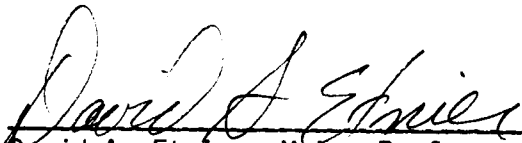


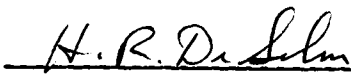
To the Graduate Council:

I am submitting herewith a thesis written by Terrell Allen Farmer entitled "Quantitative Characterization of the Polychaete Communities and the Impacts of Dredged Material Disposal Offshore from Tampa Bay, Florida." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology.

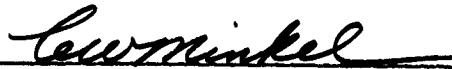

David A. Etnier, Major Professor

We have read this thesis
and recommend its acceptance:





Accepted for the Council:



Vice Provost
and Dean of the Graduate School

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Master's degree at The University of Tennessee, Knoxville, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of the source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Head of Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature

Lowell Allen Fanner

Date

2/19/86

QUANTITATIVE CHARACTERIZATION OF THE POLYCHAETE COMMUNITIES
AND THE IMPACTS OF DREDGED MATERIAL DISPOSAL
OFFSHORE FROM TAMPA BAY, FLORIDA

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Terrell Allen Farmer

March 1986

ACKNOWLEDGEMENTS

I am especially grateful to my colleagues Dr. Charles Comiskey and Mr. Craig Brandt of Science Applications International Corporation in Oak Ridge, Tennessee. Charles Comiskey designed the quantitative approach to community characterization and impact assessment used in this research, and critically reviewed the initial manuscript. Craig Brandt designed and wrote the data management computer programs and provided extensive support in generating the analyses and data products.

I am also grateful to the members of my graduate committee, Drs. David Etnier, H.R. Deselm, and Kenneth Walker, for critically reviewing the manuscript and tolerating my tardiness in completing this study.

Paul Wolf, Paul Johnson, Kevin Shaw, and Dr. Barry Vittor of Barry A. Vittor and Associates in Mobile, Alabama conducted the taxonomic analyses and provided invaluable insight regarding the autecology and synecology of the polychaetes in the eastern Gulf of Mexico.

Special thanks go to Mary Ann Warwick, Kathy Newman, Karen Dunaway, Gerri Ivey, Linda Stewart and Margaret Terrell for lending their expertise in word processing and document preparation to this thesis.

This research was funded by the U.S. Environmental Protection Agency, Criteria and Standards Division, Washington, D.C. through a contract with Science Applications International Corporation.

ABSTRACT

An investigation of the near-bottom water column and benthic habitats at one historical dredged material disposal site, one existing site, and at two proposed alternative sites located 7 to 20 nautical miles offshore from Tampa Bay, Florida was conducted during May 1982. One hundred macroinfaunal and sediment samples were collected at twenty stations in order to: (1) quantitatively characterize the polychaete communities and their relationships to environmental variables, and (2) assess the impacts of dredged material disposal.

The near-bottom salinities were euhaline and increased with increasing depth. The heterogeneous sediments were characterized by coarse to fine sands interrupted by patches of gravel, with the silt fraction increasing with increasing depth. The species diversity and density of the polychaetes decreased with increasing depth, increasing percent fines, and increasing sediment homogeneity, with the gravelly habitats generally supporting the most diverse communities. A synthesis of the environmental and community analyses results yielded six polychaete communities characteristic of the following habitats: (1) very gravelly sands, (2) coarse sands with some gravel, (3) medium and fine sands in deep water, (4) fine sands in shallow water, (5) fine sands and silts in deep water, and (6) widespread across all habitats.

The polychaete communities at the historical site have completely recovered from dredged material disposal impacts since the cessation of disposal in 1973. Near the center of the existing disposal site, the accumulation of dredged material has buried the resident infauna. The polychaete community near the center of the existing site was

characterized by opportunistic species in low numbers, indicating that the sediments were in the initial stages of recolonization.

TABLE OF CONTENTS

SECTION	PAGE
1.0 INTRODUCTION	1
1.1 Approaches to Benthic Environmental Impact Assessment . .	1
1.2 The Tampa Harbor Dredged Material Disposal Study	13
2.0 METHODS	16
2.1 Field and Laboratory Procedures	16
2.2 Data Analysis	19
2.2.1 Sediment Texture Analysis	19
2.2.2 Community-Habitat Relationships	22
3.0 RESULTS	28
3.1 Overview of the Study Area	28
3.2 Characterization of the Benthic Environment	29
3.2.1 Hydrographic, Sediment Grain Size, and Community Characteristics	29
3.2.2 Correlation Analysis of Sediment and Hydrographic Variables	31
3.2.3 Cluster Analysis of Sediment Texture Variables . .	33
3.3 Polychaete Community Analysis	35
3.3.1 Relative Composition and Abundance	35
3.3.2 Selection of the Most Ecologically Meaningful Taxa	42
3.3.3 Correlation Analysis of the Selected Taxa and Environmental Variables	43
3.3.4 TWINSPLAN Analysis	45
3.3.5 Q-Mode Cluster Analysis	48
3.3.6 R-Mode Cluster Analysis	50
3.3.7 Reciprocal Averaging Ordination Analysis	52
4.0 DISCUSSION	60
4.1 Definition of the Sample Groups	60
4.2 Definition of the Polychaete Communities	63
4.3 Impacts of Dredged Material Disposal	75
4.4 Conclusions	78
REFERENCES CITED	80
VITA	88

LIST OF TABLES

TABLE	PAGE
1.1 Description of the morphology and ecology of selected polychaete families	6
2.1 Grain size scales and conversions relating U.S. standard sieve mesh numbers, millimeters, microns, phi units, and Wentworth size classes	20
3.1 Station means for environmental and community parameters measured in 100 samples collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	30
3.2 Pearson product-moment correlation coefficients between the environmental variables measured in 100 samples collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	32
3.3 Overall relative composition of polychaete taxa in samples collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	36
3.4 Pearson product-moment correlation coefficients between selected taxa and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	44
3.5 Ordered table of sample environmental and community parameters based on the results of TWINSpan analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	47
3.6 Summary of results of stepwise multiple regression analysis of environmental variables with Axis 1 sample scores based on the ordination analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	55
3.7 Summary of results of stepwise multiple regression analysis of environmental variables with Axis 2 sample scores based on the ordination analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	56

LIST OF TABLES (Continued)

TABLE	PAGE
4.1 Summary statistics of the environmental and community parameters for each sample group resulting from a synthesis of community-level analyses of selected taxa and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	61
4.2 Polychaete communities resulting from a synthesis of the analyses of selected taxa and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	65

LIST OF FIGURES

FIGURE	PAGE
1.1 Illustrations of the typical morphologies for the errantiate polychaete families Chrysopetalidae, Dorvilleidae, Eunicidae, Glyceridae, Goniadidae, and Hesionidae	2
1.2 Illustrations of the typical morphologies for the errantiate polychaete families Lumbrineridae, Nephtyidae, Nereidae, Onuphidae, Pilargidae, and Syllidae	3
1.3 Illustrations of the typical morphologies for the sedentariate polychaete families Ampharetidae, Capitellidae, Cirratulidae, Flabelligeridae, Magelonidae, and Opheliidae	4
1.4 Illustrations of the typical morphologies for the sedentariate polychaete families Oweniidae, Paraonidae, Pectinariidae, Sabellidae, Spionidae, and Trichobranchidae	5
1.5 Tampa Bay and the adjacent Gulf of Mexico showing the four existing and alternative Offshore Dredged Material Disposal Sites sampled during the May 1982 OSV <u>Antelope</u> cruise	14
2.1 Map of the station grid utilized at the existing Offshore Dredged Material Disposal Sites A and B sampled during the May 1982 OSV <u>Antelope</u> cruise	17
2.2 Map of the station grid utilized at the proposed Offshore Dredged Material Disposal Sites 3 and 4 sampled during the May 1982 OSV <u>Antelope</u> cruise	18
3.1 Sample dendrogram resulting from Q-mode cluster analysis of sediment texture and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	34
3.2 Ordered two-way display resulting from TWINSPLAN analysis of the sample relative abundances of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	46
3.3 Sample dendrogram resulting from Q-mode cluster analysis of the densities of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	49
3.4 Taxa dendrogram resulting from R-mode cluster analysis of the densities of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	51

LIST OF FIGURES (Continued)

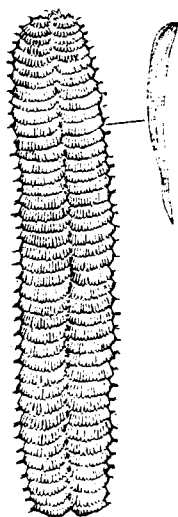
FIGURE	PAGE
3.5 Plot of the sample scores on the first two reciprocal averaging ordination axes from an analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	53
3.6 Plot of the taxa scores on the first two reciprocal averaging ordination axes from an analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV <u>Antelope</u> cruise	54

1.0 INTRODUCTION

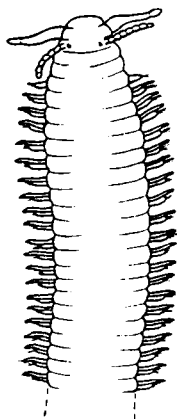
1.1 Approaches to Benthic Environmental Impact Assessment

The use of the sea as a repository for mankind's wastes has created a dire need for an increased understanding of the effects of waste disposal on marine ecosystems. The most common methods of addressing this need have employed statistical techniques and various mathematical indices based primarily on the number of individuals, the number of species, the relationships between the distributions of species and the distributions of environmental variables, and the trophic relationships of benthic macroinfaunal organisms.

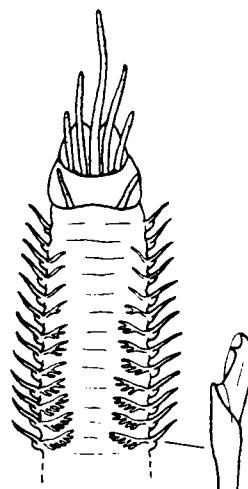
Benthic macroinfauna are defined as the organisms with limited mobility that live on or in the sediments. These organisms may be sampled quantitatively with a variety of devices, with grabs or box cores measuring 0.1 to 0.2 m² in surface area and sediment screens with a 0.5 to 1.0 mm mesh size commonly used (Holme and McIntyre 1971). Most grabs and box cores are designed to penetrate about 15 to 20 cm in soft (i.e., muddy) sediments and about 10 to 15 cm in firm (i.e., sandy) sediments. In most habitats, the polychaete worms are the most widespread and common organisms, with bivalve and gastropod molluscs, amphipod, ostracod and decapod crustaceans, echinoderms, and burrowing anemones also frequently abundant. The polychaete worms range from a few millimeters to several centimeters in length, with most of the individuals less than 10 cm long. Figures 1.1 to 1.4 present illustrations of the typical morphologies for selected polychaete families and Table 1.1 provides a brief description of the



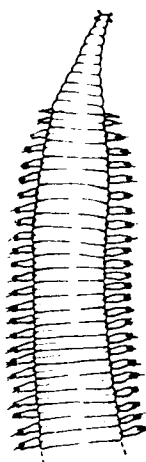
CHRYSOPETALIDAE



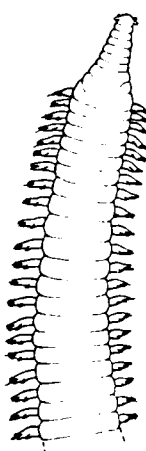
DORVILLEIDAE



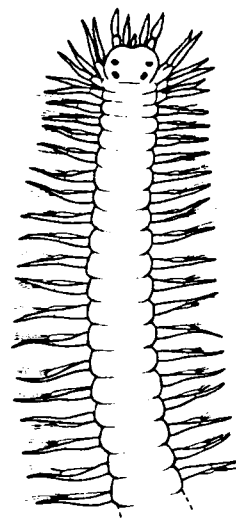
EUNICIDAE



GLYCERIDAE



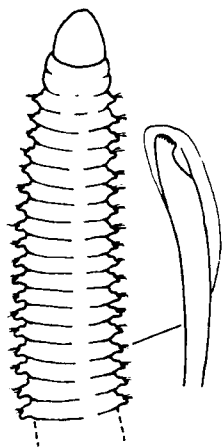
GONIADIDAE



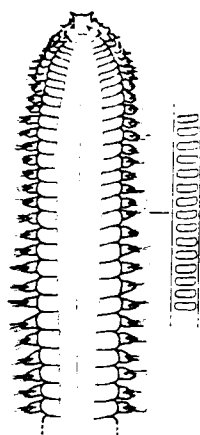
HESIONIDAE

Source: Banse, K. and K.D. Hobson. 1974. Benthic errantiate polychaetes of British Columbia and Washington. Bull. Fish. Res. Bd. Can. 185.

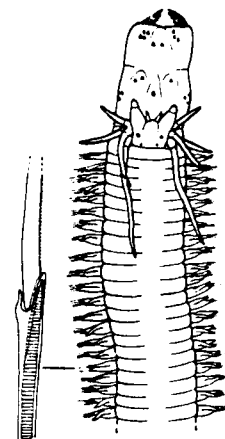
Figure 1.1. Illustrations of the typical morphologies for the errantiate polychaete families Chrysopetalidae, Dorvilleidae, Eunicidae, Glyceridae, Goniadidae, and Hesionidae.



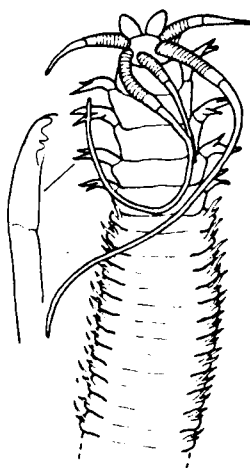
LUMBRINERIDAE



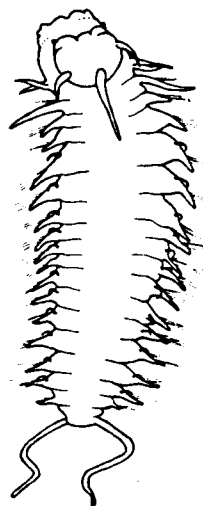
NEPHTYIDAE



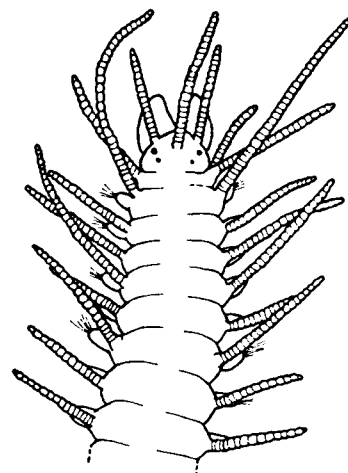
NEREIDAE



ONUPHIDAE



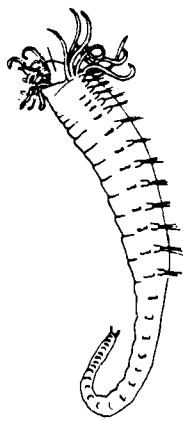
PILARGIIDAE



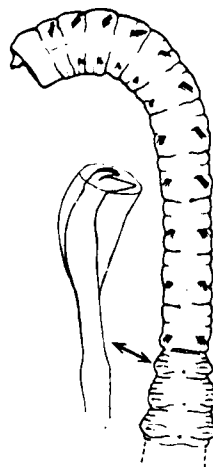
SYLLIDAE

Source: Banse, K. and K.D. Hobson. 1974. Benthic errantiate polychaetes of British Columbia and Washington. Bull. Fish. Res. Bd. Can. 185.

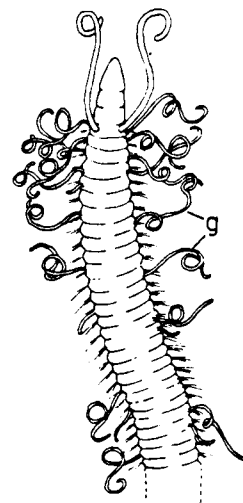
Figure 1.2. Illustrations of the typical morphologies for the errantiate polychaete families Lumbrineridae, Nephtyidae, Nereidae, Onuphidae, Pilargiidae, and Syllidae.



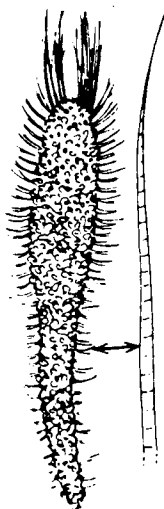
AMPHARETIDAE



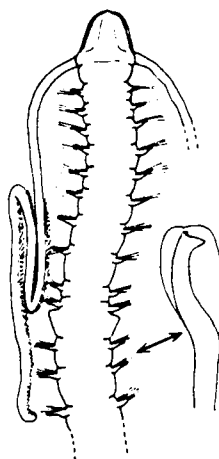
CAPITELLIDAE



CIRRATULIDAE



FLABELLIGERIDAE



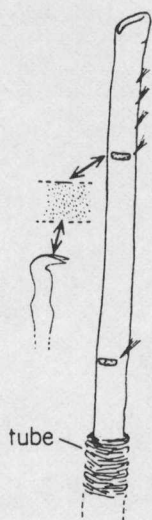
MAGELONIDAE



OPHELIIDAE

Source: Hobson, K.D. and K. Banse. 1981. Sedentariate and archiannelid polychaetes of British Columbia and Washington. Bull. Fish. Res. Bd. Can. 209.

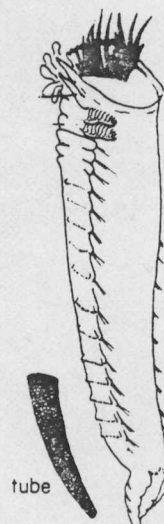
Figure 1.3. Illustrations of the typical morphologies for the sedentariate polychaete families Ampharetidae, Capitellidae, Cirratulidae, Flabelligeridae, Magelonidae, and Opheliidae.



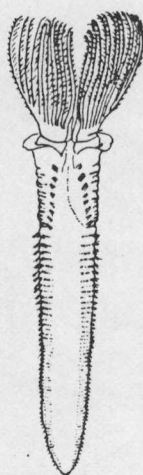
OWENIIDAE



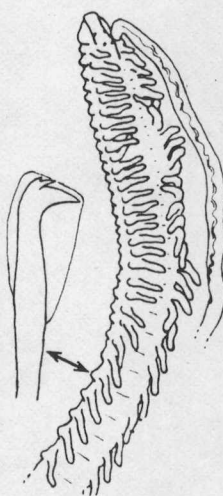
PARAONIDAE



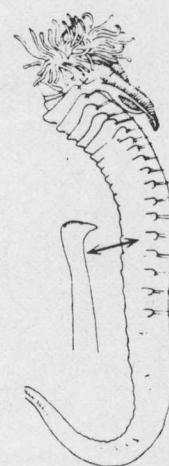
PECTINARIIDAE



SABELLIDAE



SPIONIDAE



TRICHOBRANCHIDAE

Source: Hobson, K.D. and K. Banse. 1981. Sedentariate and archiannelid polychaetes of British Columbia and Washington. Bull. Fish. Res. Bd. Can. 209.

Figure 1.4. Illustrations of the typical morphologies for the sedentariate polychaete families Oweniidae, Paraonidae, Pectinariidae, Sabellidae, Spionidae, and Trichobranchidae.

Table 1.1. Description of the morphology and ecology of selected polychaete families.

Family	Description
Chrysopetalidae	length up to 50 mm; bodies taper slightly at both ends; dorsum covered with golden-brown, flattened setae or paleae giving worm a metallic appearance; carnivorous; frequently found in crevices of rocks, shells, and reefs or on sandy bottoms
Dorvilleidae	length up to 140 mm; some species are interstitial, others crawl over sediment surface or burrow; carnivores, herbivores, and surface deposit feeders
Eunicidae	length up to 500 mm; cylindrical to oval in cross-section; usually distinctly segmented; free-living or tubicolous; inhabit coral reefs and sandy bottoms;
Glyceridae	length up to 800 mm; slender and cylindrical in cross-section, body tapered at both ends; free-living on rocks and algal mats, also burrow into sandy or muddy sediments; carnivores or subsurface deposit feeders;
Goniadidae	length up to 140 mm; cylindrical in cross-section; free-living surface dwellers or burrowers in a variety of sediments; carnivorous;
Hesionidae	length up to 50 mm; cylindrical to dorso-ventrally flattened in cross-section; free-living on coral reefs or other hard substrata, also found in sandy sediments, very small species are interstitial; herbivores, carnivores, surface, and subsurface deposit feeders;
Lumbrineridae	length up to 208 mm; cylindrical in cross-section; most species are free-living burrowers in soft bottoms, some species also found on coral reefs and other hard substrata; herbivores, carnivores, and subsurface deposit feeders;
Nephtyidae	length up to 150 mm; nearly rectangular in cross-section; free-living burrowers in sandy sediments; carnivores and subsurface deposit feeders;
Nereidae	length up to 200 mm; free-living, motile omnivores that construct temporary mucous and sand tubes;
Onuphidae	length up to 105 mm; cylindrical anteriorly, but dorsoventrally flattened posteriorly; motile tube-dwellers; omnivorous scavengers;
Pilargiidae	length up to 86 mm; cylindrical or dorso-ventrally flattened in cross-section; free-living surface-dwellers or burrowers; carnivores and omnivores;
Syllidae	length up to 10 mm; slender-bodied; free-living in cryptic, hard-bottom habitats such as coral reefs or gravel, some species inhabit soft-bottoms; carnivores or herbivores;
Ampharetidae	length up to 60 mm; sessile tube-dwellers in soft sediments; tubes constructed of mucous and sediment and frequently extend horizontally above the substrate; surface deposit feeders; more common in deeper water

Table 1.1. (Continued)

Family	Description
Capitellidae	length up to 200 mm; elongate, cylindrical in cross-section; most species are free-living on soft bottoms, but at least two species inhabit mucous-lined tubes; surface and subsurface deposit feeders; several species are very opportunistic
Cirratulidae	length up to 250 mm; cylindrical in cross-section; most species are free-living but some species build mud or calcareous tubes; surface deposit feeders
Flabelligeridae	length up to 53 mm; "cage" of long setae surround head region, and sediment grains often adhere to mucous secretions giving grainy appearance; free-living on variety of substrates, some species inhabit U-shaped burrows, and some species may build tubes; surface deposit or filter feeders
Magelonidae	length up to 60 mm; free-living burrowers in muds and sands; burrows are mucous-lined; surface deposit feeders
Opheliidae	length up to 60 mm; body may be stout and short, slender and fusiform, or inflated anteriorly and slender posteriorly; burrow in sands and muds; subsurface deposit feeders
Oweniidae	length up to 40 mm; body long and thread-like; tubicolous with the tubes constructed from sand grains, shell particles, or tests from surrounding substrate; filter, surface deposit, and subsurface deposit feeders;
Paraonidae	length up to 30 mm; slender-bodied; inhabit spiral-shaped burrows in a variety of substrates; herbivores or surface deposit feeders;
Pectinariidae	length up to 90 mm; cone-shaped body; inhabit cone-shaped tubes constructed from sand grains, shell particles or pieces of coral; subsurface deposit feed with the mouth and tube oriented downwards in muddy or sandy sediments;
Sabellidae	length up to 75 mm; body modified anteriorly to form branchial crown; tubicolous with the tubes constructed from mud, sand or shell particles; tubes may be attached to hard substrata or buried in the sediment; filter or surface deposit feeders;
Spionidae	length up to 100 mm; inhabit temporary or permanent mucous-lined tubes in a variety of sediments; some species bore into hard substrates or bivalve shells; filter or surface deposit feeders; several species are opportunistic
Trichobranchidae	length up to 45 mm; body modified anteriorly to form numerous tentacular feeding filaments; tubicolous inhabitants of muds, sands, and silty detritus deposits often found in seagrass beds; surface deposit feeders

morphology and ecology of each family as taken from Uebelaker and Johnson (1984) and Fauchald and Jumars (1979).

