APPENDIX E:

Benthic Response Index

Southern California Bight Pilot Project: Benthic Response Index for Assessing Infaunal Communities on the Mainland Shelf of Southern California

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ABSTRACT

Although benthic infaunal communities are commonly measured to assess the effectiveness of environmental management in protecting biological resources, the tools used to interpret the resulting data are often subjective or site-specific. Presented herein is an objective, quantitative index for application throughout the southern California coastal shelf environment that measures the condition of a benthic assemblage, with defined thresholds for levels of environmental disturbance. The index was calculated using a two-step process in which ordination analysis was employed to establish a pollution gradient within a 717-sample data set. Then the pollution tolerance of each species was determined based upon its abundance along the gradient. The index is calculated as the abundance-weighted average pollution tolerance of species in a sample. Thresholds were established for reference condition as well as for four levels of biological response. Reference condition was established as the index value in samples taken far from areas of anthropogenic activity and for which no contaminants exceeded the Effects Range Low (ER-L) screening levels. The four response levels were established as the index values at which key community attributes were lost. Independent data sets were used to validate the index in three ways. First, index sensitivity to a spatial gradient of exposure to a discharge from a point source was tested. Second, index response to a temporal gradient of exposure to a discharge from a point source was examined, testing index robustness to natural temporal variation. Third, the effect of changes in natural habitat (e.g., substrate, depth, and latitude) on index sensitivity was tested by evaluating the ability of the index to segregate samples taken in areas with high and low chemical exposure across a gradient of physical habitats. The index was successfully validated. We caution, however, that when applied, the index does not differentiate natural and anthropogenic disturbances. In addition, sites with index values less than 33 represent only minor biological deviation from reference and require confirmatory sampling before concluding that the site is altered.

INTRODUCTION

Effective environmental management requires biological indicators to assess status and/or trends in resources of interest. Benthic infauna have been used extensively as indicators of environmental status in the marine environment. Repeated studies have demonstrated that benthos respond predictably to various kinds of natural and anthropogenic stress (Pearson and Rosenberg 1978, Dauer 1993, Tapp *et al.* 1993, Wilson and Jeffrey 1994, Weisberg *et al.* 1997). Benthos have many characteristics that make them useful indicators, including their potential high exposure to stress. Contaminants accumulate in sediments; in estuarine environments exposure to low concentrations of oxygen is most severe in near-bottom waters. Because benthic organisms also have limited mobility and cannot avoid adverse conditions, benthic assemblages, unlike most pelagic fauna, reflect local environmental conditions (Gray 1979).

Another advantage of benthic infauna as indicators is their taxonomic diversity, which includes organisms with a wide range of physiological tolerances, feeding modes, and trophic interactions, making them sensitive to a wide array of environmental stressors (Pearson and Rosenberg 1978; Rhoads *et al.* 1978; Boesch and Rosenberg 1981). This advantage, however, can also be a disadvantage as the diversity of responses can be hard to interpret. Environmental managers can become frustrated and confused when a great deal of rigor is employed in quantifying which species are increasing or decreasing over time (or space), but a high degree of subjectivity is employed, often with dissension among scientists, to integrate and assess whether the sum extent of the changes are indicative of an improving or declining environment (O'Connor and Dewling 1986).

Several efforts have been undertaken to address this concern. The efforts generally fall into three categories. First, single community attribute measures, including measures such as species diversity or abundance:biomass ratios, have been used to summarize data beyond the level of individual species (Warwick and Clarke 1993, 1994). While these measures can be useful in some circumstances, Pearson and Rosenberg (1978) have suggested that benthos respond to pollution stress in stages, with different measures necessary to capture the varying responses. Second, the multi-metric index combines multiple measures of community response into a single index to more effectively capture the different types of response that occur at different levels of stress (Nelson 1990, Engle *et al.* 1994, Weisberg *et al.* 1997).

Third, species composition information is used directly, usually by describing the assemblage patterns in a comparative multivariate space (Smith *et al.* 1988, Field *et al.* 1982). Norris (1995) has suggested that multivariate approaches provide higher sensitivity in assessing perturbation than methods based upon assemblage metrics. However, implementation and output from multivariate approaches are often too complex to transmit easily to managers (Gerritsen 1995). Individual species information has also been used in several indices by assigning pollution tolerance scores to various members of the community and then calculating an average pollution tolerance score of the species found at a site (Hilsenhoff 1977, Word 1980a,b, 1990). This approach is easily communicated to managers, but assignment of pollution tolerance scores has typically been subjective. In this report, we develop a new technique for assigning pollution tolerance scores based upon multivariate analysis with the objective of combining the ease of communication of the tolerance score approach with the analytical rigor of multivariate statistics.

METHODS

Our index is the abundance-weighted average pollution tolerance of species occurring in a sample and is similar to the weighted average approach used in gradient analysis (Goff and Cottam 1967, Whittaker 1973, Gauch 1982). The index formula is:

$$I_s = \frac{\sum_{i=1}^{n} a_{si}^{f} p_i}{\sum_{i=1}^{n} a_{si}^{f}} \qquad (1)$$

where I_s is the index value for sample s, n is the number of species for sample s, p_i is the position for species i on the pollution gradient (pollution tolerance score), and a_{si} is the abundance of species i in sample s. The a_{si}^{f} are abundance weights, with the exponent f providing for a transformed abundance weight. Species in the sample without p_i values are ignored, and species with abundance of zero are not used in the sum when $f=0$. In this and subsequent descriptions, sample is used equivalently with sampling unit and is one grab taken at a station in an individual time period (survey).

Determining the pollution tolerance score (p_i) for the species involved three steps: 1) assembling a calibration data set, 2) conducting ordination analysis to place each sample in the calibration data set on a pollution gradient, and 3) computing the average position of each species along the gradient. Before calculating the tolerance score, we also tested community metrics such as the number of taxa and total abundance to determine if they could be used to discriminate impacted and reference sites. These steps are discussed in more detail below.

ASSEMBLING THE CALIBRATION DATA SET

Macrobenthic infaunal data from six southern California Bight sampling programs were used in index development (Figure E1, Table E1). The data were selected to provide a range of benthic responses to pollution across several decades and over a range of depth and sediment habitats. All samples were collected with grabs, screened through 1.0 mm sieves, and identified to the lowest possible taxonomic level. Taxonomic inconsistencies among programs were eliminated by cross-correlating the species lists, identifying differences in nomenclature or taxonomic level, and consulting taxonomists from each program to resolve discrepancies. In some cases, species were lumped into higher categories to maintain comparability with historical data. Data were limited to the summer period from July 1 to September 30.

If replicate samples were taken at a station, the most "typical" of the replicates was selected. Typical replicates were determined by computing the average dissimilarity value (see the Ordination Analysis subsection below), contrasting each replicate with the other replicates. The replicate with the lowest average dissimilarity was selected as the typical replicate.

METRIC TESTING

The utility of metrics for discriminating altered and reference sites was evaluated by comparing the distribution of values in two group of stations selected from the ordination data set. For a metric to be useful, the distribution of values in impacted and reference stations should be different. Ideally, the range of values in the two groups will not overlap.

The first group of stations, called the reference group, contained stations that were most likely not affected by anthropogenic activities. A station was included in the reference group if: 1) no chemical was above Long *et al.* (1995) Effects Range Median (ER-M) concentration, 2) no more than 2 chemicals were above Long *et al.* (1995) Effects Range Low (ER-L) concentration, 3) total organic carbon (TOC) was within the 99th percentile of the distribution for the regression between TOC and fines (Bergen *et al.* 1995), and the station was not within a potentially affected area. Potentially affected areas included the areas within the monitoring grids around wastewater outfalls, areas within 3 km of the 11 largest rivers and stormdrains, Santa Monica Bay, Los Angeles/Long Beach Harbor and any sample with petroleum in the sediment. The second group included stations that were most likely to have been affected by anthropogenic activities. A station was included in the second group if the concentration of any chemical was higher than the Long *et al.* (1995) ER-M value.

The difference in the distribution of values in the two groups was determined by calculating the percent of values in the ≥1ER-M category that were below the minimum value in the reference category as well as the percent above the maximum value in the reference category. The percents were then tested with a one-sided exact bionomial test to determine if the percent was 80% or higher. Since benthic communities in the SCB are known to segregate by depth (Bergen *et al.* in press), comparisons were made for three depth zones: 1) ≤ 30 m, 2) >30-120 m and 3) >120 m.

Twenty-five metrics were tested (Table E2). These included measures of diversity, evenness, abundance, biomass, species composition and feeding mode. Shannon-Wiener Diversity (H') is $\sum_{i=1}^{s}(p_i)(\log_2 p_i)$ where s is the number of species and p_i is the proportion of the total sample belonging to the ith species. Margalef diversity is

$\frac{s-1}{\log_e(T)}$ where T is the total number of organisms in a sample. Evenness (J') is H'/$\log_2$s. Dominance is $\sum_{i=1}^{s} p_i^2$. The Infaunal Trophic Index (ITI) was calculated using the species classification in Word and Mearns (1982). For the functional measures, each species was categorized in one of four feeding modes: 1) surface/subsurface carnivore, 2) suspension feeder, 3) surface deposit feeder, and 4) subsurface deposit feeder. The categorization was based upon Fauchald and Jumars (1979), Word (1990) and the experience of the biologists.

ORDINATION ANALYSIS

The ordination was based upon principal coordinates analysis (Gower 1966, 1967; Sneath and Sokal 1973; Pielou 1984), in which the ordination space is computed directly from a dissimilarity matrix contrasting all pairs of samples. Dissimilarity was quantified using the Bray-Curtis dissimilarity index (Bray and Curtis 1957, Clifford and Stephenson 1975). Prior to the dissimilarity index computations, data were square root transformed and standardized by the species mean of values greater than zero (Smith 1976, Smith *et al.* 1988). Dissimilarity values greater than 0.80 were re-estimated using the step-across procedure (Williamson 1978, Bradfield and Kenkel 1987). The step-across procedure corrects for loss in sensitivity of the dissimilarity index as the amount of community change increases. This correction is important when quantifying extended gradients of biological change with ordination (Swan 1970, Austin and Noy-Meir 1971, Beals 1973).

The pollution gradient within the ordination space was defined as a direction vector connecting the average position of the most polluted and least polluted endmembers, similar to the approach used by Smith and Bernstein (1985) and Bernstein and Smith (1986). The average positions of the endmembers were computed only from the two-dimensional ordination subspace containing the pollution gradient. Endmembers were identified as samples from sites with known pollution histories, and sites for which the quality of the benthic community had been established previously based upon comparison to reference sites. Multiple sites and samples, covering a wide range of years, latitudes and sediment types, were used in defining endmembers to avoid confounding the pollution gradient with other habitat gradients within the ordination space. The direction of the depth and sediment size gradients in the ordination subspace were plotted to assess if they were orthogonal to, and therefore independent of, the pollution direction vector.

Ordination analysis was conducted separately for three different depth zones, based upon Bergen *et al.*'s (in press) demonstration that benthic communities within the SCB segregate by depth; separate ordinations were developed for 10-35 m, 25-130 m, and 110-324 m. The depth ranges were selected to overlap so that index values could be standardized across depth ranges.

Rare species were eliminated prior to all analyses. For the 10-35 m and 110-324 m depth ranges, all species occurring in fewer than three samples were eliminated; for the

25-130 m depth range, all species occurring in fewer than four samples were eliminated. The numbers of species remaining for the shallow, mid-, and deep depth ranges were 379, 477, and 267, respectively.

POSITION OF SPECIES ON THE GRADIENT

The weighted average position of each species on the pollution gradient was computed as:

$$p_i = \frac{\sum_{j=1}^{t} a_{ij}^{e} g_j}{\sum_{j=1}^{t} a_{ij}^{e}} \qquad (2)$$

where e is an abundance transformation exponent, allowing for transformation of the abundance weights, and t is the number of samples to be used in the sum, with only the highest t species abundance values included in the sum. The g_j is the position on the pollution gradient for sample j, and a_{ij} is the abundance of species i in sample j. Sample j contains the j^{th} highest abundance count for the i^{th} species. The p_i computed in equation (2) are used as pollution tolerance scores in equation (1) to compute the index values.

The position of a sample on the pollution gradient vector (g_j) was calculated as a projection of the sample's position in the subspace onto the vector. The projections were rescaled so that the sample closest to the unpolluted end of the gradient was given a gradient score of zero, and the sample closest to the polluted end of the gradient was given a gradient score of 100.

The values for *e, t,* and *f* in equations (1) and (2) were determined by an optimization procedure to provide the combination that yielded the highest correlation between our index values and the pollution gradient projection scores. We chose this optimization approach because our goal was to recreate the pollution gradient defined in the ordination space with the index values. The procedure involved computing correlations associated with all combinations *of* *e=0, 1, .5,.333, .25*, and *f=0, 1, .5, .333, .25*, and *t=1-100*, and choosing the combination with the highest correlation.

Index scales for the three habitats were standardized so that a particular index value would indicate the same level of disturbance, regardless of the depth range. Standardization was accomplished by regressing shallow and deep range index values against mid-depth index values for samples that fell in overlap depth areas, and then rescaling the I_s values from equation (1) to the mid-depth values based on the regression equation. After the standardization of index values for depth ranges, the index values were rescaled from 0 to 100 to facilitate interpretation. This was accomplished as:

$$R_s = 100 \frac{I_s - I_{\min}}{I_{\max} - I_{\min}} \qquad (3)$$

where R_s is the rescaled value for I_s (Equation 1) , I_{min} is the minimum I_s value in the 25-130 m depth range, and I_{max} is the maximum I_s value in the 25-130 m depth range.

THRESHOLD DEVELOPMENT

To place index values in perspective, four thresholds of biological response to pollution were identified. First, we identified the reference threshold, the index value below which natural benthic assemblages normally occur. The reference threshold was defined as a value toward the upper end of the range of index values of samples taken at sites that had minimal known anthropogenic influence. Sites were included if: 1) no chemical concentration was higher than the Long *et al.* (1995) Effects Range Median (ER-M) level; 2) no more than one chemical was higher than the Long *et al.* (1995) Effects Range Low (ER-L) level; 3) total organic carbon (TOC) concentration was equal to that expected based upon the regression between sediment grain size and TOC (Bergen *et al.* 1995); and 4) the sample was collected distant from known contaminant sources (sewage discharges, rivers or storm drains, Santa Monica Bay, and Los Angeles/Long Beach Harbors, or the head of submarine canyons).

The other three thresholds involved defining levels of deviation from the reference condition. They were based upon a determination of the index values above which species, or groups of species, no longer occurred along the pollution gradient. The first of these response thresholds, which we called loss of biodiversity, was defined as the index value above which 25% of the species pool found in reference samples no longer occurred. The second threshold, loss in community function, occurred at the point that major taxonomic groups were lost from the assemblage; in our data, the first major taxonomic groups that were lost were echinoderms and arthropods. The last response threshold, defaunation, was the point at which 90% of the species pool in the reference samples no longer occurred. Index values between reference condition and the loss in biodiversity threshold were identified as marginal deviation, as benthic assemblages in this category primarily reflect a change in relative abundance among species, rather than species replacement.

The 90% upper tolerance interval bound (Hahn and Meeker 1991, Vardeman 1992) for the reference samples was used for the threshold between reference condition and marginal deviation. Specifically, the computed tolerance interval was an upper 95% confidence limit for the 90th percentile of the reference distribution of index values. To estimate the small-scale spatial variation in index values, tolerance intervals for the 95th percentile were calculated for replicate index values obtained from one sampling location at one time. Variance estimates used for the tolerance intervals were based upon pooled variance estimates of the replicates at stations with more than three replicates for the sampling period.

INDEX VALIDATION

Three types of validation were performed. The first involved testing whether the index reproduced known spatial gradients of benthic conditions near a southern California ocean outfall. The second involved reproducing known temporal gradients at a set of historically monitored sites. The third involved testing the relationship between chemical exposure and the BRI at sites throughout the SCB. In the first two tests, the validation data sets were independent of the calibration data.

The spatial gradient test was conducted using data from the County Sanitation Districts of Orange County (CSDOC), which included a gradient of stations on the 60 m isobath, from 0-7,840 m from the outfall (CSDOC 1991). Previous studies have shown that two sites located near the outfall (Stations 0 and ZB2) have altered species composition in comparison to three reference stations (13, C, and Con) which are over 3,800 m from the outfall.

The temporal analysis was conducted using data from two County Sanitation Districts of Los Angeles County (CSDLAC) collection sites, which have been sampled annually since 1972. Stull *et al*. (1986b) and Stull (1995) have shown that the first site, Station 6C (located 2,220 m from their outfall) was severely impacted in the early 1970's. This site has improved since that time. The second site, Station 0C (located 14,720 m from the outfall) was less affected than 6C, but has also improved. Our premise in the validation is that index values should decrease over time at 6C and 0C and that index values will be higher and decrease more at 6C than at 0C.

The relationship between the BRI and chemical exposure was assessed by separating samples into three categories based upon the number of chemicals exceeding Long *et al.*'s (1995) ER-M threshold and examining the degree to which BRI values overlapped among these categories. The analysis was conducted separately for our three depth strata. Our hypothesis was that 1) index values in impact categories will be higher than in reference categories and 2) index values will be consistent across depths for each impact category.

RESULTS

The calibration data set included 717 samples collected by six organizations (Table E1). Samples were taken in 10 to 324 m of water in the area between Point Conception and the United States-Mexico international border. A full range of sediment types were represented, including samples with 0-99.96% fines. Sampling dates ranged from 1973-1994.

In most instances, the distribution of values of metrics was similar in the reference and the ≥1ER-M categories (Table E3, Appendix E Attachment E1). None of the metrics had distributions that differed by more than 80% between the reference and the ≥1ER-M categories in all zones. The Infaunal Trophic Index (ITI) and ordination scores differed by more than 80% in the middle and deep zones, but not in the shallow zone. The percent of the abundance comprised by mollusks differed by more than 80% in the deep zone, but not in the mid-depth and shallow zone.

The samples used to define the reference and polluted endpoints in the ordination analyses are shown in Table E1. In all three ordination spaces, the depth gradient was orthogonal to the pollution gradient (Figure E2). For the mid-depth and deep habitats, the sediment grain size gradient was also orthogonal to the pollution gradient. In the shallow habitat, the sediment grain size gradient was slightly correlated with the pollution gradient, indicating that organic input is associated with fine sediment input in shallow depths.

The optimum *e*, *t*, and *f* values from equations (1) and (2) for the different depth ranges are summarized in Table E4. Using these parameter values, the correlation between the weighted averages from equation (1) and the pollution gradients extracted from the ordination spaces exceeded 0.95 in each of the depth habitats. These parameter values were then used to compute pollution gradient positions (p_i) for each species in the calibration data (Table E5); the distribution of selected species on the pollution gradient are shown in Figure E3.

There was a high correlation between index values in the overlap depths for the three different depth zone (Figure E4). The final index values were re-scaled so that the index values for the 25-130 m depth calibration data ranged from 0 to 100. The minimum and maximum index values for the 25-130 m calibration data were 27.4983 and 60.4481, respectively, leading to the following parameterization of equation (3):

$$R_s = 100\frac{I_s - I_{\min}}{I_{\max} - I_{\min}} = 100\frac{I_s - 27.4983}{60.4481 - 27.4983} = 100\frac{I_s - 27.4983}{32.9498} \qquad (4)$$

where I_s is the unscaled index value and R_s is the new re-scaled index value for samples. Instructions for calculating index values are shown in Appendix E Attachment E2.

THRESHOLD DEVELOPMENT

The index values for samples from uncontaminated sites varied between 0.50 and 33.2. The threshold for reference condition was set at 25, in part because the 90% tolerance interval bound equaled 25. In addition, the distribution was discontinuous and skewed beyond 25 (Figure E5). Setting the reference threshold at 25 also allowed for the possibility that some of the sites in our reference data set were anthropogenically altered by unmeasured pollutants and/or other human activities.

The threshold for loss in biodiversity was set at index value 34, at the point where 25% of the reference species pool was excluded. The threshold for loss in community function was set at at index value 44, the point where 90 and 75% of the species pool of echinoderms and arthropods, respectively, were excluded,. The threshold value for defaunation was set at index value 72, the point where 90% of the pool of reference species was excluded.

As an estimate of the uncertainty associated with a specific index value, the one-tailed 95% tolerance interval size for replicates at a particular location and time was computed to be 3.4. This means that 90% of the time, index values for replicate samples for a particular location-survey will tend to be within 3.4 units of the mean value for that location-survey. For example, if the index value for a specific sample was 39 (Response Level II), then it is very unlikely that replicates from the same location-survey would be found in either of the adjacent response levels.

INDEX VALIDATION

Our index correctly characterized benthic condition across the spatial gradient near the CSDOC outfall (Figure E6). Station 0 (located nearest to the outfall) had index values from 26.1-33.4, while Station ZB2, also within the influence of the outfall had values from 28.6-33.9. Index values at the three stations outside of the outfall influence, Stations 13, C and Con, ranged from 14.9-19.3, below the reference threshold. Stations between these spatial extremes had intermediate index values.

Our index also correctly characterized the temporal gradients near the CSDLAC outfall (Figure E7). At Station 6C, where Stull *et al.* (1986b) found dramatic improvements in benthic condition, index values fell from 120 in 1972 to an average of 40-45 in each of the last three years. The decrease in index values in 1975-76 reflects the reported improvement in benthic communities associated with the invasion of the echiuroid *Listriolobus pelodes* (Stull *et al.* 1986a,b). Similar to Stull *et al.* (1995), we also found that index values at Station 0C (located at the margins of outfall influence) also improved; however, the change was smaller than at Station 6C.

The first two validation efforts test the predictive capability of the index when physical habitat, particularly depth, is held relatively constant. The third test examines response relative to chemical exposure across a wide array of depth, substrate, and latitudinal gradients. Index values at chemically unimpaired sites were found to be consistent across these gradients (Figure E8), although a few of the samples in each habitat exceeded our threshold of 25 for reference condition. None of the supposedly reference sites had values beyond Response Level I. A relatively high differentiation was found between index values for reference sites and samples from sites with known chemical exposure. Samples having at least one chemical exceeding the ER-M threshold had index values ranging from 19.5-69.6, while every sample from sites with more than one chemical exceeding ER-M had an index value exceeding 36 (Figure E9). Within each impact category, index values were consistent across depth.

DISCUSSION

Multivariate ordination analyses have been found to be powerful tools for assessing perturbations to benthic infaunal assemblages (Smith *et al*. 1988, Norris 1995). The concern with multivariate approaches has been their complexity in application (Gerritsen 1995) and distance from simple biological explanation (Elliott 1994, Fore *et al*. 1996). Our index resolves many of these challenges by converting the complex multivariate information into an easily interpreted and testable set of individual species pollution tolerance scores. The pollution tolerance values captured most of the information in the ordination analyses of the calibration data, as a high correlation was found between our index values and the ordination scores depicting the pollution stress gradient. This high correlation means that when computing index values for new data, little information is lost by computing the index instead of performing an additional ordination analysis. At any rate, conducting ordination analyses for each set of new data would be highly impractical.

Benthic assessments have traditionally been conducted by examining changes in community or individual species abundance, an approach that is confounded by natural temporal variability associated with annual and intra-annual recruitment processes. Our index approach is based upon the type (pollution tolerance) of species in a sample, and is less sensitive to peaks in abundance of individual species. We observed low seasonal variability in index values, especially at the less stressed stations where the condition of the benthic community should be relatively constant (Figure E6).

Previous assessments have also primarily focused on characterizing environmental conditions and gradients at local spatial scales, in which depth, latitude, and grain size have been controlled as much as possible. Benthic assemblages have rarely been used to assess ecological condition across habitats because the structure of benthic assemblages also reflects natural variation related to salinity, sediment type, latitude, and depth (Boesch 1973, 1977; Dauer *et al*. 1984, 1987; Holland *et al*. 1987; Schaffner *et al*. 1987; Snelgrove and Butman 1994; Heip and Craeymeersch 1995). Furthermore, it is difficult to separate variation in the condition of the assemblage caused by habitat differences from variation caused by anthropogenic stresses. This habitat confounding has been minimized in site-specific assessments by limiting comparisons to nearby reference sites from the same type of habitat. Confounding has been avoided in trends studies by continually returning to the same site, which also keeps habitat constant.

Our index appears to be robust to this natural habitat variability. In standardizing our index scale across the three depth zones, we found high correlations between independently calculated index values in the overlapping depth zones (Figure E4), indicating a consistency in relative pollution stress levels. We also found that index values at reference stations were not systematically related to depth, grain size, and latitude (Figure E8). We again attribute this robustness to our reliance on the types of species present, not on the abundance of individual species.

ALTERNATE INDEX DEVELOPMENT METHODS

Three separate sets of species tolerance scores were developed, corresponding to the three depth zones identified by cluster analysis (Bergen *et al.* 1997). To assess the need for independent index calibration by depth zone, we attempted to develop a single index from an ordination analysis of all depths combined. We found that a single vector could not characterize the pollution gradient adequately at all depths, and the pollution direction vectors computed separately for the depth zones were not parallel in the ordination space. Presumably, the influence of depth on individual species distributions is stronger than the response to stress over such a large depth gradient, reinforcing our decision to conduct separate ordination analyses for the three depth zones.

Most species were found in more than one depth zone. Our inability to identify a unidirectional pollution vector when all depth zones were combined in a single ordination space suggests an inconsistency of pollution response across depth zones for at least some species. Figure E10 shows the relationship between the species p_i values for the different depth zones. If the same species indicated the same relative level of stress at all depths, the points for the p_i values would tightly cluster around a straight line and the correlation for the different depths would be high. The correlation is moderately high (r = 0.74, 0.75), but there are some species that differed significantly among the depth zones. We suggest that the pollution tolerance of a species need not be the same among depth zones; as a species gets closer to the edge of its distribution gradient, its tolerance to pollution may decline.

One approach we considered in index development was to eliminate or downweight species that occur over a wide range of the pollution gradient, based upon the hypothesis that widely-occurring species are weaker indicators than species that occur in a narrow range of the pollution gradient. However, we found this hypothesis to be false; most of the pollution-tolerant species were opportunists that occurred over a broad range of the pollution gradient, albeit at lower densities at reference sites (Figures E3 and E11). Eliminating or downweighting these species reduced the correlation between our index and the multivariate pollution gradient.

The threshold for reference condition was established at 25, rather than at the 33 value where some of the reference sites in both the calibration and validation data sets scored. By using a value beloe the maximum, we were allowing for the possibility that some of our reference sites may have been impacted by pollutants or activities we did not measure. We had reason to believe that this was, in fact, the case as most stations with index values were in the vicinity of a river mouth. This allowance has been made in the development of other benthic indices (Weisberg *et al.* 1997). The elimination of vaues higher than 25 could result in the overestimation of the magnitude of biological response when our index is applied. In addition, sample variability was quantified as approximately 3 units, but not used to adjust our thresholds. Philosophically, we felt it was more appropriate to err on the conservative side of classifying sites that may exceed reference as falling in a marginal deviation category and to use the index as a screening tool. Users of the index, though, are cautioned that sites with index values less than 33 represent not only minor biological deviation from reference, but also require confirmatory sampling before concluding that the site is altered.

COMPARISON WITH OTHER INDEX APPROACHES

The use of abundance-weighted pollution tolerance scores in our index is similar to the use of feeding modes as a measure of pollution tolerance in the infaunal trophic index (ITI) (Word 1978, 1980a, 1980b, 1990). Our application expands upon the ITI in several ways. First, we used an empirical approach to develop pollution tolerance scores for individual species rather than extrapolating pollution tolerance from feeding mode. Despite differences in methodology, a high correlation was found between the values we apply to individual species. When differences do occur, they can usually be attributed to a lack of information about the feeding mode of a species, which in some cases led Word (1980b) to ascribe all members of a family to the same trophic group. We found that p-values can differ substantially among members of the same family, similar to the findings of Chang *et al.* (1992).

The second major difference between our method and the ITI is that we developed pollution tolerance values for a larger number of species. In part, the expanded range reflects the larger, more encompassing data sets that are available now compared to the period when the ITI was developed. Also, incomplete knowledge of trophic categories and inconsistency of trophic modes across different habitats for several species limited the number of species used in the ITI development. As a result, based upon external (non-calibration) data from outfall monitoring programs, the ITI values uses an average of about 50% of the species in a sample, compared to 84% in our index. The use fewer species (along with the use of untransformed abundance weights) makes the ITI subject to greater fluctuation in individual species abundances. We tested the sensitivity of the BRI and ITI to individual species by systematically removing the most abundant species and correlating the revised index values with the original values (Figure E12). Even when the 10 most abundant species for each sample were dropped from the computations, the correlation with the original BRI index values was still as high as .96, confirming the robustness of our index. On the other hand, the correlation for the ITI was approximately .66 when the top ten species were removed. The correlation for the ITI showed the largest reduction when the single most abundant species was eliminated, indication that a single abundant species can have a major effect on ITI values.

