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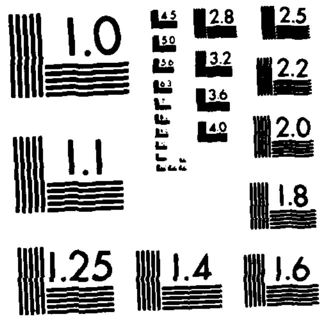
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A Study of the Benthic Macrofauna at the Central Long Island Sound Disposal Site

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PREFACE

This report was prepared under project assignment number TU0220, "Damos Sampling and Analysis," Principal Investigator, A. L. Brooks. The sponsoring activity is the New England Division, Army Corps of Engineers, Program Manager, Richard C. Semonian.

The technical reviewer for this report was Mr. B. Cole, Code 33A.

The author acknowledges the financial support provided by the Army Corps of Engineers, New England Division. They also furnished grain size data and most of the analyses of heavy metal and volatile solid content of sediment grabs collected from the study area. Chemical analyses of earlier collections were performed by Pamela Huntley.

Most of the species identification and initial processing of the benthic invertebrates was done by Caroline Karp; earlier data of this nature were provided by members at the research staff of the New England Aquarium.

Many persons assisted during the field operations by collecting hundreds of grab samples. I thank them all, but special thanks to Dr. Robert W. Morton, Dr. Everett Jones, Gary Paquette, and Mark Silvia.

Finally, I wish to thank the men of the R/V UCONN, Captain Jack Blume, Captain Larry Birch, and "Red" Banker for their congenial cooperation and flawless ship handling.

Reviewed and Approved: 14 May 1984

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Sediments of multiple sites within the Central Long Island Sound (CLIS) disposal site of New Haven, CT, were examined for grain size distribution, heavy metals content, volatile solids, and benthic organisms as part of a study of the effects of dredged material disposal and capping operations.

CLIS sediments can be classified according to their grain size, content of heavy metals, and volatile solids. It is shown that a greater percentage

20. Continued

of samples collected from the natural bottom were higher in heavy metal and volatile solid content than was seen at the center of the capped disposal mounds. This indicated the success of the capping operation in isolating the highly contaminated underlying dredge spoil from the surrounding sediments.

The study also showed the striking effect of sediment grain size and composition on the community structure of the benthic population as well as the remarkable ability of benthic organisms to recolonize recently deposited sedimentary material.

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INTRODUCTION

This report presents the results of an intensive ongoing study of the macrobenthos in sediment samples collected from an active dredge material disposal site located in Long Island Sound offshore from New Haven, Connecticut. The research is part of a larger, long-term project, the Disposal Area MOnitoring System (DAMOS), conducted under the sponsorship of the New England Division of the U.S. Army Corps of Engineers (Annual Reports, 1979, 1980). DAMOS was initiated in the summer of 1977 to examine two major aspects of monitoring dredged material disposal: (1) the physical and chemical stability of the disposed material, and (2) the impact on the biota in and adjacent to the disposal mounds.

During the course of the DAMOS program, over 800 sediment samples have been collected for analysis of biological content from active, inactive, or potential dredge material disposal sites between Rockland, Maine, and western Long Island Sound. Analyses of samples collected during the spring and summer of 1979 have been reported previously (DAMOS Annual Reports for 1978, 1979, and 1980). Most of the data included here are from samples collected from the Central Long Island Sound (CLIS) disposal site during the spring and summer of 1980. However, occasional reference will be made to data resulting from earlier collections, especially when acquired prior to disposal operations.

This report is a consolidation of recent information on heavy metal concentration, grain size characteristics, and bottom sediment organic material content. It also presents a correlation of these data with the numerical densities and species composition of the benthic populations at the studied sites. In addition, the use of a precision navigation and bathymetric data acquisition system has afforded a unique opportunity to examine the fine-scale spatial relationships between samples within a repetitive series of bottom sediment grabs (see DAMOS Annual Report, 1979, Vol. I).

DESCRIPTION OF THE DISPOSAL SITE AREA

The CLIS disposal site lies approximately 10 km SSE of the entrance to New Haven harbor (figure 1). Water depth is approximately 20 m and the energy regime is dominated by low energy tidal currents permitting the accumulation of sediments that are composed primarily of silt and clay. Mean surface sediment temperatures range from a low 2°C in January and February to a high 22°C in July and August; salinity ranges between about 25-28°/oo. Additional information on the oceanographic and physical measurements made at this site may be found in the DAMOS Annual Reports for 1978, 1979, and 1980. Other studies at or in the vicinity of the CLIS site are reported by Sanders, 1956; Riley, 1956; Rhoads, 1972, 1973a, 1973b, 1974a, 1974b, and 1974c; and Rhoads et al., 1975.

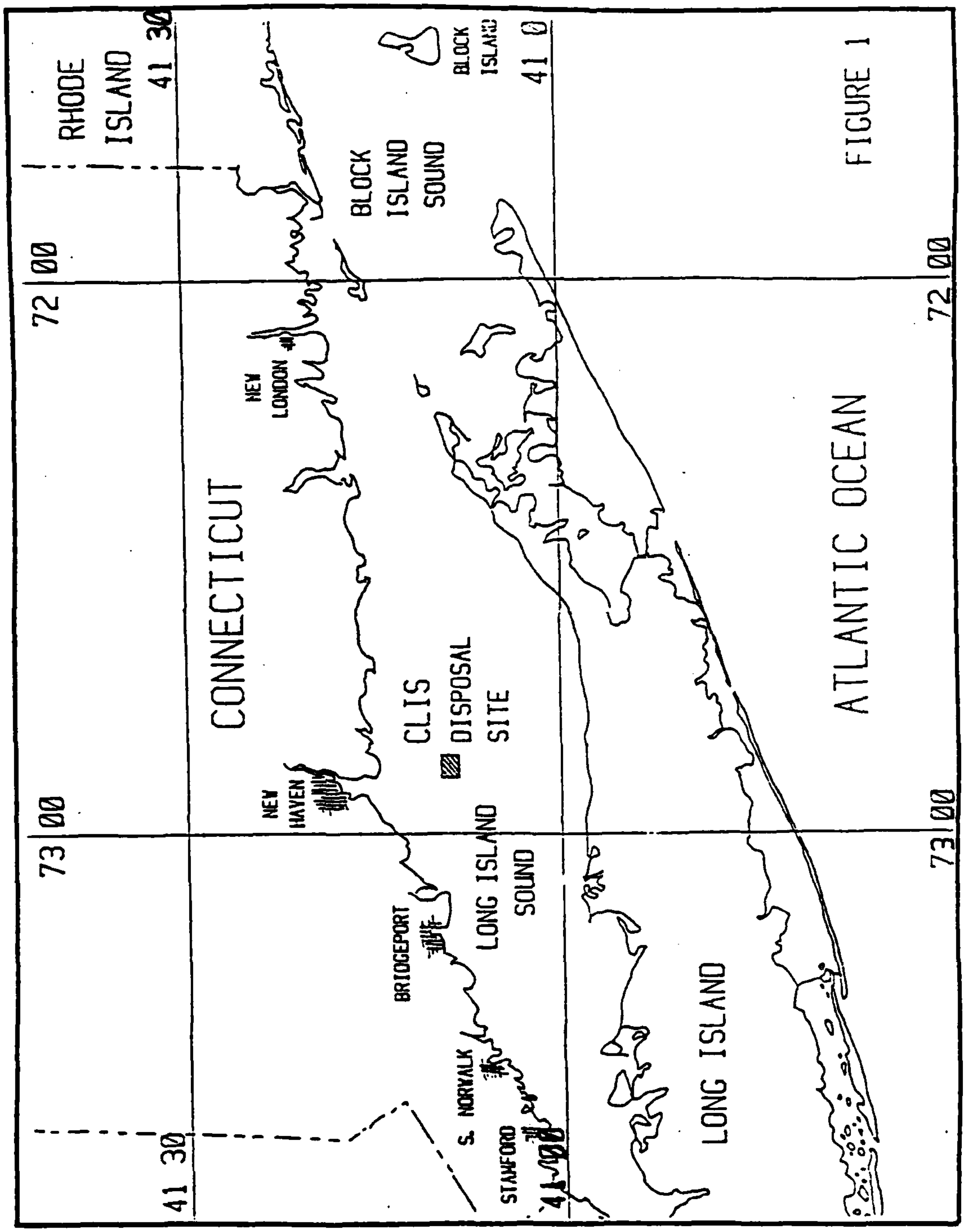


Figure 1. Location of Central Long Island Sound Disposal Site

DREDGE MATERIAL DISPOSAL HISTORY

The New Haven dredging project of 1974 was the only significant dumping at the CLIS disposal site until the disposal of dredged material from Stamford and Norwalk harbors. The chronology and rationale for the dredging and disposal of Stamford harbor material and the subsequent capping of the north and south mounds that were created is discussed in detail by Morton (1980). Morton (1981) also detailed the Norwalk harbor dredging and disposal operations.

During the spring of 1979, dredged material from Stamford harbor was deposited at two locations within the CLIS site at the north and south mounds. The south mound was capped with silt from New Haven harbor and the sediment at the north mound was capped with a fine sand removed from the outer channel at New Haven.

At the Norwalk disposal mound dredged material (relatively high in contaminants) was capped with material dredged from the outer section of Norwalk harbor. According to Morton (1980), "The objectives of these capping procedures were to isolate the enriched material from benthic fauna and the overlying water column and to evaluate the relative merits of sand and silt as capping materials in terms of coverage, stability, effectiveness in isolating contaminants, and recolonization potential."

The chronology of these events and their respective dredged material volumes are summarized in table 1.

Table 1. Dates and Volumes for the Stamford-New Haven and Norwalk Harbor Dredging Projects

DREDGING LOCATION AND DATES		DUMP LOCATIONS AND QUANTITIES (CY)	
Stamford Harbor Branch Channel		South Pile	North Pile
25 March - 22 April 1979		49,525	--
23 April - 16 June 1979		--	40,275
26 Sept - 18 Oct 1979		7,725	--
	Total	57,250	40,275
New Haven Harbor 35' Channel (Cap)			
1 May - 15 June 1979		143,125	--
16 June - 21 June 1979		--	84,000
29 Jan - June 1980		144,725	--
	Total	287,850	84,000
Norwalk Harbor			
11 April - 30 May 1980		88,829	--
31 Jan - 3 June 1981		235,809	--
	Total	324,638	

STATION LOCATIONS

The specific stations and their relative positions are shown in figure 2. An additional station, designated CLIS Reference (CLIS REF) is located approximately 1 km south of the site. Within this area, disposal points are designated according to the source of dredged material (i.e., Stamford-New Haven (STNH) or Norwalk-New Haven (NORNH)). Biological and sediment stations are further labeled according to their position in relation to the center of the disposal site (i.e., Stamford-New Haven-North-pile center is STNH-N-CTR).

The original New Haven disposal site (NHDS) is shown in figure 2. One additional station from which samples have been collected but which is not shown in the figure is referred to as the New Haven Reference (NH REF) (also Rhoads' 1978 reference station) located about 5.5 km to the northwest.

The center station (CTR) is located on the approximate top center of the disposal mound. The inner edge (I.E.) lies just within the extreme limit of the flanks of the mound where organisms may be influenced by direct contact with a thin veneer of dredge material overlaying natural sediments. The outer edge (O.E.) stations are the natural bottom in areas well removed from the transitional zone, but close enough to reasonably expect an occasional presence of some dredge material components.

The location of these stations was determined from bathymetric survey records, examination of closely spaced sediment grabs along transects to the north, east, south, and west of the mound center, and diver observations. Diver observations were made, for the most part, by Lance Stewart and Robert DeGoursey. Stewart reports (1980) that the limits of the disposal mound at the south site could be determined after dumping by the presence of cohesive clay mounds and differences in texture and color between the dredge material and the natural bottom. Disposal mound boundaries at the north site were easily delineated by the presence of shell debris associated with the sand cap. According to Stewart "... the clearest evidence of the presence of new material was the absence of the solitary hydroid, Corymorpha pendula, which were buried by the disposal operation." This species, present in the spring in high densities on natural bottom, appears to be an excellent indicator of the margins of recently deposited dredge material. During the summer it is replaced by the burrowing anemone, Ceriantheopsis americanus, which has also proved useful in detection of disposal mound margins.

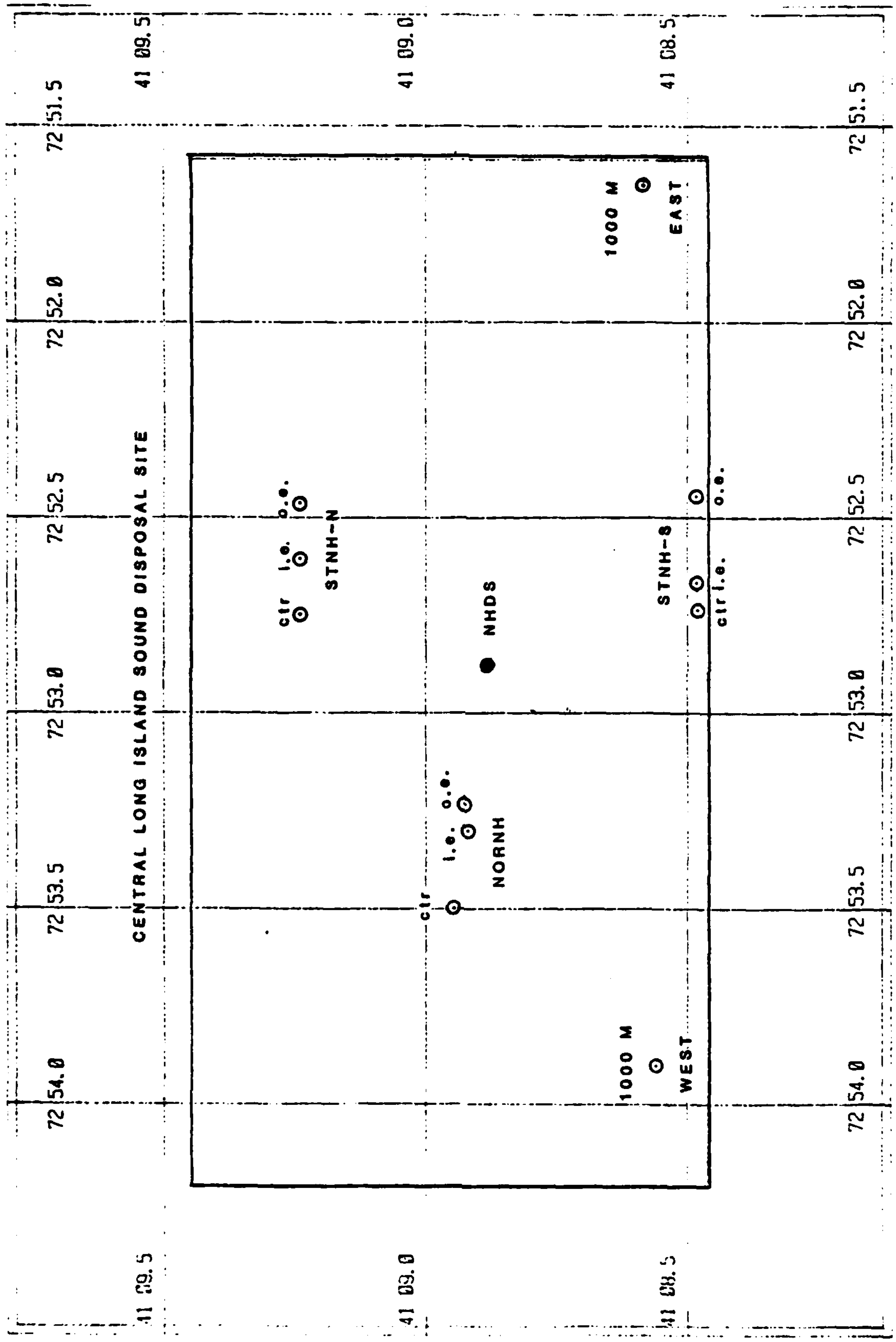


Figure 2. Central Long Island Sound Disposal Site

METHODS AND MATERIALS

A detailed description of the sampling methods and procedures has been presented in previous progress reports (DAMOS Contributions 13 and 14, 1980); summaries are included in DAMOS Annual Reports for 1978, 1979 and 1980.

SAMPLING SCHEDULE

Table 2 shows the dates on which sediment samples for analysis of biological content were collected at the CLIS stations. The numbers in parentheses after each date indicate the number of samples collected. Numerous cruises, not shown in the table, have been made during bathymetric surveys and bulk sediment samples were collected for physical and chemical analyses. Each site shown in table 2 will first be examined individually. Later sections will endeavor to draw these individual results together in a comprehensive comparison of all the New Haven sites.

A complete survey of bathymetry, bulk sediment grabs for chemical and physical analysis, and biological grabs was conducted before disposal operations in order to obtain baseline information at each site. Predisposal collections of sediment for analysis of the benthos were made at the proposed center of the Stamford-New Haven south mound and at stations 1000 m to the east and west of this center point on 26 January 1979 (see table 2). On 21 March 1979, predisposal collections were made at the proposed center of the Stamford-New Haven north mound; on 1 April 1980, baseline information was obtained from the proposed center of the Norwalk-New Haven site. Although cruises have often been made to monitor the progress of disposal operations, once dumping was begun, samples of the benthos were collected only after completion of disposal.

SAMPLING PROCEDURES

Prior to January 1979 samples of the benthos were collected with an anchor dredge; since then a Smith-McIntyre bottom sampler has been used. When full, the sampler holds about 14 l of sediment and samples 0.1 m^2 of sediment surface. Since 1979, studies at the New Haven disposal sites were intensified and the number of grabs for analysis of the benthos was increased from five to ten per station and three stations (i.e. CTR, I.E., and O.E.) were established at each site.

Two 100 ml subsamples of sediment were taken from each of the ten biological grabs collected from each station. A complete grain size analysis was performed on one of the subsamples and the other was analyzed for content of five heavy metals (i.e., chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn)) and percent volatile solids. Analyses were performed by the New England Division of the Army Corps of Engineers and are complete for all grabs collected through the winter of 1981-82. Speciation and identification of benthic organisms are complete for all samples collected up through the spring-summer of 1979. Analysis of the benthos in at least three of the ten samples collected from each of the New Haven stations during the spring-summer 1980 is complete and forms the basis for this report. All other samples are archived and awaiting examination.

Table 2. Sample Collection Dates

		Winter-Spring 1977-78	Spring-Summer 1978	Winter 1978-79	Spring-Summer 1979	Spring 1980	Summer 1980	Winter 1980-81	Summer 1981	Winter 1981-82
1.	New Haven Dump Site (Original)	04/13/78(3)	07/29/78(3)	01/19/79(5)	05/21/79(5)	----	----	----	----	----
2.	New Haven Reference (N.W. Control)	04/13/78(3)	07/29/78(3)	01/19/79(5)	05/21/79(5)	----	----	----	----	----
3.	Central Long Island Sound Reference	----	----	----	----	04/01/80(10)	09/04/80(10)	01/26/81(10)	08/19/80(10)	01/30/82(10)
4.	Stamford-New Haven-N-CTR	----	----	----	03/21/79(5)	04/01/80(10)	09/04/80(10)	01/28/81(10)	----	01/30/82(10)
5.	Stamford-New Haven-N-I.E. (200m E)	----	----	----	----	04/02/80(10)	09/04/80(10)	01/28/81(10)	----	01/30/82(8)
6.	Stamford-New Haven-N-O.E. (400m E)	----	----	----	----	04/02/80(10)	----	01/28/81(10)	----	02/04/82(8)
7.	Stamford-New Haven-S-CTR.	----	----	01/26/79(5)	08/09/79(5)	----	09/05/80(10)	01/25/81(10)	----	01/29/82(10)
8.	Stamford-New Haven-S-I.E. (100m E)	----	----	----	----	----	09/05/80(10)	01/25/80(10)	----	01/29/82(8)
9.	Stamford-New Haven-S-O.E. (300m E)	----	----	----	----	----	09/03/80(10)	----	----	----
10.	Stamford-New Haven-S-O.E. (400m E)	----	----	----	----	----	----	01/26/81(10)	----	01/29/82(8)
11.	Stamford-New Haven-S-(1000m E)	----	----	01/26/79(5)	05/21/79(5) 08/09/79(5)	----	----	----	----	----
12.	Stamford-New Haven-S-(1000m W)	----	----	01/26/79(5)	05/22/79(5) 08/09/79(5)	----	----	----	----	----
13.	Norwalk-New Haven-CTR	----	----	----	----	04/01/80(10)	----	----	08/20/81(10)	02/4-5/82(1[illegible]
14.	Norwalk-New Hven-I.E. (300m E)	----	----	----		----	----	----	08/21/81(10)	02/4-5/82(8)
15.	Norwalk-New Haven-O.E. (450m E)	----	----	----	----	----	----	----	08/20/81(10)	02/4-5/82([illegible]

RESULTS AND DISCUSSION

CENTRAL LONG ISLAND SOUND REFERENCE (CLIS REF)

The CLIS REF station, as its name implies, was established as a reference station against which the other New Haven sites could be compared. It is located about 1 km south of the STNH-S disposal mound in an area where the sediments and benthic population are characteristic of the natural bottom in the region. The CLIS REF station was first sampled on 1 April 1980 and again on 5 September 1980, 26 January 1981, 19 August 1981, and 30 January 1982. No biological data are yet available for the three most recent collections.

Sediment Grain Size

Appendix A presents the sediment mean grain size in millimeters and phi (ϕ) units for each biological grab collected at the CLIS disposal site. Mean grain sizes measured from sediments collected at the CLIS REF station are remarkably consistent and, the sample-to-sample variability is the lowest for any of the New Haven sites. Examination of the overall means for grain size, however, is somewhat misleading because the values for Q_1 and Q_3 (not shown in Appendix A) used to calculate the mean and standard deviation for the April 1980 series of grabs differ considerably from the comparable values for the September 1980 and the January and August 1981 series. That a real difference exists between these two sets of data is further shown by the differences in the percent silt and clay composition. Sediments collected in April 1980 are composed of almost 90% silt and about 8% clay. The percent composition of sediments collected on the other three dates, however, are internally consistent but with a silt content of about 65% and a clay content of about 30%. After examining survey log records, it was apparent that the April samples were collected from a location somewhat removed from that designated as CLIS REF. However, because of the between sample similarity in sediment chemistry and predominant species, the samples are treated as CLIS REF station sediments.

Sediment Chemistry

Sediment chemistry means for Cr, Cu, Pb, Ni and Zn, percent volatile solids (EPA method of determination), and the pooled means of Cr, Cu and Pb for samples collected from CLIS disposal site on each of four dates are given in Appendix B. At the CLIS REF station, the concentrations of the parameters are roughly comparable over all four sampling dates although considerable differences in variance are apparent.

