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BENTHIC BORROW AREA INVESTIGATIONS, SOUTH SHORE OF LONG ISLAND, NEW YORK

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CONTENTS

I. INTRODUCTION

This report describes the results of a seasonal survey carried out during 1981 along the South Shore of Long Island. Eight potential borrow sites, which would supply material for an extensive beach nourishment program planned by the U.S. Army Corps of Engineers, were studied (Figure 1). The goal of this survey was to provide baseline information on both the sediment characteristics and the distribution, abundance, and diversity of the macrobenthos in each potential borrow area.

II. METHODS

1. Sampling Procedures

Data for this study were collected during three seasonal cruises aboard the R/V ONRUST. A total of 65 stations were sampled on each of the three cruises. Figure 2 shows the location of each sampling station. In this figure, each of the eight potential borrow areas are designated by a single letter code ranging from A for the western most to H for the eastern most area. Stations within a borrow area are given a numerical identifer along with a borrow area letter code. Thus station A8 represents station 8 within borrow site A.

Stations were located along transects which ran roughly perpendicular to the shoreline. The number of transects per site and the number of stations per transect were determined in consultation with the Army Corps. The water depth at each station is given in Figure 3. Sampling at a site was restricted to locations between the 30′ and 60′ depth contours. Loran C was used for navigation. Loran coordinates for each sampling station were recorded on the first cruise and used to locate stations on subsequent cruises. The longitude and latitude of each station is given in Table 1. Sampling dates may be found in Table 2.

Quantitative biological samples were collected using a 0.1 square meter Smith-McIntyre grab. Three replicate grabs were taken at each sampling station (Figure 2). Upon retrieval of the grab, the doors of the bucket were opened and a ruler was used to measure the depth of the sample below the top of the bucket. These measurements were recorded and later used to calculate the volume of the sample. The contents of the Smith-McIntyre grab were then emptied into a plastic tray and a small (<50 cc) sediment sample was taken. Sediment samples were placed in labelled whirl-pak bags. A small amount of ethyl alcohol was added before sealing the bag to inhibit bacterial activity.

Grab samples were sieved onboard immediately after collection. Sieves were constructed of 1 mm diameter Nitex screening. After washing, all material retained on the screen (e.g., animals, detritus, sand, gravel, shell fragments, etc.) was transferred to labelled sample jars. Samples were preserved for biological analysis in 5% buffered formalin and stained with rose bengal.

Qualitative epifaunal samples were collected using a 1.5 m long epibenthic sled. This sled was identical in design but somewhat smaller than the device described by Hessler and Sanders (1966). The mouth of the sled used in this project was 50 cm wide by about 25 cm high. The collecting net was constructed of 0.25 inch stretch nylon.

Sled tows were taken at 39 of the 65 sampling stations (Figure 4). The sled was towed for 5 minutes on the bottom in a direction perpendicular to the transect line (i.e., roughly parallel to the shoreline). Material collected in the sled net was transferred to labelled sample containers and preserved in 5% buffered formalin.

2. Sediment Characterization - Laboratory Procedures

In the laboratory the whirl-pak bags containing sediment samples were opened and allowed to stand for about one hour prior to processing. This permitted the alcohol which was added to the samples on shipboard to evaporate. There was no significant evaporation of water during this period. After standing, the sediment was removed from the bag, mixed thoroughly, and split into two subsamples. One subsample was used for textural analysis, and the other primarily for loss on ignition. A schematic diagram of the steps taken in the following sections to characterize the sediment samples is given in Figure 5.

a. Class Partitioning

Immediately after spliting, a portion of the sediment sample (approximately 40 g) was put into a 100 ml volumetric flask. Distilled water at room temperature was used to wash down any material adhering to the glass above the etched capacity line. The flask was gently agitated by hand to remove air bubbles trapped within the sediment and filled with distilled water to the capacity line. The flask with sediment and water was then weighed on a Mettler PC400 balance. The contents of the flask was next washed onto a 0.0625 mm screen and thoroughly wet sieved to remove the silt-clay fraction of the sample. The material remaining on the screen (i.e., the sand and gravel fractions) was, using the same procedure as above, transferred back into the flask and weighed. The weight of the silt-clay fraction (W_{s-c}) was computed from the two successive weighings using the following formula:

$$W_{s-c} = \frac{x_1 - x_2}{(1 - \rho_w / \rho_{s-c})}$$

where x_1 and x_2 are the two weight measurements, ρ_w is the density of the water, and ρ_{s-c} is the density of the silt-clay fraction (2.65 g/cc). The derivation of this equation and a discussion of the accuracy of this technique for obtaining the weight of the silt-clay fraction may be found in Appendix A.

The sand and gravel fractions remaining in the flask were next washed through a stack of two sieves -- one with a mesh size of 2 mm and the other with a 0.0625 mm mesh. The gravel fraction was retained on the coaser sieve, and the finer sieve collected the sand fraction. Both fractions were transferred to tared aluminum dishes, dried at 60° C, and weighed.

Data were calculated and reported as percentages of the total sample weight. Total sample weight was determined by summing the weights of the individual fractions (silt-clay, sand, and gravel).

b. Sand Grain-Size Analysis

The dry sand fraction obtained in the previous step was set aside for detailed grain-size analysis. The grain-size distribution of this fraction was determined on the Marine Sciences Research Center's rapid sediment analyzer. A description of this device may be found in Appendix A. This analysis produced a curve of cumulative weight vs. particle diameter for the sand fraction.

c. Loss on Ignition

Percent loss on ignition was used as a measure of the total organic material in the sediments. A 5-10 g sample of dried sediment was placed in a clean, tared Coors crucible. The samples were weighed and combusted at or slightly below 500° C for 4-6 hours. Samples were then allowed to cool and were reweighed to determine weight loss. Organic content values were computed as percentages of the total sample weight.

Byers, et al. (1978) found that the technique, using ignition at 500° C, recovered 99.4% of added organic matter in test samples. In addition, loss of $CaCO_3$, which becomes an important factor at temperatures approaching 550° C, is not a problem when combusting at or slightly below 500° C (Hirota and Szyper, 1975).