Our approach to index development differs significantly from approaches used on the east and Gulf coasts of the United States, where multi-metric indices are widely used (Engle *et al.* 1994, Weisberg *et al.* 1997). The difference in our approach reflects the different level of stress in the two areas. Pearson and Rosenberg (1978) have suggested that benthos respond sequentially to different levels of stress, with species replacement occurring at the lowest level and loss in diversity, abundance and biomass occurring at increasingly higher levels of stress. In Chesapeake Bay and the Gulf of Mexico, where multi-metric indices have been developed, hypoxia was prevalent; sites with low diversity and abundance were an integral part of the index calibration and validation data sets. Hypoxia was virtually absent in our study area. Weisberg *et al*. (1997) noted that the most sensitive metrics in Chesapeake Bay, particularly in lower stress environments, were based upon species replacement.

While the BRI appears to have immediate applicability along the continental shelf of the SCB, opportunities exist for further development. We have not yet tested its applicability in harbors or bays, where a higher level of exposure may exist. We have also not attempted to differentiate the effects of natural stress from anthropogenic stress. For example, benthos at sites near rivers experience natural salinity stress during the rainy season and may experience higher sediment organic content from natural runoff sources. Similarly, natural oil seeps in southern California can mimic the effect of anthropogenic pollution. Weisberg *et al*. (1997) recognized similar difficulties in differentiating the effects of natural and anthropogenically generated hypoxia in Chesapeake Bay. While these natural forms of stress do not invalidate the use of the index, they do lead to caution in interpretation of alterations from background communities and provide a focus for future research efforts to determine the cause of these effects.

LITERATURE CITED

Austin, M. P. and I. Noy-Meir. 1971. The problem of non-linearity in ordination experiments with two-gradient models. *Journal of Ecology* 59: 762-773.

Beals, E. W. 1973. Ordination: Mathematical elegance and ecological naiveté. *Journal of Ecology* 61:23-35.

Bergen, M., S.B. Weisberg, D. Cadien, A. Dalkey, D. Montagne, R.W. Smith, J.K. Stull and R.G. Velarde. In Press. Assessment of benthic infauna on the mainland shelf of Southern California. Southern California Coastal Water Research Project, Westminster, CA.

Bergen, M., E. Zeng and C. Vista. 1995. The Southern California Bight Pilot Project: an experiment in cooperative regional monitoring. IEEE Oceans '95 Conference Proceedings: 526-536.

Bernstein, B.B. and Smith, R.W. 1986. Community approaches to monitoring. IEEE Oceans '86 Conference Proceedings: 934-939.

Boesch, D.F. 1973. Classification and community structure of macrobenthos in the Hampton Roads area, Virginia. *Marine Biology* 21:226-244.

Boesch, D.F. 1977. A new look at the zonation of benthos along the estuarine gradient. pp. 245-266 *in* B.C. Coull (ed.), Ecology of Marine Benthos. University of South Carolina Press. Columbia, SC.

Boesch, D.F. and R. Rosenberg. 1981. Response to stress in marine benthic communities. p. 179-200 *in* G.W. Barret and R. Rosenberg (eds.), Stress Effects on Natural Ecosystems. John Wiley and Sons. New York, NY.

Bradfield, G.E. and N.C. Kenkel. 1987. Nonlinear ordination using shortest path adjustment of ecological distances. *Ecology* 68: 750-753.

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* 27:325-349.

Chang, S., F.W. Steimle, R.N. Reid, S.A. Fromm, V.S. Zdanowicz and R. Pikanowski. 1992. Association of benthic macrofauna with habitat types and quality in the New York Bight. *Marine Ecology Progress Series* 99:237-251.

Clifford, H.T. and W. Stephenson. 1975. An Introduction to Numerical Classification. Academic Press. New York, NY.

County Sanitation Districts of Orange County. 1991. 1991 Annual Report. County Sanitation Districts of Orange County. Fountain Valley, CA.

CSDOC. County Sanitation Districts of Orange County.

Dauer, D.M. 1993. Biological criteria, environmental health and estuarine macrobenthic community structure. *Marine Pollution Bulletin* 26:249-257.

Dauer, D.M, R.M. Ewing and A.J. Rodi, Jr. 1987. Macrobenthic distribution within the sediment along an estuarine salinity gradient. Internationale Revue der Gesamten *Hydriobiologie* 72:529-538.

Dauer, D.M., T.L. Stokes, Jr., H.R. Barker, Jr., R.M. Ewing and J.W. Sourbeer. 1984. Macrobenthic communities of the lower Chesapeake Bay. IV. Baywide transects and the inner continental shelf. Internationale Revue der Gesamten *Hydriobiologie* 69:1-22.

Elliott, M. 1994. The analysis of macrobenthic community data. *Marine Pollution Bulletin* 28:62-64.

Engle, V.D., J.K. Summers and G.R. Gaston. 1994. A benthic index of environmental condition of Gulf of Mexico estuaries. *Estuaries* 17:372-384.

Fauchald, K. and P.A. Jumars. 1979. The diet of worms: A study of polychaete feeding guilds. *Oceanography and Marine Biology Annual Review* 17:193-284.

Field, J.G., K.R. Clarke and R.M. Warwick. 1982. A practical strategy for analyzing multispecies distribution patterns. *Marine Ecology Progress Series* 8: 37-52.

Fore, L.S., J.P. Karr and R.W. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. *Journal of the North American Benthological Society* 15:212-231.

Gauch, H.G., Jr. 1982. Multivariate analysis in community ecology. Cambridge Studies in Ecology. Cambridge University Press. New York, NY.

Gerritsen, J. 1995. Additive biological indices for resource management. *Journal of the North American Benthological Society* 14:451-457.

Goff, F.G., and G. Cottam. 1967. Gradient analysis: The use of species and synthetic indices. *Ecology* 48:793-806.

Gower, J.C. 1966. Some distance properties of latent root and vector methods used in multivariate analysis. *Biometrica* 53: 325-338.

Gower, J.C. 1967. Multivariate analysis and multidimensional geometry. The Statistician 17: 13-28.

Gray, J.S. 1979. Pollution-induced changes in populations. *Transactions of the Royal Philosophical Society of London (B)* 286:545-561.

Hahn, G.J. and W.Q. Meeker. 1991. Statistical Intervals. A Guide for Practitioners. John Wiley & Sons, Inc. New York, NY.

Heip, C. and J.A. Craeymeersch. 1995. Benthic community structures in the North Sea. *Helgolander Meeresuntersuchungen* 49:313-328.

Hilsenhoff, W.L. 1977. Use of arthropods to evaluate water quality of streams. Technical Bulletin. Wisconsin Department of Natural Resources 100. 15 p.

Holland, A.F., A. Shaughnessey and M.H. Heigel. 1987. Long-term variation in mesohaline Chesapeake Bay benthos: Spatial and temporal patterns. *Estuaries* 10:227-245.

Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19: 81-97.

Nelson, W.G. 1990. Prospects for development of an index of biotic integrity for evaluating habitat degradation in coastal ecosystems. *Chemistry and Ecology* 4:197-210.

Norris, R.H. 1995. Biological monitoring: The dilemma of data analysis. *Journal of the North American Biological Society* 14:440-450.

O'Connor, J.S. and R.T. Dewling. 1986. Indices of marine degradation: Their utility. *Environmental Management* 10:335-343.

Pearson, T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology Annual Review* 16: 229-311.

Pielou, E.C. 1984. The Interpretation of Ecological Data. John Wiley and Sons. New York, NY.

Rhoads, D.C., P.L. McCall and J.Y. Yingst. 1978. Disturbance and production on the estuarine sea floor. *American Scientist* 66:577-586.

Schaffner, L.C., R.J. Diaz, C.R. Olson and I.L. Larsen. 1987. Faunal characteristics and sediment accumulation processes in the James River Estuary, Virginia. *Estuarine, Coastal and Shelf Science* 25:211-226.

Smith, R.W. 1976. Numerical Analysis of Ecological Survey Data. Ph.D. Dissertation. University of Southern California. Los Angeles, CA.

Smith, R.W. and B.B. Bernstein. 1985. Index 5: A multivariate index of benthic degradation. Report prepared for NOAA, under contract to Brookhaven Nat. Lab. 118 p. (Available from authors at EcoAnalysis Inc., 221 E. Matilija Street, Ojai, CA 93023.)

Smith, R.W., B.B. Bernstein and R.L. Cimberg. 1988. Community-environmental relationships in the benthos: Applications of multivariate analytical techniques. Chapter 11, p. 247-326 *in:* Marine Organisms as Indicators. Springer-Verlag. New York, NY.

Sneath, P.A. and R.R. Sokal. 1973. Numerical Taxonomy. W.H. Freeman and Co. San Francisco, CA.

Snelgrove, P.V. and C.A. Butman. 1994. Animal-sediment relationships revisited: Cause vs. effect. *Oceanography and Marine Biology Annual Review* 32:111-177.

Stull, J. 1995. Two decades of biological monitoring, Palos Verdes, California, 1972 to 1992. *Bulletin of the Southern California Academy of Sciences* 94:21-45.

Stull, J.K., C.I. Haydock, and D.E. Montagne. 1986a. Effects of *Listriolobus pelodes* (Echiura) on coastal shelf benthic communities and sediments modified by a major California waste water discharge. *Estuarine, Coastal and Shelf Science* 22:1-17.

Stull, J., C.I. Haydock, R.W. Smith, and D.E. Montagne. 1986b. Long-term changes in the benthic community on the coastal shelf of Palos Verdes, Southern California. *Marine Biology* 91:539-551.

Swan, J.M.A. 1970. An examination of some ordination problems by use of simulated vegetational data. *Ecology* 51: 89-102.

Tapp, J.F., N. Shillabeer and C.M. Ashman. 1993. Continued observation of the benthic fauna of the industrialized Tees estuary, 1979-1990. *Journal of Experimental Marine Biology and Ecology* 172:67-80.

Vardeman, S.B. 1992. What about the other intervals? *The American Statistician* 46: 193-197.

Warwick, R.M. and K.R. Clarke. 1993. Comparing the severity of disturbance: A meta-analysis of marine macrobenthic community data. *Marine Biology Progress Series* 92:221-244.

Warwick, R.M. and K.R. Clarke. 1994. Relearning the ABC: Taxonomic changes and abundance/biomass relationships in disturbed benthic communities. *Marine Biology* 118:739-744.

Whittaker, R.H. 1973. Direct gradient analysis: Techniques. pp. 54-73 *in:* Handbook of Vegetation Science. Part V. Ordination and Classification of Communities. Dr. W. Junk b.v., The Hague.

Wilson, J.G. and D.W. Jeffrey. 1994. Benthic biological pollution indices in estuaries. pp. 311-327 *in* J.M. Kramer (ed.), Biomonitoring of Coastal Waters and Estuaries. CRC Press. Boca Raton, FL.

Weisberg, S.B., J.A. Ranasinghe, D.M. Dauer, L.C. Schaffner, R.J. Diaz and J.B. Frithsen. 1997. An estuarine benthic index of biotic integrity (B-ITI) for Chesapeake Bay. *Estuaries* 20:149-158.

Williamson, M.H. 1978. The ordination of incidence data. J. Ecol. 66: 911-920.

Word, J.Q. 1978. The infaunal trophic index. pp. 19-39 *in:* Southern California Coastal Water Researc Project Annual Report. El Segundo, CA.

Word, J.Q. 1980a. Extension of the infaunal trophic index to a depth of 800 meters. pp. 95-101 *in:* Southern California Coastal Water Researc Project Biennial Report 1979-1980. Long Beach, CA.

Word, J.Q. 1980b. Classification of benthic invertebrates into Infaunal Trophic Index feeding groups. pp. 103-121 *in:* Southern California Coastal Water Researc Project Biennial Report 1979-1980. Long Beach, CA.

.
Word, J.Q. 1990. The infaunal trophic index, a functional approach to benthic community analyses. Ph.D. Dissertation. University of Washington. Seattle, WA.

Word, J.Q. and A.J. Mearns. 1982. Forecasting effects of sewage solids on marine benthic communities. pp. 495-512 *in:* G.F. Meyer (ed.). Ecological stress and the New York Bight: Science and management. Estuarine Research Federation. Columbia, SC.

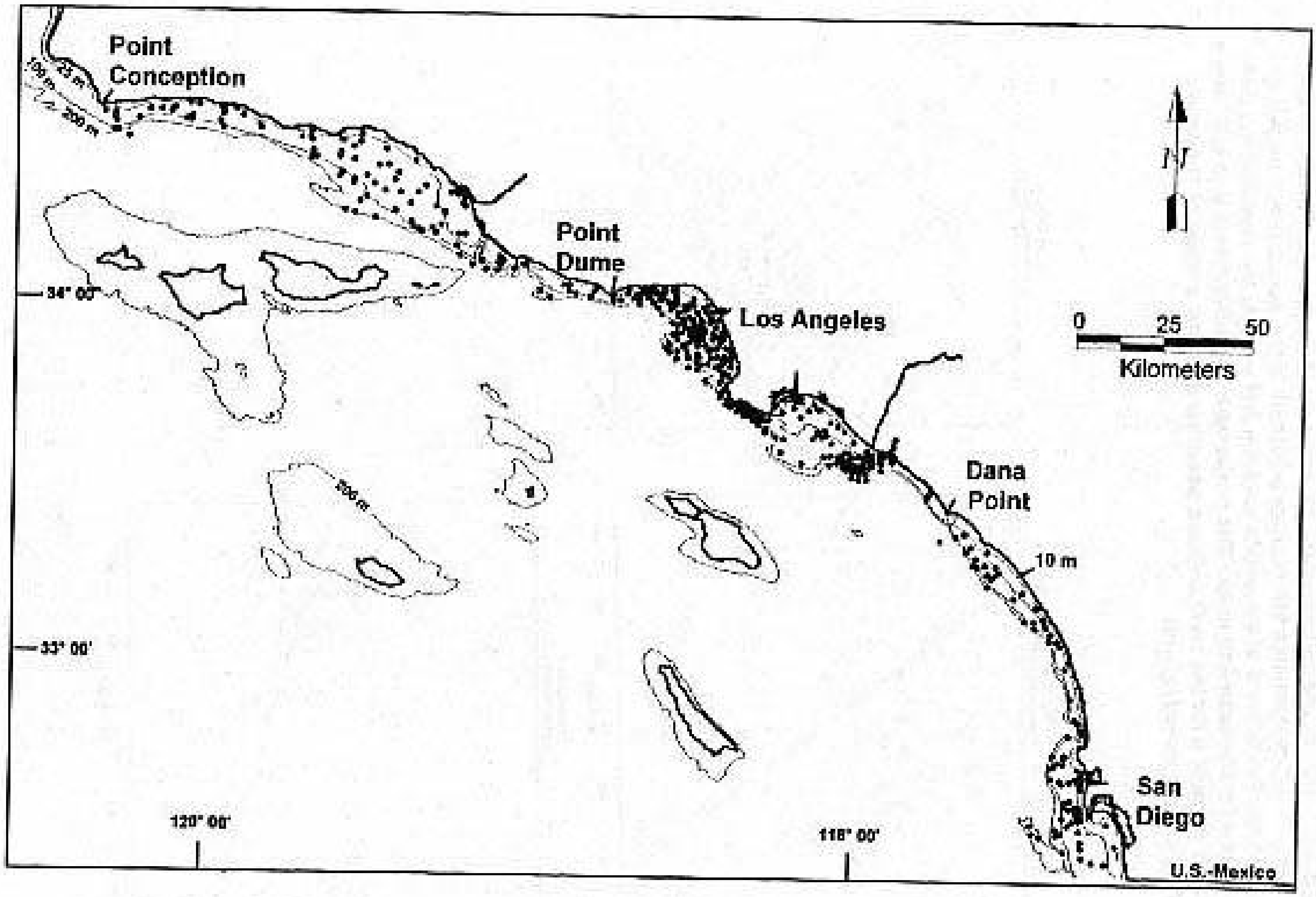


Figure E1. Location of sites used in the calibration data set.

Figure E2. Plot of ordination results for the three depth zones. The line in each ordination space connects the average positions of the polluted and unpolluted endpoints. Projections of the points onto the line provide the pollution gradient positions for the sampling units. The projections are scaled from 0 to 100, with a scaled value of 0 for the least polluted sampling unit and a value of 100 for the most polluted sampling unit.

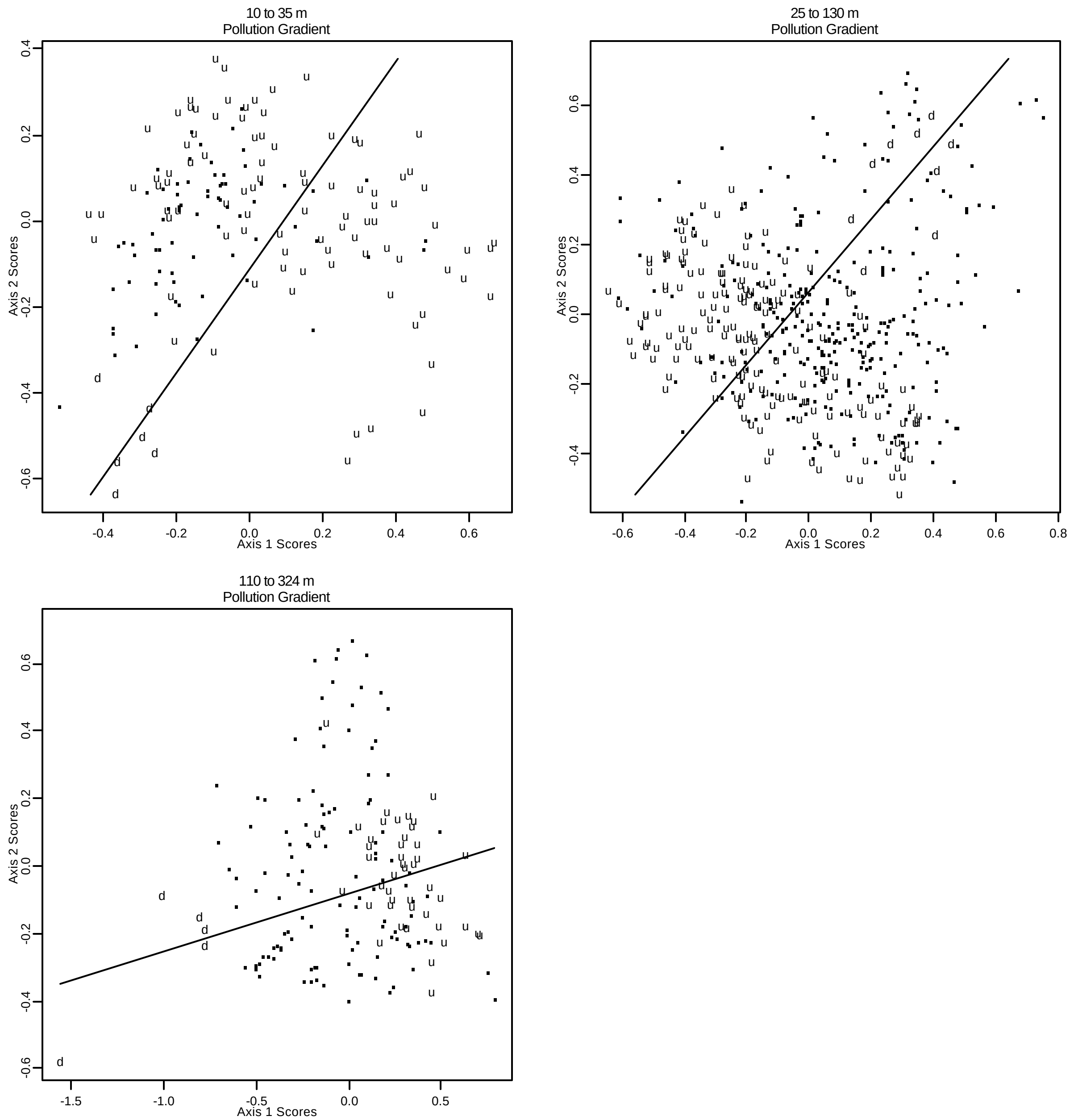


Figure E3. Selected species distributions along the pollution gradient for the 25-130 m depth zones. The species are in order of their positions along the pollution gradient, as indicated by their p_i values. The number preceding the species name is the rank order of the p_i value when all species are ranked in ascending order. The pollution gradient is defined from the ordination space (Figure E2).

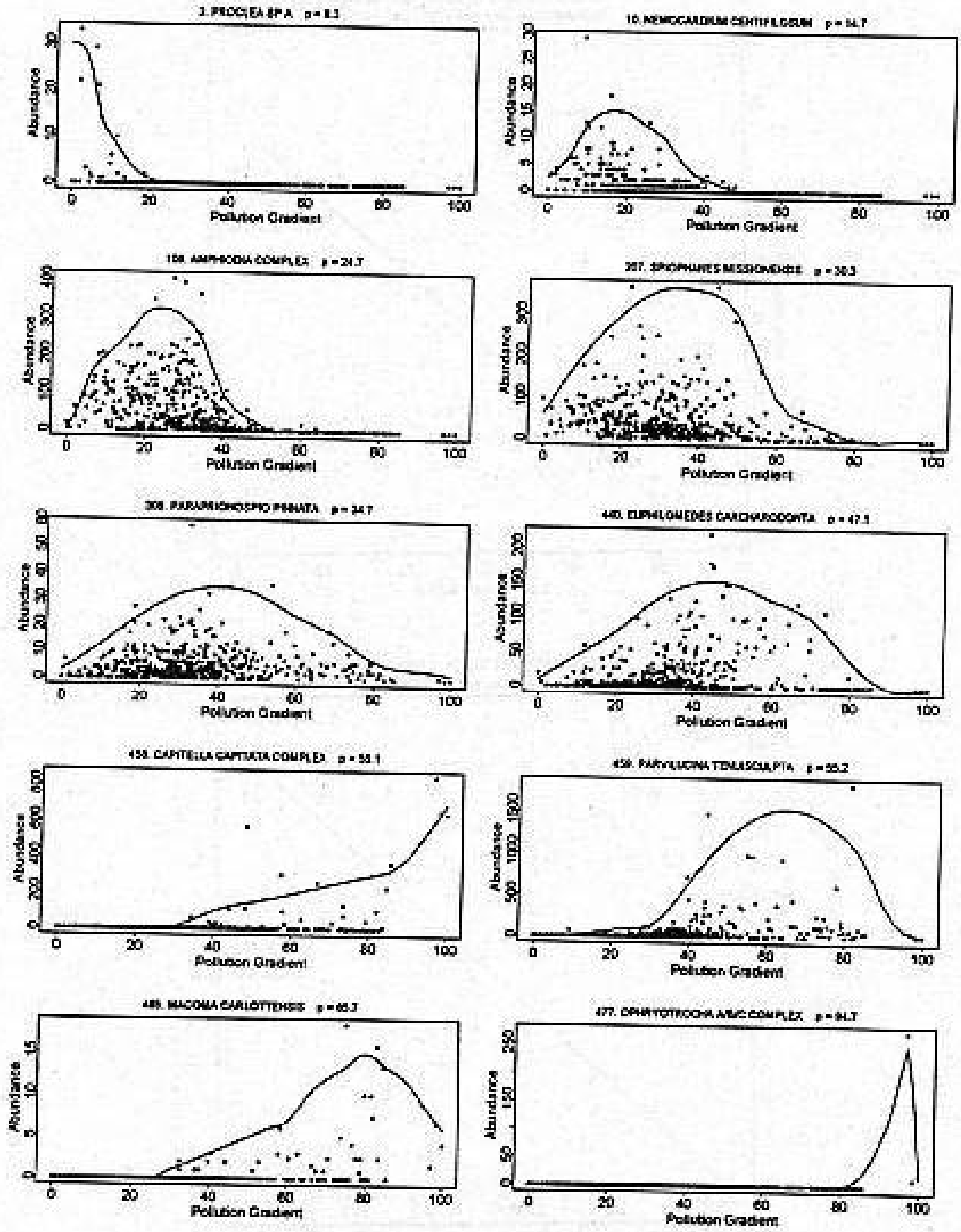
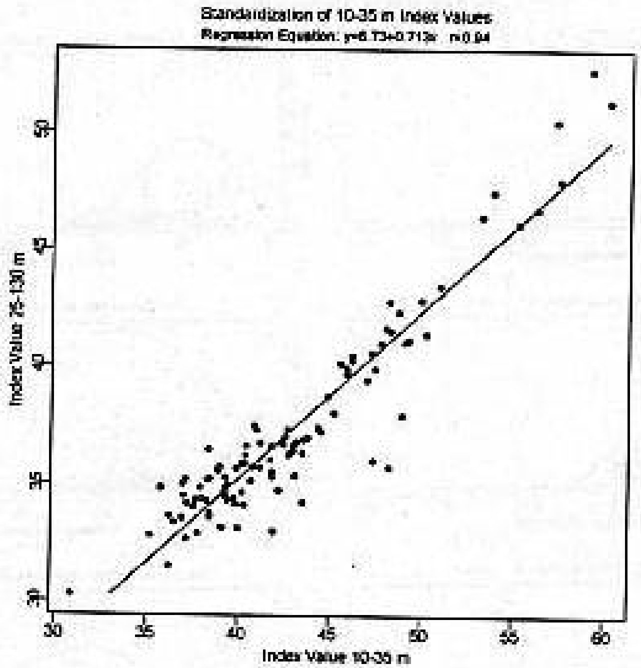


Figure E4. The index value pairs computed in the overlapping parts of the depth ranges. The regression equations were used to rescale index values from the shallow and deep depth ranges (x in the regression equation) to the scale of the middle depth range (y in regression equation).



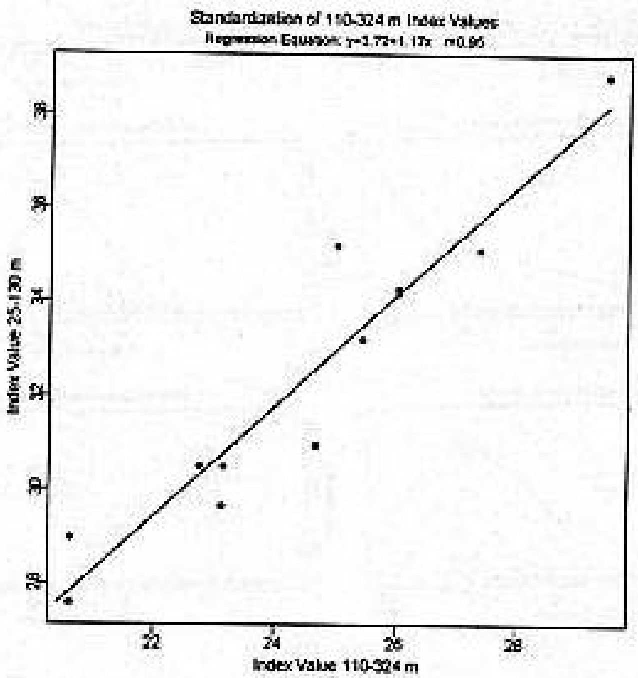
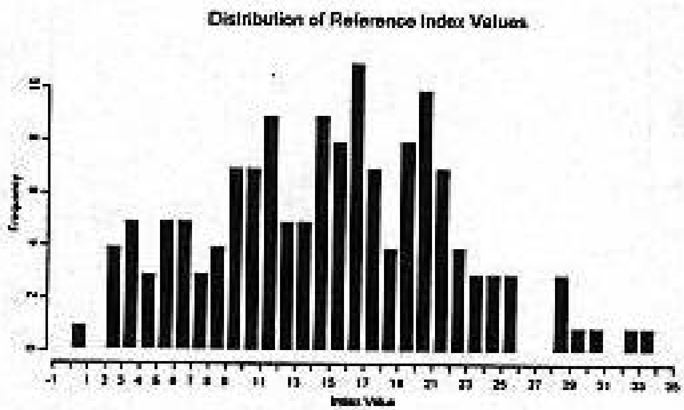


Figure E6. Histogram showing the distribution of reference index values.