The Army Corps of Engineers has compiled a list of sediment test data for marine sediments based on the mean values of 20 chemical parameters in 792 samples from 43 harbors within the North Atlantic Tidal System (Corps of Engineers, 1982). Comparable mean values for selected parameters have been calculated from 225 biological-type sediment samples collected from all of the stations included here. A comparison of this data set with means and standard deviations reported for the Corps data is shown in table 3. Although the total number of samples collected was 225, it was not possible to use all of the data because the concentration of heavy metals in some sediment samples was below the limit of the analytical tests. The exclusion of these values from the calculation of mean and standard deviation resulted in higher values than would have been calculated if all samples had been available. In all cases, however, the means and standard deviations of heavy metal concentrations for the New Haven disposal site are well below COE data derived from harbor samples. This comparison furnishes a point of reference and indicates that the sediments of the natural bottom at the CLIS REF station and other locations within the CLIS disposal site are significantly lower in concentration of Cr, Cu, Pb, Ni, Zu, and volatile solids than most harbor material sampled by the Corps.

Table 3. Comparison of Means and Standard Deviations Between U.S. Army Corps of Engineer Harbor Samples and CLIS Disposal Site Samples

	COE DATA			NEW HAVEN DATA		
PARAMETER	Mean	Std Dev	N	Mean	Std Dev	N
Chromium (PPM)	160.0	311.5	598	66.8	37.7	223
Copper (PPM)	259.8	533.8	601	76.8	38.5	217
Lead (PPM)	145.3	282.8	601	58.4	25.3	195
Nickel (PPM)	49.2	44.8	600	43.4	24.9	197
Zinc (PPM)	283.0	363.2	601	171.9	76.1	225
Volatile Solids (%)	6.18	4.47	536	5.4	2.0	225

Benthic Macrofauna

Appendix C presents the benthic macrofauna data summary for samples collected in April and September 1980, as well as the mean number of individuals (N) per grab sample, the mean number of species (S), the mean value for the Shannon-Weaver index of diversity (H), the mean value for the equitability index (J), and the 95% confidence intervals of these means. As mentioned previously, benthic macrofauna data for samples collected prior to 1980 are reported in DAMOS Annual Reports for 1978, 1979, and 1980.

Data showing the numeric density of the predominant species in the benthos at the CLIS disposal site are given in Appendix D. The format for these tables essentially follows that recommended by Swartz (1978). Predominant species are defined as those making up at least 2% of the total number of individuals in the entire sample. The coefficient of dispersion (CD), which is the variance/mean ratio, indicates a random (CD=1), a clumped (CD<1) or even (CD>1) distribution of a species on the bottom. Other columns in these tables are self-explanatory. One additional comment concerns the identification of two anemones believed to be Cerianthus borealis and Ceriantheopsis americanus. Two distinct species have been found in the New Haven samples, but until taxonomic uncertainties are clarified, they are listed as Ceriantharian sp. A and Ceriantharian sp. B.

Discussion

Throughout the DAMOS benthos studies sample-to-sample and station-to-station variability in numbers of individuals and species composition has been high. Seasonal and annual fluctuations of certain species at the New Haven sites may be quite stable while others may suddenly appear, often in high population densities, complete their life cycle, and disappear within weeks. The interpretation of such fluctuations is further complicated by varying degrees of patchiness that may result in greater differences between closely spaced samples than in those more widely separated. The reasons for such fluctuations and patchiness have been attributed to numerous factors that include climate (COE, 1956); dispersion or concentration of planktonic larvae by freshwater runoff or currents (Ayers, 1956); factors affecting the settling of larvae on a suitable substrate and their successful metamorphosis to the adult benthic form; the influence of physical disturbance on ecological succession (Rhoads et al., 1978), and catastrophic or subtle effects brought about by environmental changes in response to man's activities. Due to these considerations, benthic populations undergo natural perturbations that may vary in space, time, magnitude and character. The extensive data base that has resulted from long term sampling of the natural bottom of New Haven sites has provided insights into the patterns of change in the community structure that are helpful in interpreting sample-to-sample differences in biological composition over time and space. In general, the composition of predominant species in natural-bottom New Haven stations reflects, to a greater degree, the season in which the collection was made rather than the station from which the organisms were collected.

Study of the data shows that the polychaete worm, Nephthys incisa, is present in relatively constant, high numbers in all natural bottom New Haven sediments during all months sampled. Another polychaete, Melinna cristata, was present in moderately high, moderately variable numbers during most months sampled and occurred at most stations. The mollusc, Nucula proxima, that predominates in samples collected during the spring and summer is present at most stations, but fluctuates widely in number of individuals per sample. Another mollusc, Mulinia lateralis, is found in moderate-to-low numbers at most stations in the spring but was found to reach a peak in abundance at only two stations during the summer. A mollusc that appears to predominate during the summer is Yoldia limatula, though it was also abundant at one station in late spring. The phoronid worm, Phoronis architecta, appears in low-to-moderate numbers in late winter samples and increases in abundance in the spring. It is rarely predominant in summer months. The solitary hydroid, Corymorpha pendula, already discussed as an indicator of disposal mound margins, is present in large numbers on most natural bottom areas off New Haven but for only a relatively short period in the spring. And finally, the two burrowing anemones, Ceriantharian sp. A, which predominates in late winter and spring, and Ceriantharian sp. B, which appears in the summer, are found in moderate numbers at most natural bottom stations.

The composition of the predominant species in the benthic community at CLIS REF station for the spring and summer is shown in Appendix D and fits the generalized case. Nucula proxima is abundant at this station in both seasons, but between-sample variability in numbers of individuals is fairly high. The ever present Nephthys incisa is ranked second in abundance on both dates with an approximately equal number of individuals in all grabs. Corymorpha pendula and Ceriantharian sp. A, present in the spring samples, are replaced by Ceriantharian sp. B in the summer collection. Yoldia limatula, another species that peaks in the summer, is present in the summer samples but absent from the spring collection. The outstanding exception to the general case is Phoronis architecta, which comprises 11.9% of the total number of individuals in the spring samples but also occurs as a dominant (4.2%) in the summer. This is the only natural-bottom station, however, where this species has occupied a predominant position during the summer.

STAMFORD-NEW HAVEN-NORTH-CENTER, INNER EDGE AND OUTER EDGE (STNH-N-CTR, I.E., O.E.)

Bulk sediment samples and biological grabs were collected from the natural bottom at the proposed center of the New Haven north site in March 1979, about one month before the disposal of Stamford Harbor channel material began. Postdisposal samples for which grain size and heavy metal data are available from the STNH-N-CTR and I.E. stations on 1-2 April 1980, 4 September 1980 and 28 January 1981. Samples from the O.E. station were collected on 2 April 1980 and 28 January 1981.

Sediment Grain Size

Sediment mean grain size and percent gravel, sand, silt and clay for all grabs collected from the above stations are shown in Appendix A. The mean grain size and percent size class data for the postdisposal samples at the three stations show sediments with distinctly different characteristics. Sediments at the center, where the sand cap was not penetrated by the Smith-McIntyre grab sampler, show an overall mean grain size of 0.23 mm, classified as a medium-to-fine sand. As might be expected, the between-grab variability is greatest at the center of the disposal pile and diminishes with increasing distance from the center. This pattern of variability has been observed at other recently deposited disposal mounds. The condition is due, at least in part, to the fact that the bulk of the dredged material from each separate scow load drops immediately to the bottom and remains there. Turbidity currents generated at the time of dumping flow toward the flanks creating an increasing degree of uniformity of sedimentary material as they differentially deposit their sediment load.

Mean grain size at the I.E. station was classified as very fine sand to coarse silt; thus, reflecting the mix of material collected when the grab sampler penetrated the veneer of surface sand to the underlying finer material. Grain size data for material collected at the north mound O.E. station show this sediment to be similar in mean grain size to the natural bottom sediments at the CLIS REF station and are classified as medium to fine silt.

As might be expected, there are rather drastic changes in the percent composition of sediment size classes between the three stations at the north site. CTR sediment (which is all cap material) is over 92% sand. Sediment 200 m east of CTR, at the I.E. station, is composed of about 50% sand, 40% silt, and 10% clay. At the O.E. station, 400 m east of the mound center, sediments are similar in composition to those found at the CLIS REF station.

There appears to be a trend toward an increasing percent silt-clay fraction at the CTR and the I.E. stations as a function of time. This observation suggests that in-situ processes are gradually depositing natural material over the dredged material mound. This same conclusion was reached by Stewart (1980) during a diving inspection of the north site in September 1980. The character of the data at the O.E. station, however, does not allow one to reach the same conclusion. In this case there is a significant decrease in percent silt with a corresponding increase in percent clay. If these are natural sediments, as is believed, the deposition of additional natural material should be undetectable.

Sediment Chemistry

The sediment chemistry means and their standard deviations for the STNH-N-CTR, I.E., and O.E. stations are given in Appendix B. These data were generated from analyses of sediment taken from the same samples used for grain size analysis. The concentration of measured chemical parameters in the sediments at the mound center was the lowest of any sediments collected from the study area and, in several cases, was below the detectable limit of the analytical test. The chemical data for the CTR and I.E. stations show a trend toward lower concentrations over the duration of the 19 month sampling period. Though the evidence is inconclusive, this observation suggests that there may have been some initial low level leaching of material through the sand cap. A comparison of the heavy metal concentrations at the north CTR and I.E. stations with those at the CLIS REF, however, reveals that, in nearly every case, concentrations are lower on the pile flank than on the natural bottom.

Sediment chemistry means at the O.E. station, 400 m east of the north pile center, are distinctly higher than at the CTR or I.E. and closely resemble values obtained for sediments at the CLIS REF.

Benthic Macrofauna

Benthic macrofauna total data summaries for the north stations are shown in Appendix C. Predisposal samples collected in March 1979 at the proposed center of the north site are quite low in numbers of species and numbers of individuals. This results from a normal reduction in population densities during the winter and early spring. In April 1980, one year after the predisposal collections and 10 months after completion of the capping operation, a moderate increase in total numbers of individuals occurred at all three north mound stations. At the CTR station there was a statistically significant increase in numbers of species between the March 1979 and April 1980 collections. During the five months between the April and September 1980 samplings, population densities and numbers of species continued to increase at the CTR and I.E. with a statistically significant increase in number of individuals at the latter station.

As is readily apparent from Appendix D, which gives numeric density data for predominant species at the north mound stations, the species composition of the benthic population residing in the fine sand cap at the pile center differs drastically from the predisposal community and from postdisposal populations at the I.E. and O.E. stations. For the most part, the predominant species compositions of the predisposal collections at the CTR station were very similar to the post disposal samples from the O.E. stations and the CLIS REF station. Community structure at the I.E. station more closely resembles that at the O.E. station, but contains a greater proportion of early colonizers. Most of the differences in species composition between listings for the predisposal CTR and postdisposal O.E. stations can be attributed to seasonal changes in the community structure rather than proximity to, or distance from, a disposal mound.

Discussion

As is well known, the grain size distribution of sedimentary material has a profound effect on the structure of the resident benthic population. This is clearly shown for the north site stations if one examines the relative contribution of feeding types within the predominant species at each station. In the predisposal collections at the proposed north mound CTR, post disposal samples from the I.E. in September 1980, and O.E. in April 1980, 68 to 73% of the total number of individuals classified as predominant species were deposit feeders while suspension feeders comprised between 11 and 21% of the total. After disposal, these ratios were roughly reversed at the north CTR station from 52 to 64% suspension feeders and 6 to 16% deposit feeders. The population at the I.E. station in April 1980 exhibits a structure that appears intermediate between these two extremes with approximately equal percentages (50% suspension feeders and 39% deposit feeders) of each feeding type. The size class composition shows a significant increase in clay content between the April and September collections at the I.E. station that may explain the shift in proportions of feeding types observed between the dates.

In effect, the disposal mound at the north site has created an island of fine sand surrounded by soft sediments with high percentages of silt and clay. Because of the widely different character of the cap material and the surrounding sediments (permitting ease in recognition of both elements) and the confined nature of the cap material (resulting from carefully controlled point dumping) this site has afforded an excellent opportunity to examine results of the capping operation in terms of sediment grain size distributions, effects on sediment chemistry, and the influence of these factors on the benthic populations on and adjacent to the disposal mound. Evidence has been presented that shows the ability of the sand cap to contain all measured chemical parameters within the contaminated sediments, which it covers at least to a degree of contamination that does not exceed the natural bottom. Additional evidence has shown the remarkable ability of benthic organisms to rapidly establish a community of organisms on the sand cap that is totally different in species composition and feeding type and greater in numbers of species and numbers of individuals than in the surrounding bottom. It also suggests that the population at the I.E. station closely resembles that of the O.E., but is influenced slightly by the adjacent disposal mound. This is reflected in differences in the proportions of deposit versus suspension feeders and appears to be related to differences in percent composition of sediment size classes.

STAMFORD-NEW HAVEN-SOUTH-CENTER, INNER EDGE, OUTER EDGE (STNH-S-CTR, I.E., O.E.) AND 1000 m EAST AND WEST OF THE MOUNT CENTER

Disposal of Stamford material at the south site began on 25 March 1979 and ended on 22 April 1979. The mound was capped by silt from New Haven harbor between 1 May and 15 June 1979. Additional cap material was deposited between 29 January and 3 June 1980. Predisposal collections of sediments for grain size analysis, sediment chemistry, and biological content were taken from the proposed CTR of the disposal pile and 1000 m to the east and west of the CTR on 26 January 1979. Samples were again collected from the latter two stations on 21-22 May 1979. On 9 August 1979, approximately two months after the initial phase of the capping operation, collections were made at the center of the newly created mound and at stations 1000 m to the east and west of the mound. Additional samples were collected from the mound center and the I.E. and O.E. stations on 5 September 1980 and again on 25-26 January 1981 (approximately three and eight months, respectively, following completion of the second phase of capping).

Sediment Grain Size

Predisposal sediments at the south site center (Appendix A) were somewhat larger in mean grain size, contained higher percentages of sand, and lower percentages of silt and clay than sediments at the CLIS REF. Samples collected at the CTR in September 1980, three months after completion of the capping operation, indicated a still coarser sediment with slightly lower percentages of silt and clay and larger percentages of sand-sized material than was present at this station prior to disposal. By January 1981, almost eight months after disposal, samples at the CTR indicated a generally finer sediment than seen in September 1980 and a sediment composition approaching that of the original bottom. This slight, but noticeable change, is probably due to the fracturing and erosion of cohesive clumps of dredged material caused by natural physical forces and the activity of benthic organisms (first suggested by Stewart, 1980). This would result in a smoothing of the mound surface as fine materials accumulate in the inter-clump depressions and voids. Sediments at the I.E. station (Appendix A) appear to reflect some influence of the cap material, but because of the general similarity between this material and the sediments of the natural bottom, the degree of influence is difficult to ascertain.

The O.E. station was established at a point located 300 m to the east of the CTR and samples were collected from there in September 1980. The sediments here had the distinct appearance of dredged material. As a result, the station was moved to a point 400 m to the east of the pile center when it was next sampled on 25 January 1981. Mean grain size on this date was somewhat larger than the original bottom due mostly to the single high value for grab number 2. Sediment size class composition, however, is nearly identical to that of the original natural bottom.

Sediment Chemistry

Sediment chemistry means for STNH-S-CTR, I.E., and O.E. stations are shown in Appendix B. In general, concentrations of heavy metals at the center in September 1980 and January 1981 (three months and eight months, respectively, after capping) were similar but somewhat higher than in the predisposal sediments at the CLIS REF station. Heavy metal content at the I.E. station in September 1980 closely resembled that of the center material but was noticeably reduced to the levels seen at the CLIS REF by the time it was sampled in January 1981. High heavy metal content in the sediments collected from the STNH-S-O.E. station in September 1980 was undoubtedly due to the sampling of clean-up material from Stamford harbor. Sediment chemistry means for collections made in January 1981 at the newly established O.E. station reveal values that closely resemble concentrations in predisposal, natural bottom sediments.

Benthic Macrofauna

The distribution of benthic macrofauna is summarized for STNH-S-CTR, I.E. and O.E. stations in Appendix C. The low level between-sample variability in numbers of individuals collected in the predisposal samples in January 1979 lends credence to the reliability of the counts, as well as the calculated mean number of individuals per grab sample. When sampled in August 1979, slightly less than two months after completion of phase one of the capping operation, the numbers of individuals at the south CTR station was drastically reduced. These data, though indicating low population densities, show the ability of the benthos to begin the recolonization of a disposal mound in a relatively short period of time. Samples taken one year later in September 1980 at the mound CTR and O.E. station contain a mean number of individuals per grab that is almost identical with that found in samples collected on the same date at CLIS REF. The apparent low population density at the I.E. station in September 1980 is probably related to disposal of clean-up material from Stamford.

Numeric density data for predominant species at stations from the south site are shown in Appendix D. It is evident that the differences in species composition between stations at the south site are far more subtle than at the north sites. At the north site, the differences were closely related to mean grain size and, perhaps even more importantly, to sediment size class composition with little apparent relationship to the concentration of heavy metals. As pointed out by Walker et al. (1979), "Although benthic fauna appears to be relatively insensitive to the observed concentrations of metals in the sediments, other variables (which are unspecified) highly correlated with metal concentrations may have a significant effect." Assuming that the physical character of the sediment is as important in structuring the benthic community at the south site as it is at the north site, the relatively minor differences observed in species composition at the south site CTR, I.E., and O.E. stations are not surprising. The sedimentary material used to cap the south pile is similar in mean grain size and size class composition to that of the original bottom sediments in the immediate area. Slight differences do not seem capable of altering the long-term predominant species composition. Short-term changes appear to be related to seasonal fluctuations in species abundance, successional changes, burial, and subsequent recolonization effects.

Nephthys incisa appears to be the most dominant species in predisposal samples taken in January 1979 and occurs again in postdisposal sediments collected in August 1979 and September 1980 from the CTR, I.E. and O.E. stations. Yoldia limatula, though absent from the dredged material deposited in August 1979 had established itself in the CTR, I.E. and O.E. station sediments by September 1980.

Discussion

Because of the small number of organisms (34) collected from the mound CTR in August 1979 (two months after first-phase disposal), an individual satisfies the definition established for a predominant species and, therefore, all species are listed as predominant. This may be somewhat misleading, but the list points out some interesting facts. The unusually large number of species suggests that some of the forms may be opportunistically attempting to occupy a recently defaunated niche in which competing, established species are reduced or absent. The relative abundance of epifauna, such as the sand shrimp, Crangon septemspinosa, the cancer crab, Cancer erroratus, the hermit crab, Pagurus longicarpus, and the spider crab, Libinia emarginata, suggests that the dredged material may provide a concentration of food matter suitable for such predator-scavengers. According to Rhoads (1978) most early colonizing species "feed on suspended or recently sedimented plankton and detritus, either at the sediment surface or by filtering overlying water . . . Because those suspension feeders usually live at, or near, the sediment surface they are vulnerable prey. Pioneering species may therefore be especially important food sources for commercially exploited fish and crustaceans."

When the CTR station was again sampled thirteen months later, after phase two capping, the only species common to the two sampling dates was Nephthys incisa. A form commonly encountered in natural sediments during the summer, Yoldia limatula, had established itself as well as four species (Ampelisca abdita, Ampelisca vadorum, Mulinia lateralis, and Owenia fusiformis) considered by Rhoads (1978) to be early colonizing species on recently disturbed sediment. Material collected on this date from the I.E. station was similar in species composition with its content of the omnipresent Nephthys incisa, the occurrence of the summer species, Yoldia limatula, and the presence of two of the opportunistic early colonizers, Ampelisca abdita and Owenia fusiformis. At the O.E. station, Nephthys incisa and Yoldia limatula were again present and an additional summer form, Nucula proxima, was in abundance. The predominant species composition at this station more nearly approaches the structure of the natural bottom community than does the CTR or I.E. stations, in spite of the fact that high sediment chemistry means indicate these sediments may have been collected from an errant dump.

Based on such data, it appears that reestablishment of a community of species that are normal with respect to the natural bottom assemblage may require a greater period of time on the disposal mound than at the O.E. station because of the addition of opportunistic species to the area. In this sense, the dredged material mound and burial effects creates an impact on the area benthos.

NORWALK-NEW HAVEN-CENTER, INNER EDGE AND OUTER EDGE (NORNH-CTR, I.E. AND O.E.)

The first phase of disposal of Norwalk harbor material at the Norwalk-New Haven site was begun on 11 May 1980 and ended on 30 May 1980. Additional dredged material was deposited between 31 January and 3 June, 1981. (See table 1.) Predisposal collections of sediments were taken at the center of the site on 1 April 1980 (about 1-1/2 months before the start of disposal operations). The CTR, I.E., and O.E. stations were next sampled on 20 and 21 August 1981 and 4 and 5 February 1982 (about 2-1/2 and 8 months, respectively, after completion of dumping activities). Sediment grain size and chemical analyses are complete for predisposal samples and those collected in August 1981; thus far, however, only the April 1980 samples have been examined for biological content.

Sediment Grain Size

Sediment mean grain size data for the Norwalk-New Haven stations are shown in Appendix A. Predisposal sediments at the CTR station are similar in mean grain size, but contain a higher percentage of silt and sand and a lower percentage of clay than those collected at the CLIS REF in September 1980 and January and August 1981. Postdisposal sediments collected at the CTR and I.E. in August 1981 (2-1/2 months after dumping) are essentially identical in mean grain size and size class composition. Sediments at the O.E. contain somewhat lower amounts of sand and a slightly greater amount of silt and clay. The similarity between characteristics of O.E. sediments and those of the original bottom is not as pronounced as might be expected and may indicate the presence of dredge material.

Sediment Chemistry

Sediment chemistry means for the Norwalk-New Haven stations are shown in Appendix B. Heavy metal concentrations in predisposal collections at the CTR are generally elevated over those measured at the CLIS REF, especially for Cu and perhaps Zn. The striking difference between the heavy metal content in sediments at the two stations is the between-sample variability that is much higher at the predisposal Norwalk station. The high variability and generally elevated concentration of heavy metals leads one to suspect that the presumed natural bottom sediments may have been influenced in some undetermined manner by previous disposal operations in the vicinity. On the other hand, sediment grain size, one of the important factors in determining a sediment's content of heavy metals, shows low sample-to-sample variability. Postdisposal collections at the CTR, I.E., and O.E. stations reveal (with the possible exception of Ni) an even higher concentration of heavy metals that decreases slightly in the O.E. sediments.

Benthic Macrofauna

Very little can be said regarding the benthos at the Norwalk site because the only data currently available are on the predisposal collections. A summary of the total biological content of predisposal samples is presented in Appendix C.

Numeric density data for the predominant species found in the baseline April 1980 samples collected from the center of the Norwalk disposal mound are shown in Appendix D. Of the six predominant species found here, five are also found at CLIS REF stations and the species rankings at the two stations are similar.

