Species Composition
Diversity of Polychae
in the New York Bi

by John Frey

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SPECIES COMPOSITION AND DIVERSITY OF POLYCHAETES IN THE NEW YORK BIGHT

by

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ABSTRACT

This study is part of a larger investigation of the biological consequences of waste disposal in the New York Bight. Polychaetes from the samples of three cruises (December, 1972, February and May 1973) in the Bight were identified. "Bamboo worms" (families Maldanidae and Oweniidae were the most abundant and ubiquitous polychaetes and would therefore be the best indicator species to monitor pollution in the area. No temporal changes in the densities of polychaete populations were evident, but summer and fall collections must be analyzed to complete the seasonal distribution. It is suggested that there is an optimal sediment size for polychaetes, above and below which the populations decrease. Faunal homogeneity indices for all pairs of samples were computed and plotted, giving a bimodal distribution. It is likely that the left peak of this graph is due to two aberrant samples, without which the data would be normally distributed. A normal distribution indicates an intergrading of polychaete species rather than the distinct communities indicated by a bimodal distribution.

INTRODUCTION

The oceans have been used for the disposal of sewage sludge and dredging spoils for over a century, but the biological consequences of this practice have received little attention. It is clear now that ocean waste disposal adversely affects marine animals. Several studies have concentrated on this problem, and most of these have included a study of benthic or bottom-living organisms. Most scientists agree that benthic organisms are the best biological indicators of this kind of pollution (Butcher, 1955; Gross and Wallen, 1968; NOAA, 1972).

Few studies of the species diversity and abundance of benthic animals have been done in the New York Bight, an area used extensively for waste disposal. The Woods Hole Oceanographic Institute surveyed benthic organisms in the Bight during a study of geological resources in 1956, but unfortunately no samples were taken within the waste disposal area. In 1968 the National Marine Fisheries Service initiated a program of benthic core, grab, dredge, and trawl collections in the disposal areas of the New York Bight (NOAA, 1972). Sediment samples, important in determining the distribution of animals and the species composition of benthic communities, were taken along with the biological samples.

The NOAA group found that benthic communities were markedly affected by waste dumping. Few individuals and species were present in areas that have been covered with spoils or sludge. Sanders (1968) points out that species diversity in marine communities is highly correlated with the stability of the physical environment. It is likely that physical and chemical changes in the sediments caused by waste disposal stress benthic populations and reduce species diversity.

The NOAA report suggested that benthic organisms may be killed in several ways by ocean dumping. Animals may simply be buried by the wastes. Highly reducing organics in the wastes may lower oxygen concentrations in the sediments to intolerable levels. Benthic animals may be killed by toxic materials in the wastes, including heavy metals which are known to be in high concentrations in disposal areas. The levels of metals such as chromium, copper, lead, and zinc in these areas far exceed those known to be harmful to marine life (Gross et al., 1971).

The EPA's National Coastal Pollution Research Program is presently conducting a long-term study of the benthic fauna of a proposed experimental dump-site in the New York Bight. This investigation enables a direct comparison of benthic populations in an area before, during, and after the initiation of sludge dumping.

This summer, as part of the larger project described above, I identified polychaetes (marine annelids) from samples taken in the Bight in 1972 and 1973. The abundance, species diversity, richness, and faunal homogeneity of the benthic community were documented in relation to season, area, and bottom sediments. This information will be used in the establishment of a baseline of pre-dump conditions at the experimental site.

MATERIALS AND METHODS

Benthic samples were collected with a .1m^2 Smith-MacIntyre grab from the R/V Rorqual of the National Oceanic and Atmospheric Administration, Sandy Hook, New Jersey. Surveys were conducted on December 3-7, 1972; February 5-9 (sampling completed Febraury 20-22), 1973; and May 7-11, 1973. Nine different stations were sampled in total, but all were not sampled on each cruise. Station A was located 0.25 nautical miles due east of buoy NB, approximately 15 n.m. south of Fire Island, New York. The other stations were spread symmetrically around Station A. Stations B, C, D, and E were located 2.1 n.m. northwest, northeast, southeast, and southwest of Station A, respectively. Stations F, G, H, and J lay 1 n.m. south, west, north, and east of Station A, respectively. During the December cruise, samples were collected at Stations A through E. All stations were sampled during the February cruise, while only Station A was sampled in May. Between 1 and 6 (usually 5) samples were taken at each station during each survey. Temperature, salinity, and dissolved oxygen measurements were taken at each station, and sediment samples were collected for heavy metals, particle size, and organic content analysis. Biological samples were separated from the sediments with a 1.0mm screen, preserved in ethanol, and later sorted into major taxa. I identified the polychaetes using a Wild dissecting microscope. The key of Gosner, 1971; Pettibone, 1968; and Smith, 1964 were used for identification.

