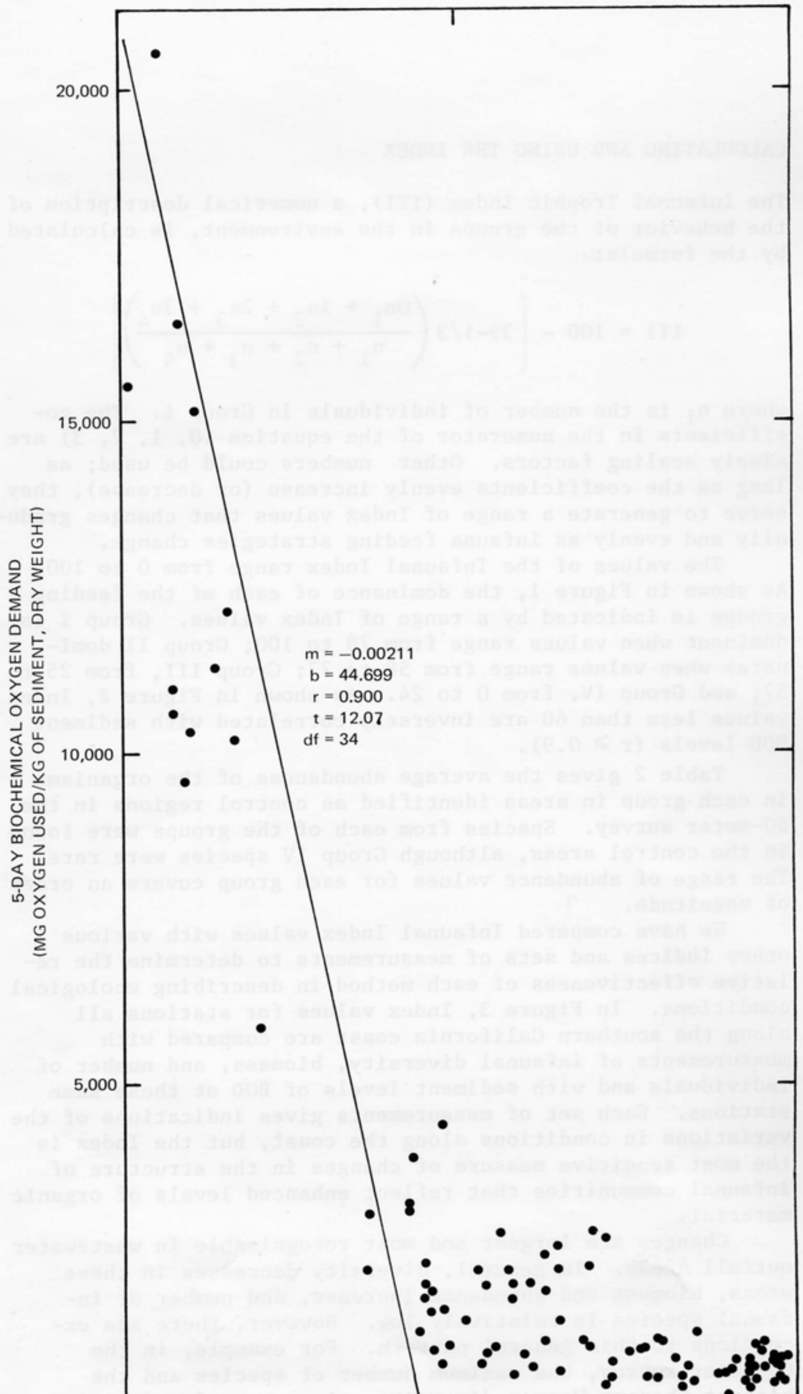

Figure 2. Relationship between Infaunal Trophic Index values and sediment concentrations of BOD. The significant correlation between Infaunal Index values lower than 50 and increases in BOD suggests that changes in BOD may be an important factor in the change of Index values.