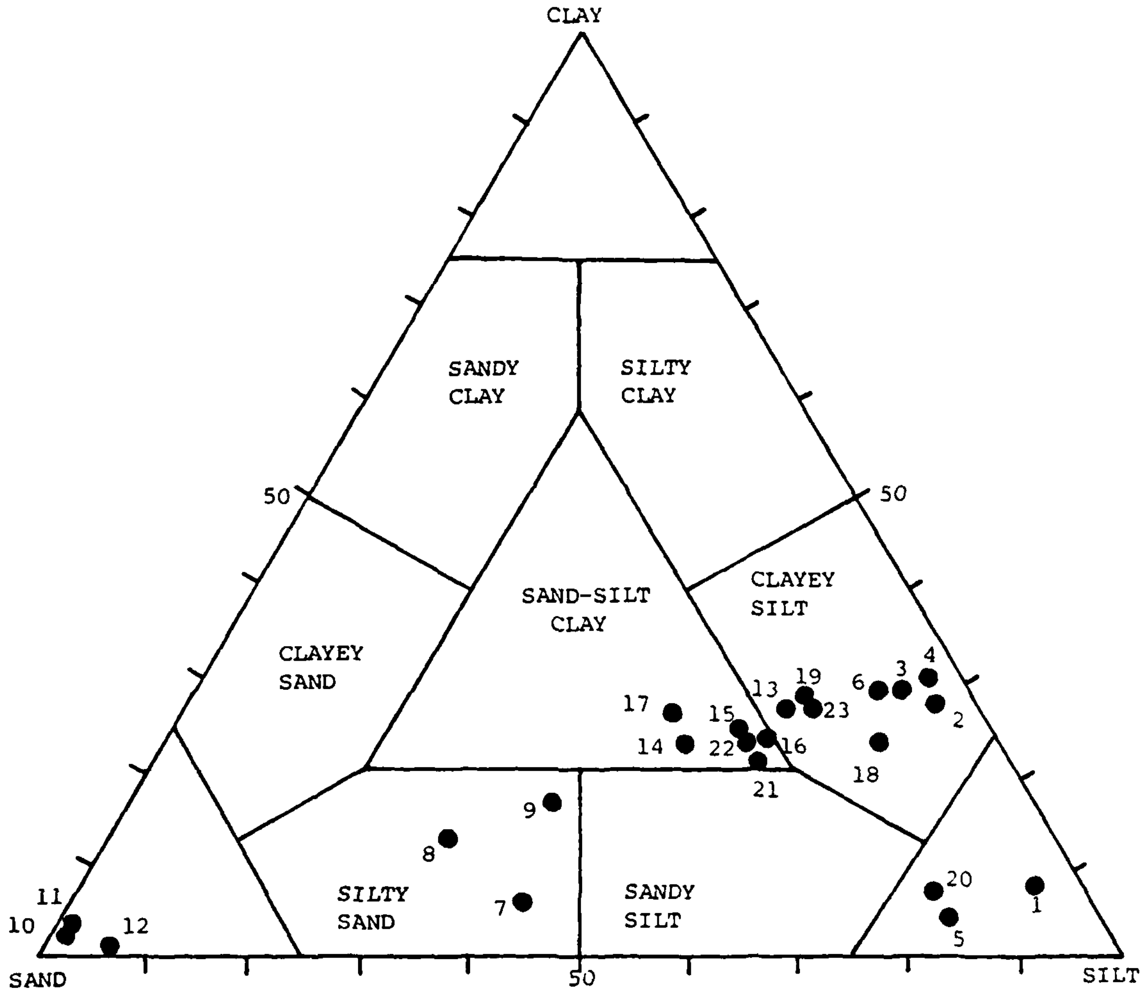
COMPARISON OF THE CENTRAL LONG ISLAND SOUND REFERENCE AND DREDGE MATERIAL DISPOSAL SITES

SEDIMENT COMPOSITION

In preceding sections of this report, the grain size characteristics of the sediments at each sampling station within the CLIS disposal site were examined in detail. These data are presented in summary form in figure 3, which is a graphic method for classifying sediments according to their percent content of sand, silt, and clay. The subdivisions are made according to the system suggested by Shepard (1954). In most cases, each plotted point represents the mean of ten grab samples. Using this system of nomenclature, 35% of the sediments collected from the CLIS sites are classified as clayey silt, 26% as sand-silt-clay and 13% occur in each of the categories sand, silty sand, and silt. All samples classified as sand were collected from the cap material at the center of the STNH-N disposal mound and the silty sand samples came from the I.E. station of the same site. Sediments classed as sand-silt-clay were collected from the CTR and I.E. stations of the STNH-S mound and the Norwalk site. With one exception (figure 3, sample no. 13), all samples classified as clayey silt were collected from either the CLIS REF site or from O.E. stations at the north, south, and Norwalk sites. This observation points out the consistency of natural sediments in the vicinity of the CLIS site.

Depending on location, sediment composition between individual grabs collected at one station can vary widely or show a remarkable between-grab consistency. In general, the sediments at the I.E. stations are characteristically highly variable whereas the O.E. stations and natural sediments exhibit low between-grab variances. To illustrate these differences in variability, two 10-grab sample sets have been plotted in figure 4. The mean values for these stations are also shown as points no. 4 and 9 in figure 3. In contrast to the tightly grouped data from the CLIS REF site, samples from STNH-N-I.E. on 28 January 1981 show much greater variability.

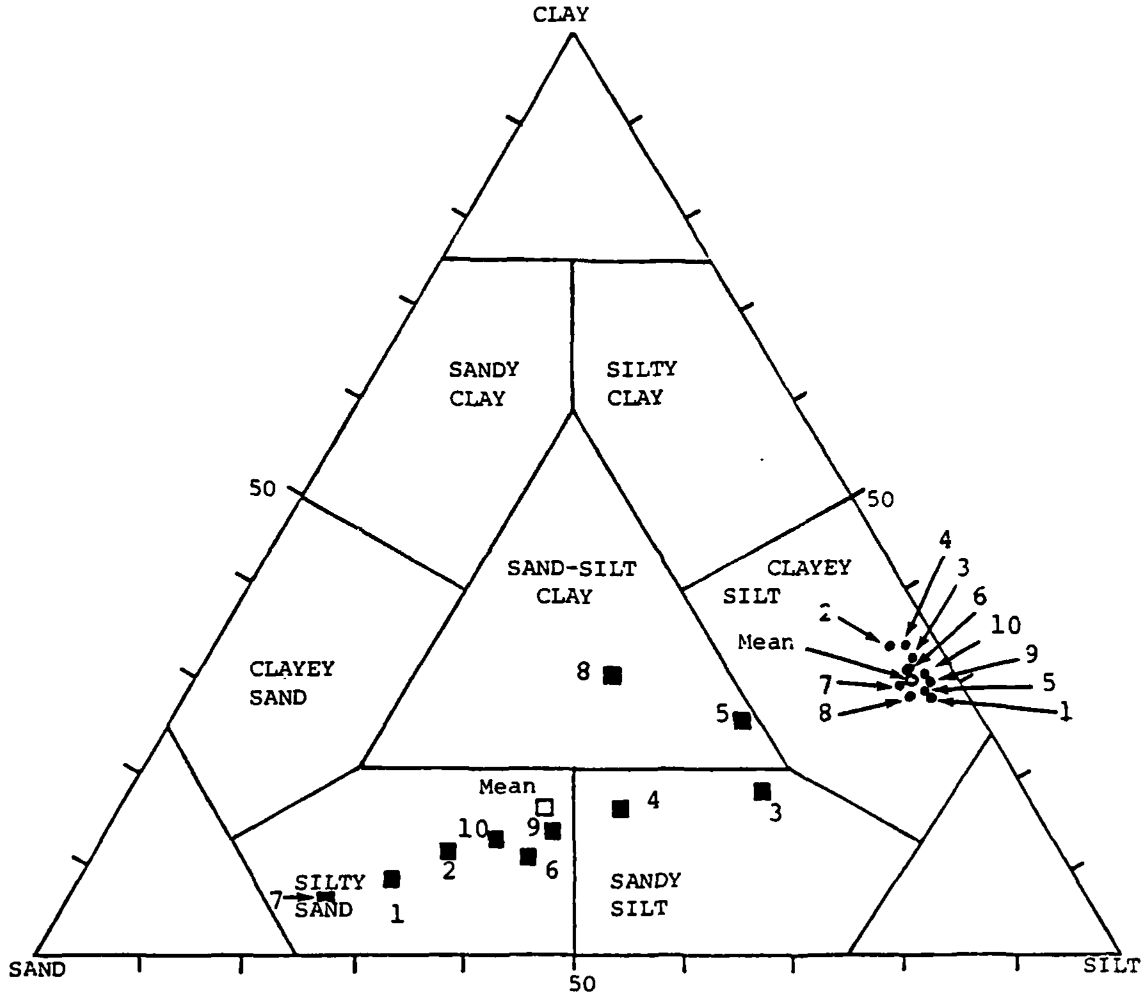
The variance in mean gain size in sediments collected at the CLIS REF site is very low (4×10^{-6}), while the STNH-N-I.E. samples show a variance two orders of magnitude greater (8×10^{-4}). Some of this is undoubtedly related to the inherent variability of the dredge material, but may also be related to the penetration of the grab sampler through the relatively thin veneer of dredge material to varying volumes of the underlying natural bottom sediments, or to the variability in the horizontal distance between grabs.



1. CLIS REF 1 APR '80.
2. CLIS REF 5 SEPT '80.
3. CLIS REF 26 JAN '81.
4. CLIS REF 19 AUG '81.
5. STNH-N-OE 2 APR '80.
6. STNH-N-OE 28 JAN '81.
7. STNH-N-IE 2 APR '80.
8. STNH-N-IE 4 SEPT '80.
9. STNH-N-IE 28 JAN'81.
10. STNH-N-CTR 1 APR '80.
11. STNH-N-CTR 4 SEPT '80.
12. STNH-N-CTR 28 JAN '81.
13. STNH-S-CTR 26 JAN '79.*
14. STNH-S-CTR 5 SEPT '80.
15. STNH-S-CTR 22 JAN '81.
16. STNH-S-IE 5 SEPT '80.
17. STNH-S-IE 25 JAN '81.
18. STNH-S-OE 3 SEPT '80.
19. STNH-S-OE 26 JAN '81.
20. NRWLK-NH-CTR 1 APR '80.*
21. NRWLK-NH-CTR 20 AUG '81.
22. NRWLK-NH-IE 21 AUG '81.
23. NRWLK-NH-CE 21 AUG '81.

* Predisposal collections

Figure 3. Classification of Sediments at the New Haven Study Sties



STNH-N-I.E.
28 JAN 1981

Grabs 1-10 (■) and Overall Mean (□).

CLIS Reference
19 AUG 1981

Grabs 1-10 (●) and Overall Mean (○).

Figure 4. Variability in Sediment Composition at CLIS Reference and STNH-N-I.E. Stations

The use of mean grain size to characterize sediments is widespread and, because it is more easily manipulated than percent content of sand, silt, and clay, it has been chosen to characterize the sediment for analysis of the benthic data.

At this point, it may be instructive to examine the spatial relationship within and between a given set of grab samples, especially since very little information of this type is available in the literature. The precision of the Decca Trisponder Navigation System used during DAMOS field sampling has allowed the location of each grab to be determined with pinpoint accuracy and, thus, the distance between any series of grabs can be calculated. Throughout the DAMOS sampling program, it was desirable to group repetitive grabs within as small an area of the bottom as possible. The ability to maintain a tight grouping is primarily dependent upon good helmsmanship in the initial on-station positioning of the ship, but it is also dependent upon conditions of wind, tide, currents, and water depth. Analysis of almost 200 grabs (nearly 10 grabs at 20 stations) collected from the New Haven study area showed that in the most tightly grouped set, the maximum separation between grabs was slightly more than 5 m. In the worst case, a maximum separation of 35 m occurred with an average maximum separation within grab sets over all 20 stations of about 18 m. This probably represents a grouping that is as tight as can be expected without the difficult and time-consuming process of two-point mooring on the precise coordinates of each sampling station. It also suggests that the variability observed between repetitive samples is due to natural conditions at the site and not variability imposed as a result of excessive spatial separation of successive grabs.

SEDIMENT CONTENT OF HEAVY METALS AND VOLATILE SOLIDS

The results of the analyses of sediment for content of heavy metals and volatile solids have also been presented for each of the sampling sites in the preceeding sections. This section will summarize the data for use in interpretation of benthic population parameters.

The frequency distribution of values for concentration in ppm of five heavy metals is shown in figure 5. The data used to construct this graph were derived from samples collected throughout the CLIS site during 1979 and 1980, and are believed to be a representative cross-section of all sediment types that might be found. With the exception of Pb (N=248), the distribution of each of the five heavy metals is based on analyses of 253 grab samples. Figure 5 indicates that the distribution of Cr, Cu, and Pb are similar, with the greatest number of samples having concentrations between 40 and 80 ppm. Ni and Zn, however, have different distributions with maximum concentrations between 20 and 40 ppm for Ni and 140-180 for Zn. If it is assumed that these sample distributions are representative of sediments of the CLIS, then it is possible to stratify any sediment sample with respect to the level of heavy metal contamination.

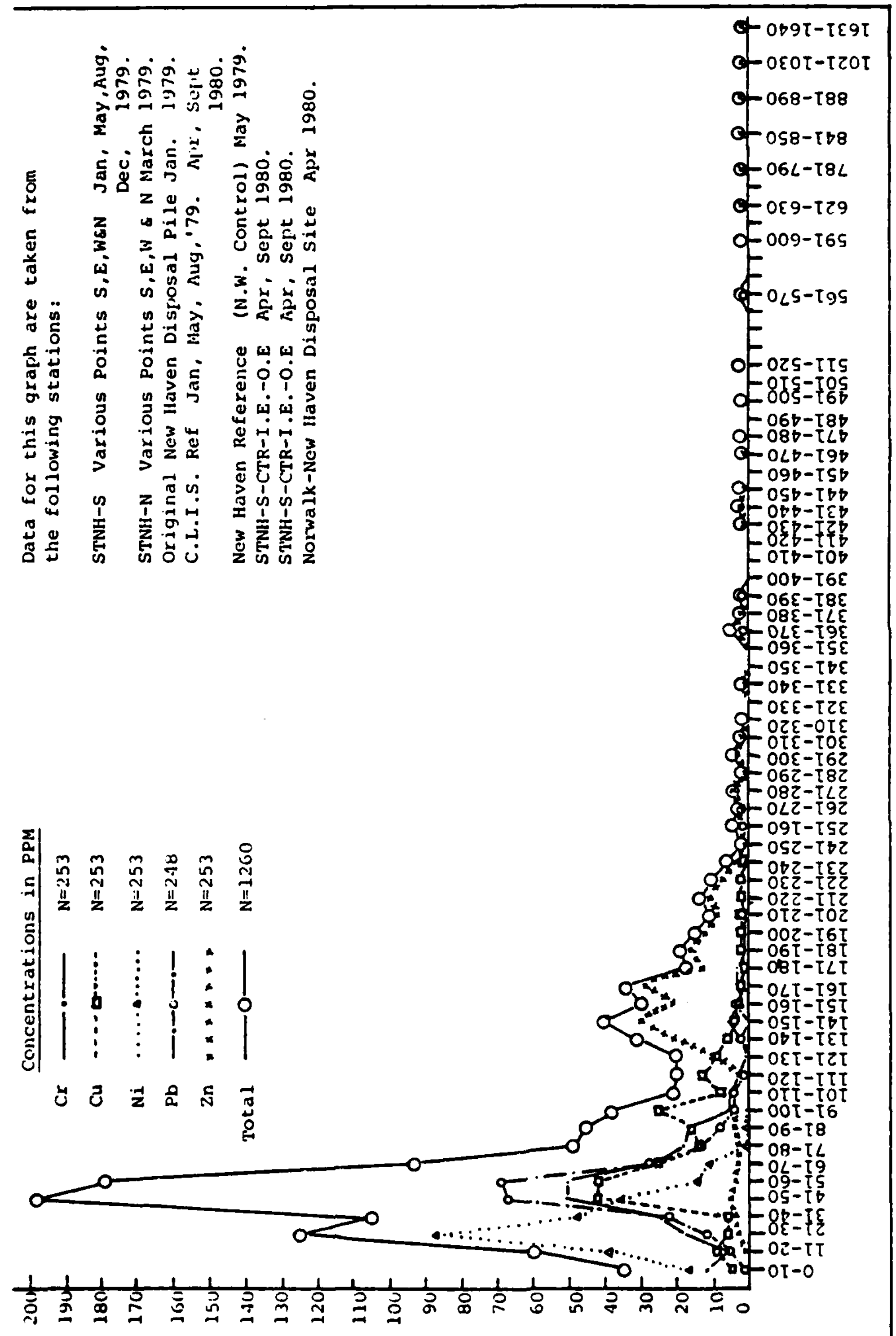


Figure 5. Frequency Distribution of Five Heavy Metals in Sediments From the New Haven Study Sites

In their study of sediments of the New York Bight, Walker et al. (1979) noted a high correlation between the concentrations of Cr, Cu, Pb, Ni, and Zn and used a pooled value for heavy metals as a variable of stratification. As can be seen in figure 6, these five heavy metals are also correlated in the sediments of the current study area such that the concentration of all heavy metals are directly related and a high value for any given metal is associated with high values for all. Although the concentration of the five heavy metals in the CLIS area sediments are directly related, the frequency distributions for Cr, Cu, and Pb (which bear a close resemblance to each other) differ considerably from those of Ni and Zn. For these reasons, an average value for Cr, Cu, and Pb has been chosen to stratify the heavy metal concentration of the study area sediments. Since the peak in the frequency of occurrence for Cr, Cu, and Pb occurs at concentrations between 40 and 60 ppm, a cut-point between high and low levels of heavy metal concentration has been established at 50 ppm. Sediments with concentrations less than 50 ppm are classified as low values while those with greater concentrations are considered high.

If the means of the pooled heavy metal concentrations of Cr, Cu, and Pb are plotted against mean grain size at each CLIS station (figure 7), the lower concentration of heavy metals are found in the coarser sediments with higher concentrations occurring in the finer material. The correlation coefficient (R=-0.56) is somewhat lower than might have been expected and probably reflects the influence of dredge material contaminants.

ORGANIC MATTER

A third variate, which is known to influence the species composition and numerical density of benthic communities, is the relative quantity of organic matter in the sediment. Analyses for the content of organic matter in terms of percent of volatile solids (EPA method analyses) were performed on each grab collected. The frequency distribution curve for these data (figure 8) indicates a distribution that approaches a normal, bell-shaped curve with a peak at about 6%. Based on this information, a cut off point between high and low values for volatile solids was established at 5.99%.

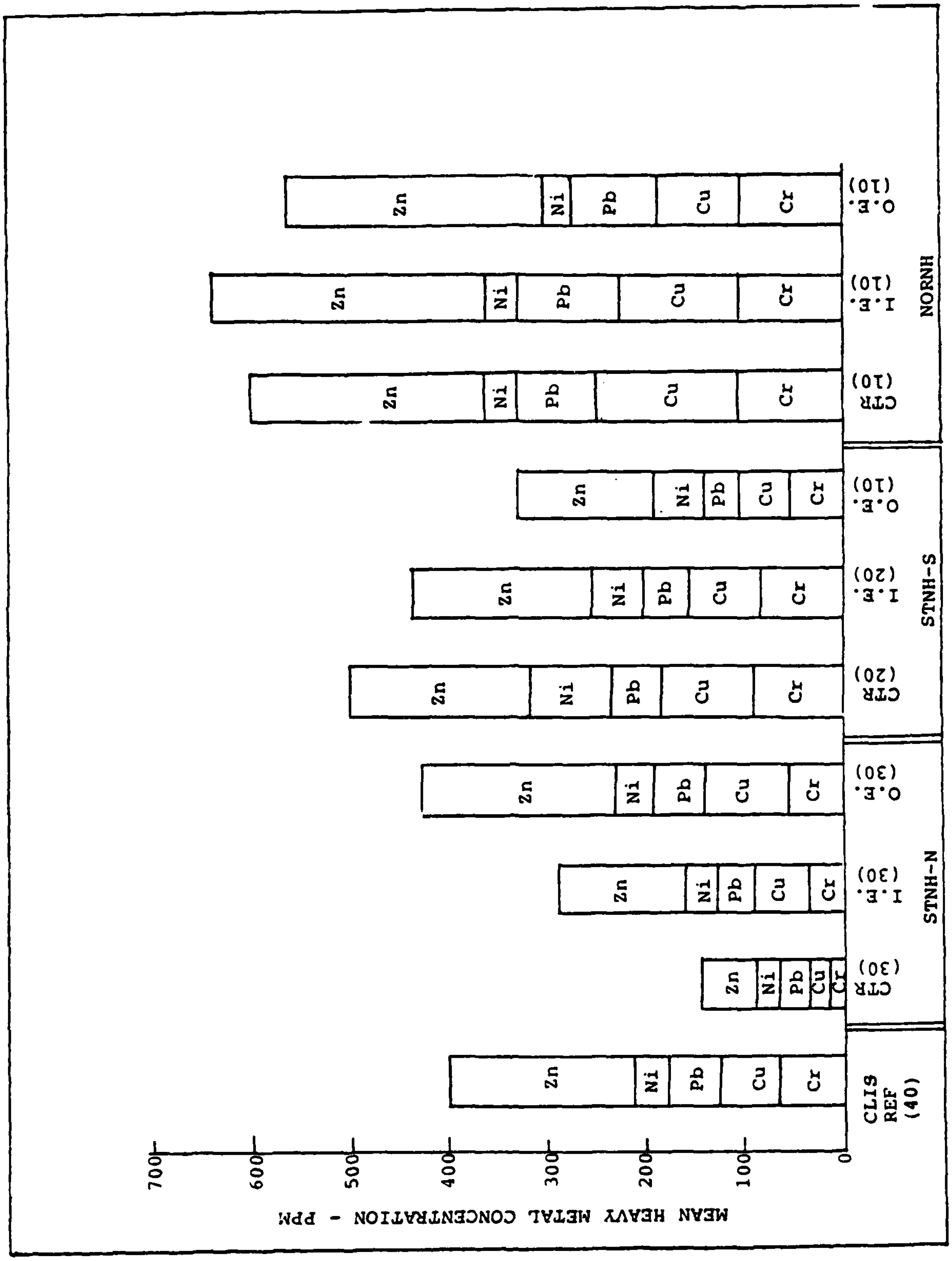


Figure 6. Mean Heavy Metal Concentration at CLIS Disposal Site

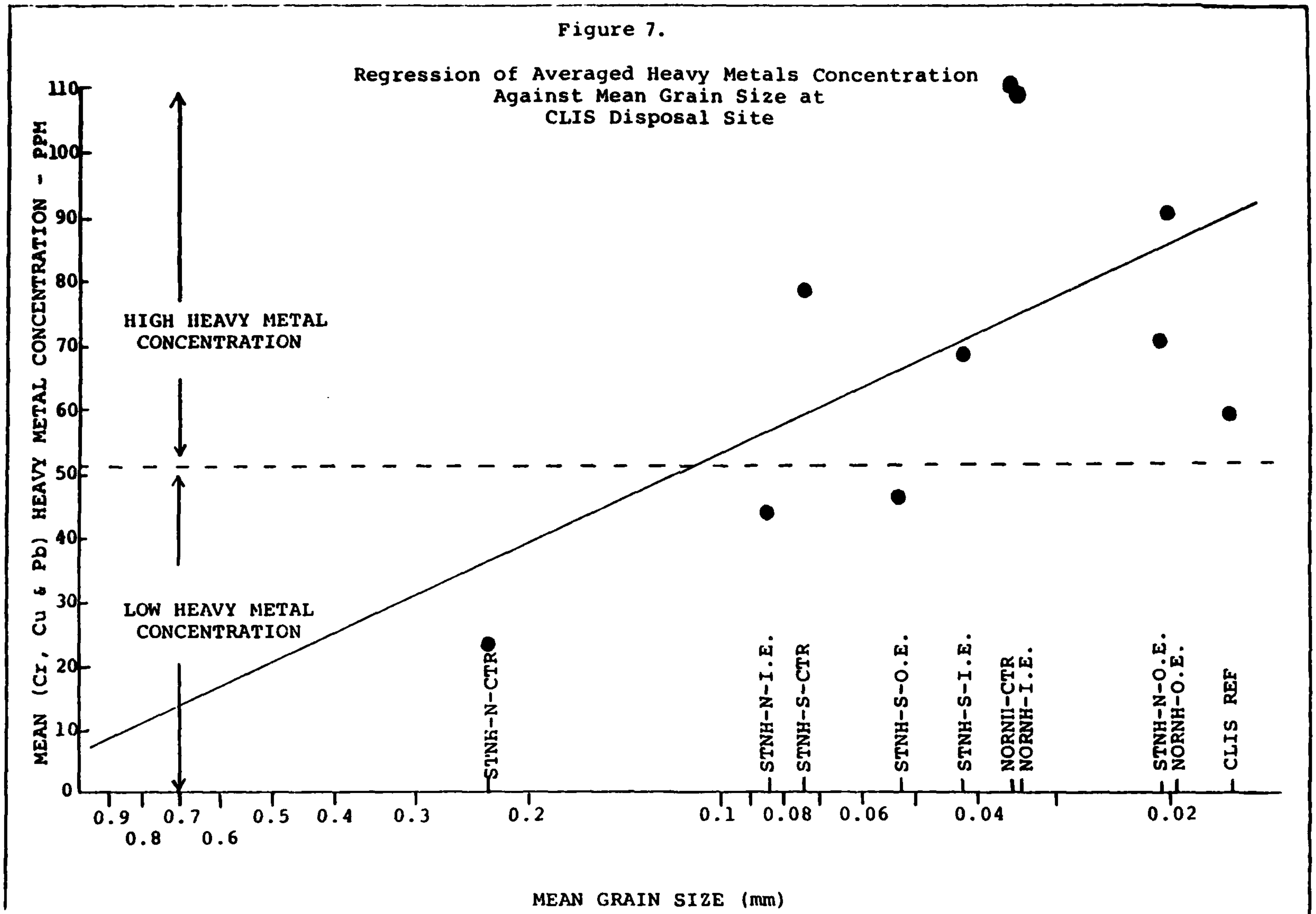


Figure 7. Regression of Averaged Heavy Metals Concentration Against Mean Grain Size at CLIS Disposal Site