STATISTICAL METHODS

The "species diversity" of the samples was assessed in terms of an information theory index (the Shannon equation) as described in Lloyd, Zar, and Karr, 1968: $H' = \Sigma p_i \log p_i$. p_i, intended to be the true proportions of species in a population, is usually estimated by n_i/N, where N is the total number of individuals, and n_i is the number of individuals of a particular specie. The above equation may be rewritten as : $H' = c/N [N \log_{10} N - \Sigma n_i \log_{10} n_i]$ where c is a scale factor for conversion of base 10 logarithms to another base.

Sanders' (1960) "affinity index" was calculated as a measure of the faunal homogeneity between pairs of samples. The percentage of the total number of individuals in each sample (columns in Figure 1) that each species represents was determined. The index of affinity for a pair of samples was calculated by summing the smaller percentages of those species present in both samples. This measure of the percentage of the total fauna common to both samples was computed for all possible pairs of samples and the values arranged in a "trellis diagram" (Figure 4).

RESULTS

Forty-two species and 1064 specimens of polychaetes were present in the benthic samples (Table 1). The most common worms and their abundances were: *Clymenella zonalis*, 257; *Goniadella gracilis*, 115; *Leichone dispar*, 67; *Clymenella torquata*, 57; *Lumbrineris acuta*, 51; *Nichomache lumbricalis*, 45; and *Nephtys picta*, 45. The first four species in this list accounted for almost half of the total number of polychaetes, and all seven species accounted for 60 percent. *Clymenella zonalis*, *Leichone dispar*, *Clymenella torquata*, and *Nichomache lumbricalis* are all "bamboo worms" (so-called because of elongated segments) of the families Maldanidae and Oweniidae. *Clymenella zonalis* was the most ubiquitous as well as the most abundant polychaete in the samples, being present at all but one station.

Since each column in Table 1 represents a different number of samples, the totals cannot be compared. Therefore, densities were computed by dividing the totals for each column by the number of samples for that column X $.1m^2$ (the "bite size" of the Smith MacIntyre grab). The resulting numbers represent the densities of polychaetes per $meter^2$ for each station during the indicated month. The densities at Station B were very low (Table 1, Figure 1). There is no clear relation between density and month. At stations A and B, for example, the density of animals was greater during December than during February, while the reverse is true for Stations C, D, and E.

The species richness, or the number of species, ranged from 3 to 21 (Table 1). At all stations except B, the species richness during February exceeded that of December.

To compare the sediment data with species density and richness, the rows of Table 2 were ranked according to the particle diameter (in mm) greater than the 50th percentile (the particle size in the sample which is greater than 50 percent of the ramaining particle sizes); for Station A in December, for example, this was 0.35 mm. The densities and species richnesses, also ranked, are plotted against the ranked sediment data in Figures 2 and 3. The points trace out rough parabolas with several outliers (the worst of which are for the two Station B samples.

The H' values are listed in Table 3 below according to station (first letter) and month (second letter). Station A in December, for example, is represented by AD.

Table 3. Species Diversity Values

Sample	H'
AD	3.0066
AF	3.5676
AM	3.5266
BD	2.7473
BF	1.5215
CD	1.8498
CF	3.2901
DD	2.9816
DF	3.4266
ED	3.0806
EF	3.7482
FF	2.4694
GF	1.6699
HF	2.8550
IF	2.8184

The mean value of H' is 2.8312, the high value is for sample EF, and the low value is for sample BF.

The affinity index values range from 0 to 71 percent. Many of the low values are accounted for by samples BF and CD. For example, 23 out of 31 of the values up to 37 are accounted for by these samples. None of the values above 37 are from these two samples. The values of sample BF were the lowest, with only 3 of 10 being above 10. Sample BD has several low values, but also has several values above 40. Figure 5 indicates how many values samples BF and CD account for.