3. Sediment Characterization - Statistical Analysis

For this project, Folk's (1974) statistical parameters were chosen for the analysis of the sediment data. Statistical parameters were computed using the following formulas ($\phi = \log_2$ of particle size in mm):

(a) Median grain size, Md, is the size at which half of the particles by weight are larger and half are smaller.

$$Md = \phi_{50}$$

(b) Mean grain size, Mz, is the mean of the cumulative distribution curve (Folk, 1974).

$$Mz = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

(c) Inclusive graphic standard deviation (sorting coefficient), σ_I, is a measure of the spread or uniformity of the grain size distribution (Folk, 1974).

$$\sigma_I = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$$

(d) Inclusive graphic skewness, Sk_I, is a measure of the degree of asymmetry of the grain-size distribution.

$$Sk_I = \frac{\phi_{16} + \phi_{84} - 2\phi_{50}}{2(\phi_{84} - \phi_{16})} + \frac{\phi_5 + \phi_{95} - 2\phi_{50}}{2(\phi_{95} - \phi_5)}$$

(e) Graphic kurtosis, K_G, measures the ratio between the sorting in the tails of the distribution to that in the central part.

$$K_G = \frac{\phi_{95} - \phi_5}{2.44(\phi_{75} - \phi_{25})}$$

An interpretation of the values of these statistical parameters is given in Table 3.

4. Benthic Fauna - Laboratory Procedures

Upon returning to the laboratory, biological samples were transferred to 70% ethyl alcohol. Samples were analyzed using a two stage process. In the first stage, animals were picked from the sediments, detritus, etc. under a dissecting microscope and sorted to phylum level. In the second stage, animals were sorted to species level whenever possible and enumerated. A number of taxonomic keys were used in making the identification. These included Abbot (1974), Bigelow and Schroeder (1953), Bousfield (1973), Emerson and Jacobson (1976), Fauchild (1977), Gosner (1971), McClane (1978), Morris (1973), Pettibone (1963), and Smith (1964). All data were initially entered on log sheets and later transferred to a computer.

5. Benthic Fauna - Data Analysis

A number of derived parameters or indices (abundance, number of species, Shannon-Wiener diversity, equitability, and rarefaction diversity) were computed from the Smith-McIntyre grab data. These computations were carried out on the pooled results of the replicate grabs at each station.

Abundances are reported as the number of individuals per square meter. Abundance estimates were obtained by dividing the results of the pooled replicate grabs by the total sample area (0.3 m^2). Number of species is given as the total number of distinct taxa found in the replicate grabs for that station.

Three indices of diversity were used to analyze the faunal data. The first index is the commonly used Shannon-Wiener information function:

$$H'(s) = - \sum_{i=1}^{s} p_i \log_2 p_i$$

where s is the total number of species and p_i is the proportion of individuals in the population belonging to the ith species (i = 1,2,3,....,s).

The second index of diversity is the equitability or eveness function:

$$V' = H'(s) \;/\; H'_{max}$$

where $H'_{max} = \log_2 s$. This index has a maximum value of 1. The higher the value of V', the more evenly individuals in the population are distributed amoung the s species.

The third index of diversity is Hurlbert's (1971) modification of the rarefaction technique. Given the species-abundance distribution observed in the sample, the rarefaction method predicts the expected number of species in a random subsample of size m taken without replacement. The combinatoric function for rarefaction diversity is of the form:

$$E[S_m N] = \Sigma \ 1 - \frac{\binom{N - N_i}{m}}{\binom{N}{m}}$$

where

$$\binom{N - N_i}{m} = \frac{(N-N_i)!}{(N-N_i-m)!m!}$$

$$\binom{N}{m} = \frac{N!}{(N-m)!m!}$$

and where N_i is the abundance of species i, N is the total number of individuals in the sample, and S_m is a random variable representing the number of species in a subsample of size m.

Table 1. Station Latitude and Longitude

Station	Latitude	Longitude
A1	40 36´ 58"	73 14´ 59"
A2	40 36´ 42"	73 14´ 55"
A3	40 36´ 00"	73 15´ 08"
A4	40 37´ 13"	73 13´ 55"
A5	40 36´ 41"	73 13´ 42"
A6	40 36´ 18"	73 13´ 35"
A7	40 37´ 26"	73 12´ 53"
A8	40 37´ 13"	73 12´ 06"
A9	40 36´ 38"	73 11´ 55"
B1	40 38´ 39"	73 06´ 42"
B2	40 38´ 20"	73 06´ 37"
B3	40 37´ 55"	73 06´ 28"
B4	40 37´ 35"	73 06´ 16"
B5	40 39´ 01"	73 05´ 18"
B6	40 38´ 36"	73 05´ 10"
B7	40 38´ 06"	73 04´ 57"
B8	40 37´ 54"	73 04´ 45"
B9	40 39´ 24"	73 03´ 45"
B10	40 39´ 05"	73 03´ 36"
B11	40 38´ 30"	73 03´ 18"
B12	40 37´ 42"	73 03´ 11"
C1	40 41´ 11"	72 58´ 30"
C2	40 40´ 58"	72 58´ 12"
C3	40 40´ 42"	72 57´ 56"
C4	40 40´ 06"	72 57´ 48"
C5	40 41´ 48"	72 56´ 54"
C6	40 41´ 51"	72 56´ 42"
C7	40 40´ 58"	72 56´ 23"
D1	40 43´ 41"	72 51´ 06"
D2	40 43´ 17"	72 50´ 59"
D3	40 42´ 56"	72 50´ 51"
D4	40 44´ 06"	72 49´ 38"
D5	40 43´ 40"	72 49´ 37"
D6	40 43´ 17"	72 49´ 18"
E1	40 48´ 31"	72 33´ 40"
E2	40 48´ 08"	72 33´ 30"
E3	40 47´ 26"	72 33´ 23"
E4	40 48´ 25"	72 32´ 30"
E5	40 47´ 35"	72 32´ 26"