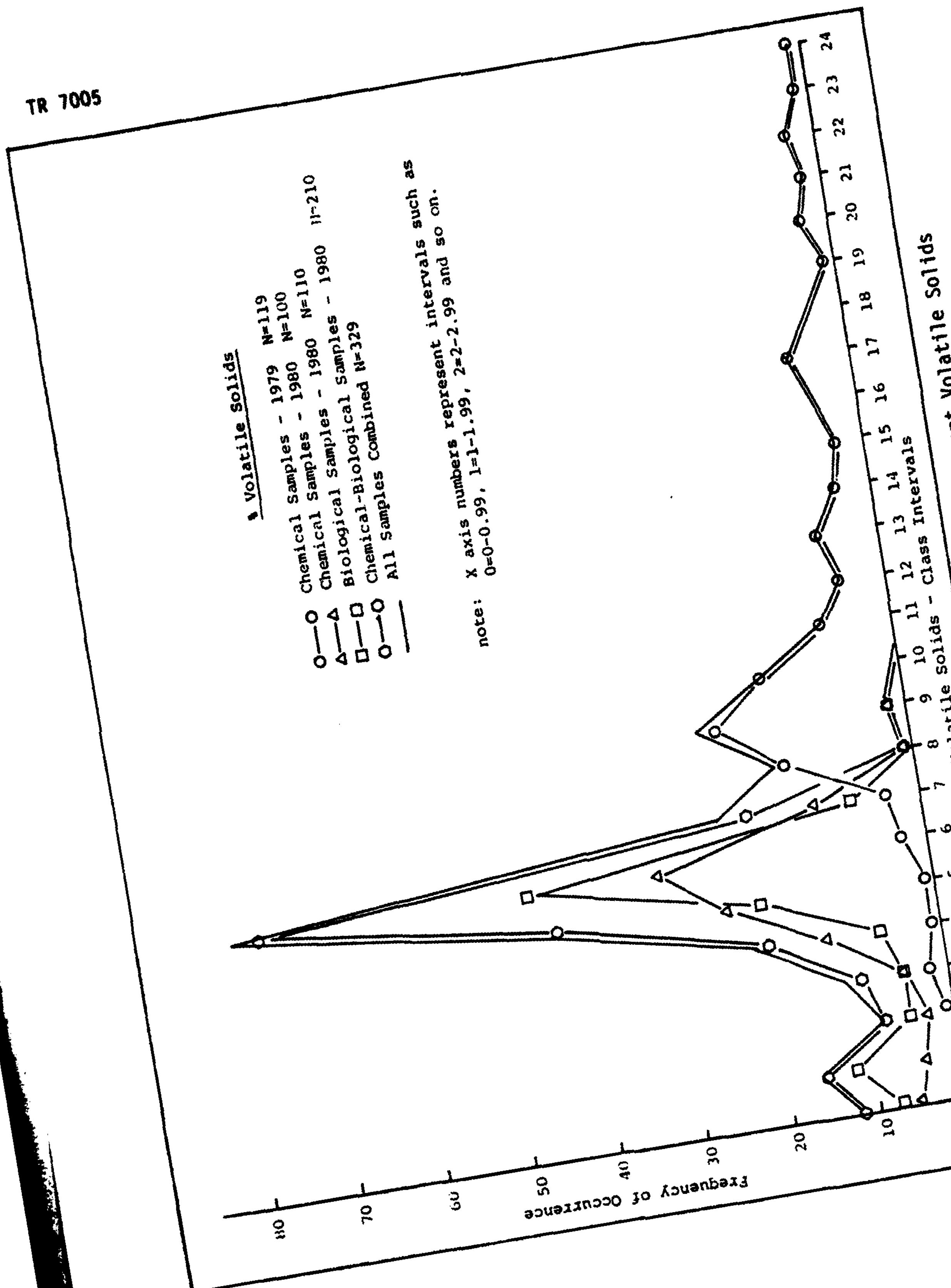


Figure 8. Frequency Distribution for Percent Volatile Solids

SEDIMENT CLASSIFICATION

Having established cut-points between high and low values for heavy metals and percent volatile solids, it is only necessary to partition sediment mean grain size into four categories to generate a matrix of 16 discrete combinations for classification. Based on generally accepted principles regarding the response of sedimentary material to varying current velocities as well as attendant consequences that might influence benthic organisms, mean grain size cut-points for New Haven sediments were established at 1.0, 0.20, and 0.31 mm. This system of sediment stratification follows that suggested by Walker et al. (1979) and results in the stratification matrix presented in figure 9. At the bottom center of each block, odd numbers in parentheses indicate low volatile solids and even numbers indicate high volatile solids. Samples in blocks 1 through 8 are low in heavy metals, whereas blocks 9 through 16 indicate a high heavy metal content. The numbers in the four corners of the blocks (beginning at the upper left of each block, and proceeding clockwise) represent the number of grabs in that stratum collected during cruises 1 through 4. Larger figures in the upper center of each block give the total number of grabs within this data set that occur in the stratum and the figures in the lower center express the percentage of the total samples occurring within each stratum. The largest number of grabs (42%) occur in stratum 16, a sediment category with fine mean grain size and high content of heavy metals and volatile solids. While figure 9 provides a system by which the overall number of grabs collected at the New Haven sites may be stratified, the strata designations at each station must also be examined (see figure 10). In this figure, the percentage of grabs occurring within each stratum is plotted for each sampling station. It shows, for example, that 75% (i.e., 30) of the grabs collected at the CLIS REF site are classified as fine sediment (high in heavy metals and volatile solids (stratum 16)) and that 87% (i.e., 26) of the grabs collected from the cap material at the STNH-N-CTR fall in stratum 3, which is a relatively coarse sediment (low in heavy metals and volatile solids). Furthermore, the similarity in strata designations for natural sediments of the original bottom (i.e., CLIS REF and NORNH-Baseline) and those of the O.E. stations is readily apparent.

The data presented in figure 10 have been combined to generate table 4, which shows the relative proportion of the grabs at each station occurring in the respective sediment categories. The table shows that grabs collected from the natural sediments of the CLIS REF, NORNH Baseline and O.E. stations are generally classified as high in heavy metals and usually high in volatile solids. In contrast, varying proportions of the grabs from five disposal site stations occurred in the categories of least contamination. Based on this information and the knowledge that dredged material from Stamford was significantly higher in heavy metals and volatile solids than natural sediments at the CLIS site, one can conclude that capping operations at STNH-S and STNH-N were successful in isolating contaminants from the biota and water column.

Coarse S^1 1.00mm S^2 0.20mm S^3 0.031mm S^4 Fine

		S^1	S^2	S^3	S^4
Low Heavy Metals (50.9 PPM or less)	Low Volatile Solids (0.5.99%)	0 (1)	10 9 26 12% 7 (3) 0	3 9 31 14% 19 (5) 0	0 0 1 0.5% 1 (7) 0
	High Volatile Solids (6.00% or more)	0 (2)	0 (4)	0 (6)	1 1 5 2% 3 (8) 0
High Heavy Metals (51PPM or greater)	Low Volatile Solids (0-5.99%)	0 (9)	0 (11)	7 11 24 11% 3 (13) 3	3 4 22 10% 13 (15) 2
	High Volatile Solids (6.00% or more)	0 (10)	0 (12)	2 4 26 7% 1 (14) 9	24 22 92 42% 20 (16) 26

CRUISE I - APRIL '80

1. CLIS REF [10]
2. STNH-N-CTR [10]
3. STNH-N-I.E. [10]
4. STNH-N-O.E. [10]
5. NORNH [10] (BASELINE)

CRUISE II - SEPT '80

6. CLIS REF [10]
7. STNH-S-CTR [10]
8. STNH-S-I.E. [10]
9. STNH-S-O.E. [10]
10. STNH-N-CTR [10]
11. STNH-N-I.E. [10]

CRUISE III - JAN '81

12. CLIS REF [10]
13. STNH-S-CTR [9]
14. STNH-S-I.E. [9]
15. STNH-S-O.E. [9]
16. STNH-N-CTR [10]
17. STNH-N-I.E. [10]
18. STNH-N-O.E. [10]

CRUISE IV - AUG '81

19. CLIS REF [10]
20. NORNH-CTR [10]
21. NORNH-I.E. [10]
22. NORNH-O.E. [10]

TOTAL NO. OF GRABS = 217

Figure 9. Physical Strata Definition Chart

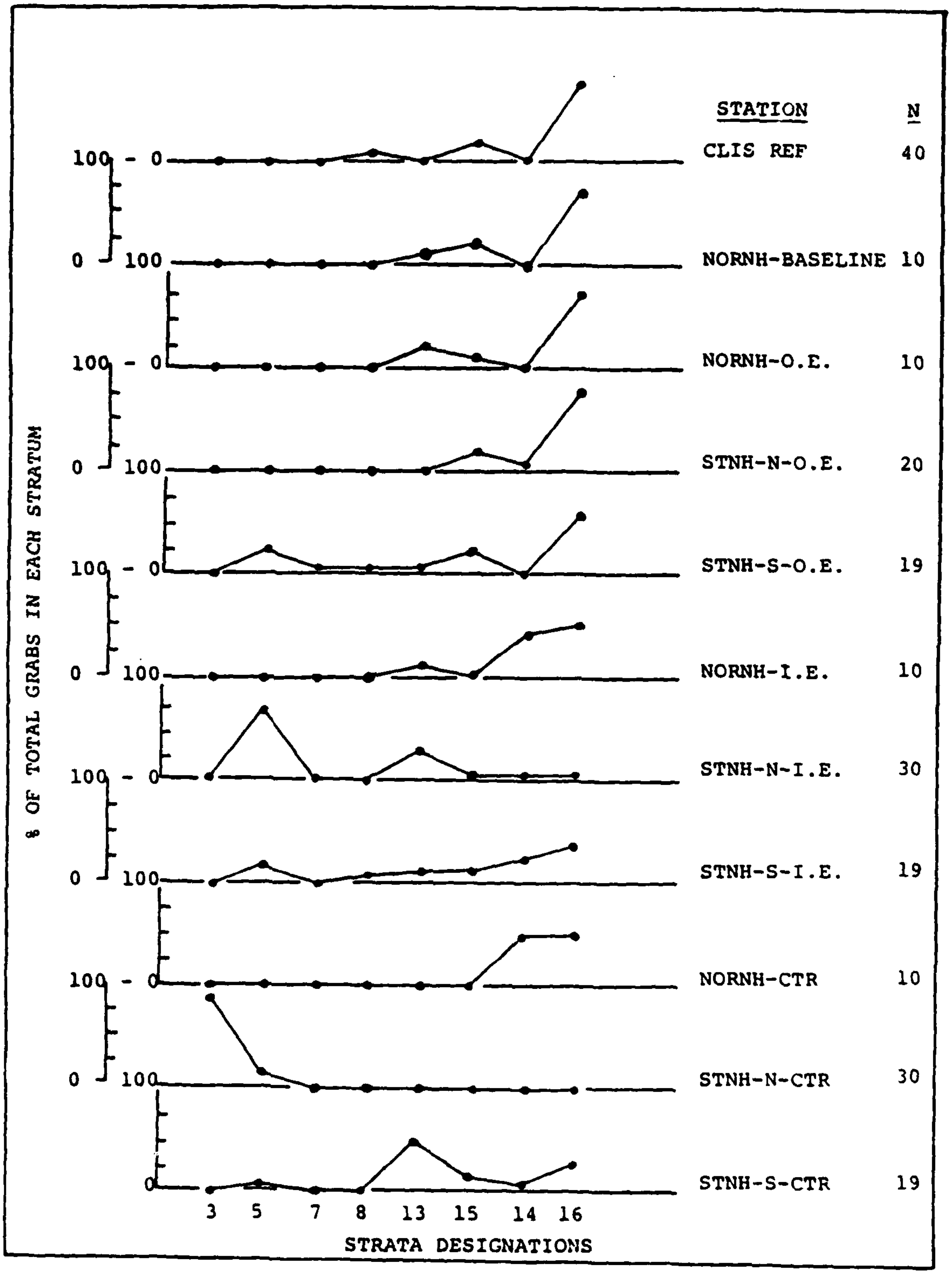


Figure 10. Distribution of Sediment Strata Designations at Stations Within the CLIS Disposal Site

Table 4.
Distrubution of Sediments at Stations Within the CLIS Disposal Site According to Content of Heavy Metals and Volatile Solids.

	CLIS Ref	NORNH-Baseline	NORNH-O.E.	STNH-N-O.E.	STNH-S-O.E.	NORNH-I.E.	STHN-N-I.E.	STNH-S-I.E.	NORNH-Ctr	STNH-N-Ctr	STNH-S-Ctr
1. Strata 14 and 16 High Metals-High Solids.	75	70	70	80	53	90	6	58	100	0	31
2. Strata 13 and 15 High Metals-Low Solids	18	30	30	20	16	10	30	22	0	0	63
3. Stratum 8 Low Metals-High Solids	8	0	0	0	5	0	0	5	0	0	0
4. Strata 3,5 and 7 Low Metals- Low Solids	0	0	0	0	26	0	63	16	0	100	5

THE BENTHIC MACROFAUNA OF THE NEW HAVEN DISPOSAL SITES, SPRING AND SUMMER, 1980

The master species lists for DAMOS samples collected during the spring and summer 1980 cruises are shown in Appendixes E and F, respectively. Species collected during earlier DAMOS cruises were presented in the 1979 and 1980 DAMOS Annual Reports. Examination of the master species lists reveals that the benthic community at the New Haven sites is numerically dominated by relatively few species, a condition often noted in other benthic populations.

Since a 1 mm sieve screen was used to obtain the benthic samples, very small organisms such as Forminifera, Copepods, Cladocerans, Ostracods, Nematodes, and Arachnoids are not included. The occurrence of colonial forms (such as sponges, bryozoans, and certain hydrozoans) has been noted in these master species lists, but no attempt was made to count the number of individuals comprising the colonies. One additional taxon, the Cirrepedia (barnacles), has also been excluded from the count of total numbers of individuals.

In previous sections, the mean number of individuals (N) per grab sample, the mean number of species (S), the mean value for the Shannon-Weaver index of diversity (H), equitability index means (J), and the 95% confidence intervals have been presented for each disposal site. These data are compiled and summarized in figure 11, which shows that at the south site no statistically significant difference in N, S, or H' can be demonstrated between the reference site samples and either the pre or postdisposal samples. Similarly, at the north site, no signficant difference in N, S, or H' can be shown between predisposal samples and samples recovered from the reference site. Fifteen months after completion of the north site capping operation, however, N and S exhibited a significant increase over samples collected during the same month from the reference site. No such differences exist for any of the H' data.

To show more dramatically the relationship between N and S at the reference site and at the center of the north and south mounds, data extracted from figure 11 have been used to construct figure 12. Lack of data for the CLIS REF site during the winter of 1979 made it necessary to compare predisposal collections at the north and south sites with data collected at the New Haven Reference (a site on natural bottom located to the northwest of the disposal area that was sampled in the early stages of this research) The figure shows that in the winter of 1979, prior to disposal, N and S were roughly comparable at all three sites. A comparison of samples collected in April 1980 at the CLIS REF site and the STNH-N-CTR (which had been capped 10 months earlier) indicates roughly comparable values for N and S. By September 1980 there had been a significant increase in N and S at the STNH-N-CTR.

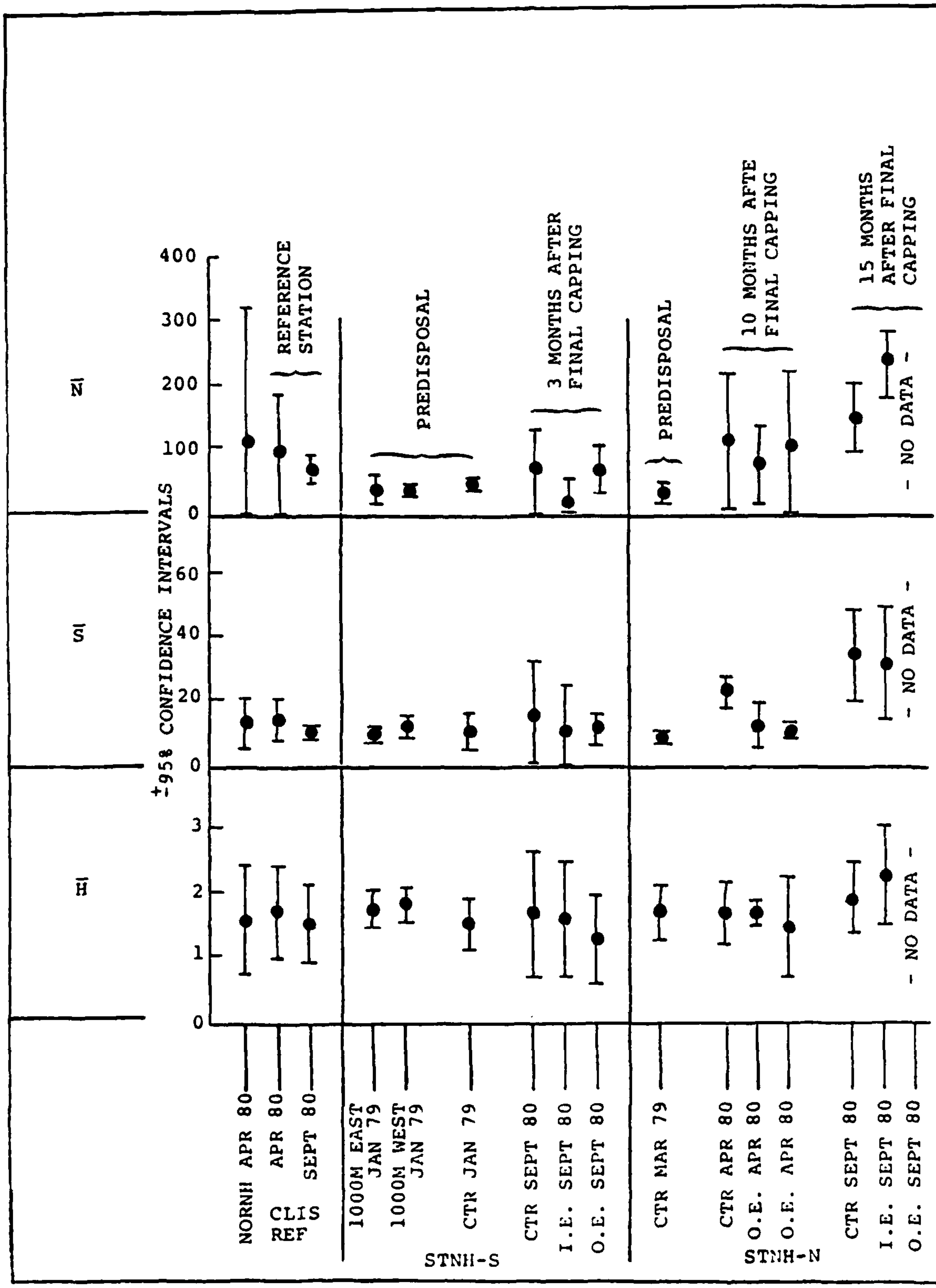


Figure 11. Mean Statistics for CLIS Disposal Site (Total Benthic Population)

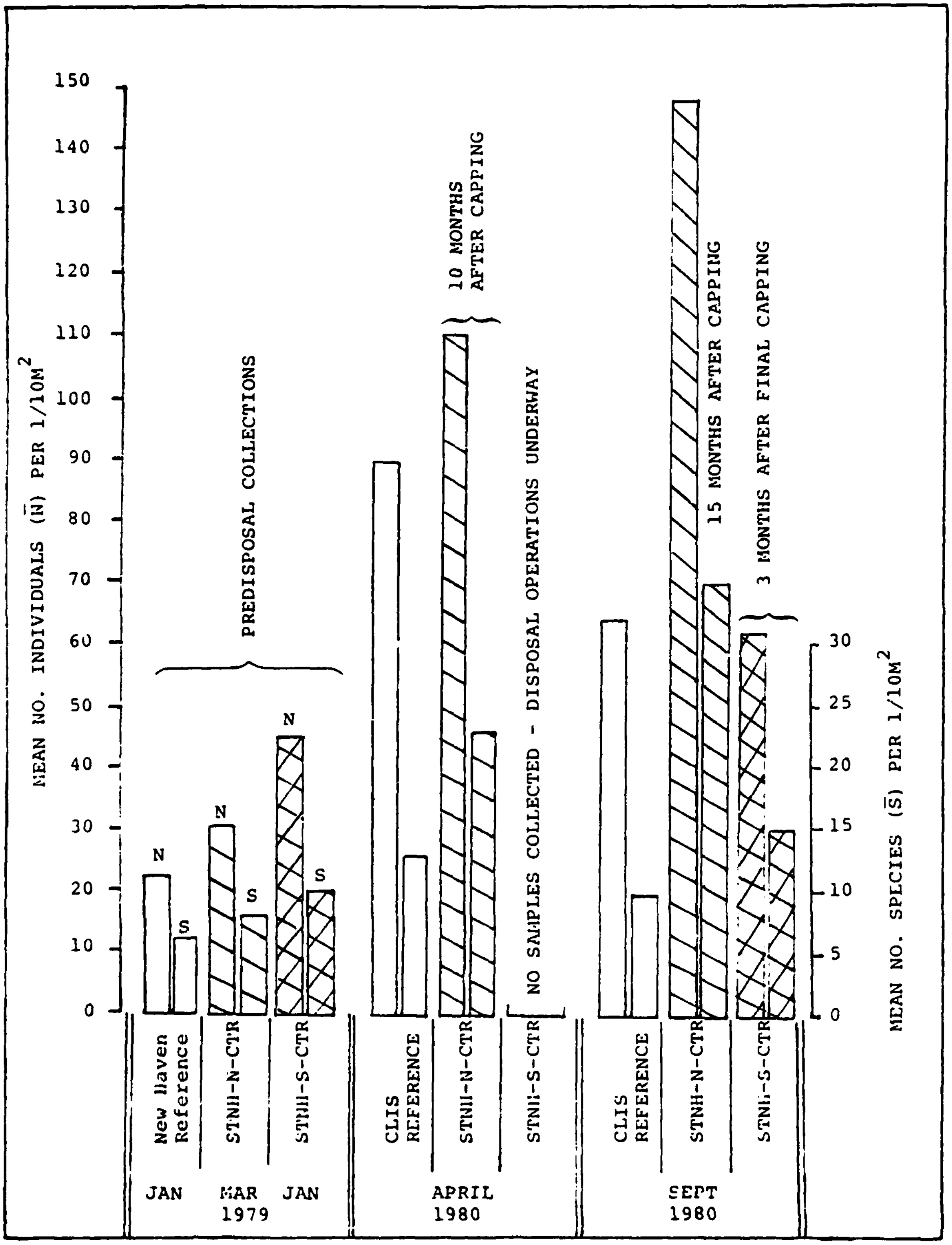


Figure 12. Comparison of N and S at CLIS Reference, STNH-N and STNH-S Center Stations

No samples were taken at the STNH-N-CTR station during April 1980 because additional disposal was underway. However, by September, only three months after completion of the capping, the N and S values were comparable to those at the reference site. Thus, in terms of N and S, there exists no evidence to support the hypothesis of a deleterious effect of dredged material disposal on the benthos at the STNH-N or S sites. Data for the north mound suggest an enhancement of the population and at the south mound the data show evidence of a rapid return to normal levels following disposal. However, N and S are not the only factors of potential importance in determining the impact of disposal activity on a benthic population, particularly, because the species composition can change markedly in response to a change in sediment grain size characteristics.