Macroinfaunal organisms are important environmental research topics for several reasons. Because they are relatively immobile and their benthic habitat represents a sink for accumulation of contaminants, they serve as integrators of the environmental quality of the area they inhabit. When this is considered in light of their trophic importance to the continental shelf ecosystem, the potential for transfer of contaminants to higher levels of the food chain, the population and community-level structural responses of the macroinfauna to contaminants, and the relative ease of taxonomic identification (as compared to the meiofauna and microfauna), this group of organisms becomes the key biotic component for the development of mathematical and biological techniques for environmental impact assessment.

Numerous approaches have been used in the assessment of environmental impacts. Many investigators have applied the theoretical concept of species diversity to impact assessment, usually employing the Shannon-Wiener information statistic (Shannon and Weaver 1963) or graphical techniques that treat the distribution of individuals among species such as rarefaction (Sanders 1968, Hurlbert 1971). In recent years, sediment bioassay (toxicity test) techniques have been widely utilized in impact assessment (Chapman and Long 1983, Swartz et al. 1982). Another major approach to environmental impact assessment is to monitor the abundance of a single "indicator" species or an "indicator" group composed of several species that have known responses to the

type of impact under consideration (Brinkhurst 1967, Reish 1957, 1960). A major refinement of the "indicator species" or "indicator group" techniques has been the development of impact assessment methods that consider data on faunal composition along with existing knowledge of the pollution-induced responses and trophic ecology of selected organisms (Brinkhurst et al. 1969, Howmiller and Scott 1977, Word 1978, 1981, Word and Striplin 1981).

One promising approach to impact assessment involves a comparison of the distribution of individuals among species to a log-normal distribution (Gray and Mirza 1979, Gray 1980, 1981). The log-normal distribution fits macroinfaunal data from unpolluted areas well and shows a break when data from polluted areas are plotted, reflecting increased numerical dominance by opportunistic species. This technique allows the identification of the species that first increase in abundance during the initial stages of environmental impact.

With the possible exception of the log-normal approach, the most serious shortcomings of the impact assessment techniques mentioned above are a lack of sensitivity to pollution-induced faunal changes and the inability to quantitatively relate species or community distributions to the distributions of environmental variables. The conceptualization of benthic macroinfaunal communities as individual species distributed along gradients of environmental change or disturbance, and the use of multivariate statistical techniques in the definition of communities and their relationships to environmental variables offers promise for overcoming these shortcomings.

The theory that macroinfaunal community structure and composition are, at least in part, the result of the distributions of individual species along spatial and temporal gradients of environmental change or disturbance has recently gained wide acceptance in benthic ecology (Stephenson et al. 1970), and provides the ecological basis for the community approach to quantitative environmental impact assessment. This theory contrasts sharply with the biocoenoses or dominance school formulated by Peterson (1918, 1924) and Sparck (1937) and the "parallel level-bottom communities" concept of Thorson (1957, 1958), which generally regarded benthic communities as discrete entities bounded at adjacent communities by discontinuities in the habitat. Researchers tending towards individualistic or continuum community concepts include Sanders (1956), Lie (1974), Boesch (1971), Johnson (1971), and Comiskey et al. (1983).

Sanders defined macroinfaunal communities in Buzzard's Bay and Long Island Sound, and described both the biological and physical interactions that were important in determining faunal distributions (Sanders 1956, 1958, 1960, 1969).

Lie and co-workers, working in Puget Sound and off the Washington coast, were among the first to apply multivariate gradient analysis techniques such as factor analysis in the delineation of macroinfaunal communities (Lie 1974, Lie and Kelly 1974).

Boesch has applied gradient analysis techniques to the delineation of macroinfaunal communities in the Chesapeake Bay area (Boesch 1971,

1973, 1977a) and has authored an excellent guide to the use of numerical classification techniques in aquatic impact assessment (Boesch 1977b).

In a study of Tomales Bay, California, Johnson (1971) described three macroinfaunal communities distributed along a gradient of sediment type, and related the occurrence of species outside of their typical habitat to environmental stability as indicated by diversity. Johnson (1972) presents a conceptual model that envisions marine benthic communities as temporal mosaics characterized by different levels of succession resulting from localized disturbances.

Rhoads and co-workers have primarily researched the relationships between macroinfaunal community composition and the habitat changes accompanying the feeding and burrowing activities of benthic deposit feeding organisms (Rhoads and Young 1970, 1971, Rhoads 1974, Rhoads et al. 1977).

Levinton (1977) found that the reworking of the substrate by deposit feeders made it a physically unsuitable habitat for suspension feeding organisms and demonstrated physical interference between deposit feeding bivalves by means of laboratory experiments.

Comiskey and co-workers have applied multivariate gradient analysis techniques in the delineation of plankton, macroinfauna, and demersal nekton communities in the Gulf of Mexico (Comiskey et al. 1980, Comiskey and Farmer 1981, Shaw et al. 1982, Kennedy et al. 1983) and used the distributions of macroinfaunal communities and environmental variables to assess the impacts of sewage disposal in Puget Sound (Comiskey et al. 1983). These researchers have also authored guides to the

development of data base management systems for pollution research and monitoring (Brandt et al. 1986) and to the design and implementation of quantitative environmental monitoring programs (Comiskey and Brandt 1982).

Two of the most widespread contaminants impacting marine ecosystems are organic matter, usually discharged in the form of sewage sludge or pulp wastes, and dredged material resulting from the construction and maintenance of shipping lanes and harbors. Dredged material may contain a number of contaminants, with organic matter, trace metals, and petroleum hydrocarbons of frequent concern.

Pearson and Rosenberg (1978) found that macroinfaunal communities exhibit a characteristic successional pattern along a decreasing gradient of organic matter accumulation. In a study of the effects of dredged material disposal in Monterey Bay, California (Oliver et al. 1977), the successional pattern along a decreasing gradient of dredged material disposal was similar in many respects to the successional pattern along a decreasing gradient of organic enrichment.

The successional patterns following both anthropogenic and natural disturbances are very similar because it is the life-history strategies of the opportunistic species that determine the initial patterns rather than a tolerance to the disturbance (Reish 1970, McCall 1979, Gray 1981). If the disturbance is transitory, the opportunistic (i.e., r-selected) species are replaced by species that have less flexible life-history strategies (i.e., K-selected species).

In summary, it must be emphasized that the distributions of benthic macroinfaunal organisms are shaped through a complex interaction of both physical and biological factors. Theories attempting to explain the distribution of these organisms that rely on the influence of any single factor or concept must be regarded as oversimplifications. Quoting from Johnson (1972) ". . . the answer to the question of whether communities are discrete or continuous is yes! Some communities are continuous and some discontinuous depending on the slope of environmental gradients and on the complexity of the community. There is a complete spectrum in nature. . . ."

1.2 The Tampa Harbor Dredged Material Disposal Study

In response to environmental concerns regarding the disposal of dredged materials in the eastern Gulf of Mexico offshore from Tampa Bay, Florida, the U.S. Environmental Protection Agency (EPA) designed a field sampling program and collected the data needed to conduct a quantitative study of the benthic environment at one existing disposal site (Site A), one historical disposal site (Site B), and at two alternative disposal sites (Sites 3 and 4) in May of 1982 (Figure 1.5). Complete macroinfaunal taxonomic analysis was not possible due to budgetary constraints. Therefore, the class Polychaeta, which accounts for more than 60% of the macroinfaunal species in the study area (Bureau of Land Management 1979), was selected for taxonomic identification and enumeration.

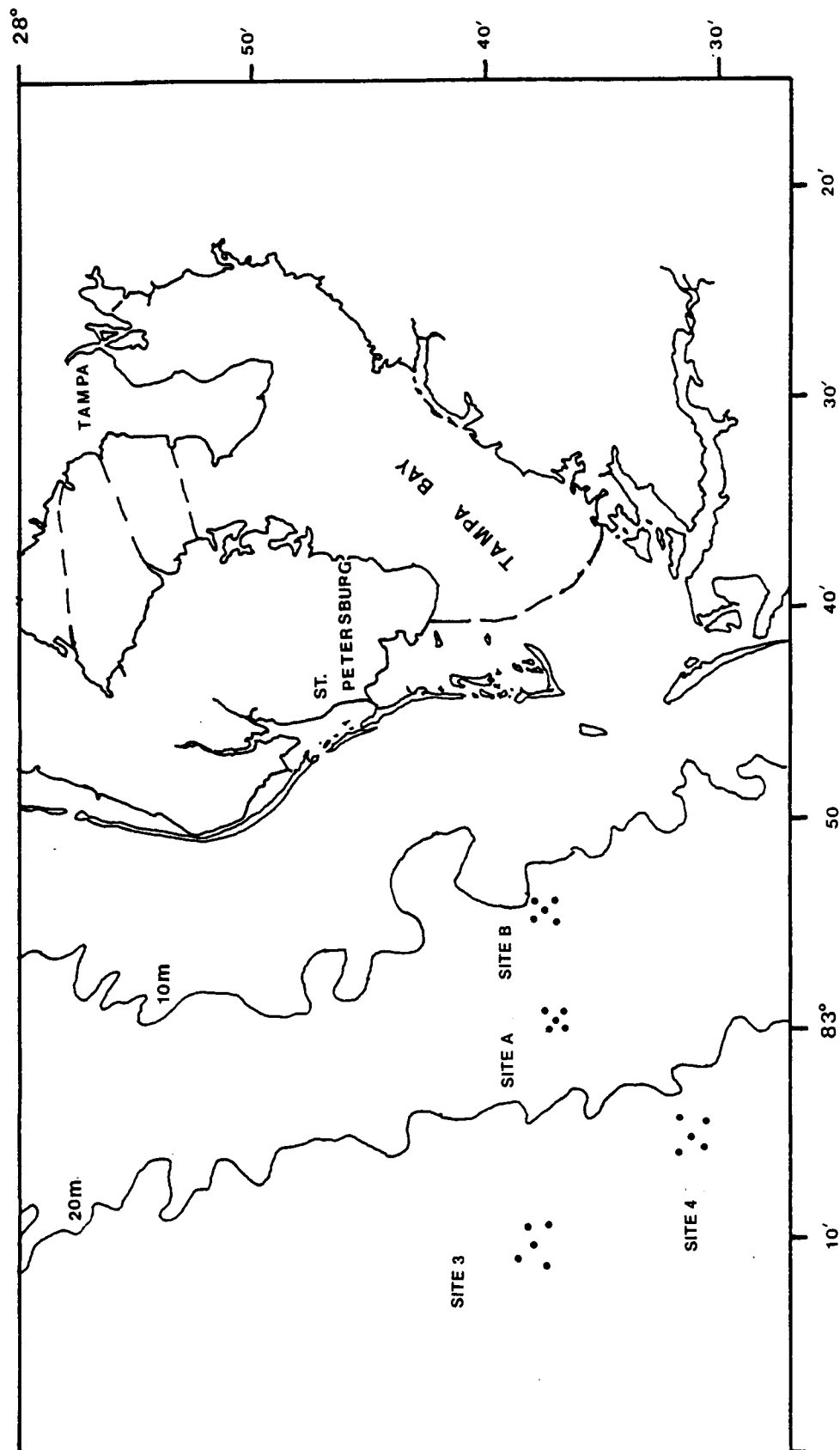


Figure 1.5. Tampa Bay and the adjacent Gulf of Mexico showing the four existing and alternative Offshore Dredged Material Disposal Sites sampled during the May 1982 OSV Antelope cruise.

A total of 1,901,800 cubic yards of dredged material was dumped at Site B between 1969 and 1973, whereas a total of 629,700 cubic yards of material was dumped at Site A during the same time period (U.S. Environmental Protection Agency 1983). No dredged material was dumped at Sites A or B from 1973 to mid-1980. During the period from June 1980 to December 1982, a total of 4,939,600 cubic yards of material was dumped at Site A. No material has been dumped at Sites 3 or 4.

These four disposal sites are between 7 and 20 nautical miles (nm) from Tampa Bay in depths ranging from 11 to 26 m. The EPA contracted Science Applications International Corporation (SAIC) to conduct a quantitative analysis and synthesis of the resulting data.

2.0 METHODS

2.1 Field and Laboratory Procedures

The sampling arrays were configured as squares centered over each of the four sites with sampling stations located at the center and at each of the four corners near the edges of the sites (Figures 2.1 and 2.2). The sampling arrays were designed to characterize the benthic environment at each of the four sites. Therefore, no attempt was made to randomly sample within habitats nor along gradients of environmental change. The sampling design did not include control stations located in habitats and depths similar to the dredge spoil disposal stations. All samples were collected from aboard the EPA Ocean Survey Vessel (OSV) Antelope between May 15 and May 20, 1982.

Single near-bottom water samples were collected at each station using 30 liter (l) Niskin bottles. Temperature was measured on deck as soon as each bottle was brought onboard. Salinity was measured using a Guildline Autosol Model 8400 Salinometer. The temperature of all samples was 20°C at the time of determination. Copenhagen water was used as the primary standard and 20% of the samples were run in duplication.

Five replicate 0.1 m² box core samples were collected at each station. From each box core sample, a surface subsample (2 cm depth) was taken for grain size analysis. The remainder of each box core sample was sieved through a 1.0 mm mesh. All organisms were relaxed with MgCl₂, and preserved with a rose-bengal stained, 10% formalin-seawater mixture. These samples were then shipped to the laboratory

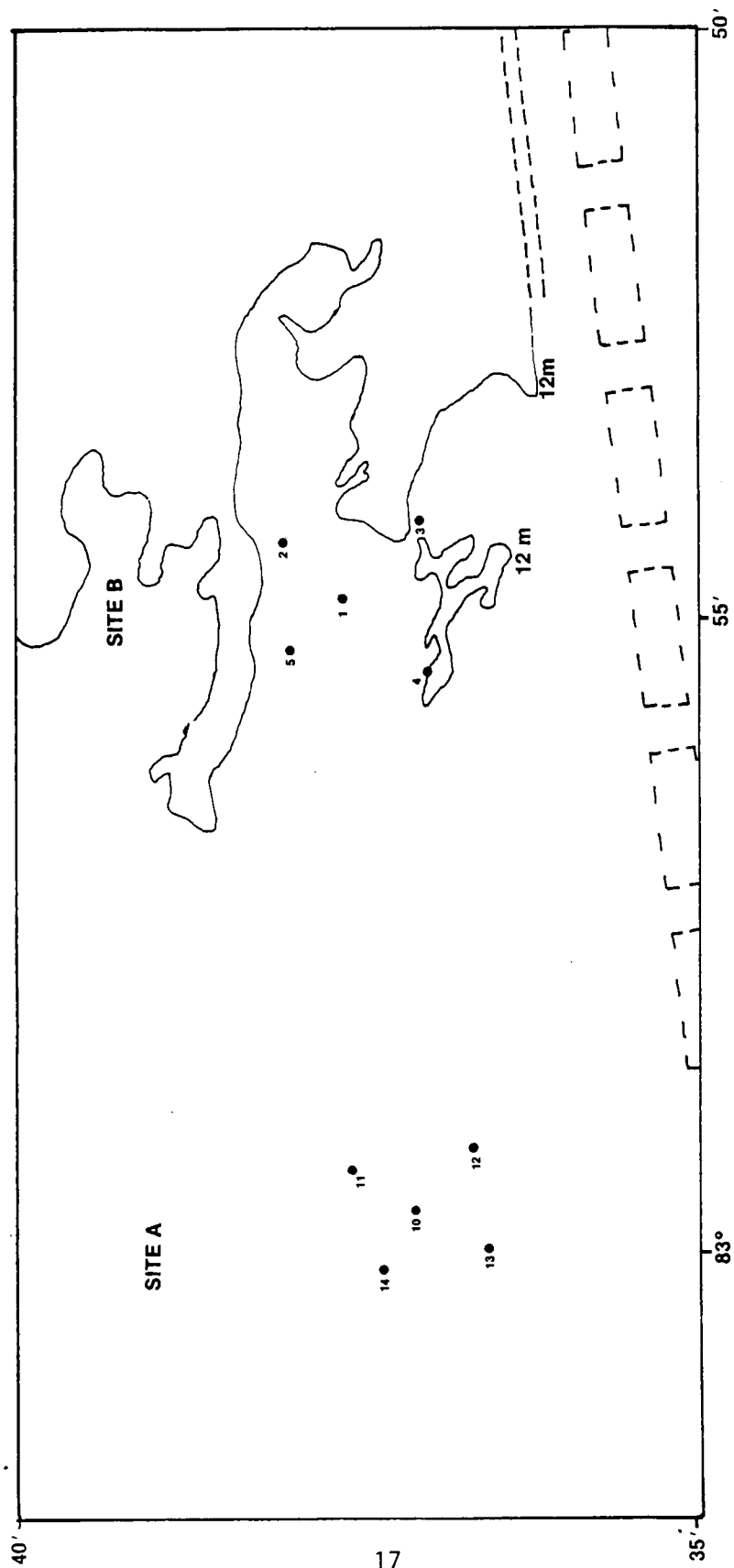


Figure 2.1. Map of the station grid utilized at the existing Offshore Dredged Material Disposal Sites A and B sampled during the May 1982 OSV Antelope cruise.

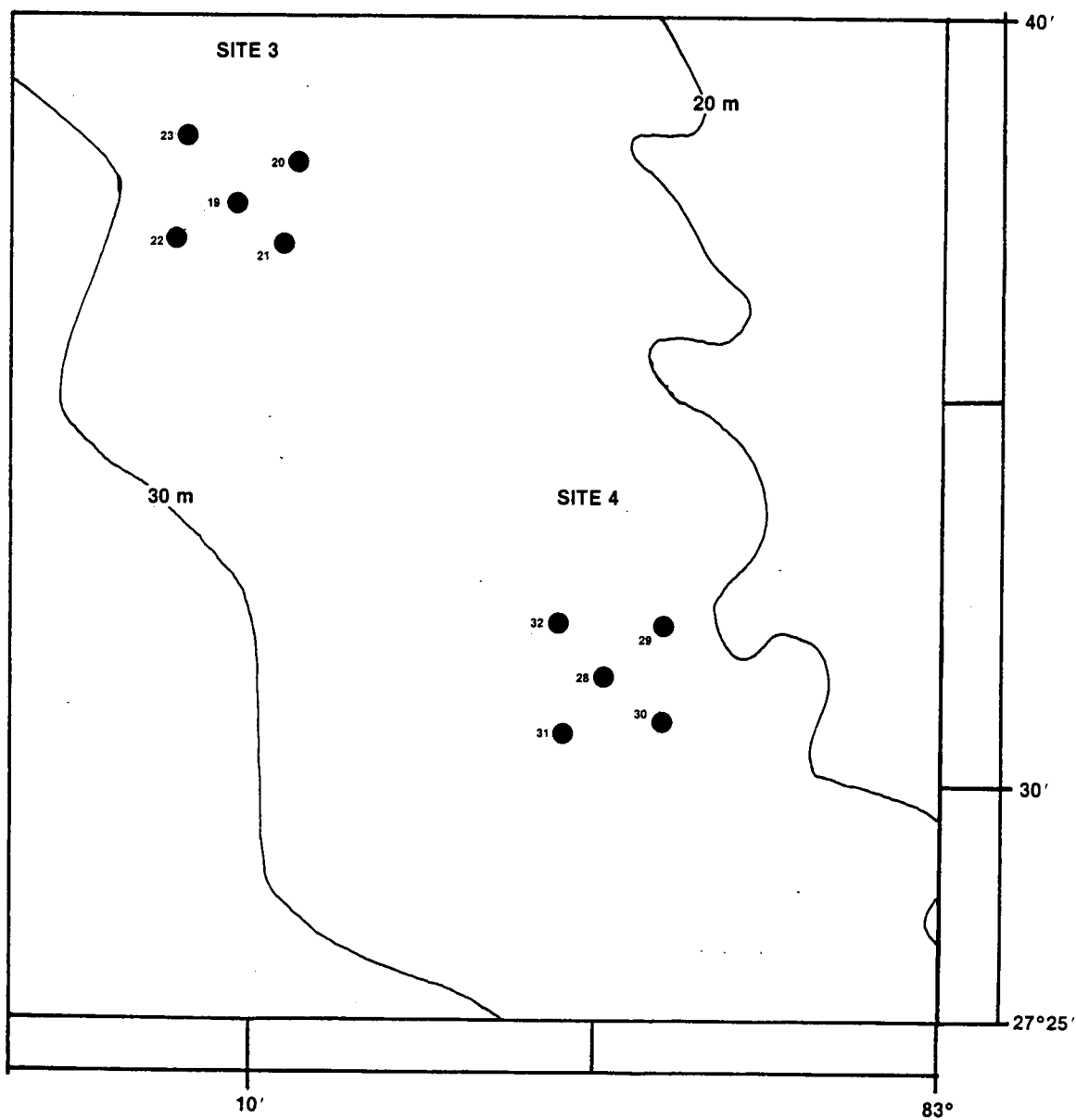


Figure 2.2. Map of the station grid utilized at the proposed Offshore Dredged Material Disposal Sites 3 and 4 sampled during the May 1982 OSV Antelope cruise.

of Barry A. Vittor and Associates in Mobile, Alabama for identification and enumeration of the Polychaeta.

The grain size analysis was conducted at the SAIC Environmental Chemistry Laboratory in La Jolla, California following the procedures outlined in Folk (1974). Approximately 100 g of sediment from each box core sample were washed through a 62 micron sieve to separate the gravel and sand fraction from the silt and clay fraction. The sand and gravel fraction was dry sieved at 1 phi intervals from -1 to +4 phi. Phi is the particle size diameter expressed as the negative logarithm to the base 2 of the diameter in millimeters. The sieve stack was mechanically shaken for 10 minutes, and the sediment passing through the sieves was added to the silt and clay fraction. Samples containing greater than 16% (by weight) silt plus clay were analyzed by the pipette method, with addition of a dispersant (2.5 g of Calgon per liter of deionized water) to prevent flocculation. Deflocculated samples were brought to volume in a 1000-ml cylinder and agitated for 30 seconds. Pipette withdrawals were made at specific times to delineate the silt and clay fractions (> +4 to +10 phi) at 1 phi intervals.

2.2 Data Analysis

2.2.1 Sediment Texture Analysis

Sediment texture data were entered into the data base as cumulative dry weights at phi intervals from -4.0 to +10.0. The grain size scales and categories (Table 2.1), and statistical formulas were taken from Folk (1974). The following sediment statistics were computed:

Table 2.1. Grain size scales and conversions relating U.S. standard sieve mesh numbers, millimeters, microns, phi units, and Wentworth size classes.

U. S. Standard Sieve Mesh #	Millimeters	Microns	Phi (ϕ)	Wentworth Size Class	
			-20		
	4096		-12		
	1024		-10	Boulder (-8 to -12 ϕ)	
Use _____	256		-8		GRAVEL
wire _____	64		-6	Cobble (-6 to -8 ϕ)	
squares _____	16		-4	Pebble (-2 to -6 ϕ)	
5 _____	4		-2		
6 _____	3.36		-1.75		
7 _____	2.83		-1.5	Granule	
8 _____	2.38		-1.25		
10 _____	2.00		-1.0		
12 _____	1.68		-0.75		
14 _____	1.41		-0.5	Very coarse sand	
16 _____	1.19		-0.25		
18 _____	1.00		0.0		
20 _____	0.84		0.25		
25 _____	0.71		0.5	Coarse sand	
30 _____	0.59		0.75		
35 _____ 1/2 _____	0.50	500	1.0		
40 _____	0.42	420	1.25		
45 _____	0.35	350	1.5	Medium sand	SAND
50 _____	0.30	300	1.75		
60 _____ 1/4 _____	0.25	250	2.0		
70 _____	0.210	210	2.25		
80 _____	0.177	177	2.5	Fine sand	
100 _____	0.149	149	2.75		
120 _____ 1/8 _____	0.125	125	3.0		
140 _____	0.105	105	3.25		
170 _____	0.088	88	3.5	Very fine sand	
200 _____	0.074	74	3.75		
230 _____ 1/16 _____	0.0625	62.5	4.0		
270 _____	0.053	53	4.25		
325 _____	0.044	44	4.5	Coarse silt	
	0.037	37	4.75		
_____ 1/32 _____	0.031	31	5.0		
Analyzed _____ 1/64 _____	0.0156	15.6	6.0	Medium silt	MUD
_____ 1/128 _____	0.0078	7.8	7.0	Fine silt	
by _____ 1/256 _____	0.0039	3.9	8.0	Very fine silt	
	0.0020	2.0	9.0		
Pipette _____	0.00098	0.98	10.0	Clay	
	0.00049	0.49	11.0		
or _____	0.00024	0.24	12.0		
	0.00012	0.12	13.0		
Hydrometer _____	0.00006	0.06	14.0		

Source: Folk, R.L. 1974. Petrology of sedimentary rocks. Hemphill Press.

