BENTHIC SAMPLING IN THE VICINITY OF SEWAGE OUTFALLS OFF TANGUISSON AND AGANA, GUAM, MARIANA ISLANDS

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"Benthic Community Structure of Reef Sediments in the Vicinity of Sewage Outfalls at Tanguisson and Agana, Guam, Mariana Islands"

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ABSTRACT

This study characterizes the taxon richness and abundance of benthic fauna from nearshore sediments off Tanguisson Point and Agana, Guam, Mariana Islands. This effort addresses United States Environmental Protection Agency requirements of 301(h) waiver permits for baseline data prior to the construction/extension of two new outfalls to replace those currently in operation. Living infauna and epifauna exceeding 1 mm in any dimension were collected with a modified van Veen grab from three stations off Agana and four stations off Tanguisson Point (three replicates each). All samples were collected in July 2001 at depths of 39.6 to 91.4 m. Polychaetes were the most diverse and abundant component with 1,164 individuals belonging to 82 taxa (typically representing species) among 29 families. Overall, polychaetes were more abundant off Tanguisson than off Agana. Thirty-one other taxa (totaling 1,539 individuals) were differentiated in the general invertebrate samples: Anthozoa, Arachnida, Chaetognatha, Crustacea (9 taxa), Echinodermata (3 taxa), Hemichordata, Hydrozoa, Kinorhyncha (2 taxa), Mollusca (3 taxa), Nematoda, Nemertea, Oligochaeta, Phoronida, Platyhelminthes, Porifera, Sipuncula, and Urochordata. Nematodes and mollusks were represented at both sites, but the Tanguisson locality was characterized by a higher abundance of them than Agana. Patterns of polychaete abundance and taxon richness were similar at both sites and appear comparable to those from similar habitats near outfalls off O'ahu, Hawai'i. Multi-dimensional scaling analyses suggest that each locale has a distinct polychaete assemblage, but that differences between stations within and outside each proposed mixing zone boundary are small. Sediment cores were also taken to analyze the time-averaged micromollusk assemblages represented by fossil and sub-fossil shell remains. A total of 3,476 specimens comprised of 3,005 gastropods and 471 bivalves representing 158 taxa were

identified. Micromollusks ranged from 310 per 15 cm^3 (Tanguisson Station T-SW) to 726 per 15 cm^3 (Agana Station A-SE). Micromollusk taxa ranged from 52 per 15 cm^3 (at Agana) to 77 per 15 cm^3 (at Tanguisson). The micromollusk samples represent diverse coral reef-associated fauna, dominated by detritivores such as members of the family Cerithiidae, but with virtually no predatory or carnivorous specimens present.

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INTRODUCTION

National regulations, e.g. U. S. Clean Water Act of 1972, specify that sewage effluent should be at the secondary treatment level for discharge into all U. S. coastal waterways. Government agencies of island localities surrounded by steep-sloped bathymetry and oligotrophic waters may apply for a 301(h)-waiver permit. The U. S. Environmental Protection Agency 301(h)-waiver permit is required by public works and state agencies to release primary treatment effluent into the nearshore environment. Benthic infaunal and epifaunal assemblages are characterized by their taxon richness and abundance as part of benthic monitoring programs at outfalls in such locations. This study, which may be the first evaluation of the benthos at the two sewage outfalls of Guam, followed a protocol similar to the biomonitoring 301(h) waiver for the outfalls of O'ahu, Hawai'i. It also provided an opportunity to compare the Guam outfall communities with those of O'ahu to help guide future outfall and monitoring activities.

This study also investigated which, if any, polychaete species may represent indicator species in the sandy benthos at the prospective outfall locations. Species commonly present prior to construction and operation of outfalls, but absent afterwards, may be responding to the environmental disturbance. Species that can utilize the organic component of sewage as a food resource may produce large numbers of offspring, thrive near the operating outfalls, and often exclude other species. By identifying the major infaunal and epifaunal components of sampling stations inside and outside of the proposed mixing zone boundary (MZB), future biomonitoring programs can more accurately assess the impacts, if any, operation of the outfalls may have on the adjacent benthic community.

The micromollusks and invertebrates were sampled and analyzed separately. The invertebrates included all fauna not considered micromollusks. The polychaete component of

the invertebrate samples was analyzed in greater detail due to their relatively high abundance and diversity. Polychaetes are such an abundant and diverse group of invertebrates in tropical ecosystems that designated analyses of their role in benthic communities are warranted, as they are indicative of the general health of small regions of local ecosystems. The assemblages were compared both within and between the two locations.

MATERIAL AND METHODS

Study Sites

Both sampling locations were on the northwestern coast of Guam near 13° N latitude and 144° E longitude (Figures 1 and 2). Depths ranged from 39.6 to 52.1 m off Tanguisson Point and 65.5 to 91.4 m at the Agana outfall (Table A.1 and A.2). The existing Agana outfall discharges approximately eight million gallons per day (mgd) of effluent at a depth of 65.8 m. The proposed outfall will release effluent approximately 122 m farther seaward at a depth of approximately 84 m. The Agana site benthos was sampled at three stations: A-NE and A-SW outside the proposed MZB and only one replicate of A-SE inside the proposed boundary. The existing Tanguisson outfall discharges approximately 6 mgd at the 39.5 m depth. The proposed outfall will be located about 85 m farther seaward at a depth of approximately 43 m. Tanguisson was characterized at four stations: T-SE and T-NW outside the proposed MZB, T-SW astride the boundary, and T-NE inside the boundary.

Sampling Methods

Twenty-one sediment samples intended for invertebrate analysis were collected by GMP Associates, Inc. on July 20 and 22, 2001. Cores 7.6 cm in diameter and 10 cm deep, having a volume of approximately 500 cm^3, were requested by the investigators. The cores

were taken from replicate modified van Veen grab samples that collect an undisturbed quadrant of bottom sediment and overlying water. A recommendation to retain overlying water and small infauna and motile epifauna (i.e., crustaceans) was made. The cores were fixed in 15% buffered formalin with rose bengal indicator in Nalgene containers. In addition, 5 cm diameter by 5 cm deep sediment cores were collected at the same time for micromollusk analysis. These were placed on ice to prevent discoloration of the shells. Three replicates for each analysis were taken at each sampling station. Field replicates labeled 1, 3, and 5 from each station were processed for invertebrate analysis, while replicates labeled 2, 4, and 6 were processed for micromollusk analysis.

The forty-two sediment samples were flown in coolers as soon as possible after collection and preservation to Honolulu, Hawai'i. Custody was transferred to the staff of the Wormlab at the Zoology Department, University of Hawai'i, on the afternoon of July 23, 2001. Micromollusk samples were stored in a refrigerator until they could be processed.

Sample Condition

The sample condition was evaluated upon arrival at the Zoology Department. The label information, color and texture of the sand, amount of overlying liquid in each container (Table A.1), whether container lids fit tightly, and whether cool to touch were noted for each replicate. Samples were topped off with buffered 15% formalin with rose bengal stain as needed. Samples varied considerably from the proposed volume of 500 cm^3. The volume collected actually ranged from about 65 cm^3 to nearly 420 cm^3. Samples also varied considerably in the amount of overlying water and fixative, suggesting that field sampling may have been more irregular than proposed or typical as compared to other biomonitoring programs.

Sample Processing

Invertebrate Samples - Handling, processing, and preservation of biological samples followed EPA procedures as modified for samples taken adjacent to ocean outfalls off O'ahu (U.S. EPA 1987, Nelson et al. 1987, Russo et al. 2000, Swartz et al. 2000, 2001). Samples were fixed in 15% buffered formalin for a minimum of 24 hours. Fixed samples were elutriated using the technique of Sanders et al. (1965). This method removes most infauna and epifauna not heavily calcified from sandy sediments. Fresh water was added as the samples were agitated to suspend animals before being washed into a 0.5-mm mesh sieve. This process was repeated several times. Larger coral rubble fragments were treated using an acid dissolution procedure and also poured through a 0.5-mm mesh sieve in order to sample the cryptic, encrusting, or boring taxa (Brock and Brock 1977).

Polychaetes and other invertebrates retained on the sieve were transferred to a container, stained with rose bengal, and stored in 70% ethanol. Because the individuals were alive at the time of collection, these samples are considered to be a real-time snapshot of the resident assemblage. Invertebrates were sorted to major taxa (e.g., nematodes, crustaceans, mollusks, echinoderms, and polychaetes) using a dissecting microscope. They were identified and enumerated using compound microscopes. All invertebrate samples were processed by August 15, 2001, and all identification and enumeration were completed by October 1, 2001.

Micromollusk Samples - The micromollusk sediment samples (15 cm^3 each) provided for identification (Table A.2) and counts of micromollusks were processed in September 2001.

Data Analysis

Invertebrate Samples - Data collected were entered and arranged using Microsoft Excel© 8.0a. Analyses were performed with two statistical packages: MINITAB 12.0 (Minitab,

Inc. 1998) and PRIMER© 4.0 (Carr 1997). Samples from the stations were summarized with descriptive statistics (e.g., mean, median, standard deviation) and biological indices of diversity and evenness (Shannon-Wiener, H'; Pielou's, J'). Invertebrate richness as reported includes 82 polychaete taxa as well as 31 higher-level taxa, including: Anthozoa, Arachnida, Crustacea (9 taxa), Chaetognatha, Echinodermata (3 taxa), Hemichordata, Hydrozoa, Kinorhyncha (2 taxa), Mollusca (3 taxa), Nematoda, Nemertea, Oligochaeta, Phoronida, Platyhelminthes, Porifera, Sipuncula, and Urochordata. Data normality (Kolmogorov-Smirnov D-Statistic) and homogeneity of variances of total abundance and taxon richness of all stations were tested to determine if they agreed with the assumptions for analyses of variances (ANOVA). For data that satisfied these assumptions, ANOVA tests were performed. If not, the data was transformed (square root) and analyzed again. When transformation did not reconcile normality and equivalent variance, a non-parametric test (Kruskal-Wallis) was employed to determine if any statistical differences existed among stations or sites (using pooled replicate data).

The final level of statistical analyses involved hierarchical agglomerative cluster analyses and multi-dimensional scaling of double-square-root transformed abundance and taxa data. As with previous tests, the replicates pooled by the seven stations and two sites were also analyzed, but in this case the 21 individual replicates could also be examined. The resulting dendrograms and ordination plots provide a view of these assemblages that is based on the individual taxa identified at a higher degree of taxonomic resolution than the previously mentioned indices and tests.

Micromollusk samples - Station positions were recorded for all samples, but their orientation to the proposed diffuser and ZMB was missing from the original field notes. Therefore, the following micromollusk results are necessarily limited to lists of taxa and

counts, percent abundance of taxa, and a dendrogram (performed using MINITAB 10Xtra) of stations for the taxa of micromollusks present in the samples. Because the micromollusks were not separated into living and dead shell material, they represent time-averaged collections that integrate conditions at a site over a long period of time rather than at any single point in time.

RESULTS

Invertebrates

A total of 2,703 individuals were present in the Tanguisson and Agana invertebrate samples. Invertebrate taxa are listed in Tables 1 and 2. The Tanguisson sediments contained 2,090 organisms in 12 replicates, and the Agana sediments had produced 613 in 9 replicates (Tables 3 and 4). The nine crustacean taxa identified (Amphipoda, Copepoda, Cumacea, Crustacea sp. 1, Decapoda, Isopoda, Ostracoda, Stomatopoda, and Tanaidacea) from both sites were similar in abundance. Harpacticoid copepods and amphipods were commonly abundant crustacean taxa at both sites. Agana produced five times more tanaids per replicate than Tanguisson. Otherwise, crustacean assemblages appear similar between the outfall locations and among all outfall stations at this resolution. Nematodes and bivalve mollusks were more numerous in the Agana sediments than those in the Tanguisson sediments (Tables 1 and 2). Figures 3 and 4 depict the percent abundance of invertebrate individuals and taxa that are comprised of polychaetes. The highest total and mean abundance of invertebrate individuals at the Tanguisson outfall were recorded from Station T-SE, followed by Stations T-NE, T-NW, and T-SW. As for the Agana outfall, Station A-NE had the largest total and mean abundance, whereas A-SE and A-SW had fewer invertebrates (Figure 5). Taxon richness at Tanguisson was

highest at Station T-SW, followed by Stations T-SE, T-NW, and T-NE, whereas at Agana, it was higher at Stations A-SE, A-NE, and lowest at Station A-SW (Figure 6).

The replicates and stations were characterized by descriptive statistics as well as diversity and evenness indices (Figures 7 to 9; Tables B.1 to B.3). At Tanguisson, diversity and evenness values were highest at Station T-SW followed by Stations T-NW, T-NE, and T-SE (with increasing variances of the mean). Values for Agana stations were similar. Statistical comparisons of stations (abundance and taxon richness) were performed, and the results are summarized in Table B.4. The only ANOVA result indicating a significant difference was between the square root transformed invertebrate abundance of pooled replicates of each outfall (Tables B.5 and B.6). Total abundance at Tanguisson was significantly higher than at Agana. This is largely due to the consistently high nematode counts at Tanguisson. Hierarchical agglomerative cluster analysis and non-metric multi-dimensional scaling (MDS) show the relationship of replicates (Figure 10) and stations (Figure 11) from both outfall sites. While there is some mingling among replicates of different sites, the overall view suggests distinct invertebrate assemblages at the Tanguisson and Agana outfalls, but similar assemblages among stations within each outfall location.

Polychaetes

The highest total and mean abundance of polychaete individuals at the Tanguisson outfall were recorded from Station T-SE, followed by Stations T-NW, T-NE, and T-SW. As for the Agana outfall Station, A-NE had the largest total and mean abundance, with Stations A-SE and A-SW having fewer polychaetes (Figure 12). At Tanguisson, taxon richness was highest at Station T-SW, followed by Stations T-SE, T-NW, and T-NE, whereas at the Agana outfall it was highest at Station A-SE, followed by Station A-NE, and lowest at Station A-SW (Figure

13). These results correspond to similar diversity patterns among higher invertebrate taxonomic groupings. Numerically dominant polychaete taxa at Agana were Pilargidae sp. 1, Capitellidae sp. 1, Syllidae sp. 5, Sabellidae sp. 3, and Pilargidae sp. 3. Dominant polychaetes at Tanguisson were Sabellidae sp. 3, Pilargidae sp. 1, Oweniidae sp. 1, and Hesionidae sp. 4.

Descriptive statistics as well as diversity and evenness indices (Figures 14 to 16; Tables B.7 to B.9) were used to characterize the replicates and stations. Diversity and evenness values decreased from Station T-SW to Stations T-NW, T-NE, and T-SE at Tanguisson but were similar throughout the Agana stations. Statistical comparisons of stations (abundance and taxon richness) were performed, and the results are summarized in Table B.10. No result of ANOVA tests or pairwise comparisons of replicates and stations indicated a significant difference in abundance or taxon richness. Cluster analysis and MDS ordinations show the relationship of replicates (Figure 17) and stations (Figure 18) from both outfall sites. Replicates generally grouped by outfall but not by station. If replicates are pooled by station and analyzed, the relationship between the assemblages at the two outfall sites is more evident. Stations inside and outside of the proposed MZB appear similar, supporting their later use as control and experimental sampling stations. The lack of significant statistical differences between stations at this point in time suggests that future differences will reflect either natural community fluctuations or environmental perturbation due to the construction or operation of the new outfalls. The former would be expected to occur at all stations similarly, while significant differences in abundance or richness occurring at stations inside the MZB, but not outside, would likely be attributable to the outfall's influence on the benthos.

Micromollusks

A total of 3,476 specimens comprised of 3,005 gastropods and 471 bivalves representing 158 taxa were identified (Tables 7 to 9). Micromollusks ranged from 310 per 15 cm^3 (Tanguisson Station T-SW) to 726 per 15 cm^3 (Agana Station A-SE) (Figure 19). Mollusk taxa ranged from 52 per 15 cm^3 (at Agana) to 77 per 15 cm^3 (at Tanguisson) (Figure 20). The highest numbers of gastropods per sample, 31 to 41 shells per cm^3, were at Stations T-NE, A-SW, and A-SE; the lowest number, 18.7 shells per cm^3, was at Station T-SW. The highest numbers of bivalves per sample, 7 to 10 shells per cm^3, were at Stations A-SW and A-SE; the lowest numbers, 1.4 and 2.4 bivalves per cm^3, were at Stations T-SE and T-NE. A cluster analysis of similarity (Euclidean distance, single linkage method, standardized variables) (Figure 21) indicated a similarity of 17% among Stations T-NW, A-NE, A-SW, T-SW, and T-SE. Station T-NE was the least similar of all sampled stations.

The most abundant mollusks in the samples were the presumably detritivorous cerithids. Nine species in five genera (*Cerithidium*, *Diala*, *Scaliola*, *Bittium*, and *Cerithium*) and 279 specimens recognized only as "cerithids" account for 23% of the gastropods counted. Another 18% of the gastropods were represented by the minute (3 to 4 mm diameter) Orbitestellidae (*Orbitestella*, *Omalogyra*) and the equally minute trochacean, *Cyclostremiscus* (Figure 22). Several families of gastropods were noticeably absent or occur in very small numbers: only 54 specimens of *Balcis*, which is parasitic on sea cucumbers and sea urchins, were recorded. Virtually no *Mitra*, *Terebra*, Turridae, or *Conus* specimens were found.

DISCUSSION AND CONCLUSIONS

The purpose of this study was to characterize and analyze two components of the benthic infaunal community from areas adjacent to the proposed improvements for the

Tanguisson and Agana ocean outfalls. This study can be compared, to some extent, with previous efforts at the same general location by Kohn and White (1977, at Tanguisson in the intertidal zone) and a recent ecological study of 101 polychaete species known from Guam (Bailey-Brock 1999). Both studies combined data from rock, rubble, and algal substrata, whereas this outfall study focused predominantly on a deeper sand habitat with a very small rubble component.

Data collection methods and results support comparison with biomonitoring efforts regarding Sand Island outfall (O'ahu), which discharges approximately 70 mgd of effluent at a depth of 70 m (Bailey-Brock 1995, 1996, 1999). Fewer polychaetes have been recorded from Guam, Saipan, and other islands in the Mariana chain though, and much work remains to be done on profiling the infauna of the region in general. The five dominant polychaetes, except for Hesionidae sp. 4, are present in Hawai'i sediments and are dominant taxa at Sand Island and Barbers Point sewage outfalls (e.g., Swartz et al. 2000, 2001). Capitellidae sp. 1 and other members of the *Capitella* complex flourish in sediments laden with detritus and are indicators of organic enrichment. Other characteristics of these organisms are that they are often present in large numbers, and can facilitate a reduction in the abundance of other taxa. Capitellids were conspicuously more abundant at Tanguisson (135 individuals among 12 replicates) than at Agana (3 individuals among 9 replicates). Pilargids were also noticeably more abundant at Tanguisson (448 individuals among 12 replicates) than at Agana (32 individuals among 9 replicates). These values seem to reflect the generally higher productivity and diversity (at all taxonomic levels) recorded at Tanguisson, and they do not suggest impact indicators since other species are not excluded. Syllidae sp. 5 is broadly distributed in shallow sand sediments in Hawai'i waters. Syllidae sp. 5 was abundant at Agana (87 individuals) but not at Tanguisson

where only four specimens were found in the sediment. Mean polychaete densities at the Tanguisson (16,632 individuals/m^2) and Agana (6,292 individuals/m^2) outfalls are comparable to those found at outfall sites in Hawai'i. The mean polychaete densities at the Sand Island outfall ranged from 7,289 to 16,368 individuals/m^2 for three depths (~20, 50, and 100 m), Barbers Point yielded 25,457 individuals/m^2 at 33 m, and the Waianae outfall averaged 11,043 individuals/m^2 at 61 m (Russo et al. 2000; Swartz et al. 2000, 2001). The year-to-year difference in raw abundance is most likely due to the patchy distribution of many of these polychaete taxa. The taxonomic composition of stations and fluctuations of commonly dominant taxa tend to be more informative about the general health of the benthos adjacent to the outfalls.