To examine this aspect of the benthos at the CLIS disposal sites, a list of species was compiled by consolidating the predominant species listed in the Tables of Numeric Density for all stations within the study area. These data are presented in table 5 and table 6; which present a matrix of the 23 species versus the 33 grab samples of interest collected at the CLIS stations in April and September of 1980. The matrix gives for each species the percent of the total number of individuals occurring as predominant species. The stratum to which each grab has been assigned based on the physical variables described previously is also given. These data are graphically displayed in the 3-dimensional plot shown in figure 13. In terms of predominant species, which at most of the stations comprise about 90% of the total number of individuals, the distribution portrayed in figure 13 is the result of the culmination of complex biological, physical, chemical, and climatic influences, as well as the chronology of disposal events acting on study site populations.

Numerous aspects of the structure of the community are immediately apparent. Most striking is the difference in species composition seen at the center of the north disposal site. This is the only site where the bivalve mollusc, Tellina versicolor (species 18), occurred as a predominant species. Another mollusc, the razor clam, Ensis directus (22), and four species of annelids, Spiophanes bombyx (19), Glycera americana (20), Caulleriella filiarensis (21), and Aricidea neosuecica (23), also achieved predominant species status only at this site. This station is equally unique for the absence of Nucula proxima (1) and Nephthys incisa (2), which occurred as a predominant species in most other grab samples collected.

Sediments at the center of the south mound were unique by virtue of the presence of the arthropod, Ampelisca vadorum (16). Another arthropod, Ampelisca abdita (15) and the annelid, Owenia fusiformis (14), were also present at the south site center as well as at the STNH-S-I.E. site. These sites were sampled only three months after final capping and it has been suggested by Rhoads et al. (1978) that the latter two species may colonize a recently disturbed seafloor opportunistically.

The figure shows a general similarity in predominant species content between the CLIS REF site and O.E. stations, especially when data for like months are compared. It seems probable that the apparent differences can be attributed to seasonal changes in population structure.

Table 5. Consolidated List of Predominant Species Found at the CLIS Disposal Site

PREDOMINANT SPECIES	PHYLUM	FEEDING TYPE
1. Nucula proxima	M	SDF
2. Nephthys incisa	A	NSDF
3. Phoronis architecta	P	SF
4. Mulinia lateralis	M	SF
5. Saccoglossus kowalevskii	H	U
6. Corymorpha pendula	CN	SF
7. Ceriantharian sp. A	CN	SF
8. Ceriantharian sp. B	CN	SF
9. Retusa canaliculata	M	C/SDF
10. Yoldia limatula	M	SDF
11. Melinna cristata	A	SDF
12. Nassarius trivittatus	M	NSDF-Scav
13. Loimia medusa	A	U
14. Owenia fusiformis	A	DF
15. Ampelisca abdita	AR	DF
16. Ampelisca vadorum	AR	SF/DF
17. Pectinaria gouldii	A	NSDF
18. Tellina versicolor	M	SF
19. Spiophanes bombyx	A	DF
20. Glycera americana	A	DF
21. Caulleriella filiarensis	A	U
22. Ensis directus	M	SF
23. Aricidea neosuecica	A	NSDF

Legend:

M - Mollusca
A - Annelida
P - Phoronida
H - Hemichordata
C - Carnivore
U - Unknown

CN - Cnidaria
AR - Arthropoda
SF - Suspension Feeder
DF - Deposit Feeder

SDF - Selective Deposit Feeder
NSDF - Non-selective Deposit Feeder

Table 6. Percent Composition of Predominant Species in New Haven Reference and Disposal Site Grabs

Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Strata	
33	-	-	8	-	-	-	-	-	-	-	-	6	-	-	-	-	-	78	3	-	-	4	1	3	STNH-N
32	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	75	9	-	-	7	7	3	CTR
31	-	-	2	-	-	-	-	-	-	-	-	6	-	-	-	-	-	83	3	-	-	3	2	3	9/80
30	22	11	17	-	-	-	-	-	-	13	-	4	8	21	-	-	5	-	-	-	-	-	-	5	STNH-N
29	45	12	11	-	-	-	-	-	-	14	-	1	1	14	-	-	2	-	-	-	-	-	-	5	I.E.
28	25	13	12	-	-	-	-	-	-	15	-	7	3	20	-	-	4	-	-	-	-	-	-	5	9/80
27	-	10	-	7	-	-	-	-	-	8	-	-	-	25	10	39	2	-	-	-	-	-	-	13	STNH-S
26	-	16	-	-	5	-	-	-	-	6	-	-	-	28	3	38	5	-	-	-	-	-	-	13	CTR
25	-	26	-	-	-	-	-	-	-	6	-	-	-	35	-	32	-	-	-	-	-	-	-	13	9/80
24	-	11	-	-	-	-	-	-	-	22	-	28	-	28	11	-	-	-	-	-	-	-	-	16	STNH-S
23	-	50	-	-	-	-	-	-	-	-	-	-	-	13	38	-	-	-	-	-	-	-	-	14	I.E.
22	-	83	-	-	-	-	-	-	-	-	-	17	-	-	-	-	-	-	-	-	-	-	-	14	9/80
21	63	29	-	-	-	-	-	-	-	1	-	7	-	-	-	-	-	-	-	-	-	-	-	16	STNH-S
20	44	42	-	-	-	-	-	-	-	2	-	5	7	-	-	-	-	-	-	-	-	-	-	16	O.E.
19	74	15	-	-	-	-	-	-	-	5	-	2	5	-	-	-	-	-	-	-	-	-	-	16	9/80
18	61	21	5	-	-	-	-	6	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	CLIS
17	45	27	6	-	-	-	-	6	6	10	-	-	-	-	-	-	-	-	-	-	-	-	-	16	REF
16	62	24	3	-	-	-	-	8	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	16	9/80
15	-	-	12	-	-	-	-	-	-	-	-	2	-	-	-	-	-	71	10	5	-	-	-	3	STNH-N
14	-	-	3	-	-	-	-	-	-	-	-	15	-	-	-	-	-	62	9	5	5	-	-	3	CTR
13	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	63	22	3	3	-	-	3	4/80
12	9	20	32	35	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	STNH-N
11	33	20	19	26	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	I.E.
10	14	34	32	14	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	4/80
9	9	32	30	9	-	-	6	-	11	-	4	-	-	-	-	-	-	-	-	-	-	-	-	14	STNH-N
8	74	6	6	10	-	-	2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	O.E.
7	67	14	5	7	-	-	4	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	16	4/80
6	63	13	6	10	-	-	4	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	16	Norwalk
5	76	8	6	9	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	16	NH
4	5	40	10	5	-	-	25	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	15	4/80
3	40	25	7	13	8	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	CLIS
2	63	13	12	6	2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	REF
1	22	22	24	22	4	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	4/80

Species

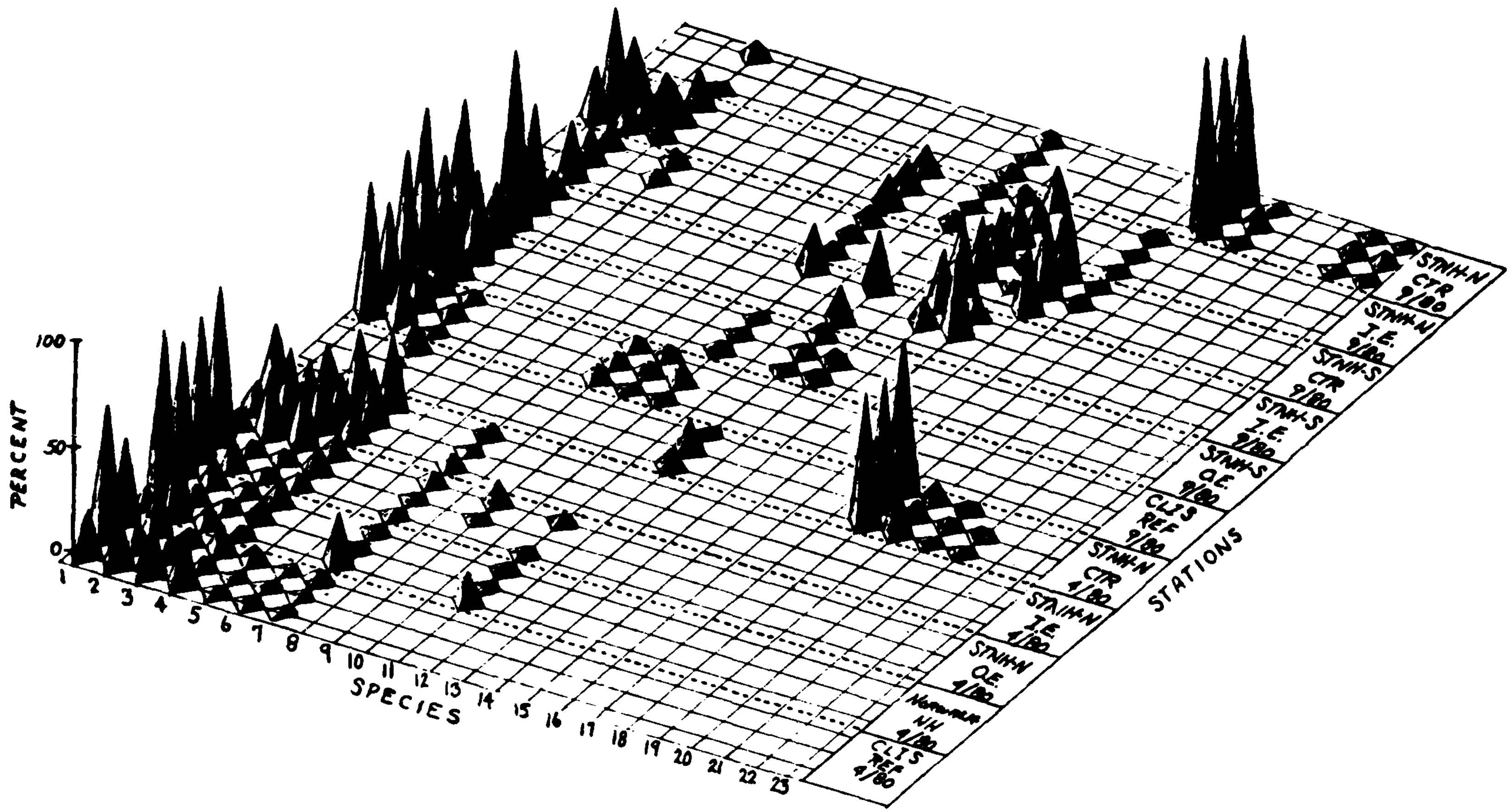


Figure 13. 3-D Plot of Percent Composition of Predominant Special at New Haven Reference and Disposal Sites

Figure 13 indicates that the soft bottom community in the study area is numerically dominated by Nucula proxima (1) and Nephthys incisa (2). Because of a lack of biomass data for the current study, it is difficult to compare these results with those reported by Sanders (1956) in his study of the benthos in the same area during 1952-54. It is interesting to note that at his station 2, a station close to the STNH sites, he reports that Nucula proxima made up 42.9% of the biomass of small animals while 27.6% was comprised of Nephthys incisa. This observation suggests that the predominant species of the soft bottom community have not experienced a drastic change in composition over 30 years.

With the exception of Saccoglossus kowalevskii, a hemichordate, the predominant species listed in table 5 and displayed in figure 13 fall into five phyla. Their distribution is shown for the CLIS REF site and pre- and postdisposal collections at the north and south mounds (see figure 14). Most of the relationships in this figure are confusing and difficult to interpret. Perhaps its greatest value is to call attention to the folly of lumping species into taxonomic hierarchies without considering specific differences in feeding type, physiology, life history, environmental preference, and a host of other biological factors pertinent to life styles of individual species. In spite of these shortcomings, a few generalizations seem warranted. Figure 14 shows that the ratio of annelids to molluscs is lower at the north mound sites than at the south mound sites. It also shows that, for the most part, a similarity of composition of these hierarchies between the natural sediments at the CLIS REF site and the O.E. stations.

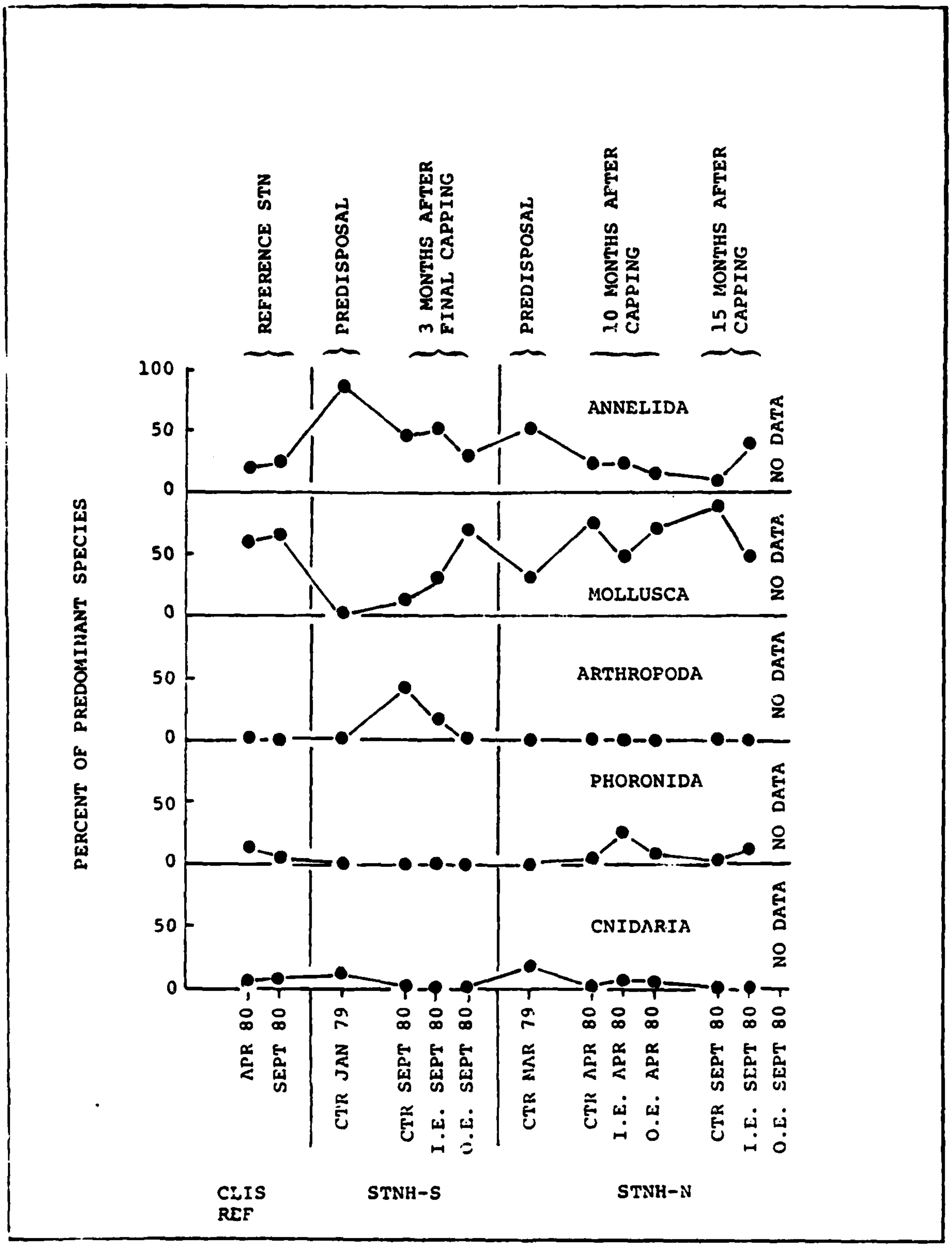


Figure 14. Distribution Within Five Major Phyla of the Predominant Species at the CLIS Disposal Site

SUMMARY

Sediments at multiple sites within the CLIS Disposal Site off New Haven, CT, were examined for grain size distribution, and content of heavy metals, volatile solids, and benthic organisms as part of a study of the effects of dredged material disposal and capping operations. The following information summarizes the study:

- Thirty-five percent of the sediments were classified as clayey silt, 26 percent as sand-silt-clay and 13 percent occurred in each of the categories sand, silty-sand, and silt.

- Between-grab variability in the composition of sand, silt, and clay was lowest in the natural bottom sediments of the reference station and at the O.E. of the disposal mounds. Highest variability occurred at the I.E. stations.

- Within the confines of a given sampling station, variability in sediment mean grain size is not related to the spatial distribution of repetitive grabs.

- Concentration in the sediments of the five heavy metals (Cr, Cu, Pb, Ni, and Zn) are directly related, i.e., when the concentration of one is high the other four are also high.

- The frequency distribution curves for Cr, Cu, and Pb were very similar and allowed a common cut-point between high and low concentrations of these metals to be established at 51 ppm and also justified the use, in this research, of a pooled average value as a variable of stratification.

- In a similar analysis, the cut-point between high and low values of volatile solids was set at 5.99%

- Sediments were partitioned into 4 size categories, which, in conjunction with the 4 categories resulting from the partitioning of heavy metals and volatile solids, permitted the generation of a matrix of 16 discrete combinations of these three variates for classification of CLIS sediments.

- Higher concentrations of heavy metals and volatile solids were found in the finer sediments.

- Sediments high in heavy metal and volatile solid content occurred in a greater percentage of the grabs collected at the REF, baseline, and O.E. stations than at the CTR of the capped STNH-N and STNH-S disposal sites.

- At the STNH-N CTR mound (15 months after capping) the mean number of individuals (N) and mean number of species (S) was significantly higher than in samples taken in the same month from the REF station or in predisposal collections.

- Three months after final capping, at the STNH-S mound center, the values for N and S were roughly comparable to those at the REF station and suggest a rapid recolonization of dredged material.

- There was a striking difference between the species composition at the STNH-N CTR and the other stations. Two species of molluscs and four species of annelids achieved predominant species status at this station only, while the most predominant species at most other stations, Nucula proxima and Nepthys incisa, were absent.

- Sediments at the STNH-S CTR and I.E. stations were unique by virtue of the presence of two arthropods Ampelisca vadorum and A. abdita, and the annelid, Owenia fusiformis. The latter two, and perhaps all three species, may have opportunistically colonized these recently deposited materials.

- The soft bottom community of the study area is dominated numerically by the mollusc, Nucula proxima, and the polychaete, Nephthys incisa, the same two species that Sanders (1956) found to comprise 42.9 and 27.6%, respectively, of the biomass in this area during 1952-1954.

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Appendix A.

Sediment mean grain size in mm's and phi units for biological grab samples collected in the vicinity of the Central Long Island Sound Disposal Site.

The sample mean grain size is defined as:

$$\frac{Q_1 + Q_3}{2}$$

where Q_1 and Q_3 are the first and third quartiles, respectively, of the sediment cumulative curve. The overall mean grain size and standard deviation in mm's and Ø are also given for each sampling date. In addition, the sediment composition in terms of mean percent gravel, sand, silt and clay (grade scales defined according to Wentworth's (1922) size classification) are also presented. Because the distribution of a set of percentages is usually not normal, the calculation of standard deviations for the latter means has been omitted.