1. median diameter;
2. median phi;
3. graphic mean phi (Folk mean);
4. sorting coefficient (inclusive graphic standard deviation);
5. inclusive graphic skewness;
6. graphic kurtosis (a measure of the relative flatness or peakedness of a distribution as compared to a normal distribution);
7. percent gravel (< -1.0 phi);
8. percent sand (> -1.0 to 4.0 phi);
9. percent silt (> 4.0 to 8.0 phi);
10. percent clay (> 8.0 phi).

The sorting classifications used were:

- < 0.35 phi - very well sorted;
- 0.35 to 0.50 phi - well sorted;
- 0.50 to 0.71 phi - moderately well sorted;
- 0.71 to 1.00 phi - moderately sorted;
- 1.00 to 2.00 phi - poorly sorted;
- 2.00 to 4.00 phi - very poorly sorted;
- > 4.00 phi - extremely poorly sorted.

The skewness classifications used were:

- 1.00 to 0.30 - strongly fine skewed;
- 0.30 to 0.10 - fine skewed;
- 0.10 to -0.10 - nearly symmetrical to symmetrical;
- -0.10 to -0.30 - coarse skewed;
- -0.30 to -1.00 - strongly coarse skewed.

The kurtosis classifications used were:

- <0.67 - very platykurtic;
- 0.67 to 0.90 - platykurtic;
- 0.90 to 1.11 - mesokurtic;
- 1.11 to 1.50 - leptokurtic;
- 1.50 to 3.00 - very leptokurtic;
- >3.00 - extremely leptokurtic.

2.2.2 Community-Habitat Relationships

A hierarchical analytic approach developed by Charles Comiskey and co-workers (Comiskey and Brandt 1982, Brandt et al. 1986) was used that integrated data base management techniques, mathematical indices, and univariate, bivariate, and multivariate statistical techniques to:

1. characterize the strongest ecological trends;
2. identify the most ecologically meaningful taxa for inclusion in detailed community characterization analyses;
3. quantitatively define the relationships between the spatial patterns in the distribution of environmental variables and the spatial patterns in the structure and distribution of polychaete communities.

The following analytic steps were employed:

1. compute species diversity, evenness, species richness, total number of taxa in each sample, total number of individuals in each sample, and the relative percent composition;
2. conduct Two-Way Indicator Species Analyses (TWINSpan) on the taxa selected from the relative composition analysis in order

- to select the most ecologically meaningful taxa for inclusion in detailed community characterization analyses;
3. compute basic descriptive statistics for replicated data for the community parameters and environmental variables;
 4. test assumptions of parametric analysis and transform data if necessary;
 5. compute the abiotic and biotic correlation coefficients;
 6. use TWINSpan, Q- and R- mode cluster analysis, reciprocal averaging ordination analysis, and regression analysis to define the major spatial trends in the distribution of the polychaete communities, identify homogeneous subregions of the study area, and quantitatively relate major trends in polychaete community distribution to trends in environmental variables.

Species diversity was calculated using the Shannon-Wiener information statistic (Shannon and Weaver 1963)

$$H' = \sum_{i=1}^N P_i \ln P_i$$

where P_i is the fraction of total individuals belonging to the i th taxa and N is the total number of taxa collected in the sample. The formula for evenness was taken from Pielou (1966)

$$J = H' / \ln S$$

where S is the number of taxa in the pooled sample. The formula for species richness was taken from Margalef (1951)

$$D = S - 1 / \ln N$$

where S is the total number of taxa and N is the number of individuals.

The basic descriptive statistics that were calculated in this study included tests of parametric analyses, which identified the need for data transformation. These calculations were conducted within the context of a one-way factorial ANOVA. Within this context, tests for normality and heteroscedasticity were conducted. The ANOVA design was a one-way fixed effects model with equal number of observations (5 replicates) in each cell (or station). For this analysis, the center station at each of the four sites was chosen as being representative of the range of conditions found over the study area. The main purpose for this ANOVA approach was not to determine significant differences in station means, but to attribute the variance in each particular variable of interest to among- and within-station effects in order to attain the best estimate of the error mean square. The error mean square, grand means, and error degrees of freedom were then used in the applications of basic descriptive statistics discussed below.

The W test developed by Shapiro, Wilk and Chen (1968) was used to test for normality. Bartlett's B test (Bartlett 1937) and Cochran's C test (Cochran 1941) were used to test homogeneity of variances.

The Two-Way Indication Species Analysis (TWINSpan) program (Hill 1979a) first dichotomously classifies samples using three different ordination routines at each dichotomization, and then classifies taxa

within the context of the sample classification through a similar series of ordination routines. In order to link the Q- and R-mode orderings, fidelities of the taxa at each of the previously derived sample groups are used as variables. This direct relationship between the sample (Q-mode) and taxa (R-mode) orderings produces an ecologically meaningful display of the data matrix. The ordering of the taxa and samples allows the display of the ecological gradients in the distributions of communities and habitats. This display is then used to identify the taxa most characteristic of particular habitats.

The data input to TWINSpan were the pooled relative compositions for the selected taxa or families. The numbers from 1 to 5 in the TWINSpan displays are the classes of relative composition calculated from the input data. The classes were: 1 = 0-2%; 2 = 2-5%; 3 = 5-10%; 4 = 10-15%; and, 5 = 15-100%.

Cluster analysis provides dendrograms of variable (R-mode) and sample (Q-mode) groupings, with the groupings indicating the most closely associated variables or samples. Sample (Q-mode) and taxa (R-mode) clusterings were performed using an hierarchical, agglomerative, unweighted pair-group method with Czekanowski's coefficient as the distance measure. Program options were executed to standardize values of each variable on a zero to one-hundred (0-100) scale, so that the numerically dominant species were no more important than the less abundant species. Czekanowski's coefficient S_{jk} has the following form:

$$S_{jk} = \frac{2 \sum_{i=1}^p \min(x_{ij}, x_{ik})}{\sum_{i=1}^p (x_{ij} + x_{ik})}$$

where S_{jk} is the similarity index (ranging from 0 to 1),

X_{ij} is the density of taxa i in sample j ,

X_{ik} is the density of taxa i in sample k , and

N is the number of taxa.

All double zero entries were excluded from the calculation.

Reciprocal averaging ordination analysis yields a spatial display of taxa and sample relationships expressed on geometric axes, thereby reducing the complex multidimensionality of a large taxa by sample data matrix to the dimensionality of two or three ordination axes. An advantage of reciprocal averaging ordination analysis is that it performs simultaneous taxa (R-mode) and sample (Q-mode) ordinations, thereby providing a means of visually relating species trends to sample trends in space and time. The graphic display of species trends in sample space and sample trends in species space yields relative locations on the ordination axes that can be interpreted as ecological gradients or ecological distances (Whittaker 1967, Whittaker and Gauch 1973, Gauch 1977). The reciprocal averaging ordination routine from the Detrended Correspondence Analysis (DECORANA) program (Hill 1979b) was used.

Multiple regression analysis was used to relate the reciprocal averaging ordination scores (dependent variables) to environmental (predictor) variables. A stepwise multiple regression procedure in the Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975)

was used to determine the amount of variance in the scores that could be explained by the environmental variables.

3.0 RESULTS

3.1 Overview of the Study Area

The physical oceanography of the study region is dominated by the interaction between the Mississippi River discharge and the Gulf Loop Current, with local freshwater runoff generally having a minor influence. The extent of the Loop Current influence is dependent upon the volume of water entering the Gulf through the Yucatan Straits and the discharge from the Mississippi River. The southerly flow of the Loop Current intrudes during the summer and fall onto the west Florida shelf, transporting both tropical larvae from Caribbean seas and pollutants emanating from the Mississippi River discharge (State University System Institute of Oceanography 1975, Bureau of Land Management 1979). Near-bottom current velocities generally range up to 0.7 knots (kn), but may increase to 3 to 4 kn during severe storms or hurricanes (U.S. Environmental Protection Agency 1983). Near-bottom salinities are generally marine.

The shallow continental shelf offshore from Tampa Bay, Florida consists of a drowned karst topography that is characterized by a gently rolling bottom covered with a thin layer of sandy and gravelly unconsolidated sediments, with intermittent limestone outcroppings, sinkholes, and fissures (Bureau of Land Management 1977). These sediments are inhabited by a very diverse macroinfaunal community that includes species characteristic of temperate, sub-tropical, and tropical environments. The outcrops provide hard substrata for the attachment of corals, algae and associated epibenthic organisms.

3.2 Characterization of the Benthic Environment

3.2.1 Hydrographic, Sediment Grain Size, and Community Characteristics

All of the stations were located on the near-shore continental shelf in depths ranging from 11.6 to 25.9 m (Table 3.1). Although the near-bottom salinities were euhaline (30 - 40 ppt) and generally uniform, the shallower stations were consistently less saline than the deeper stations.

The sediments were primarily characterized by moderately to poorly sorted medium to fine sands, with the silt fraction generally increasing with increasing depth. Grain size distributions at most of the stations were nearly symmetrical to symmetrical and mesokurtic to leptokurtic. These sandy sediments were interrupted by patches of gravel, and the gravelly sediments tended to be more poorly sorted. The only appreciable clay fractions recorded were the result of dredged material disposal at Station A-10. Due primarily to the patchy distribution of gravel and the presence of dredged material, substantial between-station sediment heterogeneity was evident. In general, Stations B-02, B-03, and 4-30 were the coarsest-textured, whereas Stations 3-19, 4-28, and 4-29 were the finest-textured. Station A-10 was relatively fine-textured and very poorly sorted due to the presence of dredged material.

The species diversity and density of the polychaetes in the study area generally decreased with increasing depth, increasing percent silt and clay, and increasing sediment homogeneity. Most of the values for H' and J fell in the 2.0 to 3.0 and 0.80 to 0.95 ranges, respectively. The highest species diversities were generally found in the poorly

Table 3.1. Station means for environmental and community parameters measured in 100 samples collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

Station	Depth (m)	Salinity (ppt)	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Mean Phi	Sorting Coeff. (phi)	Skewness	Kurtosis	Total Taxa	Total Indiv.	H'	J	Species Richness
A-10	11.9	36.18	11.76	61.12	22.30	4.82	2.48	2.37	0.04	1.32	4.2	6.4	1.34	0.95	3.59
A-11	12.5	36.12	0.38	99.08	0.54	0.00	1.86	0.77	-0.07	0.93	14.8	23.8	2.52	0.95	14.48
A-12	12.8	36.17	3.72	94.90	1.38	0.00	2.06	1.11	-0.20	1.16	16.4	27.2	2.62	0.94	16.09
A-13	14.9	36.22	5.20	93.68	1.12	0.00	1.63	1.28	-0.11	0.98	29.2	92.4	2.61	0.79	28.96
A-14	13.1	36.10	4.82	92.40	2.78	0.00	1.45	1.16	0.04	1.33	28.4	80.8	2.83	0.87	28.16
B-01	11.6	35.98	0.82	98.04	1.14	0.00	2.53	0.87	-0.13	1.99	14.2	70.0	2.09	0.81	14.11
B-02	12.5	35.74	35.48	63.56	0.96	0.00	-0.34	1.70	0.03	0.94	34.4	132.6	2.88	0.83	35.18
B-03	11.6	35.69	31.34	67.88	0.58	0.00	-0.37	1.57	0.01	1.03	45.2	314.0	2.91	0.77	43.82
B-04	13.1	35.83	6.80	92.16	1.04	0.00	2.01	0.99	-0.01	1.33	18.8	42.0	2.50	0.89	18.49
B-05	13.4	35.80	8.02	91.54	0.44	0.00	1.65	0.99	-0.06	1.13	20.0	61.6	2.53	0.88	19.72
3-19	24.4	36.50	0.30	81.64	17.78	0.28	3.20	0.98	-0.07	1.06	8.0	26.0	1.36	0.68	7.67
3-20	24.7	36.51	3.28	91.52	5.20	0.00	2.03	1.00	-0.06	1.19	26.8	62.0	2.90	0.89	26.55
3-21	24.4	36.50	0.36	91.14	8.50	0.00	2.69	0.94	0.06	1.14	17.4	34.6	2.52	0.88	17.12
3-22	25.6	36.51	0.18	95.72	4.10	0.00	2.50	0.84	0.01	1.23	23.6	49.2	2.88	0.91	23.34
3-23	25.9	36.52	0.44	91.60	7.90	0.06	1.99	0.92	-0.02	1.09	15.6	33.4	2.34	0.89	15.30
4-28	23.5	36.45	0.14	86.50	13.36	0.00	3.04	0.95	-0.03	1.04	15.4	41.8	2.27	0.83	15.13
4-29	21.3	36.42	0.22	91.26	8.52	0.00	2.97	0.91	-0.04	1.08	12.8	29.2	2.29	0.90	12.50
4-30	22.3	36.43	32.66	66.68	0.66	0.00	-0.17	1.51	-0.06	0.95	29.4	61.2	3.03	0.92	29.14
4-31	21.6	36.48	1.60	96.28	2.12	0.00	1.97	0.86	0.02	1.18	41.0	149.0	3.04	0.83	40.79
4-32	21.9	36.47	0.20	91.92	7.88	0.00	2.82	0.89	0.12	1.20	18.2	45.8	2.47	0.86	17.93

sorted sediments with the highest gravel percentages (i.e., in the most heterogeneous habitats). Stations B-02, B-03, 4-30, and 4-31 were generally the most diverse, speciose, and productive in terms of number of individuals, whereas Stations A-10 and 3-19 were generally the least diverse, speciose, and productive.

3.2.2 Correlation Analysis of Sediment and Hydrographic Variables

The correlation analysis yielded several values stronger than 0.80 (Table 3.2), with depth and salinity showing the strongest relationship ($r = +0.89$). Depth and salinity were positively related to mean phi, median phi and percent silt, and negatively related to percent gravel and sorting coefficient; indicating that salinity and fineness of sediment texture increased with increasing depth, and that the poorly sorted, gravelly sediments tended to be located in the shallower depths. Percent sand was positively related to mean and median phi, and negatively related to percent gravel.

Percent gravel was negatively related to median and mean phi, and positively related to sorting coefficient, again indicating that the coarser-textured sediments tended to be more poorly sorted. The other relatively strong relationships involving percent gravel were all negative, including those with depth, salinity and percent silt.

Sorting coefficient was positively related to percent gravel and percent clay and negatively related to percent sand, mean phi, median phi, depth, and salinity, indicating that the sandiest samples tended to be the best sorted. The positive relationship with percent clay was primarily due to the samples from Station A-10. These samples contained

Table 3.2. Pearson product-moment correlation coefficients between the environmental variables measured in 100 samples collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Mean Phi	Sorting Coeff.	Skewness	Kurtosis	Median Phi	Salinity	Depth
Percent Gravel	1.0000	-0.7605*	-0.3512*	0.1780	-0.7786*	0.8223*	0.0658	-0.2834	-0.8062*	-0.4911*	-0.4176*
Percent Sand	-0.7605*	1.0000	-0.1663	-0.5285*	0.5667*	-0.8641*	-0.1393	0.2455	0.6137*	0.2502	0.1863
Percent Silt	-0.3512*	-0.1663	1.0000	0.4509*	0.4785*	0.1277	0.2373	0.0728	0.4866*	0.5428*	0.4605*
Percent Clay	0.1780	-0.5285*	0.4509*	1.0000	0.1112	0.5904*	0.1225	0.0728	0.1238	-0.0019	-0.1830
Mean Phi	-0.7786*	0.5667*	0.4785*	0.1112	1.0000	-0.4728*	-0.0114	0.2001	0.8659*	0.4208*	0.2654
Sorting Coefficient	0.8223*	-0.8641*	0.1277	0.5904*	-0.4728*	1.0000	0.0924	-0.2598	-0.4913*	-0.3069*	-0.3461*
Skewness	0.0658	-0.1393	0.2373	0.1225	-0.0114	0.0924	1.0000	0.0746	-0.0529	0.0689	0.1448
Kurtosis	-0.2834	0.2455	0.0728	0.0728	0.2001	-0.2598	0.0746	1.0000	0.2299	-0.0309	-0.0989
Median Phi	-0.8062*	0.6137*	0.4866*	0.1238	0.8659*	-0.4913*	-0.0529	0.2299	1.0000	0.4578*	0.2835
Salinity	-0.4911*	0.2502	0.5428*	-0.0019	0.4208*	-0.3069*	0.0689	-0.0309	0.4578*	1.0000	0.8847*
Depth	-0.4176*	0.1863	0.4605*	-0.1830	0.2654	-0.3461*	0.1448	-0.0989	0.2835	0.8847*	1.0000

*Indicates correlations greater than 0.3.

the only appreciable clay fractions and were among the most poorly sorted.

In addition to being positively related to sorting coefficient, percent clay was negatively related to percent sand and positively related to percent silt. Skewness and kurtosis were not strongly correlated with any variable. Percent silt, in addition to being positively related to mean phi and median phi, was positively related to salinity, depth, and percent clay, and showed a modest negative relationship to percent gravel.

3.2.3 Cluster Analysis of Sediment Texture Variables

The cluster analysis results yielded five major sample groups and two outliers at the level of association indicated in Figure 3.1. The degree of within-station heterogeneity was substantial, and, in most cases, the five replicates from a single station did not occur in the same cluster group. Groups II and III represented the very sandy, moderately coarse habitats, and were primarily comprised of samples from Stations A-13, A-14, B-02, B-03, and 4-30. Group VII included the coarsest, most poorly sorted samples, which were collected at Stations B-02, B-03, and 4-30.

Virtually all of the finer-textured samples were included in Group VI, which was composed of three distinct subgroups. Group VIA was the coarsest-textured of the subgroups, and was characterized by high percent sand and low percent silt. This group primarily included samples from Stations A-11, A-12, B-05, 3-20, and 4-31. Group VIB included the finest-textured samples from the most homogeneous stations.

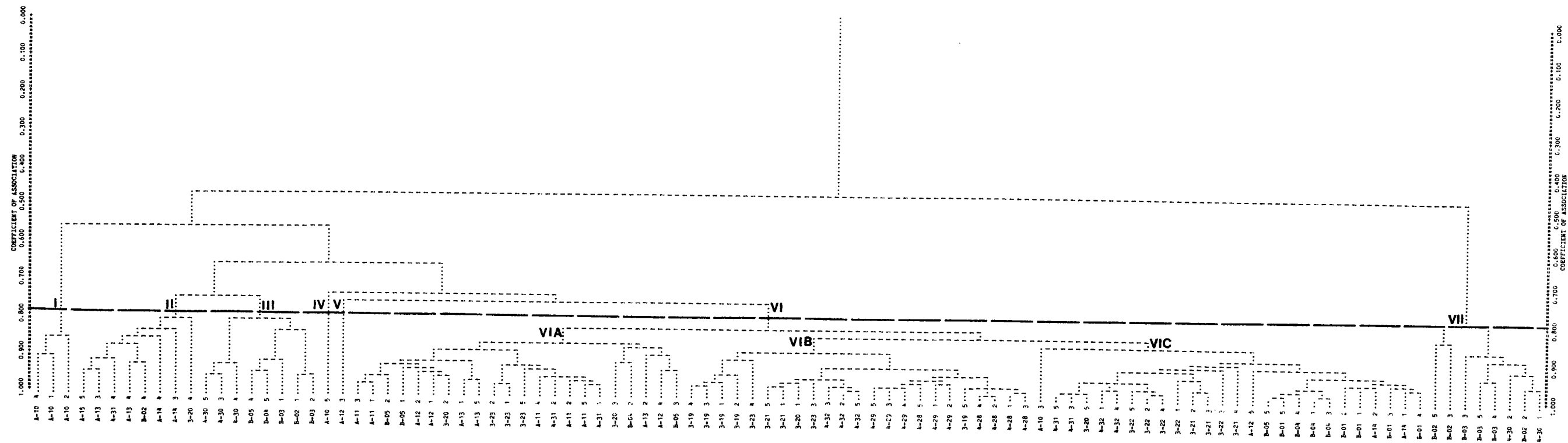


Figure 3.1. Sample dendrogram resulting from Q-mode cluster analysis of sediment texture and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

All five replicates from Stations 3-19, 4-28, and 4-29 were included in this subgroup, along with several samples from Stations 3-21, 3-23, and 4-32. The samples in Group VIC were intermediate in texture as compared to those in Groups VIA and VIB, and primarily included samples from Stations 3-21, 3-22, B-01, B-04, A-14, and 4-30. The only sample from Station A-10 that did not contain any clay was an outlier in Group VIC.

Replicates 1, 2, and 4 from Station A-10, which was located at the center of the existing dumpsite, formed Group I, and replicate 5 formed the outlying Group IV. These were the only samples with greater than 1% clay, a result of the presence of dredged material. The Group I samples were very poorly sorted, and contained relatively high proportions of gravel and silt, and the highest clay fractions recorded. Of the samples collected at Station A-10, replicate 5 was the finest-textured and best sorted, and was characterized by fine sands with low silt and gravel percentages.