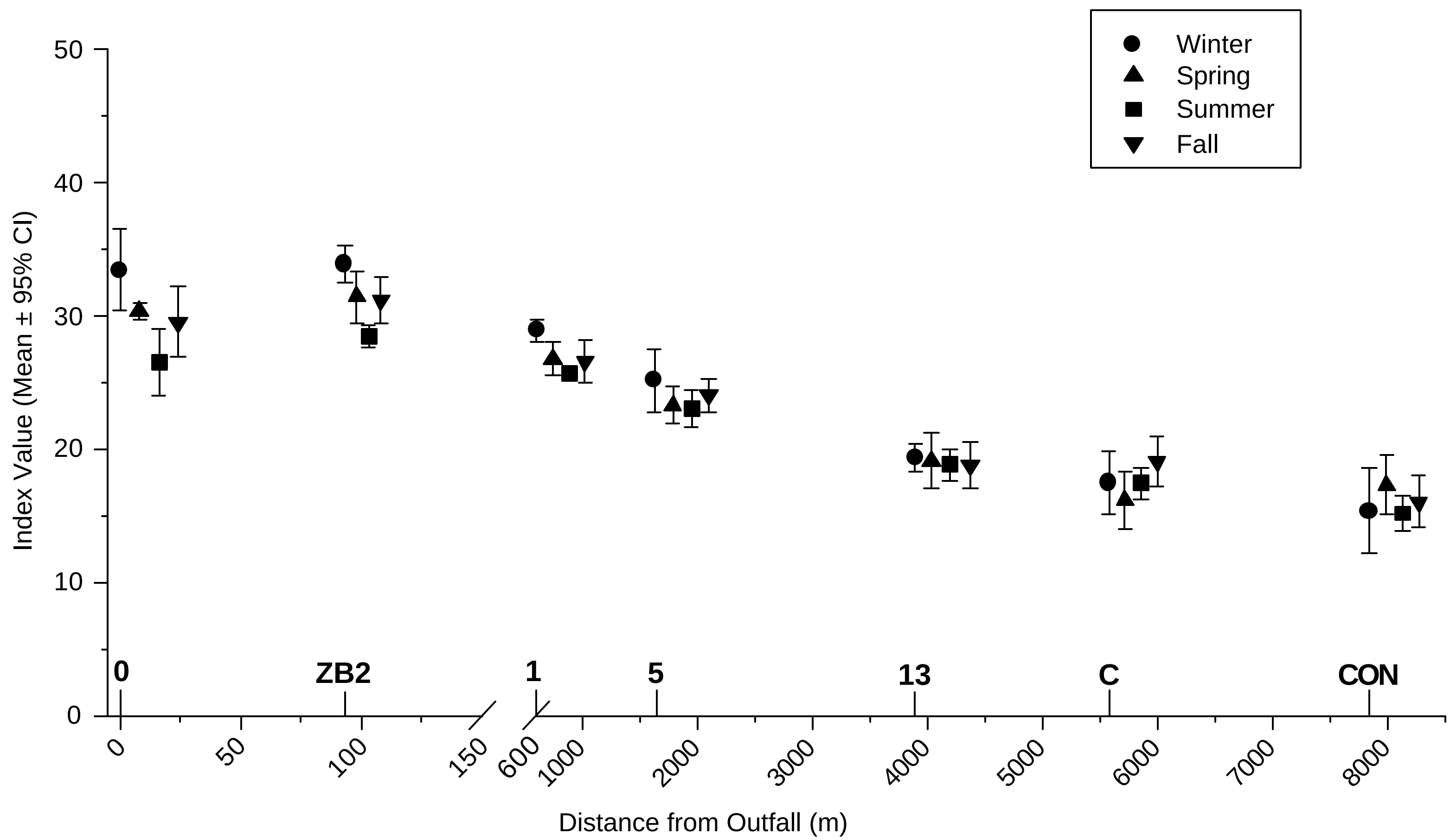


Figure E6. Benthic Response Index values for a gradient of stations near the Sanitation Districts of Orange County's outfall in 1990.

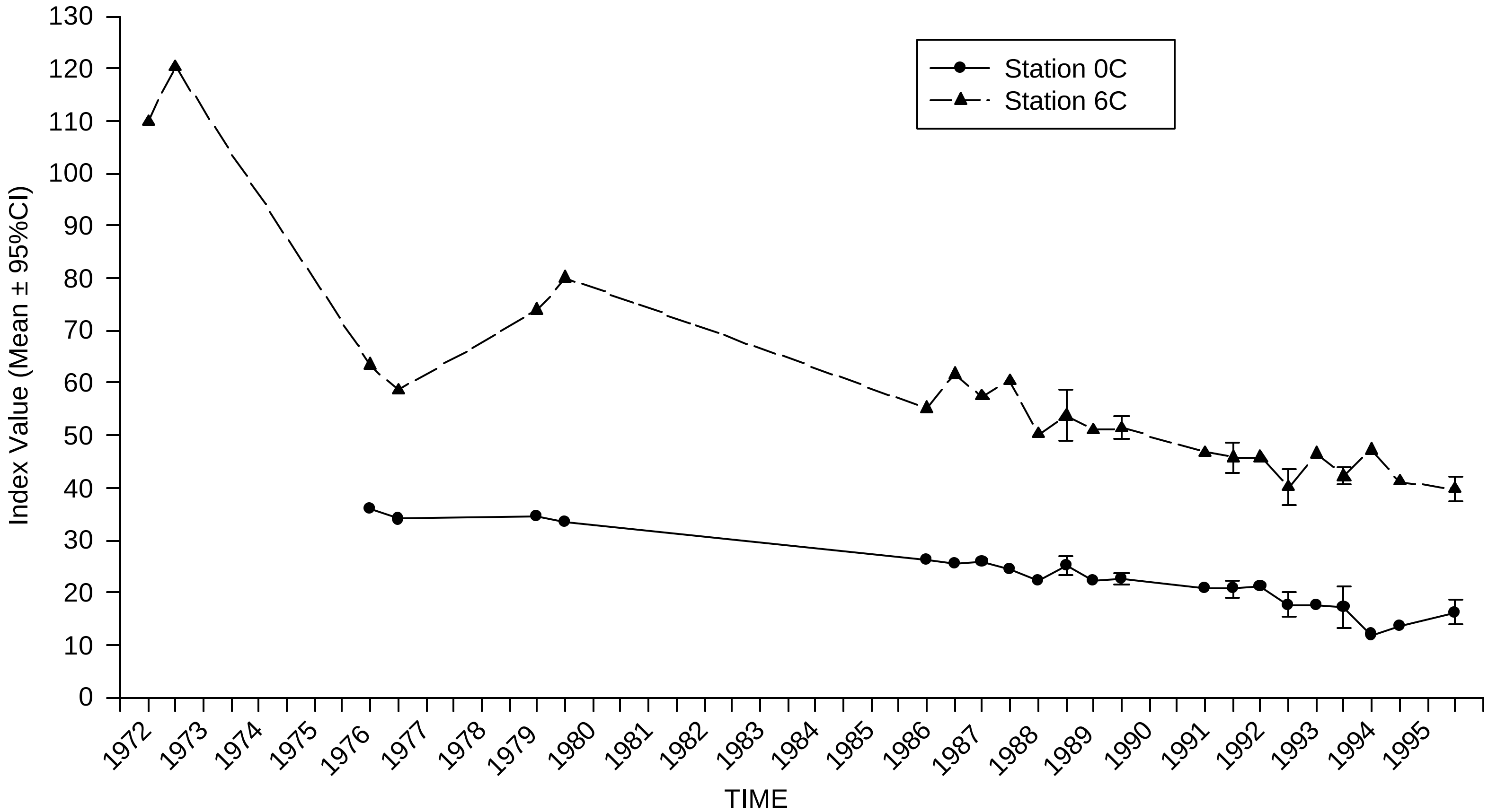


Figure E7. Benthic Response Index values for stations on the Palos Verdes Shelf monitored by the Sanitation Districts of Los Angeles County's from 1972-1995.

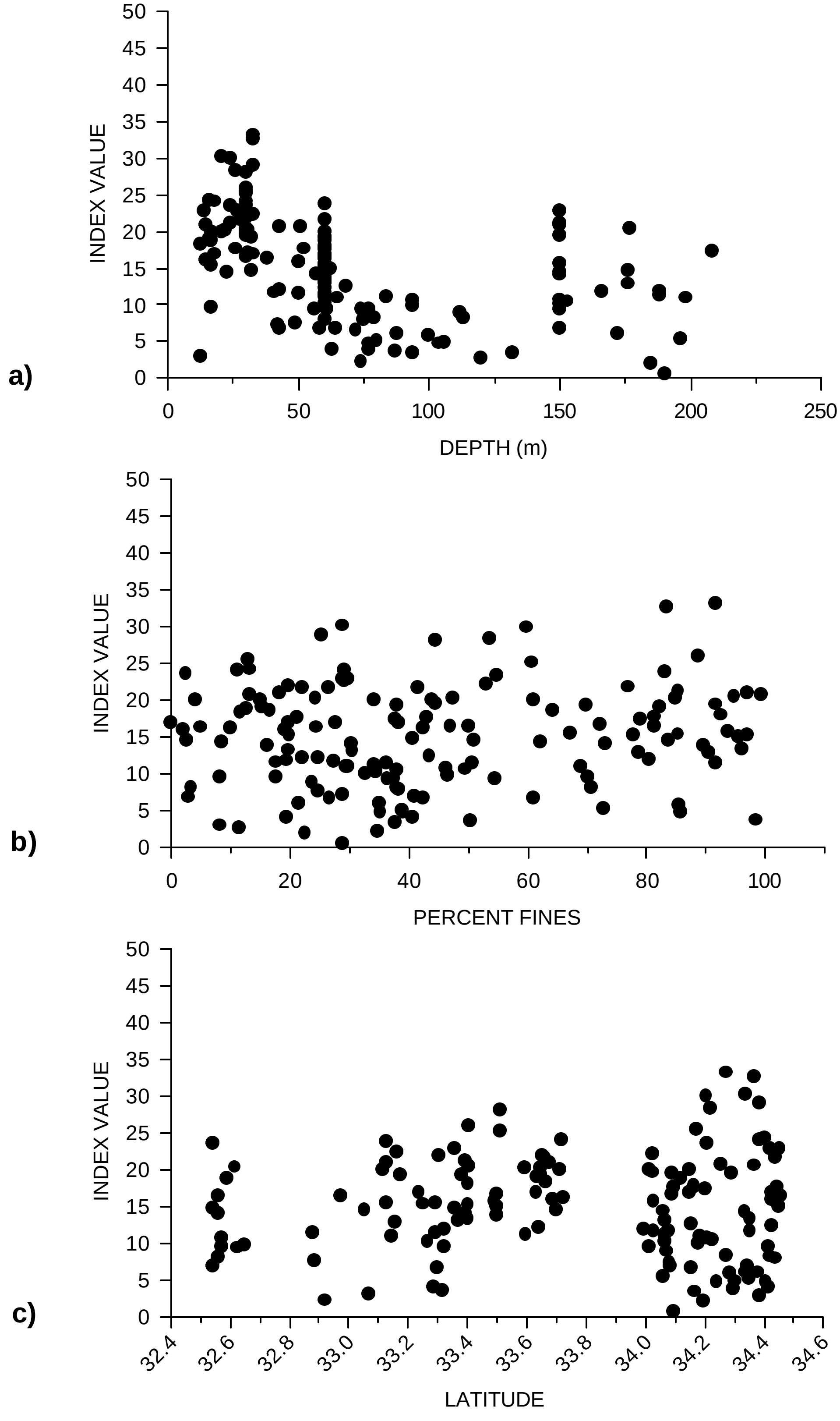


Figure E8. Benthic Response Index Values for reference stations versus: a) depth, b) percent fines and c) latitude.

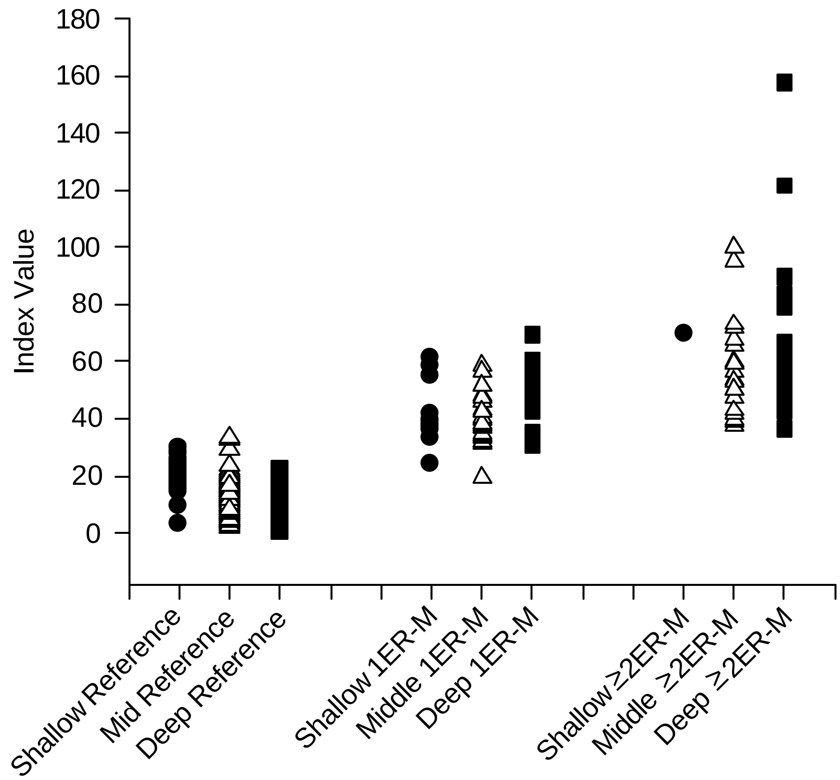


Figure E9. Benthic Response Index values within shallow, mid-depth and deep reference sites and at stations with one or more than two chemicals above the Effects Range Median (ER-M).

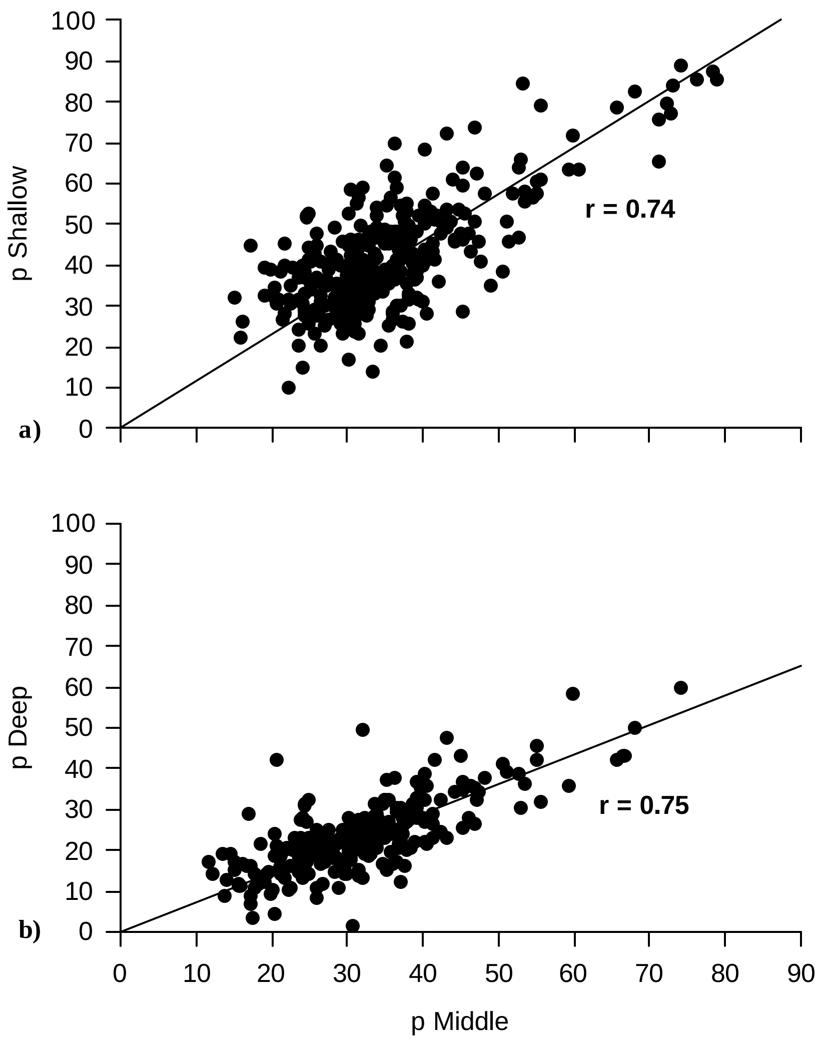


Figure E10. Relationship between the species p values in the mid-depth zone versus a) p value in the shallow zone and b) p value in the deep zone.

Figure E11. The average species range for species in the samples along the pollution gradient in the 25-130 m depth range. The pollution gradient is defined from the ordination space (Figure E2). The range of species steadily increases along the gradient (see Figure E3) up to a gradient value of approximately 85, and then levels off. The leveling off at high pollution levels is due to the addition of a small number of narrow-range species at the highest pollution levels (e.g., Ophryotrocha ABC Complex in Figure E3). The range for a species was computed as the mean distance from the species p_i value along the pollution gradient for samples with abundance >0 for the species.

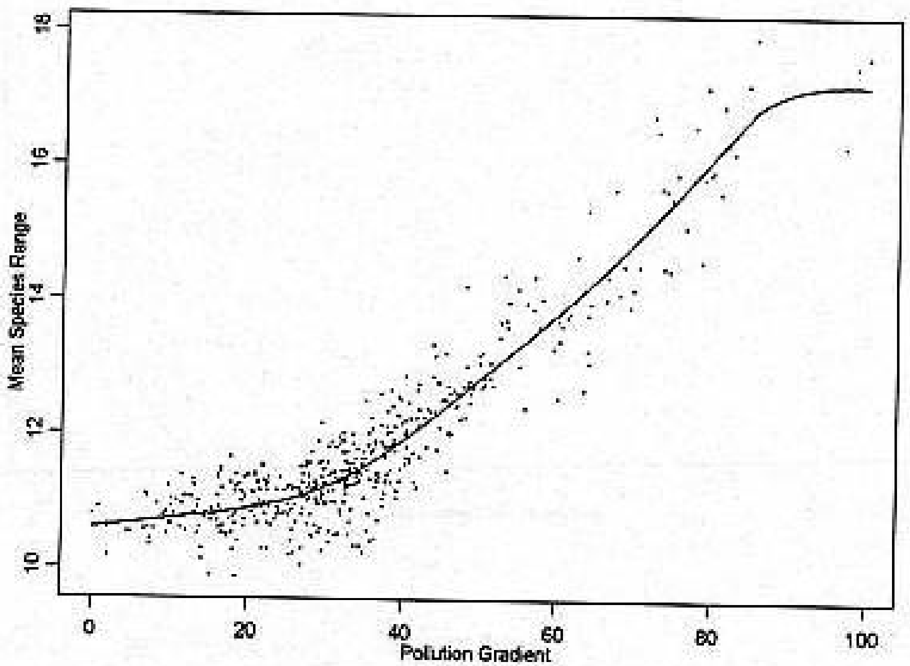


Figure E12. Effect on the Benthic Response Index and Infaunal Trophic Index of dropping the most abundant (top) species in each sample. The horizontal axis indicates the number of species dropped, and the vertical axis gives the correlation between the index value with all species and the index value with the species dropped. Indices were computed from the calibration data.

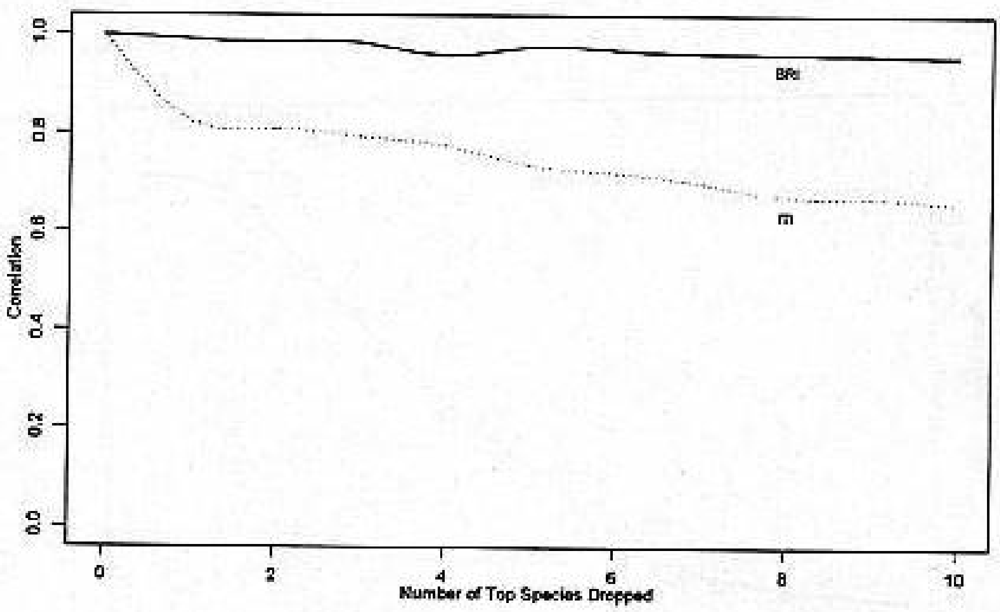


Table E1. List of stations from five Southern California Bight sampling programs used for Index development.

)UdPnatPon space	YeaU	'UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
D	1973	LA	01A	33.7445	118.4468	300	64.50	
D	1973	LA	01B	33.749	118.4447	150	62.50	
D	1973	LA	02A	33.7277	118.4272	300	67.60	
D	1973	LA	02B	33.7325	118.425	150	66.20	
D	1973	LA	03A	33.7192	118.4118	300	77.70	
D	1973	LA	03B	33.7235	118.4083	150	76.70	
D	1973	LA	04A	33.71	118.3895	300	87.00	
D	1973	LA	04B	33.716	118.3867	150	85.20	
D	1973	LA	05A	33.7004	118.3703	300	75.20	
D	1973	LA	05B	33.7084	118.3672	150	95.00	
D	1973	LA	06A	33.7	118.359	300	84.00	
D	1973	LA	06B	33.7042	118.3557	150	74.60	P
D	1973	LA	07A	33.697	118.353	300	79.80	
D	1973	LA	07B	33.701	118.3507	150	97.30	P
D	1973	LA	08A	33.6877	118.338	300	27.30	P
D	1973	LA	08B	33.693	118.3364	150	81.70	P
D	1973	LA	09A	33.6763	118.3225	300	84.50	
D	1973	LA	09B	33.682	118.32	150	82.60	
D	1973	LA	10A	33.6576	118.2998	300	73.70	
D	1973	LA	10B	33.6628	118.297	150	69.30	
D	1985	HY	5C	33.8153	118.5228	184		
D	1985	HY	7B	33.9125	118.5903	186		
D	1985	HY	E06	33.9258	118.5575	144		P
D	1985	LA	00A	33.8192	118.4522	300		
D	1985	LA	00B	33.8117	118.44	150		
D	1985	LA	01A	33.7445	118.4468	300		
D	1985	LA	01B	33.749	118.4447	150		
D	1985	LA	02A	33.7277	118.4272	300		
D	1985	LA	02B	33.7325	118.425	150		
D	1985	LA	03A	33.7192	118.4118	300		
D	1985	LA	03B	33.7235	118.4083	150		
D	1985	LA	04A	33.71	118.3895	300		
D	1985	LA	04B	33.716	118.3867	150		
D	1985	LA	05A	33.7004	118.3703	300		
D	1985	LA	05B	33.7084	118.3672	150		
D	1985	LA	06A	33.7	118.359	300		
D	1985	LA	06B	33.7042	118.3557	150		
D	1985	LA	07A	33.697	118.353	300		
D	1985	LA	07B	33.701	118.3507	150		
D	1985	LA	08A	33.6877	118.338	300		
D	1985	LA	08B	33.693	118.3364	150		
D	1985	LA	09A	33.6763	118.3225	300		
D	1985	LA	09B	33.682	118.32	150		
D	1985	LA	10A	33.6576	118.2998	300		
D	1985	LA	10B	33.6628	118.297	150		
D	1985	OC	24	33.5592	118.0175	200	71.07	
D	1985	OC	25	33.5628	118.0361	200	83.37	
D	1985	OC	27	33.5558	117.9967	200	66.17	
D	1985	OC	39	33.555	117.9744	200	35.49	
D	1985	OC	40	33.5389	117.9958	303	75.84	
D	1985	OC	41	33.5425	118.0183	303	73.94	
D	1985	OC	42	33.5661	118.0433	303	71.12	
D	1985	OC	43	33.5403	117.9725	303	42.70	
D	1985	OC	44	33.5758	118.0894	242	86.72	
D	1985	OC	C4	33.585	117.9278	187	71.55	
D	1985	OC	C5	33.5653	117.9269	324	85.57	
D	1985	SC	U04-	34.419	120.171	150	29.90	U
D	1985	SC	U05-	34.402	120.0655	150	49.80	U
D	1985	SC	U08-	34.2896	119.6889	150	91.60	U
D	1985	SC	U11-	34.1528	119.4179	150	42.30	U
D	1985	SC	U13-	34.0597	119.1728	150	60.50	U
D	1985	SC	U15-	33.998	118.8717	150	48.10	U
D	1985	SC	U50-	33.4904	117.7807	150	96.90	U
D	1985	SC	U52-	33.3933	117.6826	150	85.30	U
D	1985	SC	U54-	33.2662	117.5793	150	32.60	U
D	1985	SC	U57-	33.1268	117.3806	150	96.90	U
D	1985	SC	U60-	32.9134	117.2835	150	87.50	U
D	1985	SC	U61-	32.8249	117.362	150	48.40	U

ıUdPnatPon space	YeaU	ʾUogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
D	1985	SC	U71-	32.5711	117.3221	150	46.20	
D	1990	HY	E01	33.9842	118.7139	150	54.30	
D	1990	HY	E02	33.9778	118.6544	150	53.40	
D	1990	HY	E03	33.9725	118.6122	150	70.50	
D	1990	HY	E04	33.9567	118.5894	150	74.50	
D	1990	HY	E05	33.9422	118.575	150	41.80	
D	1990	HY	E06	33.9258	118.5575	144	82.20	
D	1990	HY	E07	33.9122	118.5714	150	33.10	
D	1990	HY	E08	33.9089	118.5969	150	22.60	
D	1990	HY	E09	33.8231	118.5172	150	95.80	
D	1990	HY	E10	33.8244	118.4631	150	50.00	
D	1990	LA	00A	33.8192	118.4522	300	76.15	
D	1990	LA	00B	33.8117	118.44	150	80.85	
D	1990	LA	01A	33.7445	118.4468	300	69.36	
D	1990	LA	01B	33.749	118.4447	150	54.78	
D	1990	LA	02A	33.7277	118.4272	300	79.28	
D	1990	LA	02B	33.7325	118.425	150	45.06	
D	1990	LA	03A	33.7192	118.4118	300	83.32	
D	1990	LA	03B	33.7235	118.4083	150	88.43	
D	1990	LA	04A	33.71	118.3895	300	88.00	
D	1990	LA	04B	33.716	118.3867	150	87.93	
D	1990	LA	05A	33.7004	118.3703	300	88.96	
D	1990	LA	05B	33.7084	118.3672	150	91.46	
D	1990	LA	06A	33.7	118.359	300	85.12	
D	1990	LA	06B	33.7042	118.3557	150	93.12	
D	1990	LA	07A	33.697	118.353	300	77.12	
D	1990	LA	07B	33.701	118.3507	150	84.18	
D	1990	LA	08A	33.6877	118.338	300	51.80	
D	1990	LA	08B	33.693	118.3364	150	93.86	
D	1990	LA	09A	33.6763	118.3225	300	93.16	
D	1990	LA	09B	33.682	118.32	150	92.40	
D	1990	LA	10A	33.6576	118.2998	300	73.36	
D	1990	LA	10B	33.6628	118.297	150	35.85	
D	1990	OC	24	33.5592	118.0175	200	73.41	
D	1990	OC	25	33.5628	118.0361	200	86.30	
D	1990	OC	27	33.5558	117.9967	200	66.43	
D	1990	OC	39	33.555	117.9744	200	38.41	
D	1990	OC	40	33.5389	117.9958	303	90.16	
D	1990	OC	41	33.5425	118.0183	303	81.60	
D	1990	OC	42	33.5661	118.0433	303	94.82	
D	1990	OC	43	33.5403	117.9725	303	55.38	
D	1990	OC	44	33.5758	118.0894	242	97.79	
D	1990	OC	C4	33.585	117.9278	187	90.16	
D	1990	OC	C5	33.5653	117.9269	324	93.91	
D	1990	SC	U13-	34.0597	119.1728	150	62.10	U
D	1990	SC	U15-	33.998	118.8717	150	46.30	U
D	1990	SC	U50-	33.4904	117.7807	150	93.80	U
D	1990	SC	U52-	33.3933	117.6826	150	73.10	U
D	1990	SC	U60-	32.9134	117.2835	150	85.60	U
D	1990	SC	U61-	32.8249	117.362	150	33.60	U
D	1990	SC	U71-	32.5711	117.3221	150	36.40	
D	1994	PP	1034	33.959667	118.64167	218	99.46	
D	1994	PP	1052	33.9395	118.60717	220	99.92	
D	1994	PP	1056	33.932167	118.56733	145	39.10	
D	1994	PP	1059	33.931167	118.58983	210	72.35	
D	1994	PP	1074	33.9115	118.5815	153	32.41	
D	1994	PP	1078	33.909333	118.603	180	48.50	
D	1994	PP	1120	33.871333	118.62533	161	36.21	
D	1994	PP	1152	33.8445	118.5875	170	43.49	
D	1994	PP	1168	33.83295	118.48772	135	50.28	
D	1994	PP	1169	33.83005	118.5088	135	88.62	
D	1994	PP	1175	33.820667	118.54937	208	56.80	
D	1994	PP	1191	33.784667	118.49258	177	49.97	
D	1994	PP	1195	33.77208	118.47137	172	57.78	
D	1994	PP	1450	33.580117	118.06847	219	64.80	U
D	1994	PP	1469	33.5718	118.04897	162	65.42	U
D	1994	PP	1551	33.35555	117.65028	176	83.69	U
D	1994	PP	1571	33.3206	117.62688	188	80.43	U
D	1994	PP	1655	33.177117	117.46128	196	78.18	U
D	1994	PP	1662	33.159317	117.42712	176	78.66	U
D	1994	PP	1737	32.877833	117.3145	188	50.59	U
D	1994	PP	1874	32.64	117.43017	151	10.61	