Reverse Blank

SEDIMENT MEAN GRAIN SIZE - CLIS REF

GRAB NUMBER	Apr 1, 1980 mm	Apr 1, 1980 Φ	Sept 5, 1980 mm	Sept 5, 1980 Φ	Jan 26, 1981 mm	Jan 26, 1981 Φ	Aug 19, 1981 mm	Aug 19, 1981 Φ
1	0.016	6.07	0.019	6.66	0.016	7.01	0.012	7.01
2	0.016	6.12	0.019	6.50	0.013	6.92	0.015	7.05
3	0.015	6.29	0.023	6.33	0.21	6.70	0.012	7.27
4	0.015	6.19	0.021	6.28	0.009	7.73	0.014	7.04
5	0.016	6.13	0.016	6.56	0.020	6.54	0.010	7.29
6	0.014	6.25	0.017	6.84	0.014	7.21	0.010	7.46
7	0.016	6.13	0.020	6.65	0.017	6.67	0.013	7.01
8	0.021	5.92	0.021	6.31	0.015	6.75	0.014	6.90
9	0.012	6.21	0.016	6.80	0.014	6.88	0.010	7.35
10	0.017	6.21	0.016	6.80	0.014	6.88	0.010	7.35
MEAN	0.016	6.18	0.019	6.54	0.015	6.93	0.012	7.16
STD. DEV.	0.002	0.14	0.002	0.20	0.003	0.34	0.002	0.18

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0	0	0	0
% SAND	5.0	4.8	6.1	3.3
% SILT	87.3	68.2	64.2	65.6
% CLAY	7.8	27.1	29.8	31.2

SEDIMENT MEAN GRAIN SIZE - STNH-N-CTR

GRAB NUMBER	Apr 1, 1980 mm	Φ	Sept 4, 1980 mm	Φ	Jan 28, 1981 mm	Φ	mm	Φ
1	0.245	2.10	0.278	1.96	0.210	2.31		
2	0.215	2.27	0.248	2.08	0.036	5.17		
3	0.235	1.78	0.250	2.13	0.215	2.29		
4	0.215	2.27	0.180	2.74	0.215	2.31		
5	0.270	1.96	0.235	2.19	0.235	2.17		
6	0.220	2.22	0.300	1.94	0.260	2.02		
7	0.240	2.212	0.268	2.03	0.200	2.35		
8	0.230	2.16	0.290	1.90	0.240	2.17		
9	0.255	2.02	0.228	2.21	0.185	2.50		
10	0.265	1.99	0.238	2.13	0.220	2.24		
MEAN	0.239	2.09	0.252	2.13	0.202	2.55		
STD. DEV.	0.020	0.15	0.035	0.24	0.062	0.93		

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN*	MEAN
% GRAVEL	0.5	1.7	0.1	
% SAND	97.2	95.1	92.9	
% SILT	2.4	3.3	6.8	
% CLAY	0	0	0.2	

* Based on nine grabs.

SEDIMENT MEAN GRAIN SIZE - STNH- N-I.E.

GRAB NUMBER	Apr 2, 1980 mm	Φ	Sept 4, 1980 mm	Φ	Han 28, 1981 mm	Φ	mm	Φ
1	0.089	4.22	0.099	4.10	0.102	3.74		
2	0.083	4.35	0.095	4.31	0.091	4.11		
3	0.088	4.30	0.103	3.90	0.031	5.78		
4	0.082	4.45	0.082	4.45	0.065	4.85		
5	0.083	4.35	0.108	3.75	0.029	6.21		
6	0.089	4.26	0.075	4.47	0.083	4.35		
7	0.087	4.40	0.104	4.03	0.115	3.54		
8	0.094	4.22	0.095	4.29	0.051	5.98		
9	0.099	4.18	0.084	4.80	0.075	4.75		
10	0.088	4.35	0.057	4.79	0.087	4.45		
MEAN	0.088	4.31	0.090	4.29	0.073	4.78		
STD. DEV.	0.005	0.09	0.015	0.35	0.029	0.93		

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0.1	0	0	
% SAND	52.7	55.7	44.9	
% SILT	42.2	31.7	39.6	
% CLAY	5.2	12.7	15.6	

SEDIMENT MEAN GRAIN SIZE - STNH-N- O.E.

GRAB NUMBER	Apr 2, 1980 mm	Φ	Jan 28, 1981 mm	Φ	mm	Φ	mm	Φ
1	0.026	5.63	0.012	6.88				
2	0.024	5.59	0.015	6.99				
3	0.023	5.63	0.016	7.01				
4	0.035	5.29	0.010	7.39				
5	0.020	5.81	0.019	6.50				
6	0.029	5.43	0.017	6.59				
7	0.021	5.76	0.013	7.07				
8	0.025	5.61	0.015	6.71				
9	0.022	5.76	0.020	6.44				
10	0.021	5.72	0.018	6.54				
MEAN	0.025	5.62	0.016	6.81				
STD. DEV.	0.005	0.16	0.003	0.31				

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0	0		
% SAND	14.5	8.8		
% SILT	80.9	62.5		
% CLAY	4.7	28.7		

SEDIMENT MEAN GRAIN SIZE - STNH-S-CTR

GRAB NUMBER	Predisposal Jan 26, 1979 mm	Φ	Sept 5, 1980 mm	Φ	Jan 25, 1981 mm	Φ	mm	Φ
1	0.029	6.05	0.128	4.63	0.021	6.56		
2	0.022	6.40	0.142	4.40	0.022	6.47		
3			0.148	4.71	0.189	4.30		
4			0.058	5.59	0.025	6.36		
5			0.020	6.46	0.015	6.75		
6			0.141	4.56	0.204	4.15		
7			0.036	5.78	0.040	5.84		
8			0.111	4.47	0.024	6.30		
9			0.013	6.99	-	-		
10			0.054	5.14	0.027	6.18		
MEAN	0.026	6.23	0.085	5.27	0.063	5.88		
STD. DEV.	0.005	0.25	0.054	0.91	0.076	0.97		

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	1.3	1.6	1.8	
% SAND	18.3	29.3	22.8	
% SILT	55.3	47.7	50.6	
% CLAY	25.3 (N=2)	21.6 (N=10)	24.8 (N=9)	

SEDIMENT MEAN GRAIN SIZE - STNH-S-I.E.

GRAB NUMBER	Sept 5, 1980 mm	Sept 5, 1980 Φ	Jan 25, 1981 mm	Jan 25, 1981 Φ	mm	Φ	mm	Φ
1	0.048	5.38	0.032	6.01				
2	0.040	5.60	0.036	6.06				
3	0.017	6.53	0.024	6.42				
4	0.110	4.60	0.012	7.46				
5	0.028	5.92	0.027	6.38				
6	0.014	6.90	0.011	7.30				
7	0.030	5.99	0.153	3.58				
8	0.032	5.94	0.037	5.94				
9	0.016	6.63	0.089	4.72				
10	0.018	6.84	0.068	5.29				
MEAN	0.035	6.03	0.049	5.92				
STD. DEV.	0.029	0.72	0.044	1.16				

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0	0.2		
% SAND	20.3	28.1		
% SILT	55.8	45.9		
% CLAY	23.9	25.9		

SEDIMENT MEAN GRAIN SIZE - STNH-S-O.E.

GRAB NUMBER	Sept 3, 1980 300 M East mm	Φ	Jan 26, 1981 400 M East mm	Φ	mm	Φ	mm	Φ
1	0.016	6.66	0.039	5.74				
2	0.012	7.34	0.238	4.20				
3	0.016	6.10	0.073	5.20				
4	0.014	6.98	0.010	7.42				
5	0.018	5.89	0.009	7.04				
6	0.013	6.80	0.019	6.77				
7	0.020	6.75	0.025	6.07				
8	0.053	5.44	0.038	5.74				
9	0.013	6.86	0.015	6.73				
10	0.021	6.35	-	-				
MEAN	0.020	6.52	0.052	6.10				
STD. DEV.	0.012	0.57	0.073	1.01				

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0.4	2.0		
% SAND	11.4	16.5		
% SILT	65.5	56.4		
% CLAY	22.7	25.1		

SEDIMENT MEAN GRAIN SIZE - STNH-S-1000 M East

GRAB NUMBER	Jan 26, 1979 mm	Φ	May 22, 1979 mm	Φ	Aug 9, 1979 mm	Φ	mm	Φ
1	0.015	6.90	0.032	6.17	0.016	7.25		
2								
3								
4								
5								
6								
7								
8								
9								
10								
MEAN	-	-	-	-	-	-		
STD. DEV.	-	-	-	-	-	-		

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0	0	0	
% SAND	4	25	3.5	
% SILT	64	48	60	
% CLAY	32	27	36.5	

SEDIMENT MEAN GRAIN SIZE - STNH-S-1000 M West

GRAB NUMBER	Jan 26, 1979 mm	Φ	May 22, 1979 mm	Φ	Aug 9, 1979 mm	Φ	mm	Φ
1	0.020	6.54	0.023	6.80	0.015	7.22		
2								
3								
4								
5								
6								
7								
8								
9								
10								
MEAN	-	-	-	-	-	-		
STD. DEV.	-	-	-	-	-	-		

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	TR	0	0	
% SAND	9	15	11	
% SILT	63	52	55.5	
% CLAY	28	33	33.5	

SEDIMENT MEAN GRAIN SIZE - NORNH-CTR

GRAB NUMBER	Apr 1, 1980 mm	Φ	Aug 20, 1981 mm	Φ	mm	Φ	mm	Φ
1	0.019	5.93	0.079	4.93				
2	0.031	5.40	0.053	5.41				
3	0.028	5.33	0.033	6.09				
4	0.030	5.51	0.032	6.09				
5	0.017	6.05	0.029	5.83				
6	0.015	6.13	0.041	5.64				
7	0.011	6.56	0.028	5.90				
8	0.050	5.06	0.018	6.45				
9	0.019	6.03	0.017	6.59				
10	0.020	5.94	0.018	6.34				
MEAN	0.024	5.79	0.035	5.89				
STD. DEV.	0.011	0.45	0.019	0.50				

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0.6	0.2		
% SAND	14.9	23.4		
% SILT	79.5	54.6		
% CLAY	5.1	21.9		

SEDIMENT MEAN GRAIN SIZE - NORNH-I.E.

GRAB NUMBER	Aug21, 1981 mm	Φ	mm	Φ	mm	Φ	mm	Φ
1	0.025	6.22						
2	0.026	6.38						
3	0.074	4.93						
4	0.012	6.99						
5	0.034	5.92						
6	0.025	6.28						
7	0.024	6.25						
8	0.032	5.97						
9	0.033	5.97						
10	0.053	5.22						
MEAN	0.034	6.01						
STD. DEV.	0.018	0.58						

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0.7			
% SAND	22.7			
% SILT	52.7			
% CLAY	24.1			

SEDIMENT MEAN GRAIN SIZE - NORNH-O.E.

GRAB NUMBER	Aug 21, 1981 mm	Φ	mm	Φ	mm	Φ	mm	Φ
1	0.035	5.92						
2	0.033	6.07						
3	0.013	6.78						
4	0.018	6.73						
5	0.014	6.80						
6	0.017	6.92						
7	0.025	6.24						
8	0.025	6.22						
9	0.016	6.58						
10	0.014	6.83						
MEAN	0.021	6.51						
STD. DEV.	0.008	0.36						

MEANS OF 10 GRABS

	MEAN	MEAN	MEAN	MEAN
% GRAVEL	0			
% SAND	16.0			
% SILT	57.1			
% CLAY	27.0			

Appendix B.

Sediment Chemistry Means

Reverse Blank

SEDIMENT CHEMISTRY MEANS - CLIS REF

PARAMETER	APR 1, 1980 MEAN	N	STD.DEV.	SEPT 5, 1980 MEAN	N	STD.DEV.	JAN 26, 1981 MEAN	N	STD.DEV.	AUG 19, 1981 MEAN	N	STD.DEV.
Cr (PPM)	48	10	3.6	74	10	6.6	62	10	6.5	71	10	2.7
Cu (PPM)	71	10	13.0	47	10	7.7	60	10	3.7	65	10	2.5
Pb (PPM)	55	10	8.8	50	10	14.2	41	10	1.7	63	10	10.8
Ni)PPM)	49	10	17.0	48	10	17.1	45	10	9.5	35	10	5.3
Zn (PPM)	182	10	19.0	170	10	17.0	170	10	12.9	195	10	37.8
% of Vol Solids	6.4	10	--	6.4	10	--	6.1	10	--	6.3	10	--
Pooled Mean of Cr, Cu & Pb	58	30	4.0	57	30	3.8	54	30	2.8	66	30	4.5

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	64	11.3	40
Cu (PPM)	61	11.7	40
Pb (PPM)	52	12.6	40
Ni (PPM)	44	13.9	40
Zn (PPM)	179	25.0	40
% of Vol Solids	6.3	--	40

SEDIMENT CHEMISTRY MEANS - STNH-N-CTR

PARAMETER	MAR 21, 1979 MEAN	N	STD.DEV.	APR 1, 1980 MEAN	N	STD.DEV.	SEPT 4, 1980 MEAN	N	STD.DEV.	JAN 28, 1981 MEAN	N	STD.DEV.
Cr (PPM)	67	3	4.0	6	10	2.3	23	10	4.9	<13	10	--
Cu (PPM)	61	3	3.6	47	10	13.2	9	10	4.9	<10	10	--
Pb (PPM)	49	3	2.0	41	10	21.0	<23	10	--	<20	10	--
Ni)PPM)	22	3	1.2	12	10	20.0	27	10	6.7	<30	10	--
Zn (PPM)	157	3	8.3	52	10	26.0	69	10	41.4	47	10	18.4
% of Vol Solids	9.4	3	--	1.3	10	--	1.0	10	--	1.1	10	--
Pooled Mean of Cr, Cu & Pb	59	9	8.4	31	30	8.2	18	30	--	20	30	--

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	<14	--	30
Cu (PPM)	<22	--	30
Pb (PPM)	<28	--	30
Ni (PPM)	<23	--	30
Zn (PPM)	56	30.6	30
% of Vol Solids	1.1	--	30

SEDIMENT CHEMISTRY MEANS - STNH-N-I.E.

PARAMETER	APR 2, 1980 MEAN	N	STD.DEV.	SEPT 4, 1980 MEAN	N	STD.DEV.	JAN 28, 1981 MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	32	10	9.8	40	10	5.9	36	10	15.9			
Cu (PPM)	84	10	15.3	37	10	8.9	39	10	14.2			
Pb (PPM)	49	10	8.0	49	10	18.5	<27	10	--			
Ni)PPM)	22	10	9.3	39	10	6.3	<31	10	--			
Zn (PPM)	153	10	85.0	125	10	31.4	112	10	40.6			
% of Vol Solids	5.0	10	--	3.4	10	--	4.2	10	--			
Pooled Mean of Cr, Cu & Pb	55	30	7.0	42	30	9.4	34	30	--			

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	36	11.5	30
Cu (PPM)	53	25.6	30
Pb (PPM)	<41	--	30
Ni (PPM)	<31	--	30
Zn (PPM)	130	58.0	30
% of Vol Solids	4.2	--	30

SEDIMENT CHEMISTRY MEANS - STNH-N-O.E.

PARAMETER	APR 2, 1980 MEAN	N	STD.DEV.	JAN 28, 1981 MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	46	10	7.1	63	10	2.9						
Cu (PPM)	100	10	10.0	71	10	3.0						
Pb (PPM)	57	10	9.8	30	10	3.6						
Ni)PPM)	33	10	6.2	44	10	1.7						
Zn (PPM)	204	10	65.0	182	10	15.2						
% of Vol Solids	6.7	10	--	6.1	10	--						
Pooled Mean of Cr, Cu & Pb	68	30	8.3	61	30	2.3						

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	54	10.1	20
Cu (PPM)	86	16.7	20
Pb (PPM)	54	8.0	20
Ni (PPM)	39	6.9	20
Zn (PPM)	193	47.3	20
% of Vol Solids	6.4	--	20

SEDIMENT CHEMISTRY MEANS - STNH-S-CTR

PARAMETER	PREDISPOSAL JAN 26, 1979 MEAN	N	STD.DEV.	SEPT 5, 1980 MEAN	N	STD.DEV.	JAN 25, 1981 MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	48	3	4.6	84	10	13.7	94	10	27.7			
Cu (PPM)	54	3	7.2	93	10	18.6	98	10	29.0			
Pb (PPM)	43	3	4.0	64	10	21.3	<35	10	--			
Ni)PPM)	16	3	2.1	46	10	6.2	122	10	38.6			
Zn (PPM)	149	3	20.2	174	10	34.9	184	10	39.6			
% of Vol Solids	11.9	3	--	5.7	10	--	5.6	10	--			
Pooled Mean of Cr, Cu & Pb	48	9	6.6	80	30	15.9	<76	30	--			

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	89	21.9	20
Cu (PPM)	96	23.9	20
Pb (PPM)	<50	--	20
Ni (PPM)	84	47.6	20
Zn (PPM)	179	36.7	20
% of Vol Solids	5.7	--	20

These overall figures do not include the predisposal values.

SEDIMENT CHEMISTRY MEANS - STNH-S-I.E.

	SEPT 5, 1980			JAN 25, 1981								
PARAMETER	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	98	10	17.3	65	10	20.9						
Cu (PPM)	82	10	28.3	61	10	28.2						
Pb (PPM)	63	10	22.8	<37	10	--						
Ni)PPM)	49	10	7.8	<54	10	--						
Zn (PPM)	213	10	48.3	144	10	46.2						
% of Vol Solids	6.6	10	--	5.6	10	--						
Pooled Mean of Cr, Cu & Pb	81	30	20.5	54	30	--						

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	82	25.3	20
Cu (PPM)	72	29.6	20
Pb (PPM)	<50	--	20
Ni (PPM)	<52	--	20
Zn (PPM)	179	58.3	20
% of Vol Solids	6.1	--	20

SEDIMENT CHEMISTRY MEANS - STNH-S-O.E.

	SEPT 3, 1980 300M EAST			JAN 26, 1981 400M EAST								
PARAMETER	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	162	10	19.5	53	10	10.2						
Cu (PPM)	135	10	18.1	51	10	16.2						
Pb (PPM)	72	10	37.7	<36	10	--						
Ni)PPM)	49	10	9.1	<52	10	--						
Zn (PPM)	255	10	52.9	138	10	38.4						
% of Vol Solids	6.6	10	--	6.0	10	--						
Pooled Mean of Cr, Cu & Pb	123	30	17.4	46	30	--						

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)			
Cu (PPM)			
Pb (PPM)			
Ni (PPM)			
Zn (PPM)			
% of Vol Solids			

SEDIMENT CHEMISTRY MEANS - STNH-S-1000M EAST

PARAMETER	JAN 26, 1979 MEAN	N	STD.DEV.	MAY 21, 1979 MEAN	N	STD.DEV.	AUG 9, 1979 MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	39	3	0	53	3	4.2	43	3	1.5			
Cu (PPM)	46	3	1.2	48	3	4.0	50	3	2.0			
Pb (PPM)	47	3	1.2	47	3	3.5	50	3	0.6			
Ni)PPM)	23	3	1.2	22	3	1.0	22	3	0.0			
Zn (PPM)	146	3	5.6	139	3	8.1	139	3	6.5			
% of Vol Solids	16	3	--	17	3	--	9	3	--			
Pooled Mean of Cr, Cu & Pb	44	9	3.9	49	9	4.3	48	9	3.5			

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	45	6.4	9
Cu (PPM)	48	3.0	9
Pb (PPM)	48	2.2	9
Ni (PPM)	22	1.0	9
Zn (PPM)	141	6.9	9
% of Vol Solids	14	--	9

SEDIMENT CHEMISTRY MEANS - STNH-S-1000M WEST

PARAMETER	JAN 26, 1979 MEAN	N	STD.DEV.	MAY 22, 1979 MEAN	N	STD.DEV.	AUG 9, 1979 MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	39	3	1.2	50	3	5.0	48	3	1.5			
Cu (PPM)	47	3	2.5	52	3	6.8	56	3	2.1			
Pb (PPM)	45	3	1.0	47	3	4.9	52	3	2.1			
Ni)PPM)	20	3	1.5	20	3	1.5	22	3	1.0			
Zn (PPM)	141	3	5.1	142	3	18.7	147	3	9.1			
% of Vol Solids	16	3	--	14	3	--	10	3	--			
Pooled Mean of Cr, Cu & Pb	43	9	3.9	50	9	5.4	52	9	3.8			

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)	46	5.9	9
Cu (PPM)	51	5.3	9
Pb (PPM)	48	4.1	9
Ni (PPM)	21	1.6	9
Zn (PPM)	144	11.1	9
% of Vol Solids	13	--	9

SEDIMENT CHEMISTRY MEANS - NORNH-CTR

	APR 2, 1980			AUG 20, 1981								
PARAMETER	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	64	10	18.0	104	10	33.2						
Cu (PPM)	100	10	32.0	143	10	36.8						
Pb (PPM)	57	10	12.0	82	10	31.7						
Ni)PPM)	53	10	14.0	33	10	4.3						
Zn (PPM)	210	10	86.0	235	10	58.4						
% of Vol Solids	6.2	10	--	7.0	10	--						
Pooled Mean of Cr, Cu & Pb	74	30	19.4	110	30	29.0						

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)			
Cu (PPM)			
Pb (PPM)			
Ni (PPM)			
Zn (PPM)			
% of Vol Solids			

SEDIMENT CHEMISTRY MEANS - NORNH-I.E.

	AUG 21, 1981											
PARAMETER	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	104	10	11.2									
Cu (PPM)	120	10	14.9									
Pb (PPM)	104	10	11.9									
Ni)PPM)	31	10	3.2									
Zn (PPM)	278	10	22.0									
% of Vol Solids	6.7	10	--									
Pooled Mean of Cr, Cu & Pb	109	30	10.8									

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)			
Cu (PPM)			
Pb (PPM)			
Ni (PPM)			
Zn (PPM)			
% of Vol Solids			

SEDIMENT CHEMISTRY MEANS - NORNH-O.E.

PARAMETER	AUG 21, 1981 MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.	MEAN	N	STD.DEV.
Cr (PPM)	99	10	19.3									
Cu (PPM)	85	10	22.2									
Pb (PPM)	87	10	10.5									
Ni)PPM)	30	10	0.0									
Zn (PPM)	260	10	81.8									
% of Vol Solids	6.2	10	--									
Pooled Mean of Cr, Cu & Pb	90	30	16.5									

	OVERALL MEAN	STANDARD DEVIATION	N
Cr (PPM)			
Cu (PPM)			
Pb (PPM)			
Ni (PPM)			
Zn (PPM)			
% of Vol Solids			

Appendix C.

Benthic macrofauna data summary for samples collected in April and September of 1980. The mean number of individuals (N), the mean number of species (S), the mean value for the Shannon-Weaver index of diversity (H), equitability index means (J), and the 95% confidence intervals of these means, are presented for each grab sample.

BENTHIC MACROFAUNA DATA SUMMARY - CLIS REF

DATE	APR 1, 1980			SEPT 5, 1980		
GRAB NUMBER	2	6	7	1	2	3
NO. SPECIES PER SAMPLE	13	16	11	10	10	11
NO. INDIVIDUALS PER SAMPLE	62+	130+	76+	67+	56	69+
NO. PHYLA PER STATION		7			6	
NO. SPECIES PER STATION		20			15	
NO. INDIVIDUALS PER STATION		268+			192+	

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
APR 1, 1980	89	0-179	13	7-20	1.68	0.93-2.43	0.72	0.45-0.99	3
SEPT 5, 1980	64	47-81	10	9-12	1.49	0.92-2.06	0.66	0.44-0.88	3

BENTHIC MACROFAUNA DATA SUMMARY - STNH-N-CTR

DATE	MAR 21, 1979					APR 1, 1980			SEPT 4, 1980		
GRAB NUMBER	1	2	3	4	5	1	2	3	1	2	3
NO. SPECIES PER SAMPLE	10	8	9	8	5	21	25	23	30	41	34
NO. INDIVIDUALS PER SAMPLE	44	17	41	30	16	121+	145+	63+	170+	147+	128+
NO. PHYLA PER STATION			6				7			7	
NO. SPECIES PER STATION			20				38			56	
NO. INDIVIDUALS PER STATION			148				329+			445+	

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
MAR 21, 1979	30	13-46	8	6-10	1.66	1.18-2.14	0.80	0.66-0.94	5
APR 1, 1980	110	5-214	23	18-28	1.73	1.26-2.20	0.62	0.52-0.72	3
SEPT 4, 1980	148	96-201	35	21-49	1.94	1.39-2.49	0.59	0.47-0.71	3

BENTHIC MACROFAUNA DATA SUMMARY - STNH-N-I.E.