The invertebrate samples from the stations, as well as from the outfall sites as a whole, were compared on the basis of abundance and taxon richness of general invertebrate taxa (all) and the polychaete taxa (alone). The only significant difference found was the higher average abundance of all live invertebrates at Tanguisson. This difference was primarily due to the abundance of three taxa: nematodes, polychaetes, and bivalves. Multivariate statistical analyses showed that although the polychaete assemblages differ between the two outfall sites, they are similar among stations within each proposed outfall improvement area. Polychaetes were markedly more abundant at Station T-SE than at other Tanguisson stations.

The faunal composition of micromollusks is distinctly skewed toward detritivores. There is a relatively high proportion of pyramidellids (7.1%) and opisthobranchs (8.1%) among the gastropods. Pyramidellids are associated with other gastropods and worms; opisthobranchs are frequently sand dwellers. The high diversity of the samples is characteristic of coral reef faunas in the western Pacific. No single taxon dominates the samples. Similar micromollusk

assemblages have been recorded from Fanning and Johnson Islands. These samples differ from those recorded for O'ahu, where one or two gastropod species tend to dominate.

Although the analyses were restricted to comparisons of stations within an outfall and the two sites as a whole, it is clear that the differences among all stations are small. The different depths, and possibly sediment grain size composition of the samples, may explain differences observed among the Tanguisson and Agana stations. Reliable, replicated data regarding the grain-size distribution and organic content of sediments taken concurrently with benthic faunal samples would help in characterizing stations in future efforts. Additionally, extreme care should be taken to retain as much of the water overlying the collected sediments as possible. Many of the samples received had little or none of this water. This may be the reason for the rather low abundance of crustaceans in the Guam sediments compared to other Pacific Island sediments, because these organisms are usually active at the sediment-water interface. Other invertebrates collected are more often found within the sediments and are likely to be retained even with some loss of over-sediment water. Irregularities indicated by the variable sample volumes may mask environmental differences among stations, but given the data presented here, the general invertebrate and polychaete assemblages present at each station, within their respective outfall sites, appear directly comparable for the future purpose of establishing control and experimental biomonitoring stations. In closing, maintaining three replicates per station as a minimum (and 5 replicates as a maximum) is recommended, but ensuring that all replicates of at least one station at the Agana location are taken from within the MZB is also critical to future biomonitoring programs.

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TEXT FIGURES

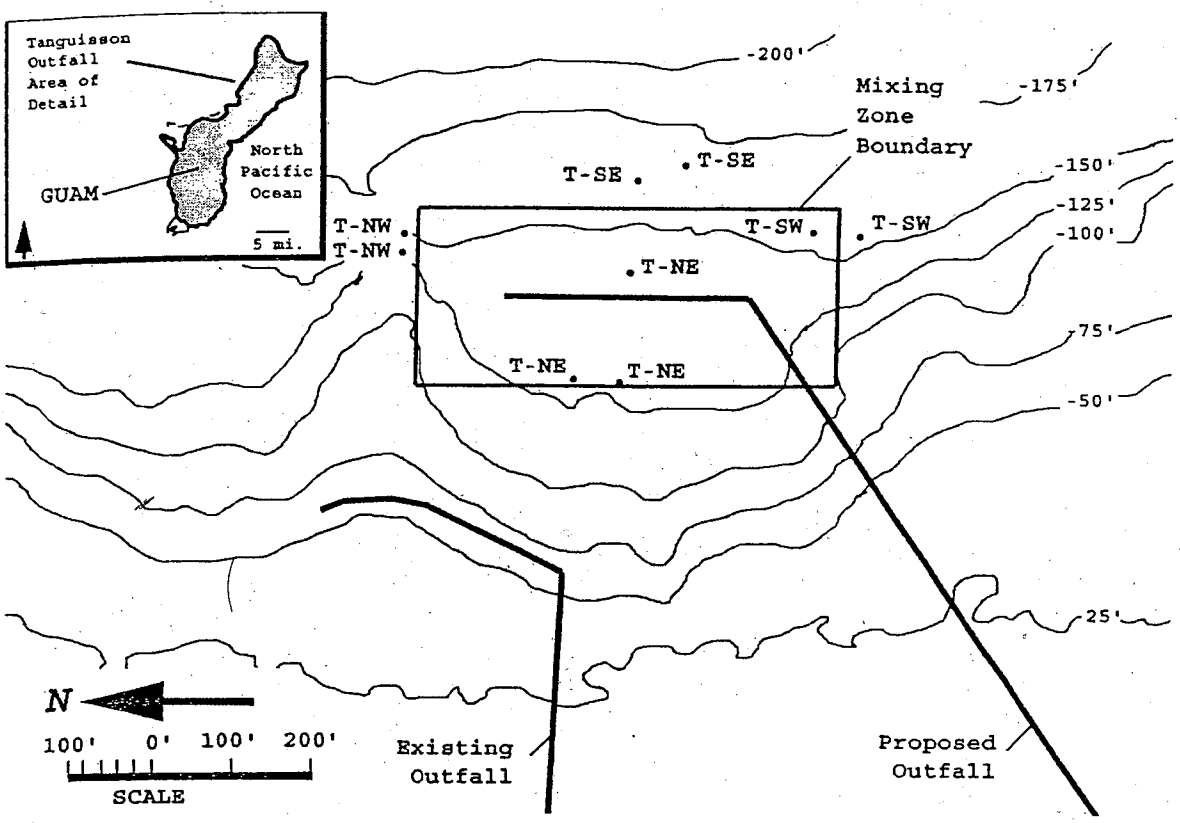


Figure 1. Site map for Tanguisson ocean outfall, Guam. The repeated points for the stations represent the invertebrate and micromollusk sampling locations

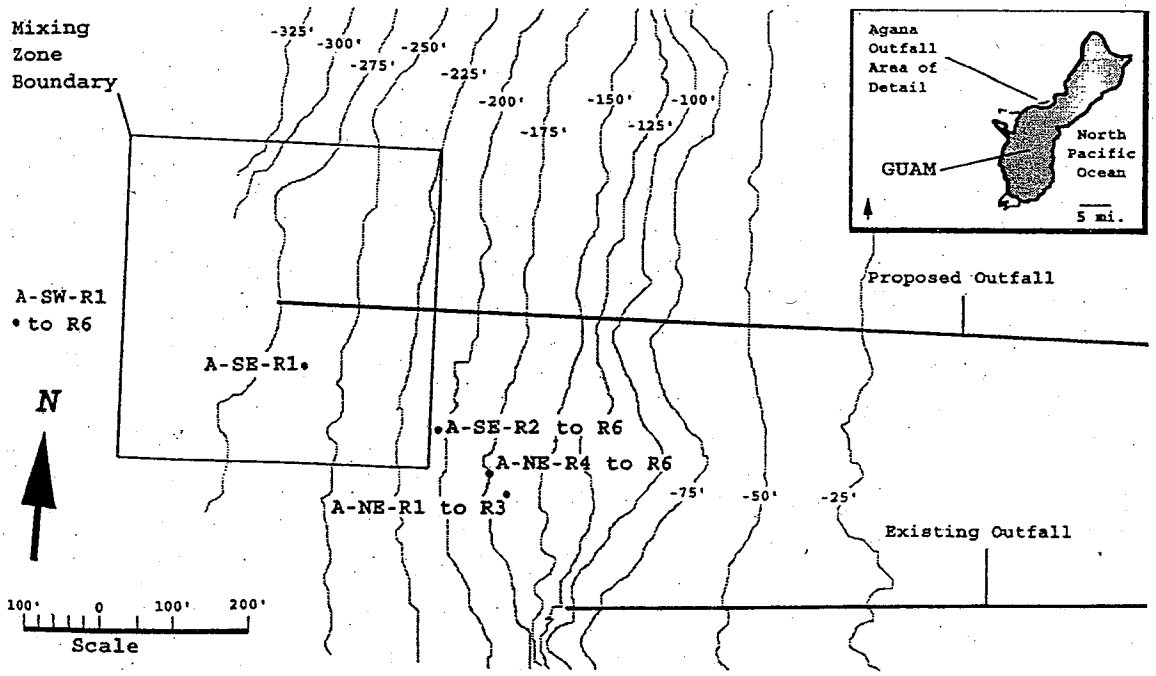


Figure 2. Site map for Agana ocean outfall sampling locations, Guam, 2001

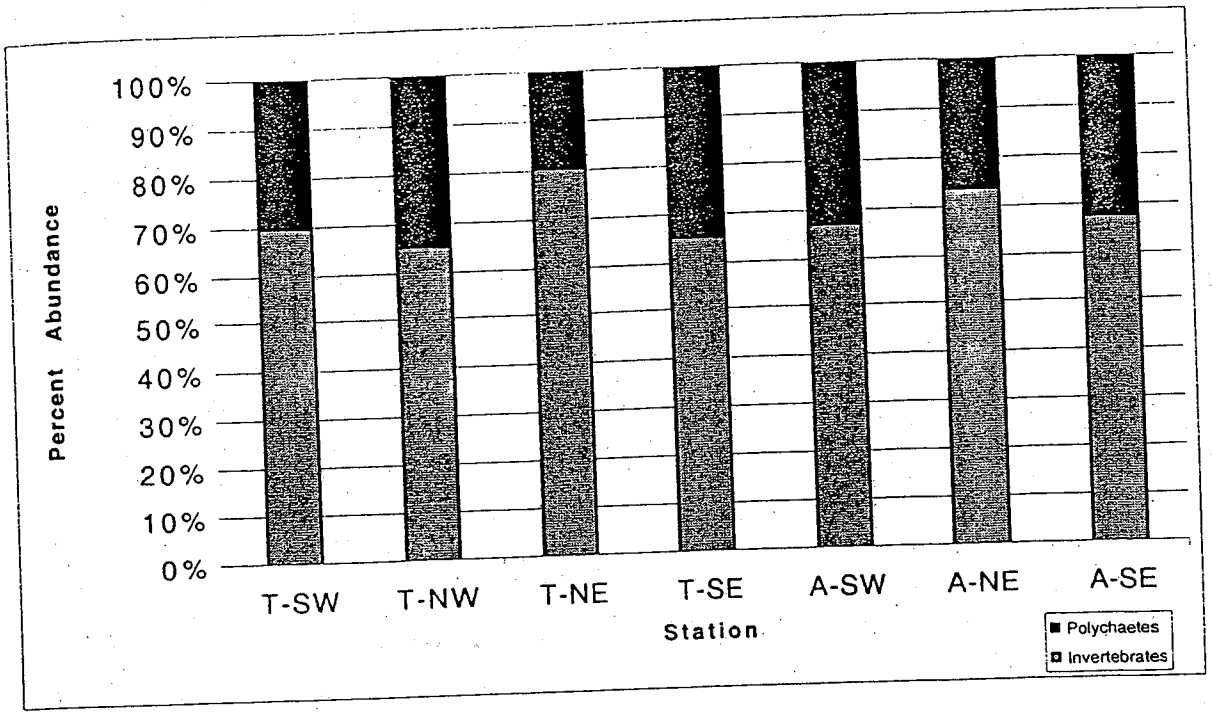


Figure 3. Percent abundance of polychaetes as a subset of the invertebrate individuals, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

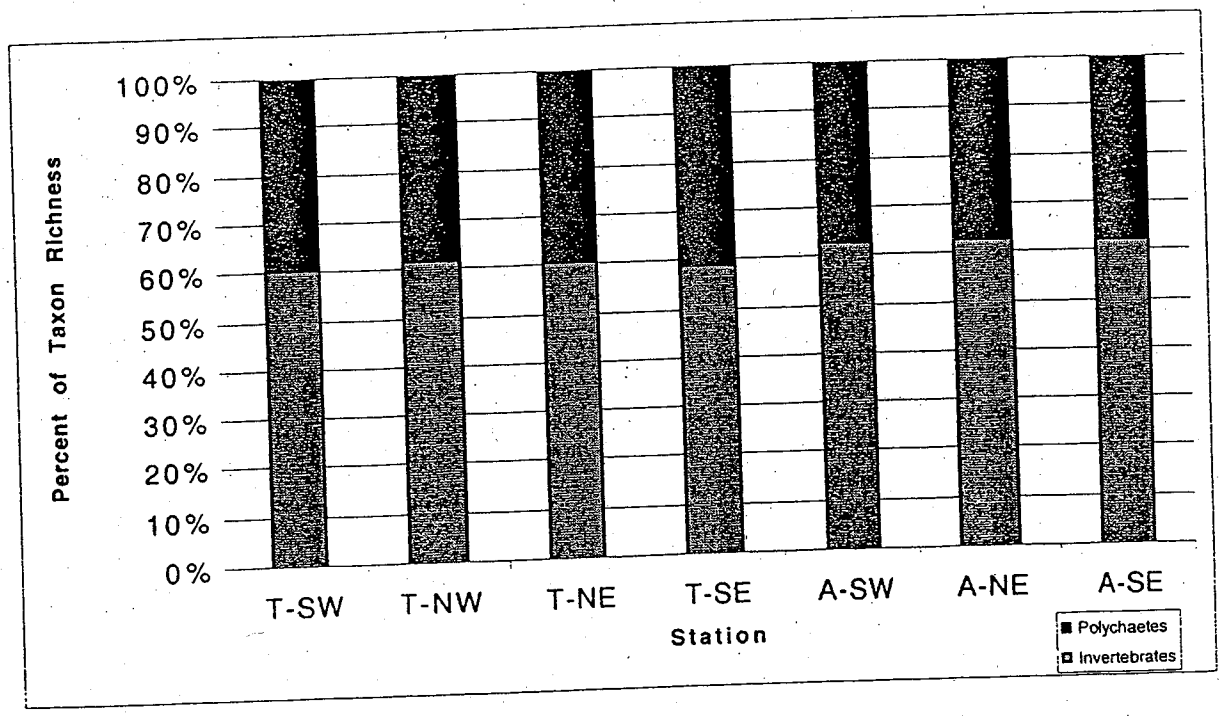


Figure 4. Percent polychaetes as a subset of the invertebrate samples of total invertebrate taxa, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

AGA 4196

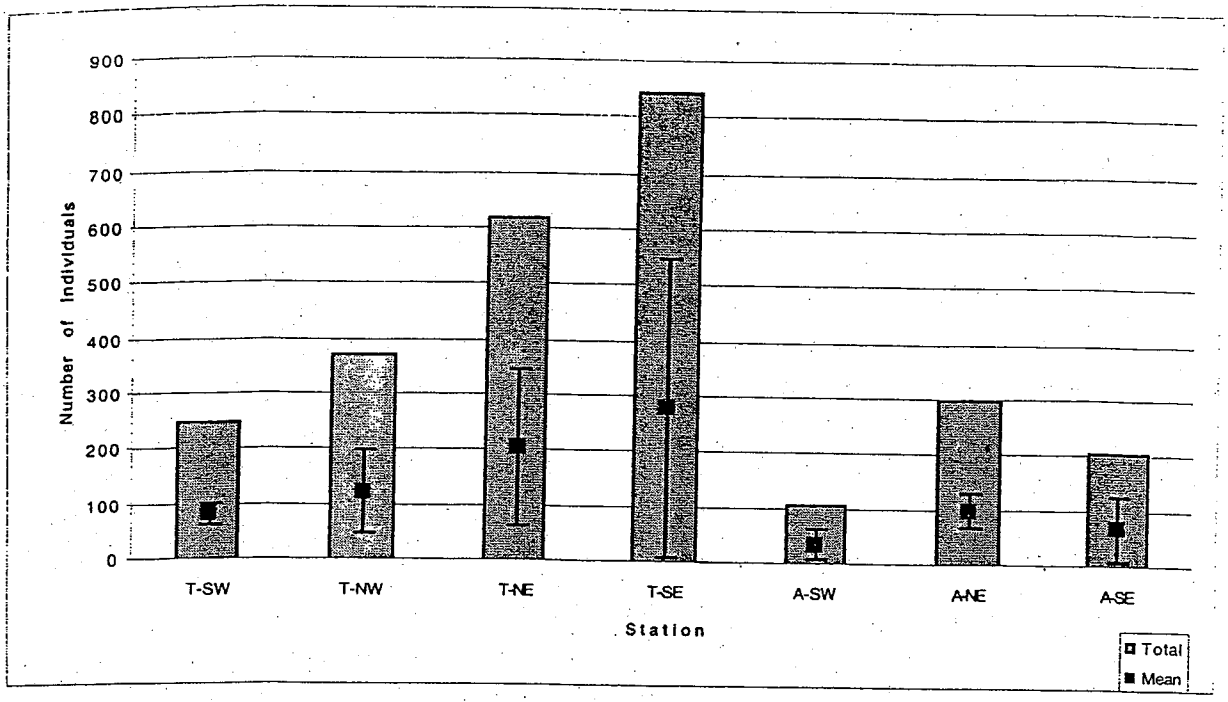


Figure 5. Total and mean (± 1 SD) abundance of invertebrates, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