UdPnatPon space	YeaU	UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
D	1994	PP	1888	32.63	117.349	179	60.69	
D	1994	PP	1905	32.618667	117.42233	150	18.73	
D	1994	PP	1908	32.616833	117.34667	177	47.42	U
D	1994	PP	1916	32.6085	117.39833	138		U
D	1994	PP	255	34.38	120.3991	172	21.56	U
D	1994	PP	381	34.33125	119.78365	156	82.22	U
D	1994	PP	604	34.22755	119.61892	153	37.92	U
D	1994	PP	670	34.202817	119.66537	208	37.77	U
D	1994	PP	682	34.19715	119.63373	185	22.55	U
D	1994	PP	708	34.184917	119.56937	198	29.82	U
D	1994	PP	739	34.164783	119.4461	132	37.77	U
D	1994	PP	753	34.1557	119.42623	137	38.75	U
D	1994	PP	815	34.0953	119.29272	190	28.96	U
D	1994	PP	834	34.077383	119.08557	175	95.97	
D	1994	PP	859	34.058683	119.20637	196	72.86	U
D	1994	PP	976	33.9944	119.00008	166	19.44	U
M	1973	LA	01C	33.7585	118.4398	60	75.60	
M	1973	LA	02C	33.7393	118.4222	60	89.10	
M	1973	LA	03C	33.7287	118.4032	60	91.40	
M	1973	LA	04C	33.7233	118.3833	60	93.80	
M	1973	LA	05C	33.7152	118.3648	60	89.90	
M	1973	LA	06C	33.7085	118.3533	60	94.50	
M	1973	LA	07C	33.7057	118.3478	60	96.30	
M	1973	LA	08C	33.6985	118.3332	60	91.10	
M	1973	LA	09C	33.689	118.3167	60	92.50	
M	1973	LA	10C	33.6696	118.2955	60	67.30	
M	1977	SC	U01-60	34.4292	120.4458	60		
M	1977	SC	U02-60	34.3681	120.3667	60		
M	1977	SC	U03-60	34.4411	120.2653	60		
M	1977	SC	U04-60	34.4278	120.1667	60		U
M	1977	SC	U05-60	34.4375	120.0672	60		U
M	1977	SC	U06-60	34.4045	119.9467	60		U
M	1977	SC	U07-60	34.3806	119.7819	60		U
M	1977	SC	U08-60	34.3528	119.6875	60		U
M	1977	SC	U09-60	34.3042	119.5	60		
M	1977	SC	U10-60	34.225	119.4581	60		
M	1977	SC	U11-60	34.1639	119.3861	60		U
M	1977	SC	U12-60	34.1208	119.3056	60		U
M	1977	SC	U13-60	34.0639	119.1656	60		U
M	1977	SC	U14-60	34.0278	118.9569	60		U
M	1977	SC	U15-60	34.0125	118.8589	60		U
M	1977	SC	U16-60	33.9986	118.7986	60		U
M	1977	SC	U17-60	33.9925	118.7736	60		U
M	1977	SC	U18-60	33.9967	118.7322	60		U
M	1977	SC	U19-60	34	118.6875	60		U
M	1977	SC	U20-60	34	118.6425	60		U
M	1977	SC	U21-60	33.9925	118.5992	60		U
M	1977	SC	U22-60	33.9722	118.5647	60		U
M	1977	SC	U23-60	33.9433	118.5406	60		
M	1977	SC	U25-60	33.91	118.525	60		P
M	1977	SC	U26-60	33.8925	118.525	60		
M	1977	SC	U27-60	33.8722	118.4722	60		
M	1977	SC	U28-60	33.845	118.4433	60		
M	1977	SC	U29-60	33.8042	118.4375	60		
M	1977	SC	U30-60	33.7833	118.45	60		
M	1977	SC	U31-60	33.7317	118.415	60		P
M	1977	SC	U32-60	33.7236	118.3825	60		P
M	1977	SC	U33-60	33.7133	118.3583	60		P
M	1977	SC	U35-60	33.6883	118.315	60		
M	1977	SC	U36-60	33.6458	118.2642	60		
M	1977	SC	U37-60	33.6056	118.2467	60		
M	1977	SC	U38-60	33.5767	118.1806	60		
M	1977	SC	U39-60	33.5967	118.0636	60		
M	1977	SC	U40-60	33.5867	118.0458	60		
M	1977	SC	U41-60	33.5825	118.0347	60		
M	1977	SC	U42-60	33.5806	118.025	60		
M	1977	SC	U43-60	33.5792	118.0139	60		
M	1977	SC	U44-60	33.5722	118.0111	60		
M	1977	SC	U45-60	33.5761	118.0089	60		P
M	1977	SC	U46-60	33.5744	117.9969	60		
M	1977	SC	U47-60	33.5731	117.9931	60		
M	1977	SC	U48-60	33.5703	117.9825	60		

UdPnatPon space	YeaU	UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
M	1977	SC	U49-60	33.5861	117.8922	60		
M	1977	SC	U50-60	33.5017	117.775	60		U
M	1977	SC	U51-60	33.3822	117.7333	60		U
M	1977	SC	U52-60	33.4017	117.6583	60		U
M	1977	SC	U53-60	33.3689	117.6358	60		U
M	1977	SC	U54-60	33.2933	117.5583	60		U
M	1977	SC	U55-60	33.2367	117.4958	60		U
M	1977	SC	U56-60	33.1767	117.43	60		U
M	1977	SC	U57-60	33.1267	117.355	60		U
M	1977	SC	U58-60	33.0533	117.3283	60		U
M	1977	SC	U59-60	32.975	117.3083	60		U
M	1977	SC	U60-60	32.8958	117.275	60		U
M	1977	SC	U61-60	32.825	117.32	60		U
M	1977	SC	U62-60	32.7567	117.3067	60		U
M	1977	SC	U63-60	32.6883	117.2883	60		
M	1977	SC	U64-60	32.6806	117.2858	60		
M	1977	SC	U68-60	32.6639	117.2808	60		
M	1977	SC	U69-60	32.6556	117.2783	60		
M	1977	SC	U70-60	32.6	117.2708	60		
M	1977	SC	U71-60	32.5583	117.265	60		
M	1985	HY	1A	33.932	118.5228	52		
M	1985	HY	1B	33.9639	118.5228	44		
M	1985	HY	2A	33.925	118.5075	52		
M	1985	HY	3A	33.9125	118.5031	49		
M	1985	HY	3B	33.9125	118.4747	39		
M	1985	HY	4A	33.8989	118.5075	58		
M	1985	HY	4B	33.8742	118.4758	75		
M	1985	HY	4C	33.8444	118.4394	78		
M	1985	HY	5A	33.8903	118.5228	57		
M	1985	HY	5B	33.8575	118.5228	72		
M	1985	HY	6A	33.897	118.5403	64		
M	1985	HY	6B	33.8742	118.57	77		
M	1985	HY	7A	33.9125	118.5403	64		
M	1985	HY	8A	33.9275	118.5403	64		
M	1985	HY	C01	33.9969	118.7139	60		
M	1985	HY	Z02	33.9075	118.5244	61		
M	1985	LA	00C	33.8053	118.4287	60		
M	1985	LA	01C	33.7585	118.4398	60		
M	1985	LA	02C	33.7393	118.4222	60		
M	1985	LA	03C	33.7287	118.4032	60		
M	1985	LA	04C	33.7233	118.3833	60		
M	1985	LA	05C	33.7152	118.3648	60		
M	1985	LA	06C	33.7085	118.3533	60		P
M	1985	LA	07C	33.7057	118.3478	60		P
M	1985	LA	08C	33.6985	118.3332	60		
M	1985	LA	09C	33.689	118.3167	60		
M	1985	LA	10C	33.6696	118.2955	60		
M	1985	OC	0	33.5753	118.0086	56		
M	1985	OC	1	33.5772	118.0147	56		
M	1985	OC	10	33.5808	118.0333	60	28.41	
M	1985	OC	12	33.5728	117.9831	58	17.90	
M	1985	OC	13	33.5875	118.0481	59	33.11	
M	1985	OC	17	33.5653	118.0011	91	19.30	
M	1985	OC	18	33.5656	118.0133	91	22.48	
M	1985	OC	19	33.5678	118.0186	91	27.41	
M	1985	OC	2	33.5819	118.0069	49		
M	1985	OC	20	33.5753	118.0361	100	56.75	
M	1985	OC	21	33.5889	118.0303	45	28.72	
M	1985	OC	22	33.5836	117.9839	45	38.02	
M	1985	OC	23	33.5661	117.9844	100	25.91	
M	1985	OC	29	33.5836	118.0508	100	59.23	
M	1985	OC	3	33.5722	118.01	60		
M	1985	OC	30	33.5922	118.0475	45	28.03	
M	1985	OC	31	33.5875	117.9625	45	34.90	
M	1985	OC	32	33.5778	117.9619	59	9.23	
M	1985	OC	33	33.5728	117.9633	100	15.58	
M	1985	OC	36	33.5886	117.9567	45	33.10	
M	1985	OC	37	33.5806	117.9553	56	18.73	
M	1985	OC	38	33.5786	117.9536	100	59.56	
M	1985	OC	4	33.5747	117.995	56		
M	1985	OC	5	33.5783	118.0258	59		
M	1985	OC	6	33.5908	118.0167	36		

)UdPnatPon space	YeaU›	UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	:nd PoPntc
M	1985	OC	7	33.59	118.0047	38		
M	1985	OC	8	33.5844	117.9917	44		
M	1985	OC	9	33.5722	117.9906	59		
M	1985	OC	C	33.5992	118.0883	56	18.51	
M	1985	OC	C2	33.6025	117.9322	55	89.15	
M	1985	OC	C3	33.5992	117.9325	98	75.32	
M	1985	SC	U04-60	34.4278	120.1667	60	38.40	U
M	1985	SC	U05-60	34.4375	120.0672	60	42.40	U
M	1985	SC	U08-60	34.3528	119.6875	60	17.70	U
M	1985	SC	U11-60	34.1639	119.3861	60	79.10	U
M	1985	SC	U13-60	34.0639	119.1656	60	34.40	U
M	1985	SC	U15-60	34.0125	118.8589	60	66.50	U
M	1985	SC	U50-60	33.5017	117.775	60	95.50	U
M	1985	SC	U52-60	33.4017	117.6583	60	96.80	U
M	1985	SC	U54-60	33.2933	117.5583	60	91.60	U
M	1985	SC	U57-60	33.1267	117.355	60	83.20	U
M	1985	SC	U60-60	32.8958	117.275	60	7.60	U
M	1985	SC	U61-60	32.825	117.32	60	47.70	U
M	1985	SC	U71-60	32.5583	117.265	60	3.40	
M	1985	SD	A02	32.6562	117.278	59	50.05	
M	1985	SD	A03	32.6517	117.2972	80	77.84	
M	1985	SD	A04	32.6845	117.307	80	66.28	
M	1985	SD	A05	32.6887	117.2878	62	65.68	
M	1985	SD	A08	32.664	117.2807	63	56.15	
M	1985	SD	A09	32.6805	117.2853	63	50.44	
M	1985	SD	A10	32.6583	117.2688	46	29.08	
M	1985	SD	A11	32.6663	117.2712	49	43.94	
M	1985	SD	A12	32.6745	117.2737	46	11.80	
M	1985	SD	A13	32.6828	117.2762	47	27.02	
M	1985	SD	A14	32.6905	117.2772	47	26.97	
M	1985	SD	A15	32.6683	117.2817	60	44.13	
M	1985	SD	A16	32.6763	117.2842	60	40.31	
M	1985	SD	B01	32.5833	117.2697	62		
M	1985	SD	B03	32.757	117.3063	59	47.69	
M	1985	SD	B04	32.7517	117.3313	79	82.91	
M	1985	SD	B05	32.8208	117.3267	60	49.51	
M	1990	HY	B01	34.0081	118.7139	45	85.70	
M	1990	HY	B02	34.0117	118.6464	45	87.80	
M	1990	HY	B03	34.0069	118.5961	45	64.60	
M	1990	HY	B04	33.9867	118.5531	45	56.50	
M	1990	HY	B05	33.9667	118.5292	45	51.20	
M	1990	HY	B06	33.9411	118.5094	45	50.60	
M	1990	HY	B07	33.9214	118.5053	45	57.00	
M	1990	HY	B08	33.8967	118.4742	45	35.70	
M	1990	HY	B09	33.8792	118.4567	45	31.40	
M	1990	HY	B10	33.8411	118.4167	45	20.70	
M	1990	HY	C01	33.9969	118.7139	60	87.40	
M	1990	HY	C02	33.9986	118.6494	60	82.90	
M	1990	HY	C03	33.9925	118.6031	60	31.40	
M	1990	HY	C04	33.9714	118.5667	60	21.50	
M	1990	HY	C05	33.9533	118.5542	60	17.00	
M	1990	HY	C06	33.9281	118.5347	60	28.00	
M	1990	HY	C07	33.8931	118.5375	60	11.80	
M	1990	HY	C08	33.8792	118.5236	60	24.20	
M	1990	HY	C09A	33.8547	118.4381	60	25.50	
M	1990	HY	C10	33.8481	118.4178	60	63.30	
M	1990	HY	D01	33.9078	118.55	74	3.50	
M	1990	HY	D02	33.8944	118.5889	80	53.60	
M	1990	HY	D03	33.8631	118.5875	80	21.40	
M	1990	HY	D04	33.8519	118.525	80	25.40	
M	1990	HY	D05	33.8486	118.4803	80	56.00	
M	1990	HY	Z01	33.9147	118.525	60	70.30	
M	1990	HY	Z02	33.9075	118.5244	61	61.20	
M	1990	LA	00C	33.8053	118.4287	60	37.90	
M	1990	LA	01C	33.7585	118.4398	60	55.43	
M	1990	LA	02C	33.7393	118.4222	60	60.79	
M	1990	LA	03C	33.7287	118.4032	60	58.66	
M	1990	LA	04C	33.7233	118.3833	60	78.26	
M	1990	LA	05C	33.7152	118.3648	60	85.55	
M	1990	LA	06C	33.7085	118.3533	60	81.03	P
M	1990	LA	07C	33.7057	118.3478	60	85.55	P
M	1990	LA	08C	33.6985	118.3332	60	58.74	

UdPnatPon space	YeaU	UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
M	1990	LA	09C	33.689	118.3167	60	79.82	
M	1990	LA	10C	33.6696	118.2955	60	47.03	
M	1990	OC	0	33.5753	118.0086	56		
M	1990	OC	1	33.5772	118.0147	56		
M	1990	OC	10	33.5808	118.0333	60	38.42	
M	1990	OC	12	33.5728	117.9831	58	12.41	
M	1990	OC	13	33.5875	118.0481	59	32.88	
M	1990	OC	17	33.5653	118.0011	91	20.46	
M	1990	OC	18	33.5656	118.0133	91	27.87	
M	1990	OC	19	33.5678	118.0186	91	35.63	
M	1990	OC	2	33.5819	118.0069	49		
M	1990	OC	20	33.5753	118.0361	100	58.27	
M	1990	OC	21	33.5889	118.0303	45	34.85	
M	1990	OC	22	33.5836	117.9839	45	33.95	
M	1990	OC	23	33.5661	117.9844	100	25.15	
M	1990	OC	29	33.5836	118.0508	100	57.63	
M	1990	OC	3	33.5722	118.01	60		
M	1990	OC	30	33.5922	118.0475	45	27.00	
M	1990	OC	31	33.5875	117.9625	45	37.99	
M	1990	OC	32	33.5778	117.9619	59	15.17	
M	1990	OC	33	33.5728	117.9633	100	26.18	
M	1990	OC	36	33.5886	117.9567	45	47.48	
M	1990	OC	37	33.5806	117.9553	56	20.05	
M	1990	OC	38	33.5786	117.9536	100	58.93	
M	1990	OC	4	33.5747	117.995	56		
M	1990	OC	5	33.5783	118.0258	59		
M	1990	OC	6	33.5908	118.0167	36		
M	1990	OC	7	33.59	118.0047	38		
M	1990	OC	8	33.5844	117.9917	44		
M	1990	OC	9	33.5722	117.9906	59		
M	1990	OC	C	33.5992	118.0883	56	18.30	
M	1990	OC	C2	33.6025	117.9322	55	93.04	
M	1990	OC	C3	33.5992	117.9325	98	91.81	
M	1990	OC	CON	33.5956	118.0636	59	20.66	
M	1990	OC	ZB	33.5747	118.0033	56	17.80	
M	1990	OC	ZB2	33.5761	118.0086	56	19.32	
M	1990	SC	U13-60	34.0639	119.1656	60	30.50	U
M	1990	SC	U15-60	34.0125	118.8589	60	60.90	U
M	1990	SC	U50-60	33.5017	117.775	60	89.60	U
M	1990	SC	U52-60	33.4017	117.6583	60	96.10	U
M	1990	SC	U60-60	32.8958	117.275	60	37.20	U
M	1990	SC	U61-60	32.825	117.32	60	45.40	U
M	1990	SC	U71-60	32.5583	117.265	60	5.10	
M	1990	SD	A02	32.6562	117.278	59	49.53	
M	1990	SD	A03	32.6517	117.2972	80	72.28	
M	1990	SD	A04	32.6845	117.307	80	71.35	
M	1990	SD	A05	32.6887	117.2878	62	47.51	
M	1990	SD	A08	32.664	117.2807	63	35.17	
M	1990	SD	A09	32.6805	117.2853	63	56.19	
M	1990	SD	A10	32.6583	117.2688	46	4.69	
M	1990	SD	A11	32.6663	117.2712	49	35.92	
M	1990	SD	A12	32.6745	117.2737	46	2.96	
M	1990	SD	A13	32.6828	117.2762	47	14.25	
M	1990	SD	A14	32.6905	117.2772	47	30.73	
M	1990	SD	A15	32.6683	117.2817	60	43.63	
M	1990	SD	A16	32.6763	117.2842	60	40.15	
M	1990	SD	B01	32.5833	117.2697	62	5.74	
M	1990	SD	B03	32.757	117.3063	59	49.70	
M	1990	SD	B04	32.7517	117.3313	79	71.64	
M	1990	SD	B05	32.8208	117.3267	60	38.57	
M	1990	SD	B07	32.7633	117.2902	45	30.06	
M	1994	PP	1001	33.985333	118.60767	89	40.57	
M	1994	PP	1003	33.984	118.569	53	35.41	U
M	1994	PP	1005	33.9825	118.53733	40	32.16	U
M	1994	PP	1014	33.974167	118.55883	53	35.81	
M	1994	PP	1027	33.948667	118.51383	45	57.55	
M	1994	PP	103	34.42055	120.18388	93	41.77	
M	1994	PP	1040	33.951667	118.5505	58	41.63	
M	1994	PP	1045	33.948	118.53833	54	37.12	U
M	1994	PP	1049	33.943833	118.53683	55	34.37	U
M	1994	PP	1065	33.923167	118.50267	49	50.47	
M	1994	PP	1072	33.9165	118.5465	71	35.69	

)UdPnatPon space	YeaU	)UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
M	1994	PP	1085	33.9015	118.47883	47	40.14	
M	1994	PP	1091	33.896167	118.5415	64	12.58	U
M	1994	PP	1096	33.89383	118.51916	56	45.89	
M	1994	PP	1103	33.885833	118.55267	70	44.71	
M	1994	PP	1106	33.883	118.61433	84	45.05	
M	1994	PP	1108	33.882833	118.49717	58	59.66	
M	1994	PP	1109	33.8825	118.51733	58	25.39	
M	1994	PP	1110	33.879833	118.56933	75	41.18	
M	1994	PP	1118	33.874667	118.61433	83	12.09	
M	1994	PP	1119	33.872167	118.46367	60	34.25	
M	1994	PP	112	34.417767	120.07648	79	37.86	U
M	1994	PP	1121	33.871	118.49133	64	47.47	
M	1994	PP	1122	33.870667	118.481	78	67.15	
M	1994	PP	1126	33.867167	118.48583	84	74.59	
M	1994	PP	1128	33.864667	118.55833	75	52.13	
M	1994	PP	1142	33.8523	118.46112	75	46.63	
M	1994	PP	1146	33.851167	118.55283	79	43.33	
M	1994	PP	1148	33.850333	118.51733	100	81.57	
M	1994	PP	115	34.416383	120.33678	63	19.49	U
M	1994	PP	1150	33.847667	118.5515	82	40.18	
M	1994	PP	1170	33.82975	118.44917	83	30.17	
M	1994	PP	1173	33.8258	118.41622	60	35.97	
M	1994	PP	1187	33.789167	118.44522	54	33.62	
M	1994	PP	1214	33.727583	118.4142	104	62.20	
M	1994	PP	122	34.414717	120.41442	77	17.69	U
M	1994	PP	1267	33.689133	118.30055	43	40.66	
M	1994	PP	1340	33.640917	118.23883	43	24.65	U
M	1994	PP	136	34.40985	119.94912	57	67.32	U
M	1994	PP	1418	33.597067	118.10977	84	29.50	U
M	1994	PP	1426	33.5937	118.05247	45	25.35	U
M	1994	PP	1455	33.577083	118.03025	72	25.92	U
M	1994	PP	1468	33.572283	117.96412	104	34.99	U
M	1994	PP	150	34.405883	120.40885	77	35.22	U
M	1994	PP	1560	33.338167	117.61928	70	67.34	
M	1994	PP	1570	33.322633	117.58872	56	70.24	U
M	1994	PP	1574	33.317967	117.61265	94	50.44	U
M	1994	PP	1585	33.29895	117.58048	72	60.89	U
M	1994	PP	1595	33.2856	117.56975	77	40.70	U
M	1994	PP	1667	33.143983	117.37797	65	68.96	U
M	1994	PP	1728	32.9215	117.2955	74	34.80	U
M	1994	PP	1734	32.885	117.27217	49	24.87	U
M	1994	PP	1757	32.826333	117.324	56	36.47	U
M	1994	PP	1767	32.805	117.34683	87	58.54	U
M	1994	PP	1769	32.803167	117.3285	74	50.32	U
M	1994	PP	1770	32.796333	117.35967	94	39.49	U
M	1994	PP	1774	32.793	117.3705	103	35.08	
M	1994	PP	1794	32.764	117.3665	97	30.15	U
M	1994	PP	1797	32.757667	117.33783	85	65.72	U
M	1994	PP	1825	32.707667	117.30433	71	51.66	U
M	1994	PP	1828	32.704	117.31933	85	59.12	U
M	1994	PP	1833	32.694333	117.32333	91	55.67	U
M	1994	PP	1836	32.682333	117.27467	72	68.77	U
M	1994	PP	1839	32.6775	117.27467	42	13.30	U
M	1994	PP	1850	32.661333	117.32933	106	42.22	U
M	1994	PP	1871	32.642	117.31167	89	44.77	U
M	1994	PP	1892	32.6275	117.2745	61	54.45	U
M	1994	PP	2001	32.5455	117.2325	43	3.06	U
M	1994	PP	228	34.388367	119.7885	49	59.27	U
M	1994	PP	232	34.386733	119.8142	56	55.99	U
M	1994	PP	252	34.380933	119.62662	42	99.00	U
M	1994	PP	289	34.3694	119.64722	51	94.73	U
M	1994	PP	32	34.447733	120.22302	62	40.71	U
M	1994	PP	334	34.35115	119.7759	80	38.98	U
M	1994	PP	360	34.341217	119.69108	64	26.66	U
M	1994	PP	365	34.337667	119.76462	88	35.02	U
M	1994	PP	371	34.335167	119.64275	57	30.40	U
M	1994	PP	38	34.4442	120.06448	52	43.01	U
M	1994	PP	398	34.324233	119.53312	53	99.97	
M	1994	PP	407	34.321567	119.56273	62	99.50	
M	1994	PP	446	34.301617	119.68037	106	85.62	U
M	1994	PP	460	34.29385	119.60048	87	98.36	U
M	1994	PP	474	34.28665	119.5107	70	99.96	

UdPnatPon space	YeaU	UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
M	1994	PP	480	34.284883	119.64237	100	85.39	U
M	1994	PP	503	34.2729	119.57535	90	91.04	
M	1994	PP	535	34.25615	119.53995	82	98.79	
M	1994	PP	537	34.25433	119.43502	43	99.30	U
M	1994	PP	542	34.254017	119.49203	68	92.46	
M	1994	PP	577	34.240083	119.59933	104	39.05	U
M	1994	PP	59	34.436667	120.23307	75	38.22	U
M	1994	PP	60	34.4361	120.00448	45	37.06	U
M	1994	PP	661	34.205267	119.50637	94	49.38	U
M	1994	PP	714	34.177817	119.45438	94	46.56	U
M	1994	PP	757	34.152	119.37165	68	43.46	U
M	1994	PP	827	34.082433	119.21852	58	40.87	U
M	1994	PP	830	34.080783	119.16953	42	28.91	U
M	1994	PP	831	34.079567	119.1572	41	27.48	U
M	1994	PP	846	34.065067	119.11555	63	29.48	
M	1994	PP	85	34.426533	120.41188	50	19.22	U
M	1994	PP	890	34.02735	118.93965	50	36.28	U
M	1994	PP	9	34.45845	120.14752	38	24.54	U
M	1994	PP	916	34.015833	118.63383	40	63.61	U
M	1994	PP	918	34.014167	118.69633	36	59.12	U
M	1994	PP	920	34.013333	118.66217	42	70.95	U
M	1994	PP	921	34.013117	118.93952	74	37.50	U
M	1994	PP	936	34.007833	118.68317	48	71.75	U
M	1994	PP	937	34.006667	119.02963	84		U
M	1994	PP	942	34.006667	118.7205	45	68.09	U
M	1994	PP	943	34.0065	118.59533	43	52.10	
M	1994	PP	947	34.005317	118.91848	90	35.65	U
M	1994	PP	949	34.003833	118.6385	54	69.86	U
M	1994	PP	960	33.998833	118.59433	51	42.53	U
M	1994	PP	972	33.995667	118.67217	49	62.50	
M	1994	PP	977	33.9935	118.62283	62	47.08	
M	1994	PP	988	33.990167	118.79767	64	31.45	U
M	1994	PP	993	33.988667	118.5925	60	36.00	
M	1994	PP	997	33.987667	118.6685	78	54.83	U
M. D	1985	HY	8B	33.9494	118.57	117		
M. D	1985	HY	8C	33.9797	118.6047	112		
M. D	1994	PP	1028	33.965833	118.58817	126	70.05	
M. D	1994	PP	1067	33.922833	118.55417	110	25.90	
M. D	1994	PP	1131	33.862	118.61133	125		U
M. D	1994	PP	1159	33.836867	118.43758	127	42.18	
M. D	1994	PP	1162	33.834617	118.52512	121	71.06	
M. D	1994	PP	1444	33.584917	117.9315	122	50.19	U
M. D	1994	PP	1903	32.619333	117.335	111	44.73	U
M. D	1994	PP	245	34.38245	120.41465	120	11.59	U
M. D	1994	PP	499	34.274467	119.64338	113	70.65	U
M. D	1994	PP	823	34.070433	119.25042	112	23.71	U
S	1985	HY	A02	33.9186	118.4444	17		
S	1985	HY	DN01	34.0236	118.6	24		
S	1985	HY	DN03	33.9797	118.5075	23		
S	1985	HY	DN06	33.9033	118.4558	24		
S	1985	HY	DN08	33.8503	118.4167	24		
S	1985	SD	B02	32.7667	117.2667	15	6.77	
S	1990	HY	A01	33.9853	118.4947	17	1.20	
S	1990	HY	A02	33.9186	118.4444	17	7.80	
S	1990	HY	A03	33.8672	118.4167	18	10.80	
S	1994	PP	1019	33.970667	118.48	15	12.06	U
S	1994	PP	1025	33.968333	118.476	14	6.03	U
S	1994	PP	1046	33.947667	118.46017	12	14.75	U
S	1994	PP	1081	33.904667	118.44067	15	5.14	U
S	1994	PP	1090	33.897167	118.442	18	5.96	U
S	1994	PP	1123	33.87095	118.4187	15	8.86	U
S	1994	PP	1208	33.73405	118.14513	13	76.35	
S	1994	PP	1222	33.722033	118.20733	15	9.93	
S	1994	PP	1223	33.72255	118.12125	12	25.06	U
S	1994	PP	1224	33.721583	118.13125	14	4.62	U
S	1994	PP	1227	33.717833	118.16028	18	29.16	U
S	1994	PP	1236	33.710533	118.24497	17	4.19	U
S	1994	PP	1256	33.698117	118.18613	23	8.58	U
S	1994	PP	1272	33.686867	118.09065	16	2.01	U
S	1994	PP	1287	33.67783	118.067	15	13.39	U
S	1994	PP	1300	33.6664	118.10862	24	18.24	U
S	1994	PP	1306	33.665	118.04593	13	11.64	U