3.3 Polychaete Community Analysis

3.3.1 Relative Composition and Abundance

The annelid component of the 100 samples collected at the 20 stations yielded 295 lowest practical identification level (LPIL) taxa and 6,915 individuals (Table 3.3). With the exception of the archiannelid Polygordius spp. and the class Oligochaeta, all of these taxa are members of the class Polychaeta. For all samples combined, the composition was very evenly distributed, with only three taxa

Table 3.3. Overall relative composition of polychaete taxa in samples collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

Taxon Name	Percent Composition	Mean Percent Composition	Cumulative Percent Composition	Occurrence	Cumulative Abundance	Density (#/M**2)	Index of Dispersion
<i>Prionospio cristata</i>	8.704	8.704	7.954	0.760	550.	55.00	11.55
<i>Eunice vittata</i>	2.091	10.796	6.985	0.170	1033.	48.30	97.48
Sabellidae	6.438	17.234	5.061	0.770	1383.	35.00	5.58
Oligochaeta	1.923	19.157	4.107	0.290	1667.	28.40	25.19
<i>Aonides mayaguezensis</i>	1.207	20.364	3.847	0.200	1933.	26.60	31.08
<i>Aglaophamus verrilli</i>	7.948	28.312	3.731	0.410	2191.	25.80	8.31
<i>Onuphis</i> sp. H	1.327	29.639	3.124	0.130	2407.	21.60	185.01
<i>Mediomastus californiensis</i>	2.541	32.181	3.008	0.430	2615.	20.80	11.50
<i>Polygordius</i> spp.	1.893	34.074	2.936	0.310	2818.	20.30	42.15
<i>Goniadides caroliniae</i>	1.176	35.250	2.401	0.250	2984.	16.60	10.43
<i>Paraprionospio pinnata</i>	5.512	40.762	2.285	0.570	3142.	15.80	2.76
<i>Plakosyllis quadrioculata</i>	0.531	41.292	2.111	0.120	3288.	14.60	34.70
<i>Prionospio cirrifera</i>	0.906	42.198	1.620	0.190	3400.	11.20	11.15
<i>Myriocheilus oculata</i>	1.985	44.183	1.547	0.510	3507.	10.70	2.04
<i>Owenia fusiformis</i>	2.407	46.590	1.504	0.520	3611.	10.40	1.59
<i>Dentatisyllis caroliniae</i>	0.568	47.158	1.432	0.150	3710.	9.90	12.31
Malcanidae	1.786	48.944	1.345	0.430	3803.	9.30	3.07
<i>Onuphis nebulosa</i>	2.357	51.301	1.330	0.340	3895.	9.20	3.70
<i>Nephtys picta</i>	2.614	53.915	1.316	0.400	3986.	9.10	2.62
<i>Lumbrineris</i> sp. D	1.359	55.274	1.302	0.190	4076.	9.00	13.75
<i>Onuphis</i>	1.716	56.990	1.244	0.220	4162.	8.60	12.07
<i>Spiophanes</i> cf. <i>berkeleyorum</i>	2.045	59.035	1.229	0.320	4247.	8.50	3.53
<i>Cirrophorus</i>	0.904	59.939	1.171	0.340	4328.	8.10	4.56
<i>Chone americana</i>	1.259	61.198	1.128	0.320	4406.	7.80	3.93
<i>Lumbrineris</i>	0.727	61.925	1.099	0.250	4482.	7.60	15.93
<i>Aricidea</i> sp. C	0.843	62.768	0.940	0.250	4547.	6.50	9.09
<i>Nematoneis unicornis</i>	0.806	63.575	0.882	0.170	4608.	6.10	11.82
<i>Lumbrineris latreilli</i>	0.640	64.215	0.868	0.220	4668.	6.00	3.80
<i>Megalomma</i> sp. A	1.192	65.406	0.839	0.280	4726.	5.80	2.79
<i>Magelona pattibonae</i>	0.735	66.141	0.839	0.220	4784.	5.80	3.28
<i>Parapionosyllis longicirrata</i>	0.258	66.399	0.810	0.090	4840.	5.60	9.50
<i>Exogone laurai</i>	0.393	66.793	0.810	0.170	4896.	5.60	4.63
<i>Hemipodus roseus</i>	0.197	66.990	0.781	0.060	4950.	5.40	11.20
<i>Terebellides stroemi</i>	1.079	68.069	0.766	0.270	5003.	5.30	2.57
Terebellidae	0.838	68.907	0.738	0.300	5054.	5.10	2.83
Ampharetidae	0.859	69.766	0.665	0.270	5100.	4.60	2.08
<i>Spiophanes bombyx</i>	1.194	70.961	0.651	0.340	5145.	4.50	1.32
<i>Nephtys simoni</i>	0.633	71.594	0.622	0.180	5188.	4.30	3.02
Onuphidae	1.108	72.701	0.622	0.200	5231.	4.30	3.77
Spionidae	0.999	73.700	0.607	0.200	5273.	4.20	3.18
<i>Palaenotus heteroseta</i>	0.166	73.866	0.564	0.110	5312.	3.90	6.16
<i>Lyposyllis</i> sp. A	0.171	74.037	0.521	0.090	5348.	3.60	8.11
<i>Glycera</i> sp. D	0.656	74.693	0.506	0.100	5383.	3.50	7.93
<i>Mastobranchus</i> sp. A	0.480	75.173	0.506	0.200	5418.	3.50	3.66
<i>Spio pattibonae</i>	0.832	76.006	0.492	0.210	5452.	3.40	1.86
<i>Exogone dispar</i>	0.329	76.335	0.463	0.150	5484.	3.20	2.77
<i>Ancistrosyllis hartmanae</i>	0.155	76.490	0.448	0.110	5515.	3.10	4.35
<i>Prionospio</i>	0.560	77.050	0.419	0.110	5544.	2.90	3.99
Nereidae	0.661	77.711	0.376	0.190	5570.	2.60	1.60
<i>Fabriciella</i> sp. A	0.355	78.066	0.362	0.130	5595.	2.50	3.18
<i>Magelona polydentata</i>	0.831	78.897	0.347	0.100	5619.	2.40	5.99
<i>Synelmis albi</i>	0.471	79.368	0.347	0.150	5643.	2.40	2.03

Table 3.3 (Continued)

Taxon Name	Mean Percent Composition	Cumulative Percent Composition	Pooled Percent Composition	Occurrence	Cumulative Abundance	Mean Density (#/M**2)	Index of Dispersion
<i>Arctidea</i> sp. Q	0.240	79.608	0.347	0.120	5667.	2.40	3.12
<i>Armandia maculata</i>	0.481	80.089	0.347	0.130	5691.	2.40	4.72
<i>Isolda pulchella</i>	0.469	80.558	0.333	0.160	5714.	2.30	1.48
<i>Lumbrineris verrilli</i>	0.483	81.040	0.318	0.100	5736.	2.20	2.99
Serpulidae	0.254	81.294	0.318	0.100	5758.	2.20	3.63
<i>Ceratonereis longicirrata</i>	0.237	81.531	0.318	0.120	5780.	2.20	2.35
<i>Ehlersia ferrugina</i>	0.082	81.613	0.304	0.050	5801.	2.10	4.93
<i>Amphicteis scaphobranchiata</i>	0.395	82.008	0.304	0.130	5822.	2.10	3.01
<i>Palaenotus</i> sp. A	0.208	82.216	0.304	0.110	5843.	2.10	3.49
Acrociirridae	0.085	82.301	0.289	0.070	5863.	2.00	4.95
Chone	0.665	82.966	0.289	0.100	5883.	2.00	3.43
Magelona	0.540	83.506	0.289	0.110	5903.	2.00	2.12
<i>Poecilochaetus</i> sp. A	0.079	83.585	0.275	0.030	5922.	1.90	8.79
<i>Lumbrineris ernesti</i>	0.512	84.097	0.275	0.140	5941.	1.90	1.46
Sigalionidae B	0.046	84.143	0.260	0.040	5959.	1.80	7.11
<i>Arctidea verrilli</i>	0.353	84.495	0.260	0.010	5977.	1.80	18.00
<i>Podarke obscura</i>	0.081	84.577	0.260	0.060	5995.	1.80	4.98
<i>Ampharete</i> sp. A	0.429	85.006	0.246	0.130	6012.	1.70	1.43
<i>Harmothoe spinifera</i>	0.206	85.212	0.246	0.090	6029.	1.70	2.15
<i>Parapionosyllis</i> sp. A	0.094	85.306	0.246	0.080	6046.	1.70	3.33
<i>Glycera dibranchiata</i>	0.371	85.676	0.231	0.140	6062.	1.60	1.10
Terebellidae B	0.202	85.879	0.202	0.080	6076.	1.40	2.17
<i>Arctidea</i> sp. L	0.275	86.154	0.202	0.080	6090.	1.40	2.31
<i>Arctidea</i>	0.189	86.342	0.188	0.100	6103.	1.30	1.50
Phyllodoce	0.351	86.693	0.188	0.130	6116.	1.30	0.88
<i>Glycera americana</i>	0.339	87.032	0.174	0.110	6128.	1.20	1.06
<i>Diopatra</i> sp. B	0.240	87.272	0.174	0.080	6140.	1.20	1.73
<i>Leiocapitella</i> sp. B	0.355	87.628	0.174	0.110	6152.	1.20	1.06
Eunice	0.048	87.676	0.159	0.040	6163.	1.10	6.04
<i>Arctidea</i> cf. <i>finitima</i>	0.098	87.773	0.159	0.040	6174.	1.10	4.20
<i>Gypris brevipalpa</i>	0.088	87.862	0.159	0.060	6185.	1.10	2.37
<i>Axiobella mucosa</i>	0.138	88.000	0.159	0.090	6196.	1.10	1.27
<i>Nereis riisei</i>	0.090	88.090	0.159	0.040	6207.	1.10	3.84
<i>Glycera</i> sp. F	0.151	88.241	0.159	0.100	6218.	1.10	1.08
<i>Arctidea</i> sp. E	0.079	88.319	0.159	0.030	6229.	1.10	5.12
<i>Eulalia</i>	0.062	88.382	0.159	0.050	6240.	1.10	3.10
<i>Tharyx</i> cf. <i>annulosus</i>	0.461	88.843	0.145	0.100	6250.	1.00	0.91
Paraonidae	0.207	89.050	0.145	0.090	6260.	1.00	1.11
<i>Hydroides</i> sp. B	0.046	89.096	0.145	0.010	6270.	1.00	10.00
Cirratulidae	0.159	89.255	0.145	0.080	6280.	1.00	1.31
Phyllodoceidae	0.092	89.347	0.145	0.080	6290.	1.00	1.52
<i>Therochaeta</i> sp. A	0.135	89.482	0.145	0.050	6300.	1.00	2.73
<i>Schistomeringos pectinata</i>	0.078	89.560	0.145	0.090	6310.	1.00	1.11
<i>Opisthodonta</i> sp. B	0.070	89.630	0.130	0.030	6319.	0.90	5.63
Nephtyidae	0.156	89.786	0.130	0.080	6328.	0.90	1.14
<i>Exogone atlantica</i>	0.082	89.868	0.130	0.050	6337.	0.90	2.27
<i>Amphictene</i> sp. A	0.321	90.189	0.130	0.060	6346.	0.90	1.59
<i>Arctidea</i> sp. B	0.133	90.323	0.130	0.070	6355.	0.90	1.59
<i>Typosyllis</i>	0.024	90.346	0.130	0.030	6364.	0.90	4.51
<i>Protodorrillaea bifida</i>	0.091	90.437	0.130	0.050	6373.	0.90	2.49
<i>Typosyllis</i> sp. B	0.077	90.515	0.116	0.040	6381.	0.80	2.19
<i>Poecilochaetus</i>	0.023	90.538	0.116	0.020	6389.	0.80	3.96

Table 3.3 (Continued)

Taxon Name	Mean Percent Composition	Cumulative Percent Composition	Pooled Percent Composition	Occurrence	Cumulative Abundance	Mean Density (#/M**2)	Index of Dispersion
<i>Glycera</i>	0.084	90.622	0.116	0.050	6397.	0.80	1.94
<i>Mediomastus</i>	0.060	90.682	0.116	0.050	6405.	0.80	2.44
<i>Chone</i> sp. E	0.206	90.888	0.116	0.080	6413.	0.80	0.93
<i>Trichobranchus glacialis</i>	0.060	90.948	0.116	0.030	6421.	0.80	3.20
<i>Hydroids</i> sp. D	0.035	90.983	0.116	0.050	6429.	0.80	2.44
<i>Ehlersia</i> cf. <i>cornuta</i>	0.046	91.029	0.101	0.040	6436.	0.70	2.09
<i>Syllis gracilis</i>	0.016	91.045	0.101	0.020	6443.	0.70	3.54
<i>Leitoscoloplos</i> sp. A	0.083	91.128	0.101	0.040	6450.	0.70	2.09
<i>Arctidea fragilis</i>	0.146	91.274	0.101	0.040	6457.	0.70	2.67
<i>Phyllodoce arenae</i>	0.214	91.488	0.101	0.070	6464.	0.70	0.94
<i>Pisione remota</i>	0.068	91.557	0.101	0.050	6471.	0.70	1.52
<i>Ancistrosyllis jonesi</i>	0.056	91.613	0.101	0.050	6478.	0.70	1.52
<i>Polynoidae</i>	0.154	91.767	0.101	0.060	6485.	0.70	1.23
<i>Opisthodonta</i> sp. A	0.145	91.912	0.087	0.050	6491.	0.60	1.29
<i>Eunicidae</i>	0.033	91.945	0.087	0.030	6497.	0.60	2.97
<i>Pseudovermilia occidentalis</i>	0.070	92.015	0.087	0.040	6503.	0.60	1.62
<i>Pettibonella</i> sp. A	0.074	92.089	0.087	0.030	6509.	0.60	1.96
<i>Prionospio steenstrupi</i>	0.139	92.228	0.087	0.040	6515.	0.60	1.62
<i>Diopatra tridentata</i>	0.137	92.364	0.087	0.060	6521.	0.60	0.95
<i>Odotosyllis shoplei</i>	0.024	92.389	0.087	0.040	6527.	0.60	1.62
<i>Capitellidae</i>	0.266	92.654	0.087	0.060	6533.	0.60	0.95
<i>Syllidae</i>	0.078	92.733	0.087	0.030	6539.	0.60	2.30
<i>Malacoceros indicus</i>	0.071	92.804	0.087	0.040	6545.	0.60	1.62
<i>Sigambra bassi</i>	0.092	92.896	0.087	0.060	6551.	0.60	0.95
<i>Goniada littorea</i>	0.255	93.151	0.087	0.050	6557.	0.60	1.29
<i>Glycera oxycephala</i>	0.235	93.386	0.072	0.040	6562.	0.50	1.36
<i>Chaetopteridae</i>	0.142	93.528	0.072	0.040	6567.	0.50	1.36
<i>Apoprionospio dayi</i>	0.179	93.707	0.072	0.050	6572.	0.50	0.96
<i>Cistena gouldii</i>	0.120	93.826	0.072	0.050	6577.	0.50	0.96
<i>Trichobranchidae</i>	0.113	93.939	0.072	0.040	6582.	0.50	1.36
<i>Axiobella</i>	0.095	94.035	0.072	0.030	6587.	0.50	1.77
<i>Cirrophorus branchiatus</i>	0.041	94.075	0.072	0.040	6592.	0.50	1.36
<i>Phyllodoce longipes</i>	0.114	94.190	0.072	0.030	6597.	0.50	2.17
<i>Rullierinereis</i> sp. B	0.066	94.256	0.072	0.050	6602.	0.50	0.96
<i>Scolecopsis</i> sp. A	0.084	94.339	0.072	0.050	6607.	0.50	0.96
<i>Sthenelais</i>	0.049	94.388	0.072	0.020	6612.	0.50	2.58
<i>Pilargidae</i> A	0.058	94.446	0.072	0.040	6617.	0.50	1.36
<i>Typosyllis corallicoloides</i>	0.048	94.494	0.072	0.030	6622.	0.50	2.17
<i>Axiobella</i> sp. A	0.146	94.641	0.072	0.030	6627.	0.50	1.77
<i>Artacamella hancocki</i>	0.044	94.685	0.058	0.030	6631.	0.40	1.47
<i>Phyllodoce castanea</i>	0.063	94.748	0.058	0.030	6635.	0.40	1.47
<i>Typosyllis</i> cf. <i>lutea</i>	0.025	94.773	0.058	0.030	6639.	0.40	1.47
<i>Brania clavata</i>	0.032	94.806	0.058	0.020	6643.	0.40	2.48
<i>Phyllodoce</i> sp. D	0.174	94.980	0.058	0.020	6647.	0.40	2.48
<i>Pseudopolydora</i> sp. A	0.046	95.026	0.058	0.040	6651.	0.40	0.97
<i>Boquea enigmatica</i>	0.024	95.050	0.058	0.040	6655.	0.40	0.97
<i>Eunice</i> sp. A	0.060	95.109	0.058	0.040	6659.	0.40	0.97
<i>Arabella mutans</i>	0.018	95.127	0.058	0.040	6663.	0.40	0.97
<i>Scoloplos rubra</i>	0.029	95.157	0.058	0.030	6667.	0.40	1.47
<i>Typosyllis</i> sp. E	0.013	95.170	0.058	0.030	6671.	0.40	1.47
<i>Neovermilia</i> sp. A	0.017	95.187	0.058	0.020	6675.	0.40	2.48
<i>Pisione</i> sp. A	0.052	95.239	0.058	0.020	6679.	0.40	2.48

Table 3.3 (Continued)

Taxon Name	Mean Percent Composition	Cumulative Percent Composition	Pooled Percent Composition	Occurrence	Cumulative Abundance	Mean Density (#/M**2)	Index of Dispersion
<i>Autolytus</i> sp. A	0.016	95.255	0.058	0.020	6683.	0.40	2.48
<i>Stenelais</i> sp. B	0.054	95.309	0.058	0.020	6687.	0.40	2.48
<i>Loimia</i> sp. A	0.129	95.437	0.058	0.030	6691.	0.40	1.47
<i>Phyllococe fragilis</i>	0.029	95.467	0.058	0.030	6695.	0.40	1.47
<i>Diopatra cuprea</i>	0.026	95.493	0.058	0.030	6699.	0.40	1.47
<i>Nereis</i>	0.011	95.504	0.043	0.030	6702.	0.30	0.98
<i>Magelona</i> sp. R	0.044	95.548	0.043	0.030	6705.	0.30	0.98
Flabelligeridae	0.017	95.565	0.043	0.030	6708.	0.30	0.98
<i>Chaetozone</i> sp. B	0.093	95.658	0.043	0.030	6711.	0.30	0.98
<i>Ceratocophale oculata</i>	0.013	95.671	0.043	0.020	6714.	0.30	1.65
<i>Nephtys squamosa</i>	0.030	95.700	0.043	0.030	6717.	0.30	0.98
Lumbrineridae	0.097	95.797	0.043	0.020	6720.	0.30	1.65
<i>Glycera abbranchiata</i>	0.065	95.862	0.043	0.030	6723.	0.30	0.98
<i>Syllides hanseii</i>	0.021	95.883	0.043	0.030	6726.	0.30	0.98
<i>Haplosyllis spongicola</i>	0.052	95.935	0.043	0.020	6729.	0.30	1.65
<i>Sthenelais</i> sp. C	0.013	95.949	0.043	0.010	6732.	0.30	3.00
<i>Polydora</i> sp. D	0.006	95.955	0.043	0.010	6735.	0.30	3.00
<i>Pectinaria</i>	0.046	96.000	0.043	0.030	6738.	0.30	0.98
<i>Ehlersia</i> sp. E	0.052	96.053	0.043	0.030	6741.	0.30	0.98
<i>Glycera tessellata</i>	0.085	96.138	0.043	0.030	6744.	0.30	0.98
<i>Amphictelis</i>	0.070	96.208	0.043	0.030	6747.	0.30	0.98
<i>Aricidea wassii</i>	0.061	96.270	0.043	0.030	6750.	0.30	0.98
<i>Onuphis aremita</i>	0.116	96.385	0.043	0.030	6753.	0.30	0.98
<i>Eunice websteri</i>	0.040	96.425	0.043	0.010	6756.	0.30	3.00
<i>Ampharete</i> sp. B	0.134	96.559	0.043	0.020	6759.	0.30	1.65
<i>Microphthalmus</i> sp. E	0.014	96.573	0.043	0.020	6762.	0.30	1.65
<i>Megalomma quadrioculatum</i>	0.017	96.590	0.043	0.030	6765.	0.30	0.98
<i>Gyptis vittata</i>	0.010	96.600	0.043	0.020	6768.	0.30	1.65
Goniadidae	0.026	96.626	0.043	0.020	6771.	0.30	1.65
<i>Chone</i> sp. F	0.025	96.650	0.043	0.010	6774.	0.30	3.00
<i>Leitoscoloplos</i> sp. B	0.139	96.789	0.029	0.020	6776.	0.20	0.99
<i>Phyllococe</i> sp. E	0.027	96.817	0.029	0.010	6778.	0.20	2.00
<i>Leitoscoloplos</i>	0.068	96.884	0.029	0.020	6780.	0.20	0.99
<i>Magelona</i> sp. F	0.036	96.920	0.029	0.020	6782.	0.20	0.99
<i>Heteropodarke</i> cf. <i>heteromorpha</i>	0.081	97.001	0.029	0.020	6784.	0.20	0.99
<i>Levinsonia</i> sp. F	0.039	97.040	0.029	0.020	6786.	0.20	0.99
<i>Pectinaria regalis</i>	0.063	97.103	0.029	0.020	6788.	0.20	0.99
<i>Syllides floridanus</i>	0.024	97.127	0.029	0.020	6790.	0.20	0.99
<i>Arabella</i>	0.004	97.131	0.029	0.010	6792.	0.20	2.00
<i>Typosyllis</i> sp. H	0.006	97.137	0.029	0.020	6794.	0.20	0.99
<i>Psammolyce stenidophora</i>	0.022	97.158	0.029	0.010	6796.	0.20	2.00
<i>Notomastus</i>	0.038	97.196	0.029	0.010	6798.	0.20	2.00
Amphinomidae	0.009	97.206	0.029	0.020	6800.	0.20	0.99
<i>Aricidea</i> sp. P	0.010	97.215	0.029	0.020	6802.	0.20	0.99
<i>Podarke</i>	0.019	97.235	0.029	0.020	6804.	0.20	0.99
<i>Spiochaetopterus</i>	0.124	97.359	0.029	0.020	6806.	0.20	0.99
<i>Paramphinoe jeffreysii</i>	0.008	97.366	0.029	0.010	6808.	0.20	2.00
<i>Microphthalmus hartmanae</i>	0.004	97.370	0.029	0.010	6810.	0.20	2.00
<i>Polydora</i> sp. A	0.008	97.379	0.029	0.020	6812.	0.20	0.99
<i>Hesionura elongata</i>	0.051	97.430	0.029	0.020	6814.	0.20	0.99
<i>Nephtys</i>	0.021	97.451	0.029	0.020	6816.	0.20	0.99
Pectinariidae	0.051	97.502	0.029	0.020	6818.	0.20	0.99

Table 3.3 (Continued)

Taxon Name	Mean Percent Composition	Cumulative Percent Composition	Pooled Percent Composition	Occurrence	Cumulative Abundance	Mean Density (#/M**2)	Index of Dispersion
Eulepethidae	0.043	97.545	0.029	0.020	6820.	0.20	0.99
Sphaerosyllis aciculata	0.063	97.608	0.029	0.020	6822.	0.20	0.99
Protodoryllia kefersteini	0.074	97.682	0.029	0.010	6824.	0.20	2.00
Hydroides microtus	0.022	97.704	0.029	0.020	6826.	0.20	0.99
Spiochaetopterus oculatus	0.207	97.911	0.029	0.020	6828.	0.20	0.99
Diopatra	0.065	97.975	0.029	0.010	6830.	0.20	2.00
Nainereis	0.028	98.004	0.029	0.020	6832.	0.20	0.99
Chaetopterus varicopedatus	0.049	98.052	0.029	0.010	6834.	0.20	2.00
Polydora socialis	0.032	98.085	0.029	0.020	6836.	0.20	0.99
Lumbrineris inflata	0.009	98.094	0.029	0.020	6838.	0.20	0.99
Microspio pigmentata	0.024	98.118	0.014	0.010	6839.	0.10	1.00
Polycirrus	0.030	98.148	0.014	0.010	6840.	0.10	1.00
Piromis roberti	0.005	98.153	0.014	0.010	6841.	0.10	1.00
Eteone lactea	0.043	98.196	0.014	0.010	6842.	0.10	1.00
Scyphoprotus	0.005	98.201	0.014	0.010	6843.	0.10	1.00
Myriowenia cf. californiensis	0.019	98.220	0.014	0.010	6844.	0.10	1.00
Notomastus hemipodus	0.004	98.224	0.014	0.010	6845.	0.10	1.00
Orbiniidae	0.011	98.234	0.014	0.010	6846.	0.10	1.00
Hesionidae	0.004	98.239	0.014	0.010	6847.	0.10	1.00
Ceratonereis	0.006	98.245	0.014	0.010	6848.	0.10	1.00
Phyllodoce mucosa	0.040	98.285	0.014	0.010	6849.	0.10	1.00
Agapriopsis	0.022	98.307	0.014	0.010	6850.	0.10	1.00
Sabellaria	0.200	98.507	0.014	0.010	6851.	0.10	1.00
Polynoidae H	0.038	98.545	0.014	0.010	6852.	0.10	1.00
Scoloplos	0.005	98.550	0.014	0.010	6853.	0.10	1.00
Sigambra tentaculata	0.111	98.661	0.014	0.010	6854.	0.10	1.00
Phyllodoce groenlandica	0.014	98.676	0.014	0.010	6855.	0.10	1.00
Nephtys sp. A	0.014	98.690	0.014	0.010	6856.	0.10	1.00
Caulericiella cf. alata	0.007	98.697	0.014	0.010	6857.	0.10	1.00
Saccocirrus	0.004	98.701	0.014	0.010	6858.	0.10	1.00
Neoleprea sp. A	0.002	98.703	0.014	0.010	6859.	0.10	1.00
Cirriiformia sp. B	0.018	98.720	0.014	0.010	6860.	0.10	1.00
Heteropodarka sp. A	0.004	98.724	0.014	0.010	6861.	0.10	1.00
Harmothoe sp. E	0.059	98.783	0.014	0.010	6862.	0.10	1.00
Aricidea philibinae	0.021	98.804	0.014	0.010	6863.	0.10	1.00
Goniada teres	0.014	98.818	0.014	0.010	6864.	0.10	1.00
Streblosoma hartmanae	0.008	98.826	0.014	0.010	6865.	0.10	1.00
Aricidea sp. A	0.007	98.834	0.014	0.010	6866.	0.10	1.00
Saccocirridae	0.002	98.836	0.014	0.010	6867.	0.10	1.00
Exogone	0.059	98.894	0.014	0.010	6868.	0.10	1.00
Microphthalamus sp. D	0.006	98.901	0.014	0.010	6869.	0.10	1.00
Lumbrineris sp. B	0.053	98.953	0.014	0.010	6870.	0.10	1.00
Caulericiella sp. D	0.020	98.973	0.014	0.010	6871.	0.10	1.00
Pista	0.067	99.040	0.014	0.010	6872.	0.10	1.00
Dasybranchus lumbricoides	0.029	99.070	0.014	0.010	6873.	0.10	1.00
Typosyllis prolifera	0.003	99.072	0.014	0.010	6874.	0.10	1.00
Brania wellfleetensis	0.020	99.092	0.014	0.010	6875.	0.10	1.00
Aphrogonia sp. A	0.024	99.116	0.014	0.010	6876.	0.10	1.00
Scoloplos sp. D	0.029	99.146	0.014	0.010	6877.	0.10	1.00
Magelona phyllisae	0.033	99.179	0.014	0.010	6878.	0.10	1.00
Asychis	0.006	99.186	0.014	0.010	6879.	0.10	1.00
Lumbrineris coccinea	0.014	99.200	0.014	0.010	6880.	0.10	1.00