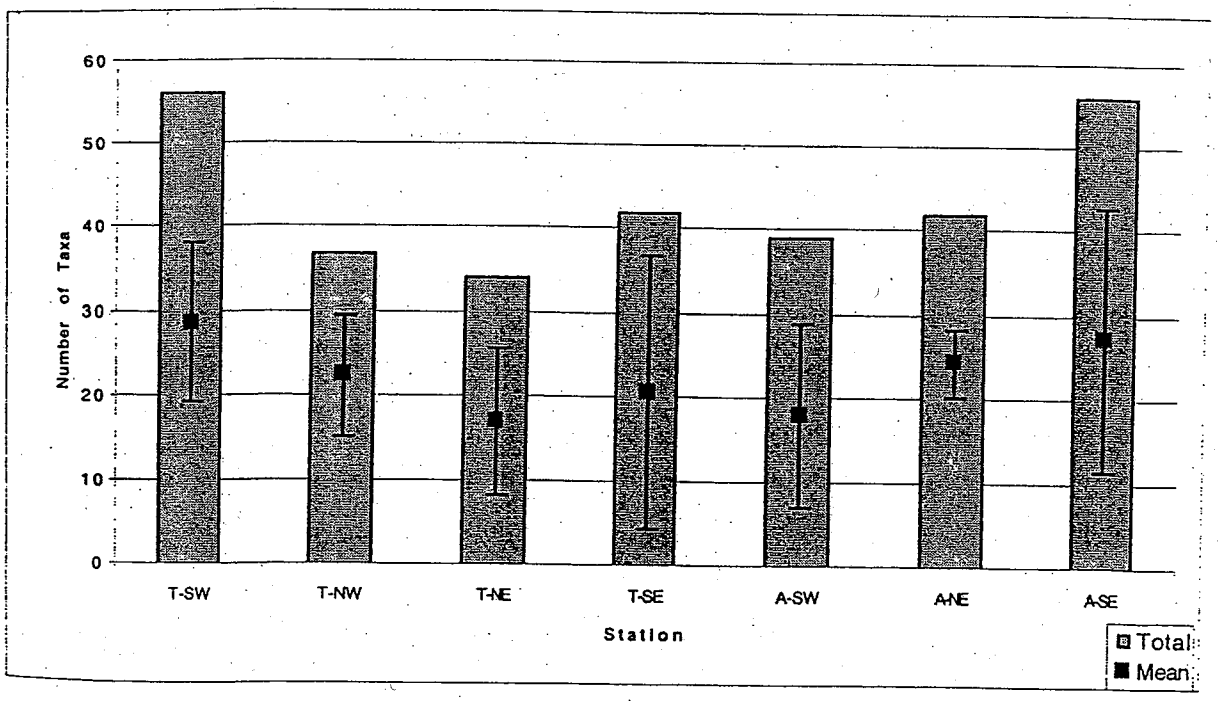


Figure 6. Total and mean (± 1 SD) taxon richness of invertebrates, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

AGA 4197

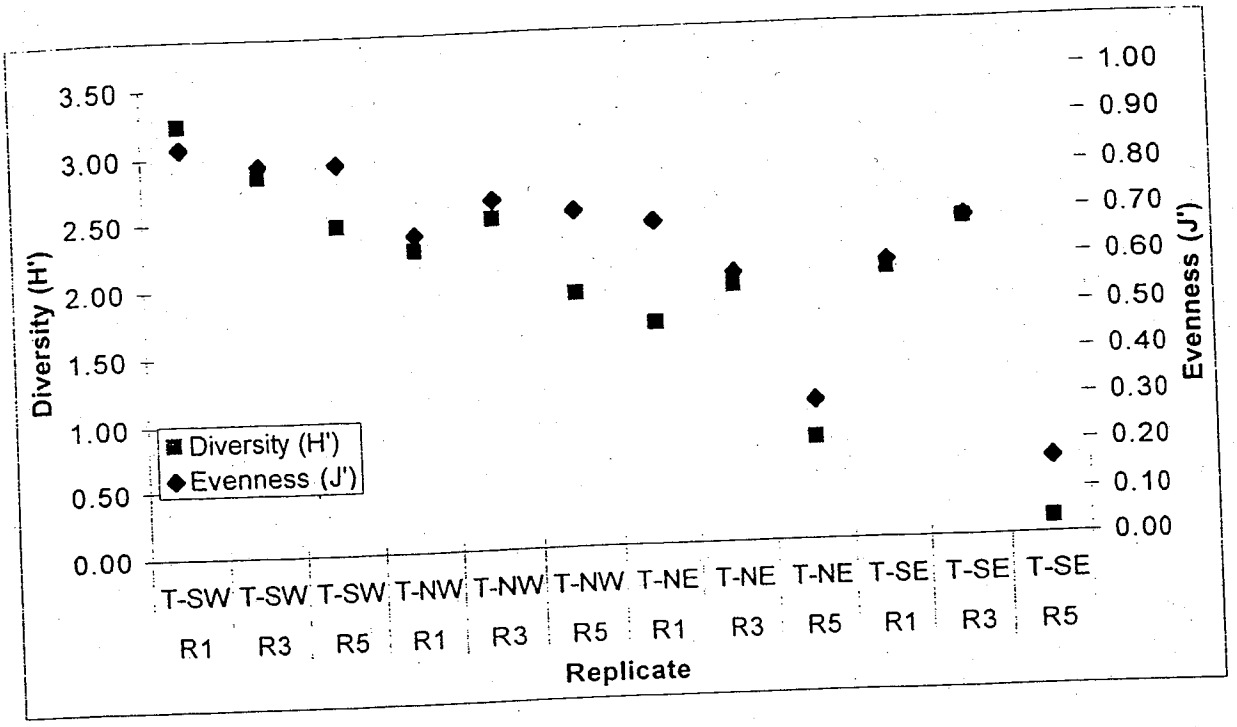


Figure 7. Shannon-Wiener diversity (H') and Pielou's evenness (J') indices for invertebrate taxa, Tanguisson ocean outfall sampling stations, Guam, 2001

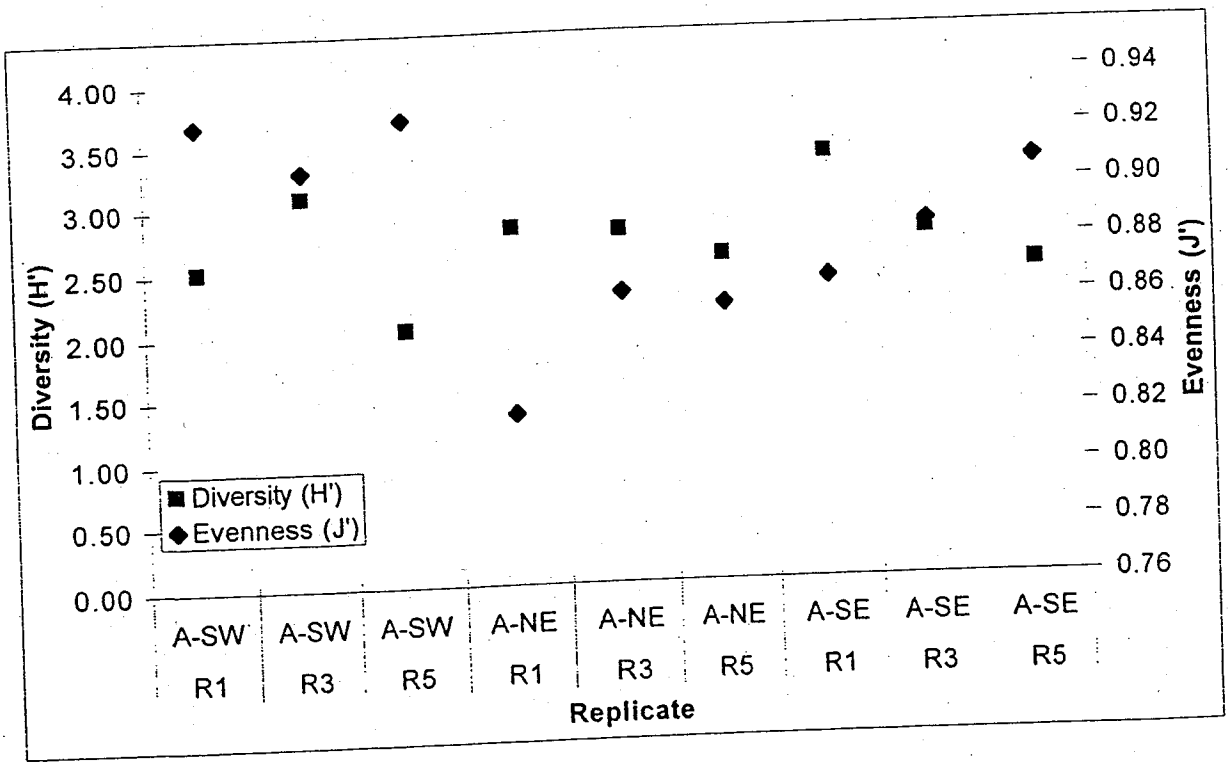


Figure 8. Shannon-Wiener diversity (H') and Pielou's evenness (J') indices for invertebrate taxa, Agana ocean outfall sampling stations, Guam, 2001

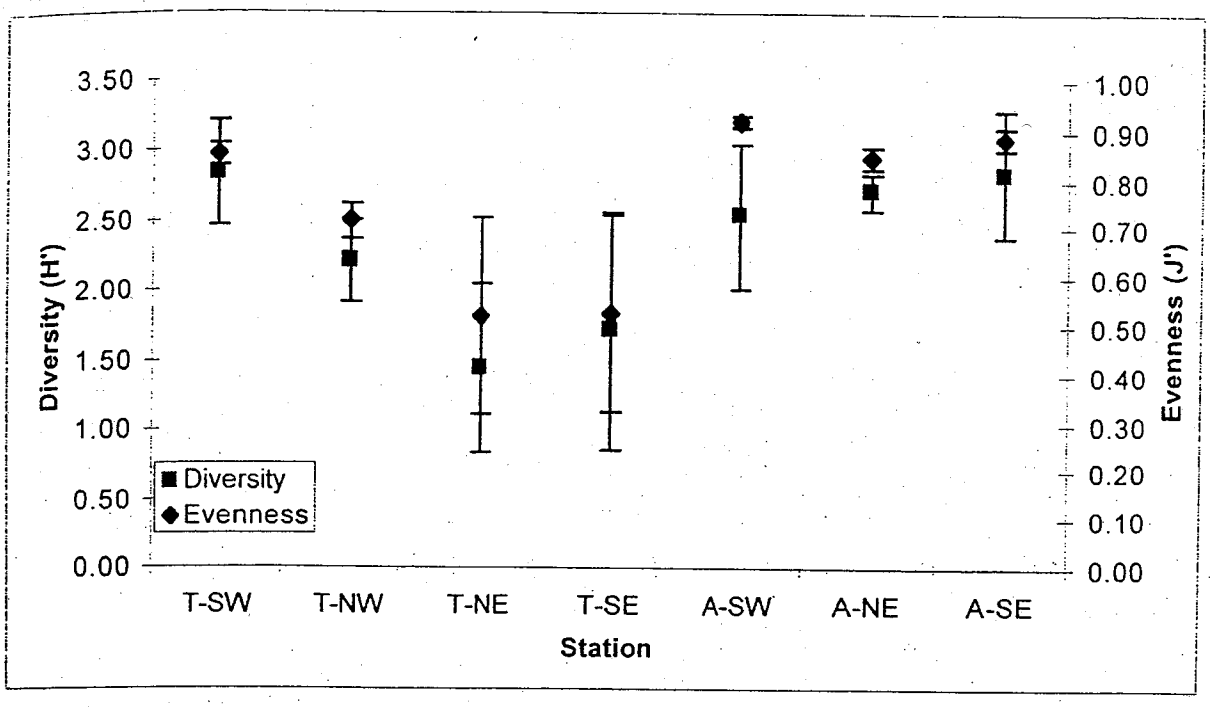


Figure 9. Mean (± 1 SD) diversity (H') and evenness (J') indices for invertebrate taxa, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

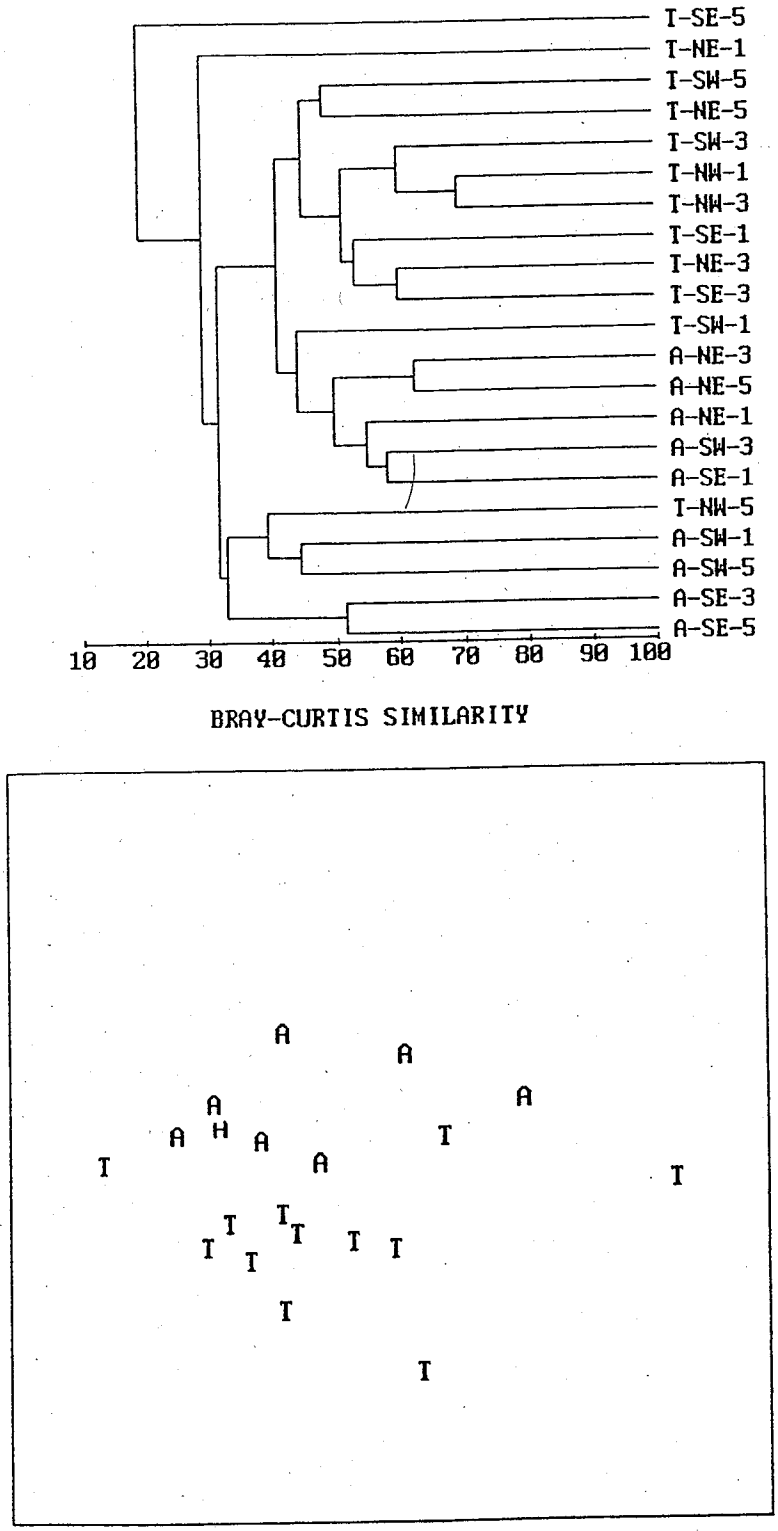
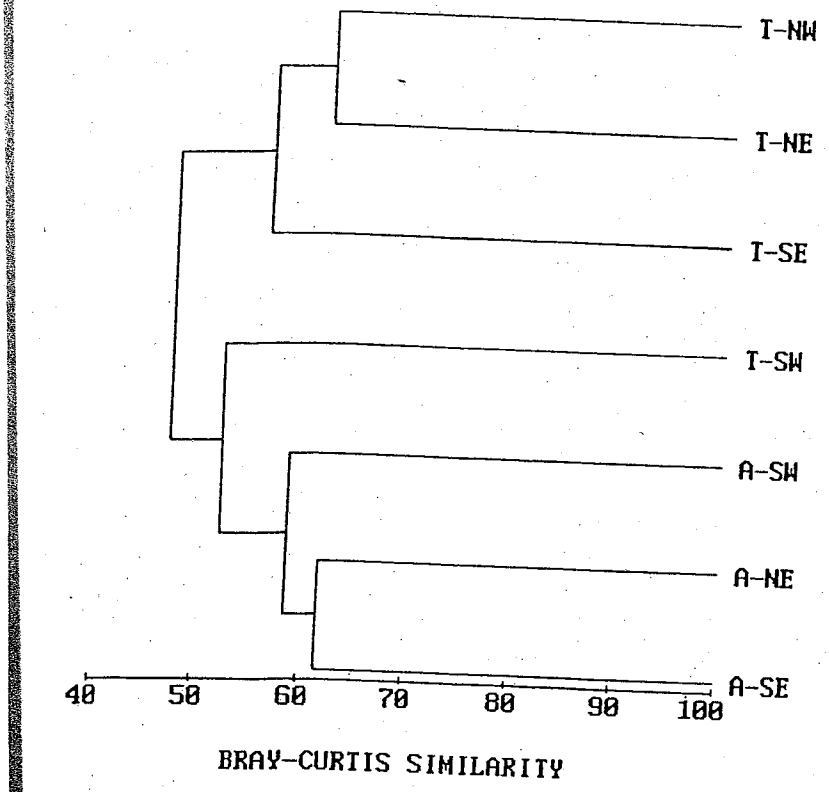
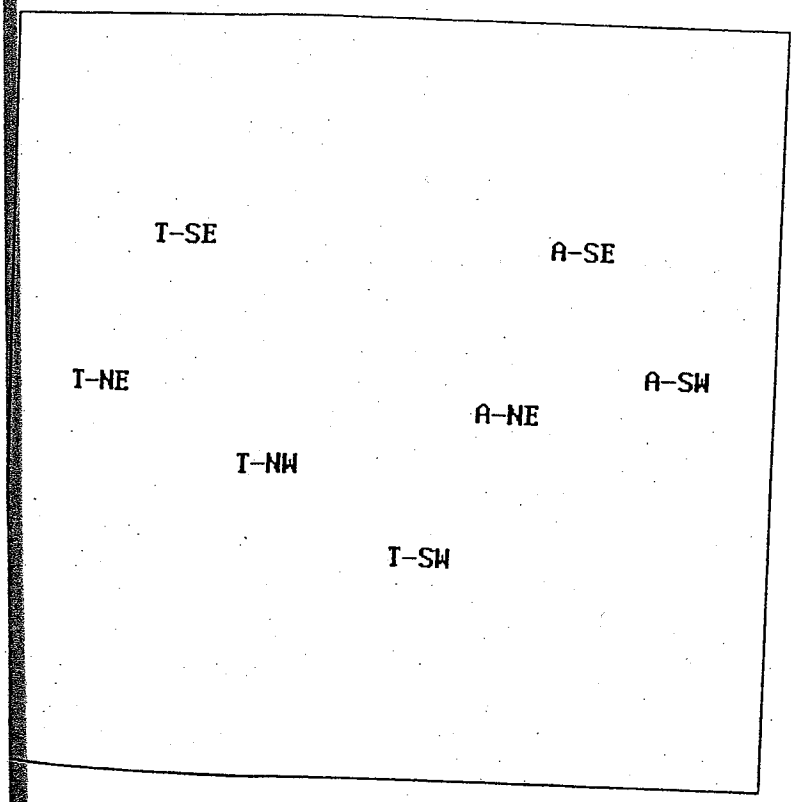


Figure 10. Hierarchical agglomerative cluster analysis (top) and non-metric multi-dimensional scaling (bottom, stress = 0.15) of double-square-root transformed replicate invertebrate abundance for the Tanguisson and Agana ocean outfall sampling statikons, Guam, 2001





igure 11. Hierarchical agglomerative cluster analysis (top) and non-metric multi-dimensional scaling ottom, stress = 0.04) of double-square-root transformed invertebrate pooled replicate abundance for the nguisson and Agana ocean outfall sampling stations, Guam, 2001