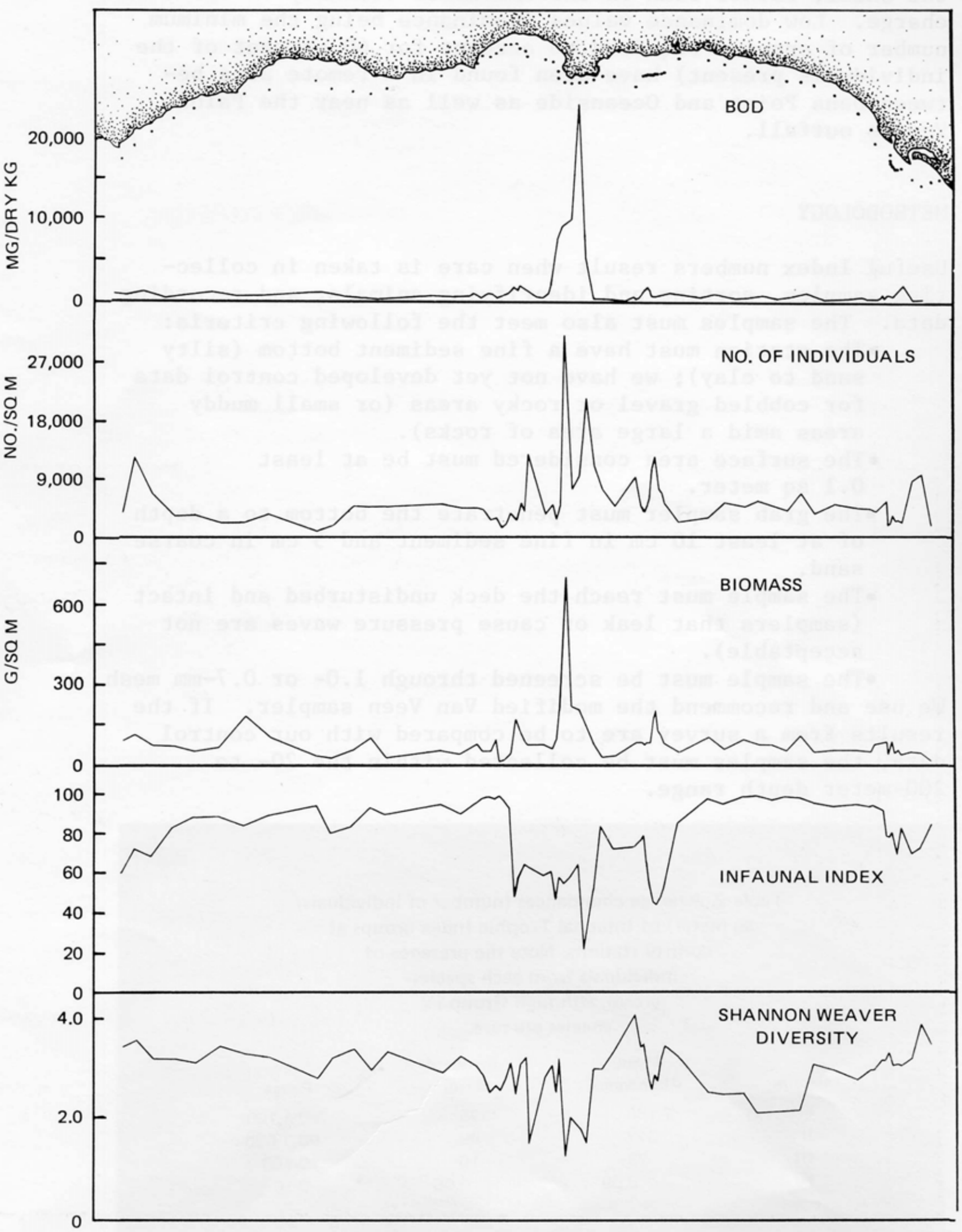

Figure 3. Comparison of five measures of sediment conditions at 60-meter stations along the southern California coast, 1977.