Table 3.3 (Continued)

Taxon Name	Mean Percent Composition	Cumulative Percent Composition	Pooled Percent Composition	Occurrence	Cumulative Abundance	Mean Density (#/M**2)	Index of Dispersion
<i>Paranaitis polynoides</i>	0.023	99.223	0.014	0.010	6881.	0.10	1.00
<i>Cirrophorus</i> sp. E	0.014	99.237	0.014	0.010	6882.	0.10	1.00
<i>Chloaia</i>	0.025	99.262	0.014	0.010	6883.	0.10	1.00
<i>Lumbrineris dayi</i>	0.038	99.301	0.014	0.010	6884.	0.10	1.00
<i>Leiochirides</i>	0.023	99.324	0.014	0.010	6885.	0.10	1.00
<i>Onuphis atlantisa</i>	0.008	99.332	0.014	0.010	6886.	0.10	1.00
<i>Sphaerosyllis glandulata</i>	0.005	99.336	0.014	0.010	6887.	0.10	1.00
<i>Aricidea</i> sp. O	0.017	99.353	0.014	0.010	6888.	0.10	1.00
<i>Glycera</i> sp. E	0.036	99.389	0.014	0.010	6889.	0.10	1.00
<i>Scyphoproctus</i> sp. A	0.005	99.394	0.014	0.010	6890.	0.10	1.00
<i>Euchone</i>	0.024	99.418	0.014	0.010	6891.	0.10	1.00
<i>Paranaitis</i>	0.014	99.432	0.014	0.010	6892.	0.10	1.00
<i>Armandia agilis</i>	0.013	99.445	0.014	0.010	6893.	0.10	1.00
<i>Tharyx</i> sp. A	0.004	99.449	0.014	0.010	6894.	0.10	1.00
<i>Sclerobregma stenocorum</i>	0.004	99.453	0.014	0.010	6895.	0.10	1.00
<i>Ergoniatia</i> sp. B	0.013	99.466	0.014	0.010	6896.	0.10	1.00
<i>Asychis elongata</i>	0.018	99.484	0.014	0.010	6897.	0.10	1.00
<i>Travisia hobsonae</i>	0.034	99.519	0.014	0.010	6898.	0.10	1.00
<i>Dionatra</i> sp. A	0.005	99.523	0.014	0.010	6899.	0.10	1.00
Oweniidae	0.016	99.539	0.014	0.010	6900.	0.10	1.00
<i>Lumbrineris candida</i>	0.005	99.544	0.014	0.010	6901.	0.10	1.00
<i>Armandia</i>	0.200	99.744	0.014	0.010	6902.	0.10	1.00
<i>Eulalia sanguinea</i>	0.008	99.751	0.014	0.010	6903.	0.10	1.00
<i>Potamilla</i> sp. B	0.006	99.758	0.014	0.010	6904.	0.10	1.00
<i>Notomastus lineatus</i>	0.004	99.762	0.014	0.010	6905.	0.10	1.00
<i>Ceratonereis irritabilis</i>	0.036	99.797	0.014	0.010	6906.	0.10	1.00
<i>Chaetozone</i> cf. <i>gayheadia</i>	0.007	99.804	0.014	0.010	6907.	0.10	1.00
<i>Ehlersia</i>	0.017	99.821	0.014	0.010	6908.	0.10	1.00
<i>Laonice cirrata</i>	0.020	99.842	0.014	0.010	6909.	0.10	1.00
<i>Nephtys</i> sp. D	0.091	99.933	0.014	0.010	6910.	0.10	1.00
<i>Pseudoeurythoe</i> sp. B	0.006	99.939	0.014	0.010	6911.	0.10	1.00
<i>Paralanice</i> sp. A	0.019	99.958	0.014	0.010	6912.	0.10	1.00
<i>Ampharete</i>	0.008	99.966	0.014	0.010	6913.	0.10	1.00
<i>Schistomeringos rudolphi</i>	0.014	99.980	0.014	0.010	6914.	0.10	1.00
Polynoidae E	0.020	100.000	0.014	0.010	6915.	0.10	1.00
Sample Summary: Samples = 100 Total Taxa = 295 Total Density = 691.50							

(Prionospio cristata, Eunice vittata, and Sabellidae spp.) comprising greater than 5% of the pooled percent composition. A total of 25 taxa each exceeded 1% of the community, and cumulatively accounted for 62% of the total number of individuals. Three of these 25 taxa, Plakosyllis quadrioculata, Onuphis sp. H, and Eunice vittata, exhibited very limited distributions, occurring in only 12, 13 and 17 samples, respectively.

3.3.2 Selection of the Most Ecologically Meaningful Taxa

The limitations on the number of variables that may be included in multivariate analyses and concerns regarding the validity of trends among very rare taxa dictates the selection of a subset of taxa when analyzing speciose communities. Taxa selection is a difficult and subjective process that requires an understanding of the taxonomy and ecology of the organisms under consideration. The taxa selection process can be greatly facilitated through the use of quantitative analysis techniques. In this investigation, relative percent composition analyses were used to eliminate the very rare taxa (i.e., those taxa represented by only 1 or 2 individuals), and the higher level taxa (i.e., phylum, class, order, and family identifications). Then TWINSpan analysis was used to assess the distributions and ecological relationships of the remaining taxa. The results of the TWINSpan analysis permitted the exclusion of the taxa that were randomly distributed across the samples in relatively low numbers, and allowed the inclusion of the taxa that may have occurred in relatively low numbers overall, but were highly restricted to a particular habitat (i.e., they showed a high fidelity to a particular habitat type).

The taxa subsetting process resulted in the selection of 68 taxa for inclusion in the detailed community analyses.

3.3.3 Correlation Analysis of the Selected Taxa and Environmental Variables

The correlation analysis of 68 selected taxa and community parameters with environmental variables revealed 35 taxa that showed strong relationships which consisted of two major trends (Table 3.4). The first and most important trend was for increasing abundance of 26 of the taxa with an increasing gravel component. Species of the family Syllidae (e.g., Dentatisyllis carolinae, Plakosyllis quadrioculata, Exogone lourei and Parapionosyllis longicirrata) were particularly important in defining this coarse sediment trend. The community parameters (e.g., total number of taxa, total number of individuals, and diversity) also generally increased with an increasing gravel fraction. The second major trend, exhibited by Aglaophamus verrilli, Paraprionospio pinnata, Spiophanes cf. berkeleyorum, and Leiocapitella sp. B, was just the opposite of the first. These taxa increased in abundance with a decreasing gravel component and an increasing silt component. Nematonereis unicornis and Terebellides stroemi increased with increasing salinity and depth. Nephtys picta showed an affinity for sandy sediments with a relatively uniform grain size (i.e., a lower sorting coefficient).

Table 3.4. Pearson product-moment correlation coefficients between selected taxa and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Mean Phi	Sorting Coeff.	Skewness	Kurtosis	Salinity	Depth
<i>Nephtys plicata</i>	-0.3230*	0.4515*	-0.3650*	-0.1732	0.2375	-0.4018*	-0.2420	0.2755	-0.2561	-0.2869
<i>Aglaphanus varicilli</i>	-0.5055*	0.1410	0.6489*	-0.0356	0.4287*	-0.2876	0.1156	0.0447	0.4373*	0.4668*
<i>Pararionosipio pinnata</i>	-0.3525*	0.1820	0.3745*	-0.1935	0.3775*	-0.0708	0.0088	0.0035	0.3406*	0.1259
<i>Spiophanes cf. berkeleyorum</i>	-0.4337*	0.1756	0.5130*	-0.1066	0.3393*	-0.2656	0.2140	0.0157	0.5000*	0.5308*
<i>Onuphis nebulosa</i>	-0.3209*	0.2144	0.2143	-0.1328	0.2242	-0.2719	0.1822	0.1029	0.2431	0.2870
<i>Leiocapitella</i> sp. B	-0.2782	0.0584	0.3678*	-0.0406	0.2076	-0.1524	0.0980	-0.0789	0.2917	0.3293*
<i>Nematonereis unicornis</i>	-0.2710	0.2136	0.0601	-0.0969	0.1656	-0.2530	0.0875	0.0255	0.3692*	0.4078*
<i>Iserbellides stromboli</i>	-0.1623	0.0886	0.1098	-0.1194	0.1134	-0.1329	0.1377	0.0088	0.3393*	0.4222*
<i>Goniada littorea</i>	-0.0916	0.1542	-0.1508	-0.0533	0.0918	-0.1567	-0.0760	0.3287*	-0.1785	-0.1665
<i>Amphictene</i> sp. A	-0.1064	0.1746	-0.1950	-0.0584	0.0889	-0.1462	-0.1938	0.1865	-0.3402*	-0.2243
<i>Prionosipio cristata</i>	-0.3453*	0.1610	-0.2462	-0.2097	-0.3439*	0.2451	0.0476	-0.2430	-0.2980	-0.2433
<i>Polysipho sp.</i>	0.3557*	-0.0870	-0.3380*	-0.1372	-0.3383*	0.2458	-0.0996	-0.1877	-0.3184*	-0.3072*
<i>Lumbrineris latreilli</i>	0.4707*	-0.0291	-0.3399*	-0.1164	-0.5883*	0.3013*	0.0721	-0.1463	-0.4141*	-0.3373*
<i>Dumetia sp.</i>	0.6107*	-0.4017*	-0.3257*	-0.0924	-0.7044*	0.3601*	-0.0278	-0.2051	-0.2757	-0.1169
<i>Dumetia sp.</i>	0.6240*	-0.3420*	-0.3530*	-0.0924	-0.6331*	0.3607*	0.1814	-0.2049	-0.3291*	-0.1935
<i>Onice vittata</i>	0.7082*	-0.5763*	-0.3514*	-0.0995	-0.7662*	0.4539*	0.0373	-0.2545	-0.4755*	-0.2479
<i>Prionosipio cirrifera</i>	0.5991*	-0.4184*	-0.3589*	-0.1047	-0.6359*	0.3578*	0.1274	-0.1570	-0.4264*	-0.2765
<i>Mediomastus californiensis</i>	0.6597*	-0.4106*	-0.3866*	-0.0472	-0.5395*	0.4973*	0.1286	-0.2374	-0.6010*	-0.5254*
<i>Goniadodes carolinæ</i>	0.7669*	-0.4629*	-0.3777*	-0.1231	-0.7012*	0.5197*	0.1344	-0.2880	-0.5021*	-0.3502*
<i>Exogone louri</i>	0.5457*	-0.3533*	-0.3100*	-0.0998	-0.5991*	0.3506*	0.1944	-0.1570	-0.4278*	-0.2970
<i>Aonides mayaguezensis</i>	0.7368*	-0.5620*	-0.3509*	-0.1038	-0.7417*	0.5140*	0.1267	-0.2797	-0.6137*	-0.4033*
<i>Plakosyllis quadriculata</i>	0.6447*	-0.6100*	-0.3113*	-0.0780	-0.7992*	0.4251*	0.0468	-0.1285	-0.5227*	-0.3183*
<i>Exogone dispar</i>	0.5133*	-0.3999*	-0.2735	-0.0933	-0.5831*	0.3556*	0.0390	-0.2258	-0.5316*	-0.3522*
<i>Palaenotus heteroseta</i>	0.5912*	-0.4766*	-0.2782	-0.0777	-0.6919*	0.4047*	0.0859	-0.2121	-0.5722*	-0.3692*
<i>Hemipodus roseus</i>	0.4480*	-0.3120*	-0.2506	-0.0587	-0.6129*	0.2803	0.1088	-0.1249	-0.4628*	-0.3015*
<i>Pararionosyllis</i> sp. A	0.4565*	-0.3724*	-0.1621	-0.0649	-0.5305*	0.3512*	0.0619	-0.1908	-0.3403*	-0.2357
<i>Ancistrosyllis hartmanae</i>	0.5127*	-0.3433*	-0.2739	-0.0772	-0.6897*	0.3173*	0.1022	-0.1272	-0.3621*	-0.2462
<i>Hyposyllis</i> sp. A	0.5763*	-0.5712*	-0.2650	-0.0688	-0.7060*	0.3868*	0.0199	-0.1397	-0.3664*	-0.2035
<i>Eblersia ferruginea</i>	0.4323*	-0.4363*	-0.1865	-0.0524	-0.5649*	0.2969	-0.0467	-0.1593	-0.4041*	-0.2525
<i>Schistomeringos pectinata</i>	0.4408*	-0.2477	-0.1857	-0.0733	-0.4627*	0.2973	0.0911	-0.0999	-0.1667	-0.1030
<i>Pararionosyllis longicirrata</i>	0.4789*	-0.2885	-0.2736	-0.0699	-0.5629*	0.2865	0.0946	-0.2044	-0.3525*	-0.2103
<i>Podarka obscura</i>	0.3553*	-0.2110	-0.2344	-0.0554	-0.3680*	0.2226	0.2233	-0.1485	-0.3581*	-0.2243
<i>Aricidea</i> sp. Q	0.4001*	-0.2715	-0.2687	-0.0817	-0.6242*	0.1986	-0.0162	-0.1495	-0.0625	0.0157
<i>Aricidea</i> sp. C	0.3200*	-0.0195	-0.2473	-0.1214	-0.2674	0.2211	0.2456	-0.1252	-0.1657	-0.1842
<i>Myriochele oculata</i>	0.3022*	-0.1420	-0.1539	-0.1608	-0.1524	0.2137	0.0621	-0.1780	-0.1709	-0.1231
Total taxa	0.4001*	-0.0680	-0.4803*	-0.4744*	-0.5013*	0.0874	0.1134	-0.2504	-0.1865	-0.0121
Total individuals	0.4326*	-0.1607	-0.3816*	-0.4063*	-0.5556*	0.1532	0.1134	-0.2329	-0.2326	-0.0308
Diversity	0.2300	0.0511	-0.4532*	-0.4372*	-0.3346*	-0.0294	0.0026	-0.1585	-0.0992	0.0253
Richness	0.3832*	-0.0515	-0.4825*	-0.4912*	-0.4920*	0.0671	0.0712	-0.2283	-0.1811	-0.0035

*Indicates correlations greater than 0.3.

3.3.4 TWINSPAN Analysis

The two-way display resulting from the TWINSPAN analysis of the 100 samples is presented in Figure 3.2, and Table 3.5 presents the environmental and community-level variables for these 100 samples, with the samples ordered in the same manner as in the TWINSPAN display. Viewing Figure 3.2 and Table 3.5 in concert allows a direct observation of the relationships of the taxa and sample distributions to environmental gradients and the distributions of community-level variables.

Sediment texture was the most important environmental variable, with the first dichotomy of the sample array dividing the coarsest-textured samples (Sample Group II) from those of finer texture (Sample Group I). The taxa in Group IIB2 exhibited distributions virtually limited to the coarsest-textured samples, which were primarily collected at Stations B-02, B-03, and 4-30. Plakosyllis quadrioculata, Dentatisyllis carolinae, Parapionosyllis longicirrata, Eunice vittata, and Aonides mayaquezensis were most characteristic of this trend.

A few taxa (e.g., Magelona pettiboneae and Glycera sp. F) showed an affinity for the less gravelly-coarse sand habitat of Sample Group IIA, which was largely composed of samples from Stations A-13 and A-14. Another distinct group of taxa (Group IA2) was most indicative of the shallow, fine sands of Stations B-01, B-04, and B-05 (Sample Group IB), with Nephtys picta, Spio pettiboneae, and Goniada littorea most characteristic of this trend. The finest-textured samples, which were primarily collected at Sites 3 and 4, were placed in Group IA on

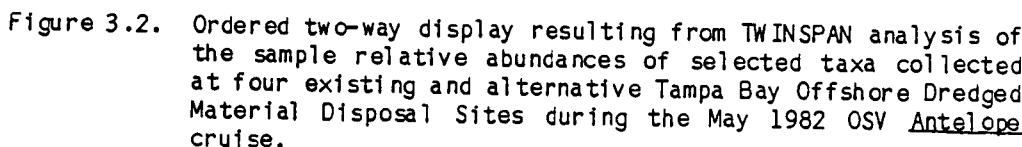


Table 3.5. Ordered table of sample environmental and community parameters based on the results of TWINSpan analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

Sample	Depth	Salinity	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Mean Phi	Sorting Coeff.	Skewness	Kurtosis	Median Phi	Total Taxa	Total Indiv.	H'	J	Species Richness
IA-10 3	39.0	36.1837	3.70	84.40	11.90	0.00	2.57	1.33	-0.06	1.56	2.53	5.00	5.00	1.61	1.00	4.38
IA-10 1	39.0	36.1837	10.80	86.30	38.40	8.50	2.67	2.98	0.04	1.31	2.86	5.00	9.00	1.46	0.91	4.51
IA-10 5	39.0	36.1837	2.10	90.70	13.10	4.10	2.95	1.41	0.27	1.72	2.71	7.00	5.00	0.95	0.86	2.28
IA-19 3	80.0	36.5094	0.10	80.00	19.60	0.30	3.30	0.96	-0.10	1.09	3.16	3.00	11.00	1.67	0.86	6.59
IA-19 5	80.0	36.5094	0.80	85.90	13.30	0.00	3.09	0.92	-0.08	1.05	3.18	2.00	19.00	0.24	0.35	1.63
IA-12 3	82.0	36.1730	9.40	88.60	2.00	0.00	1.88	1.56	-0.36	0.93	2.35	17.00	31.00	2.63	0.93	16.71
IA-19 1	80.0	36.5094	0.30	81.70	18.00	0.00	3.22	0.99	-0.12	1.10	3.28	5.00	18.00	1.08	0.67	4.65
IA-23 2	95.0	36.5268	0.90	99.20	0.40	0.00	1.32	0.78	-0.06	1.12	1.39	5.00	21.00	1.37	0.82	5.67
IA-01 5	38.0	35.9890	0.60	98.10	1.30	0.00	2.67	0.78	0.01	1.50	2.59	14.00	235.00	0.74	0.28	13.32
IA-21 1	90.0	36.5070	0.10	86.30	11.40	0.00	2.86	1.00	0.11	1.11	2.75	15.00	33.00	2.14	0.99	14.71
IA-21 2	90.0	36.5070	0.20	95.40	4.40	0.00	2.78	0.80	0.06	1.08	2.69	22.00	18.00	2.90	0.94	21.72
IA-14 1	83.0	36.0966	0.40	96.80	2.80	0.00	2.40	0.92	-0.12	1.51	2.46	17.00	26.00	2.68	0.95	16.72
IA-19 2	80.0	36.5094	0.10	80.90	18.70	0.30	3.16	1.02	-0.03	1.00	3.12	16.00	43.00	2.10	0.75	15.73
IA-19 4	80.0	36.5094	0.20	79.70	19.30	0.80	3.25	1.03	-0.08	1.07	3.29	10.00	83.00	1.73	0.75	9.73
IA-20 1	81.0	36.5109	0.20	86.10	13.70	0.00	3.00	0.94	0.09	1.03	2.92	17.00	41.00	2.37	0.84	15.73
IA-21 3	90.0	36.5070	0.10	86.30	11.40	0.00	2.78	0.80	0.06	1.08	2.69	17.00	34.00	2.41	0.95	16.72
IA-21 4	80.0	36.5070	0.40	90.90	8.70	0.00	2.08	1.03	-0.00	1.35	2.16	16.00	41.00	2.39	0.86	15.73
IA-21 5	80.0	36.5070	0.20	88.20	11.60	0.00	2.93	0.95	0.08	1.06	2.85	17.00	31.20	2.45	0.86	16.71
IA-22 2	84.0	36.5129	0.10	95.00	4.90	0.00	2.50	0.86	0.03	1.29	2.49	21.20	40.30	2.82	0.93	20.73
IA-22 5	84.0	36.5129	0.10	95.80	4.10	0.00	2.53	0.80	0.04	1.36	2.51	22.00	44.00	2.82	0.91	21.74
IA-23 3	85.0	36.5268	0.10	88.00	11.90	0.00	2.62	1.08	0.15	1.10	2.58	11.00	19.00	2.16	0.90	10.36
IA-23 4	85.0	36.5268	0.20	73.50	26.30	0.30	3.20	1.18	-0.11	0.88	3.22	52.20	52.20	2.92	0.73	22.82
IA-28 1	77.0	36.4534	0.10	87.30	12.60	0.00	3.02	0.95	-0.03	1.04	3.03	15.00	31.00	2.39	0.89	14.71
IA-28 2	77.0	36.4534	0.10	89.20	14.70	0.00	3.06	0.97	-0.04	1.03	3.07	15.00	38.20	2.37	0.88	14.72
IA-28 3	77.0	36.4534	0.10	86.80	13.10	0.00	3.04	0.96	-0.06	1.05	3.06	18.00	36.00	2.39	0.93	17.74
IA-28 4	77.0	36.4534	0.20	89.10	14.70	0.00	3.07	0.99	-0.04	1.02	3.09	14.00	37.00	2.08	0.79	13.74
IA-28 5	77.0	36.4534	0.20	88.10	11.70	0.00	3.00	0.93	0.01	1.04	2.98	15.00	51.00	2.10	0.78	14.74
IA-29 1	70.0	36.4282	0.20	91.60	8.20	0.00	3.00	0.90	-0.10	1.09	3.03	9.00	29.20	1.88	0.86	8.70
IA-29 2	70.0	36.4282	0.60	90.90	8.50	0.00	2.94	0.98	-0.07	1.18	2.92	14.30	41.00	2.39	0.89	13.73
IA-29 3	70.0	36.4282	0.10	92.00	7.90	0.00	2.98	0.87	-0.03	1.04	2.96	16.00	33.00	2.56	0.92	15.71
IA-29 4	70.0	36.4282	0.10	90.20	9.70	0.00	2.98	0.92	-0.02	1.08	2.97	13.00	23.20	2.28	0.89	12.68
IA-29 5	70.0	36.4282	0.10	91.60	8.30	0.00	2.96	0.88	0.03	1.04	2.92	12.00	20.00	2.40	0.96	11.67
IA-32 1	72.0	36.4691	0.10	91.60	8.30	0.00	2.74	0.86	0.11	1.35	2.62	18.00	18.00	2.51	0.96	18.70
IA-32 2	72.0	36.4691	0.30	90.30	9.40	0.00	2.66	0.93	0.10	1.13	2.76	25.00	53.00	2.79	0.87	24.75
IA-32 3	72.0	36.4691	0.20	91.90	7.90	0.00	2.83	0.87	0.14	1.16	2.71	10.00	26.00	1.82	0.79	9.69
IA-32 4	72.0	36.4691	0.30	92.80	6.90	0.00	2.78	0.89	0.11	1.22	2.67	19.00	73.00	2.45	0.83	18.77
IA-32 5	72.0	36.4691	0.10	91.00	8.70	0.00	2.87	0.90	0.12	1.12	2.76	18.00	49.00	2.49	0.86	17.74
IA-01 1	38.0	35.9890	0.60	98.70	0.90	0.00	2.26	0.92	-0.25	1.51	2.40	9.20	15.00	2.08	0.95	8.63
IA-23 1	95.0	36.5268	0.90	98.40	0.90	0.00	1.33	0.78	-0.02	1.22	1.52	25.00	19.00	2.34	0.91	23.75
IA-20 2	81.0	36.5109	0.60	97.00	2.40	0.00	2.13	0.86	-0.11	1.09	2.22	27.00	52.20	2.98	0.90	26.76
IA-20 5	81.0	36.5109	0.40	95.50	4.10	0.00	2.71	0.75	0.10	1.34	2.52	24.00	45.00	2.80	0.88	23.73
IA-22 1	84.0	36.5129	0.30	97.70	2.00	0.00	2.80	0.78	0.00	1.02	2.73	30.00	59.20	3.11	0.91	29.75
IA-22 3	84.0	36.5129	0.30	95.00	4.70	0.00	2.26	0.92	-0.04	1.13	2.32	21.00	57.20	2.67	0.88	20.75
IA-22 4	84.0	36.5129	0.10	96.10	3.80	0.00	2.83	0.86	0.01	1.32	2.46	24.00	46.00	2.98	0.94	23.74
IA-31 1	71.0	36.4828	0.80	98.50	0.40	0.00	1.80	0.82	-0.01	1.05	1.73	46.00	226.20	3.22	0.83	22.82
IA-31 2	71.0	36.4828	1.10	98.40	0.50	0.00	1.84	0.84	-0.06	1.00	1.80	37.00	116.00	3.12	0.86	36.79
IA-31 3	71.0	36.4828	0.10	95.90	4.00	0.00	2.71	0.73	0.12	1.40	2.61	30.00	92.00	2.83	0.93	29.78
IA-31 5	71.0	36.4828	0.30	95.50	4.20	0.00	2.70	0.74	0.11	1.43	2.60	23.00	54.00	2.54	0.91	22.75
IA-11 1	41.0	36.1287	0.90	98.20	0.90	0.00	1.55	0.94	-0.01	0.97	1.54	14.00	23.00	2.51	0.95	13.68
IA-12 1	42.0	36.1730	8.10	98.50	1.20	0.00	1.20	0.98	-0.19	1.06	1.58	20.00	42.00	2.70	0.90	19.73
IA-12 4	43.0	36.0966	0.20	98.40	1.30	0.00	2.30	0.88	-0.17	1.35	2.41	17.00	14.00	2.52	0.86	16.74
IA-10 2	39.0	36.1837	22.80	50.80	21.90	4.50	1.95	3.03	-0.06	0.93	2.22	3.00	3.00	1.10	1.00	2.03
IA-10 4	39.0	36.1837	19.40	43.40	30.20	7.30	2.26	3.18	0.01	1.04	2.47	5.00	10.00	1.56	0.97	4.56
IA-11 2	41.0	36.1287	0.20	99.60	0.20	0.00	1.75	0.77	0.05	1.03	1.67	12.00	22.00	2.41	0.97	11.68
IA-11 3	41.0	36.1287	0.10	99.30	0.40	0.00	2.10	0.69	-0.21	0.82	2.19	10.00	12.00	2.25	0.98	9.60
IA-12 3	42.0	36.1730	0.80	97.30	1.90	0.00	2.20	0.80	-0.11	1.32	2.30	13.00	16.00	2.48	0.96	12.65
IA-13 1	49.0	36.2282	0.60	98.90	0.50	0.00	2.00	1.05	-0.27	1.00	2.01	16.00	16.00	2.09	0.98	12.77
IA-13 4	49.0	36.2282	11.90	86.90	1.20	0.00	1.04	1.58	0.03	0.84	1.05	36.00	156.00	2.38	0.66	35.30
IA-13 5	49.0	36.2282	1.10	97.90	1.00	0.00	2.07	1.16	-0.30	1.05	2.35	15.00	25.00	2.44	0.90	14.69
IA-11 1	41.0	36.1287	0.10	99.30	0.60	0.00	2.15	0.67	-0.22	0.84	2.26	18.00	28.00	2.68	0.93	17.70
IA-11 5	41.0	36.1287	0.40	99.00	0.60	0.00	1.74	0.82	0.01	0.99	1.68	20.00	34.00	2.77	0.92	19.72
IA-12 2	42.0	36.1730	1.50	97.70	1.50	0.00	2.10	0.98	-0.18	1.14	2.30	19.00	28.00	2.80	0.95	18.70
IA-12 5	42.0	36.1730	3.20	94.70	2.10	0.00	2.65	1.09	-0.20	1.65	2.69	15.00	17.00	2.51	0.88	12.68
IB-04 4	43.0	35.9382	0.30	98.60	1.10	0.00	2.60	0.74	-0.02	1.43	2.54	19.00	32.00	2.56	0.87	18.71
IB-05 5	44.0	35.8060	0.80	98.00	1.20	0.00	2.64	0.79	-0.00	1.50	2.57	17.00	25.00	2.50	0.88	16.69
IB-01 2	39.0	35.9890	0.30	99.30	0.40	0.00	2.36	0.76	-0.17	1.53	2.45	10.00	14.00	2.40	0.96	9.62
IB-01 3	38.0	35.9890	0.80	97.30	1.90	0.00	2.66	0.77	-0.13	1.38	2.64	21.00	50.00	2.62	0.93	20.74
IB-01 5	38.0	35.9890	1.00	96.00	1.40	0.00	2.71	0.93	-0.09	1.52	2.63	18.00	36.00	2.62	0.91	17.72
IB-04 2	43.0	35.9382	1.50	96.40	2.10	0.00	2.32	1.22	-0.26	1.29	2.47	29.00	78.00	2.62	0.78	28.77
IB-05 1	44.0	35.8060	1.20	98.60	0.20	0.00	1.96	0.80	-0.15	0.96	1.98	12.00	32.00	2.26	0.83	11.71
IB-05 3	44.0	35.8060	3.30	96.50	0.20	0.00	1.61	1.03	-0.17	1.25	1.64	14.00	30.00	2.39	0.90	13.71
IB-04 1	43.0	35.9382	0.30	98.30	0.90	0.00	2.51	0.67	-0.32	1.35	2.50	17.00	17.00	2.40	1.03	10.33
IB-04 3	43.0	35.9382														