DISCUSSION

The data of Table 1 shows that "bamboo worms" are the most abundant and ubiquitous polychaetes found in the New York Bight samples. These worms, therefore, may be good indicator species for following the biolgical effects of sewage and sludge dumping in the Bight.

Table 1 also reveals that although there is great variation between stations, Station B is clearly anomalous. The densities of polychaetes for these two samples are the lowest of all the samples. The species richness of the February sample at Station N (Sample BF) is the lowest of all samples. In all samples other than those of Station B, the species richness was greater during February than December. Sample BF also has the lowest diversity index, and the lowest affinity index values. The smaller abundance and diversity values may be due to coarser sediments at this station.

There is no clearly discernible temporal effect on density of polychaetes. Undoubtedly both distributions and abundances change seasonally, but more data is needed to describe these changes.

Figures 2 and 3 may indicate an optimal sediment size for polychaetes. Above and below the optimal particle size the populations fall off.

The affinity indices (Figure 4) tells us which samples are most alike ecologically, and which have markedly different faunal composition. Sanders (1960) found that benthic samples from Buzzards Bay with low affinity indices had in common much lower silt-clay percentages than the other samples. In this study, the samples CD and BF accounted for most of the low index values. Station BF was characterized by larger (although not the largest of the samples) sediments, but sample CD had the second smallest sediments of all the samples. Perhaps the low affinity indices of samples CD and BF are due to another physical characteristic of the sediments such as organics content.

Figure 7 appears to be a bimodal distribution. This may indicate different communities of polychaetes, since a peak of low affinity values indicates ecologically unlike samples. It may also be that samples CD and BF, which account for most of the low values, are aberrant. The rest of the graph follows fairly well a normal distribution, indicating an intergrading of species rather than distinct, separable communities. Since Sample BF may come from an area with sediments unfavorable for polychaetes, it is possible that the left peak of Figure 5 represents not a distinctly different community, but a stressed one.

This study has provided more information on the benthic biology of the New York Bight. More data, however, is needed to answer certain questions. The seasonality of distribution and abundance of benthic organisms, for example, is likely but unverifiable with the present data. An interesting relationship between sediments and species diversity and density emerged from this study. More data is required to verify the relationship, and other physical parameters of the sediments should be determined and correlated with the life histories of the polychaetes found in the samples. There is apparantly a gradient of polychaete communities, but this problem also needs further research. More data would reveal whether CD and BF are aberrant samples or actually indicate distinct communities. All information contained in this study, particularly the density and diversity data, may be compared with future benthic samples in the continuing program of assessing the biological impact of waste disposal in the New York Bight.

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	Station A Dec.	Feb.	May	B Dec.	Feb.	C Dec.	Feb.	D Dec.	Feb.	E Dec.	Feb.	F Feb.	G Feb.	H Feb.	I Feb.	Totals
Lepdiametric commensalis			2		4	1	2	1						2		12
Phloe minuta		2														2
Phloe sp.			2													2
Polynoid (family)	1						1									2
Sigalion arenicota	2	1	2	8	2	1	1		1	5	1			1	3	28
Stnenelais limicola		3														3
Aglaophamus circinata			11				8				2	1				22
Aglaophamus verilli		12	3		4	2	1	1	1	3						27
Glyceda capitata		1							3	1						5
Glyceda dibranchiata							1		1		4	1	1	1		9
Goniadella gracilis	23	1	8	3		30		10	17	8	1	4			10	115
Nephtys buceda		1														1
Nephtys paradaa											2					2
Nephtys picta	12	2	1	1		1	3	3	5	1	5	4	2		5	45
Aricidea Suecia			2						3		1	1			1	8
Lumbrineris acuta	5	1				3	1	1	18	2	3	3		1	13	51
Lumbrineris fragilis	2	4	2					3	1	2	4			1		19
Lumbrineris latreilli																
Lumbrineris unident			2													2
Notocirrus spiniferus	3						2									5
Scoloplos rubra						1										1
Clymenella torquata	22	6	12	8			1	1	5		1	1				57
Clymenella zonalis	39	19	38	5		•1	20	11	24	6	7	56	12	3	16	257
Leichone dispar	7	9	2	1			9	5	2	8	8	6			10	67
Nichomache lumbricalis	9	7	11	1			2		3	2	1	5	4			45
Petalopractus tenuis	2	4	2	2			7	1	4	1	1					24
Rhodine attenuata	1	1	1	2								2				7
Orbinia ornata		4	1						6		10	2		2		25
Orbinia swani						1										1
Scalibregma inflatum			10				10		3		7	4			1	35
Eteone lacted		1														1
Eteone trilineata											1			1		2
Syllidae (family)									1							1
Dorvilleidae (family)											1	1				2
Stauronereis rudolph		1														1
Polydora sp.															2	2
Spionidae (family)							1						1			2
Spiophanes bombyx			4									2				6
Tharyx acutus	3		1			3			4		1	2			2	16
Terebellidae (family)							1									1
Ampharetidae (family)			6													6
Aricidea quadrilobata	2						3									3
Totals	131	80	123	31	10	44	71	40	102	39	61	95	20	12	63	
No. of Samples	6	5	5	5	5	4	5	3	5	4	5	5	1	1	5	
Density per m^2	218.6	160	246	62	20	110	142	133.3	204	97.5	122	190	200	120	126	
Species Richness	15	19	21	9	3	10	17	11	18	11	19	16	5	8	10	