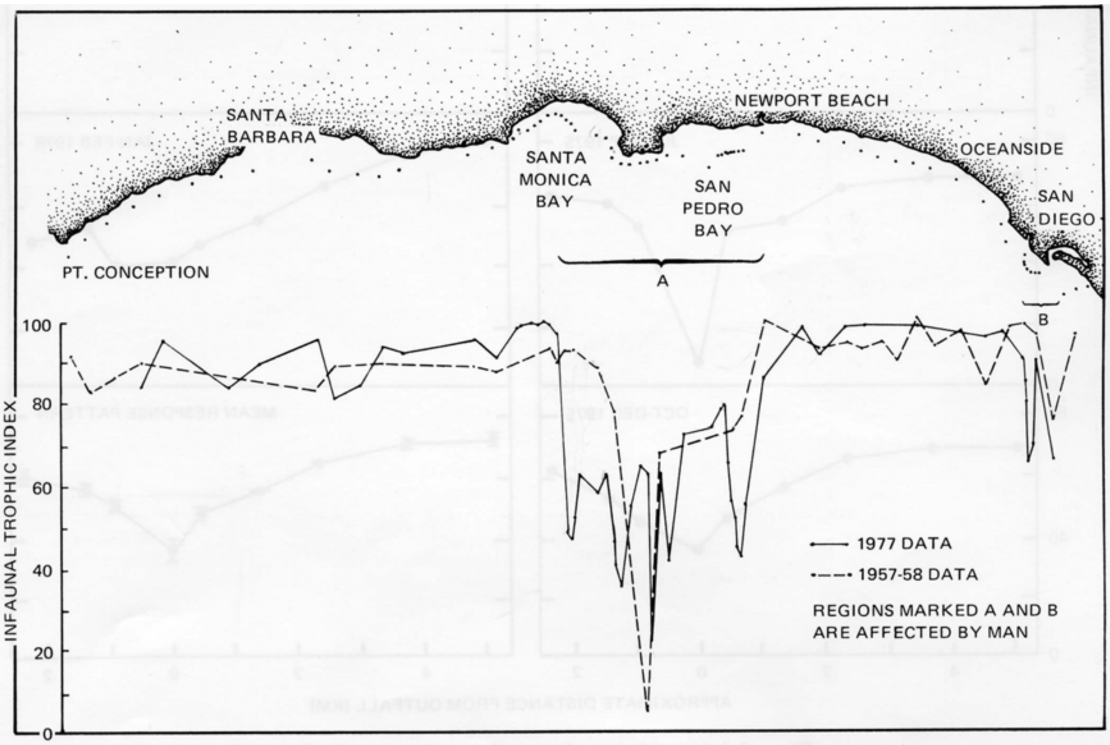

Figure 4. Infaunal Trophic Index values calculated from data collected by the Project in 1977 and from data collected by the Allan Hancock Foundation in 1957-58.

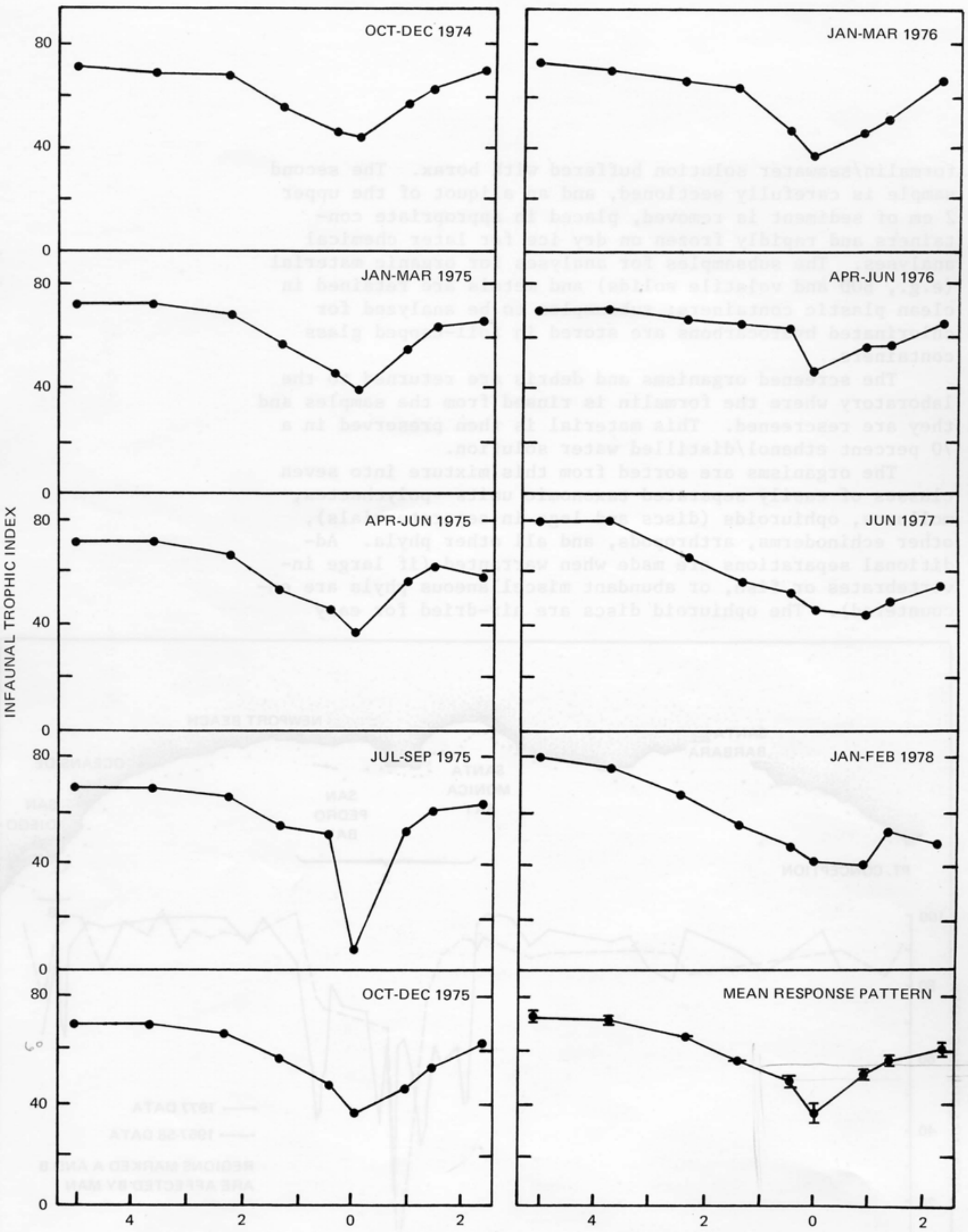

Figure 5. Infaunal Index values at nine stations near the Orange County outfalls over a 4-year period. Note the minimal seasonal variation and the unusually low value for the station nearest the outfall in summer 1975.