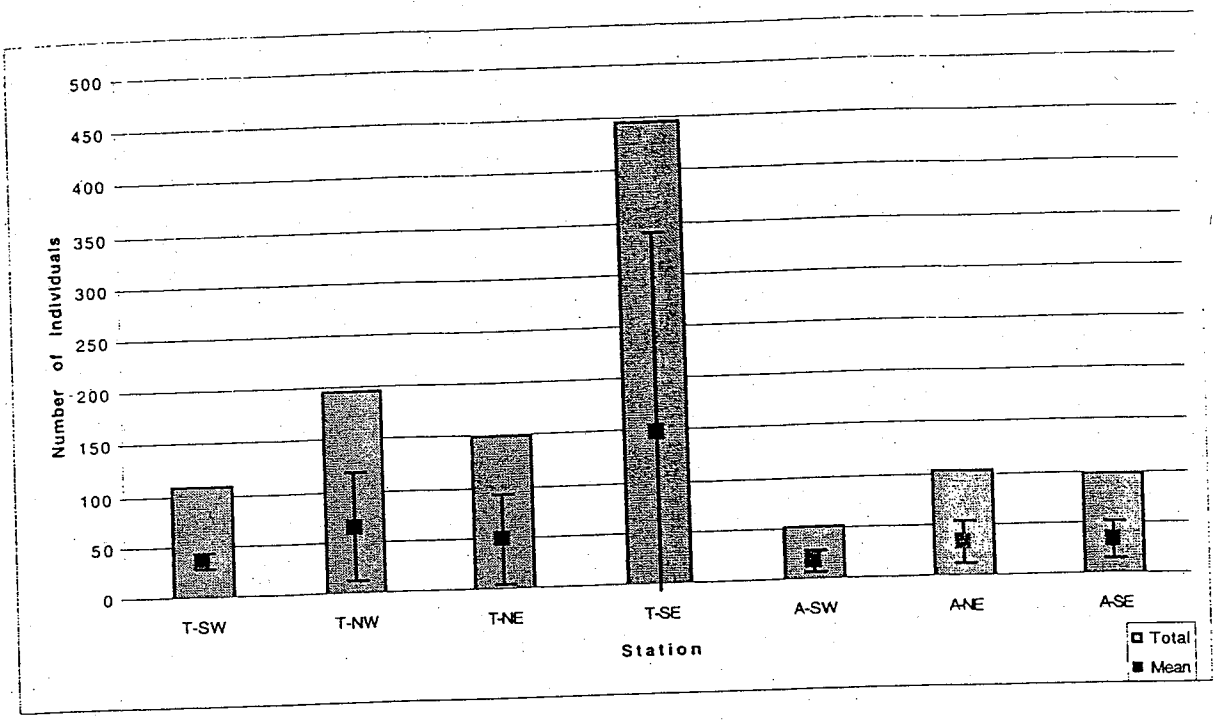


Figure 12. Total and mean (± 1 SD) abundance of polychaetes, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

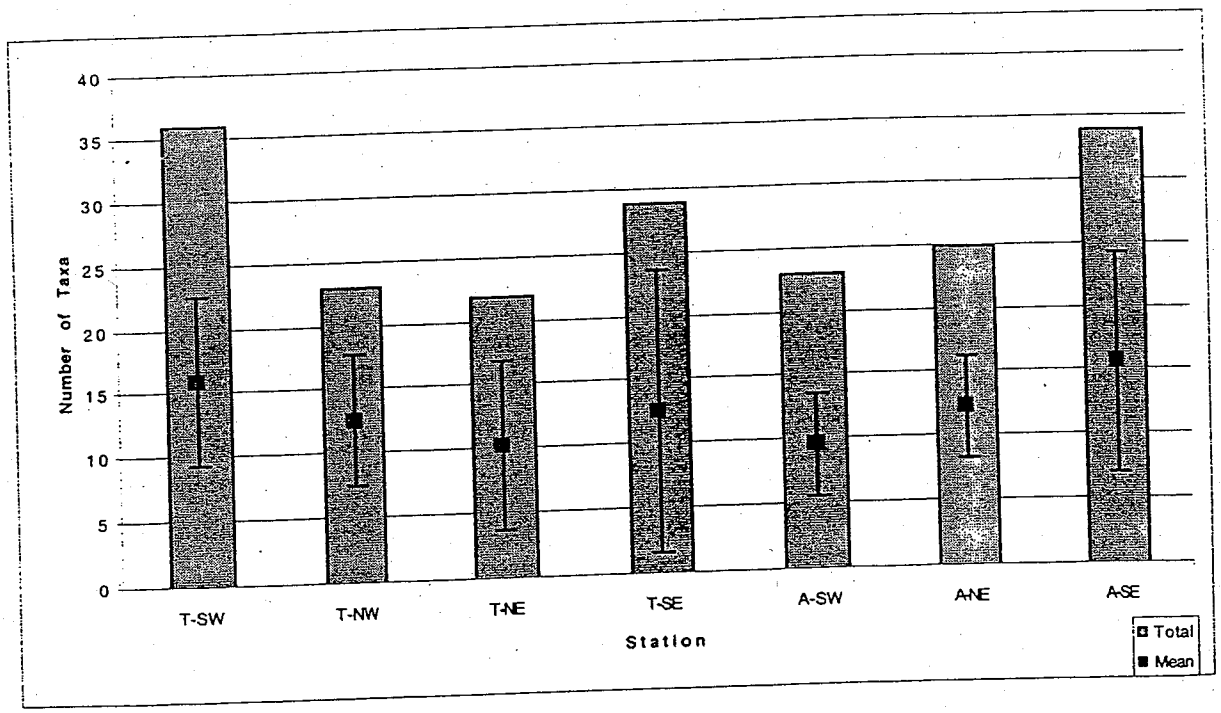


Figure 13. Total and mean (± 1 SD) taxon richness of polychaetes, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

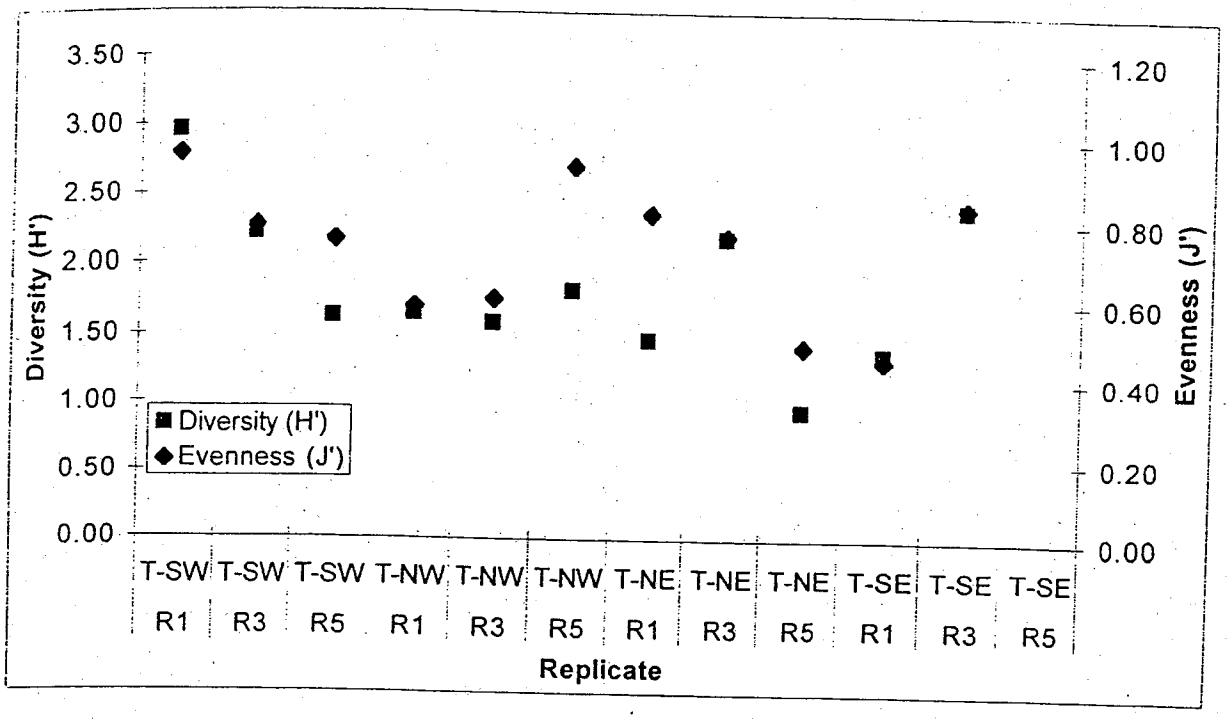


Figure 14. Shannon-Wiener diversity (H') and Pielou's evenness (J') indices for polychaete taxa, Tanguisson ocean outfall sampling stations, Guam, 2001

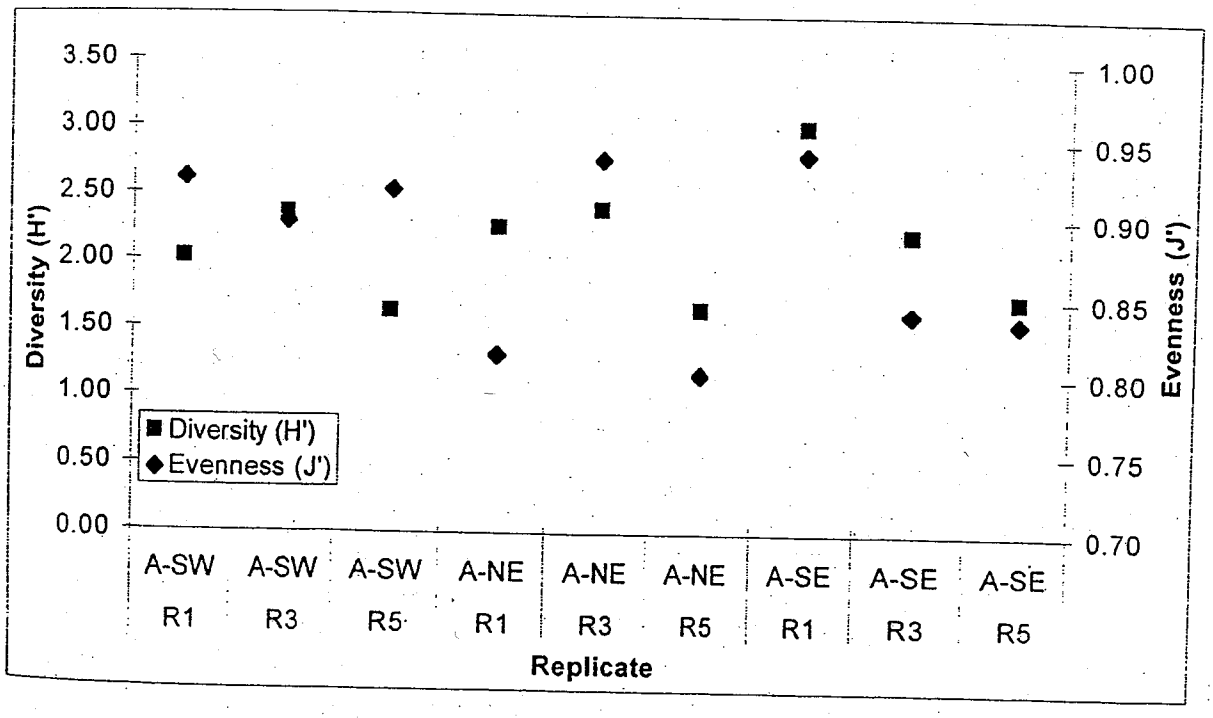


Figure 15. Shannon-Wiener diversity (H') and Pielou's evenness (J') indices for polychaete taxa, Agana ocean outfall sampling stations, Guam, 2001

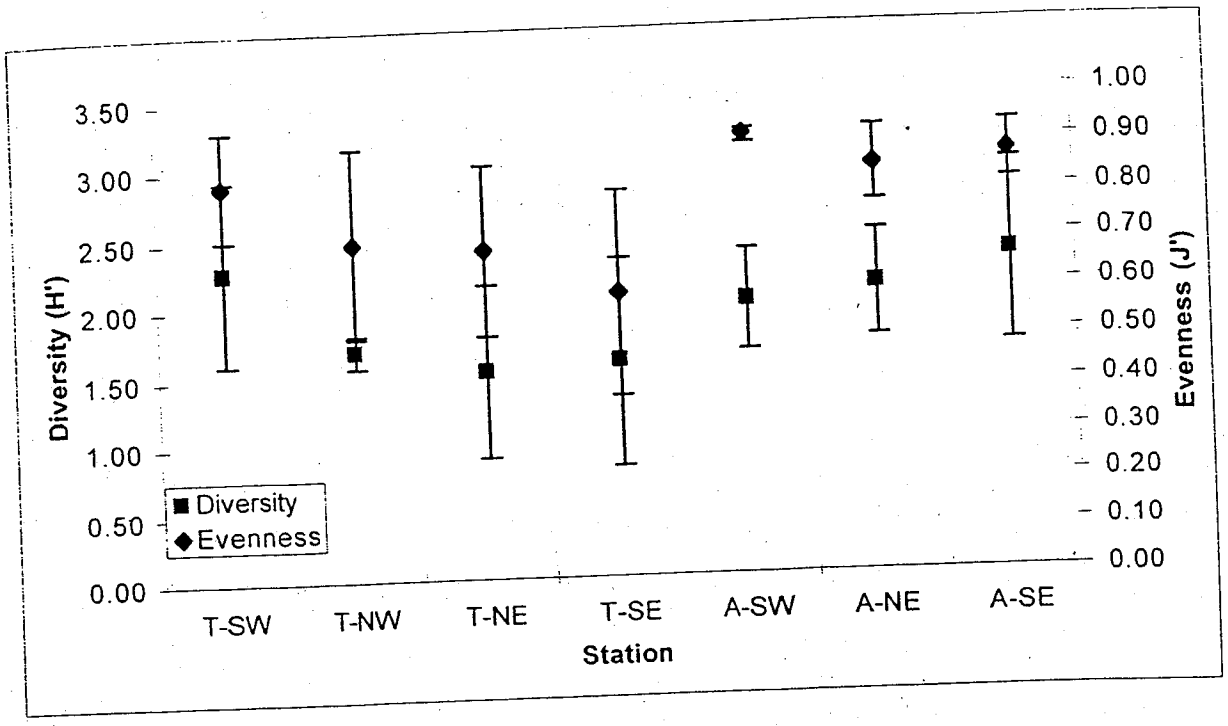


Figure 16. Mean (± 1 SD) diversity (H') and evenness (J') indices for polychaete taxa, Tanguisson and Agana ocean outfall sampling station, Guam, 2001

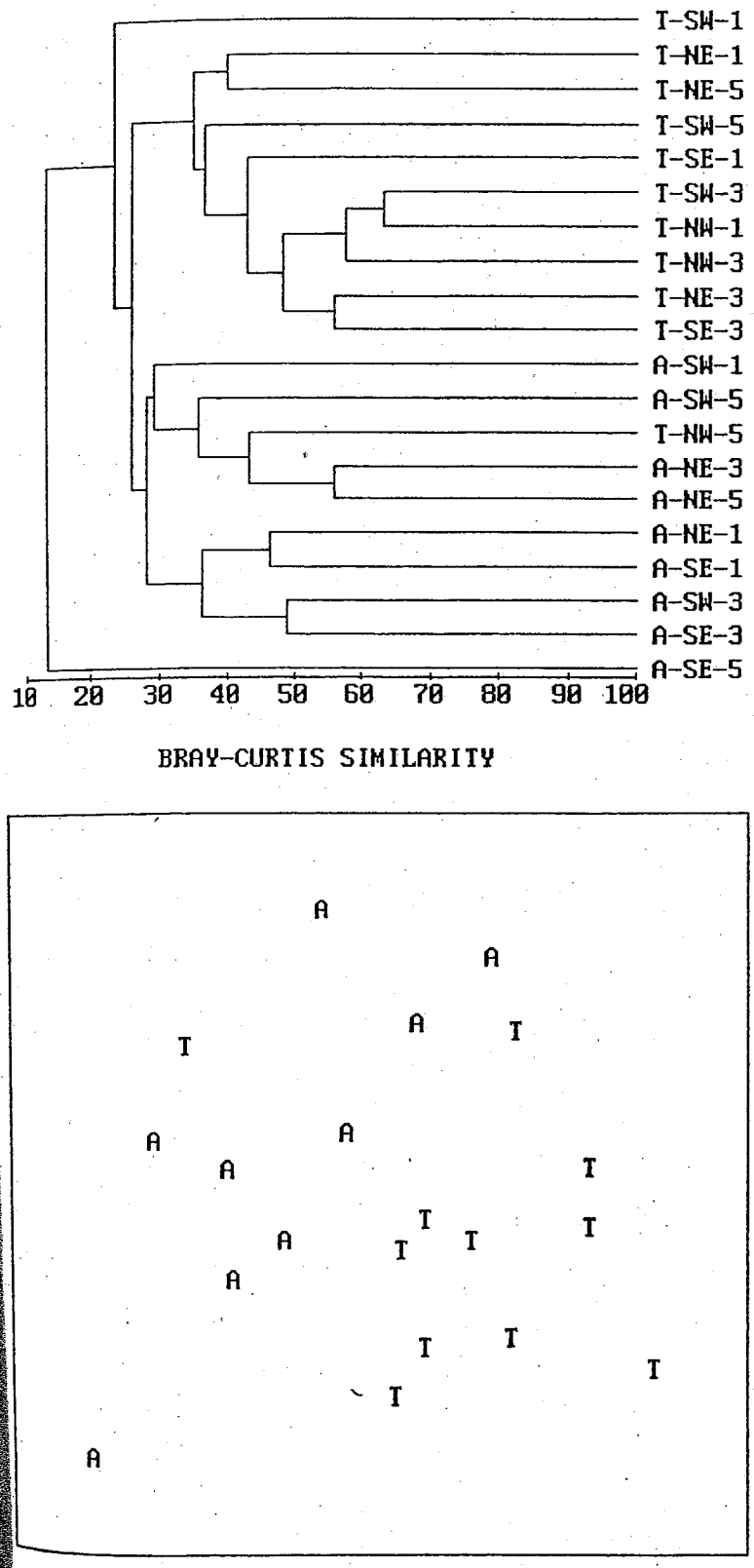
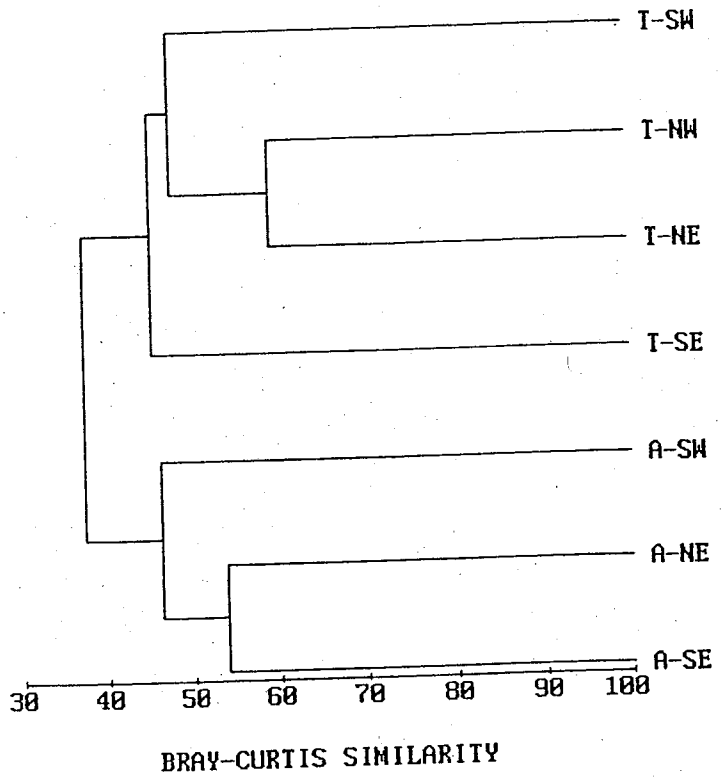