UdPnatPon space	YeaU	UogUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPntc
S	1994	PP	1348	33.635533	118.01522	16	12.60	U
S	1994	PP	1378	33.615083	117.97435	17	16.69	U
S	1994	PP	1399	33.606583	117.95763	16	9.73	U
S	1994	PP	1401	33.605033	117.97145	22	31.68	
S	1994	PP	1424	33.59475	117.92222	22	15.16	U
S	1994	PP	1550	33.3572	117.58207	14	29.26	U
S	1994	PP	161	34.403833	119.78115	16	13.35	U
S	1994	PP	1617	33.252833	117.46823	17	19.89	U
S	1994	PP	1634	33.213183	117.42523	14	24.27	U
S	1994	PP	1635	33.213017	117.41882	13	17.07	U
S	1994	PP	1650	33.182317	117.40057	16	18.85	U
S	1994	PP	1654	33.1793	117.39853	17	18.16	U
S	1994	PP	1684	33.070983	117.31602	13	8.15	U
S	1994	PP	1739	32.8715	117.25667	21	14.23	U
S	1994	PP	1776	32.7905	117.28283	24	11.81	U
S	1994	PP	1780	32.784167	117.26817	15	6.56	U
S	1994	PP	1793	32.76583	117.27366	22	8.77	U
S	1994	PP	1799	32.754833	117.26917	17	7.88	U
S	1994	PP	1804	32.7505	117.2785	24	12.67	U
S	1994	PP	1811	32.739167	117.272	16	6.88	U
S	1994	PP	1867	32.647	117.18733	17	8.35	U
S	1994	PP	1944	32.59	117.16117	17	16.65	U
S	1994	PP	366	34.337483	119.44682	21	28.81	U
S	1994	PP	530	34.258167	119.32553	20	94.67	U
S	1994	PP	533	34.25745	119.32988	21	78.87	U
S	1994	PP	540	34.2541	119.30723	19	94.59	U
S	1994	PP	552	34.250133	119.28585	15	37.34	U
S	1994	PP	560	34.246067	119.28293	15	22.67	U
S	1994	PP	595	34.232533	119.29198	17	51.29	U
S	1994	PP	617	34.223	119.2823	15	36.68	U
S	1994	PP	652	34.2082	119.34722	24	54.76	U
S	1994	PP	665	34.204467	119.3463	24	59.79	U
S	1994	PP	758	34.1509	119.27972	18	27.68	U
S	1994	PP	759	34.150733	119.29808	21	43.87	U
S	1994	PP	820	34.088883	119.07395	10	8.76	U
S	1994	PP	884	34.0295	118.63367	20	21.26	
S	1994	PP	886	34.0285	118.66917	16	29.94	
S	1994	PP	894	34.024833	118.66533	22	53.17	
S	1994	PP	897	34.024333	118.59733	23	49.45	
S	1994	PP	900	34.023	118.74683	18	34.30	
S	1994	PP	902	34.022333	118.70383	18	35.53	U
S	1994	PP	903	34.021833	118.68167	22	41.28	
S. M	1973	LA	01D	33.767	118.4358	30	4.70	
S. M	1973	LA	02D	33.7448	118.4202	30	43.10	
S. M	1973	LA	03D	33.7327	118.3998	30	37.00	
S. M	1973	LA	04D	33.7312	118.3793	30	70.10	P
S. M	1973	LA	05D	33.7233	118.3618	30	33.60	P
S. M	1973	LA	06D	33.7172	118.347	30	43.10	P
S. M	1973	LA	07D	33.7138	118.3425	30	22.90	P
S. M	1973	LA	08D	33.7073	118.3292	30	58.20	P
S. M	1973	LA	09D	33.7002	118.3117	30	17.80	P
S. M	1973	LA	10D	33.6926	118.2873	30	73.90	
S. M	1985	HY	0C	34.0214	118.6	27		
S. M	1985	HY	2B	33.9403	118.4872	34		
S. M	1985	HY	DN02	34.0017	118.5403	25		
S. M	1985	HY	DN04	33.9519	118.4861	28		
S. M	1985	HY	DN05	33.9308	118.4667	27		
S. M	1985	HY	DN07	33.8761	118.4339	25		
S. M	1985	LA	00D	33.801	118.421	30		
S. M	1985	LA	01D	33.767	118.4358	30		
S. M	1985	LA	02D	33.7448	118.4202	30		
S. M	1985	LA	03D	33.7327	118.3998	30		
S. M	1985	LA	04D	33.7312	118.3793	30		
S. M	1985	LA	05D	33.7233	118.3618	30		
S. M	1985	LA	06D	33.7172	118.347	30		
S. M	1985	LA	07D	33.7138	118.3425	30		
S. M	1985	LA	08D	33.7073	118.3292	30		
S. M	1985	LA	09D	33.7002	118.3117	30		
S. M	1985	LA	10D	33.6926	118.2873	30		
S. M	1985	OC	11	33.5992	118.0017	30	32.12	
S. M	1985	OC	14	33.6083	118.0306	30	8.55	
S. M	1985	OC	15	33.5964	117.9708	30	45.87	

)UdPnatPon space	YeaU›UogUam		StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	Ξnd PoPntc
S. M	1985	OC	26	33.5983	118.0158	30	12.49	
S. M	1985	OC	28	33.5992	117.9872	30	33.89	
S. M	1985	OC	34	33.6089	118.0425	30	10.97	
S. M	1985	OC	35	33.5978	117.9597	30	48.29	
S. M	1985	OC	C1	33.6039	117.9317	31	82.74	
S. M	1985	SC	U04-30	34.4619	120.175	30	37.10	U
S. M	1985	SC	U05-30	34.4551	120.0739	30	26.80	U
S. M	1985	SC	U08-30	34.387	119.6884	30	11.30	U
S. M	1985	SC	U11-30	34.1726	119.3568	30	13.00	U
S. M	1985	SC	U13-30	34.0884	119.1513	30	37.90	U
S. M	1985	SC	U15-30	34.0244	118.8518	30	44.40	U
S. M	1985	SC	U50-30	33.5101	117.7675	30	60.70	U
S. M	1985	SC	U52-30	33.4048	117.6544	30	88.60	U
S. M	1985	SC	U54-30	33.302	117.5449	30	76.80	U
S. M	1985	SC	U57-30	33.1134	117.3473	30	34.20	U
S. M	1985	SC	U60-30	32.8946	117.2688	30	9.20	U
S. M	1985	SC	U71-30	32.542	117.1902	30	2.50	
S. M	1990	LA	00D	33.801	118.421	30	18.01	
S. M	1990	LA	01D	33.767	118.4358	30	25.03	
S. M	1990	LA	02D	33.7448	118.4202	30	34.70	
S. M	1990	LA	03D	33.7327	118.3998	30	35.98	
S. M	1990	LA	04D	33.7312	118.3793	30	26.42	
S. M	1990	LA	05D	33.7233	118.3618	30	43.64	
S. M	1990	LA	06D	33.7172	118.347	30	27.04	
S. M	1990	LA	07D	33.7138	118.3425	30	22.44	
S. M	1990	LA	08D	33.7073	118.3292	30	41.07	
S. M	1990	LA	09D	33.7002	118.3117	30	15.62	
S. M	1990	LA	10D	33.6926	118.2873	30	31.57	
S. M	1990	OC	11	33.5992	118.0017	30	31.72	
S. M	1990	OC	14	33.6083	118.0306	30	12.44	
S. M	1990	OC	15	33.5964	117.9708	30	42.33	
S. M	1990	OC	26	33.5983	118.0158	30	11.25	
S. M	1990	OC	28	33.5992	117.9872	30	37.45	
S. M	1990	OC	34	33.6089	118.0425	30	13.58	
S. M	1990	OC	35	33.5978	117.9597	30	43.28	
S. M	1990	OC	C1	33.6039	117.9317	31	91.25	
S. M	1990	SC	U13-30	34.0884	119.1513	30	47.00	U
S. M	1990	SC	U15-30	34.0244	118.8518	30	19.70	U
S. M	1990	SC	U50-30	33.5101	117.7675	30	44.50	U
S. M	1990	SC	U52-30	33.4048	117.6544	30	84.80	U
S. M	1990	SC	U60-30	32.8946	117.2688	30	9.80	U
S. M	1990	SC	U71-30	32.542	117.1902	30	3.30	
S. M	1994	PP	1026	33.967	118.4965	26	34.96	U
S. M	1994	PP	1042	33.949667	118.47967	25	54.24	
S. M	1994	PP	1100	33.887167	118.45417	34	11.64	U
S. M	1994	PP	1232	33.714133	118.3475	34	36.07	
S. M	1994	PP	1312	33.659783	118.13113	28	21.99	U
S. M	1994	PP	1321	33.653217	118.10197	28	26.49	U
S. M	1994	PP	1328	33.6485	118.117	31	24.31	U
S. M	1994	PP	1332	33.644917	118.14528	32	15.40	U
S. M	1994	PP	1355	33.632217	118.08635	33	19.79	U
S. M	1994	PP	1406	33.6034	118.05022	35	20.49	U
S. M	1994	PP	1415	33.5987	118.01638	33	24.16	U
S. M	1994	PP	1417	33.598083	117.96947	31	38.76	U
S. M	1994	PP	1572	33.318667	117.55528	28	39.99	
S. M	1994	PP	16	34.4527	120.02815	27	28.92	U
S. M	1994	PP	1660	33.1639	117.39302	33	52.98	U
S. M	1994	PP	1791	32.769	117.27883	27	1.58	U
S. M	1994	PP	189	34.39905	119.62103	30	89.42	U
S. M	1994	PP	2011	32.542667	117.19267	32	2.78	U
S. M	1994	PP	234	34.385783	119.68078	33	25.46	U
S. M	1994	PP	297	34.36495	119.54235	33	83.33	U
S. M	1994	PP	46	34.440667	120.30175	31	0.00	U
S. M	1994	PP	502	34.27315	119.40943	33	91.53	U
S. M	1994	PP	621	34.220067	119.3739	26	53.56	U
S. M	1994	PP	814	34.095683	119.16613	26	21.28	U
S. M	1994	PP	833	34.0775	119.0787	27	17.72	U
S. M	1994	PP	899	34.023167	118.61033	28	49.79	U
S. M	1994	PP	908	34.020333	118.664	31	65.47	U
S. M	1994	PP	929	34.01	118.7505	35	66.10	U

UdPnatPon space	YeaU	ProgUam	StatPon	LatPtude	LongPtude	Depth(m)	%FPnes	End PoPnts

a Ordination space

D = 110 - 324 m
M = 25 - 130 m
S = 10 - 35 m

b Program

HY = City of Los Angeles, Environmental Monitoring Division
LA = County Sanitation Districts of Los Angeles County
OC = County Sanitation Districts of Orange County
PP = Southern California Bight Pilot Project
SC = Southern California Coastal Water Research Project
SD = City of San Diego, Metropolitan Wastewater Department

c Endpoints

P = Polluted
U = Unpolluted

For SC 1977 percent fines is calculated by (100 - % sand).

Table E2. Metrics tested during index development

Metrics
Number of Taxa / sample
Shannon-Wiener Diversity Index (H')
Dominance
Evenness
Total Abundance / m^2
Percent Abundance as:
Annelida
Arthropoda
Ophiuroidea
Misc. Echinodermata
Mollusca
Other Phyla
Total Biomass (gms wet weight / m^2)
Percent Biomass as:
Annelida
Arthropoda
Ophiuroidea
Misc. Echinodermata
Mollusca
Other Phyla
Ordination Score
ITI
Proportion of Surface / Subsurface Carnivores
Proportion of Suspension Feeders
Proportion of Surface Deposit Feeders
Proportion of Suspension / Surface Deposit Feeders
Proportion of Subsurface Deposit Feeders

Table E3. Percent of values in ³1 ER-M category which are below or exceed the reference minimum and reference maximum values for shallow (£30 m), mid-depth (31-120 m) and deep (>120 m) depth zones. Values that are separated by more than 80% from reference values as tested by a one-sided exact binomial test (p<0.08) are bolded.

	Shallow Percent		Mid-depth Percent		Deep Percent	
Metrics	< Reference Minimum	> Reference Maximum	< Reference Minimum	> Reference Maximum	< Reference Minimum	> Reference Maximum
Number of Taxa / Sample	0.0	0.0	20.0	0.0	16.0	0.0
Shannon-Wiener Diversity Index (H')	36.0	0.0	12.0	0.0	44.0	0.0
Dominance	45.0	0.0	4.0	0.0	34.0	0.0
Evenness	0.0	27.0	0.0	4.0	0.0	16.0
Total Abundance / m2	0.0	27.0	4.0	12.0	0.0	63.0
Percent Abundance as:						
Annelida	0.0	27.0	0.0	4.0	9.0	34.0
Arthropoda	27.0	0.0	52.0	0.0	0.0	0.0
Ophiuroidea	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Echinodermata	0.0	0.0	0.0	0.0	0.0	0.0
Mollusca	0.0	27.0	0.0	40.0	0.0	**94.0**
Other Phyla	0.0	9.0	0.0	4.0	0.0	19.0
Total Biomass (gms wet weight / m2)	0.0	9.0	0.0	16.0	0.0	3.0
Percent Biomass as:						
Annelida	0.0	0.0	8.0	4.0	9.0	13.0
Arthropoda	0.0	0.0	0.0	0.0	0.0	3.0
Ophiuroidea	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Echinodermata	0.0	0.0	0.0	0.0	0.0	0.0
Mollusca	0.0	0.0	0.0	40.0	0.0	81.0
Other Phyla	0.0	18.0	0.0	16.0	0.0	6.0
Ordination Score	0.0	55.0	0.0	**96.0**	0.0	**97.0**
ITI	27.0	0.0	**96.0**	0.0	**100.0**	0.0
Proportion of Surface / Subsurface Carnivores	27.0	0.0	0.0	4.0	41.0	0.0
Proportion of Suspension Feeders	27.0	0.0	20.0	4.0	88.0	0.0
Proportion of Surface Deposit Feeders	18.0	18.0	28.0	0.0	44.0	0.0
Proportion of Suspension / Surface Deposit Feeders	18.0	9.0	40.0	0.0	47.0	0.0
Proportion of Subsurface Deposit Feeders	18.0	9.0	40.0	0.0	47.0	0.0

Table E4. Optimum values for the parameters in equations (1) and (2).

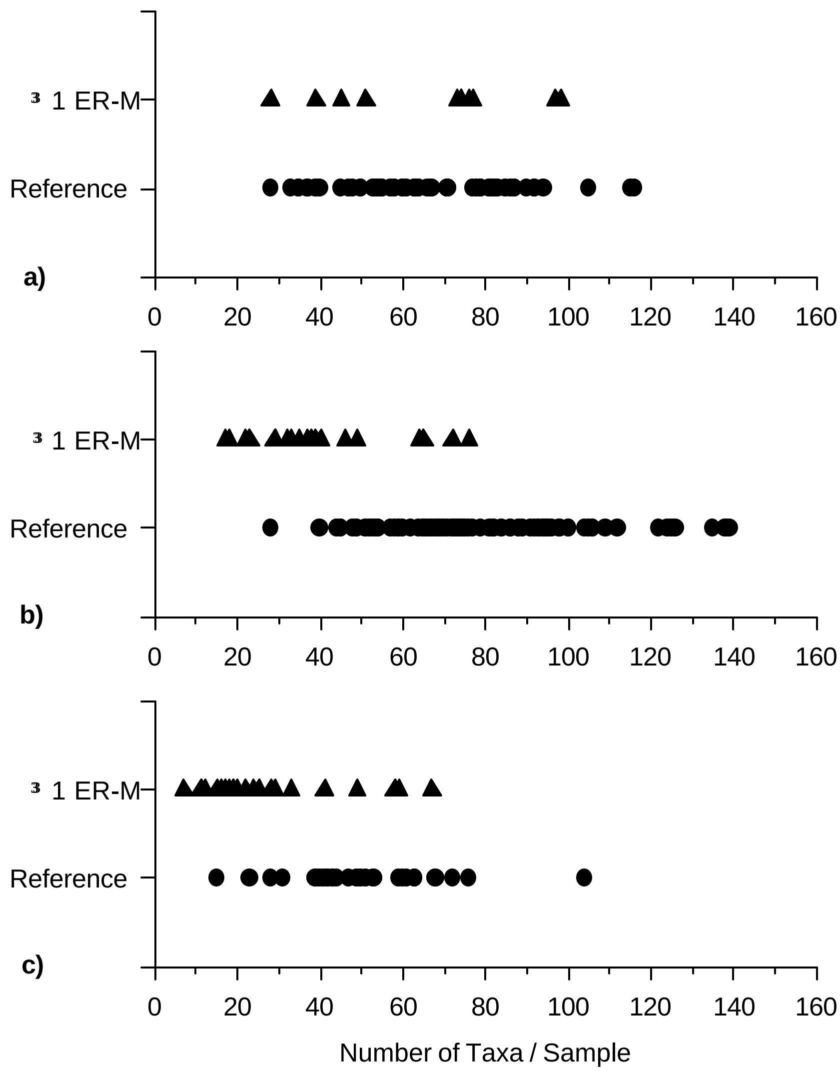
Depth Range	*e*	*t*	*f*	Correlation
10-35 m	0	7	.333	.972
25-130 m	0	41	.333	.970
110-324 m	0	48	.333	.980

Table E5. Species positions (p_i) on the pollution gradient for each depth range.

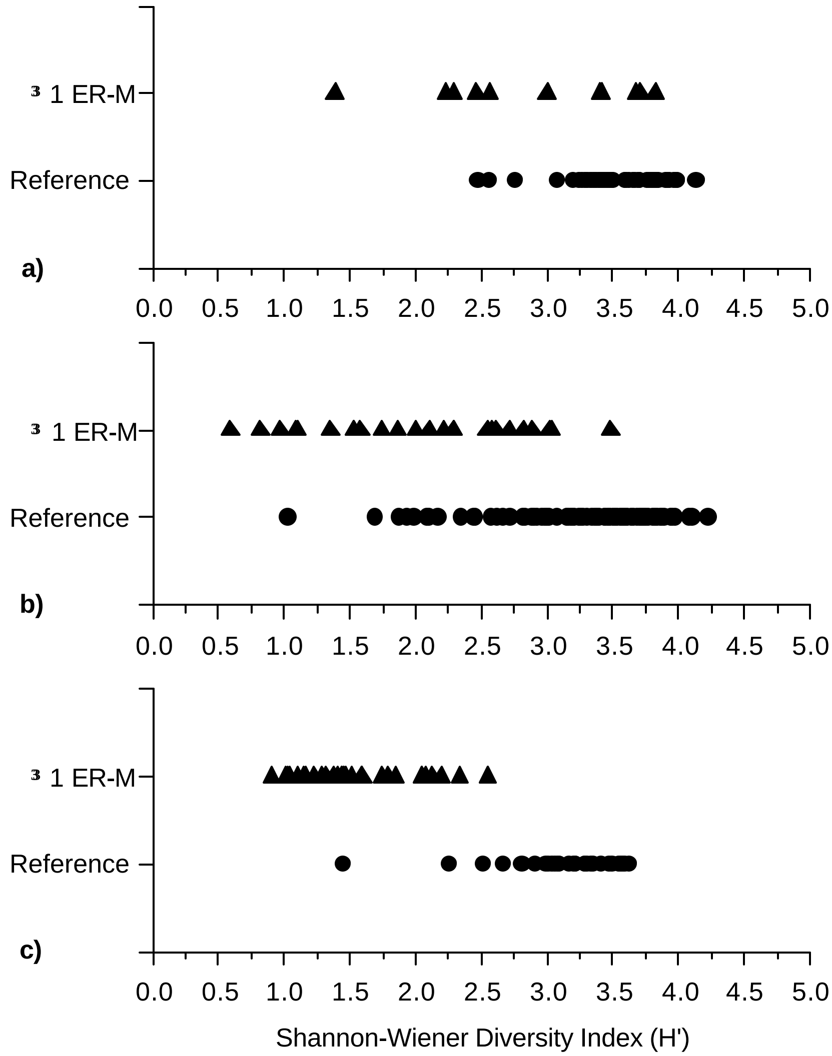
Species	Pdeep	Pmid	Pshallow
Acanthaxius spinulicaudus		30.4	
Acidostoma hancocki		33.0	39.5
Acila castrensis	27.4	24.0	
Acmira sp.	20.5	38.1	48.0
Acoetes pacifica	16.2	23.8	
Acteocina culcitella	25.1	32.4	28.2
Acteocina harpa		38.3	32.2
Acteocina inculta			55.6
Acteon traskii		29.4	45.5
Acuminodeutopus heteruropus		29.4	22.9
Adontorhina cyclia	18.2	20.5	
Aedicira pacifica		32.2	
Aglaja ocelligera	36.6	39.2	42.1
Aglaophamus erectans	25.7		
Aglaophamus verrilli	20.1	22.0	
Alia tuberosa		76.3	85.0
Allia antennata	23.0	24.9	
Allia cf. *nolani*		24.8	
Allia ramosa	18.1	25.9	36.7
Allocentrotus fragilis	27.0		
Alvania acutelirata		25.7	
Alvania rosana	13.9	12.2	
Amaeana occidentalis	17.1	36.7	29.8
Amage anops	16.3	34.7	34.2
Ampelisca agassizi	18.1	28.7	27.7
Ampelisca brachycladus		33.6	37.4
Ampelisca brevisimulata	18.9	33.2	38.4
Ampelisca careyi	18.1	23.8	36.6
Ampelisca cristata		34.1	36.1
Ampelisca hancocki complex	17.0	24.1	39.5
Ampelisca indentata		24.0	37.1
Ampelisca milleri		28.5	32.0
Ampelisca pacifica	19.6	24.9	52.4
Ampelisca pugetica	11.5	26.9	35.3
Ampelisca romigi		32.0	49.4
Ampelisca shoemakeri		29.2	
Ampelisca unsocalae	28.2	33.8	41.0
Ampelisciphotis podophthalma		27.5	34.9
Ampharete acutifrons	26.7	24.6	
Ampharete arctica	18.9	32.4	33.8
Ampharete labrops		44.8	53.3
Amphichondrius granulosus	16.0	21.4	
Amphicteis glabra		27.0	
Amphicteis scaphobranchiata	22.4	37.1	44.5
Amphideutopus oculatus	18.9	30.2	28.6
Amphiodia complex	16.9	24.7	51.7
Amphioplus sp.	19.3	28.3	29.7
Amphipholis sp.	17.5	24.4	38.2
Amphissa undata	41.8	20.7	30.5
Amphissa versicolor		27.6	
Amphiura acrystata	12.2	19.3	39.3
Amygdalum pallidulum	14.7	19.8	
Anchicolurus occidentalis			11.0
Ancistrosyllis sp.	27.6	46.1	47.7
Anobothrus gracilis	22.7	23.8	
Anonyx lilljeborgi		19.5	
Anotomastus gordiodes		31.2	24.0
Aoroides sp.	13.0	32.2	29.5
Aphelochaeta/Monticellina	31.4	55.7	60.9
Aphrodita sp.		28.6	34.4
Apistobranchus ornatus		20.6	32.0
Aplacophora	23.1	33.8	46.6
Apoprionospio pygmaea		36.1	37.1
Arabella sp.		39.5	51.7
Araphura sp. A	22.2	27.4	35.5
Araphura sp. B	21.4	26.4	
Argissa hamatipes		36.1	39.7
Arhynchite californicus	37.1		
Aricidea wassi		35.6	35.1
Armandia brevis	59.3	74.3	88.8
Armina californica		38.2	49.5
Artacamella hancocki	12.8	24.2	30.5
Aruga holmesi	14.0	21.3	
Aruga oculata		31.0	41.4
Asabellides lineata	18.4	21.4	38.3
Asteropella slatteryi	25.0	27.6	26.3
Astropecten verrilli	16.4	29.7	26.4
Autolytus sp.		28.8	
Axinopsida serricata	37.3	36.4	61.4
Bathyleberis sp.	16.0	37.6	50.4
Bathymedon pumilus	16.1	22.5	
Bathymedon vulpeculus	21.1		
Bemlos audbettius	8.2	26.0	27.6
Bittium complex	25.4	32.6	27.5
Blepharipoda occidentalis			19.3
Boccardia basilaria		40.5	52.6
Boccardiella hamata	45.4		
Brada pluribranchiata		13.6	
Brada villosa		25.7	42.7
Branchiostoma californiense			20.1
Brisaster latifrons	21.2		
Brissopsis pacifica	17.9		
Byblis veleronis	10.6	26.0	44.6
Caecum crebricinctum	10.6	22.5	30.5
Calinaticina oldroydii		35.4	45.9
Calyptraea fastigiata		34.0	41.5
Campylaspis canaliculata		25.4	28.2
Campylaspis hartae		21.9	
Campylaspis rubromaculata	16.5	26.7	31.1
Campylaspis sp. D			40.5
Cancer gracilis		40.1	30.6
Cancer jordani		31.1	33.0
Capitella capitata complex	45.5	55.1	60.2
Carazziella sp.		37.1	54.5
Cardiomya sp.	23.0	27.3	
Caudina arenicola		33.5	
Caulleriella alata		72.9	76.9
Caulleriella gracilis	20.4	24.7	
Cephalophoxoides homilis	10.7	17.7	
Cerapus tubularis complex		31.5	22.7
Ceriantharia	15.2	31.6	45.9
Cerithiopsis sp.		32.0	
Chaetopterus variopedatus			42.3
Chaetozone armata		37.0	43.5
Chaetozone corona		44.3	45.8
Chaetozone setosa complex	21.1	36.9	40.7
Chione sp.		71.4	65.1
Chloeia pinnata	27.9	33.8	46.5
Chone complex	27.9	32.4	31.3
Cirratulus sp.		36.4	48.2
Cirriformia sp.		39.5	31.1
Cirrophorus branchiatus	19.5		
Cirrophorus furcatus		34.2	36.3
Clymenella complanata		24.3	36.9
Clymenura gracilis	11.5	15.6	
Compsomyax subdiaphana		41.1	53.1
Conus californicus		71.2	75.5
Cooperella subdiaphana		41.6	51.0
Corbula sp.		38.8	
Corophium sp.		38.7	41.0
Corymorpha sp.		19.1	32.2
Cossura sp.	26.2	41.4	57.3
Crangon alaskensis			29.0
Crenella decussata		30.4	45.7
Crepidula sp.		37.6	43.6
Cryptomya californica			67.7
Cumella sp. A		25.8	
Cuspidaria parapodema	26.2	33.5	
Cyclaspis nubila			26.5
Cyclocardia sp. P	28.9	17.1	
Cylichna diegensis	35.0	39.7	41.4
Decamastus gracilis	36.7	45.5	63.7
Deilocerus planus		27.8	42.8
Delectopecten	19.0	13.7	
Dendraster excentricus		30.9	24.4
Dentalium sp.	21.9	30.3	27.8
Diastylis californica		33.1	35.3
Diastylis paraspinulosa	20.1		
Diastylis pellucida	31.5		
Diastylis sp. A	22.6	27.7	
Diastylopsis tenuis		33.5	13.8
Diopatra ornata	27.5	39.3	38.5