Table 1. The species composition of the New York Bight samples.

EQUIVALENT DIAMETER (mm) GREATER THAN THE GIVEN PERCENTILE
AVERAGE OF ALL SUBSAMPLES

Percentile	5	16	25	50	75	84	95
Station			December 1972				
A	0.84	0.49	0.44	0.35	0.27	0.23	0.16
B_{cm}	0.77	0.52	0.46	0.36	0.30	0.27	0.19
B_{cs}	0.74	0.50	0.45	0.35	0.31	0.28	0.21
D	1.28	0.66	0.49	0.40	0.30	0.29	0.23
E	2.08	1.16	0.78	0.45	0.34	0.30	0.26
C	0.43	0.34	0.30	0.23	0.18	0.16	0.12
			February 8, 1973				
A	0.67	0.49	0.44	0.35	0.28	0.26	0.20
B	1.09	0.68	0.54	0.41	0.33	0.30	0.24
C	0.52	0.41	0.37	0.30	0.25	0.21	0.15
			February 21-22, 1973				
D	0.90	0.58	0.49	0.40	0.32	0.29	0.21
E	0.66	0.46	0.42	0.34	0.28	0.26	0.19
F	0.67	0.47	0.42	0.35	0.28	0.25	0.19
G	0.85	0.53	0.47	0.39	0.31	0.29	0.22
H	0.35	0.27	0.24	0.19	0.15	0.13	0.10
I	1.32	0.87	0.66	0.44	0.35	0.32	0.26
			May 8, 1973				
A	0.73	0.55	0.48	0.36	0.27	0.25	0.18

Table 2. New York Bight bottom sediment size analysis summary.