Table 1 (cont´d). Station Latitude and Longitude

Station	Latitude	Longitude
F1	40 51´ 24"	72 24´ 0"
F2	40 51´ 03"	72 23´ 48"
F3	40 50´ 46"	72 23´ 30"
F4	40 51´ 56"	72 22´ 38"
F5	40 51´ 34"	72 22´ 17"
F6	40 51´ 04"	72 22´ 03"
F7	40 52´ 25"	72 21´ 16"
F8	40 52´ 06"	72 20´ 53"
F9	40 51´ 35"	72 20´ 41"
F10	40 53´ 03"	72 19´ 51"
F11	40 52´ 42"	72 19´ 33"
F12	40 52´ 11"	72 19´ 12"
F13	40 53´ 37"	72 18´ 36"
F14	40 53´ 20"	72 18´ 14"
F15	40 52´ 37"	72 17´ 55"
G1	40 56´ 15"	72 11´ 27"
G2	40 55´ 39"	72 11´ 10"
G3	40 55´ 10"	72 10´ 57"
G4	40 56´ 48"	72 10´ 01"
G5	40 56´ 15"	72 09´ 48"
G6	40 55´ 36"	72 09´ 21"
H1	40 58´ 30"	72 04´ 59"
H2	40 58´ 06"	72 04´ 48"
H3	40 58´ 51"	72 03´ 22"
H4	40 58´ 16"	72 02´ 42"
H5	40 57´ 42"	72 02´ 27"

Table 2. Sampling Schedule

	Date	Site
CRUISE I (Spring)	20 April	D & E
	21 April	H & G
	22 April	F
	23 April	C & B (Stations 9-12)
	24 April	B (Stations 1-8) & A
CRUISE II (Summer)	27 July	D & E
	28 July	H & G
	30 July	F
	31 July	C & B (Stations 9-12 Tows) (Stations 1-12 Grabs)
	3 August	B (Stations 1-4 Tows) A (Stations 7-9 Tows)
	4 August	A (Stations 1-9 Grabs) (Stations 1-3 Tows)
CRUISE III (Fall)	5 October	D & E
	6 October	H & G F (Stations 3,6,9-12 Grabs) (Stations 13-15 Tows)
	8 October	F (Stations 1,2,4,5,7,8, 10,11 Grabs) C (Stations 5-7 Grabs)
	9 October	C (Stations 1-4) B (Stations 1-12 Grabs)
	23 October	A & B (Stations 1-4, 9-12 Tows)

Table 3. Interpretation of sediment paramenters.

A) Sediment classification by particle size (Wentworth scale).

Class	Grain Size Phi	 Millimeters
Gravel	<-1	>2.0
Very Coarse Sand	0	1.0 - 2.0
Coarse Sand	1	0.5 - 1.0
Medium Sand	2	0.25 - 0.5
Fine Sand	3	0.125 - 0.25
Very Fine Sand	4	0.0625 - 0.125
Silt-Clay	> 4	<0.0625

B) Sediment classification by sorting coefficient (Folk, 1974).

Sorting Coefficient	Degree of Sorting
<0.35	Very well sorted
0.35 - 0.50	Well sorted
0.50 - 0.71	Moderately well sorted
0.71 - 1.00	Moderately sorted
1.00 - 2.00	Poorly sorted
2.00 - 4.00	Very poorly sorted

C) Sediment classification by skewness (folk, 1974).

Skewness Values	Degree of Skewness
+1.00 to +0.30	Strongly fine-skewed
+0.30 to +0.10	Fine-skewed
+0.10 to -0.10	Near-symmetrical
-0.10 to -0.30	Coarse-skewed
-0.30 to -1.00	Strongly coarse-skewed

D) Sediment classification by kurtosis (Folk, 1974).

Kurtosis Values	Degree of Kurtosis
<0.67	Very platykurtic
0.67 - 0.90	Platykurtic
0.90 - 1.11	Mesokurtic
1.11 - 1.50	Leptokurtic
1.50 - 3.00	Very leptokurtic
>3.00	Extremely leptokurtic