ATTACHMENT E1:

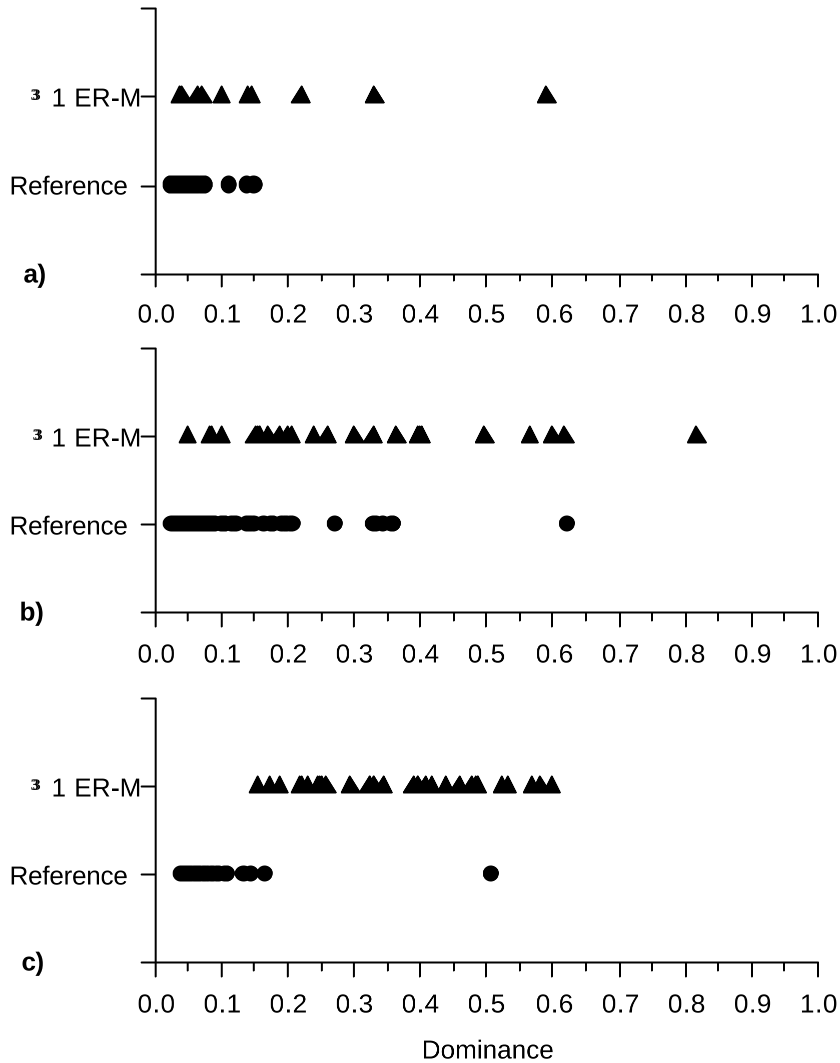
Values of Metrics in the Reference and ≥ 1ER-M
Categories for Shallow, Mid-depth and Deep Stations



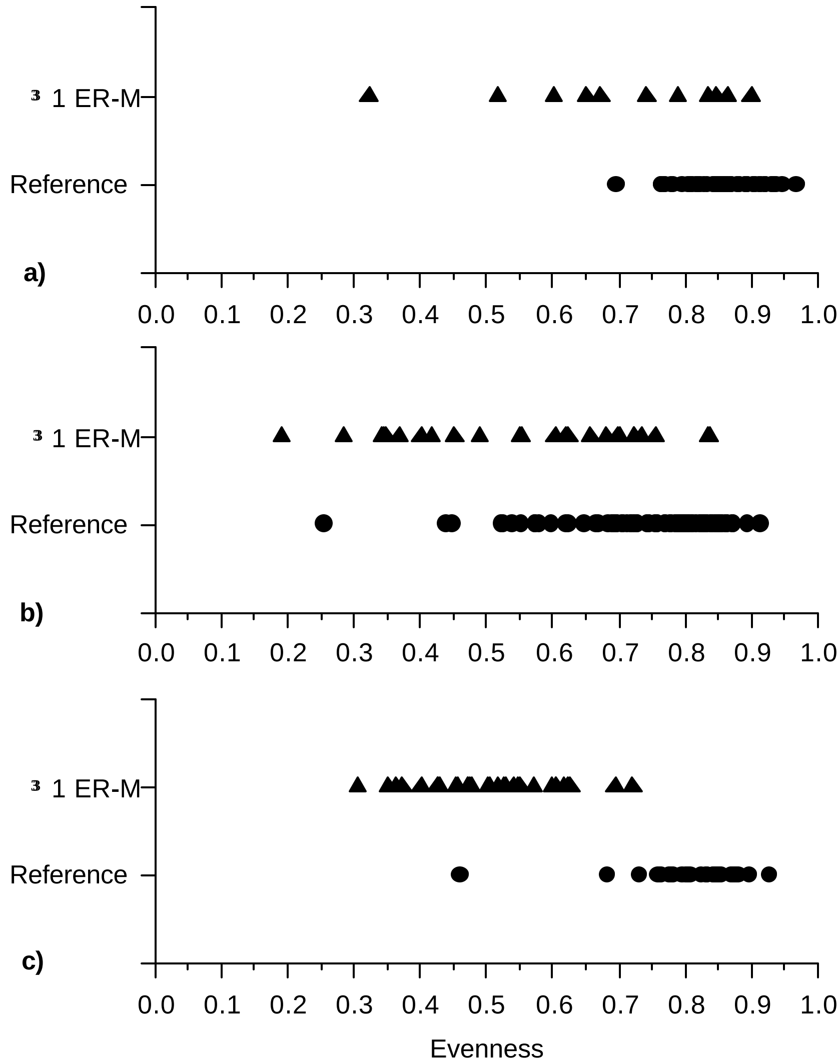
Attachment 1a . Value for number of taxa / sample in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



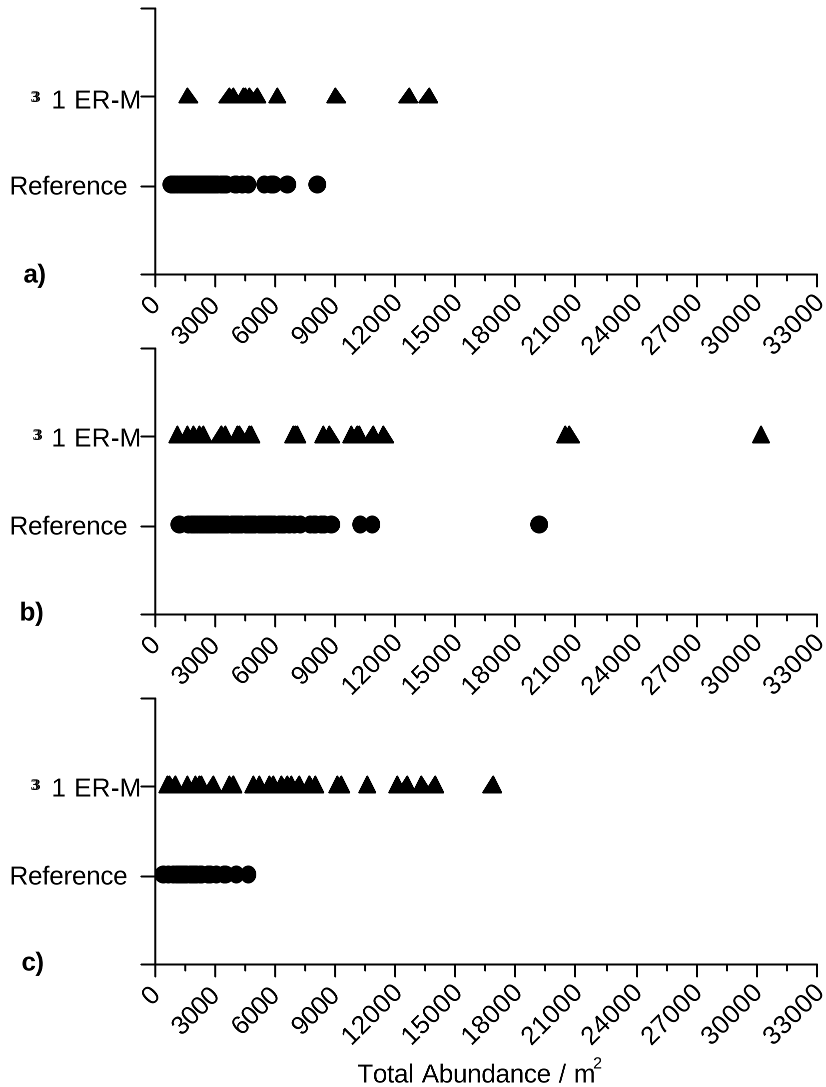
Attachment 1b . Value for Shannon-Wiener Diversity Index (H') in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



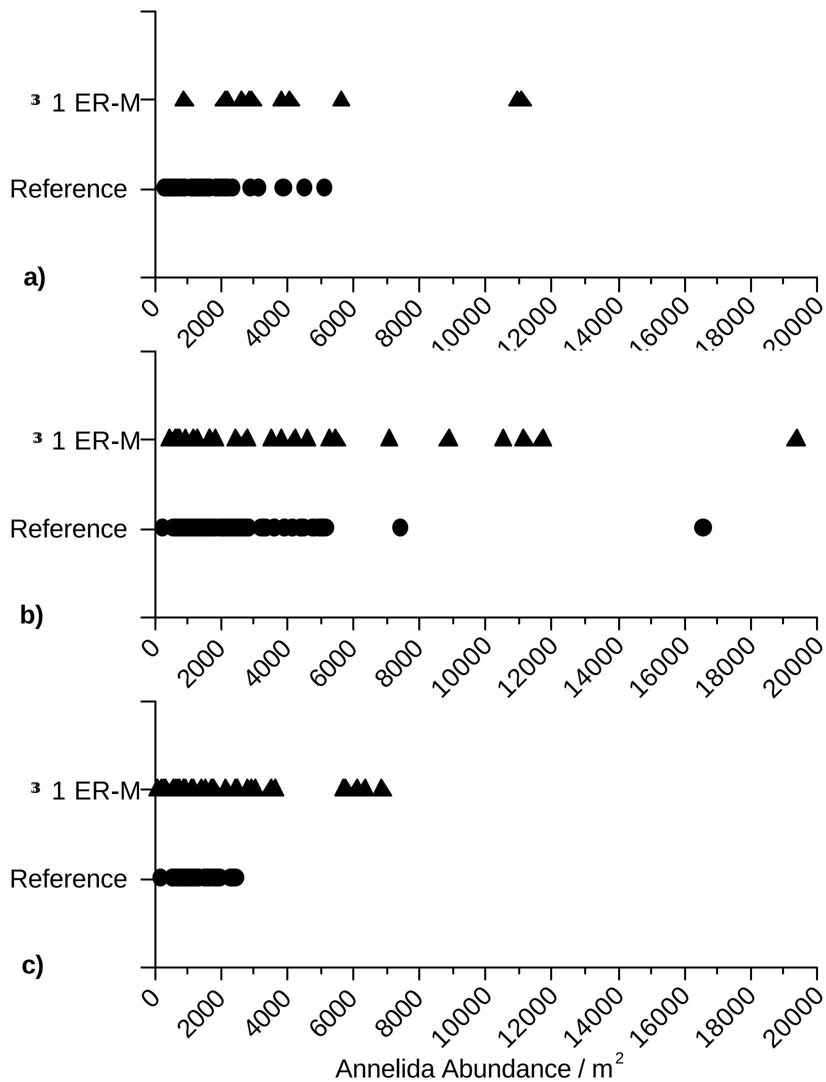
Attachment 1c . Value for dominance in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



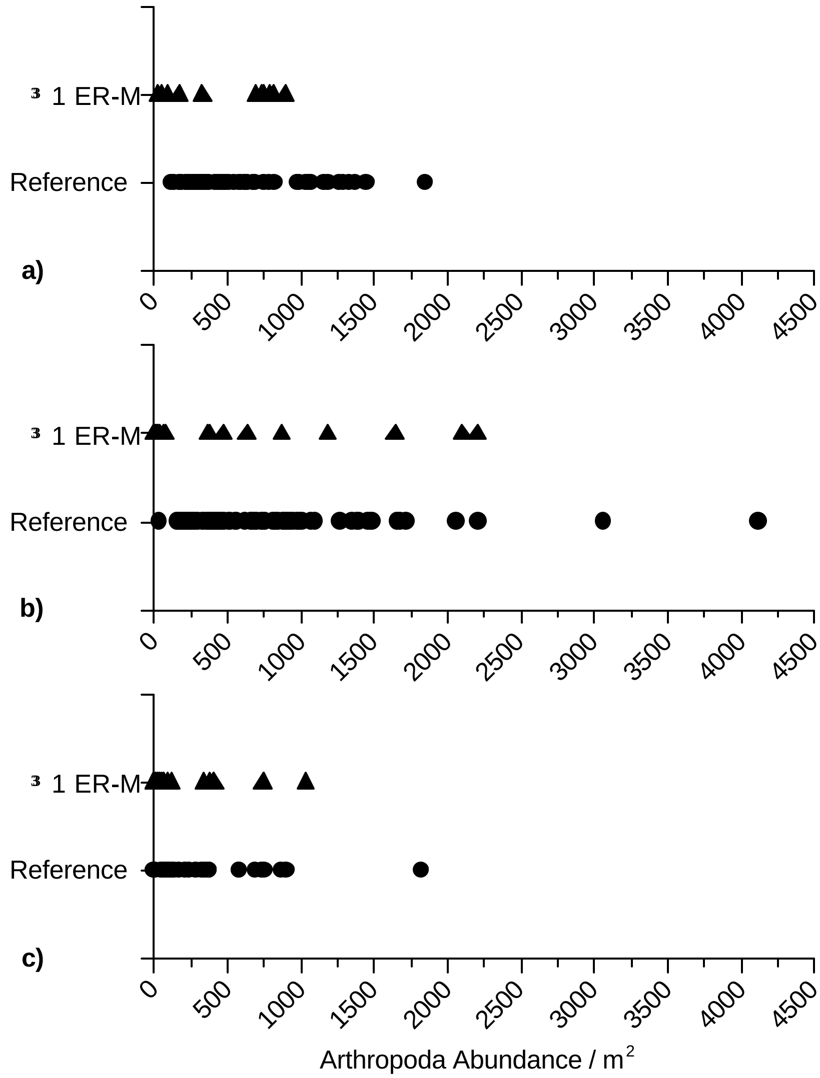
Attachment 1d. Value for evenness in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



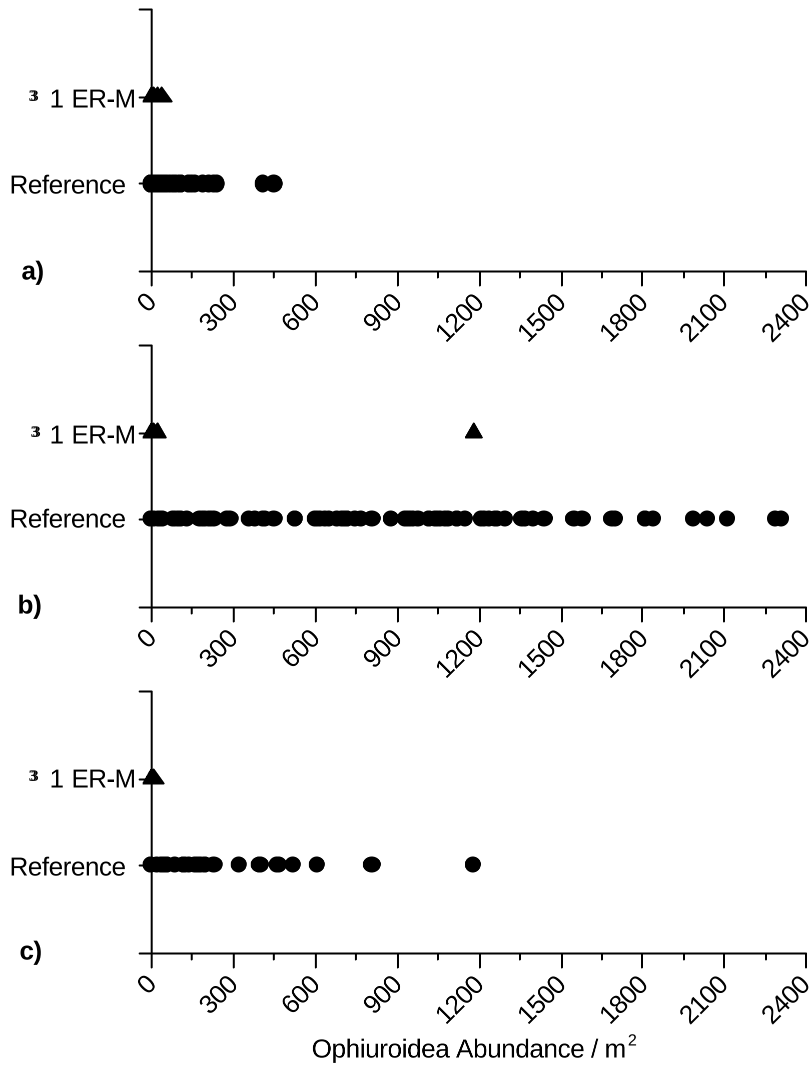
Attachment 1e . Value for total abundance / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



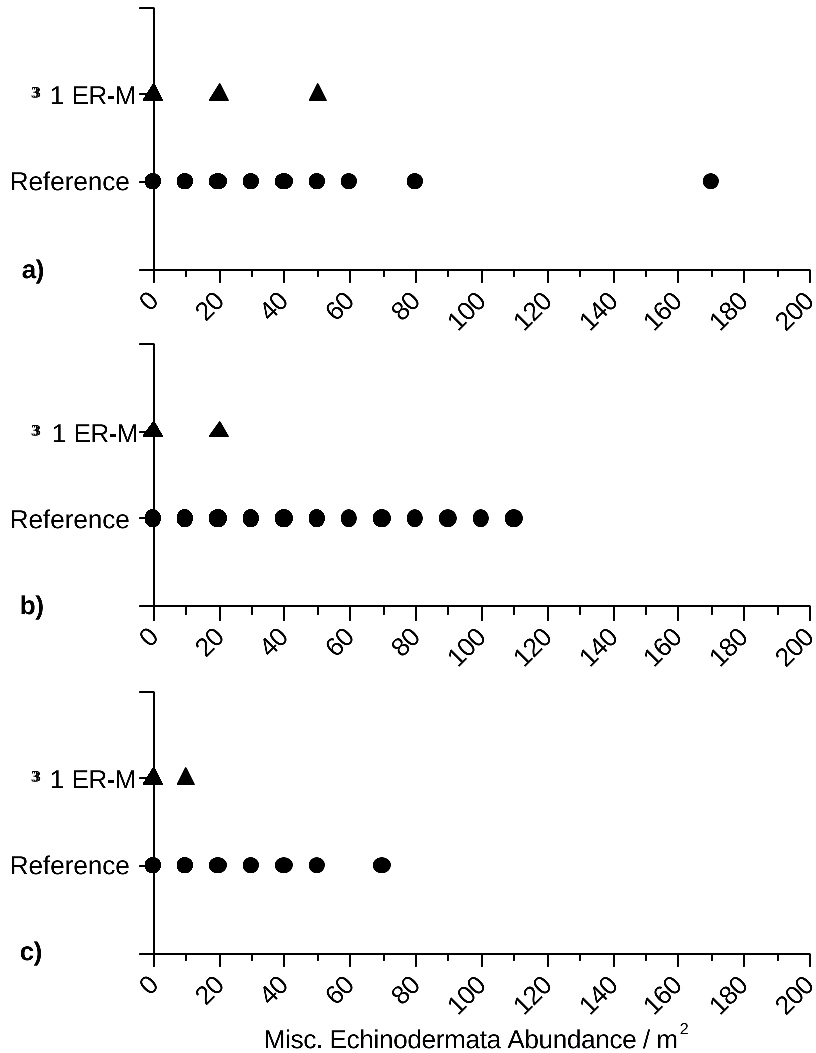
Attachment 1f . Value for annelida abundance / m² in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



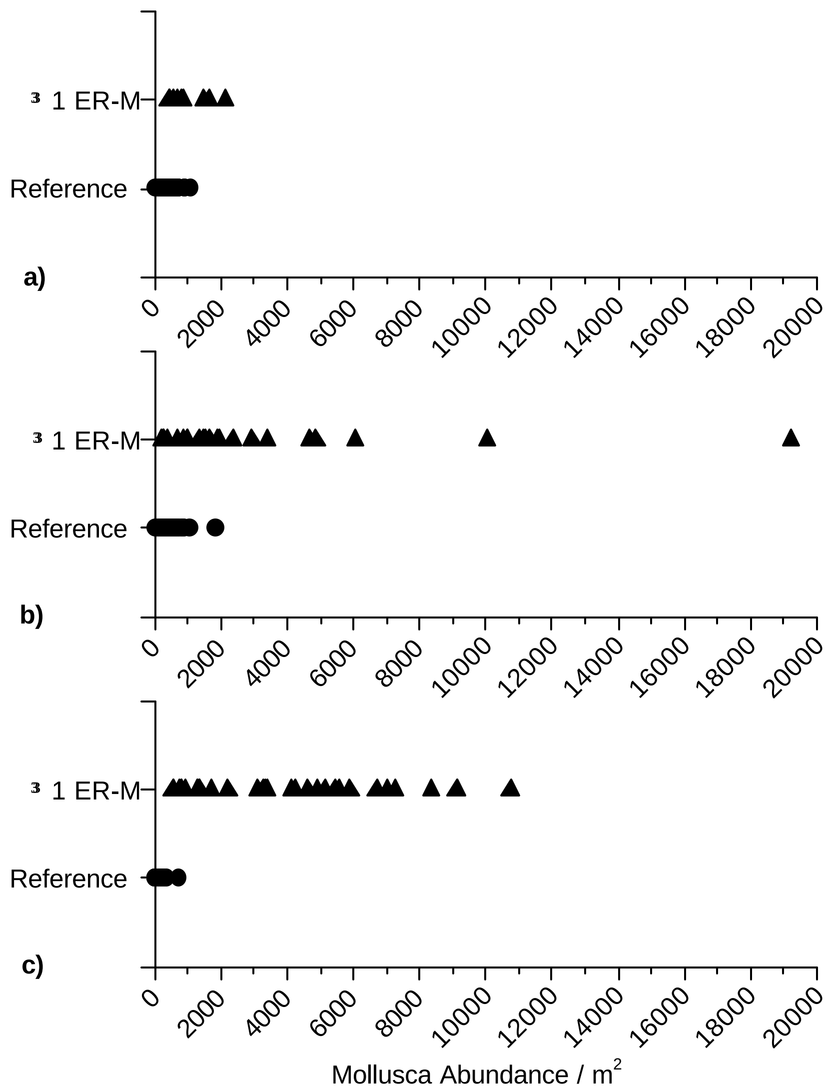
Attachment 1g . Value for arthropoda abundance / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



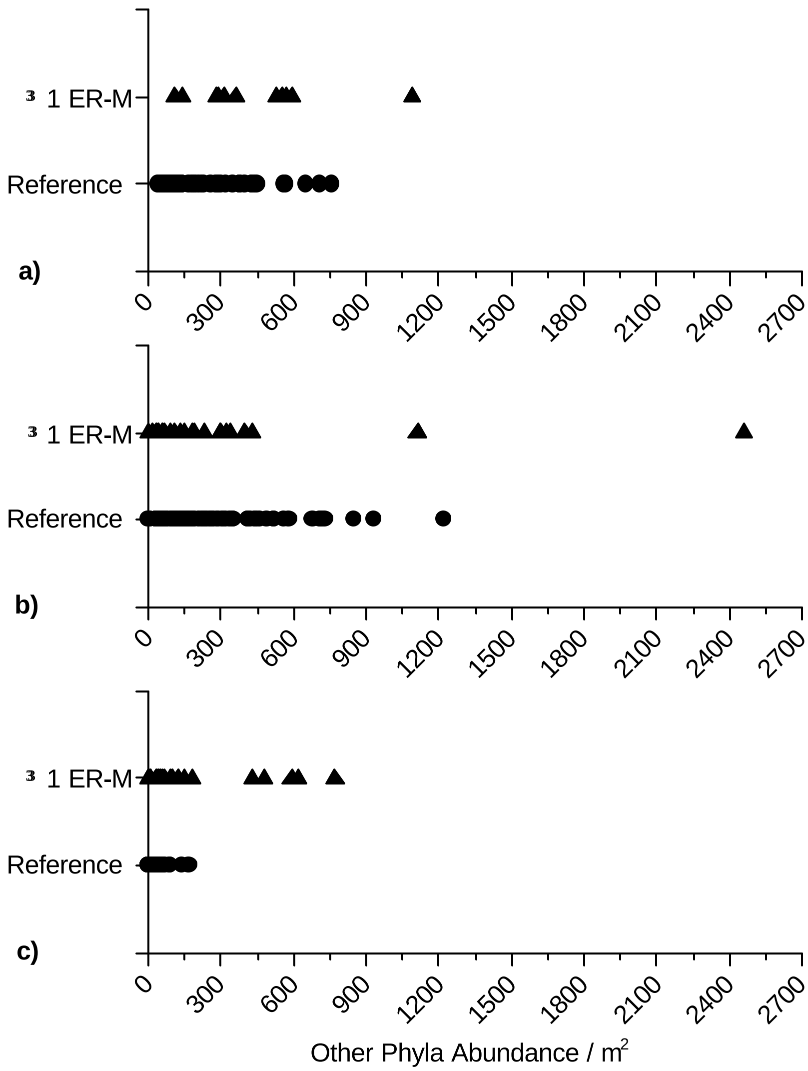
Attachment 1h . Value for ophiuroidea abundance / m ^{2} in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



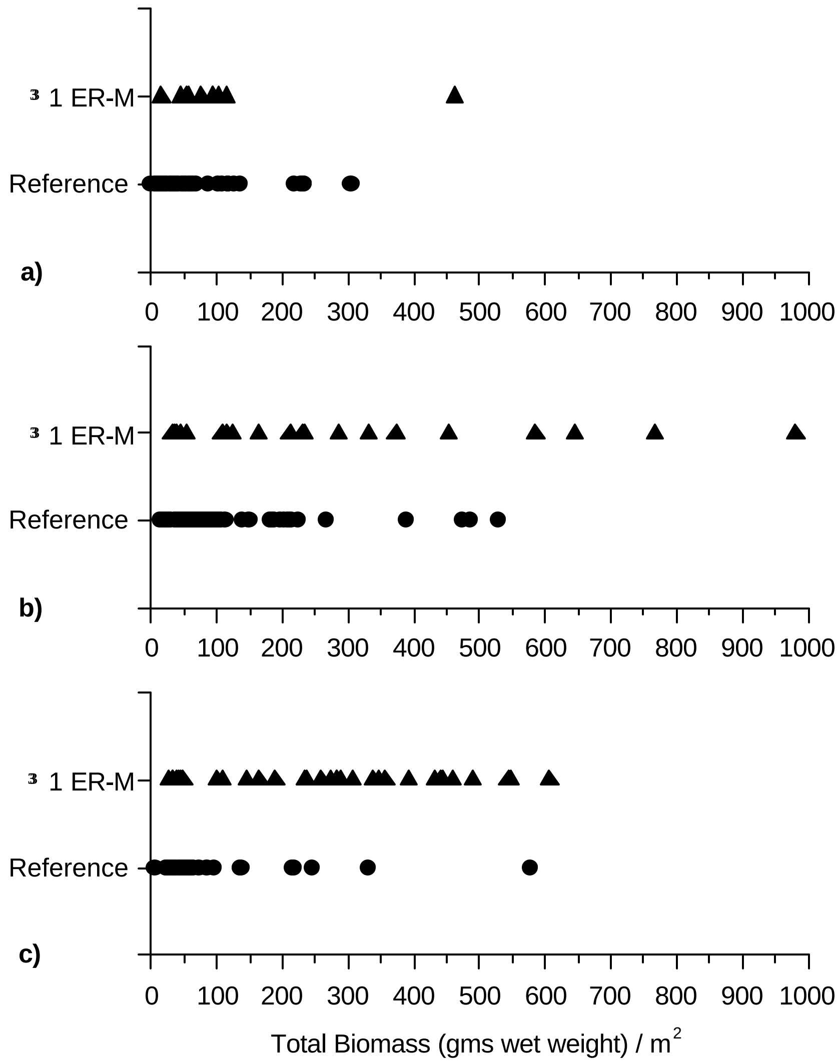
Attachment 1i . Value for misc. echinodermata abundance / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