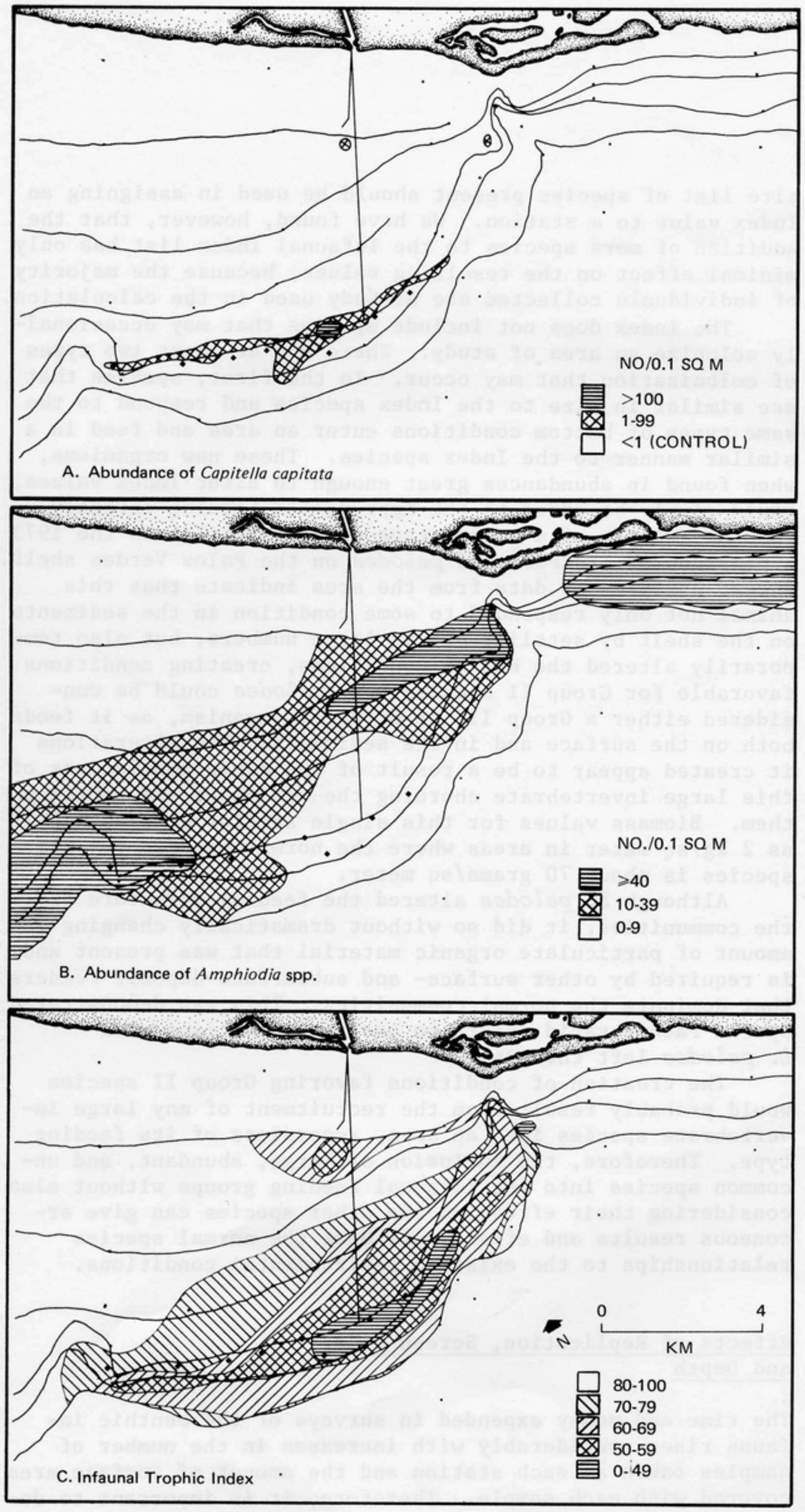

Figure 7. Distribution of two indicator species—a tolerant organism (Part A) and a sensitive species (par (Part B)—near the Orange County outfall and Infaunal Trophic Index values for the same area (Part C). Only the Infaunal Index values provide a geographically continuous record of sediment conditions in the area sampled.