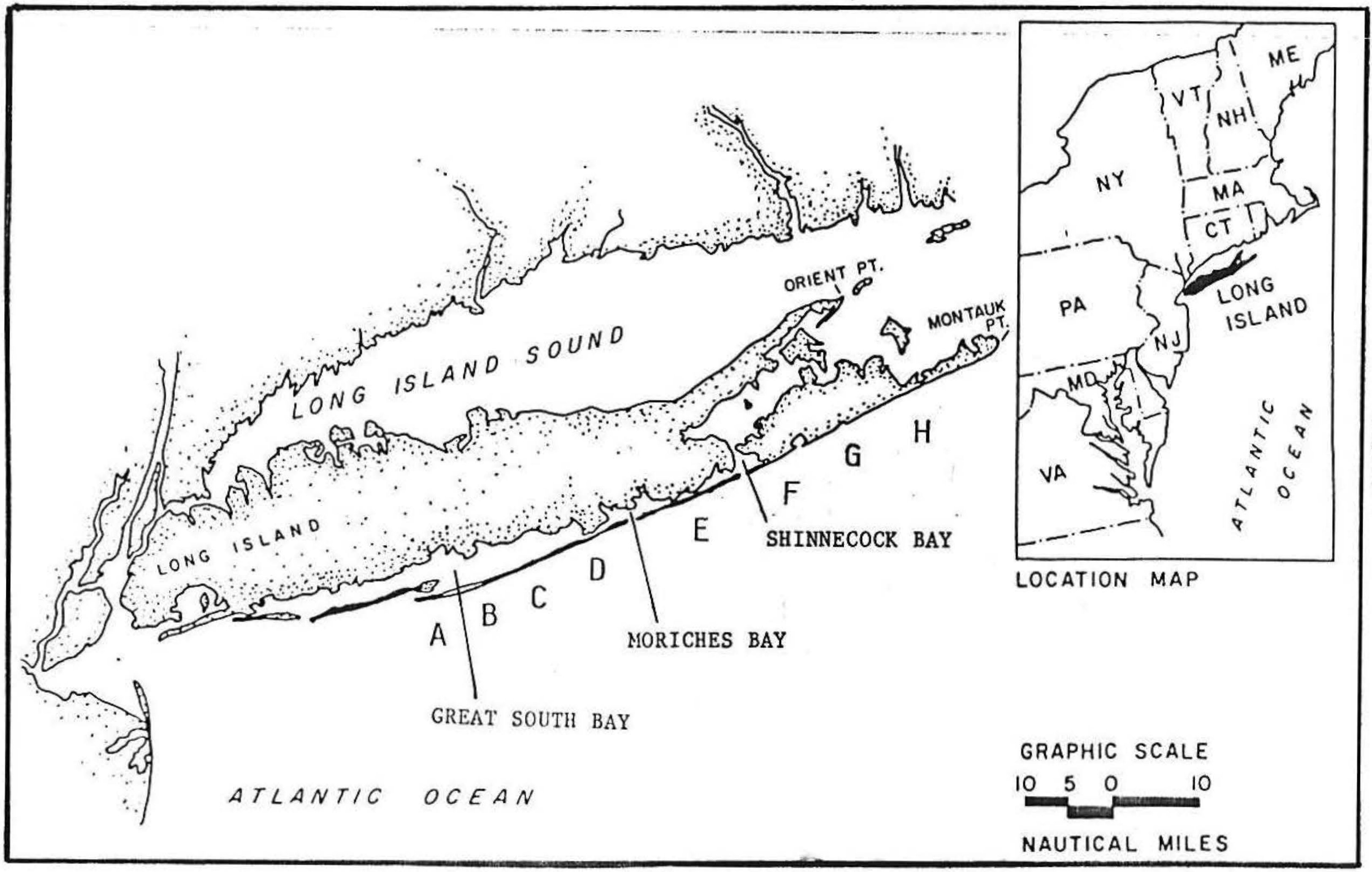

LONG ISLAND SOUND
ORIENT PT.
MONTAUK PT.
LONG ISLAND
A
B
C
D
E
F
G
H
GREAT SOUTH BAY
MORICHES BAY
SHINNECOCK BAY
ATLANTIC OCEAN
ME
VT
NH
NY
MA
CT
PA
NJ
LONG ISLAND
MD
VA
ATLANTIC OCEAN
LOCATION MAP
GRAPHIC SCALE
10 5 0 10
NAUTICAL MILES