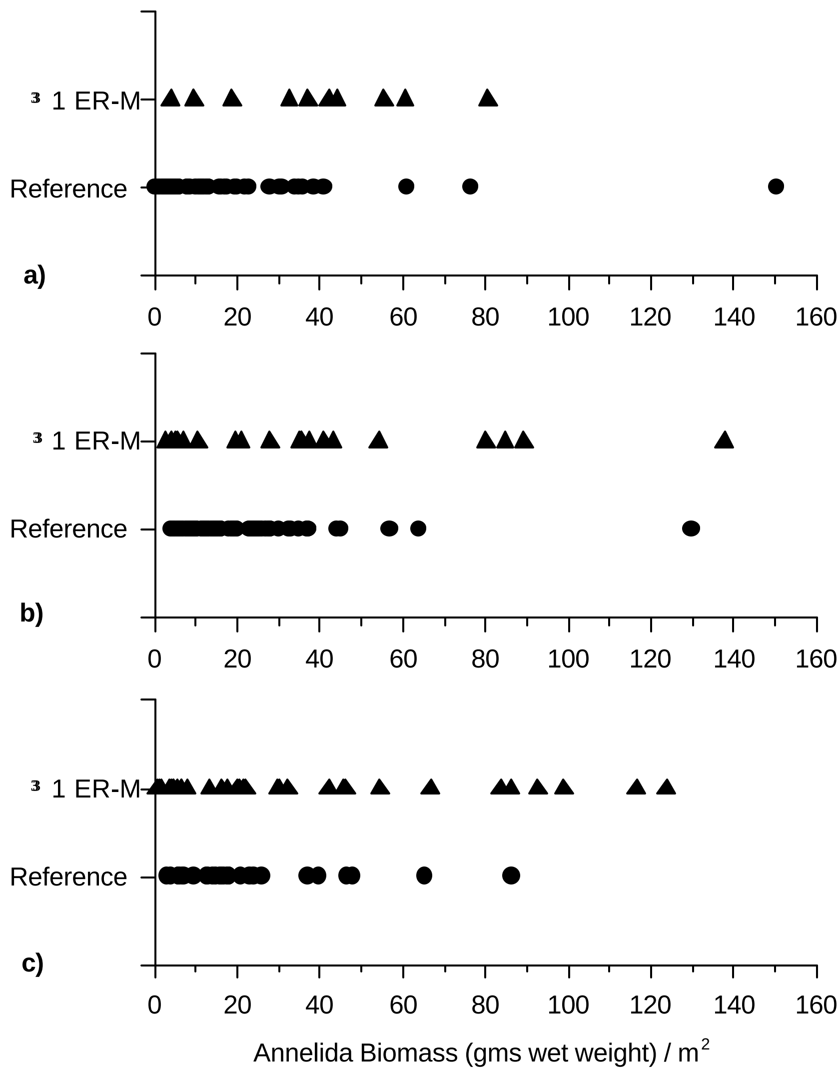
Attachment 1j . Value for mollusca abundance / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



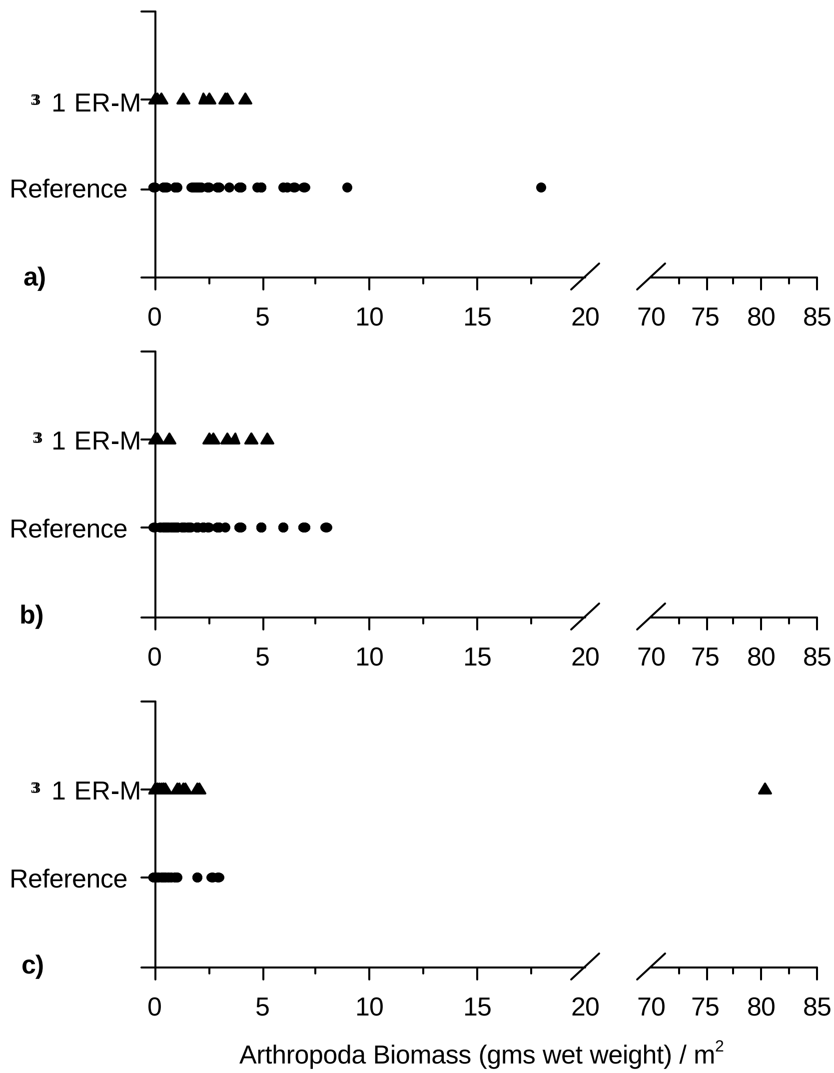
Attachment 1k . Value for other phyla abundance / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



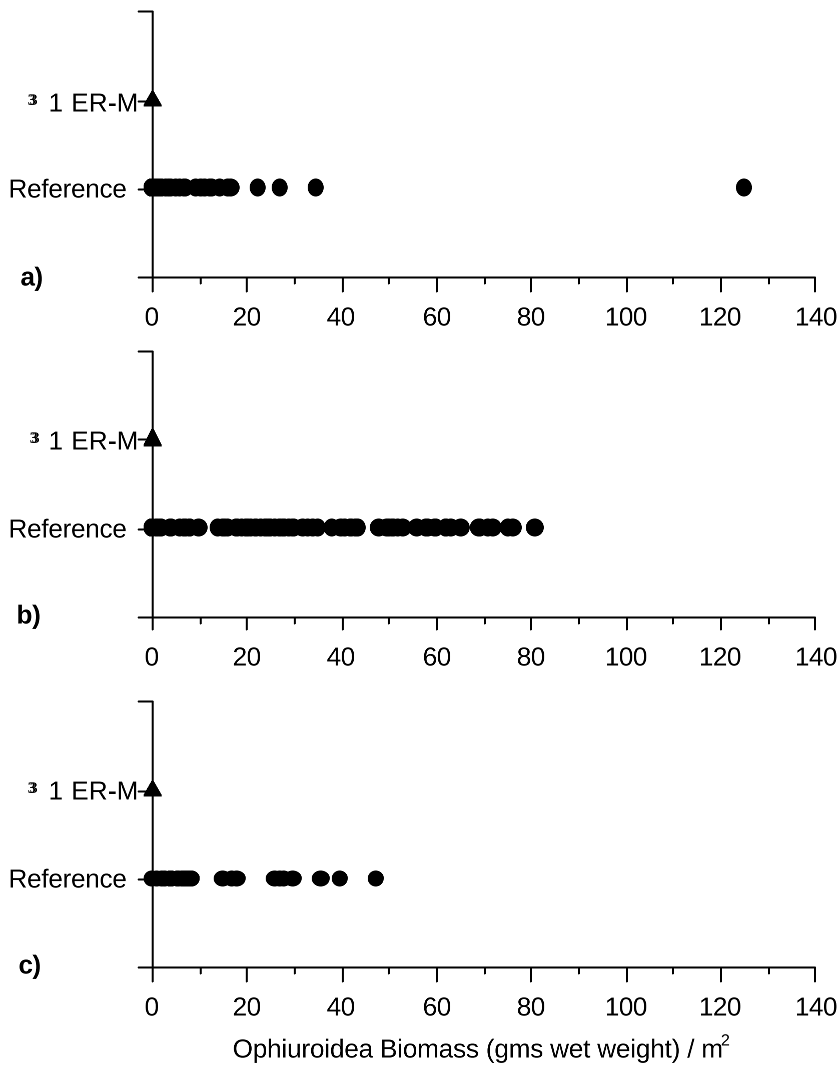
Attachment 1l . Value for total biomass (gms wet weight) / m^2 in reference and ³1 ER-M categories for: a) shallow (£30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



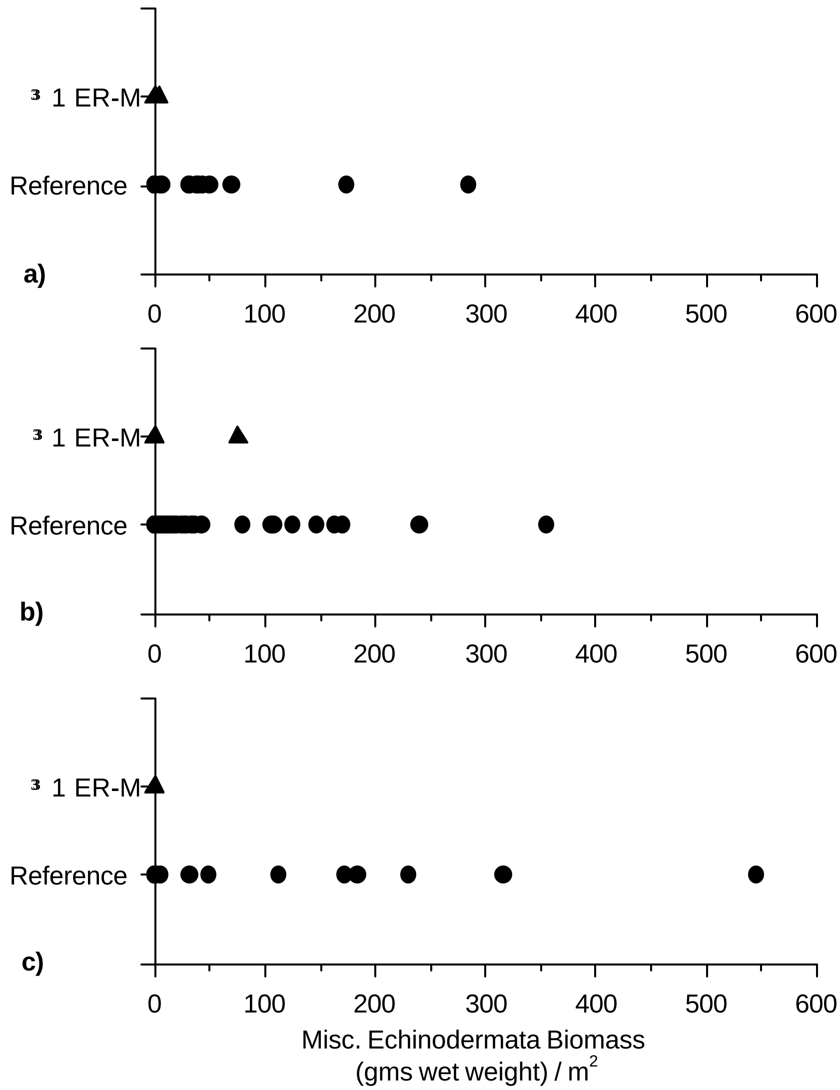
Attachment 1m. Value for annelida biomass (gms wet weight) / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



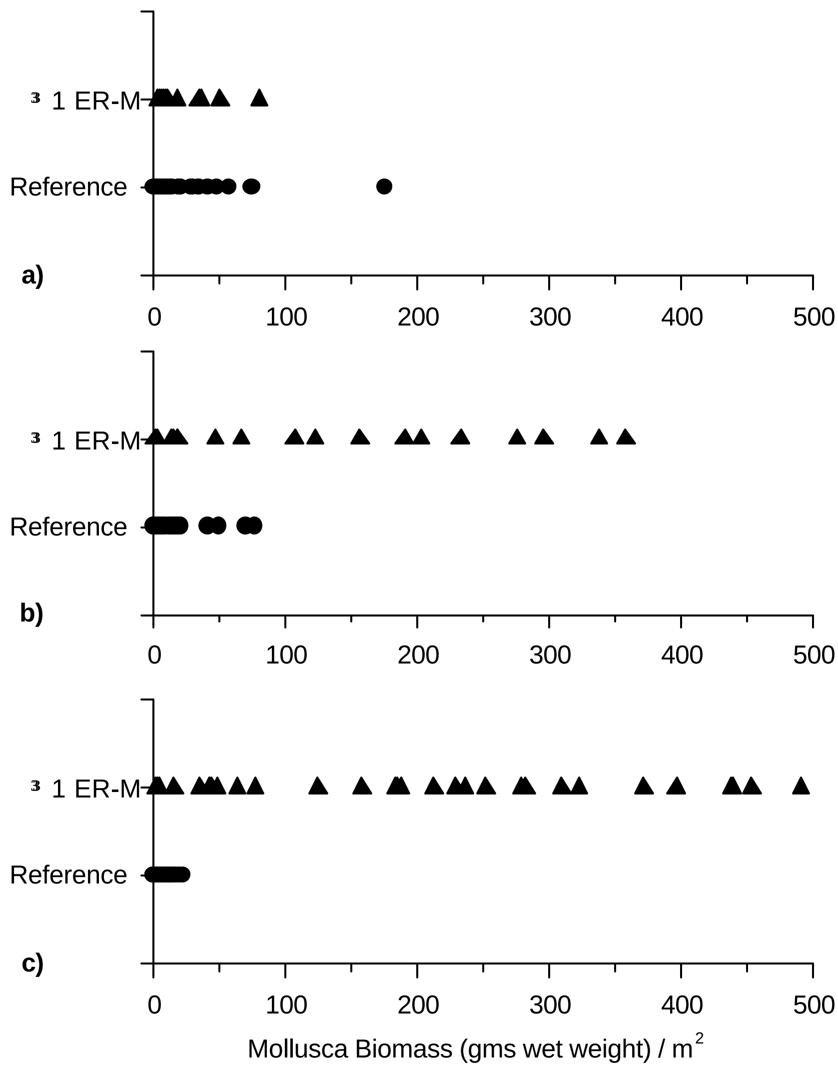
Attachment 1n. Value for arthropoda biomass (gms wet weight) / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



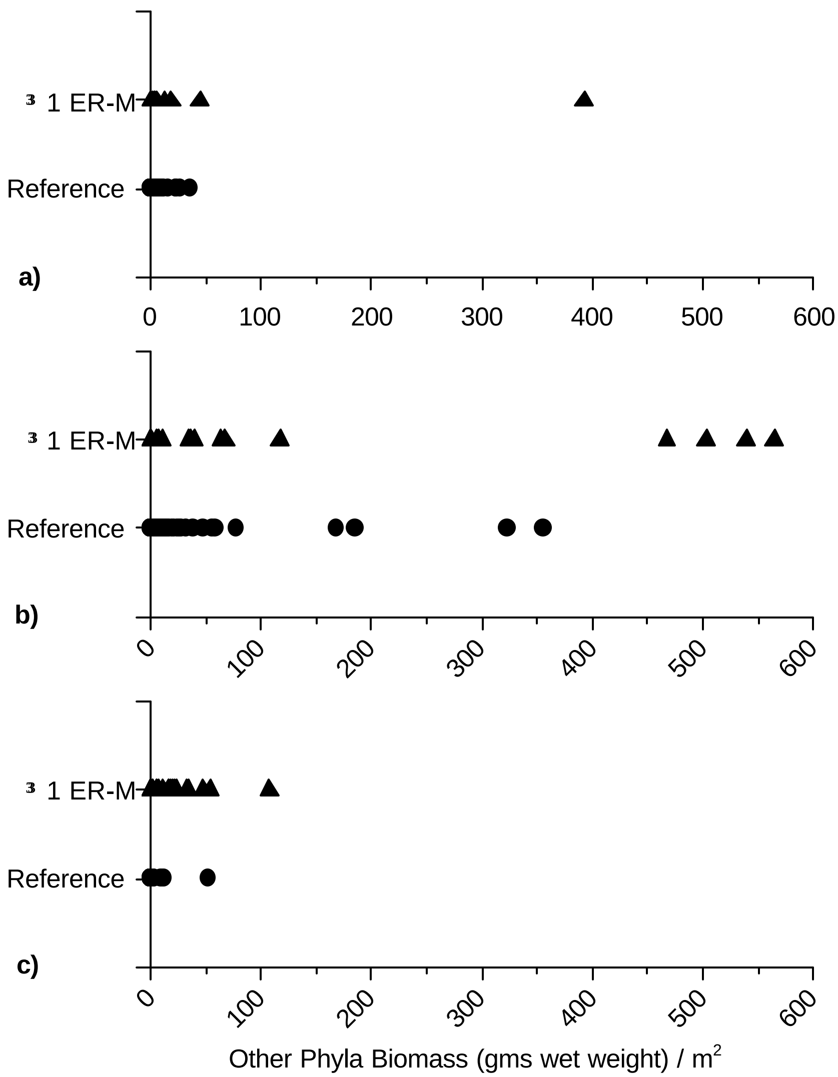
Attachment 1o. Value for ophiuroidea biomass (gms wet weight) / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



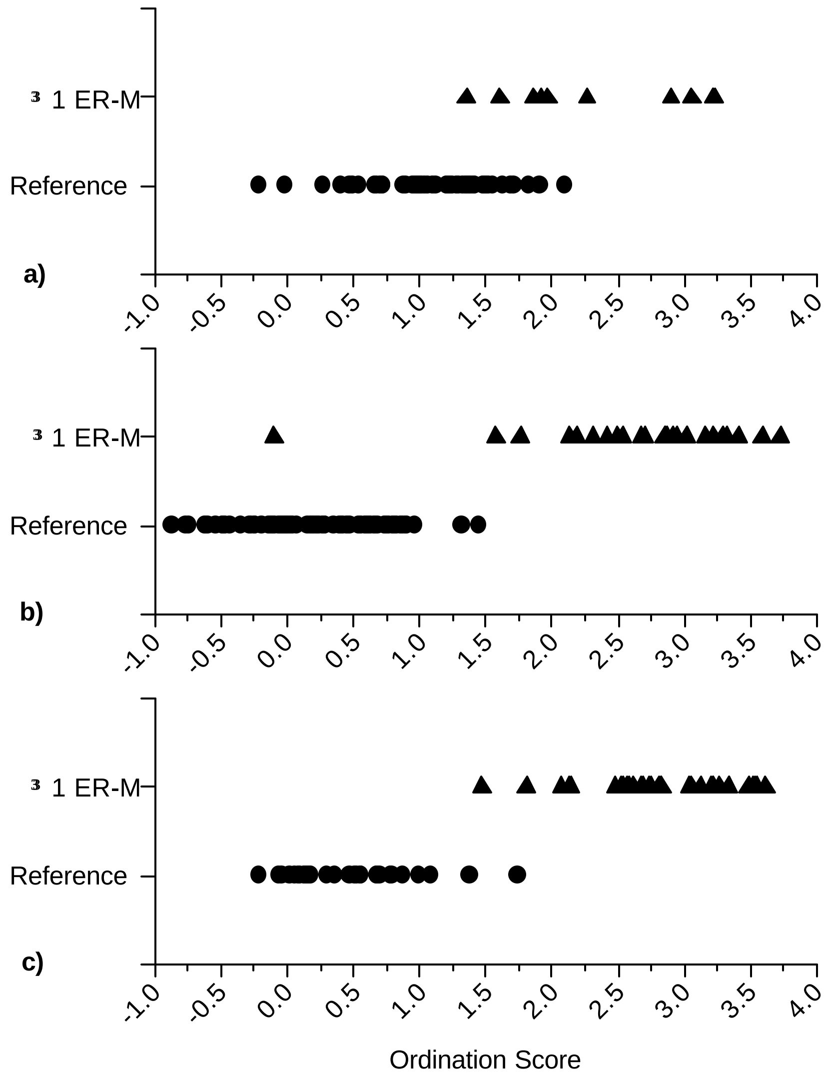
Attachment 1p. Values for misc. echinodermata biomass (gms wet weight) / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



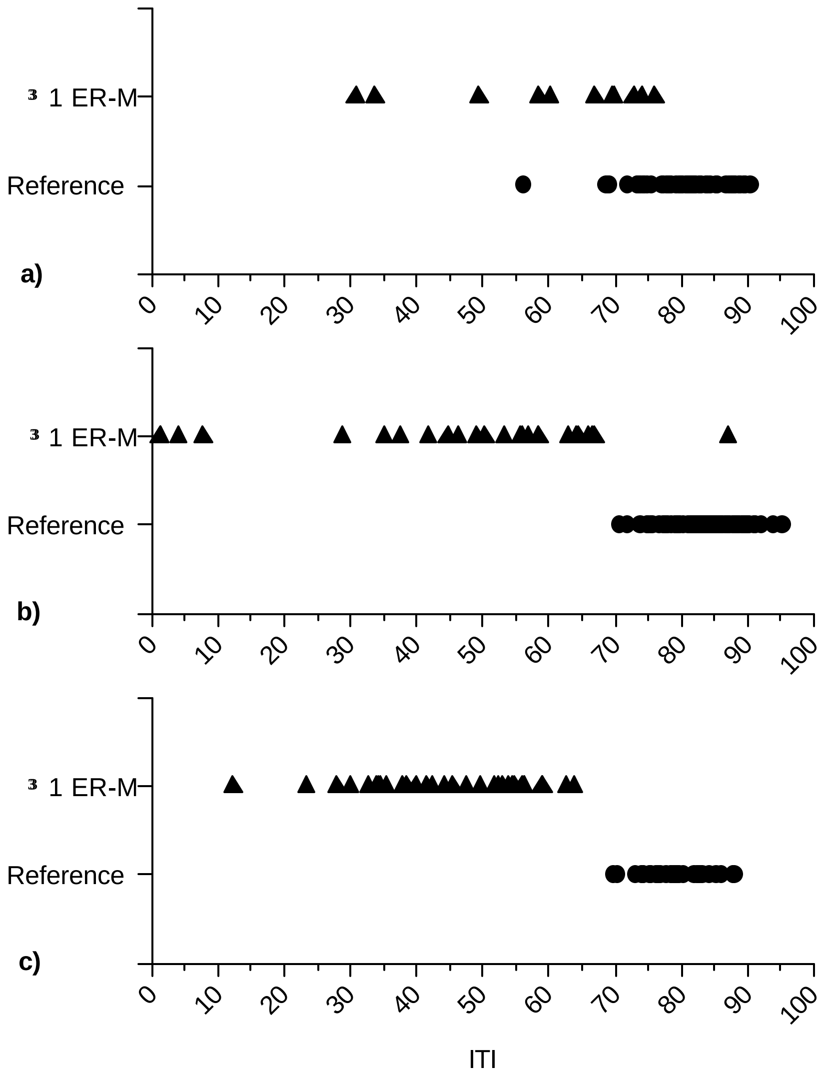
Attachment 1q. Value for mollusca biomass (gms wet weight) / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



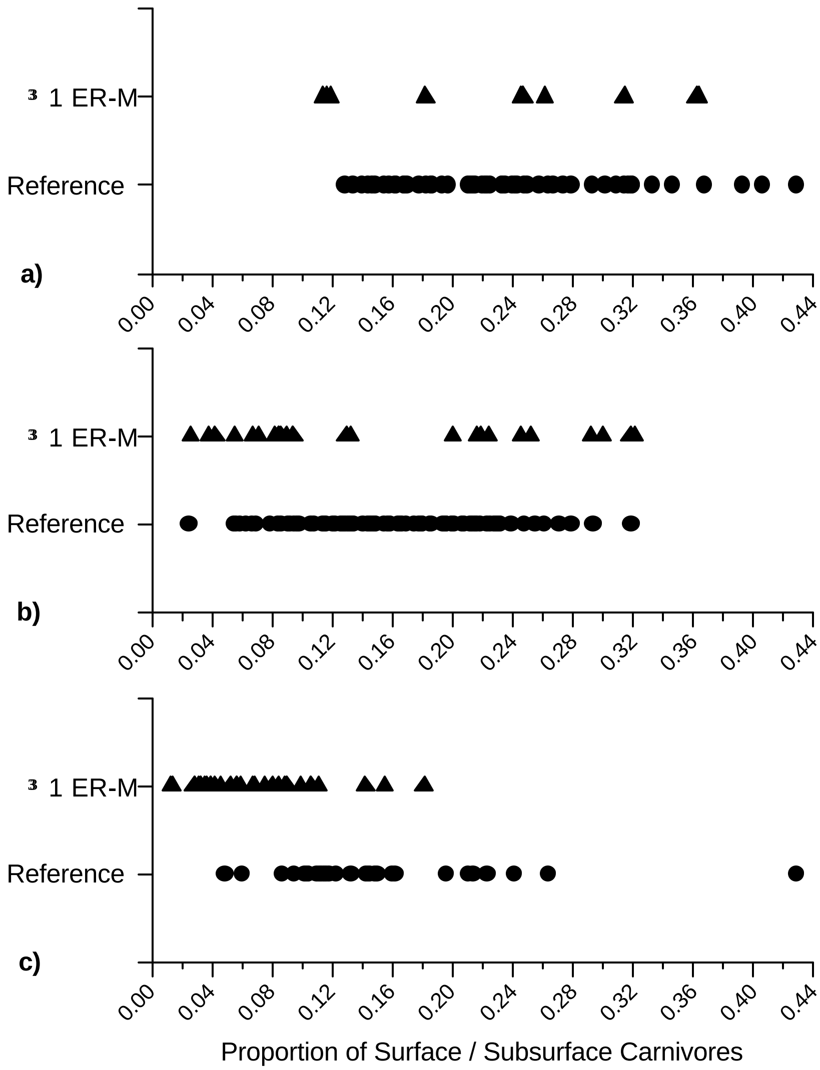
Attachment 1r. Value for other phyla biomass (gms wet weight) / m^2 in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