DATE	APR 2, 1980			SEPT 4, 1980		
GRAB NUMBER	1	2	3	1	2	3
NO. SPECIES PER SAMPLE	9	12	15	30	26	40
NO. INDIVIDUALS PER SAMPLE	49+	96+	77+	213+	255+	231+
NO. PHYLA PER STATION		8			8	
NO. SPECIES PER STATION		20			56	
NO. INDIVIDUALS PER STATION		222+			699+	

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
APR 2, 1980	74	15-133	12	5-20	1.67	1.52-1.82	0.75	0.60-0.90	3
SEPT 4, 1980	233	181-285	32	14-50	2.30	1.51-3.09	0.72	0.55-0.89	3

BENTHIC MACROFAUNA DATA SUMMARY - STNH-N-O.E.

DATE	APR 2, 1980		
GRAB NUMBER	2	3	4
NO. SPECIES PER SAMPLE	11	12	11
NO. INDIVIDUALS PER SAMPLE	140	118+	50+
NO. PHYLA PER STATION		8	
NO. SPECIES PER STATION		19	
NO. INDIVIDUALS PER STATION		308+	

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
APR 2, 1980	103	0-219	11	10-13	1.50	0.68-2.32	0.64	0.24-1.04	3

BENTHIC MACROFAUNA DATA SUMMARY - STNH-S-CTR

DATE	JAN 26, 1979					AUG 9, 1979					SEPT 5, 1980		
GRAB NUMBER	1	2	3	4	5	1	2	3	4	5	1	2	3
NO. SPECIES PER SAMPLE	18	11	7	6	9	7	5	7	3	3	8	22	15
NO. INDIVIDUALS PER SAMPLE	47+	41+	44+	39+	53	9	7	9	5	4	35+	83+	69+
NO. PHYLA PER STATION			7					5				6	
NO. SPECIES PER STATION			26					15				26	
NO. INDIVIDUALS PER STATION			224+					34				187+	

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
JAN 26, 1979	45	38-52	10	5-15	1.50	1.13-1.87	0.67	0.63-0.71	5
AUG 9, 1979	7	4-10	5	3-8	1.46	0.90-2.02	0.94	0.89-0.99	5
SEPT 5, 1980	62	1-124	15	0-32	1.70	0.73-2.67	0.82	0.62-1.02	3

BENTHIC MACROFAUNA DATA SUMMARY - STNH-S-I.E.

DATE	SEPT 5, 1980		
GRAB NUMBER	1	2	3
NO. SPECIES PER SAMPLE	17	7	7
NO. INDIVIDUALS PER SAMPLE	33+	12+	8+
NO. PHYLA PER STATION		6	
NO. SPECIES PER STATION		21	
NO. INDIVIDUALS PER STATION		53+	

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
SEPT 5, 1980	18	0-51	10	0-25	1.59	0.65-2.53	0.92	0.80-1.04	3

BENTHIC MACROFAUNA DATA SUMMARY - STNH-S-O.E.

DATE	SEPT 3, 1980		
GRAB NUMBER	1	2	3
NO. SPECIES PER SAMPLE	9	11	13
NO. INDIVIDUALS PER SAMPLE	67+	52+	80+
NO. PHYLA PER STATION		5	
NO. SPECIES PER STATION		19	
NO. INDIVIDUALS PER STATION		199+	

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
SEPT 3, 1980	66	32-101	11	6-16	1.30	0.63-1.97	0.60	0.35-0.85	3

BENTHIC MACROFAUNA DATA SUMMARY - STNH-S 1000M EAST

DATE	JAN 26, 1979					MAY 21, 1979					AUG 9, 1979				
GRAB NUMBER	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
NO. SPECIES PER SAMPLE	10	7	8	11	10	9	7	9	17	10	14	9	11	19	10
NO. INDIVIDUALS PER SAMPLE	36	18	25	51	42+	36	32+	35+	65+	36+	165	37	58	107+	124+
NO. PHYLA PER STATION			6					7					8		
NO. SPECIES PER STATION			24					24					30		
NO. INDIVIDUALS PER STATION			172+					204+					491+		

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
JAN 26, 1979	34	18-51	9	7-11	1.70	1.39-2.01	0.77	0.65-0.89	5
MAY 21, 1979	41	24-58	10	6-15	1.83	1.41-2.25	0.79	0.70-0.88	5
AUG 9, 1979	98	34-162	13	8-18	1.71	1.47-1.95	0.69	0.59-0.79	5

BENTHIC MACROFAUNA DATA SUMMARY - STNH-S 1000M WEST

DATE	JAN 26, 1979					MAY 22, 1979					AUG 9, 1979				
GRAB NUMBER	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
NO. SPECIES PER SAMPLE	12	13	14	10	9	12	15	10	10	10	21	13	14	13	12
NO. INDIVIDUALS PER SAMPLE	42+	36	41	23	28+	43	39	37	30	25+	225+	132	145	138	145+
NO. PHYLA PER STATION			9					7					8		
NO. SPECIES PER STATION			32					31					33		
NO. INDIVIDUALS PER STATION			170+					174+					785+		

DATE	$\bar{N}$	95% CONF. INT.	$\bar{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
JAN 26, 1979	34	24-44	12	9-14	1.83	1.54-2.12	0.74	0.66-0.84	5
MAY 22, 1979	35	26-44	11	9-14	2.02	1.73-2.31	0.83	0.78-0.88	5
AUG 9, 1979	157	109-205	15	10-19	1.55	1.41-1.69	0.58	0.54-0.62	5

BENTHIC MACROFAUNA DATA SUMMARY - NORNH-CTR

DATE	APR 1, 1980		
GRAB NUMBER	2	4	5
NO. SPECIES PER SAMPLE	8	14	12
NO. INDIVIDUALS PER SAMPLE	23	191+	107
NO. PHYLA PER STATION		8	
NO. SPECIES PER STATION		18	
NO. INDIVIDUALS PER STATION		321+	

DATE	$\ddot{N}$	95% CONF. INT.	$\ddot{S}$	95% CONF. INT.	$\bar{H}$	95% CONF. INT.	$\bar{J}$	95% CONF. INT.	n
APR 1, 1980	107	0-316	11	4-19	1.53	0.69-2.37	0.66	0.11-1.21	3

Appendix D.

Predominant species are defined as those species which make up at least two percent of the total number of individuals in the entire sample. The coefficient of dispersion (CD) which is the variance/mean ratio indicates a random (CD=1), a clumped (CD>1) or even (CD<1) distribution of these species on the bottom.

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DAMCS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION CENTRAL LONG ISLAND SOUND REFERENCE — DATE 1 APRIL 1980

PREDOMINANT SPECIES	GRAB NUMBER 2	6	7	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nucula proxima	12	75	29	115	38.7	32.6	27.5	0-119.7	1	43.3	43.3
2. Nephthys incisa	12	15	18	45	15.0	3.0	0.6	7.6 - 22.5	2	16.8	60.1
3. Phoronis architecta	13	14	5	32	10.7	4.9	2.2	0-22.9	3	11.9	72.0
4. Mulinia lateralis	12	7	9	28	9.3	2.5	0.7	3.1 - 15.5	4	10.4	82.4
5. Saccoglossus kowalevskii	2	2	6	10	3.3	2.3	1.5	0-9.0	5	3.7	86.1
6. Corymorpha pendula	2	4	1	7	2.3	1.5	1.0	0-6.0	6	2.6	88.7
8. Ceriantharian sp. A	1	1	4	6	2.0	1.7	1.5	0-6.2	7	2.2	90.9
TOTAL	54	118	72	244	81.3	33.0	12.4	0-163.3			
TOTAL NO. OF SPECIES COLLECTED	13	16	11	20	13.3	2.5	0.5	7.1 - 19.6			
SPECIES DIVERSITY (H')	1.95	1.26	1.72	5.03	1.68	0.30		0.93- 2.43			
EQUITABILITY (J')	0.81	0.53	0.75	2.15	0.72	0.11		0.45- 0.99			

TOTAL NO. INDIVIDUALS THIS STN = 268(3 GRABS)

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION CENTRAL LONG ISLAND SOUND REFERENCE — DATE 5 SEPT 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nucula proxima	39	23	38	100	33.3	9.0	2.4	10.9-55.7	1	52.6	52.6
2. Nephthys incisa	15	14	13	42	14.0	1.0	0.7	11.5-16.5	2	22.1	74.7
3. Ceriantharian sp. B	5	3	4	12	4.0	1.0	0.3	1.5-6.5	3	6.3	81.0
4. Phoronis architecta	2	3	3	8	2.7	0.6	0.1	1.2-4.2	4	4.2	85.2
5. Retusa canaliculata	1	3	4	8	2.7	1.5	0.8	0-6.4	4	4.2	89.4
6. Yoldia limatula	1	5	0	6	2.0	2.6	3.4	0-8.5	5	3.2	92.6
TOTAL	63	51	62	176	58.7	6.7	0.8	42.1-75.4			
TOTAL NO. OF SPECIES COLLECTED	10	10	11	15	10.3	0.6	0.03	8.8-11.8			
SPECIES DIVERSITY (H')	1.28	1.73	1.46		1.49	0.23		0.92-2.06			
EQUITABILITY (J')	0.58	0.75	0.64		0.66	0.09		0.44-0.88			

TOTAL NO. INDIVIDUALS THIS STN = 190 (3 GRABS)

PREDUMP

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-NORTH-CENTER

Date 21 MARCH 1979

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nephtys incisa	11	7	18	7	11	54	10.8	4.5	1.9	5.2-16.4	1	36.5	36.5
2. N[illegible] proxima	3	2	11	7	1	24	4.8	4.1	3.5	0-9.9	2	16.2	52.7
3. [illegible] sp. A	6	2	3	5	2	18	3.6	1.8	0.9	1.3-5.9	3	12.2	64.9
4. Mulinia lateralis	0	2	1	6	0	9	1.8	2.5	3.5	0-4.9	4	6.1	71.0
5. Pherusa affinis	7	0	1	0	1	9	1.8	2.9	4.7	0-5.5	4	6.1	77.1
6. Macoma tenta	3	0	4	0	0	7	1.4	1.9	2.6	0-3.8	5	4.7	81.8
7. Mel[illegible]na cristata	6	1	0	0	0	7	1.4	2.6	4.8	0-4.6	5	4.7	86.5
8. Edwardsia elegans	3	0	1	0	0	4	0.8	1.3	2.1	0-2.4	6	2.7	89.2
9. Nassarius trivittatus	3	0	1	0	0	4	0.8	1.3	2.1	0-2.4	6	2.7	91.9
TOTAL	42	14	40	25	15	136	27.2	13.3	6.5	10.7-43.7			
TOTAL NO. OF SPECIES COLLECTED	10	8	9	8	5	20	8.0	1.9	0.5	5.7-10.3			
SPECIES DIVERSITY (H')	[illegible]	1.79	1.59	1.82	1.04		1.66	0.39		1.18-2.14			
EQUITABILITY (J')	0.91	0.86	0.72	0.88	0.65		0.80	0.11		0.66-0.94			

TOTAL NO. INDIVIDUALS THIS STN = 148

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-NORTH-CENTER

DATE 4 SEPT 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Tellina versicolor	103	63	[illegible]	242	80.7	19.3	4.6	32.8-128.7	1	58.2	58.2
2. Nassarius trivittatus	8	3	5	16	5.3	2.5	1.2	0-11.5	2	3.8	62.0
3. Spiophanes bombyx	4	9	2	15	5.0	2.6	1.4	0-11.5	3	3.6	65.6
4. Ensis directus	4	6	4	14	4.7	1.2	0.3	1.7-7.7	4	3.4	69.0
5. [illegible] architects	3	0	7	10	3.3	3.5	3.7	0-12.0	5	2.4	71.4
6. [illegible]	2	6	1	9	3.0	2.6	2.3	0-9.5	6	2.2	73.6
TOTAL	134	[illegible]	90	306	102.0	19.1	3.6	54.6-149.5			
TOTAL NO. OF SPECIES COLLECTED	30	41	34	56	35.0	5.6	0.9	21.1-48.9			
SPECIES DIVERSITY (H')	1.7[illegible]	2.1[illegible]	1.92		1.94	0.22		1.39-2.49			
EQUITABILITY (J')	0.54	0.63	0.59		0.59	0.05		0.47-0.71			

TOTAL NO. INDIVIDUALS THIS STN = 416 (3 GRABS)

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-NORTH-CENTER　　　　DATE 1 APRIL 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Tellina versicolor	59	59	29	147	49.0	17.3	6.1	5.0-92.0	1	49.3	49.3
2. Spiophanes bombyx	21	9	4	34	11.3	8.7	6.7	0-32.9	2	11.4	60.7
3. Nassarius trivittatus	8	14	1	23	7.7	6.5	5.5	0-23.9	3	7.7	68.4
4. Glycera americana	3	5	2	10	3.3	1.5	0.7	0-7.0	4	3.4	71.8
5. Caulleriella filiarensis	3	5	0	8	2.7	2.5	2.3	0-8.9	5	2.7	74.5
6. Phoronis architecta	0	3	5	8	2.7	2.5	2.3	0-8.9	5	2.7	77.2
TOTAL	94	95	41	230	76.7	30.9	12.4	0-153.4			
TOTAL NO. OF SPECIES COLLECTED	21	25	23	38	23.0	2.0	0.2	18.0-28.0			
SPECIES DIVERSITY (H')	1.56	[illegible]	[illegible]	5.18	1.73	0.19		[illegible]			
EQUITABILITY (J')	0.58	0.66	0.63	1.87	0.62	0.04		0.52-0.72			

TOTAL NO. INDIVIDUALS THIS STN =298(3 GRABS)

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-NORTH-INNER EDGE (200M EAST) DATE 2 APRIL 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Mulinia lateralis	6	23	23	52	17.3	9.8	5.6	0-41.7	1	23.4	23.4
2. Phoronis architecta	14	17	21	52	17.3	3.5	0.7	8.6-26.0	1	23.4	46.8
3. Nephtys incisa	15	18	13	46	15.3	2.5	0.4	9.1-21.5	2	20.7	67.5
4. Nucula proxima	6	23	6	41	13.7	13.3	12.9	0-46.7	3	18.5	86.0
5. Ceriantharian sp.	4	1	3	8	2.7	1.5	0.8	0-6.4	4	3.6	89.6
TOTAL	45	88	66	199	66.3	21.5	7.0	12.9-119.8			
TOTAL NO. OF SPECIES COLLECTED	9	12	15	20	12	3.0	0.8	4.5- 19.5			
SPECIES DIVERSITY (H')	1.60	1.69	1.72	5.0	1.[illegible]	0.06		1.52- 1.82			
EQUITABILITY (J')	0.52	0.71	0.72	2.25	0.75	0.06		0.60- 0.90			

TOTAL NO. INDIVIDUALS THIS STN = 222 (3 GRABS)

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-NORTH-INNER EDGE (200M EAST) DATE 4 SEPT 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nucula proxima	45	103	40	188	62.7	35.0	19.6	0-149.7	1	27.7	27.7
2. Owenia fusiformis	35	31	38	104	34.7	3.5	0.4	26.0-43.4	2	15.3	43.0
3. Yoldia limatula	27	31	23	81	27.0	4.0	0.6	17.1-36.9	3	11.9	54.9
4. Phoronis architecta	21	25	31	77	25.7	5.0	1.0	13.3-38.1	4	11.4	66.3
5. Nephthys incisa	24	28	20	72	24.0	4.0	0.7	14.1-33.9	5	10.6	76.9
6. Nassarius trivitattus	13	3	8	24	8.0	5.0	3.1	0-20.4	6	3.5	80.4
7. Loimia medusa	6	3	14	23	7.7	5.7	4.2	0-21.9	7	3.4	83.8
8. Pectinaria gouldii	8	5	10	23	7.7	2.5	0.8	1.5-13.9	7	3.4	87.2
TOTAL	179	229	184	592	197.3	27.5	3.8	129.0-265.6			
TOTAL NO. OF SPECIES COLLECTED	30	26	40	56	32.0	7.2	1.6	14.1-49.9			
SPECIES DIVERSITY (H')	2.36	1.95	2.58		2.30	0.32		1.51-3.09			
EQUITABILITY (J')	0.77	0.54	0.75		0.72	0.07		0.55-0.89			

TOTAL NO. INDIVIDUALS THIS STN = 678 (3 GRABS)

AD-A141 987   A STUDY OF THE BENTHIC MACROFAUNA AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE(U) NAVAL UNDERWATER SYSTEMS CENTER NEW LONDON CT NEW LONDON LAB.. A L BROOKS   2/2

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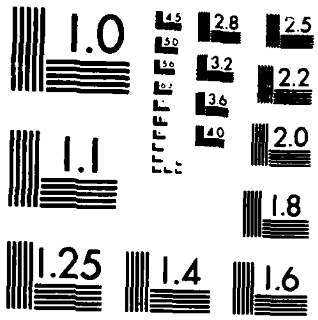

MICROCOPY RESOLUTION TEST CHART
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DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-NORTH-OUTER EDGE (400M EAST) DATE 2 APRIL 1980

PREDOMINANT SPECIES	GRAB 2	NUMBER 3	4	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nucula proxima	87	80	4	171	57.0	46.0	37.1	0-171.3	1	55.5	55.5
2. Nepnthys incisa	18	7	15	40	13.3	5.7	2.4	0-27.5	2	13.0	68.5
3. Phoronis architecta	6	7	14	27	9.0	4.4	2.2	0-19.9	3	8.8	77.3
4. Mulinia lateralis	9	11	4	24	8.0	3.6	1.6	0-16.9	4	7.8	85.1
5. Ceriantharian sp. A	4	2	3	9	3.0	1.0	0.3	0.5-5.5	5	2.9	88.0
6. Retusa canaliculata	0	3	5	8	2.7	2.5	2.3	0-8.9	6	2.6	90.6
7. Melinna cristata	5	0	2	7	2.3	2.5	2.7	0-8.5	7	2.3	92.9
TOTAL	129	110	47	286	95.3	42.9	19.3	0-202.0			
TOTAL NO. OF SPECIES COLLECTED	11	12	11	19	11.3	0.58	0.03	9.9-12.8			
SPECIES DIVERSITY(H')	1.41	1.22	1.37	4.50	1.50	0.33		0.68-2.32			
EQUITABILITY (J')	0.59	0.51	0.81	1.91	0.64	0.16		0.24-1.04			

TOTAL NO. INDIVIDUALS THIS STN = 308(3 GRABS)

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

PREDUMP

STATION STAMFORD-NEW HAVEN-SOUTH-CENTER

Date 26 JANUARY 1979

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nephtys incisa	20	16	23	16	25	100	20.0	4.1	0.8	15.0-25.0	1	44.6	44.6
2. Melinna cristata	8	9	10	17	16	60	12.0	4.2	1.5	6.8-17.2	2	26.8	71.4
3. Ceriantharian sp. A	4	4	6	3	3	20	4.0	1.2	0.4	2.5-5.5	3	8.9	80.3
4. Saccoglossus kowalevskii	1	4	0	0	3	8	1.6	1.8	2.0	0-3.9	4	3.6	83.9
TOTAL	33	33	39	36	47	188	37.6	5.8	47.9	30.4-44.9			
TOTAL NO. OF SPECIES COLLECTED	17	11	7	6	9	26	10.0	4.4	1.9	4.6-15.4			
SPECIES DIVERSITY (H')	1.91	1.66	1.35	1.11	1.46		1.50	0.30		1.13-1.87			
EQUITABILITY (J')	0.66	0.69	0.69	0.52	0.67		0.67	0.03		0.63-0.71			

TOTAL NO. INDIVIDUALS THIS STN = 224

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-CENTER — Date 9 AUGUST 1979

	PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEANS	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1.	Nephthys incisa	2	2	1	3	2	10	2.0	0.7	0.2	1.1-2.9	1	29.4	29.4
2.	Axius serratus	0	1	2	0	1	4	0.8	0.8	0.8	0-1.8	2	11.8	41.2
3.	Cerebratulus sp.	1	2	0	0	0	3	0.6	0.9	1.4	0-1.7	3	8.8	50.0
4.	Crangon septemspinosa	0	0	1	1	1	3	0.6	0.5	0.4	0-1.3	3	8.8	58.8
5.	Cancer irroratus	0	0	2	0	0	2	0.4	0.9	2.0	0-1.5	4	5.9	64.7
6.	Melinna cristata	2	0	0	0	0	2	0.4	0.9	2.0	0-1.5	4	5.9	70.6
7.	Pagurus longicarpus	0	1	0	1	0	2	0.4	0.5	0.6	0-1.1	4	5.9	76.5
8.	Ceriantharian sp.	0	0	1	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	79.4
9.	Clymenella zonalis	0	1	0	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	82.3
10.	Libinia emarginata	1	0	0	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	85.2
11.	Pherusa affinis	1	0	0	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	88.1
12.	Polydora ligni	0	0	1	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	91.0
13.	Solen viridis	0	0	1	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	93.9
14.	Unciola irrorata	1	0	0	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	96.8
15.	Upogebia affinis	1	0	0	0	0	1	0.2	0.4	0.8	0-0.8	5	2.9	100.0
	TOTAL	9	7	9	5	4	34	6.8	2.3	0.8	4.0-9.6			
	TOTAL NO. OF SPECIES COLLECTED	7	5	7	3	3	15	5.0	2.0	0.8	2.5-7.5			
	SPECIES DIVERSITY (H')	1.89	1.55	1.89	0.95	1.04		1.46	0.45		0.90-2.02			
	EQUITABILITY (J')	0.97	0.96	0.97	0.87	0.95		0.94	0.04		0.89-0.99			

TOTAL NO. INDIVIDUALS THIS STN = 34

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-CENTER DATE 5 SEPT 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Ampelisca vadorum	10	24	24	58	19.3	8.1	3.4	0-39.4	1	34.1	34.1
2. Owenia fusiformis	11	18	15	44	14.7	3.5	0.8	6.0-23.4	2	25.9	60.0
3. Nephthys incisa	8	10	6	24	8.0	2.0	0.5	3.0-13.0	3	14.1	74.1
4. Yoldia limatula	2	4	5	11	3.7	1.5	0.6	0-7.4	4	6.5	80.6
5. Ampelisca abdita	0	2	6	8	2.7	3.1	3.6	0-10.4	5	4.7	85.3
6. Mulinia lateralis	0	3	4	7	2.3	2.1	1.9	0-7.5	6	4.1	89.4
7. Pectinaria gouldii	0	3	1	4	1.3	1.5	1.7	0-5.0	7	2.4	91.8
TOTAL	31	64	61	156	52.0	18.3	6.4	6.5-97.5			
TOTAL NO. OF SPECIES COLLECTED	8	22	15	26	15.0	7.0	3.3	0-32.4			
SPECIES DIVERSITY (H')	1.25	1.99	1.84		1.70	0.39		0.73-2.67			
EQUITABILITY (J')	0.91	0.78	0.77		0.82	0.08		0.62-1.02			