Figure 1

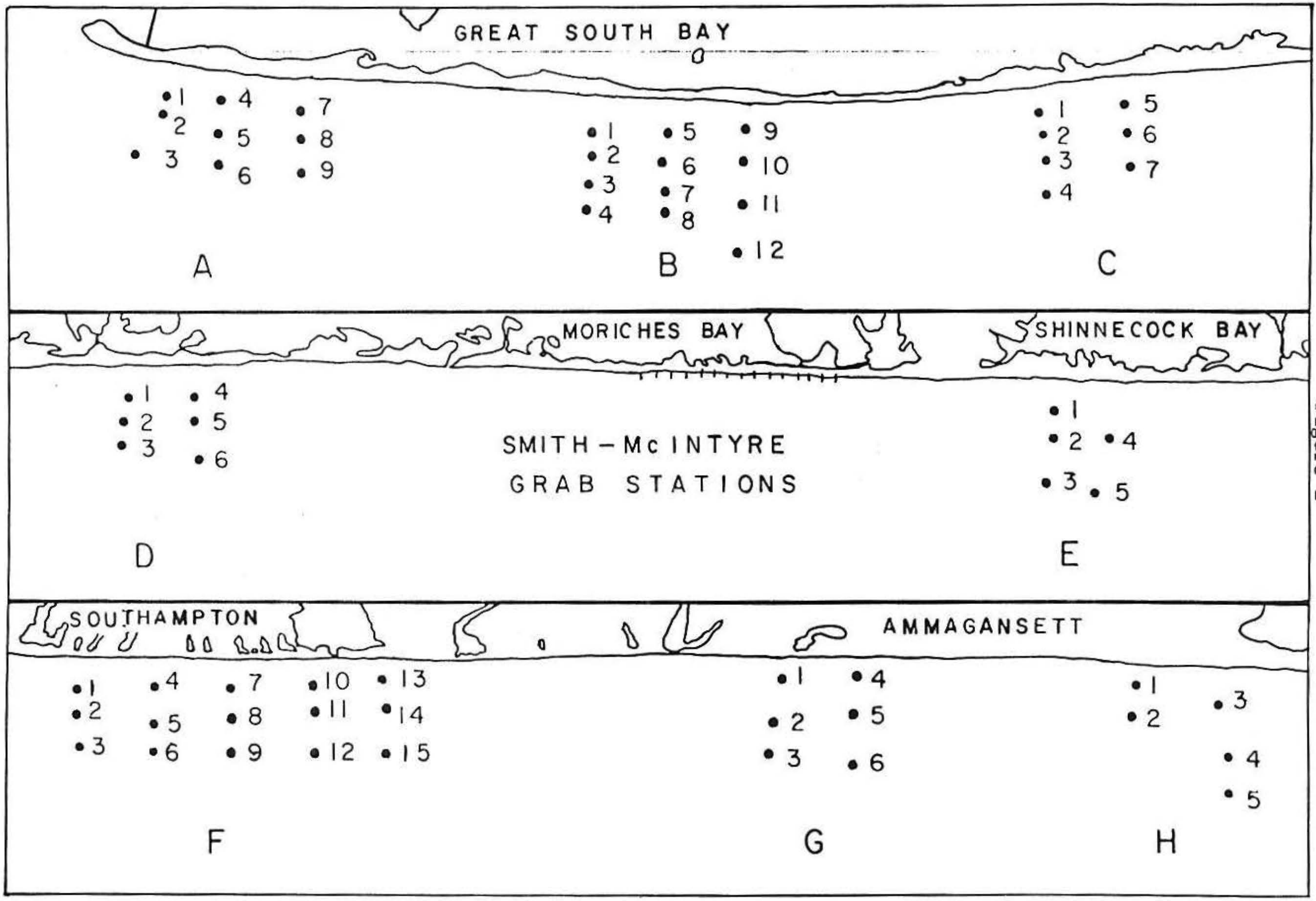

GREAT SOUTH BAY
A
B
C
MORICHES BAY
SHINNECOCK BAY
SMITH – McINTYRE GRAB STATIONS
D
E
SOUTHAMPTON
AMMAGANSETT
F
G
H

Figure 2

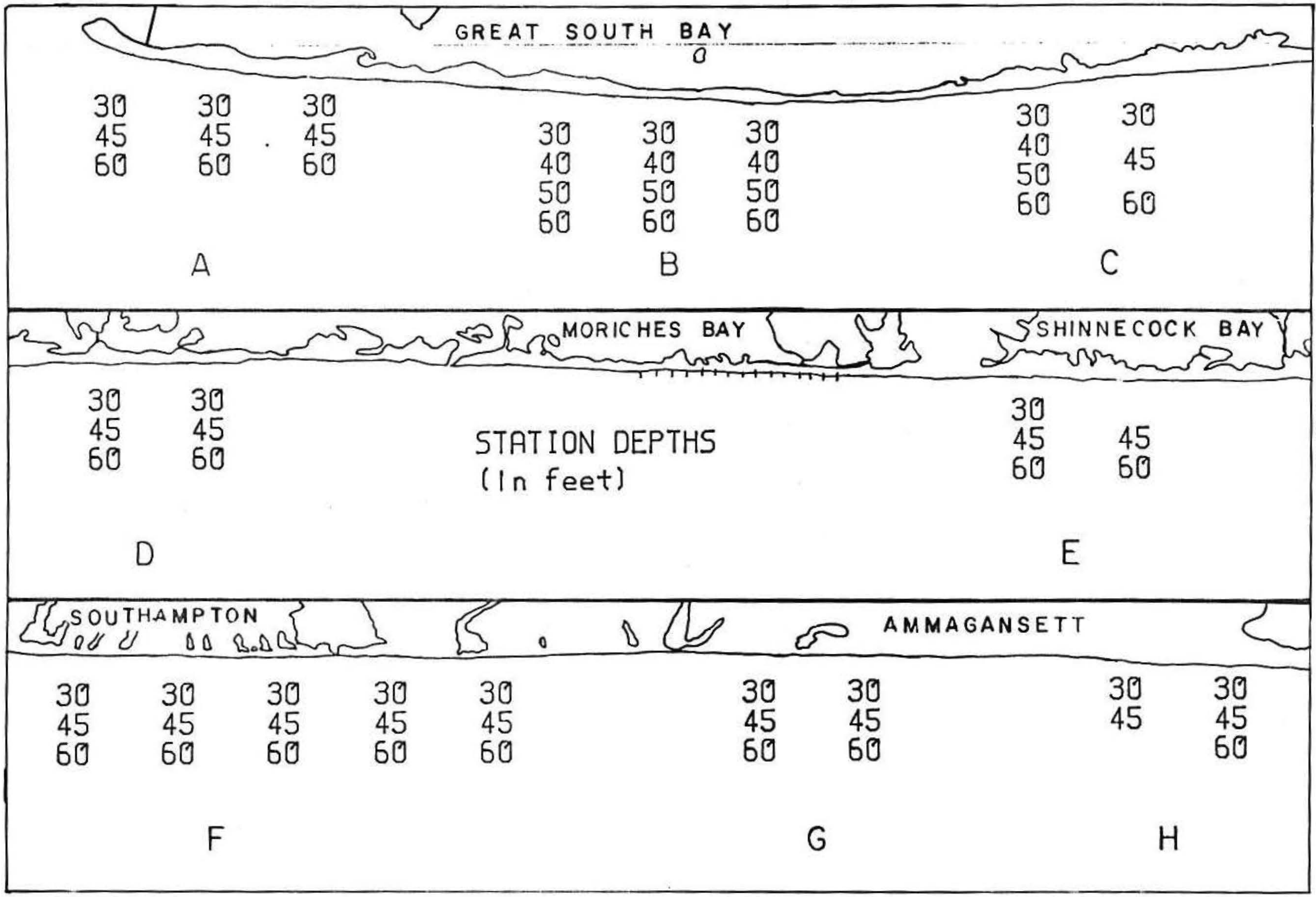

GREAT SOUTH BAY
30 45 60
30 45 60
30 45 60
30 40 50 60
30 40 50 60
30 40 50 60
30 40 50 60
30 45 60
A
B
C
MORICHES BAY
SHINNECOCK BAY
30 45 60
30 45 60
STATION DEPTHS
(In feet)
30 45 60
45 60
D
E
SOUTHAMPTON
AMMAGANSETT
30 45 60
30 45 60
30 45 60
30 45 60
30 45 60
30 45 60
30 45 60
30 45
30 45 60
F
G
H