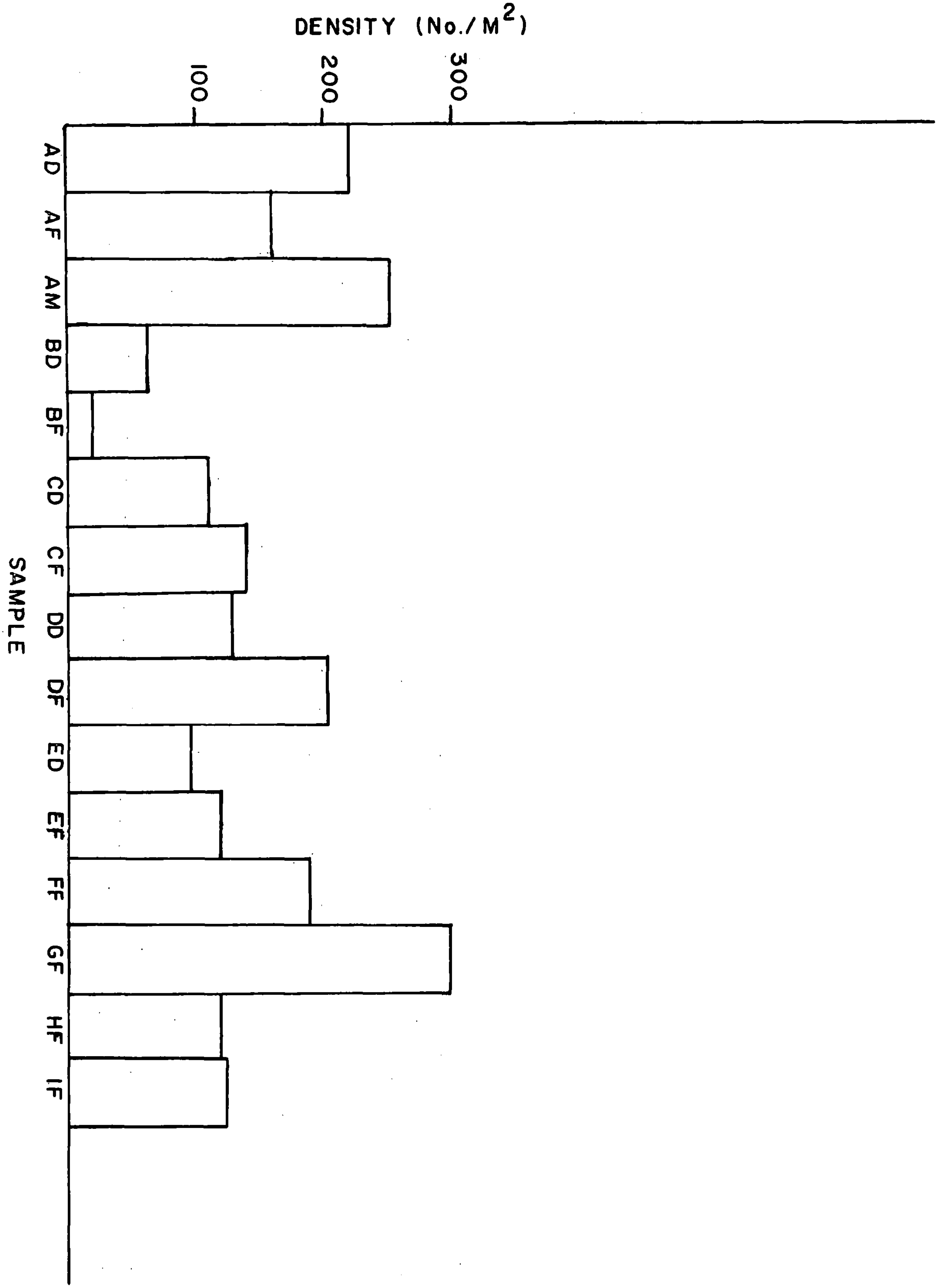

Fig. 1. Densities of polychaetes in the New York Bight samples.