Figure 17. Hierarchical agglomerative cluster analysis (top) and non-metric multi-dimensional scaling (bottom, stress = 0.20) of double-square-root transformed replicate polychaete abundance for the Tanguisson and Agana ocean outfall sampling stations, Guam, 2001



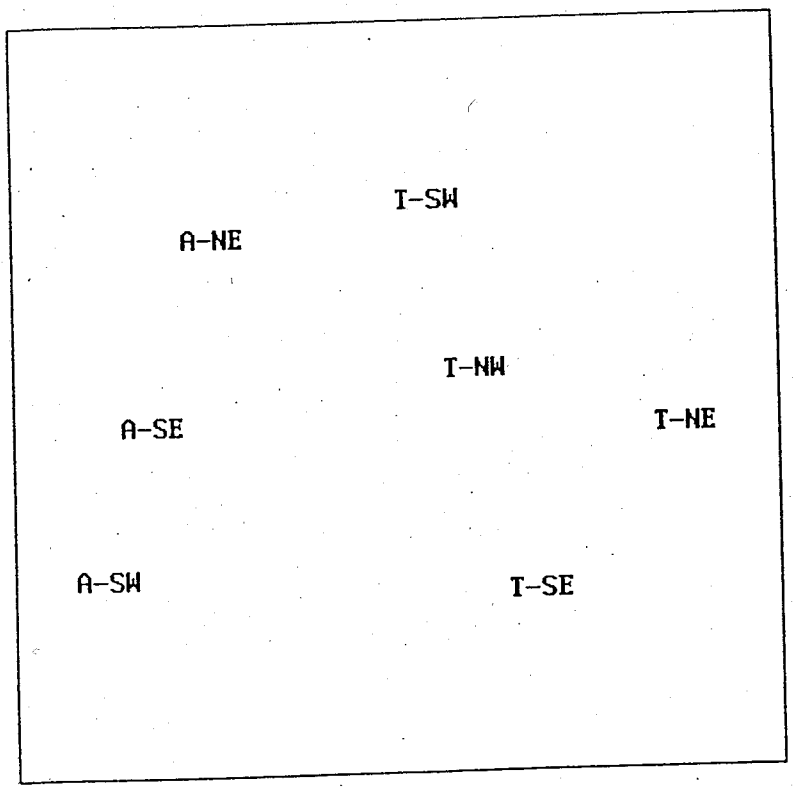


Figure 18. Hierarchical agglomerative cluster analysis (top) and non-metric multi-dimensional scaling (bottom, stress = 0.08) of double-square-root transformed polychaete pooled replicate abundance for the Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

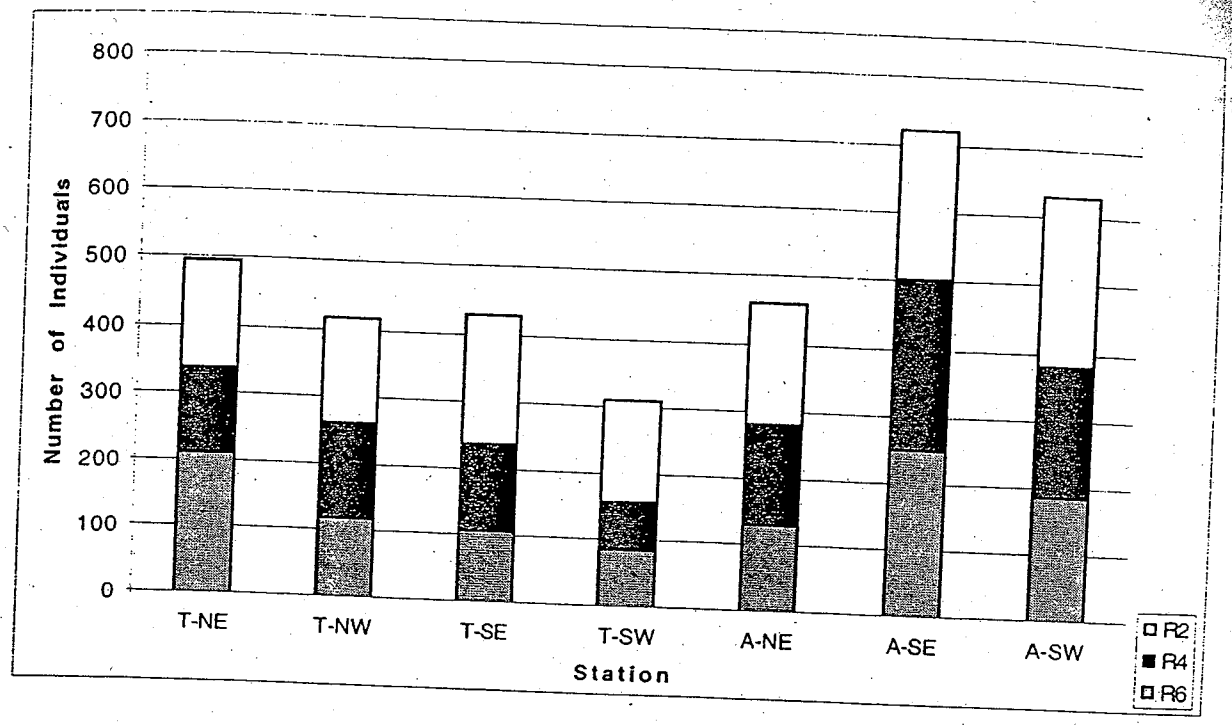


Figure 19. Number of micromollusks (per 15 cm^3) Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

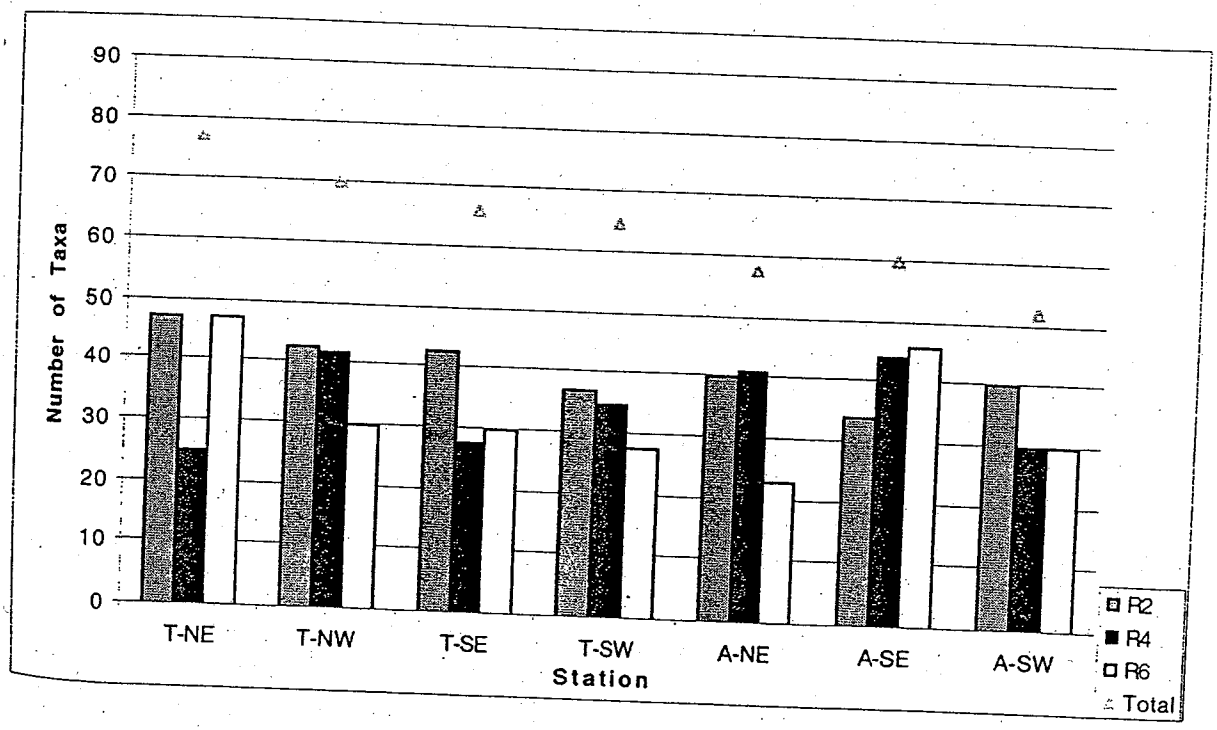


Figure 20. Number of micromollusk taxa (per 15 cm^3) Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

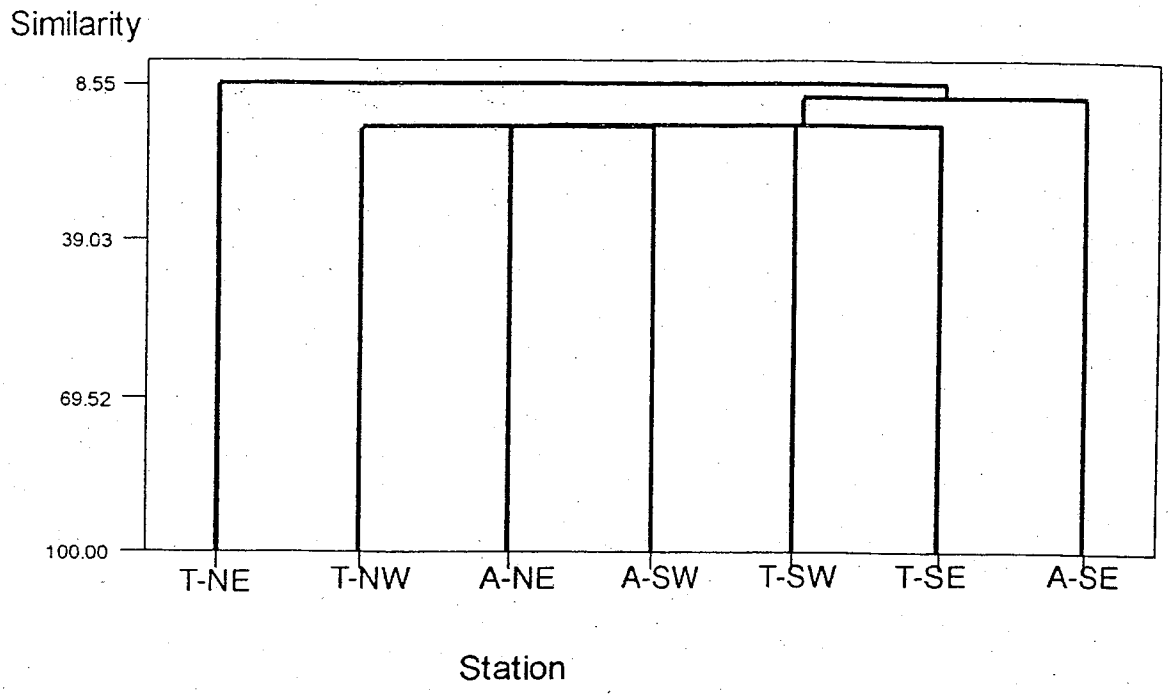


Figure 21. Dendrogram for standardized micromollusk data showing euclidean similarity among Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

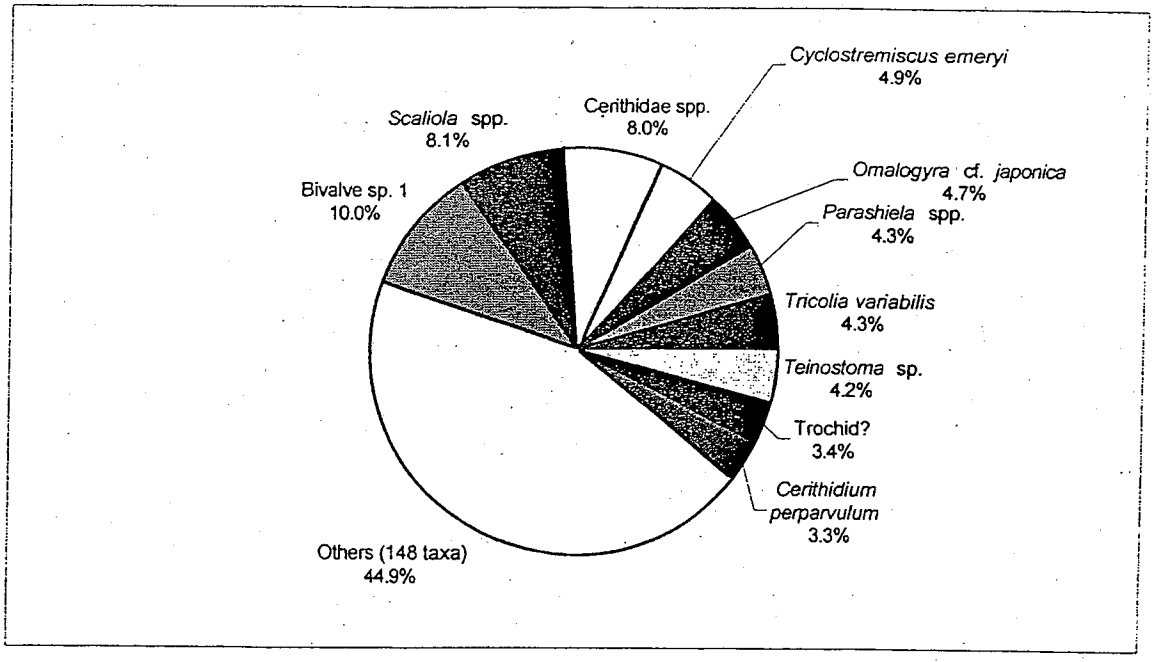


Figure 22. Pie chart showing the frequency of the most abundant micromollusk taxa in samples from Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

TEXT TABLES

Table 1. Abundance of invertebrate taxa by replicate and total for the Tanguisson ocean outfall sampling stations, Guam, 2001

Invertebrate Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
POLYCHAETA																
Amphinomidae sp. 1				**0**				**0**				**0**				**0**
Ampharetidae sp. 1				**0**				**0**				**0**				**0**
Capitellidae sp. 1	0	6	1	**7**	14	1	1	**16**	2	12	2	**16**	68	19	0	**87**
Capitellidae sp. 2	1	0	0	**0**	0	1	0	**1**	0	1	0	**1**	0	0	0	**0**
Capitellidae sp. 3	0	0	1	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Capitellidae sp. 4	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Capitellidae sp. 5	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**
Capitellidae sp. 6	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	2	0	**3**
Chaetopteridae sp. 1				**0**				**0**				**0**				**0**
Chysopetalidae sp. 1	2	1	0	**0**	0	2	0	**2**	0	0	0	**0**	1	0	0	**1**
Chysopetalidae sp. 2				**0**				**0**				**0**				**0**
Cirratulidae sp. 1	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Cirratulidae sp. 2	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Cirratulidae sp. 3	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	3	0	0	**3**
Cirratulidae sp. 4	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Dorvilleidae sp. 1				**0**				**0**				**0**				**0**
Dorvilleidae sp. 2	0	0	0	**0**	2	1	3	**6**	2	4	0	**6**	1	0	0	**1**
Dorvilleidae sp. 3	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Eunicidae sp. 1	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Eunicidae sp. 2				**0**				**0**				**0**				**0**
Glyceridae sp. 1	2	0	0	**2**	2	0	1	**3**	0	0	0	**0**	0	0	0	**0**
Hesionidae sp. 1	1	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Hesionidae sp. 2	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Hesionidae sp. 3				**0**				**0**				**0**				**0**
Hesionidae sp. 4	0	0	0	**0**	1	1	0	**2**	0	0	0	**0**	0	0	0	**0**
Hesionidae sp. 5	0	0	0	**0**	0	0	0	**0**	0	2	0	**2**	0	0	0	**0**

Invertebrate Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Hesionidae sp. 6	2	1	0	**0**	0	0	0	**0**	0	1	0	**1**	1	2	0	**3**
Hesionidae sp. 7	0	0	0	**0**	0	1	0	**1**	0	1	1	**2**	0	0	0	**0**
Hesionidae sp. 8	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	2	0	**2**
Lumbrineridae sp. 1	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**
Lumbrineridae sp. 2				**0**				**0**				**0**				**0**
Magelonidae sp. 1	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Magelonidae sp. 2	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	9	0	0	**9**
Nephtyidae sp. 1	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Nereididae sp. 1	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Nereididae sp. 2				**0**				**0**				**0**				**0**
Nereididae sp. 3	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Onuphidae sp. 1	0	1	0	**1**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Opheliidae sp. 1	0	1	1	**2**	1	0	0	**1**	0	1	0	**1**	0	1	0	**1**
Opheliidae sp. 2	0	0	0	**0**	1	0	0	**1**	0	1	0	**1**	1	13	0	**14**
Oweniidae sp. 1	0	1	0	**1**	1	2	0	**3**	0	0	0	**0**	0	0	0	**0**
Oweniidae sp. 2				**0**				**0**				**0**				**0**
Pholoidae sp. 1	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Phyllodocidae sp. 1	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Phyllodocidae sp. 2	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Phyllodocidae sp. 3	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Pilargidae sp. 1	0	16	11	**27**	66	40	3	**109**	0	10	23	**33**	227	1	0	**228**
Pilargidae sp. 2	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	2	0	0	**2**
Pilargidae sp. 3	0	2	10	**12**	16	1	0	**17**	5	12	1	**18**	0	1	0	**1**
Pilargidae sp. 4				**0**				**0**				**0**				**0**
Pisionidae sp. 1	0	0	0	**0**	0	0	0	**0**	0	5	0	**5**	0	0	0	**0**
Pisionidae sp. 2	0	0	0	**0**	0	0	0	**0**	0	7	0	**7**	0	5	0	**5**
Protodrilidae sp. 1	0	0	0	**0**	0	2	0	**2**	0	2	0	**2**	0	0	0	**0**
Questidae sp. 1				**0**				**0**				**0**				**0**