Figure 3

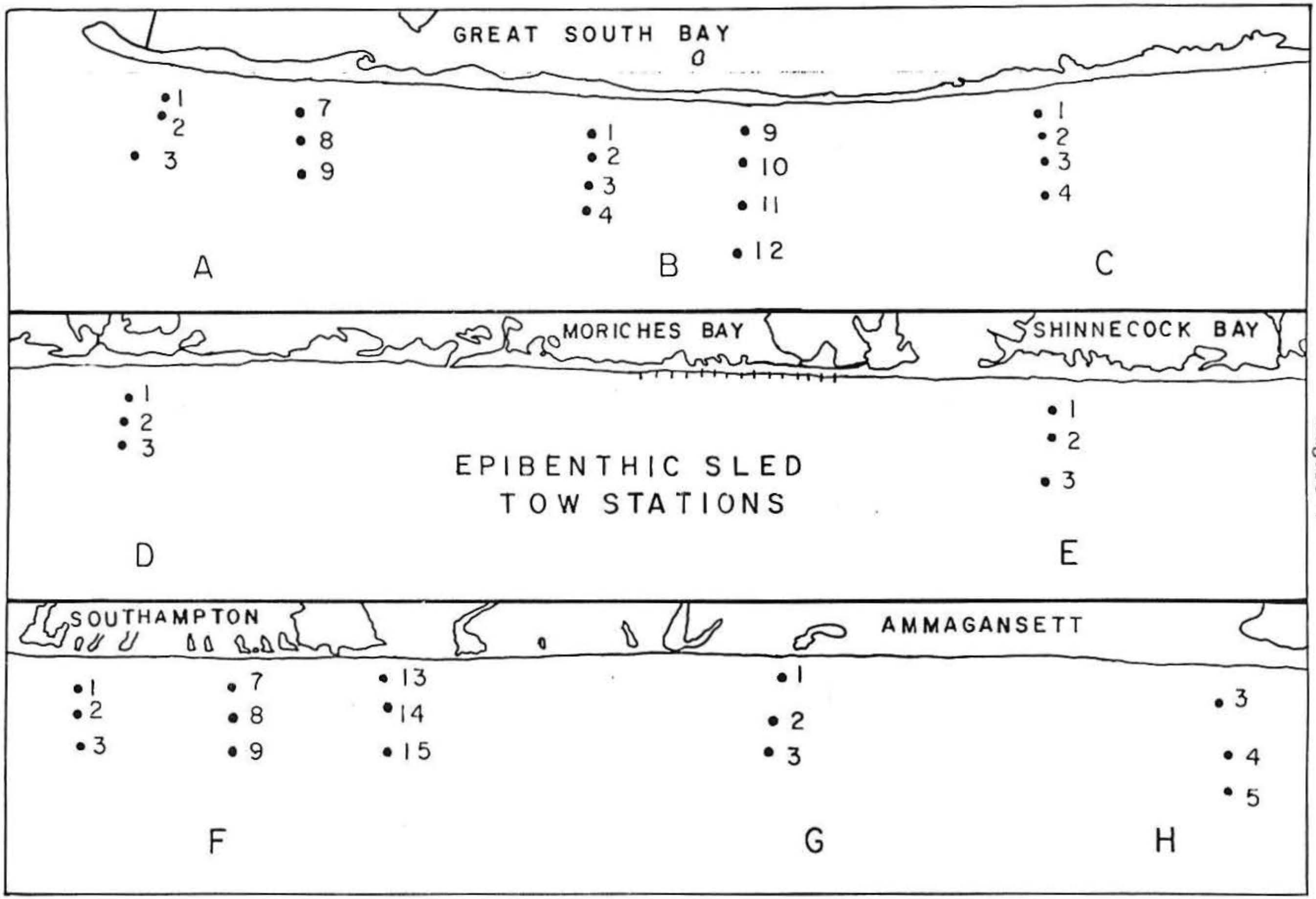
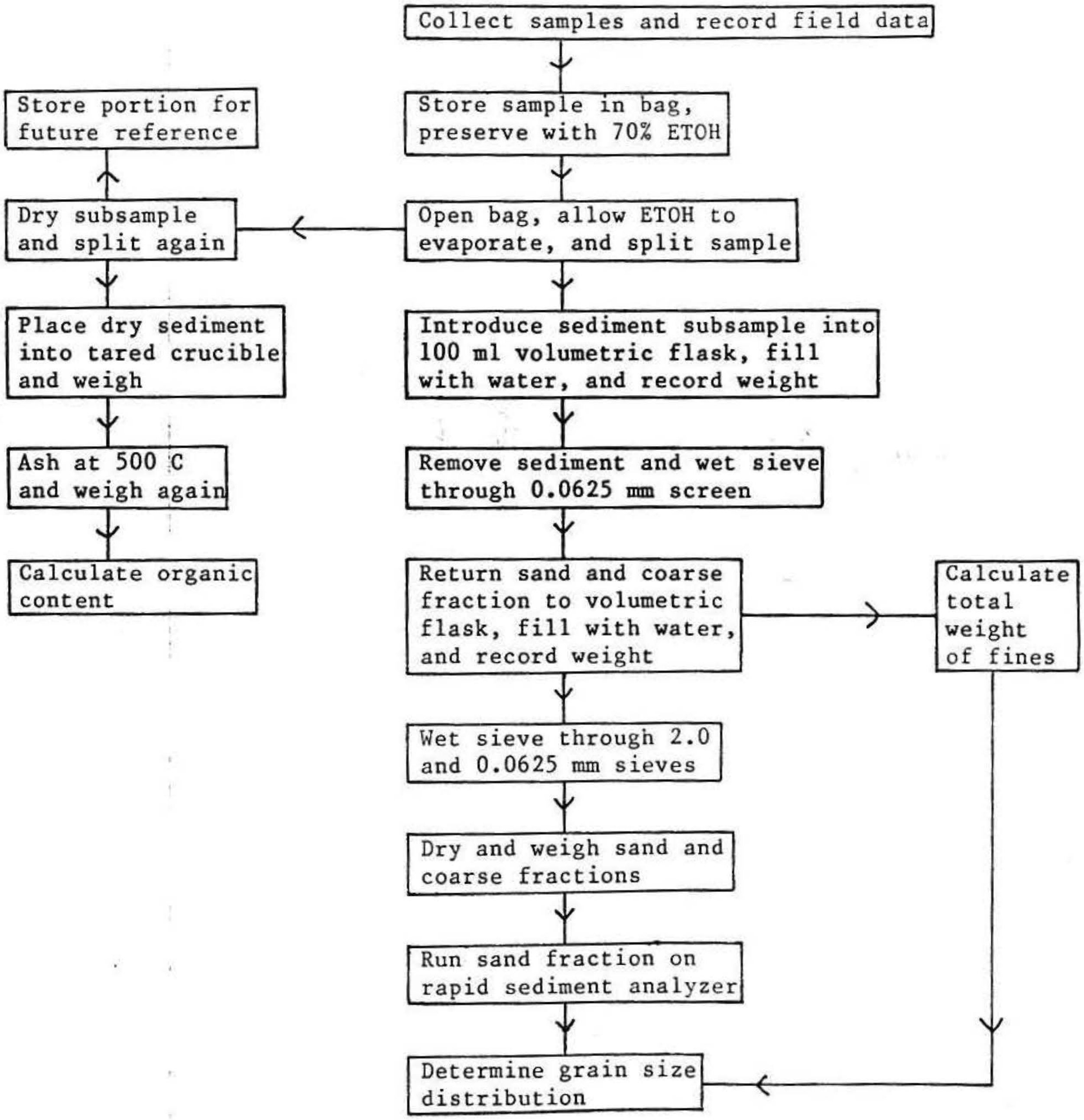

GREAT SOUTH BAY
MORICHES BAY
SHINNECOCK BAY
SOUTHAMPTON
AMMAGANSETT
EPIBENTHIC SLED TOW STATIONS
A
1
2
3
7
8
9
B
1
2
3
4
9
10
11
12
C
1
2
3
4
D
1
2
3
E
1
2
3
F
1
2
3
7
8
9
13
14
15
G
1
2
3
H
3
4
5

Figure 4

Figure 5

Schematic of Sediment Analysis Procedures



III. RESULTS

1. Sediment Characteristics

A total of 580 sediment samples collected during the three seasonal cruises were analyzed for grain size distribution and organic content. Grain size distributions for each sediment sample are presented in Appendix B. Statistical parameters derived from the sediment analysis are given in Appendix C. In this section, station and site average summaries of the sediment analysis are reported in detail. In Appendix C and in the figures presented in this section, an "*" indicates that a sediment parameter could not be computed because of insufficient data. Data was not sufficient if any of the phi sizes at the specific cumulative weights required for the computation of a sediment parameter lay outside the range of -1 to 4 phi units (see equations in the Methods Section).

a. Percent Gravel

Gravel content in the surface sediments ranged from 0 to 65.24% in the spring, from 0 to 64.78% during the summer, and from 0 to 54.06% in the fall cruise. Gravel content was less than 1% at a majority of the stations sampled (Figures 6-8). A number of stations within sites B, C, and H, however, consistently exceeded this 1% value (Figures 6-8). Gravel content was highest at the middepth (40′-50′) and offshore (60′) stations within site C (Figures 6-8). On a site average basis, there were no discernible west-east trends in percent gravel (Figure 9).