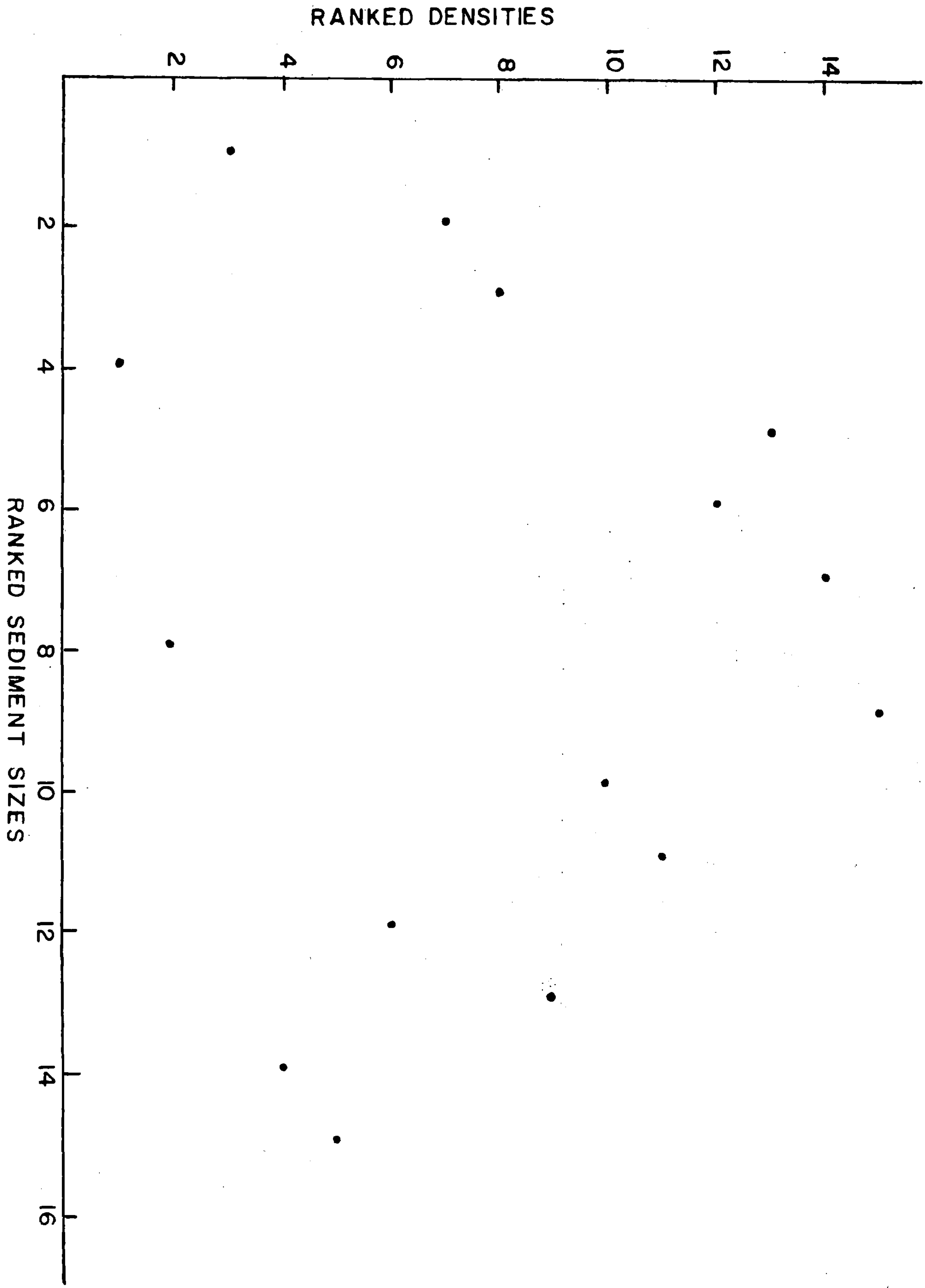

Fig. 2. Ranked density of polychaetes versus ranked sediment size at the same station.