Invertebrate Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Sabellidae sp. 1	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Sabellidae sp. 2	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Sabellidae sp. 3	1	2	0	**3**	5	7	0	**12**	0	0	1	**1**	21	5	0	**26**
Serpulidae sp. 1				**0**				**0**				**0**				**0**
Spionidae sp. 1	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	8	0	0	**8**
Spionidae sp. 2	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	3	0	0	**3**
Spionidae sp. 3	4	1	1	**6**	2	2	0	**4**	0	3	0	**3**	3	3	0	**6**
Spionidae sp. 4	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**
Spionidae sp. 5	0	1	0	**1**	0	0	0	**0**	0	1	0	**1**	1	7	0	**8**
Spionidae sp. 6				**0**				**0**				**0**				**0**
Spionidae sp. 7	0	1	0	**1**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Spionidae sp. 8				**0**				**0**				**0**				**0**
Syllidae sp. 1	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Syllidae sp. 2	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Syllidae sp. 3				**0**				**0**				**0**				**0**
Syllidae sp. 4	1	1	0	**2**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Syllidae sp. 5	3	7	0	**10**	3	5	0	**8**	9	35	1	**45**	13	11	0	**24**
Syllidae sp. 6	2	0	0	**2**	0	0	2	**2**	0	0	0	**0**	0	0	0	**0**
Syllidae sp. 7	2	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Syllidae sp. 8	0	0	0	**0**	1	0	0	**1**	0	1	0	**1**	0	2	0	**2**
Syllidae sp. 9	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Syllidae sp. 10	3	0	3	**6**	2	1	1	**4**	0	0	0	**0**	0	5	0	**5**
Terebellidae sp. 1	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Terebellidae sp. 2	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Terebellidae sp. 3				**0**				**0**				**0**				**0**
Terebellidae sp. 4				**0**				**0**				**0**				**0**
Trichobranchidae sp. 1				**0**				**0**				**0**				**0**
				0				**0**				**0**				**0**

Invertebrate Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
ANTHOZOA	15	2	0	**17**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				0				**0**				**0**				**0**
ARACHNIDA	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**
				0				**0**				**0**				**0**
CHAETOGNATHA				**0**				**0**				**0**				**0**
				0				**0**				**0**				**0**
UROCHORDATA	1	0	0	**1**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
				0				**0**				**0**				**0**
CRUSTACEA				**0**				**0**				**0**				**0**
Decapoda	2	1	0	**3**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Copepoda	4	1	2	**7**	4	10	1	**15**	0	51	6	**57**	11	31	0	**42**
Amphipoda	11	5	2	**18**	0	2	0	**2**	0	0	0	**0**	3	1	0	**4**
Crustacea sp. 1				**0**				**0**				**0**				**0**
Cumacea	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Isopoda	7	1	2	**10**	0	0	0	**0**	0	0	0	**0**	0	2	0	**2**
Ostracoda	2	0	0	**2**	0	1	0	**1**	0	2	0	**2**	4	2	0	**6**
Stomatopoda	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Tanaidacea	5	0	2	**7**	2	2	1	**5**	0	0	1	**1**	2	4	0	**6**
				0				**0**				**0**				**0**
ECHINODERMATA				**0**				**0**				**0**				**0**
Echinoidea				**0**				**0**				**0**				**0**
Holothuroidea	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Ophiuroidea	1	0	0	**1**	1	2	0	**3**	0	1	0	**1**	0	0	0	**0**
				0				**0**				**0**				**0**
HEMICHORDATA	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
				0				**0**				**0**				**0**
HYDROZOA	0	1	0	**1**	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**
				0				**0**				**0**				**0**

Invertebrate Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
KINORHYNCHA				**0**				**0**				**0**				**0**
Echinoderes sp. 1	0	0	0	**0**	0	0	0	**0**	0	3	1	**4**	0	3	0	**3**
Echinoderes sp. 2	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
				0				**0**				**0**				**0**
MOLLUSCA				**0**				**0**				**0**				**0**
Aplacophora				**0**				**0**				**0**				**0**
Bivalvia	7	7	2	**16**	8	11	6	**25**	0	4	1	**5**	54	7	1	**62**
Gastropoda	0	1	4	**5**	2	1	1	**4**	0	0	0	**0**	0	0	0	**0**
				0				**0**				**0**				**0**
NEMATODA	4	15	12	**31**	47	23	21	**91**	30	169	179	**378**	111	91	39	**241**
				0				**0**				**0**				**0**
NEMERTEA	1	2	1	**4**	3	2	0	**5**	1	6	1	**8**	12	3	0	**15**
				0				**0**				**0**				**0**
OLIGOCHAETA	0	7	0	**7**	8	8	0	**16**	7	4	0	**11**	5	1	0	**6**
				0				**0**				**0**				**0**
PHORONIDA				**0**				**0**				**0**				**0**
				0				**0**				**0**				**0**
PLATYHELMINTHES	1	0	1	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				0				**0**				**0**				**0**
PORIFERA	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				0				**0**				**0**				**0**
SIPUNCULA	0	5	1	**6**	3	3	1	**7**	1	0	0	**1**	3	3	0	**6**
Total Individuals	98	93	59	**241**	199	133	44	**376**	60	341	219	**620**	572	232	40	**844**
Total Taxa	38	29	19	**51**	27	26	14	**37**	11	27	13	**34**	29	31	2	**42**
Total Polychaetes	34	45	30	**100**	120	67	12	**199**	20	100	30	**150**	367	82	0	**449**
Total Polychaete Taxa	22	17	9	**31**	17	14	7	**23**	6	18	7	**22**	20	18	0	**29**

Table 2. Abundance of invertebrate taxa by replicate and total for the Agana ocean outfall sampling stations, Guam, 2001

Invertebrate Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	Total	R2	R4	R6	Total	R2	R4	R6	Total
POLYCHAETA												
Amphinomidae sp. 1	1	0	0	1	0	0	0	0	0	0	0	0
Ampharetidae sp. 1	0	0	0	0	0	0	0	0	0	0	1	1
Capitellidae sp. 1	0	0	0	0	0	1	0	1	0	0	0	0
Capitellidae sp. 2	0	0	0	0	0	1	0	1	0	0	0	0
Capitellidae sp. 3				0				0				0
Capitellidae sp. 4				0				0				0
Capitellidae sp. 5				0				0				0
Capitellidae sp. 6	0	0	0	0	0	0	0	0	0	0	1	1
Chaetopteridae sp. 1	1	0	0	1	0	0	0	0	0	0	0	0
Chysopetalidae sp. 1	0	1	0	1	0	0	0	0	3	0	0	3
Chysopetalidae sp. 2	0	0	0	0	0	0	0	0	3	0	0	3
Cirratulidae sp. 1	0	0	1	1	0	0	0	0	0	0	0	0
Cirratulidae sp. 2				0				0				0
Cirratulidae sp. 3	0	0	0	0	0	0	0	0	2	0	0	2
Cirratulidae sp. 4				0				0				0
Dorvilleidae sp. 1	0	0	0	0	0	0	0	0	1	0	0	1
Dorvilleidae sp. 2	0	2	3	5	0	0	0	0	0	1	1	2
Dorvilleidae sp. 3				0				0				0
Eunicidae sp. 1				0				0				0
Eunicidae sp. 2	1	2	0	3	3	0	0	3	0	0	0	0
Glyceridae sp. 1	1	1	0	2	0	1	1	2	3	6	0	9
Hesionidae sp. 1				0				0				0
Hesionidae sp. 2				0				0				0
Hesionidae sp. 3	0	0	0	0	0	0	0	0	1	0	0	1
Hesionidae sp. 4	0	5	0	5	3	4	0	7	1	4	1	6
Hesionidae sp. 5				0				0				0

Invertebrate Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Hesionidae sp. 6				**0**				**0**				**0**
Hesionidae sp. 7				**0**				**0**				**0**
Hesionidae sp. 8				**0**				**0**				**0**
Lumbrineridae sp. 1				**0**				**0**				**0**
Lumbrineridae sp. 2	0	1	0	**1**	0	0	0	**0**	1	0	0	**1**
Magelonidae sp. 1				**0**				**0**				**0**
Magelonidae sp. 2				**0**				**0**				**0**
Nephtyidae sp. 1	2	0	0	**2**	3	0	0	**3**	1	0	0	**1**
Nereididae sp. 1				**0**				**0**				**0**
Nereididae sp. 2	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Nereididae sp. 3				**0**				**0**				**0**
Onuphidae sp. 1				**0**				**0**				**0**
Opheliidae sp. 1	0	0	0	**0**	0	0	2	**2**	0	0	0	**0**
Opheliidae sp. 2				**0**				**0**				**0**
Oweniidae sp. 1	0	0	0	**0**	9	0	0	**9**	1	10	6	**17**
Oweniidae sp. 2	0	0	0	**0**	5	0	0	**5**	7	0	0	**7**
Pholoidae sp. 1				**0**				**0**				**0**
Phyllodocidae sp. 1	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Phyllodocidae sp. 2				**0**				**0**				**0**
Phyllodocidae sp. 3				**0**				**0**				**0**
Pilargidae sp. 1	4	6	3	**13**	3	2	4	**9**	2	6	0	**8**
Pilargidae sp. 2				**0**				**0**				**0**
Pilargidae sp. 3	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Pilargidae sp. 4	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Pisionidae sp. 1				**0**				**0**				**0**
Pisionidae sp. 2	0	0	0	**0**	0	0	0	**0**	0	2	1	**3**
Protodrilidae sp. 1				**0**				**0**				**0**
Questidae sp. 1	0	0	0	**0**	0	1	0	**1**	0	1	0	**1**

Invertebrate Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Sabellidae sp. 1				**0**				**0**				**0**
Sabellidae sp. 2				**0**				**0**				**0**
Sabellidae sp. 3	1	0	1	**2**	20	4	10	**34**	3	0	0	**3**
Serpulidae sp. 1	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Spionidae sp. 1	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**
Spionidae sp. 2				**0**				**0**				**0**
Spionidae sp. 3	0	5	0	**5**	1	2	0	**3**	1	1	0	**2**
Spionidae sp. 4				**0**				**0**				**0**
Spionidae sp. 5	0	0	0	**0**	1	3	1	**5**	1	0	0	**1**
Spionidae sp. 6	0	0	0	**0**	0	1	0	**1**	0	1	0	**1**
Spionidae sp. 7				**0**				**0**				**0**
Spionidae sp. 8	0	0	0	**0**	0	0	0	**0**	2	0	0	**2**
Syllidae sp. 1	0	1	0	**1**	3	0	0	**3**	3	1	0	**4**
Syllidae sp. 2	1	0	0	**1**	0	0	0	**0**	3	1	1	**5**
Syllidae sp. 3	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Syllidae sp. 4				**0**				**0**				**0**
Syllidae sp. 5				**0**				**0**				**0**
Syllidae sp. 6	0	0	0	**0**	3	1	1	**5**	0	0	0	**0**
Syllidae sp. 7	0	0	0	**0**	1	0	0	**1**	1	0	0	**1**
Syllidae sp. 8	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Syllidae sp. 9	0	2	0	**2**	0	0	0	**0**	1	0	0	**1**
Syllidae sp. 10	0	0	0	**0**	0	0	1	**1**	2	0	0	**2**
Terebellidae sp. 1				**0**				**0**				**0**
Terebellidae sp. 2				**0**				**0**				**0**
Terebellidae sp. 3	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Terebellidae sp. 4	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Trichobranchidae sp. 1	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
				0				**0**				**0**

Invertebrate Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
ANTHOZOA	0	1	0	**1**	0	0	0	**0**	1	0	0	**1**
				0				**0**				**0**
ARACHNIDA	0	0	0	**0**	0	0	1	**1**	0	0	1	**1**
				0				**0**				**0**
CHAETOGNATHA	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
				0				**0**				**0**
UROCHORDATA	0	4	0	**4**	3	12	10	**25**	4	0	0	**4**
				0				**0**				**0**
CRUSTACEA				**0**				**0**				**0**
Decapoda	0	1	0	**1**	0	2	0	**2**	1	0	0	**1**
Copepoda	0	2	0	**2**	5	8	3	**16**	7	3	1	**11**
Amphipoda	0	1	0	**1**	2	5	4	**11**	5	1	0	**6**
Crustacea sp. 1	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Cumacea	0	1	0	**1**	0	2	0	**2**	2	0	0	**2**
Isopoda	0	1	0	**1**	1	0	0	**1**	2	0	0	**2**
Ostracoda	0	3	0	**3**	2	4	3	**9**	4	0	1	**5**
Stomatopoda				**0**				**0**				**0**
Tanaidacea	2	10	0	**12**	15	5	0	**20**	15	3	1	**19**
				0				**0**				**0**
ECHINODERMATA				**0**				**0**				**0**
Echinoidea	0	1	0	**1**	2	0	0	**2**	0	0	0	**0**
Holothuroidea				**0**				**0**				**0**
Ophiuroidea				**0**				**0**				**0**
				0				**0**				**0**
HEMICHORDATA				**0**				**0**				**0**
				0				**0**				**0**
HYDROZOA				**0**				**0**				**0**
				0				**0**				**0**

Invertebrate Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	Total	R2	R4	R6	Total	R2	R4	R6	Total
KINORHYNCHA				0				0				0
Echinoderes sp. 1	0	0	0	0	0	1	2	3	0	0	0	0
Echinoderes sp. 2				0				0				0
				0				0				0
MOLLUSCA				0				0				0
Aplacophora	0	0	0	0	0	0	0	0	1	0	0	1
Bivalvia	1	1	1	3	2	1	1	4	9	2	1	12
Gastropoda	0	2	0	2	0	0	3	3	1	0	0	1
				0				0				0
NEMATODA	5	1	4	10	30	18	16	64	22	1	1	24
				0				0				0
NEMERTEA	1	3	0	4	3	0	2	5	1	0	0	1
				0				0				0
OLIGOCHAETA	2	4	2	8	4	10	3	17	5	1	0	6
				0				0				0
PHORONIDA	0	0	0	0	0	0	0	0	0	2	0	2
				0				0				0
PLATYHELMINTHES	0	0	0	0	0	0	0	0	1	0	0	1
				0				0				0
PORIFERA				0				0				0
				0				0				0
SIPUNCULA	1	1	0	2	5	2	1	8	2	1	1	4
Total Individuals	25	67	17	105	133	94	71	293	135	51	20	199
Total Taxa	15	30	9	35	28	25	20	40	45	22	15	52
Total Polychaetes	13	30	10	49	59	24	22	100	49	37	13	93
Total Polychaete Taxa	9	14	6	19	16	13	8	23	25	14	8	31

Table 3. Untransformed invertebrate abundance at Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

	Tanguisson Stations					Agana Stations			
	T-SW	T-NW	T-NE	T-SE	Total	A-SW	A-NE	A-SE	Total
R1	98	199	60	572		25	133	135	
R3	93	133	341	232		67	94	51	
R5	59	44	219	40		17	71	20	
Total	250	376	620	844	2090	109	298	206	613
Mean	83.33	125.33	206.67	281.33	174.17	36.33	99.33	68.67	68.11
Standard Deviation	21.22	77.78	140.91	269.41	155.91	26.86	31.34	59.5	45.34

Table 4. Untransformed invertebrate taxon richness at Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

	Tanguisson Stations					Agana Stations			
	T-SW	T-NW	T-NE	T-SE	Total	A-SW	A-NE	A-SE	Total
R1	38	27	11	29		15	28	45	
R3	29	26	27	31		30	25	22	
R5	19	14	13	2		9	20	15	
Total	56	37	34	42	87	39	42	56	74
Mean	28.67	22.33	17	20.67	22.17	18	24.33	27.33	23.22
Standard Deviation	9.5	7.23	8.72	16.2	10.34	10.82	4.04	15.7	10.58

Table 5. Untransformed polychaete abundance at Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

	Tanguisson Stations					Agana Stations			
	T-SW	T-NW	T-NE	T-SE	Total	A-SW	A-NE	A-SE	Total
R1	34	120	20	367		13	59	49	
R3	45	67	100	82		30	24	37	
R5	30	12	30	0		10	22	13	
Total	109	199	150	449	907	53	105	99	257
Mean	36.33	66.33	50	149.67	75.58	17.67	35	33	28.56
Standard Deviation	7.77	54	43.59	192.63	98.75	10.79	20.81	18.33	16.99

Table 6. Untransformed polychaete taxon richness, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

	Tanguisson Stations					Agana Stations			
	T-SW	T-NW	T-NE	T-SE	Total	A-SW	A-NE	A-SE	Total
R1	22	17	6	20		9	16	25	
R3	17	14	18	18		14	13	14	
R5	9	7	7	0		6	8	8	
Total	36	23	22	29	62	23	25	34	50
Mean	16	12.67	10.33	12.67	12.92	9.67	12.33	15.67	12.56
Standard Deviation	6.56	5.13	6.66	11.02	6.87	4.04	4.04	8.62	5.79

Table 7. Abundance for micromollusk component at Tanguisson ocean outfall sampling stations, Guam, 2001

Micromollusk Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
GASTROPODA																
Scissurella coronata	0	0	0	**0**	1	0	4	**5**	0	0	0	**0**	0	1	0	**1**
Scissurella pseudoequatoria	0	0	0	**0**	0	0	2	**2**	0	0	1	**1**	0	1	0	**1**
Scissurella spp.	0	8	7	**15**	1	2	0	**3**	2	0	1	**3**	0	0	0	**0**
Diodora sp.	0	0	0	**0**	0	0	1	**1**	2	0	0	**2**	4	3	0	**7**
Emarginula sp.	0	0	0	**0**	0	2	0	**2**	0	0	0	**0**	0	0	1	**1**
Tugali sp.	2	1	0	**3**	0	2	0	**2**	0	0	0	**0**	0	0	3	**3**
Limpet	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Trochus intextus	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Trochus sp.	1	0	1	**2**	0	2	0	**2**	0	5	0	**5**	1	0	3	**4**
Euchelus gemmatus				**0**				**0**				**0**				**0**
Euchelus sp.	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Gibbula sp.	7	6	0	**13**	3	0	0	**3**	0	9	0	**9**	3	0	0	**3**
Alcyna ocellata	0	0	2	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Trochid?	8	12	8	**28**	4	5	8	**17**	8	0	3	**11**	4	1	0	**5**
Cyclostremiscus emeryi	11	13	15	**39**	11	6	13	**30**	4	14	0	**18**	4	1	2	**7**
Cyclostremiscus sp. A	0	0	10	**10**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Lophocochlias minutissimus	2	0	0	**2**	2	1	0	**3**	0	0	0	**0**	0	0	0	**0**
Lophocochlias spp.	1	0	0	**1**	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**
Synaptocochlea concinna	4	0	4	**8**	1	0	0	**1**	1	0	1	**2**	0	1	0	**1**
Leptothyra rubricincta	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	3	**4**
Leptothyra sp.	0	5	9	**14**	1	4	5	**10**	5	10	0	**15**	6	2	0	**8**
Turbo sandwicensis				**0**				**0**				**0**				**0**
Tricolia variabilis	7	1	11	**19**	7	4	2	**13**	18	8	20	**46**	10	2	7	**19**
Smaragdia bryanae	0	0	0	**0**	0	0	0	**0**	0	2	0	**2**	1	1	0	**2**
Teinostoma sp.	14	0	13	**27**	8	21	0	**29**	12	4	7	**23**	0	3	0	**3**
Nerita sp. (juveniles)	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**