the second dichotomy. Some of the taxa most characteristic of these fine-textured samples were Aglaophamus verrilli, Lumbrineris ernesti, Diopatra tridentata, and Spiophanes cf. berkeleyorum. A small group of taxa (e.g., Chone americana, Mastobranchus sp. A, and Ceratonereis longicirrata) exhibited a cluster of occurrences in the deep, sandy habitats primarily represented by samples from Stations 3-20, 3-22, and 4-31. The taxa that occurred in many of the samples from Stations A-10, A-11, and A-12 were generally widespread across the study area, and included many opportunistic species (e.g., Paraprionospio pinnata, Prionospio cristata, and Myriochele oculata).

3.3.5 Q-Mode Cluster Analysis

At the level of association chosen, the dendrogram formed four major groups and three small groups (Figure 3.3). Of the major groups, Group II encompassed the shallow-water, coarse-textured habitat, with the gravelly samples from Stations B-02 and B-03 forming a distinct subgroup (IIB) and the less coarse, less gravelly samples from Stations A-13 and A-14 forming Group IIA. Group IIC defined the deep, coarse-textured, and was represented by the samples from Station 4-30.

Group III encompassed the deeper-water, finer-textured habitat of Sites 3 and 4, with samples from Stations 3-21, 3-23, 4-28, 4-29, and 4-32 most characteristic of the group. The deep-water, sandy habitat was delineated by Group IV, which included most of the samples from Stations 3-20 and 3-22. Group V included the coarse to fine sand samples collected in shallow-water. Many of the samples from Stations

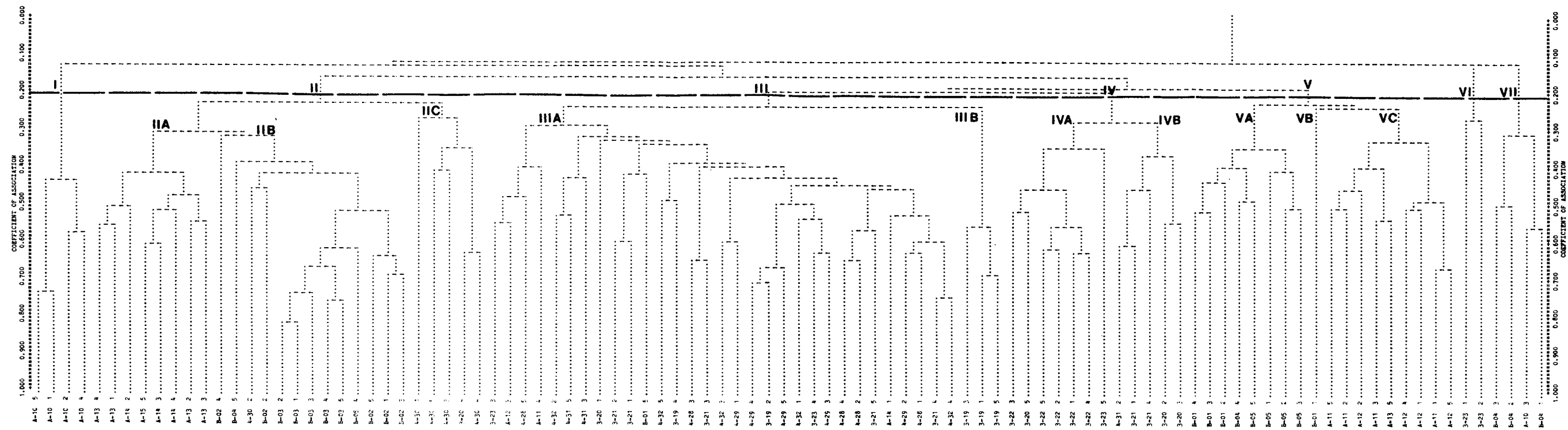


Figure 3.3. Sample dendrogram resulting from Q-mode cluster analysis of the densities of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

B-01, B-04, and B-05 formed Group VA, whereas the coarser-textured samples from Stations A-11 and A-12 formed Group VC.

Group I included four of the five replicates from Station A-10, which was located at the center of the existing dumpsite. All of these samples were depauperate, and the poorly sorted sediments reflected the accumulation of dredged material. Group VI consisted of two relatively depauperate samples from Station 3-23, whereas three replicates from Station B-04 and one from Station A-10 composed Group VII. The Group VII samples were characterized by fine sand, and were also relatively low in total numbers of individuals and taxa.

3.3.6 R-mode Cluster Analysis

The dendrogram formed eight taxa groups at the chosen level of association (Figure 3.4). The Group I taxa were most characteristic of the gravelly, coarse-textured habitat of Stations B-02, B-03, and 4-30, whereas the Group II taxa were indicative of the less gravelly, coarse sand habitat of Stations A-13 and A-14. The Group III taxa showed an affinity for the deep-water, fine sand habitat of Stations 3-20, 3-23, and 4-31. Group IVA included the taxa most closely associated with the finer-textured habitats of Sites 3 and 4, whereas the taxa that showed an affinity for the shallow-water, sandy habitat of Stations B-01, B-04, and B-05 were included in Group IVB. Group VI included the species that occurred in relatively low numbers in the finest-textured samples.

Amphictene sp. A and Tharyx cf. annulosus formed Group V. Amphictene sp. A was entirely restricted to the samples from Stations B-01, B-04, and B-05, whereas Tharyx cf. annulosus was widely

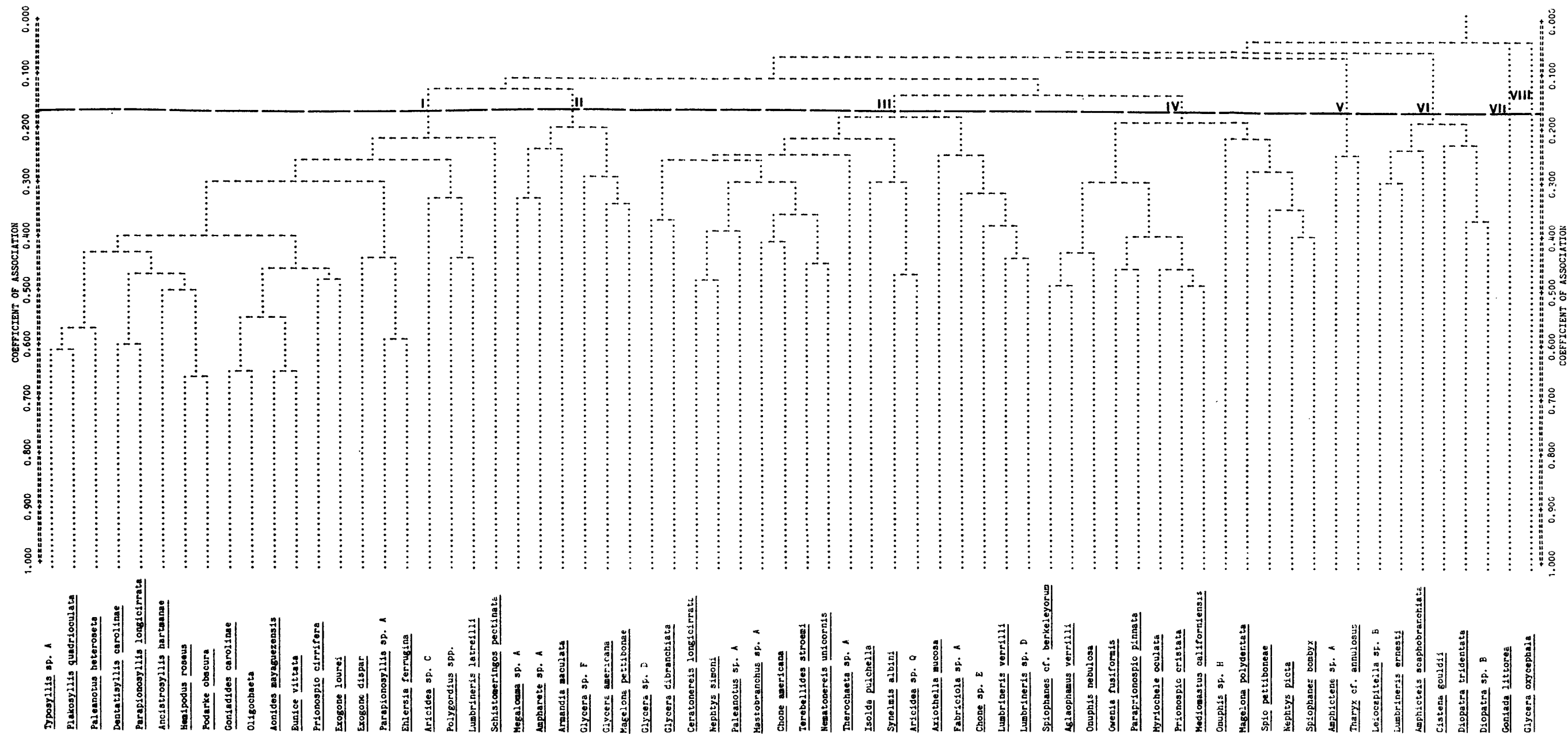


Figure 3.4. Taxa dendrogram resulting from R-mode cluster analysis of the densities of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

distributed in relatively low numbers. The grouping of these two taxa was not readily explainable in terms of environmental variables. These two taxa joined the dendrogram at a relatively low level of association, indicating little affinity with the other taxa.

Goniada littorea and Glycera oxycephala composed Groups VII and VIII, respectively. Goniada littorea was restricted to the shallow-water, fine sand habitat of Stations B-01 and B-05, whereas Glycera oxycephala was restricted to the shallow-water, medium and fine sand habitat of Stations A-11 and B-05.

3.3.7 Reciprocal Averaging Ordination Analysis

The results of the preliminary ordination analysis (not presented) and the results of the analyses discussed above were used to eliminate 11 taxa from the original suite of 68. In the preliminary ordination analysis, replicate 1 from Station B-04 was identified as an outlier, and was deleted from further analysis in order to obtain a more meaningful spread of the samples and taxa along the ordination axes.

In the subsequent analysis involving 99 samples and 57 taxa, the first two axes accounted for the vast majority of the explained variance. Therefore, only plots for Axes 1 and 2 for the samples (Figure 3.5) and taxa (Figure 3.6) are presented. In order to quantitatively relate the sample ordination axes to the environmental variables, the sample scores for Axes 1 and 2 were regressed against the environmental variables (Tables 3.6 and 3.7).

Axis 1 represented the response of the selected taxa to a sediment texture gradient, with the coarsest-textured samples on the left of

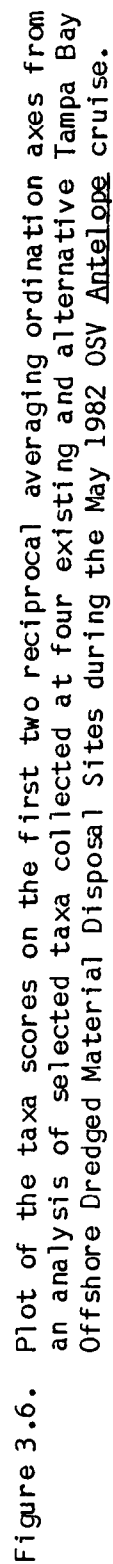


Table 3.6. Summary of results of stepwise multiple regression analysis of environmental variables with Axis 1 sample scores based on the ordination analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

Variable	Multiple R	R Square	RSQ Change	Simple R	B	Beta
Percent Gravel	0.84442	0.71305	0.71305	-0.84442	-46.96877	-0.61360
Percent Silt	0.94398	0.89110	0.17805	0.69662	35.51020	0.35029
Folk Mean	0.94635	0.89557	0.00447	0.78901	13.49096	0.10584
Percent Sand	0.94844	0.89953	0.00396	0.42632	-147.1492	-0.28407
Median Phi	0.94970	0.90193	0.00240	0.80613	17.15982	0.13579
Inclusive Graphic Skewness	0.95012	0.90273	0.00080	0.01943	-15.17467	-0.02088
Inclusive Graphic Standard Deviation	0.95056	0.90356	0.00083	-0.49218	-64.52359	-0.12188
Depth	0.95091	0.90424	0.00067	0.45393	-60.52803	-0.19142
Salinity	0.95272	0.90768	0.00345	0.58528	2351.807	0.18153
Percent Clay	0.95316	0.90851	0.00082	0.12320	-17.61345	-0.06912
Graphic Kurtosis	0.95328	0.90874	0.00023	0.24145	18.53056	0.01779
(CONSTANT)					-7378.945	

Table 3.7. Summary of results of stepwise multiple regression analysis of environmental variables with Axis 2 sample scores based on the ordination analysis of selected taxa collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

Variable	Multiple R	R Square	RSQ Change	Simple R	B	Beta
Salinity	0.33210	0.11029	0.11029	-0.33210	-4388.404	-0.59959
Percent Gravel	0.52983	0.28072	0.17044	-0.18695	-24.65630	-0.57017
Percent Silt	0.57515	0.33079	0.05007	0.04875	8.412544	0.14689
Inclusive Graphic Skewness	0.60056	0.36067	0.02988	-0.18125	-61.99251	-0.15101
Percent Sand	0.60343	0.36413	0.00346	0.07720	-122.8081	-0.41966
Percent Clay	0.60753	0.36909	0.00497	0.01607	-34.72413	-0.24121
Folk Mean	0.61316	0.37596	0.00687	0.19293	8.720720	0.12111
Median Phi	0.61543	0.37875	0.00279	0.17242	10.18731	0.14269
Depth	0.61670	0.38032	0.00157	-0.32348	-16.34405	-0.09149
Graphic Kurtosis	0.61747	0.38127	0.00095	0.13577	22.56569	0.03834
Inclusive Graphic Standard Deviation	0.61759	0.38142	0.00015	-0.09465	16.80775	0.05620
(CONSTANT)					16592.05	

the display and the finest-textured samples on the right (Figure 3.5). The samples most representative of the gravelly, coarse-textured habitat were from Stations B-02, B-03, and 4-30, with the coarsest-textured samples from Stations B-04, B-05, 3-20, and 4-31 also included. The samples located along the center portion of Axis 1 were primarily characterized by coarse and medium sands, with samples from Stations A-10, A-11, A-12, A-13, A-14, B-01, B-04, B-05, 3-20, and 3-21 most representative of this trend. The finest-textured samples from the study area were positioned on the far right of the display, and primarily included samples from Stations A-10, 3-19, 3-21, 3-22, 3-23, 4-28, 4-29, and 4-32. Percent gravel and percent silt cumulatively accounted for 89% of the variance in the Axis 1 scores (Table 3.6). Percent gravel was negatively correlated with the Axis 1 scores, whereas percent silt was positively correlated, confirming the low Axis 1 scores for the gravelly samples and the high scores for the finer-textured samples. The 11 environmental variables cumulatively accounted for 91% of the variance in the Axis 1 scores.

The weaker trends defined by Axis 2 were primarily related to salinity and depth, with the samples from the shallower, less saline stations generally located along the upper portion of the display, and the samples from the deeper, more saline stations located along the lower portion. The 11 environmental variables cumulatively accounted for 38% of the variance in the Axis 2 scores (Table 3.7). Some of the stations that were most characteristic of the shallower, less-saline

habitat included B-01, B-04, and B-05, whereas Stations 3-20, 3-22, 3-23, and 4-31 were characteristic of the deeper, more-saline habitat.

Although salinity varied little across the study area, the shallow-water samples were consistently less saline than the deeper-water samples. This consistent salinity gradient accounts for the importance of salinity in the regression equation. Because salinity varied so little, it is unlikely that changes in salinity alone could account for the changes in community structure. This salinity relationship probably represents a combination of environmental gradients that vary in an onshore-offshore manner, such as near-bottom current energies, sediment composition, hydrographic conditions, and environmental variability.

The taxa that were most characteristic of the gravelly, coarse-textured samples collected from Stations B-02, B-03, and 4-30 included Ehlersia ferrugina, Plakosyllis quadrioculata, Typosyllis sp. A, Parapionosyllis sp. A., Parapionosyllis longicirrata, Dentatisyllis carolinae, Ancistrosyllis hartmanae, Hemipodus roseus, and Eunice vittata (Figure 3.6). Within this group, Dentatisyllis carolinae and Parapionosyllis longicirrata were more characteristic of the gravelly samples from the deeper-water Station 4-30.

The taxa placed along the left-central portion of Axis 1 (e.g., Exogone dispar, Exogone lourei, Prionospio cirrifer, Goniadides carolinae, Lumbrineris laetrilli, and Mediomastus californiensis) were best represented in the less gravelly, coarse sand samples collected at Stations A-13, A-14, B-02, B-04, 3-20, 4-30, and 4-31.

The taxa along the central portion of Axis 1 were most important in the samples characterized by medium and fine sands. Within this group, the taxa along the top of the display (Amphictene sp. A, Goniada littorea, and Nephtys picta) characterized the shallow-water samples from Stations B-01, B-04, and B-05, whereas the taxa along the bottom (Ceratonereis longicirrata, Chone americana, Mastobranchus sp. A, Synelmis albin, and Nephtys simoni) were best represented at the deeper-water sample from Stations 3-20, 3-22, 4-29, 4-30, and 4-31.

The taxa on the far right of the ordination display were most important in the finest-textured samples from Stations 3-19, 3-21, 3-22, 4-28, and 4-32. These taxa included Leiocapitella sp. B, Diopatra tridentata, Diopatra sp. B, Aglaophamus verrilli, Spiophanes cf. berkeleyorum, Lumbrineris ernesti, Lumbrineris verrilli, Paraprionospio pinnata, Onuphis nebulosa, Terebellides stroemi, Nematonereis unicornis, and Glycera sp. D. Within this group, Aglaophamus verrilli was one of the few taxa well-represented in the relatively depauperate samples from Station 3-19, whereas Glycera sp. D, Therochaeta sp. A, and Nematonereis unicornis were characteristic of many of the samples from Stations 3-20 and 3-22.

4.0 DISCUSSION

4.1 Definition of the Sample Groups

Although the polychaetes encompass the majority of the taxa and individuals in soft-bottom macroinfaunal communities, they constitute but a small portion of the near-shore marine ecosystem. Algae, vascular plants, microorganisms, and other metazoans compose the benthos. In addition to the benthos, the plankton and the nekton are important components of near-shore marine ecosystems. In order to simplify the analysis and understanding of these complex ecosystems, it is necessary to compartmentalize them into taxonomic and spatial-temporal components. However, it must be emphasized that this compartmentalization and classification is arbitrary, and that these taxonomic and spatial-temporal components are functionally dependent and continuous in nature.