TOTAL NO. INDIVIDUALS THIS STN = 170 (3 GRABS)

DAMCS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-INNER EDGE (100M EAST) DATE 5 SEPT 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nephthys incisa	5	4	2	11	3.7	1.5	0.6	0-7.4	1	27.5	27.5
2. Nassarius trivittatus	5	0	1	6	2.0	2.6	3.4	0-8.5	2	15.0	42.5
3. Owenia fusiformis	5	1	0	6	2.0	2.6	3.4	0-8.5	2	15.0	57.5
4. Ampelisca abdita	2	3	0	5	1.7	1.5	1.3	0-7.0	4	12.5	70.0
5. Yoldia limatula	4	0	0	4	1.3	2.3	4.1	0-7.0	4	10.0	80.0
TOTAL	21	8	3	32	10.7	9.3	8.1	0-33.8			
TOTAL NO. OF SPECIES COLLECTED	17	7	7	21	10.3	5.8	[illegible].2	0-24.7			
SPECIES DIVERSITY (H')	1.93	1.22	1.56		1.59	0.39		0.65-2.53			
EQUITABILITY (J')	0.90	0.89	0.97		0.92	0.05		0.80-1.04			

TOTAL NO. INDIVIDUALS THIS STN = 40 (3 GRABS)

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-OUTER EDGE (300M EAST) DATE 3 SEPT 1980

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nucula proxima	46	19	44	109	36.3	15.0	6.2	0-73.6	1	56.8	56.8
2. Nephtnys incisa	9	18	20	47	15.7	5.9	2.2	1.0-30.4	2	24.5	81.3
3. Nassarius trivittatus	1	2	5	8	2.7	2.1	1.6	0-7.9	3	4.2	85.5
4. Lolmia medusa	3	3	0	6	2.0	1.7	1.5	0-6.2	4	3.1	88.6
5. Yoldia limatula	3	1	1	5	1.7	1.2	0.9	0-4.7	5	2.6	91.2
TOTAL	62	43	70	175	58.3	13.9	3.3	23.8-92.8			
TOTAL NO. OF SPECIES COLLECTED	9	11	13	19	11.0	2.0	0.4	6.0-16.0			
SPECIES DIVERSITY (H')	1.64	1.57	1.28		1.30	0.27		0.63-1.97			
EQUITABILITY (J')	0.53	0.71	0.56		0.60	0.10		0.35-0.85			

TOTAL NO. INDIVIDUALS THIS STN = 192 (3 GRABS)

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-6 (100CM EAST) Date 26 JANUARY 1979

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nephthys incisa	14	6	15	12	18	65	13.0	4.5	1.6	7.4-18.6	1	37.8	37.8
2. Melinna cristata	3	3	4	7	11	28	5.6	3.4	2.1	1.3-9.9	2	16.3	54.1
3. Gammarus annulatus	0	0	0	16	0	16	3.2	7.2	16.2	0-12.1	3	9.3	63.4
4. Ceriantharium sp. A	4	0	1	4	5	14	2.8	2.2	1.7	0.1-5.5	4	8.1	71.5
5. Saccoglossus kowalevskii	5	4	0	0	0	9	1.8	2.5	3.5	0-4.9	5	5.2	76.7
6. Phoronis architecta	2	0	1	3	1	7	1.4	1.1	0.9	0-2.8	6	4.1	80.8
7. Pherusa affinis	3	0	1	0	2	6	1.2	1.3	1.4	0-2.8	7	3.5	84.3
TOTAL	31	13	22	42	37	145	29.0	11.6	41.6	14.5-43.5			
TOTAL NO. OF SPECIES COLLECTED	10	7	7	11	13	24	9.0	1.9	0.4	6.7-11.3			
SPECIES DIVERSITY (H')	1.32	1.73	1.37	1.95	1.56		1.70	0.25		1.33-2.01			
EQUITABILITY (J')	0.83	0.39	0.66	0.81	0.68		0.77	0.10		0.65-0.89			

TOTAL NO. INDIVIDUALS THIS STN = 172

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-7 (1000M WEST) Date 26 JANUARY 1979

	PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1.	Nephthys incisa	17	21	13	11	10	72	14.4	4.6	1.5	8.7-20.1	1	42.4	42.4
2.	Ceriantharian sp. A	3	3	7	4	7	24	4.8	2.0	0.8	2.3-7.3	2	14.1	56.5
3.	Melinna cristata	5	1	5	1	5	17	3.4	2.2	1.4	0.7-6.1	3	10.0	66.5
4.	Pherusa affinis	4	1	3	0	0	8	1.6	1.3	2.0	0-3.9	4	4.7	71.2
5.	Nince nigripes	2	1	0	1	1	5	1.0	0.7	0.5	0.1-1.9	5	2.9	74.1
6.	Euclymene collaris	0	1	2	0	1	4	0.8	0.8	0.8	0-1.8	6	2.4	76.5
7.	Phoronis architecta	0	1	2	1	0	4	0.8	0.8	0.8	0-1.8	6	2.4	78.9
8.	Saccoglossus kowalevskii	0	1	2	1	0	4	0.8	0.8	0.8	0-1.8	6	2.4	81.3
	TOTAL	31	30	34	19	24	138	27.6	6.0	25.3	20.1-35.1			
	TOTAL NO. OF SPECIES COLLECTED	12	13	14	10	9	32	11.6	2.1	0.4	9.0-14.2			
	SPECIES DIVERSITY (H')	1.91	1.68	2.19	1.75	1.62		1.83	0.23		1.54-2.12			
	EQUITABILITY (J')	0.77	0.65	0.83	0.76	0.74		0.75	0.07		0.66-0.84			

TOTAL NO. INDIVIDUALS THIS STN = 170

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-6 (1000M EAST) — Date 21 MAY 1979

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nephthys incisa	19	15	11	16	11	72	14.4	3.4	0.8	10.1-18.7	1	35.3	35.3
2. Ceriantharian sp. A	8	6	8	3	6	31	6.2	2.0	0.6	3.7-8.7	2	15.2	50.5
3. Phoronis architecta	0	4	2	12	6	24	4.8	4.6	4.4	0-10.5	3	11.8	62.3
4. Melinna cristata	3	3	4	9	3	22	4.4	2.6	1.5	1.2-7.6	4	10.8	73.1
5. Corymorpha pendula	1	2	5	7	5	20	4.0	2.4	1.4	1.0-7.0	5	9.8	82.9
6. Mulinia lateralis	1	0	0	4	0	5	1.0	1.7	2.9	0-3.2	6	2.5	85.4
TOTAL	32	30	30	51	31	174	34.8	9.1	2.4	23.5-46.1			
TOTAL NO. OF SPECIES COLLECTED	9	7	9	17	10	24	10.4	3.8	1.4	5.6-15.2			
SPECIES DIVERSITY (H')	1.48	1.54	1.86	2.32	1.94		1.83	0.34		1.41-2.25			
EQUITABILITY (J')	0.67	0.79	0.85	0.82	0.84		0.79	0.07		0.70-0.88			

TOTAL NO. INDIVIDUALS THIS STN = 204

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-7 (1000M WEST) Date 22 MAY 1979

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nephtys incisa	14	10	12	9	10	55	11.0	2.0	0.4	8.5-13.5	1	31.6	31.6
2. Saccoglossus kowalevskii	9	3	5	9	5	30	6.0	2.4	1.0	3.0-9.0	2	17.2	48.8
3. Ceriantharian sp. A	6	3	4	4	0	17	3.4	2.2	1.4	0.7-6.1	3	9.8	58.6
4. Mulinia lateralis	0	6	6	0	0	12	2.4	3.3	4.5	0-6.5	4	6.9	65.5
5. Melinna cristata	2	3	4	0	1	10	2.0	1.6	1.3	0-4.0	5	5.7	71.2
6. Corymorpha pendula	1	2	0	1	3	7	1.4	1.1	0.9	0-2.8	6	4.0	75.2
7. Pherusa affinis	4	2	0	1	0	7	1.4	1.7	2.1	0-3.5	6	4.0	79.2
8. Nucula proxima	0	2	1	2	0	5	1.0	1.0	1.0	0-2.2	7	2.9	82.1
9. Phoronis architecta	2	1	1	0	0	4	0.8	0.8	0.8	0-1.8	8	2.3	84.4
10. Yoldia sapotilla	2	2	0	0	0	4	0.8	1.1	1.5	0-2.2	8	2.3	86.7
TOTAL	39	34	33	26	19	151	30.2	7.8	2.0	20.5-39.9			
TOTAL NO. OF SPECIES COLLECTED	12	15	10	10	10	31	11.4	2.2	0.4	8.7-14.1			
SPECIES DIVERSITY (H')	2.04	2.40	1.96	1.85	1.84		2.02	0.23		1.73-2.31			
EQUITABILITY (J')	0.82	0.89	0.85	0.80	0.80		0.83	0.04		0.78-0.88			

TOTAL NO. INDIVIDUALS THIS STN = 174

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD NEW HAVEN-SOUTH-6 ([illegible]M EAST) — Date 9 AUGUST 1979

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Mulinia lateralis	[illegible]	16	10	54	69	214	42.8	27.8	18.1	8.2-77.4	1	43.6	43.6
2. Nephthys incisa	22	10	20	21	22	101	20.2	6.5	2.1	12.1-28.3	2	20.6	64.2
3. Yoldia limatula	21	2	5	8	11	47	9.4	7.3	5.7	0.3-18.5	3	9.6	73.8
4. Melinna cristata	[illegible]	0	6	3	9	46	9.2	11.0	13.2	0-22.9	4	9.4	83.2
5. Ceriantharian sp. 3	5	4	8	5	5	27	5.4	1.5	0.4	3.5-7.3	5	5.5	88.7
6. Nucula proxima	6	0	0	2	2	10	2.0	2.4	2.9	0-5.0	6	2.0	90.7
TOTAL	153	32	49	93	118	445	89.0	49.5	27.5	27.5-150.5			
TOTAL NO. OF SPECIES COLLECTED	[illegible]	9	11	19	10	30	12.6	4.0	1.3	7.6-17.6			
SPECIES DIVERSITY (H')	[illegible]	1.60	1.94	1.78	1.45		1.71	0.19		1.47-1.95			
EQUITABILITY (J')	[illegible]	0.73	0.81	0.60	0.63		0.69	0.08		0.59-0.79			

TOTAL NO. INDIVIDUALS THIS STN = [illegible]

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION STAMFORD-NEW HAVEN-SOUTH-7 (1000M WEST) Date 9 AUGUST 1979

PREDOMINANT SPECIES	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Mulinia lateralis	115	75	78	84	69	421	84.2	18.7	4.2	61.0-107.4	1	53.6	53.6
2. Yoldia limatula	40	17	19	19	44	139	27.8	13.1	6.2	11.6-44.0	2	17.7	71.3
3. Nephtys incisa	10	19	21	12	14	76	15.2	4.7	1.5	9.4-21.0	3	9.7	81.0
4. Melinna cristata	20	8	5	5	6	44	8.8	6.4	4.7	0.9-16.7	4	5.6	86.6
5. Nucula proxima	4	1	4	6	4	19	3.8	1.8	0.9	1.6-6.0	5	2.4	89.0
6. Pherusa affinis	4	4	7	4	0	19	3.8	2.5	1.6	0.7-6.9	5	2.4	91.4
TOTAL	212	116	134	130	126	718	143.6	34.2	8.1	101.1-186.1			
TOTAL NO. OF SPECIES COLLECTED	21	13	14	13	12	33	14.6	3.6	0.9	10.1-19.1			
SPECIES DIVERSITY (H')	1.59	1.70	1.58	1.42	1.46		1.55	0.11		1.41-1.69			
EQUITABILITY (J')	0.55	0.62	0.60	0.56	0.59		0.59	0.03		0.54-0.62			

TOTAL NO. INDIVIDUALS THIS STN = 735

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION NORWALK-NEW HAVEN (BASELINE) DATE 1 APRIL 1980

PREDOMINANT SPECIES	GRAB NUMBER 2	4	5	TOTAL	MEAN	STD. DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nucula proxima	1	136	59	196	65.3	67.7	70.2	0-233.5	1	61.1	61.1
2. Nephthys incisa	8	14	12	34	11.3	3.1	0.9	3.6-19.0	2	10.6	71.7
3. Mulinia lateralis	1	16	9	26	8.7	7.5	6.5	0-27.3	3	8.1	79.8
4. Phoronis architecta	2	10	6	18	6.0	4.0	2.7	0-15.9	4	5.6	85.4
5. Ceriantharian sp. A	5	3	4	12	4.0	1.0	0.3	1.5-6.5	5	3.7	89.1
6. Melinna cristata	3	1	4	8	2.7	1.5	0.8	0-6.4	6	2.5	91.6
TOTAL	20	180	94	294	98.0	80.1	65.4	0-297.0			
TOTAL NO. OF SPECIES COLLETED	6	14	12	18	11.3	3.1	0.9	3.7-18.9			
SPECIES DIVERSITY (H')	1.30	1.14	1.64	4.58	1.53	0.34		0.69-2.37			
EQUITABILITY (J')	0.37	0.44	0.66	1.97	0.66	0.22		0.11-1.21			

TOTAL NO. INDIVIDUALS THIS STN = 321(3 GRABS)

Appendix E.

Master Species List and Species Occurrence in Samples Collected from the New Haven Sites Spring, 1980.

(Colonial forms are indicated by a "+". Numerals prededing +'s give the number of colonies counted-no attmpt was made to count individuals.)

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APPENDIX E

Master Species List and Species Occurrence in Samples Collected from the New Haven Sites Spring, 1980

	Species	Occurrence/ 22 Samples	No. Individuals
	Phylum PORIFERA		
1.	PORIFERA sp.	2	2+
	Phylum CNIDARIA		
	Class Hydrozoa		
2.	Bougainvillea sp.	2	2+
3.	Corymorpha pendula	9	24
4.	Thuiaria sp.	7	7+
5.	Tubularia sp.	1	1
	Class Anthozoa		
6.	Ceriantharian sp. A	18	66
7.	Edwardsia elegans	2	2
8.	Haloclava producta	1	1
	Phylum RHYNCHOCOELA		
9.	Cerebratulus sp.	1	1
10.	Micrura sp.	1	2
11.	Tubulanus pellucidus	1	1
12.	RHYNCHOCOEL sp.	1	1
	Phylum MOLLUSCA		
	Class Gastropoda		
13.	Cylichna (oryza)	1	1
14.	Hydrobia (salsa)	1	1
15.	Nassarius trivittatus	6	28
16.	Retusa canaliculata	3	9
	Class Pelecypoda		
17.	Ensis directus	1	1
18.	Lyonsia hyalina	2	2
19.	Mulinia lateralis	15	135
20.	Nucula proxima	15	553
21.	Pandora gouldiana	3	10
22.	Pandora sp.	1	1
23.	Pitar morrhuana	7	14
24.	Tellina versicolor	3	147
25.	Thracia conradi	1	1
26.	Yoldia limatula	1	1
27.	Yoldia lucida	2	2

APPENDIX E (CONT.)

	Species	Occurrence/ 22 Samples	No. Individuals
	Phylum ANNELIDA		
	Class Polychaeta		
28.	Aglaophamus circinnata	3	6
29.	Ampharete arctica	1	1
30.	Aricidea neosuecica	2	4
31.	Caulleriella filiarensis	2	8
32.	Glycera americana	5	12
33.	Glycera dibranchiata	1	1
34.	Lumbrineris fragilis	1	1
35.	MALDANID sp.	1	1
36.	Melinna cristata	11	30
37.	Nephthys incisa	19	237
38.	Nereis grayi	2	3
39.	Ninoe nigrippes	1	1
40.	Owenia fusiformis	3	5
41.	Paraonis gracilis	1	1
42.	Pherusa affinis	7	14
43.	Phyllodoce arenae	3	5
44.	Pista palmata	1	1
45.	Scoloplos fragilis	2	2
46.	Sigambra tentaculata	2	2
47.	Spiochaetopterus oculatus	2	2
48.	Spiophanes bombyx	3	34
	Class Archiannelida		
49.	Protodrilus sp.	1	6
	Phylum ARTHROPODA		
	Class Crustacea		
	Order Amphipoda		
50.	Ampelisca vadorum	4	7
51.	Uniciola irrorata	2	2
	Order Mysidacea		
52.	Neomysis americana	1	1
	Order Decapoda		
53.	Cancer irroratus	1	1
54.	Pagurus longicarpus	1	3
	Subclass Cirripedia		
55.	Balanus (amphitrite)	3	31
	Phylum BRYOZOA		
56.	Callopora au[illegible]	4	4+
57.	Cryptosula pal[illegible]	6	6+
58.	Hippothoa hya[illegible]	1	1+
59.	Membranipora te[illegible]	8	8+
60.	Parasmittina sp.	1	1+
61.	Schizomavella auriculata	3	3+

APPENDIX E (CONT.)

	Species	Occurrence/ 22 Samples	Individuals No.
62.	Schizoporella unicornis	3	3+
63.	Tubulipora sp.	1	1+
	Phylum PHORONIDA		
64.	Phoronis architecta	16	140
	Phylum ECHINODERMATA Class Holothuroidea		
65.	Caudina arenata	1	1
	Phylum HEMICHORDATA		
66.	Saccoglossus kowalevskii	14	28

TOTAL NO. OF INDIVIDUALS - SPRING, 1980 1634+

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Appendix F

Master Species List and Species Occurrence in Samples Collected from the New Haven Sites Summer, 1980.

(See note under Appendix E title.)

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APPENDIX F

Master Species List and Species Occurrence in Samples Collected from the New Haven Sites Summer, 1980

	Species	Occurrence/ 18 Samples	No. Individuals
	Phylum PORIFERA		
1.	Hymeniacidon heliophila	1	1+
	Phylum CNIDARIA		
	Class Hydrozoa		
2.	Bougainvillea sp.	6	6+
3.	HYDROZOAN sp.	1	1+
	Class Anthozoa		
4.	Ceriantharian sp. B	6	17
5.	Edwardsia elegans	4	4
6.	Haloclava producta	2	2
	Phylum RHYNCHOCOELA		
7.	Tubulanus pellucidus	2	2
8.	RHYNCHOCOEL sp.	3	5
	Phylum MOLLUSCA		
	Class Gastropoda		
9.	Boreotrophon sp.	1	1
10.	Buscycon canaliculatum	1	1
11.	Cylichna oryza	1	1
12.	Lunatia triseriata	3	5
13.	Nassarius trivittatus	13	57
14.	Natica pusilla	1	1
15.	Odostomia sumneri	1	1
16.	Polinicies duplicatus	1	1
17.	Retusa canaliculata	6	19
18.	Turbonilla interrupta	2	4
	Class Pelecypoda		
19.	Ensis directus	4	15
20.	Mulinia lateralis	7	15
21.	Nucula proxima	13	404
22.	Pandora gouldiana (juv.)	2	2
23.	Pitar morrhuana	2	2
24.	Tellina agilis	2	2
25.	Tellina versicolor	5	245
26.	Thracia septentrionalis	1	1
27.	Yoldia limatula	12	107
28.	Yoldia sapotilla	1	2

APPENDIX F (CONT.)

	Species	Occurrence/ 18 Samples	No. Individuals
	Phylum ANNELIDA		
	Class Polychaeta		
29.	Ampharete acutifrons	1	1
30.	Ampharete arctica	1	8
31.	Aricidea neosuecica	3	9
32.	Caulleriella filiarensis	3	6
33.	Euclymene collaris	2	3
34.	EUCLYMENINAE sp.	1	4
35.	Glycera americana	3	6
36.	Harmathoe extenuata	2	2
37.	Harmathoe imbricata	2	2
38.	Loimia medusa	11	38
39.	Lumbrineris fragilis	1	1
40.	MALDANID sp.	1	1
41.	Melinna cristata	3	5
42.	Nephthys incisa	15	196
43.	Nephthys picta	3	8
44.	Ninoe nigrippes	1	1
45.	Owenia fusiformis	10	156
46.	Paraonis gracilis	2	2
47.	Pectinaria gouldii	5	27
48.	Pherusa affinis	3	4
49.	Phyllodoce sp.	1	1
50.	Polycirrus sp.	4	9
51.	Polydora caeca	1	1
52.	Polydora caulleryi	1	2
53.	Polydora ligni	1	1
54.	Polydora socialis	1	1
55.	Protodrilus sp.	1	1
56.	Scalibregma inflatum	1	1
57.	Scoloplos acutus	2	2
58.	Scoloplos fragilis	1	1
59.	Sigambra tentaculata	4	7
60.	Spiochaetopterus oculatus	4	5
61.	Spiophanes bombyx	4	16
	Phylum ARTHROPODA		
	Class Crustacea		
	Subclass Cirripedia		
62.	Balanus amphitrite	1	2
63.	Balanus balanoides	1	5
	Subclass Malacostraca		
	Order Amphipoda		
64.	Ampelisca abdita	8	26
65.	Ampelisca vadorum	6	64

APPENDIX F (CONT.)

	Species	Occurrence/ 18 Samples	No. Individuals
66.	Ampelisca sp.	2	2
67.	Unciola irrorata	2	5
	Order Mysidacea		
68.	Heteromysis formosa	1	1
69.	Neomysis americana	2	2
	Order Isopoda		
70.	Edotea (triloba)	1	1
	Order Decapoda		
71.	Axius serratus	1	1
72.	Callianassa atlantica	1	1
73.	Cancer irroratus	2	2
74.	Crangon septemspinosa	1	1
75.	Megalops larvae (Brachyura)	1	2
76.	Neopanope seya	1	1
77.	Ovalippes ocellatus	2	3
78.	Pagurus longicarpus	7	10
79.	Pelia mutica (juv.)	1	4
80.	Pinnixa chaetopterana	3	7
81.	Sesarma reticulatum	1	1
82.	Upogebia affinis	5	7
	Phylum BRYOZOA		
83.	Caberea ellisii	1	1+
84.	Callopora aurita	14	14+
85.	Cribrilina punctata	1	1+
86.	Crisia eburnea	1	1+
87.	Cryptosula pallasiana	12	12+
88.	Hippothoa hyalina	2	2+
89.	Membranipora tenuis	15	15+
90.	Microporella ciliata	3	3+
91.	Nollella sp.	1	1+
92.	Parasmittina sp.	6	6+
93.	Schizomavella auriculata	7	7+
94.	Schizoporella unicornis	8	8+
95.	BRYOZOAN sp.	3	3+
	Phylum PHORONIDAE		
96.	Phoronis architecta	10	97
	Phylum ECHINODERMATA Class Asteroidea		
97.	Asteroid sp. A	1	1
98.	Asteroid sp. B	2	2
	Phylum HEMICHORDATA		
99.	Saccoglossus kowalevskii	1	1

TOTAL NO. OF INDIVIDUALS - SUMMER, 1980 - 1775+

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