Micromollusk Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Littorina pintado				**0**				**0**				**0**				**0**
Eatoniella pigmenta	0	0	4	**4**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Eatoniella sp.	4	0	7	**11**	6	0	0	**6**	2	0	0	**2**	2	2	3	**7**
Rastodens sp.	1	0	5	**6**	0	0	0	**0**	10	0	0	**10**	0	0	0	**0**
Parashiela spp.	8	9	9	**26**	6	7	1	**14**	8	3	8	**19**	13	2	4	**19**
Powellsetia fallax				**0**				**0**				**0**				**0**
Merelina granulosa				**0**				**0**				**0**				**0**
Rissoina cerithiiformis	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**
Rissoina ambigua	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	2	**2**
Rissoina imbricata	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**
Sansonia kennyi	1	0	1	**2**	0	0	0	**0**	0	5	0	**5**	1	0	0	**1**
Sansonia sp. B	0	0	0	**0**	0	0	0	**0**	0	7	4	**11**	0	0	0	**0**
Rissoids spp.	1	7	9	**17**	4	1	0	**5**	3	2	0	**5**	10	0	0	**10**
Vitrinellidae sp.	0	0	0	**0**	2	0	0	**2**	0	0	0	**0**	0	0	0	**0**
Orbitestella cf *regina*	5	0	1	**6**	2	2	0	**4**	1	6	0	**7**	5	0	1	**6**
Orbitestella sp.	4	0	2	**6**	1	0	0	**1**	3	0	0	**3**	0	0	0	**0**
Orbitestella sp. A	2	0	1	**3**	0	0	0	**0**	6	0	0	**6**	0	5	0	**5**
Orbitestella sp. B	0	0	0	**0**	3	1	0	**4**	2	0	0	**2**	0	0	0	**0**
Omalogyra cf *japonica*	9	11	13	**33**	7	4	5	**16**	11	1	9	**21**	10	5	5	**20**
Rissoella sp.	0	7	0	**7**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Rufodardanula ponderi	2	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Rufodardanula sp. A	0	1	0	**1**	0	0	0	**0**	0	0	9	**9**	0	0	0	**0**
Rufodardanula sp.				**0**				**0**				**0**				**0**
Heliacus sp.	0	0	2	**2**	3	0	0	**3**	0	0	2	**2**	0	0	0	**0**
Philippia sp.	0	0	2	**2**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Caecum cf. *glabella*	0	0	1	**1**	1	1	0	**2**	2	0	2	**4**	0	2	0	**2**
Caecum oahuense	2	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Caecum arcuatum	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**

Micromollusk Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Caecum cf *sepimentum*	1	3	0	**4**	0	0	0	**0**	0	0	2	**2**	0	0	0	**0**
Micranellum schlangi	0	1	1	**2**	1	0	0	**1**	0	0	0	**0**	0	1	1	**2**
Caecum sp. A	0	0	0	**0**	0	1	3	**4**	3	0	0	**3**	1	1	1	**3**
Strebloceras subannulatum	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Micranellum sp.				**0**				**0**				**0**				**0**
Modulus tectum	1	0	0	**1**	1	0	0	**1**	0	0	0	**0**	0	1	0	**1**
Cerithidium perparvulum	5	5	2	**12**	0	2	3	**5**	23	0	0	**23**	0	1	0	**1**
Diala scopulorum	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Diala semistriata	1	0	1	**2**	1	0	0	**1**	0	0	0	**0**	0	2	0	**2**
Diala sp.	0	0	0	**0**	0	1	8	**9**	0	0	0	**0**	0	0	0	**0**
Scaliola spp.	3	2	0	**5**	2	4	0	**6**	5	2	6	**13**	20	3	14	**37**
Bittium impendens	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	3	**3**
Bittium sp.	0	0	0	**0**	0	0	0	**0**	2	0	0	**2**	0	0	4	**4**
Cerithium nesioticum	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Cerithium sp.	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Cerithidae spp.	8	20	32	**60**	25	7	7	**39**	18	26	5	**49**	12	3	12	**27**
Plesiotrochus luteus	2	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**
Cerithiopsis spp.	0	1	0	**1**	4	0	5	**9**	3	0	5	**8**	4	1	0	**5**
Triphora spp.	0	4	1	**5**	3	3	9	**15**	4	0	2	**6**	14	2	0	**16**
Epitonium spp.				**0**				**0**				**0**				**0**
Balcis spp.	0	0	1	**1**	1	6	1	**8**	3	3	1	**7**	1	2	0	**3**
Strombus sp.	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**
Vanikoro cancellata	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**
Antisabia foliacea	1	0	1	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Hipponix pilosus				**0**				**0**				**0**				**0**
Hipponix sp.	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Natica gualteriana	3	0	0	**3**	0	0	2	**2**	2	0	0	**2**	0	0	0	**0**
Natica sp.	0	0	0	**0**	2	4	0	**6**	2	0	1	**3**	1	0	0	**1**

Micromollusk Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Gyrineum pusillum				**0**				**0**				**0**				**0**
Aspella sp.				**0**				**0**				**0**				**0**
Buccinidae sp.	0	0	0	**0**	0	0	1	**1**	0	0	1	**1**	0	0	0	**0**
Seminella sp.	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Columellidae				**0**				**0**				**0**				**0**
Nassarius papillosus	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Nassarius sp.				**0**				**0**				**0**				**0**
Cystiscus huna	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	3	**3**
Dentimargo pumila	0	0	0	**0**	0	0	3	**3**	1	0	0	**1**	0	0	0	**0**
Granula sandwicensis	0	1	0	**1**	0	1	0	**1**	0	0	0	**0**	0	1	0	**1**
Granulina sp.	0	0	1	**1**	1	0	0	**1**	0	0	0	**0**	1	0	0	**1**
Volvarina fusiformis	0	0	0	**0**	0	0	0	**0**	0	0	3	**3**	0	0	0	**0**
Mitra sp.	0	0	1	**1**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Clavus sp.				**0**				**0**				**0**				**0**
Microdaphne morrisoni	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	2	**2**
Xenuroturris sp.	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Anacithara perfecta	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Turridae spp.	0	0	1	**1**	2	3	0	**5**	1	0	0	**1**	1	3	2	**6**
Conus sp.	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Terebra spp.	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Ringicula sp.	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**
Evalea peasei				**0**				**0**				**0**				**0**
Herviera gliriella				**0**				**0**				**0**				**0**
Miralda scopulorum	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Miralda sp.				**0**				**0**				**0**				**0**
Odostomia stearnsiella				**0**				**0**				**0**				**0**
Odostomia sp.	0	0	0	**0**	0	0	0	**0**								

Micromollusk Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Turbonilla cornelliana	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	1	0	1	**2**
Turbonilla lirata	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Turbonilla spp.	0	7	1	**8**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Cephalaspidea sp.	0	0	0	**0**	0	0	8	**8**	0	0	0	**0**	0	0	0	**0**
Pupa sp.	0	0	0	**0**	0	2	1	**3**	0	0	0	**0**	0	0	0	**0**
Pupa tessellata				**0**				**0**				**0**				**0**
Hydatina sp.	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**	0	0	1	**1**
Bulla sp.	2	0	0	**2**	0	1	2	**3**	0	4	0	**4**	0	0	0	**0**
Bulla vernicosa				**0**				**0**				**0**				**0**
Atys curta				**0**				**0**				**0**				**0**
Atys debilis				**0**				**0**				**0**				**0**
Atys semistriata				**0**				**0**				**0**				**0**
Atys sp.	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**	0	4	0	**4**
Diniatys sp.	0	0	4	**4**	1	0	0	**1**	0	0	0	**0**	2	0	0	**2**
Haminoea curta	0	0	0	**0**	2	0	0	**2**	0	0	0	**0**	0	0	0	**0**
Acteocina spp.	3	1	2	**6**	1	3	4	**8**	0	0	0	**0**	0	0	0	**0**
Retusa sp.	0	1	3	**4**	1	0	0	**1**	3	1	5	**9**	2	3	0	**5**
Cylichna spp.	0	0	0	**0**	2	6	0	**8**	0	0	0	**0**	1	0	0	**1**
Berthelinia pseudochloris	0	0	0	**0**	0	0	0	**0**	4	1	0	**5**	2	0	0	**2**
Julia exquisita	1	0	2	**3**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Williamia radiata	0	0	1	**1**	0	0	0	**0**	0	1	1	**2**	0	0	0	**0**
Siphonaria sp.	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Gastropoda spp.	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
BIVALVIA																
Arcidae sp.	1	1	1	**3**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Barbatia divaricata	0	0	0	**0**	0	2	0	**2**	0	0	1	**1**	0	0	0	**0**
Barbatia sp.	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	1	1	1	**3**

Micromollusk Taxa	Number of Individuals															
	Station T-SW				Station T-NW				Station T-NE				Station T-SE			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Mytilidaes sp.	0	0	0	**0**	0	0	0	**0**	0	2	0	**2**	0	0	0	**0**
Ostrea sp.	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	1	1	0	**2**
Chlamys sp.	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	2	0	**3**
Lima sp.	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Ctena sp.	0	0	2	**2**	4	3	2	**9**	0	0	0	**0**	0	0	1	**1**
Carditella sp.	0	0	1	**1**	0	1	0	**1**	4	2	3	**9**	0	3	0	**3**
Fragum sp.				**0**				**0**				**0**				**0**
Macoma cf obliquilineata	0	0	0	**0**	2	0	0	**2**	0	0	0	**0**	1	0	0	**1**
Tellina sp.	2	0	0	**2**	0	2	0	**2**	2	1	2	**5**	0	0	0	**0**
Tellina sp. 2	2	0	0	**2**	0	1	1	**2**	0	0	1	**1**	0	0	2	**2**
Semelangulus crebrimaculatus	2	0	1	**3**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Cuspidaria sp.	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**
Bivalve sp. 1	12	0	5	**17**	13	15	16	**44**	0	0	0	**0**	0	0	3	**3**
Bivalve sp. 2				**0**				**0**				**0**				**0**
Bivalve sp. 3	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	5	0	0	**5**
Bivalve sp. 4				**0**				**0**				**0**				**0**
Bivalve sp. 5	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Bivalve sp. 6	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Bivalve sp. 7	2	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Bivalve sp 8				**0**				**0**				**0**				**0**
Bivalve sp. 9	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Bivalve sp. 10	0	1	0	**1**	0	0	0	**0**	0	1	0	**1**	0	5	0	**5**
Total Individuals	158	129	210	**497**	158	140	121	**419**	190	130	109	**429**	150	73	87	**310**
Total Individuals/cm^3	10.5	8.6	14.0	**33.1**	10.5	9.3	8.1	**27.9**	12.7	8.7	7.3	**28.6**	10.0	4.9	5.8	**20.7**
Total Taxa	47	25	50	**77**	43	42	30	**70**	131	131	131	**66**	131	131	131	**65**

Table 8. Abundance for micromollusk component at Agana ocean outfall sampling stations, Guam, 2001

Micromollusk Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	Total	R2	R4	R6	Total	R2	R4	R6	Total
GASTROPODA												
Scissurella coronata	5	6	0	**11**	0	0	0	**0**	0	0	0	**0**
Scissurella pseudoequatoria	8	1	0	**9**	0	0	0	**0**	0	0	0	**0**
Scissurella spp.	2	0	0	**2**	1	10	1	**12**	0	0	2	**2**
Diodora sp.				**0**				**0**				**0**
Emarginula sp.				**0**				**0**				**0**
Tugali sp.	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Limpet				**0**				**0**				**0**
Trochus intextus				**0**				**0**				**0**
Trochus sp.	0	0	0	**0**	0	1	0	**1**	1	0	0	**1**
Euchelus gemmatus	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Euchelus sp.	0	1	0	**1**	0	14	0	**14**	1	1	3	**5**
Gibbula sp.				**0**				**0**				**0**
Alcyna ocellata				**0**				**0**				**0**
Trochid?	7	5	12	**24**	9	4	11	**24**	3	4	2	**9**
Cyclostremiscus emeryi	13	7	12	**32**	8	22	7	**37**	1	1	5	**7**
Cyclostremiscus sp. A	0	0	0	**0**	0	7	0	**7**	0	0	0	**0**
Lophocochlias minutissimus	0	2	0	**2**	0	0	0	**0**	0	0	0	**0**
Lophocochlias spp.	0	0	0	**0**	0	0	0	**0**	5	0	0	**5**
Synaptocochlea concinna	0	2	1	**3**	2	2	4	**8**	0	2	1	**3**
Leptothyra rubricincta	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Leptothyra sp.	4	8	1	**13**	6	17	1	**24**	4	5	2	**11**
Turbo sandwicensis	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**
Tricolia variabilis	10	3	10	**23**	4	13	9	**26**	1	0	1	**2**
Smaragdia bryanae	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**
Teinostoma sp.	8	7	5	**20**	7	6	5	**18**	5	15	5	**25**
Nerita sp. (juveniles)	2	4	2	**8**	0	0	1	**1**	15	17	25	**57**

Micromollusk Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Littorina pintado	2	0	0	**2**	0	0	2	**2**	0	0	0	**0**
Eatoniella pigmenta				**0**				**0**				**0**
Eatoniella sp.				**0**				**0**				**0**
Rastodens sp.	3	0	4	**7**	0	0	0	**0**	0	0	0	**0**
Parashiela spp.	5	7	5	**17**	14	13	11	**38**	9	6	2	**17**
Powellsetia fallax	0	1	0	**1**	0	1	0	**1**	2	0	0	**2**
Merelina granulosa	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Rissoina cerithiiformis				**0**				**0**				**0**
Rissoina ambigua				**0**				**0**				**0**
Rissoina imbricata				**0**				**0**				**0**
Sansonia kennyi				**0**				**0**				**0**
Sansonia sp. B				**0**				**0**				**0**
Rissoids spp.	11	1	3	**15**	0	5	2	**7**	4	4	2	**10**
Vitrinellidae sp.				**0**				**0**				**0**
Orbitestella cf *regina*	3	0	0	**3**	3	6	12	**21**	0	0	0	**0**
Orbitestella sp.	0	0	0	**0**	0	2	2	**4**	5	2	8	**15**
Orbitestella sp. A				**0**				**0**				**0**
Orbitestella sp. B	3	8	8	**19**	0	2	21	**23**	0	0	0	**0**
Omalogyra cf *japonica*	4	3	8	**15**	6	20	12	**38**	8	4	9	**21**
Rissoella sp.				**0**				**0**				**0**
Rufodardanula ponderi				**0**				**0**				**0**
Rufodardanula sp. A				**0**				**0**				**0**
Rufodardanula sp.	0	0	0	**0**	0	7	7	**14**	0	0	0	**0**
Heliacus sp.	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**
Philippia sp.	0	0	1	**1**	0	0	1	**1**	0	0	0	**0**
Caecum cf. *glabella*	2	0	2	**4**	1	0	5	**6**	0	0	0	**0**
Caecum oahuense				**0**				**0**				**0**
Caecum arcuatum				**0**				**0**				**0**

Micromollusk Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Caecum cf *sepimentum*	1	0	0	**1**	0	0	1	**1**	0	0	1	**1**
Micranellum schlangi	0	0	4	**4**	0	1	1	**2**	5	5	4	**14**
Caecum sp. A				**0**				**0**				**0**
Strebloceras subannulatum	0	0	0	**0**	0	2	2	**4**	0	0	0	**0**
Micranellum sp.	0	0	0	**0**	0	1	1	**2**	0	0	0	**0**
Modulus tectum				**0**				**0**				**0**
Cerithidium perparvulum	1	0	4	**5**	16	1	17	**34**	17	9	8	**34**
Diala scopulorum	2	0	0	**2**	5	5	10	**20**	12	12	6	**30**
Diala semistriata	0	1	1	**2**	1	1	2	**4**	0	0	1	**1**
Diala sp.	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Scaliola spp.	3	6	5	**14**	47	26	28	**101**	51	20	35	**106**
Bittium impendens				**0**				**0**				**0**
Bittium sp.				**0**				**0**				**0**
Cerithium nesioticum				**0**				**0**				**0**
Cerithium sp.	0	0	0	**0**	0	0	0	**0**	0	2	0	**2**
Cerithidae spp.	18	7	20	**45**	4	18	14	**36**	8	12	3	**23**
Plesiotrochus luteus	0	0	0	**0**	0	0	0	**0**	2	1	0	**3**
Cerithiopsis spp.	0	2	0	**2**	0	4	2	**6**	0	0	2	**2**
Triphora spp.	3	4	0	**7**	3	1	0	**4**	3	0	0	**3**
Epitonium spp.	0	0	0	**0**	2	0	0	**2**	0	0	0	**0**
Balcis spp.	11	3	0	**14**	1	2	1	**4**	7	3	7	**17**
Strombus sp.	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Vanikoro cancellata				**0**				**0**				**0**
Antisabia foliacea				**0**				**0**				**0**
Hipponix pilosus	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Hipponix sp.				**0**				**0**				**0**
Natica gualteriana	2	3	0	**5**	0	0	0	**0**	0	0	0	**0**
Natica sp.				**0**				**0**				**0**

Micromollusk Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Gyrineum pusillum	0	0	0	**0**	3	3	1	**7**	0	0	0	**0**
Aspella sp.	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**
Buccinidae sp.	0	0	0	**0**	0	0	0	**0**	1	0	2	**3**
Seminella sp.	0	3	0	**3**	0	0	0	**0**	0	0	0	**0**
Columellidae	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**
Nassarius papillosus				**0**				**0**				**0**
Nassarius sp.	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Cystiscus huna	0	3	0	**3**	0	0	0	**0**	0	0	0	**0**
Dentimargo pumila	0	0	0	**0**	3	3	1	**7**	0	0	0	**0**
Granula sandwicensis	0	0	0	**0**	0	0	1	**1**	1	2	0	**3**
Granulina sp.				**0**				**0**				**0**
Volvarina fusiformis				**0**				**0**				**0**
Mitra sp.	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**
Clavus sp.	0	1	0	**1**	0	0	1	**1**	0	0	0	**0**
Microdaphne morrisoni				**0**				**0**				**0**
Xenuroturris sp.				**0**				**0**				**0**
Anacithara perfecta				**0**				**0**				**0**
Turridae spp.	0	8	0	**8**	4	0	0	**4**	2	0	1	**3**
Conus sp.				**0**				**0**				**0**
Terebra spp.				**0**				**0**				**0**
Ringicula sp.				**0**				**0**				**0**
Evalea peasei	0	0	0	**0**	0	1	0	**1**	1	0	0	**1**
Herviera gliriella	0	0	0	**0**	0	0	0	**0**	2	2	0	**4**
Miralda scopulorum				**0**				**0**				**0**
Miralda sp.	0	0	0	**0**	3	1	1	**5**	0	0	0	**0**
Odostomia stearnsiella	0	0	0	**0**	0	0	1	**1**	0	0	0	**0**
Odostomia sp.				**0**				**0**				**0**
Pyramidellidae spp.	6	4	3	**13**	3	1	5	**9**	4	7	5	**16**