In the preceding discussions of the results from the various community analyses, similar habitats (i.e., groups of samples) were consistently related to the same communities (i.e., groups of taxa). This is evidence of faunal assemblages that tended to inhabit particular environments. Based on a review and synthesis of the results of the analyses discussed above, six sample groups were defined (Table 4.1).

Group 1 defined the very diverse, gravelly, poorly sorted habitat. This habitat and its associated community represented the strongest trend in the data. The less gravelly, coarse and medium sand habitat was defined by Group 2. This Group was slightly less diverse and better sorted as compared to Group 1. Group 3 was composed of samples

Table 4.1. Summary statistics of the environmental and community parameters for each sample group resulting from a synthesis of community- level analyses of selected taxa and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

	Variable	MEAN	STANDARD DEVIATION	MAXIMUM	MINIMUM
Group 1 - Gravel	Depth	50.25	15.93	73.00	38.00
	Salinity	35.95	0.34	36.44	35.70
B-2 replicates 1,2,3,4,5	Percent Gravel	33.32	11.00	53.40	13.10
B-3 replicates 1,2,3,4,5	Percent Sand	65.98	11.01	85.80	45.30
B-5 replicate 4	Percent Silt	0.71	0.48	1.70	0.20
4-30 replicates 1,2,3,4,5	Percent Clay	0.00	0.00	0.00	0.00
	Mean Phi	-0.28	0.68	0.70	-1.42
	Sorting Coefficient	1.60	0.14	1.89	1.38
	Skewness	0.01	0.14	0.21	-0.19
	Kurtosis	0.98	0.14	1.13	0.70
	Mean Phi	-0.29	0.57	0.56	-1.34
	Diversity	2.95	0.24	3.46	2.42
	Evenness	0.84	0.07	0.96	0.69
	Species Richness	36.28	12.33	51.81	16.73
Group 2 - Coarse Sand with Gravel	Depth	53.44	15.87	81.00	43.00
	Salinity	36.20	0.21	36.51	35.84
A-13 replicates 2,3,4	Percent Gravel	10.53	8.65	31.80	3.50
A-14 replicates 3,4,5	Percent Sand	87.20	8.45	94.70	67.50
B-4 replicate 5	Percent Silt	2.27	2.19	6.80	0.70
3-20 replicates 3,4	Percent Clay	0.00	0.00	0.00	0.00
	Mean Phi	0.94	0.60	2.00	0.11
	Sorting Coefficient	1.37	0.28	1.76	0.95
	Skewness	0.04	0.18	0.22	-0.24
	Kurtosis	1.13	0.22	1.51	0.84
	Median Phi	0.90	0.74	2.21	-0.23
	Diversity	2.86	0.35	3.32	2.32
	Evenness	0.82	0.10	0.92	0.66
	Species Richness	32.89	5.70	43.80	25.77
Group 3 - Medium and Fine Sands, Shallow Depths	Depth	42.31	2.85	49.00	39.00
	Salinity	36.16	0.04	36.22	36.10
	Percent Gravel	1.79	2.44	9.40	0.10
A-11 replicates 1,2,3,4,5	Percent Sand	95.44	5.78	99.60	80.70
A-12 replicates 1,2,3,4,5	Percent Silt	2.51	3.97	13.10	0.20
A-13 replicates 1,5	Percent Clay	0.26	1.02	4.10	0.00
A-14 replicates 1,2	Mean Phi	2.17	0.40	2.95	1.47
A-10 replicates 3,5	Sorting Coefficient	1.01	0.26	1.56	0.67
	Skewness	-0.13	0.16	0.27	-0.36
	Kurtosis	1.17	0.29	1.73	0.82
	Median Phi	2.19	0.38	2.71	1.54
	Diversity	2.44	0.51	3.09	0.95
	Evenness	0.94	0.04	1.00	0.87
	Species Richness	15.03	6.91	32.77	2.38

Table 4.1 (Continued)

	Variable	MEAN	STANDARD DEVIATION	MAXIMUM	MINIMUM
Group 4 - Medium and Fine Sands, Deep Water	Depth	79.07	6.35	85.00	71.00
	Salinity	36.50	0.07	36.53	36.48
	Percent Gravel	0.81	1.44	5.70	0.10
	Percent Sand	96.41	1.82	98.90	92.80
	Percent Silt	2.77	1.80	4.90	0.40
	Percent Clay	0.00	0.00	0.00	0.00
	Mean Phi	2.14	0.61	2.80	0.82
	Sorting Coefficient	0.84	0.11	1.17	0.73
	Skewness	0.00	0.07	0.12	-0.11
	Kurtosis	1.20	0.15	1.43	1.00
	Median Phi	2.13	0.57	2.73	0.89
	Diversity	2.90	0.31	3.49	2.21
	Evenness	0.88	0.04	0.94	0.81
	Species Richness	29.19	13.87	68.82	12.69
Group 5 - Fine Sand	Depth	41.38	2.81	44.00	38.00
	Salinity	35.89	0.09	35.99	35.81
	Percent Gravel	0.90	0.89	3.30	0.10
	Percent Sand	98.17	1.11	99.60	96.40
	Percent Silt	0.93	0.64	2.10	0.20
	Percent Clay	0.00	0.00	0.00	0.00
	Mean Phi	2.38	0.39	2.71	1.61
	Sorting Coefficient	0.84	0.17	1.22	0.60
	Skewness	-0.11	0.10	0.03	-0.26
	Kurtosis	1.36	0.20	1.53	0.94
	Median Phi	2.40	0.29	2.64	1.64
	Diversity	2.29	0.53	2.82	0.74
	Evenness	0.86	0.18	1.00	0.28
	Species Richness	15.08	5.72	28.77	8.62
Group 6 - Fine Sand and Silt	Depth	73.38	12.15	85.00	39.00
	Salinity	36.45	0.09	36.53	36.18
	Percent Gravel	1.87	5.40	22.80	0.10
	Percent Sand	84.36	13.32	99.20	43.40
	Percent Silt	13.08	7.39	34.40	0.40
	Percent Clay	0.68	2.03	8.50	0.00
	Mean Phi	2.83	0.41	3.30	1.32
	Sorting Coefficient	1.14	0.63	3.18	0.78
	Skewness	0.01	0.08	0.15	-0.13
	Kurtosis	1.10	0.10	1.35	0.88
	Median Phi	2.83	0.39	3.36	1.39
	Diversity	2.11	0.59	2.92	0.24
	Evenness	0.85	0.11	1.00	0.35
	Species Richness	13.09	5.95	24.75	1.63

from Site A, and defined a shallow-water, moderately to poorly sorted, medium and fine sand habitat. The Group 3 mean diversity values were lower than those for Groups 1 and 2. Group 4 defined a diverse, deep-water, moderately sorted, medium and fine sand habitat. A shallow-water, moderately sorted, fine sand habitat was defined by Group 5. The Group 5 samples were the best sorted, but among the least diverse. Group 6 defined the finest-textured habitat, and was primarily composed of samples from the deeper stations. Although the samples from Station A-10 were characterized by dredged material, they were included in this group because of their faunal composition, low diversities, and fine texture.

4.2 Definition of the Polychaete Communities

Theories concerning the natural groupings of organisms have engendered considerable controversy, particularly among plant ecologists. The Scandinavian Uppsala school regarded plant communities as concrete, quantifiable units based on dominant species, whereas the central and southern European Zurich-Montpellier school regarded plant communities as mosaics made up of abstract units of various sizes based on lists of species and the degree of clumping and distribution of each species (Whittaker 1962, Mills 1969). In early twentieth century America, F. E. Clements, influenced by the Uppsala school, regarded communities as functional, evolving analogs of organisms (Clements and Shelford 1939).

More recently, a third school of thought has developed which regards communities as distributions of individual species along

gradients of environmental change (Whittaker 1962, McIntosh 1967). This school of thought has gained broad acceptance among benthic ecologists (Mills 1969, Stephenson 1970). In this thesis, the gradient or continuum community concept is accepted. The communities defined below represent polychaete assemblages that tended to occur in similar habitats at the time of sampling. This community concept does not assume species recurrence or functional self-regulation.

Based on a review and synthesis of the results of the analyses discussed above, six communities were defined. Table 4.2 presents a taxonomic listing of the species in each community, and trophic and life mode information for each species.

The taxa in Community 1 were virtually restricted to the gravelly, poorly sorted, coarse-textured habitat defined by Group 1 above. Of these 19 taxa, 17 are classified as either carnivorous or herbivorous, motile or semi-motile, jawed-feeders (Fauchald and Jumars 1979).

Members of the family Syllidae, which were most characteristic of this community, are small (usually less than 10 mm in length), carnivorous, free-living polychaetes that inhabit cryptic, epifaunal environments such as sponges, corals, hydroids, algae, and gravel (Fauchald 1977, Uebelaker and Johnson 1984). Most syllid species prey on colonial invertebrates such as hydroids (Fauchald and Jumars 1979). Eunice vittata and Paleanotus heteroseta are also carnivorous, epibenthic species often associated with coral reefs and gravelly sediments (Fauchald and Jumars 1979, Uebelaker and Johnson 1984). These carnivorous species were primarily epifaunal on the larger, gravel-sized

Table 4.2. Polychaete communities resulting from a synthesis of community-level analyses of selected taxa and environmental variables collected at four existing and alternative Tampa Bay Offshore Dredged Material Disposal Sites during the May 1982 OSV Antelope cruise.

Taxon	Trophic Type ^a	Life Mode ^b
COMMUNITY 1		
Polychaeta		
Chrysopetalidae	CMX	FE
<u>Paleanotus heteroseta</u>		
Dorvilleidae	HMJ, CMJ, SMJ	FE, B
<u>Shistomeringos pectinata</u>		
Eunicidae	HMJ, HDJ, CMJ, CDJ	B, T
<u>Eunice vittata</u>		
Glyceridae	CDJ, BMJ	B
<u>Hemipodus roseus</u>		
Goniadidae	CDJ	B
<u>Goniadides carolinae</u>		
Hesionidae	HMJ, CMJ, SMJ, BMJ	FE
<u>Podarke obscura</u>		
Lumbrineridae	HMJ, CMJ, CDJ, BMJ	B
<u>Lumbrineris laetrilli</u>		
Paraonidae	HMX, SMX	B
<u>Aricidea</u> sp. Q		
Pilargidae	CMJ	FE
<u>Ancistrosyllis hartmanae</u>		
Spionidae	FDT, SDT	T
<u>Aonides mayaquezensis</u>		
<u>Prionospio cirrifera</u>		
Syllidae	CMJ, HMJ	FE, B
<u>Dentatisyllis carolinae</u>		
<u>Ehlersia ferruginea</u>		
<u>Exogone dispar</u>		
<u>Exogone lourei</u>		
<u>Parapionosyllis</u> sp. A		
<u>Parapionosyllis longicirrata</u>		
<u>Plakosyllis quadrioculata</u>		
<u>Ityosyllis</u> sp. A		
COMMUNITY 2		
Archiannelida		
Polygordfiidae	SMX	B, FE
<u>Polygordius</u> spp.		
Polychaeta		
Capitellidae	BMX, SMX	B
<u>Mediomastus californiensis</u>		
Glyceridae	CDJ, BMJ	B
<u>Glycera americana</u>		
<u>Glycera</u> sp. F		
Magelonidae	SDT	B
<u>Magelona pettiboneae</u>		
Opheliidae	BMX	B
<u>Armandia maculata</u>		
Paraonidae	HMX, SMX	B
<u>Aricidea</u> sp. C		

Table 4.2 (Continued)

Taxon	Trophic Type ^a	Life Mode ^b
COMMUNITY 3		
Polychaeta		
Capitellidae	BMX, SMX	B
<u>Mastobranchus</u> sp. A		
Eunicidae	HMJ, HDJ, CMJ, CDJ	B, T
<u>Nematonereis unicornis</u>		
Flabelligeridae	SDT, SMT	B
<u>Itherochaeta</u> sp. A		
Glyceridae	CDJ, BMJ	B
<u>Glycera</u> sp. D		
Lumbrineridae	HMJ, CMJ, CDJ, BMJ	B
<u>Lumbrineris</u> sp. D		
<u>Lumbrineris verrilli</u>		
Nephtyidae	CMJ, BMJ	B
<u>Nephtys simoni</u>		
Nereidae	HMJ, CMJ, CDJ, FDP, SDJ	FE
<u>Ceratonereis longicirrata</u>		
Sabellidae	FST, SDT	T
<u>Chone americana</u>		
Trichobranchidae	SST	T
<u>Terebellides stroemi</u>		
COMMUNITY 4		
Polychaeta		
Cirratulidae	SMT, SDT	B
<u>Tharyx</u> cf. <u>annulosus</u>		
Glyceridae	CDJ, BMJ	B
<u>Glycera dibranchiata</u>		
Goniadidae	CDJ	B
<u>Goniada littorea</u>		
Magelonidae	SDT	B
<u>Magelona polydentato</u>		
Nephtyidae	CMJ, BMJ	B
<u>Nephtys picta</u>		
Onuphidae	HDJ, CMJ, CDJ, SDJ	T
<u>Onuphis</u> sp. H		
Pectinariidae	BMX	T, B
<u>Amphictene</u> sp. A		
Spionidae	FDT, SDT	T
<u>Spio pettiboneae</u>		

Table 4.2 (Continued)

Taxon	Trophic Type ^a	Life Mode ^b
COMMUNITY 5		
Polychaeta		
Ampharetidae	SST	T
<u>Amphicteis scaphobranchiata</u>		
Capitellidae	BMX, SMX	B
<u>Leiocapitella</u> sp. B		
Lumbrineridae	HMJ, CMJ, CDJ, BMJ	B
<u>Lumbrineris ernesti</u>		
Nephtyidae	CMJ, BMJ	B
<u>Aglaophamus verrilli</u>		
Onuphidae	HDJ, CMJ, CDJ, SDJ	T
<u>Diopatra</u> sp. B		
<u>Diopatra tridentata</u>		
<u>Onuphis nebulosa</u>		
Pectinariidae	BMX	T, B
<u>Pectinaria gouldii</u>		
Spionidae	FDT, SDT	T
<u>Spiophanes</u> cf. <u>berkeleyorum</u>		
COMMUNITY 6		
Polychaeta		
Oweniidae		
<u>Myriochele oculata</u>	BMX	T
<u>Owenia fusiformis</u>	FDT, SDT	T
Spionidae	FDT, SDT	T
<u>Paraprionospio pinnata</u>		
<u>Prionospio cristata</u>		
<u>Spiophanes bombyx</u>		

^aThe first position indicates feeding mode, the second the motility pattern, and the last position indicates the morphological structure used in feeding. These feeding types were taken from Fauchald and Jumars (1979).

In position 1: B - subsurface deposit feeder;
C - carnivore;
F - filter feeder;
H - herbivore;
S - surface deposit feeder.

In position 2: D - discretely motile;
M - motile;
S - sessile.

In position 3: J - jawed;
P - pumping;
T - tentaculate;
X - other structures, usually eversible sac-like pharynges.

^bThe life mode designations were adapted taken from Shaw et al. (1982):

B - burrower;
FE - free living;
T - tube dwelling.

particles where they preyed upon attached colonial invertebrates and other epifaunal organisms.

Other species characteristic of Community 1 included the spionids Aonides mayaquezensis and Prionospio cirrifera. These species are filter feeders or surface deposit feeders with limited motility that inhabit permanent mucus-lined burrows or tubes (Fauchald and Jumars 1979). Uebelaker and Johnson (1984) state that Aonides mayaquezensis has been collected in 24-43 m depths in coarse to fine sands along the western Florida shelf, whereas Prionospio cirrifera has been collected in sediments ranging from coarse sands to silty clays in the northern Gulf of Mexico.

Other investigations in the Gulf of Mexico have identified similar gravel-associated communities. In a fall 1983 survey conducted in the vicinity of Site 4, Parapionosyllis sp. A, Typosyllis sp. A, Dentatisyllis carolinae, Exogone lourei, Ancistrosyllis hartmanae, Aonides mayaquezensis, and Goniadides carolinae were most characteristic of the gravel and coarse sand habitat (U.S. Environmental Protection Agency 1984). The family Eunicidae was associated with gravelly sediments in a study of the soft-bottoms surrounding the Flower Gardens Banks in the northern Gulf of Mexico (Kennedy et al. 1983).

The taxa in Community 2, although generally widely distributed, were primarily associated with the less gravelly, coarse sand habitat defined by Group 2, and were secondarily associated with the very gravelly habitat defined by Group 1. The glycerids are free-living on rocks, gravel, and algal mats or actively burrow into sand or mud

substrates (Fauchald and Jumars 1979). In the northern Gulf of Mexico, Glycera americana is widespread, and has been collected in sediments ranging from gravelly sand to silty, clayey sand (Uebelaker and Johnson 1984). Polygordius spp., Mediomastus californiensis, Armandia maculata, and Aricidea sp. C are motile, surface or subsurface deposit feeders (Fauchald and Jumars 1979). Polygordius spp. and Armandia maculata were associated with very sandy sediments in Mississippi Sound and vicinity (Shaw et al. 1982). Armandia maculata is ubiquitous in the northern Gulf of Mexico in sands, silts, and clays (Uebelaker and Johnson 1984). The capitellid Mediomastus californiensis is widespread in the northern Gulf of Mexico in sediments ranging from medium sands to silts and clays, but seems to prefer sandy habitats (Uebelaker and Johnson 1984). In the fall 1983 survey of Site 4 and vicinity, the genus Mediomastus was most characteristic of medium to fine sands and coarse silts (U.S. Environmental Protection Agency 1984). Many of the capitellid species (e.g., Capitella capitata, Heteromastus filiformis, and Mediomastus ambiseta) are opportunistic and frequently abundant in areas of environmental disturbance and organic enrichment (Grassle and Grassle 1974, Gray 1979, Reish 1979, Pearson and Rosenberg 1978). Mediomastus californiensis was abundant at a station polluted by sewage and industrial wastes in Galveston Bay (Holland et al. 1973). Magelona pettiboneae is common off southwestern Florida and Texas in sands, silts, and clays (Uebelaker and Johnson 1984). In the fall 1983 survey of Site 4 and vicinity, this species was most characteristic of medium

to fine sands and coarse silts (U.S. Environmental Protection Agency 1984).

The taxa in Community 3 were primarily associated with the deeper-water, medium to fine sand habitat defined by Group 4, and were secondarily associated with the shallow-water, medium and fine sand habitat defined by Group 2. Nematonereis unicornis, Glycera sp. D, Lumbrineris sp. D, Lumbrineris verrilli, Nephtys simoni, and Ceratonereis longicirrata are motile carnivores or herbivores (Fauchald and Jumars 1979). Lumbrineris verrilli is widespread in the northern Gulf of Mexico in sediments ranging from coarse sand to silty clay (Uebelaker and Johnson 1984). In the fall 1983 survey of Site 4 and vicinity, Lumbrineris verrilli was widespread across the study area (U.S. Environmental Protection Agency 1984).

The nephtyids are generally considered to be carnivorous on small invertebrates (Fauchald and Jumars 1979), however, Sanders (1956, 1960) reported that Nephtys incisa was a subsurface deposit feeder in Long Island Sound and Buzzard's Bay. In the northern Gulf of Mexico, Nephtys simoni is restricted to the eastern Gulf in sediments ranging from coarse sands to sandy muds, whereas Ceratonereis longicirrata has been collected off the Florida coast in medium to fine sands (Uebelaker and Johnson 1984). In the fall 1983 survey conducted in the vicinity of Site 4, Nephtys simoni was most characteristic of gravelly, coarse, and medium sands (U.S. Environmental Protection Agency 1984).

Therochaeta sp. A, Chone americana, and Terebellides stroemi are tentaculate surface deposit or filter feeders (Fauchald and Jumars

1979). *Therochaeta* sp. A has been collected in the northeastern Gulf of Mexico in sediments ranging from medium to fine sands, whereas *Chone americana* is common in the eastern and western Gulf in sediments ranging from coarse sands to sandy silts (Uebelaker and Johnson 1984). *Chone americana* was most characteristic of gravelly, coarse, and medium sands in the fall 1983 survey conducted in the vicinity of Site 4 (U.S. Environmental Protection Agency 1984). *Terebellides stroemi* is widespread in the northern Gulf of Mexico, but is most prominent in the eastern Gulf (Uebelaker and Johnson 1984). This species was most characteristic of medium, fine, and very fine sands and coarse silts in the fall 1983 survey conducted in the vicinity of Site 4 (U.S. Environmental Protection Agency 1984).

The taxa in Community 4 were primarily associated with the shallow-water, fine sand habitat defined by Group 5, and were secondarily associated with both the shallow-water and deep-water medium and fine sand habitats defined by Groups 3 and 4, respectively. This community encompassed a wide variety of trophic types, with carnivores, herbivores, filter feeders, and deposit feeders represented. In the northern Gulf of Mexico, *Nephtys picta* is widespread in coarse to very fine sand, *Glycera dibranchiata* has been collected in shallow waters in medium to very fine sand along the west coast of Florida, and *Goniada littorea* has been collected at scattered locations in sediments ranging from medium sands to clayey sandy silt (Uebelaker and Johnson 1984). *Nephtys picta* and *Goniada littorea* were most characteristic of the

offshore clean sand habitat in the vicinity of Mississippi Sound (Shaw et al. 1982).

The taxa in Community 5 were primarily associated with the finest-textured sediments defined by Group 6, and were secondarily associated with the deep-water, medium and fine sand habitat defined by Group 4. This community also encompassed a wide variety of feeding types, with herbivores and deposit feeders most prevalent. Lumbrineris ernesti is widespread in the northeastern Gulf of Mexico in very fine sands and silty sands, whereas Aglaophamus verrilli and Diopatra tridentata are widespread throughout the northern Gulf in similar habitats (Uebelaker and Johnson 1984). Lumbrineris ernesti and Aglaophamus verrilli were most characteristic of medium, fine, and very fine sands and coarse silts in the fall 1983 survey conducted in the vicinity of Site 4 (U.S. Environmental Protection Agency 1984). In the vicinity of Mississippi Sound, Aglaophamus verrilli was most characteristic of the offshore muddy sand habitat (Shaw et al. 1982).

The oweniids Myriochele oculata and Owenia fusiformis, and the spionids Paraprionospio pinnata, Prionospio cristata, and Spiophanes bombyx composed Community 6. Although the Community 6 taxa were primarily associated with the fine-textured habitat defined by Group 6, these taxa were widespread and were secondarily associated with all of the habitats. Myriochele oculata is a sub-surface deposit feeder, whereas the remaining species are surface deposit- or filter feeders (Fauchald and Jumars 1979). With the addition of Mediomastus californiensis from Community 2 and the possible exception of Prionospio

cristata, these were the most opportunistic polychaete species in the study area. The characteristics of marine benthic opportunists include the ability to rapidly colonize disturbed habitats, early maturation, small body size, high mortality rates, and widespread distributions (Grassle and Grassle 1974). The relatively ubiquitous distributions of these opportunistic taxa are related to frequent localized sediment disturbances which provide colonizable habitats for the opportunistic species (Johnson 1972, McCall 1978).

Myriochele oculata is widespread in the eastern Gulf of Mexico in sediments ranging from coarse sands to clayey silts, and the absence of this species in the central and western Gulf may be due to misidentifications (Uebelaker and Johnson 1984). In the fall 1983 survey conducted in the vicinity of Site 4, Myriochele oculata was widespread across the study area (U.S. Environmental Protection Agency 1984). In Mississippi Sound, Owenia fusiformis and Myriochele oculata were among the most dominant taxa in the highly variable nearshore mud and muddy sand habitats, and were judged to be among the most opportunistic taxa in the study area (Shaw et al. 1982).