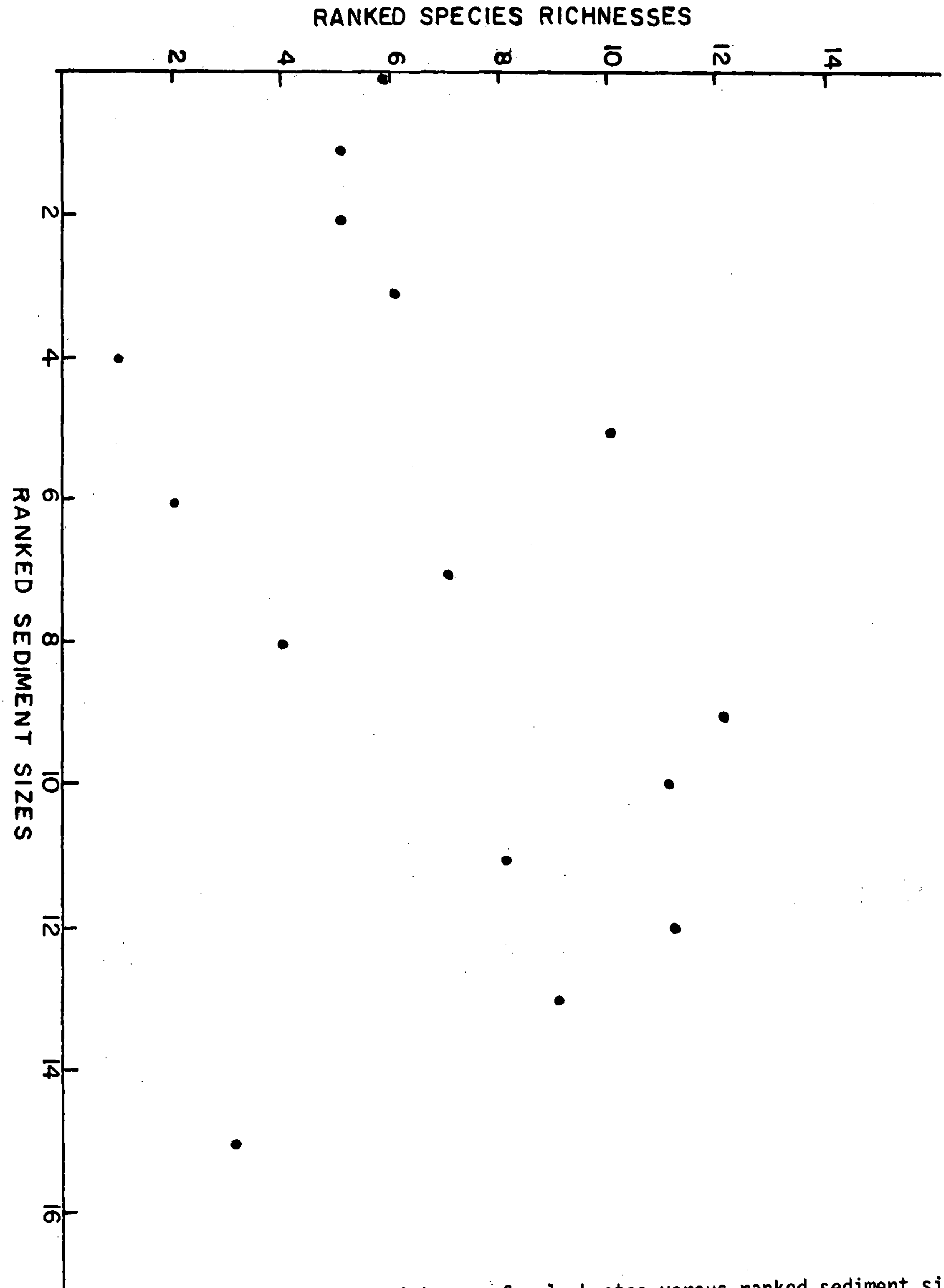

Fig. 3. Ranked species richness of polychaetes versus ranked sediment size at the same station.

	AD	AF	AM	BD	BF	CD	CF	DD	DF	ED	EF	FF	TF
AD	X												
AF	53.3	X											
AM	61.4	51.9	X										
BD	55.9	41.4	41.9	X									
BF	1.5	16.2	5.6	20.0	X								
CD	29.6	12.8	16.0	16.6	9.2	X							
CF	49.7	50.4	57.7	34.5	5.6	11.1	X						
DD	65.8	52.3	46.1	37.2	5.0	36.9	53.4	X					
DF	64.3	51.1	50.8	43.6	2.0	34.1	44.9	56.5	X				
ED	54.3	54.4	36.7	46.9	20.5	37.2	40.3	63.7	52.8	X			
EF	39.7	43.6	36.4	25.9	1.6	14.3	51.2	45.2	44.5	45.3	X		
FF	55.8	44.5	54.6	33.0	0.0	14.0	49.0	45.7	49.9	36.8	41.2	X	
IF	62.0	41.0	39.9	33.8	4.8	32.9	46.7	63.8	71.2	59.8	45.4	47.9	X

0-20 20-40 40-60 60-80

Fig. 4. A "trellis diagram" of the affinity indices for pairs of samples. The marked squares indicate into which range of index values each pair of samples falls.