Micromollusk Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Turbonilla cornelliana				**0**				**0**				**0**
Turbonilla lirata				**0**				**0**				**0**
Turbonilla spp.				**0**				**0**				**0**
Cephalaspidea sp.				**0**				**0**				**0**
Pupa sp.	0	0	0	**0**	6	1	0	**7**	0	0	0	**0**
Pupa tessellata	2	1	0	**3**	0	0	0	**0**	0	0	0	**0**
Hydatina sp.				**0**				**0**				**0**
Bulla sp.				**0**				**0**				**0**
Bulla vernicosa	0	0	0	**0**	0	5	6	**11**	0	0	0	**0**
Atys curta	3	1	0	**4**	0	0	0	**0**	7	5	0	**12**
Atys debilis	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Atys semistriata	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**
Atys sp.				**0**				**0**				**0**
Diniatys sp.				**0**				**0**				**0**
Haminoea curta				**0**				**0**				**0**
Acteocina spp.	3	1	0	**4**	1	0	2	**3**	0	0	0	**0**
Retusa sp.	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Cylichna spp.	3	5	6	**14**	3	2	1	**6**	3	1	0	**4**
Berthelinia pseudochloris	0	0	0	**0**	0	0	0	**0**	2	0	0	**2**
Julia exquisita				**0**				**0**				**0**
Williamia radiata	3	3	0	**6**	0	0	0	**0**	0	0	0	**0**
Siphonaria sp.				**0**				**0**				**0**
Gastropoda spp.	0	0	0	**0**	2	1	1	**4**	1	1	0	**2**
BIVALVIA												
Arcidae sp.	0	0	0	**0**	3	1	2	**6**	1	0	1	**2**
Barbatia divaricata				**0**				**0**				**0**
Barbatia sp.	2	1	0	**3**	0	0	0	**0**	0	0	0	**0**

Micromollusk Taxa	Number of Individuals											
	Station A-NE				Station A-SE				Station A-SW			
	R2	R4	R6	**Total**	R2	R4	R6	**Total**	R2	R4	R6	**Total**
Mytilidaes sp.				**0**				**0**				**0**
Ostrea sp.	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Chlamys sp.	0	1	0	**1**	1	0	1	**2**	0	0	0	**0**
Lima sp.	0	1	0	**1**	0	0	0	**0**	1	1	0	**2**
Ctena sp.	1	0	0	**1**	1	2	1	**4**	0	0	0	**0**
Carditella sp.				**0**				**0**				**0**
Fragum sp.	0	0	0	**0**	1	0	1	**2**	0	0	0	**0**
Macoma cf *obliquilineata*				**0**				**0**				**0**
Tellina sp.	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Tellina sp. 2				**0**				**0**				**0**
Semelangulus crebrimaculatus				**0**				**0**				**0**
Cuspidaria sp.				**0**				**0**				**0**
Bivalve sp. 1	15	21	13	**49**	46	18	29	**93**	51	50	40	**141**
Bivalve sp. 2	2	3	0	**5**	0	0	0	**0**	0	1	0	**1**
Bivalve sp. 3	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Bivalve sp. 4	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
Bivalve sp. 5	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**
Bivalve sp. 6				**0**				**0**				**0**
Bivalve sp. 7				**0**				**0**				**0**
Bivalve sp 8	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**
Bivalve sp. 9	0	0	0	**0**	0	0	0	**0**	0	0	1	**1**
Bivalve sp. 10				**0**				**0**				**0**
Total Individuals	178	152	131	**461**	221	256	249	**726**	251	197	186	**634**
Total Individuals/cm^3	11.9	10.1	8.7	**30.7**	14.7	17.1	16.6	**48.4**	16.7	13.1	12.4	**42.3**
Total Taxa	97	97	97	**58**	97	97	97	**59**	97	97	97	**52**

Table 9. Numbers, occurrence, and habits of micromollusks, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

	Tanguisson Stations				Agana Stations				
	T-SW	T-NW	T-NE	T-SE	A-SW	A-NE	A-SE	Total	Average per Station
Total No. Individuals	497	419	429	310	461	726	634	3476	496.6
No. Individuals/cm^3	33.1	27.9	28.6	20.7	30.7	48.4	42.3	231.7	33.1
No. Taxa	77	70	66	65	58	59	52	158	63.8
No. Gastropod	461	355	408	280	398	619	484	3005	429.3
No. Gastropod/cm^3	30.7	23.7	27.2	18.7	26.5	41.3	32.3	200.3	28.6
No. Bivalves	36	64	21	30	63	107	150	471	67.3
No. Bivalves/cm^3	2.4	4.3	1.4	2.0	4.2	7.1	10.0	31.4	4.5
% Sand Dwellers	10	20	11	13	17	17	23	57	8.1
% Pyramidellid	15	15	12	2	13	16	21	50	7.1
% Faunal Grazers	2	8	6	10	6	3	17	26	3.7
% Carnivores	1	4	1	1	3	<1	<1	3	0.43

All figures based on survey of 15 cm^3 sediment

APPENDIX TABLES

Appendix A. Information Regarding Sampling Stations

Table A. 1. Sample collection information for invertebrates at Agana and Tanguisson ocean outfall sampling stations, Guam, 2001

Sample	Collection		Depth	Latitude	Longitude	Sample Volume (ml)		Sediment	Location
	Date	Time	(m)	(decimal)	(decimal)	Proposed	Received	Type	Fixed
A-SW-1	7/20/01	1130	91.4	13.4871	144.7469	500	420	Fine	Field
A-SW-3	7/20/01	1130	91.4	13.4871	144.7469	500	285	Fine	Field
A-SW-5	7/20/01	1145	91.4	13.4871	144.7469	500	110	-	Lab
A-NE-1	7/20/01	1400	83.8	13.4863	144.7498	500	205	Fine	Field
A-NE-3	7/20/01	1400	83.8	13.4863	144.7498	500	175	Fine	Field
A-NE-5	7/20/01	1400	71.6	13.4864	144.7497	500	105	-	Lab
A-SE-1	7/20/01	800	83.8	13.4869	144.7486	500	NA	Fine	Field
A-SE-3	7/20/01	800	83.8	13.4866	144.7494	500	NA	Fine	Field
A-SE-5	7/20/01	800	83.8	13.4866	144.7494	500	125	-	Lab
T-NW-1	7/22/01	1000	50.3	13.5537	144.8072	500	215	Fine	Field
T-NW-3	7/22/01	1000	51.2	13.5533	144.8071	500	230	Fine	Field
T-NW-5	7/22/01	1000	51.2	13.5533	144.8072	500	80	-	Lab
T-SW-1	7/22/01	1130	52.1	13.5513	144.8069	500	200	Very Coarse	Field
T-SW-3	7/22/01	1130	50.3	13.5515	144.8069	500	245	Some Rubble	Field
T-SW-5	7/22/01	1130	51.8	13.5512	144.8062	500	65	-	Lab
T-SE-1	7/22/01	855	46.3	13.5521	144.8066	500	NA	Fine	Field
T-SE-3	7/22/01	855	46.3	13.5521	144.8066	500	NA	Fine	Field
T-SE-5	7/22/01	855	42.7	13.5523	144.8067	500	110	-	Lab
T-NE-1	7/22/01	1310	46.3	13.5523	144.8078	500	210	Some Rubble	Field
T-NE-3	7/22/01	1310	43	13.5523	144.8072	500	270	Some Rubble	Field
T-NE-5	7/22/01	1310	39.6	13.5523	144.8072	500	270	Some Rubble	Field

Table A. 2. Sample collection information for micromollusks at Agana and Tanguisson ocean outfall sampling stations, Guam, 2001

Sample	Collection		Depth (m)	Latitude (decimal)	Longitude (decimal)
	Date	Time			
A-SW-2	7/20/01	1130	91.4	13.4871	144.7469
A-SW-4	7/20/01	1130	91.4	13.4871	144.7469
A-SW-6	7/20/01	1145	91.4	13.4871	144.7469
A-NE-2	7/20/01	1400	65.5	13.4863	144.7498
A-NE-4	7/20/01	1400	83.8	13.4864	144.7497
A-NE-6	7/20/01	1400	65.5	13.4864	144.7497
A-SE-2	7/20/01	800	83.8	13.4866	144.7494
A-SE-4	7/20/01	800	83.8	13.4866	144.7494
A-SE-6	7/20/01	800	83.8	13.4866	144.7494
T-NW-2	7/22/01	1000	50.3	13.5533	144.8071
T-NW-4	7/22/01	1000	51.2	13.5533	144.8072
T-NW-6	7/22/01	1000	51.2	13.5533	144.8072
T-SW-2	7/22/01	1130	52.1	13.5515	144.8069
T-SW-4	7/22/01	1130	50.3	13.5512	144.8062
T-SW-6	7/22/01	1130	51.8	13.5512	144.8062
T-SE-2	7/22/01	855	46.3	13.5521	144.8066
T-SE-4	7/22/01	855	46.3	13.5523	144.8067
T-SE-6	7/22/01	855	42.7	13.5523	144.8067
T-NE-2	7/22/01	1310	46.3	13.5523	144.8072
T-NE-4	7/22/01	1310	43	13.5523	144.8072
T-NE-6	7/22/01	1310	39.6	13.5525	144.8078

Appendix B. Invertebrate Statistical Analyses

Table B. 1. Statistics for untransformed invertebrate abundance at Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

Statistic	Tanguisson Stations				Agana Stations		
	T-SW	T-NW	T-NE	T-SE	A-SW	A-NE	A-SE
Number	3	3	3	3	3	3	3
Mean	83.33	125.33	206.67	281.33	36.33	99.33	68.67
Median	93	133	219	232	25	94	51
Standard Error of Mean	12.25	44.91	81.35	155.54	15.51	18.1	34.35
Standard Deviation	21.22	77.78	140.91	269.41	26.86	31.34	59.5
Variance	450.33	6050.33	19854.3	72581.3	721.33	982.33	3540.33
Skewness	-1.62	-0.44	-0.39	0.8	1.56	0.74	1.22
Normality (D)	0.342ns	0.206ns	0.202ns	0.239ns	0.33ns	0.234ns	0.283ns

Significance was at $p > 0.05$ (ns = not significant, * = significant).

Table B. 2. Statistics for untransformed invertebrate taxon richness at Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

Statistic	Tanguisson Stations				Agana Stations		
	T-SW	T-NW	T-NE	T-SE	A-SW	A-NE	A-SE
Number	3	3	3	3	3	3	3
Mean	28.67	22.33	17	20.67	18	24.33	27.33
Median	29	26	13	29	15	25	22
Standard Error of Mean	5.49	4.18	5.03	9.35	6.25	2.33	9.06
Standard Deviation	9.5	7.23	8.72	16.2	10.82	4.04	15.7
Variance	90.33	52.33	76	262.33	117	16.33	246.33
Skewness	-0.16	-1.69	1.63	-1.7	1.15	-0.72	1.35
Normality (D)	0.181ns	0.361ns	0.343ns	0.363ns	0.276ns	0.232ns	0.300ns

Significance was at $p > 0.05$ (ns = not significant, * = significant).

Table B. 3. Taxon richness (d), Shannon-Wiener diversity (H'), and Pielou's evenness (J') for invertebrates at Agana and Tanguisson ocean outfall sampling stations, Guam, 2001

	Tanguisson											
	T-SW			T-NW			T-NE			T-SE		
	R1	R3	R5	R1	R3	R5	R1	R3	R5	R1	R3	R5
Richness	8.29	6.4	4.41	5.1	5.32	3.44	2.44	4.63	2.23	4.57	5.69	0.271
Diversity	3.23	2.86	2.47	2.27	2.49	1.91	1.66	1.93	0.764	2.03	2.39	0.117
Evenness	0.881	0.84	0.838	0.681	0.754	0.722	0.691	0.58	0.298	0.596	0.69	0.169

	Agana								
	A-SW			A-NE			A-SE		
	R1	R3	R5	R1	R3	R5	R1	R3	R5
Richness	4.35	6.9	2.82	6.13	5.28	4.46	9.38	5.34	4.67
Diversity	2.51	3.09	2.04	2.82	2.78	2.57	3.34	2.74	2.46
Evenness	0.926	0.909	0.927	0.821	0.863	0.858	0.867	0.886	0.908

Table B. 4. Summary of statistical analyses invertebrate abundance and taxon richness at Tanguisson, Agana, and the two sites combined

Abundance				by stations		by sites	
		TA	AG	TA&AG	SQRT(TA&A	TA&AG	SQRT(TA&A
Normality	Test Statistic	0.195ns	0.163ns	0.243*	0.155ns	0.243*	0.155ns
	p =	>0.15	>0.15	<0.01	>0.15	<0.01	>0.15
Homogeneity	Test Statistic	7.543ns	1.237ns	1.792ns	8.978ns	2.171ns	3.487ns
	p =	0.056	0.539	0.173	0.175	0.157	0.087
ANOVA		+	+	-	+	-	+
Tukey Test		ns	ns	NA	ns	NA	*

Taxon Richness				by stations	by sites
		TA	AG	TA&AG	TA&AG
Normality	Test Statistic	0.228ns	0.150ns	0.116ns	0.116ns
	p =	0.084	>0.15	>0.15	>0.15
Homogeneity	Test Statistic	1.319ns	2.389ns	3.795ns	1.047ns
	p =	0.725	0.303	0.704	0.917
ANOVA		+	+	+	+
Tukey Test		ns	ns	ns	ns

The comparisons were performed on individual stations and of sites as a whole, Tanguisson (TA), Agana (AG), and Combined (TA&AG).
Significance was at the level $p > 0.05$ Significance was at the level $p > 0.05$

Square root transformations (SQRT) were used when data did not satisfy assumption for analysis of variance (ANOVA) and a Tukey Test was used for a posteriori comparison of means.

Table B. 5. Square root transformed invertebrate abundance, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

	Tanguisson Stations				Agana Stations		
	T-SW	T-NW	T-NE	T-SE	A-SW	A-NE	A-SE
R1	9.9	14.11	7.75	23.92	5	11.53	11.62
R3	9.64	11.53	18.47	15.23	8.19	9.7	7.14
R5	7.68	6.63	14.8	6.32	4.12	8.43	4.47
Total	15.81	19.39	24.9	29.05	10.44	17.26	14.35
Mean	9.07	10.76	13.67	15.16	5.77	9.88	7.74
Standard	1.21	3.8	5.45	8.8	2.14	1.56	3.61

Table B. 6. Analysis of variance of square root transformed invertebrate abundance, Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

Source of	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	*p*
Among Sites	98	1	98	4.91	0.039*
Experimental Error	379.7	19	20		
Total	477.7	20			

Replicates were treated by outfall site without regard to station.

Significance was $p > 0.05$ (ns = not significant, * = significant).

Table B. 7. Statistics for untransformed polychaete abundance at Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

Statistic	Tanguisson Stations				Agana Stations		
	T-SW	T-NW	T-NE	T-SE	A-SW	A-NE	A-SE
Number	3	3	3	3	3	3	3
Mean	34	67	30	82	13	24	37
Median	36.33	66.33	50	149.67	17.67	35	33
Standard Error of Mean	4.48	31.18	25.17	111.22	6.23	12.01	10.58
Standard Deviation	7.77	54	43.59	192.63	10.79	20.81	18.33
Variance	60.33	2916.33	1900	37106.3	116.33	433	336
Skewness	1.23	-0.06	1.63	1.39	1.58	1.71	-0.94
Normality (D)	0.227ns	0.269ns	0.358ns	0.353ns	0.232ns	0.232ns	0.243ns

Significance was at $p > 0.05$ (ns = not significant, * = significant).

Table B. 8. Statistics for untransformed polychaete taxon richness at Tanguisson and Agana ocean outfall sampling stations, Guam, 2001

Statistic	Tanguisson Stations				Agana Stations		
	T-SW	T-NW	T-NE	T-SE	A-SW	A-NE	A-SE
Number	3	3	3	3	3	3	3
Mean	16	12.67	10.33	12.67	9.67	12.33	15.67
Median	17	14	7	18	9	13	14
Standard Error of Mean	3.79	2.96	3.84	6.36	2.33	2.33	4.98
Standard Deviation	6.56	5.13	6.66	11.02	4.04	4.04	8.62
Variance	43	26.33	44.33	121.33	16.33	16.33	74.33
Skewness	-0.67	-1.09	1.69	-1.67	0.72	-0.72	0.84
Normality (D)	0.285ns	0.176ns	0.343ns	0.304ns	0.334ns	0.368ns	0.253ns

Significance was at $p > 0.05$ (ns = not significant, * = significant).

Table B. 9. Taxon richness (d), Shannon-Wiener diversity (H'), and Pielou's evenness (J') for polychaetes at Agana and Tanguisson ocean outfall sampling stations, Guam, 2001

	Tanguisson											
	T-SW			T-NW			T-NE			T-SE		
	R1	R3	R5	R1	R3	R5	R1	R3	R5	R1	R3	R5
Richness	5.96	4.2	2.35	3.34	3.09	2.41	1.67	3.69	1.76	3.22	3.86	-
Diversity	2.97	2.22	1.64	1.66	1.6	1.82	1.47	2.2	0.951	1.37	2.43	-
Evenness	0.959	0.783	0.748	0.588	0.605	0.935	0.818	0.762	0.489	0.458	0.84	-

	Agana								
	A-SW			A-NE			A-SE		
	R1	R3	R5	R1	R3	R5	R1	R3	R5
Richness	3.12	3.82	2.17	3.68	3.78	2.26	6.17	3.6	2.73
Diversity	2.03	2.37	1.64	2.26	2.41	1.67	3.03	2.22	1.74
Evenness	0.925	0.897	0.917	0.813	0.938	0.801	0.941	0.841	0.836

Table B. 10. Summary of statistical analyses polychaete abundance and taxon richness at Tanguisson, Agana, and the two sites combined

Abundance					by stations		by sites	
		TA	SQRT(TA)	AG	TA&AG	SQRT(TA&A	TA&AG	SQRT(TA&A
Normality	Test Statistic	0.243*	0.145ns	0.161ns	0.250*	0.155ns	0.250*	0.155ns
	p =	0.049	>0.15	>0.15	<0.01	>0.15	<0.01	>0.15
Homogeneity	Test Statistic	1.331ns	8.296*	0.684ns	1.476ns	15.202*	1.917ns	9.188*
	p =	0.331	0.04	0.71	0.256	0.019	0.182	0.004
ANOVA		-	-	+	-	-	-	-
Tukey Test		NA	NA	ns	NA	NA	NA	NA
Kruskal-Wallis	Test Statistic	0.42ns			3.35ns		1.82ns	
	p =	0.935			0.763		0.177	

Taxon Richness				by stations	by sites
		TA	AG	TA&AG	TA&AG
Normality	Test Statistic	0.182ns	0.175ns	0.130ns	0.130ns
	p =	>0.15	>0.15	>0.15	>0.15
Homogeneity	Test Statistic	1.110ns	1.354ns	1.407ns	1.407ns
	p =	0.775	0.508	0.642	0.642
ANOVA		+	+	+	+
Tukey Test		ns	ns	ns	ns

The comparisons were performed on individual stations and of sites as a whole, Tanguisson (TA), Agana (AG), and Combined (TA&AG).
Significance was at the level p > 0.05 Significance was at the level p > 0.05

Square root transformations (SQRT) were used when data did not satisfy assumption for analysis of variance (ANOVA) and a Tukey Test was used for a posteriori comparison of means. When transformed data did not satisfy the assumptions, a non-parametric (Kruskal-Wallis) method was employed.