Gravel content was generally highest middepth (40′-50′) and offshore (60′) at sites A-E (Figures 10-12). At sites F-H, however, the highest gravel content was often found at the nearshore (30′) and middepth (40′-50′) stations (Figures 10-12). The variation in gravel content between cruises was less than 1% with the exception of the 30′ stations at site H, the 40′-50′ stations at sites B, C, E, and H, and the 60′ stations at sites B, C, and H (Figures 13-15).

b. Percent Sand

Sand content ranged from 33.09% to 99.98% in the spring, from 34.39% to 99.99% in the summer, and from 44.92% to 100.00% during the fall cruise (Figures 16-18). Sand content in the surface sediments was >95% at a majority of the stations sampled (Figures 16-18). Exceptions to the 95% value occurred primarily within site C (Figures 16-18). When sites C and H are excluded, a slight increase in percent sand from west to east is evident in the site averaged data (Figure 19). Percent sand was often highest nearshore (30′) at sites A-C (Figures 20-22). At sites D-H, however, highest percent sand values were consistently found at the middepth (40′-50′) and offshore (60′) stations (Figures 20-22). The variation in percent sand between cruises was less than 5% with the exception of the 40′-50′ stations at site C and the 60′ stations at sites A, C, and H (Figures 23-25).

c. Percent Silt-Clay

Silt-clay content in the surface sediments ranged from 0.00% to 45.39% in the spring, from 0.00% to 21.44% during the summer, and from 0.00% to 14.43% in the fall cruise (Figures 26-28). With the exception of site C during the spring cruise, the silt-clay content generally decreased from west to east when data were averaged by site (Figure 29). Percent silt-clay was generally highest nearshore (30′) at sites B and D-G (Figures 30-32). At sites A, C, and H, however, percent silt-clay was often highest at the middepth (40′-50′) and offshore (60′) stations (Figures 30-32). There was little seasonal variation (<3%) in percent silt-clay with the exception of the offshore (60′) stations at sites A, C, and H (Figures 33-35).

d. Organic Content

Organic content in the surface sediments ranged from 0.20% to 6.33% in the spring, from 0.27% to 3.51% in the summer, and from 0.07% to 2.47% in the fall (Figures 36-38). Organic content rarely exceeded 1% (Figures 36-38). With the exception of site C during the spring, organic content decreased slightly from west to east (Figure 39). No clearly defined trends with depth were found during any of the three cruises (Figures 40-42). Organic content varied by less than 1% between cruises with the exception of the offshore (60′) stations within sites A and C (Figures 43-45).

e. Median Grain Size

Median grain size in the surface sediments ranged from 0.097 mm (3.37 phi) to 0.616 mm (0.70 phi) in the spring, from 0.119 mm (3.07 phi) to 1.266 mm (-.034 phi) in the summer, and from 0.109 mm (3.20 phi) to 0.895 mm (0.16 phi) in the fall cruise (Figures 46-48). With the exception of sites C and D, there was a general decrease in median phi size (increase in median grain size) from west to east when data were averaged by site (Figure 49). Median phi size was consistently lowest at the middepth (40′-50′) and offshore (60′) stations (Figures 50-52). Highest median phi sizes were generally found nearshore (30′) at sites A-F and offshore (60′) for sites G-H (Figures 50-52).

The west to east gradient in median phi size changed with depth. The 30′ stations showed a well defined decrease in median phi size from west to east (Figure 53). This decrease in phi size was evident but less clearly defined for the 40′-50′ stations (Figure 54). The 60′ stations, however, showed no discernible west to east trend in median grain size (Figure 55). The variation in median phi size between cruises was lowest for the 40′-50′ stations (Figures 53-55).

f. Mean Grain Size

Mean grain size ranged from 0.119 mm (3.07 phi) to 0.607 mm (0.72 phi) during the spring, from 0.115 mm (3.12 phi) to 0.467 mm (1.10 phi) in the summer, and from 0.105 mm (3.25 phi) to 0.79 mm (0.34 phi) during the fall cruise (Figures 56-58). When sites C and D are excluded, a decrease in mean phi size from west to east is evident in the site averaged data (Figure 59). Mean phi size was generally lowest at the middepth (40′-50′) and offshore (60′) stations (Figures 60-62). Highest mean phi sizes were found nearshore (30′) for sites A-F (Figures 60-62). At sites G-H, however, mean phi size was often highest at the offshore (60′) stations (Figures 60-62).

As in the case for median phi size, the west to east gradient in mean phi size was found for the 30′ stations (Figure 63). This decrease was less evident for the 40′-50′ stations (Figure 64), and for the 60′ stations no west to east trend in mean phi size was apparent (Figure 65). The 40′-50′ stations showed the lowest seasonal variation in mean phi size (Figures 63-65).

g. Sorting Coefficient

The sorting coefficients obtained from the surface sediment samples ranged from 0.21 phi to 0.60 phi for the spring, from 0.22 phi to 0.72 phi during the summer, and from 0.17 phi to 0.70 phi during the fall cruise (Figures 66-68). No apparent west to east trend was found for the sorting coefficient when this sediment parameter was averaged by site (Figure 69). Lowest values for the sorting coefficient were generally found nearshore (30′) for sites A-D, and at either middepth (40′-50′) or offshore (60′) for sites E-H (Figures 70-72). The sorting coefficient was often highest at the middepth (40′-50′) or offshore (60′) stations for sites A-E (Figures 70-72). For sites F-H, however, highest values were generally found at the nearshore (30′) stations (Figures 70-72). The 40′-50′ stations showed the least amount of seasonal change in the sorting coefficient (Figures 73-75).