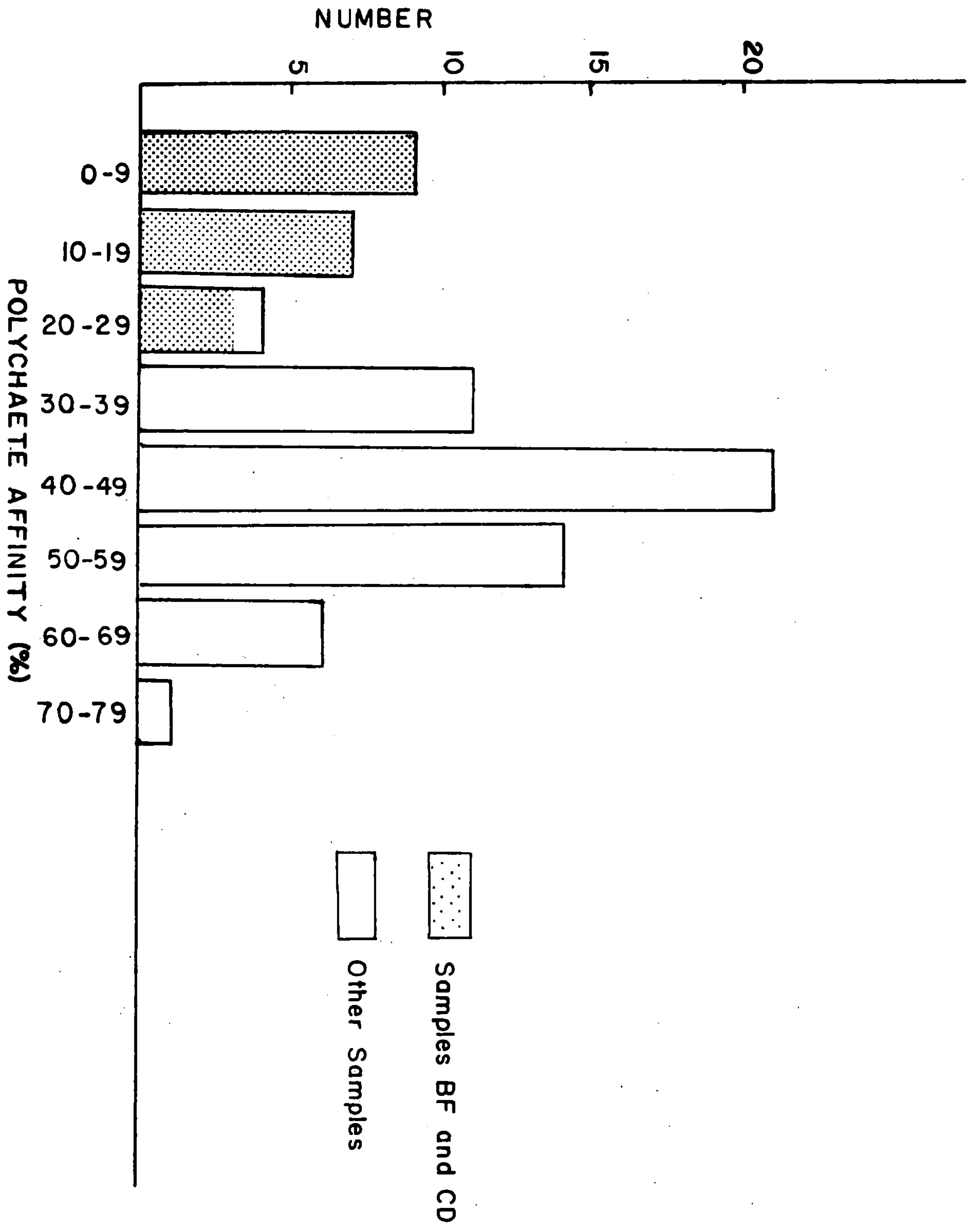

Fig. 5. The number of pairs of samples falling into discrete ranges of polychaete affinity values. The stippled areas are those values accounted for by samples BF and CD.

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THE RESOURCES DEVELOPMENT INTERNSHIP PROGRAM

The preceding report was completed by a WICHE intern during the summer of 1973 This intern's project was part of the Resources Development Internship Program administered by the Western Interstate Commission for Higher Education (WICHE).

The purpose of the internship program is to bring organizations involved in community and economic development, environmental problems and the humanities together with institutions of higher education and their students in the West for the benefit of all.

For these organizations, the intern program provides the problem-solving talents of student manpower while making the resources of universities and colleges more available. For institutions of higher education, the program provides relevant field education for their students while building their capacity for problem-solving.

WICHE is an organization in the West uniquely suited for sponsoring such a program. It is an interstate agency formed by the thirteen western states for the specific purpose of relating the resources of higher education to the needs of western citizens. WICHE has been concerned with a broad range of community needs in the West for some time, insofar as they bear directly on the well-being of western peoples and the future of higher education in the West. WICHE feels that the internship program is one method for meeting its obligations within the thirteen western states. In its efforts to achieve these objectives, WICHE appreciates having received the generous support and assistance of the Economic Development Administration, the Jessie Smith Noyes Foundation, the National Endowment for the Humanities, the National Science Foundation, and of innumerable local leaders and community organizations, including the agency that sponsored this intern project.

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