The family Spionidae includes several opportunistic species that are found world-wide in a variety of habitats (Pearson and Rosenberg 1978). Paraprionospio pinnata is one of the most ubiquitous and abundant polychaete species in the northern Gulf of Mexico in sediments ranging from coarse sands to silty clays (Uebelaker and Johnson 1984). Paraprionospio pinnata was the only taxon present in all five replicates collected at the very depauperate Station A-10, which

was characterized by dredged material. In the fall 1983 survey conducted in the vicinity of Site 4, Paraprionospio pinnata was most characteristic of the medium to very fine sand, and coarse silt habitats (U.S. Environmental Protection Agency 1984). In Mississippi Sound and vicinity, Paraprionospio pinnata was one of the most numerically dominant taxa in the offshore mud bottom, offshore mixed sediments, and offshore clean sand habitats, and was judged to be one of the most opportunistic species in the study area (Shaw et al. 1982). This species was one of the most widespread and abundant taxa in the hydrographically variable, near-shore area along the Louisiana and east Texas coasts (Comiskey and Farmer 1981). Paraprionospio pinnata has been a prominent species in polluted or disturbed habitats in numerous studies conducted in North American waters (Boesch 1973, Hinde and Boesch 1981, Swartz 1972, Reish and Winter 1954; Watling 1975).

Prionospio cristata is a relatively rare species in the northern Gulf of Mexico which has been collected in sediments ranging from fine sands to silty clayey sands (Uebelaker and Johnson 1984). Prionospio cristata was most characteristic of the medium to very fine sand and coarse silt habitats in the fall 1983 survey conducted in the vicinity of Site 4 (U.S. Environmental Protection Agency 1984). This species was most characteristic of the offshore clean sand habitat in the vicinity of Mississippi Sound, and was judged to be moderately opportunistic (Shaw et al. 1982).

Spiophanes bombyx is widespread and abundant in the northern Gulf of Mexico in sediments ranging from coarse sands to clay (Uebelaker

and Johnson 1984). In the fall 1983 survey conducted in the vicinity of Site 4, Spiophanes bombyx was widespread across the study area (U.S. Environmental Protection Agency 1984). In Mississippi Sound and vicinity, Spiophanes bombyx was most characteristic of the inshore and offshore clean sand habitats, and was judged to be one of the most opportunistic species (Shaw et al. 1982).

4.3 Impacts of Dredged Material Disposal

Macrobenthic community succession along spatial or temporal gradients of disturbance follows a characteristic pattern in near-shore marine ecosystems. This successional pattern has been shown for the effects of dredged material disposal (Oliver et al. 1977), organic enrichment (Pearson and Rosenberg 1978), storm-related bottom disturbances (Boesch et al. 1976), oil spills (Sanders et al. 1980), and red tide toxic effects (Simon and Dauer 1977). Investigations of the recovery of benthic communities following disturbance indicate that near-shore communities typically recover within a few months to a few years following the abatement of the disturbance (Oliver et al. 1977, Rhoads et al. 1978, Pearson and Rosenberg 1976, McCall 1978, Simon and Dauer 1977, Boesch et al. 1976).

Oliver et al. (1977) described the macrobenthic successional patterns following dredging and dredged material disposal in Monterey Bay, California. The initial disposal of the material buried the resident infauna, creating an afaunal zone. The afaunal zone was surrounded by a zone of environmental disturbance resulting from

increases in near-bottom turbidity, and the settling of dredged material. As the distance from the dumping site increased, smaller amounts of dredged material that were high in labile organic matter settled, producing an enriched community due to an increase in food materials, and in some cases, an increase in environmental heterogeneity. Early stage succession began within a few days with the immigration of motile crustaceans, echinoderms, and polychaetes from surrounding areas, and the settling of opportunistic polychaete and bivalve mollusc larvae. These opportunistic species may attain large populations in the presence of an adequate food supply. The latter phase of succession was characterized by the gradual re-establishment of less opportunistic species that were characteristic of the surrounding area.

Some of the factors that influence the successional pattern described above include the nature of the physical environment, the composition of the disposed material, and the structure of the surrounding communities. Communities characteristic of near-shore, highly variable habitats recover quickly due to the natural presence of opportunistic species, whereas communities characteristic of less variable habitats take longer to recover. Furthermore, if the composition of the disposed material is substantially different from the naturally occurring sediments (e.g., the disposal of very fine-textured sediments in an area naturally characterized by coarse-textured sediments), the recovered community may be considerably different from those in the surrounding areas.

The results of this investigation indicate that the polychaete communities at Site B have recovered from dredged material disposal impacts since the cessation of dumping in 1973. The sediment composition at Site B was within the range of natural variability for the study area. The polychaete communities were diverse and characteristic of those found in similar unimpacted habitats.

At Station A-10, the results of this investigation indicate that the accumulation of dredged material has buried the resident infauna, creating depauperate faunal conditions. The sediments at Station A-10 were very poorly sorted and relatively fine-textured. Four of the five replicates contained clay fractions in excess of 4%, well outside the range of natural variability for the study area. The polychaete community at Station A-10 was characterized by opportunistic species in very low numbers. The highly opportunistic spionid Paraprionospio pinnata was the only taxon present in all five replicates, indicating that the sediments are in the initial stages of recolonization. The low total numbers of individuals could be related to low levels of labile organic material, or may be the result of the community being in the very initial stages of recolonization, with most of the individuals in larval or juvenile stages that were not retained by a 1 mm seive.

The very sandy sediments at Stations A-11, A-12, A-13, and A-14 were characteristic of the study area and did not show any evidence of dredged material disposal. These stations were located along the perimeter of Site A, approximately 0.5 m from Station A-10. In the community analyses results, many of the samples from Stations A-11,

A-12, A-13, and A-14 tended to group together, indicating community differences as compared to the samples from similar habitats, such as those collected at Stations B-01, B-04, and B-05. The opportunistic spionids Paraprionospio pinnata and Owenia fusiformis were among the dominant taxa at Stations A-11, A-12, A-13, and A-14, but these taxa were far less abundant or absent from Stations B-01, B-02, and B-05. Conversely, the moderately opportunistic or equilibrium species Spio pettiboneae, Amphictene sp. A, Onuphis sp. H, and Goniada littorea were generally restricted to Stations B-01, B-02, and B-05.

This trend for the samples from Stations A-11, A-12, A-13, and A-14 to be more dominated by opportunistic species as compared to similar habitats could be related to environmental disturbance. However, when these community differences are interpreted within the context of the high natural variability of near-shore macroinfaunal communities and the limitations of the sampling design and taxonomic identification, they can not be categorically attributed to the impacts of dredged material disposal.

4.4 Conclusions

1. The near-bottom salinities ranged from 35.7 to 36.5 ppt and increased with increasing depth.
2. The sediments were primarily characterized by coarse to fine sands interrupted by patches of gravel, with the addition of a limited silt fraction that tended to increase with increasing depth.

3. The species diversity and density of the polychaetes decreased with increasing depth, increasing percent fines, and increasing sediment homogeneity, with the gravelly habitats generally supporting the most diverse communities.
4. A synthesis of the environmental and community analyses results yielded six polychaete communities that were inhabiting particular environments, and, in some cases, changes in community structure and composition were related to relatively small changes in sediment texture.
5. Substantial within-station sediment and polychaete community heterogeneity was evident, primarily due to the patchy distribution of gravel on a small spatial scale.
6. The polychaete communities at Site B have completely recovered from dredged material disposal impacts since the cessation of dumping in 1973.
7. Near the center of Site A, the accumulation of dredged material has buried the resident infauna and created a relatively fine-textured habitat characterized by opportunistic species in low numbers, indicating that the sediments are in the initial stages of recolonization.

REFERENCES CITED

REFERENCES CITED

- Bartlett, M.S. 1937. Some examples of statistical methods of research in agriculture and applied biology. *J. Roy. Statist. Soc. Supp.* 4:137-170.
- Boesch, D.F. 1971. Distribution and structure of benthic communities in a gradient estuary. Ph.D. dissertation, the College of William and Mary in Virginia.
- Boesch, D.F. 1973. Classification and community structure of macrobenthos in the Hampton Roads area, Virginia. *Mar. Biol.* 21:226-244.
- Boesch, D.F. 1977a. A new look at the distribution of benthos along the estuarine gradient. Pages 245-266 *in* B.C. Coull, ed. *Ecology of marine benthos. The Belle W. Baruch Library in Marine Science Number 6.* University of South Carolina Press.
- Boesch, D.F. 1977b. Application of numerical classification in ecological investigations of water pollution. U.S. Environmental Protection Agency, Washington, D.C. EPA 600/3-77-033.
- Boesch, D.F., M.L. Wass, and R.W. Virnstein. 1976. The dynamics of estuarine benthic communities. Pages 177-196 *in* M.L. Wiley, ed. *Estuarine processes, volume 1.* Academic Press, New York.
- Brandt, C.C., C.E. Comiskey, and T.A. Farmer. 1986. Design and development of a scientific information management and analysis system for multidisciplinary pollution research and monitoring. Pages 209-225 *in* W.K. Michener, ed. *Research data management in the ecological sciences. The Belle W. Baruch Library in Marine Science Number 16.* University of South Carolina Press.
- Brinkhurst, R.O. 1967. The distribution of aquatic oligochaetes in Saginaw Bay, Lake Huron. *Limnol. Oceanogr.* 12:137-143.
- Brinkhurst, R.O., K.E. Chua, E. Batoosing. 1969. Modifications in sampling procedures as applied to studies on the bacteria and tubificid oligochaetes inhabiting aquatic sediments. *J. Fish. Res. Bd. Can.* 26(10):2581-2593.
- Bureau of Land Management. 1977. Baseline monitoring studies, Mississippi, Alabama, Florida, outer continental shelf 1975-1976. Washington, D.C. 3 vols.
- Bureau of Land Management. 1979. The Mississippi, Alabama, Florida outer continental shelf environmental baseline survey MAFLA 1977/1978. Washington, D.C. 4 vols.
- Chapman, P.M. and E.R. Long. 1983. The use of bioassays as part of a comprehensive approach to marine pollution assessment. *Mar. Poll. Bull.* 14(3): 81-84.

- Clements, F.E. and V.E. Shelford. 1939. Bio-ecology. John Wiley, New York. 425 p.
- Cochran, W.G. 1941. The distribution of the largest set of estimated variances as a fraction of their total. *Annals of Eugenics* 11:47-52.
- Comiskey, C.E. and C.C. Brandt. 1982. Appendix A. Quantitative impact assessment. In: Marine Ecosystem Monitoring, a report by the Marine Ecosystem Monitoring Task Group, Ecology Committee, Science Advisory Board, U.S. Environmental Protection Agency, Washington, D.C.
- Comiskey, C.E. and T.A. Farmer (eds.). 1981. Characterization of the baseline oceanography of the Texoma region brine disposal sites. Volumes I and II. U.S. Department of Energy, Strategic Petroleum Reserve Office, Washington, D.C.
- Comiskey, C.E., T.A. Farmer, C.C. Brandt and S.P. Pavlou. 1983. Assessment of the impacts of sewage discharge from the West Point Treatment Plant and the Denny Way CSO on the structure of macroinfaunal communities in the Central Basin of Puget Sound. The Municipality of Metropolitan Seattle (METRO), Seattle, Washington.
- Comiskey, C., E. Waddell, R. Shokes and C. Hall. 1980. A baseline data analysis and synthesis document for the Bryan Mound Strategic Petroleum Reserve Program 12.5 Mile Disposal Site. Dravo Utility Constructor, New Orleans, Louisiana.
- Fauchald, K. 1977. The polychaete worms. Definitions and keys to the orders, families and genera. Science Series 28, Natural History Museum of Los Angeles County, California.
- Fauchald, K. and P. Jumars. 1979. The diet of worms: a study of polychaete feeding guilds. *Oceanogr. Mar. Biol. Ann. Rev.* 17:193-284.
- Folk, R.L. 1974. Petrology of sedimentary rocks. Hemphill Press, Austin, Texas.
- Gauch, H.L. 1977. ORDIFLEX. A flexible computer program for four ordination techniques: weighted averages, polar ordination, principal components analysis, and reciprocal averaging, release B. Ecology and Systematics, Cornell University, Ithaca, N.Y.
- Grassle, J.F. and J.P. Grassle. 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. *J. Mar. Res.* 32:253-284.
- Gray, J.S. 1979. Pollution-induced changes in populations. *Phil. Trans. Roy. Soc. Lon. Series B* 286:545-561.
- Gray, J.S. 1980. The measurement of effects of pollutants on benthic communities. *Rapp. P.-v. Reun. Cons. int. Explor. Mer* 179:188-193.
- Gray, J.S. 1981. Ecology of marine sediments. Cambridge University Press.

- Gray, J.S. and F.B. Mirza. 1979. A possible method for the detection of pollution-induced disturbance on marine benthic communities. *Mar. Poll. Bull.* 10:142-146.
- Hill, M. O. 1979a. TWINSpan. A computer program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ecology and Systematics, Cornell University.
- Hill, M.O. 1979b. DECORANA. A Fortran program for detrended correspondence analysis and reciprocal averaging. Ecology and Systematics, Cornell University.
- Hinde, P. and D.F. Boesch. 1981. Applications of multivariate analyses in assessing pollutant effects on marine benthos. 1. Effects of sampling design and analytical technique in assessing the chronic effects of an oil refinery. U.S. Environmental Protection Agency, Washington, D.C.
- Holland, J.S., N.J. Maciolek, and C.H. Oppenheimer. 1973. Galveston Bay benthic community structure as an indicator of water quality. *Contrib. Mar. Sci.* 17:169-188.
- Holme, N.A. and A.D. McIntyre., eds. 1971. Methods for the study of marine benthos. IBP handbook number 16. Blackwell Scientific Publications.
- Howmiller, R.P. and M.A. Scott. 1977. An environmental index based on relative abundance of oligochaete species. *J. Wat. Poll. Cont. Fed.* 49(2):809-815.
- Hurlbert, S.N. 1971. The non-concept of species diversity: a critique and alternative parameters. *Ecology* 52:577-586.
- Johnson, R.G. 1971. Animal-sediment relations in shallow water benthic communities. *Mar. Geol.* II:93-104.
- Johnson, R.G. 1972. Conceptual models of benthic marine communities. In: T.J.M. Schopf (ed.), *Models in paleobiology*. Freeman, Cooper and Co.
- Kennedy, E.A., B.M. James, W.E. Pequegnat, G.E. Hubbard, C.M. Potter, C.E. Comiskey, C.C. Brandt and T.A. Farmer. 1983. Ecological survey of the macroinfaunal community near the Flower Garden Banks. National Marine Fisheries Service, Southeast Fisheries Center, Galveston Laboratory, Galveston, Texas.
- Levinton, J.S. 1977. Ecology of shallow water deposit-feeding communities Quisset Harbor, Massachusetts. Pages 191-227 in B.C. Coull, ed. *Ecology of marine benthos*. University of South Carolina Press.
- Lie, U. 1974. Distribution and structure of benthic assemblages in Puget Sound, Washington, USA. *Mar. Biol.* 26:203-233.

- Lie, U. and J. Kelly. 1970. Benthic infauna communities off the coast of Washington and in Puget Sound: Identification and distribution of the communities. J. Fish. Res. Bd. Can. 27:621-651.
- Margalef, D.R. 1951. Diversidad de especies en les comunidades naturales. Publ. Inst. Biol. apl., Barcelona 9:5-27.
- McCall, P.L. 1978. Spatial-temporal distributions of Long Island Sound infauna: the role of bottom disturbance in a nearshore marine habitat. Pages 191-220 in M.C. Wiley, ed. Estuarine interactions. Academic Press.
- McIntosh, R.P. 1967. The continuum concept of vegetation. Bot. Rev. 33:130-187.
- Mills, E.L. 1969. The community concept in marine zoology, with comments on continua and instability in some marine communities. J. Fish. Res. Bd. Can. 26:1415-1428.
- Nie, N.H., C.H. Hull, J.G. Jenkins, K. Steinbrenner, and D.H. Bent. 1975. Statistical package for the social sciences. McGraw-Hill.
- Oliver, J.S., P.N. Slattery, L.W. Hulberg and J.W. Nybakken. 1977. Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay. Dredged Material Research Program, Technical Report D-77-27. U.S. Army Corps of Engineers, Washington, D.C.
- Pearson, T.H. and R. Rosenberg. 1976. A comparative study of the effects on the marine environment of wastes from cellulose industries in Scotland and Sweden. Ambio 5:77-79.
- Pearson, T. H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanog. Mar. Biol. Ann. Rev. 16:229-311.
- Petersen, C.G. 1918. The sea bottom and its production of fish-food. A survey of the work done in connection with valuation of the Danish waters from 1883-1917. Dansk Biol. Stat., Beretning (Reports) 25:1-62.
- Petersen, C.G. 1924. A brief survey of the animal communities in Danish waters. Amer. J. Sci. 7:343-354.
- Pielou, E.C. 1966. The measurement of diversity in different types of biological collections. J. Theoret. Biol. 13:131-144.
- Reish, D. 1957. The relationship of the polychaetous annelid Capitella capitata (Fabricius) to waste discharges of biological origin. Pages 195-200 in M. Tarzwell, ed. Biological problems in water pollution. U.S. Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

- Reish, D.J. 1960. The use of marine invertebrates as indicators of water quality. Pages 92-103 in E.A. Pearson, ed. 1st International conference on waste disposal in the marine environment, Berkeley, California. Pergamon Press.
- Reish, D.J. 1970. The effects of varying concentrations of nutrients, chlorinity and dissolved oxygen on polychaetous annelids. *Water Res.* 4:721-735.
- Reish, D.J. and H.A. Winter. 1954. The ecology of Alamitos Bay, California, with emphasis upon pollution. *Calif. Fish and Game* 40:105-121.
- Rhoads, D.C. 1974. Organism-sediment relations on the muddy sea floor. *Oceanogr. Mar. Biol. Ann. Rev.* 12:263-300.
- Rhoads, D.C. and D.K. Young. 1970. The influence of deposit feeding organisms on sediment stability and community trophic structure. *J. Mar. Res.* 28:150-178.
- Rhoads, D.C. and D.K. Young. 1971. Animal-sediment relations in Cape Cod Bay, Mass. I.A. Transect study. *Mar. Biol.* 11:242-254.
- Rhoads, D.C., R.C. Aller and M.B. Goldhaber. 1977. The influence of colonizing benthos on physical properties and chemical diagenesis of the estuarine Pages 113-138 in B.C. Coull, ed. Ecology of seafloor. marine benthos. The Belle W. Baruch Library in Marine Science Number 6. University of South Carolina Press.
- Rhoads, D.C., P.L. McCall, and J.Y. Yingst. 1978. Disturbance and production on the estuarine seafloor. *Amer. Sci.* 66(5):577-586.
- Sanders, H.L. 1956. Oceanography of Long Island Sound, 1952-1954. X. Biology of marine bottom communities. *Bull. Bingham Oceanogr. Coll.* 15:345-414.
- Sanders, H.L. 1958. Benthic studies in Buzzard's Bay. I. Animal-sediment relationships. *Limnol. Oceanogr.* 3:245-258.
- Sanders, H.L. 1960. Benthic studies in Buzzard's Bay. III. The structure of the soft-bottom community. *Limnol. Oceanogr.* 5:138-153.
- Sanders, H.L. 1968. Marine benthic diversity: a comparative study. *Am. Nat.* 102:243-282.
- Sanders, H.L. 1969. Benthic marine diversity and the stability-time hypothesis. *Brookhaven Symposia in Biology* 22:71-81.
- Sanders, H.L., J.F. Grassle, G.R. Hampson, L.S. Morse, S. Garner-Price, and C.C. Jones. 1980. Anatomy of an oil spill: long-term effects from the grounding of the barge Florida off West Falmouth, Massachusetts. *J. Mar. Res.* 38(2):265-380.
- Shannon, C.E. and W. Weaver. 1963. The mathematical theory of communication. University of Illinois Press.

- Shapiro, S.S., M.B. Wilk, and H.J. Chen. 1968. A comparative study of various tests for normality. *J. Amer. Statist. Assoc.* 63:1343-1372.
- Shaw, J.K., P.G. Johnson, R.M. Ewing, C.E. Comiskey, C.C. Brandt and T.A. Farmer. 1982. Benthic macroinfauna community characterizations in Mississippi Sound and adjacent waters. U.S. Army Engineer District, Mobile, Alabama.
- Simon, J.L. and D.M. Dauer. 1977. Reestablishment of a benthic community following natural defaunation. Pages 139-154 *in* B.C. Coull, ed. *Ecology of marine benthos*. The Belle W. Baruch Library in Marine Science Number 6. University of South Carolina Press.
- Sparck, R. 1937. The benthonic animal communities of the coastal waters. *Zool. Iceland* 1(6):1-45.
- State University System Institute of Oceanography. 1975. Compilation and summation of historical and existing physical oceanographic data from the eastern Gulf of Mexico in support of the creation of a MAFLA sampling program. Bureau of Land Management, Washington, D.C.
- Stephenson, W., W.T. Williams and G.N. Lance. 1970. The macrobenthos of Moreton Bay. *Ecol. Monogr.* 40:459-494.
- Swartz, R.C. 1972. Biological criteria of environmental change in the Chesapeake Bay. *Chesapeake Science Supplement* 13:S17-S41.
- Swartz, R.C., W.A. Deben, K.A. Sercu and J.D. Lamberson. 1982. Sediment toxicity and the distribution of amphipods in Commencement Bay, Washington, USA. *Mar. Poll. Bull.* 13(10):359-364.
- Thorson, G. 1957. Bottom communities (sublittoral and shallow shelf). *Geol. Soc. Am. Mem.* 67(1):461-534.
- Thorson, G. 1958. Parallel level-bottom communities, their temperature, adaptation, and their "balance" between predators and food animals. Pages 67-86 *in* A.A. Buzzati-Traverso, ed. *Perspectives in marine biology*. University of California Press.
- Uebelaker, J.M. and P.G. Johnson., eds. 1984. Taxonomic guide to the polychaetes of the northern Gulf of Mexico. U.S. Department of the Interior, Minerals Management Service, Metairie, Louisiana. 7 vols.
- U.S. Environmental Protection Agency. 1983. Final environmental impact statement (EIS) for Tampa Harbor, Florida ocean dredged material disposal site designation. Washington, D.C.
- U.S. Environmental Protection Agency. 1984. Studies and sample analyses for Tampa Bay survey no. 5. Washington, D.C.
- Watling, L. 1975. Analysis of structural variations in a shallow estuarine deposit-feeding community. *J. exp. mar. Biol. Ecol.* 19:275-313.

- Whittaker, R.H. 1962. Classification of natural communities. *Botan. Rev.* 28:1-239.
- Whittaker, R.H. 1967. Gradient analysis of vegetation. *Biol. Rev.* 42:207-264.
- Whittaker, R.H. and H.L. Gauch. 1973. Evaluation of ordination techniques. Pages 7-31 in R.H. Whittaker, ed. Ordination and classification of communities. Handbook of vegetation science, volume 5.
- Word, J.Q. 1978. The infaunal trophic index. Pages 19-41 in W. Bascom, ed. Coastal water research project annual report for the year ended 30 June 1978. Southern California Coastal Water Research Project, El Segundo, California.
- Word, J.Q. 1981. Classification of benthic invertebrates into Infaunal Trophic Index feeding groups. Pages 103-121 in W. Bascom, ed. Coastal water research project biennial report for the years 1979-1980. Southern California Coastal Water Research Project, Long Beach, California.
- Word, J.Q. and P.L. Striplin. 1981. Effects of municipal waste discharge on the benthic invertebrate communities living in the erosional environment off West Point: toxic and nutritional aspects. Municipality of Metropolitan Seattle (METRO), Seattle, Washington.

VITA

Terrell Allen Farmer was born in Knoxville, Tennessee on October 23, 1951. He attended Lonsdale Elementary School and was graduated from Rule High School in June 1969. The following September, he entered the University of Tennessee at Knoxville, and received a Bachelor of Arts degree in Psychology. He was admitted to the Graduate Program in Ecology at the University of Tennessee in Knoxville in the spring of 1979, and received the Master of Science degree with a major in Ecology in March 1986.

From 1979 to 1986, Mr. Farmer was employed as a consultant and later a staff scientist in the Environmental Sciences Division of Science Applications International Corporation in Oak Ridge, Tennessee. He will be employed by Science Applications International Corporation after graduation.