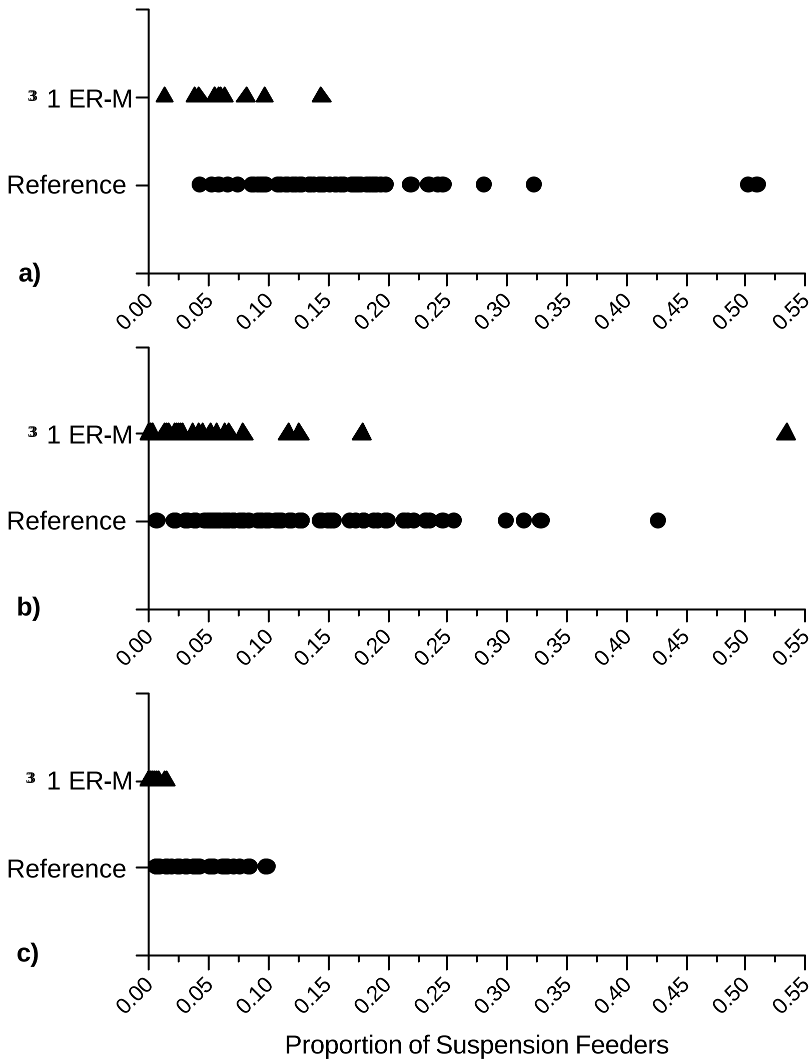
Attachment 1s. Value for ordination scores in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



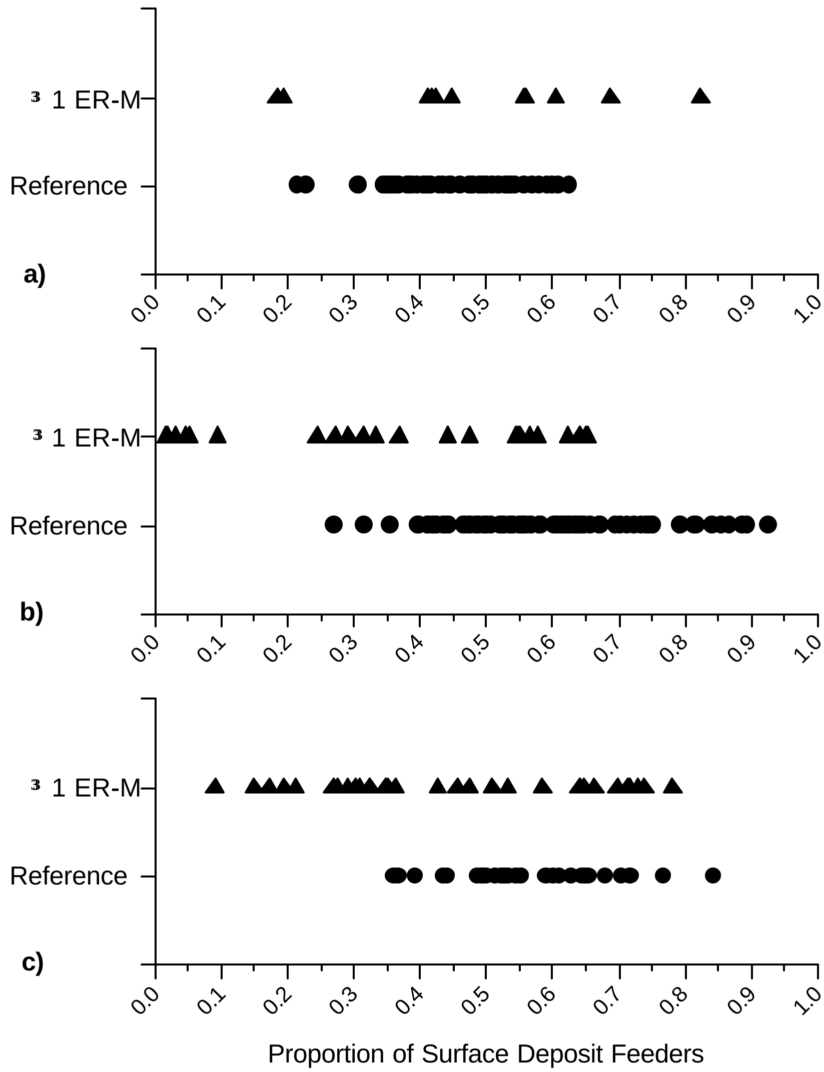
Attachment 1t. Value for ITI values in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



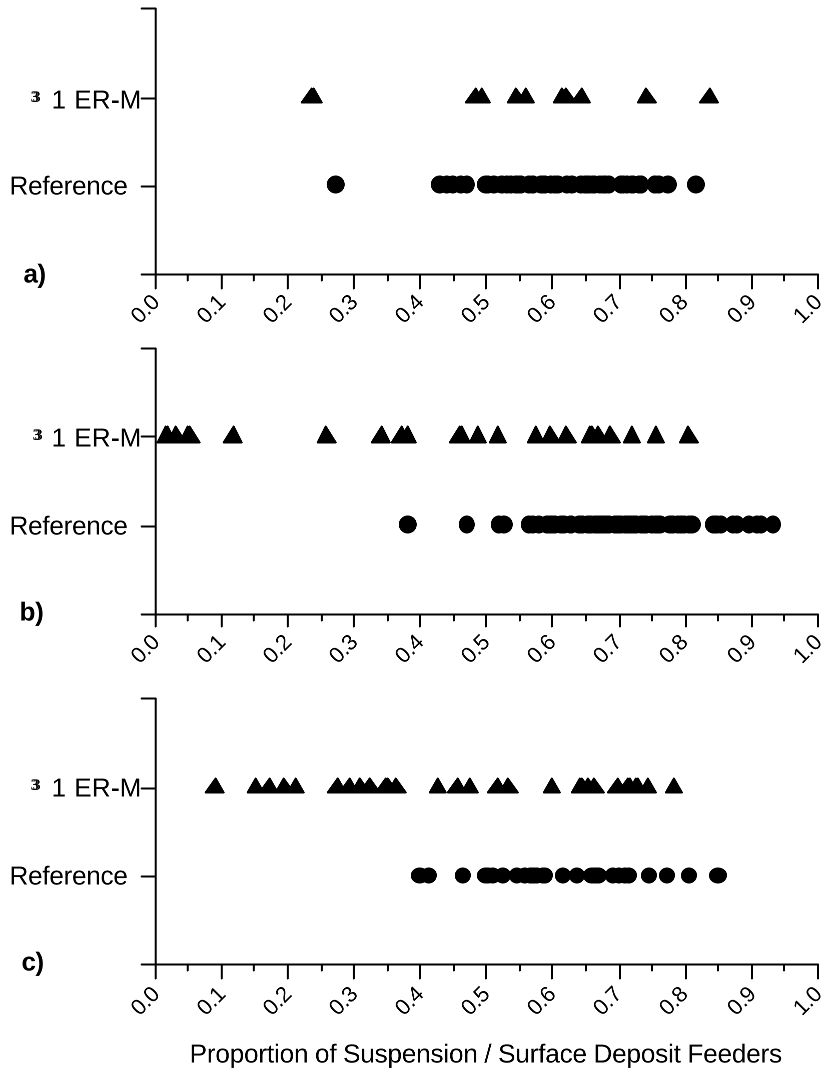
Attachment 1u. Value for proportion of surface / subsurface carnivores in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



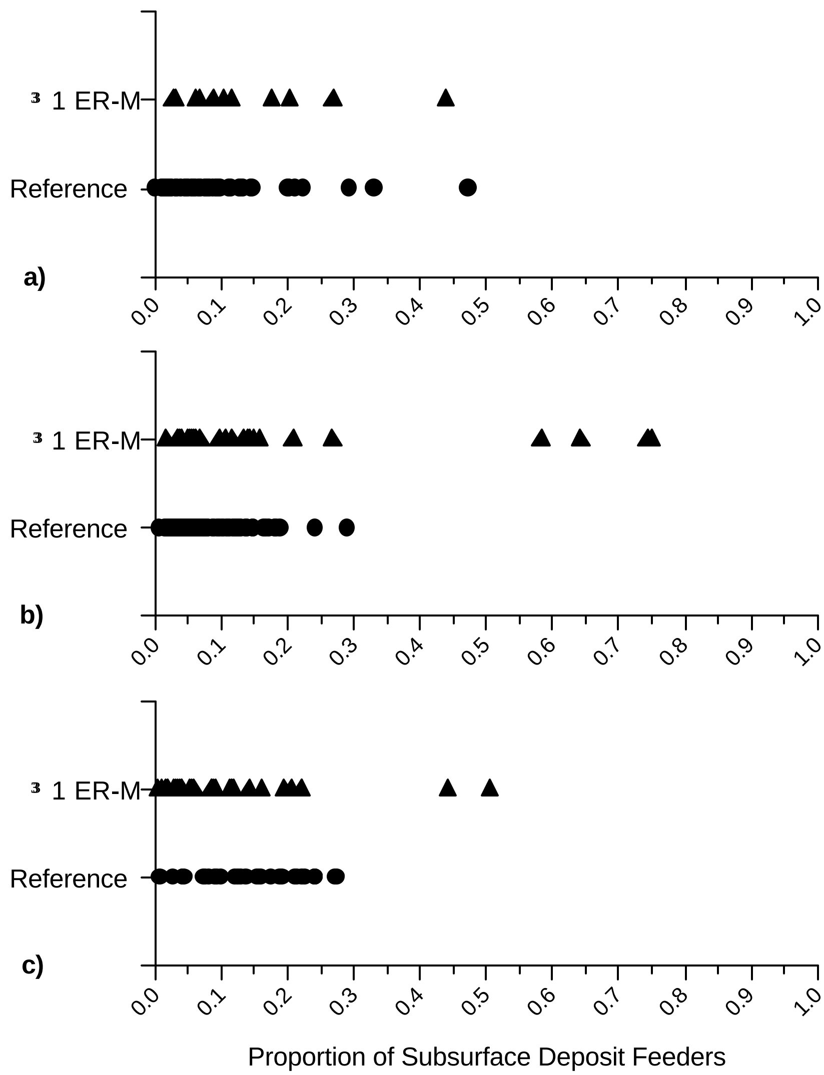
Attachment 1v. Value for proportion of suspension feeders in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



Attachment 1w. Value for proportion of surface deposit feeders in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



Attachment 1x. Value for proportion of suspension / surface deposit feeders in reference and ≥1 ER-M categories for: a) shallow (≤30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.



Attachment 1y. Value for proportion of subsurface deposit feeders in reference and ³1 ER-M categories for: a) shallow (£ 30 m), b) mid-depth (31-120 m), and c) deep (>120 m) stations.

INSTRUCTIONS FOR CALCULATING THE BENTHIC RESPONSE INDEX

Description of the Index

The Benthic Response Index is the abundance-weighted average pollution tolerance of species occurring in a sample. Pollution tolerance was determined by measuring the position of a species on a gradient between the most and least affected stations in a test data set that included 717 samples taken from the mainland shelf between Point Conception and the United States-Mexico border in 10 to 324 m of water.

The index formula is:

$$I_s = \frac{\sum_{i=1}^{n} p_i \sqrt[3]{a_{si}}}{\sum_{i=1}^{n} \sqrt[3]{a_{si}}}$$

where
I_s is the index value for sample s
n is the number of taxa for sample s; taxa without p_i values are not included in the calculation
p_i is the position for species i on the pollution gradient
a_{si} is the abundance of species i in sample s

While this formula generally describes the BRI, calculation is complicated by the need to account for the effect of depth on species distributions. Because communities differ and species responses to disturbance vary with depth, it was necessary to develop pollution tolerance scores for three depth zones: 1) 10-30 m, 2) >30-120 m, and 3) >120-324 m. In order to use the different p_i values and have a single index in all depth zones, procedures were developed to standardize and scale index values calculated for the shallow and deep zones to make them equivalent to index values calculated for the middle zone. Step-by-step instructions for index calculation follow.

1. Create a new data set with taxonomic categories consistent with the list of p_i values

The benthic data need to be changed so that the taxa names are consistent with the names in the tables of p_i values. This involves changing nomenclature and combining data for individual taxa into multi-taxa groups when necessary.

The nomenclature in the tables of p_i values is based on Edition 2 of the SCAMIT (1996) list of invertebrate species. The names in the lists have no formal nomenclatural status; they serve solely as links between reported taxa and the p_i values. The lists include multi-taxa groups (e.g., *Cossura* sp.) because it was sometimes necessary to combine individual taxa into generic or higher taxonomic categories to resolve taxonomic inconsistencies in the data set used to develop the index. The species to be included in these combined taxa are shown in Attachment 1 Table 1. Table 1 also includes recently published synonyms for some species.

In most instances, the easiest way to change the nomenclature is to create a two-column translation table with the original taxa name in the first column and the name from the list of p_i values in the second column. Taxa that are to be combined can be given the same name in the second column. Then abundance values can be summed within a sample across uniques taxa designations. Taxa that are not included in the list of p_i values are not used in calculations.

2. Associate species data with the appropriate p_i values

As noted above, there are three lists of p_i values, one for 10-30 m, one for >30-120 m and one for >120-324 m. In order to associate the benthic data with the appropriate list, samples need to grouped into the same depth categories. The index should only be applied in areas included in the geographic and depth zones of the data set used to develop the index. Samples taken in less than 10 or more than 324 m or from harbors or bays should not be included in the analysis.

3. Calculate index values for each depth zone

To calculate the index value for a station, the cube root of the abundance for each species is multiplied by the p_i value for the depth of the sample. These products are then summed and divided by the sum of the cube root of the abundance for all the species. For example, for a sample taken in 20 m with the following species

Species	p_i value	Abundance	Cube-root abundance
Amphiodia complex	51.2	2	1.26
Owenia collaris	24.8	10	2.15
Capitella capitata complex	60.2	20	2.71

$$I_p = \frac{(1.26)51.2 + (2.15)24.8 + (2.71)60.2}{1.26 + 2.15 + 2.71} = 45.91$$

I_p is the preliminary index value, prior to standardizing and rescaling (see step 4),

For a sample taken in 70 m

Species	p_i value	Abundance	Cube-root abundance
Amphiodia complex	24.7	2	1.26
Spiophanes missionensis	30.3	10	2.15
Capitella capitata complex	55.1	20	2.71

$$I_p = \frac{(1.26)24.7 + (2.15)30.3 + (2.71)55.1}{1.26 + 2.15 + 2.71} = 40.13$$

4. Standardize index values for the shallow and deep zones to the mid-depth zone

A formula is used to standardize index values for shallow and deep samples and thus make them equivalent to mid-depth index values. Index values for mid-depth samples do not need to be standardized.

For shallow stations $J_{shal} = 6.73 + 0.731 I_p$

For deep stations $J_{deep} = 3.72 + 1.17 I_p$

For mid-depth stations J_{mid}.= I_p

where J is the standardized index value.

For the shallow station above, J_{shal} = 6.73 + (0.731)(45.91) = 40.29

For a deep station with a preliminary index value of 33.52, J_{deep} = 3.72 + 1.17(33.52) = 42.94

5. Rescale index values

The final step is to rescale the standardized index values so they are all on an approximate scale of 0-100. It is possible to have values less than 0 or greater than 100 if the sum of pollution tolerance scores is beyond the range of the data used to develop the index (Bob - is this really true? I thought we had values outside of 0-100 in the ordination data, but did not want to push in the scale to accomodate a few outliers).

$$I_s = 100\left(\frac{J - 27.4983}{32.9498}\right)$$ where I_s is the final index value.

For the shallow station I_s = 100((40.29-27.4983)/32.9498) = 38.82

Attachment 2, Table 1. Taxa included in multi taxa species groups used in calculating the Benthic Response Index.

Phylum	Family	P-Name	Included Taxa
Annelida	Capitellidae	*Capitella capitata* complex*	all taxa within the genus
Annelida	Capitellidae	*Mediomastus* sp.	all taxa within the genus
Annelida	Capitellidae	*Notomastus* sp.	all taxa within the genus
Annelida	Maldanidae	*Petaloproctus* sp.	all taxa within the genus
Annelida	Maldanidae	*Praxillella* sp.	all taxa within the genus
Annelida	Cossuridae	*Cossura* sp.	all taxa within the genus
Annelida	Arabellidae	*Arabella* sp.	all taxa within the genus
Annelida	Arabellidae	*Drilonereis* sp.	all taxa within the genus
Annelida	Dorvilleidae	*Ophryotrocha* A/B/C complex	*Ophryotrocha* sp. A SCAMIT 1987, *O.* sp. B SCAMIT 1987, *O.* sp. C SCAMIT 1987 (Excl. *O.* sp.)
Annelida	Dorvilleidae	*Dorvillea (Schistomeringos) longicornis*	all taxa within the subgenus
Annelida	Eunicidae	*Marphysa* sp.	all taxa within the genus
Annelida	Lumbrineridae	*Lumbrineris* sp.	all taxa within the genus
Annelida	Onuphidae	*Mooreonuphis* spp.**	all taxa within the genus except *M. nebulosa* ; excl. *M* . sp.
Annelida	Onuphidae	*Onuphis iridescens* complex	*Onuphis iridescens, O. elegans, O.* sp. 1 Pt. Loma 1983; excl. *O* . sp.
Annelida	Fauveliopsidae	*Fauveliopsis* sp.	all taxa within the genus
Annelida	Orbiniidae	*Scoloplos armiger* complex	all forms referred to *Scoloplos armiger*
Annelida	Paraonidae	*Acmira* sp.	all taxa within the subgenus
Annelida	Paraonidae	*Allia ramosa*	*Aricidea (Allia)* sp. A SCAMIT 1996
Annelida	Paraonidae	*Allia* cf. *nolani*	*Aricidea (Allia) hartleyi*
Annelida	Paraonidae	*Levinsenia* sp.	all taxa within the genus
Annelida	Oweniidae	*Myriochele* sp.	all taxa within the genus
Annelida	Aphroditidae	*Aphrodita* sp.	all taxa within the genus
Annelida	Phyllodocidae	*Eteone* sp.	all taxa within the genus
Annelida	Phyllodocidae	*Eulalia* sp.	all taxa within the genus
Annelida	Phyllodocidae	*Phyllodoce* sp.	all taxa within the genus
Annelida	Pilargidae	*Ancistrosyllis* sp.	all taxa within the genus
Annelida	Pilargidae	*Parandalia* sp.	all taxa within the genus
Annelida	Sigalionidae	*Sthenelais* spp.	all taxa within the genus except *S. verruculosa* ; excl. *S* . sp.
Annelida	Syllidae	*Autolytus* sp.	all taxa within the genus
Annelida	Syllidae	*Pionosyllis* sp.	all taxa within the genus
Annelida	Syllidae	*Proceraea* sp.	all taxa within the genus
Annelida	Syllidae	*Sphaerosyllis* sp.	all taxa within the genus
Annelida	Syllidae	*Syllis (Typosyllis)* spp.	all taxa within the subgenus except *S. (T.) farallonensis* ; excl. *S. (T.)* sp.
Annelida	Sabellidae	*Chone* complex	*Chone, Fabrisabella , Jasmineria* ; all taxa within the genera
Annelida	Sabellidae	*Euchone* sp.	all taxa within the genus
Annelida	Chaetopteridae	*Mesochaetopterus* sp.	all taxa within the genus
Annelida	Cirratulidae	*Aphelochaeta/Monticellina* complex	*Aphelochaeta, Monticellina* ; all taxa within the genera
Annelida	Cirratulidae	*Chaetozone setosa* complex	all forms referred to *Chaetozone setosa*
Annelida	Cirratulidae	*Cirratulus* sp.	all taxa within the genus
Annelida	Cirratulidae	*Cirriformia* sp.	all taxa within the genus
Annelida	Magelonidae	*Magelona* spp.	all taxa within the genus except *M.* pitelkai and *M.* sacculata; exclude *M* .
Annelida	Spionidae	*Carazziella* sp.	all taxa within the genus
Annelida	Spionidae	*Polydora* sp.	*Polydora, Dipolydora* ; all taxa within the genera
Annelida	Spionidae	*Prionospio* A/B complex	*Prionospio* sp. A SCAMIT 1991 and *P.* sp. B SCAMIT 1991
Annelida	Spionidae	*Prionospio lighti*	*Prionospio lighti* and *P. multibranchiata*

* Complex indicates a group of undiscriminated species.

** Spp. is used when genus level identifications are not included in the group.

Attachment 2, Table 1. Taxa included in multi taxa species groups used in calculating the Benthic Response Index.

Phylum	Family	P-Name	Included Taxa
Annelida	Spionidae	*Scolelepis* spp.	all taxa within the genus except *S. occidentalis* [Exclude *S*. sp.]
Annelida	Spionidae	*Spio* sp.	all taxa within the genus
Annelida	Spionidae	*Spiophanes missionensis*	*Spiophanes duplex*
Annelida	Ampharetidae	*Lysippe* sp.	all taxa within the genus
Annelida	Ampharetidae	*Sosane occidentalis*	*Sosane occidentalis* and *Sosanopsis* sp. A SCAMIT 1996
Annelida	Terebellidae	*Lanassa* sp.	all taxa within the genus
Annelida	Terebellidae	*Polycirrus* sp.	all taxa within the genus
Annelida	Terebellidae	*Streblosoma* sp.	all taxa within the genus
Annelida	Trichobranchidae	*Terebellides* sp.	all taxa within the genus
Arthropoda	Ampeliscidae	*Ampelisca cristata*	*Ampelisca cristata cristata* and *A. cristata microdentata*
Arthropoda	Ampeliscidae	*Ampelisca hancocki* complex	all forms referred to *Ampelisca hancocki*
Arthropoda	Aoridae	*Aoroides* sp.	all taxa within the genus
Arthropoda	Corophiidae	*Corophium* sp.	all taxa within the subfamily
Arthropoda	Eusiridae	*Rhachotropis* sp.	all taxa within the genus
Arthropoda	Hyalidae	*Hyale* sp.	all taxa within the genus
Arthropoda	Isaeidae	*Photis* sp.	all taxa within the genus
Arthropoda	Isaeidae	*Protomedeia* sp.	all taxa within the genus
Arthropoda	Ischyroceridae	*Cerapus tubularis* complex	all forms referred to *Cerapus tubularis*
Arthropoda	Lysianassidae	*Hippomedon* sp.	all taxa within the genus
Arthropoda	Melphidippidae	*Melphisana bola* complex	all forms referred to *Melphisana bola*
Arthropoda	Oedicerotidae	*Monoculodes* sp.	*Monoculodes, Hartmanodes, Pacifoculodes, Deflexilodes*; all taxa within the genera
Arthropoda	Oedicerotidae	*Synchelidium* sp.	all taxa within the genus
Arthropoda	Pardaliscidae	*Pardaliscella* sp.	all taxa within the genus
Arthropoda	Phoxocephalidae	*Heterophoxus* sp.	all taxa within the genus
Arthropoda	Podoceridae	*Podocerus* sp.	all taxa within the genus
Arthropoda	Diastylidae	*Diastylis* sp. A	*Diastylis crenelata*
Arthropoda	Diastylidae	*Leptostylis* sp. A	*Leptostylis calva*
Arthropoda	Diastylidae	*Leptostylis villosa*	*Leptostylis abdidtis*
Arthropoda	Nannastacidae	*Campylaspis* sp. D	*Campylaspis maculinoduosa*
Arthropoda	Nannastacidae	*Cumella* sp. A	*Cumella californica*
Arthropoda	Nannastacidae	*Procampylaspis* sp. A	*Procampylaspis caenosa*
Arthropoda	Callianassidae	*Neotrypaea* sp.	all taxa within the genus
Arthropoda	Majidae	*Podochela* sp.	all taxa within the genus
Arthropoda	Paguridae	*Pagurus* sp.	all taxa within the genus
Arthropoda	Upogebiidae	*Upogebia* sp.	all taxa within the genus
Arthropoda	Idoteidae	*Edotia* sp.	all taxa within the genus
Arthropoda	Idoteidae	*Synidotea* sp.	all taxa within the genus
Arthropoda	Nebaliidae	*Nebalia* sp.	all taxa within the genus
Arthropoda	Leptognathiidae	*Araphura* sp. A	*Araphura breviaria*
Arthropoda	Leptognathiidae	*Araphura* sp. B	*Araphura cuspirostris*
Arthropoda	Cylindroleberidida	*Bathyleberis* sp.	*Bathyleberis, Xenoleberis*; all taxa within the genera
Arthropoda	Cylindroleberidida	*Parasterope* sp.	all taxa within the genus
Arthropoda	Rutidermatidae	*Rutiderma* sp.	all taxa within the genus
Chordata		Enteropneusta	all taxa within the class
Cnidaria	Edwardsiidae	Edwardsiidae	all taxa within the family
Cnidaria		Ceriantharia	all taxa within the order
Cnidaria	Corymorphidae	*Corymorpha* sp.	all taxa within the genus
Echinodermata	Luidiidae	*Luidia* sp.	all taxa within the genus
Echinodermata	Synaptidae	Synaptidae	*Synaptidae, Chiridotidae*; all taxa within the families

* Complex indicates a group of undiscriminated species.

** Spp. is used when genus level identifications are not included in the group.

Attachment 2, Table 1. Taxa included in multi taxa species groups used in calculating the Benthic Response Index.

Phylum	Family	P-Name	Included Taxa
Echinodermata	Amphiuridae	*Amphiodia* complex	all taxa within the genus
Echinodermata	Amphiuridae	*Amphioplus* sp.	all taxa within the genus
Echinodermata	Amphiuridae	*Amphipholis* sp.	all taxa within the genus
Echinodermata	Amphiuridae	*Dougaloplus* sp.	all taxa within the genus
Mollusca		Aplacophora	*Chaetoderma, Falcidens, Limifossor* ; all taxa within the genera
Mollusca	Corbulidae	*Corbula* sp.	*Caryocorbula, Juliacorbula* ; all taxa within the genera
Mollusca	Mytilidae	*Modiolus* sp.	all taxa within the genus
Mollusca	Nuculanidae	*Nuculana* sp.	all taxa within the genus
Mollusca	Cuspidariidae	*Cardiomya* sp.	all taxa within the genus
Mollusca	Carditidae	*Cyclocardia* spp.	*Cyclocardia ventricosa* and *C. barbarensis;* exclude *C.* sp.
Mollusca	Mactridae	Mactridae	all taxa within the family
Mollusca	Montacutidae	*Mysella* sp.	*Mysella; Rochfortia* ; all taxa within the genera
Mollusca	Petricolidae	*Petricola* sp.	all taxa within the genus
Mollusca	Solenidae	*Solen* sp.	all taxa within the genus
Mollusca	Tellinidae	*Tellina carpenteri*	*Tellina carpenteri* and *T.* sp. A
Mollusca	Thracidae	*Periploma/Thracia* complex	*Asthenothareus, Thracia;* all taxa within the genera; and *Periploma discus ;* exclude *P.* sp.
Mollusca	Veneridae	*Chione* sp.	all taxa within the genus
Mollusca	Veneridae	*Protothaca* sp.	all taxa within the genus
Mollusca	Pyramidellidae	*Odostomia* sp.	all taxa within the genus
Mollusca	Pyramidellidae	*Turbonilla* sp.	all taxa within the genus
Mollusca	Conidae	*Kurtziella beta*	*Kurtzina beta*
Mollusca	Conidae	*Ophiodermella* sp.	all taxa within the genus
Mollusca	Calyptraeidae	*Crepidula* sp.	*Crepidula, Crepipatella* ; all taxa within the genera
Mollusca	Cerithiidae	*Bittium* complex	*Bittium, Lirobittium* ; all taxa within the genera
Mollusca	Cerithiopsidae	*Cerithiopsis* sp.	all taxa within the genus
Mollusca	Epitoniidae	Epitoniidae	all taxa within the family
Mollusca	Eulimidae	*Eulima californicus*	*Eulima californicus* and *E. almo*
Mollusca	Eulimidae	*Melanella* sp.	*Balcis, Polygyreulima, Vitriolina* ; all taxa within the genus
Mollusca	Rissoidae	*Alvania acutelirata*	*Alvania compacta*
Mollusca	Vitrinellidae	*Vitrinella* sp.	all taxa within the genus
Mollusca	Lepidopleuridae	*Leptochiton* sp.	all taxa within the genus
Mollusca	Dentaliidae	*Dentalium* sp.	all taxa within the genus
Phorona		Phoronida	all taxa within the order

* Complex indicates a group of undiscriminated species.

** Spp. is used when genus level identifications are not included in the group.