h. Skewness

Station averaged values for skewness ranged from -0.31 to 0.36 for the spring, from -0.12 to 0.44 during the summer, and from -0.29 to 0.46 for the fall cruise (Figures 76-78). When this statistical parameter was averaged by site, no discernible west to east trend could be found (Figure 79). Skewness was always lowest nearshore (30′) or middepth (40′-50′) at sites A, C, E, and H (Figures 80-82). For the remaining sites (B, D, F, and G), lowest values were generally found at middepth (40′-50′) or offshore (60′) (Figures 80-82). Highest values for skewness were consistently found nearshore (30′) for sites B, D, and G, and generally at either middepth (40′-50′) or offshore (60′) for the remaining sites (A, C, E, F, and H) (Figures 80-82). The 60′ stations showed the lowest seasonal variation in skewness (Figures 83-85).

i. Kurtosis

When averaged by station, kurtosis ranged from 0.77 to 1.85 during the spring, from 0.99 to 2.31 for the summer, and from 0.87 to 2.21 in the fall (Figures 86-88). Site averaged values for this sediment parameter suggest that it was somewhat lower at the eastern sites (F-H) relative to the other potential borrow areas (A-E) (Figure 89). With the exception of site G, lowest values for kurtosis were found either at the middepth (40′-50′) or offshore (60′) stations (Figures 90-92). Kurtosis was highest nearshore (30′) or middepth (40′-50′) at sites A-F, and at either middepth (40′-50′) or offshore at sites G and H (Figures 90-92). The smallest seasonal variation in kurtosis was found at the 40′-50′ stations (Figures 93-95).

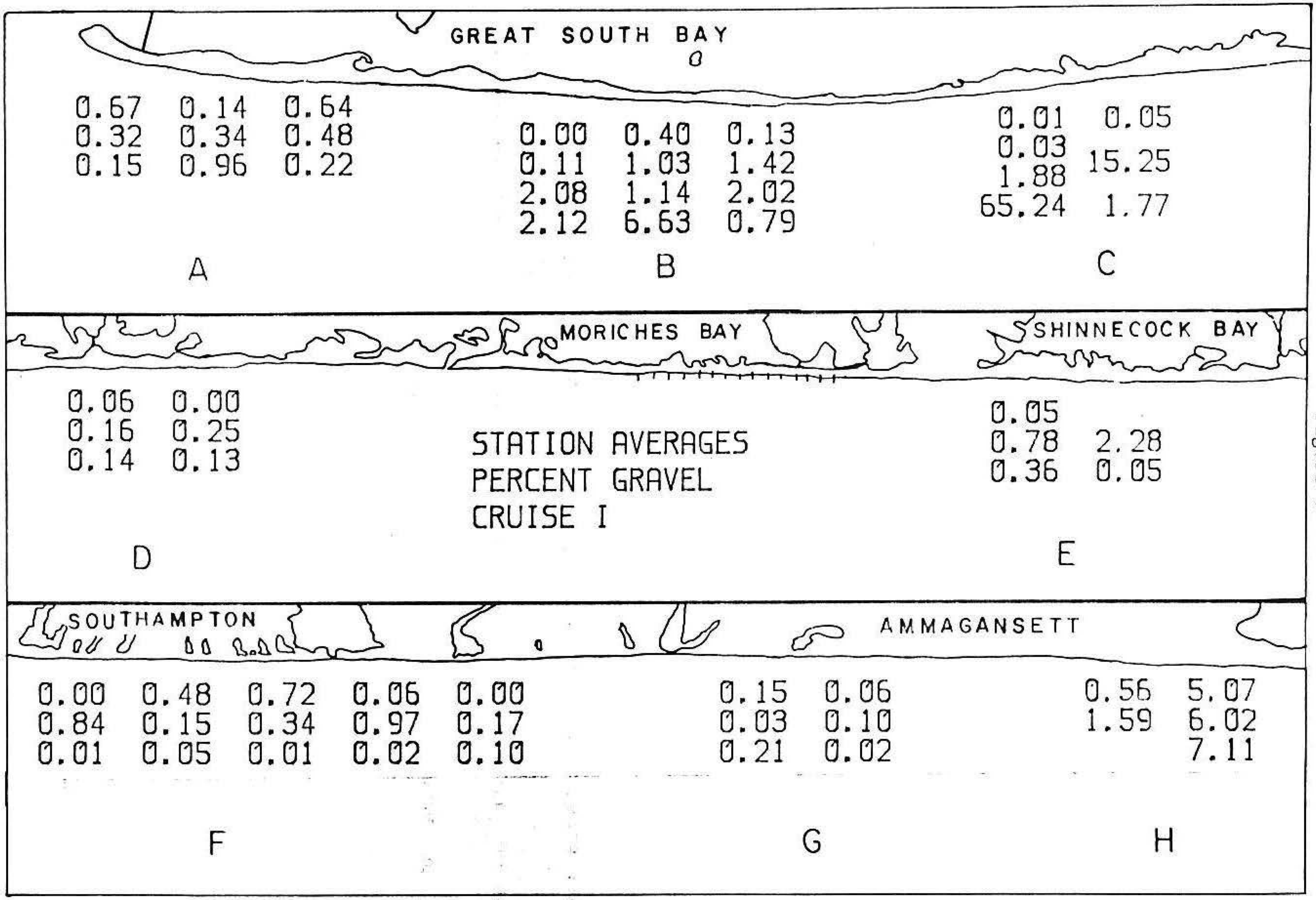

GREAT SOUTH BAY
0.67 0.14 0.64
0.32 0.34 0.48
0.15 0.96 0.22
A
0.00 0.40 0.13
0.11 1.03 1.42
2.08 1.14 2.02
2.12 6.63 0.79
B
0.01 0.05
0.03 15.25
1.88
65.24 1.77
C
MORICHES BAY
SHINNECOCK BAY
0.06 0.00
0.16 0.25
0.14 0.13
D
STATION AVERAGES
PERCENT GRAVEL
CRUISE I
0.05
0.78 2.28
0.36 0.05
E
SOUTHAMPTON
AMMAGANSETT
0.00 0.48 0.72 0.06 0.00
0.84 0.15 0.34 0.97 0.17
0.01 0.05 0.01 0.02 0.10
F
0.15 0.06
0.03 0.10
0.21 0.02
G
0.56 5.07
1.59 6.02
7.11
H

Figure 6

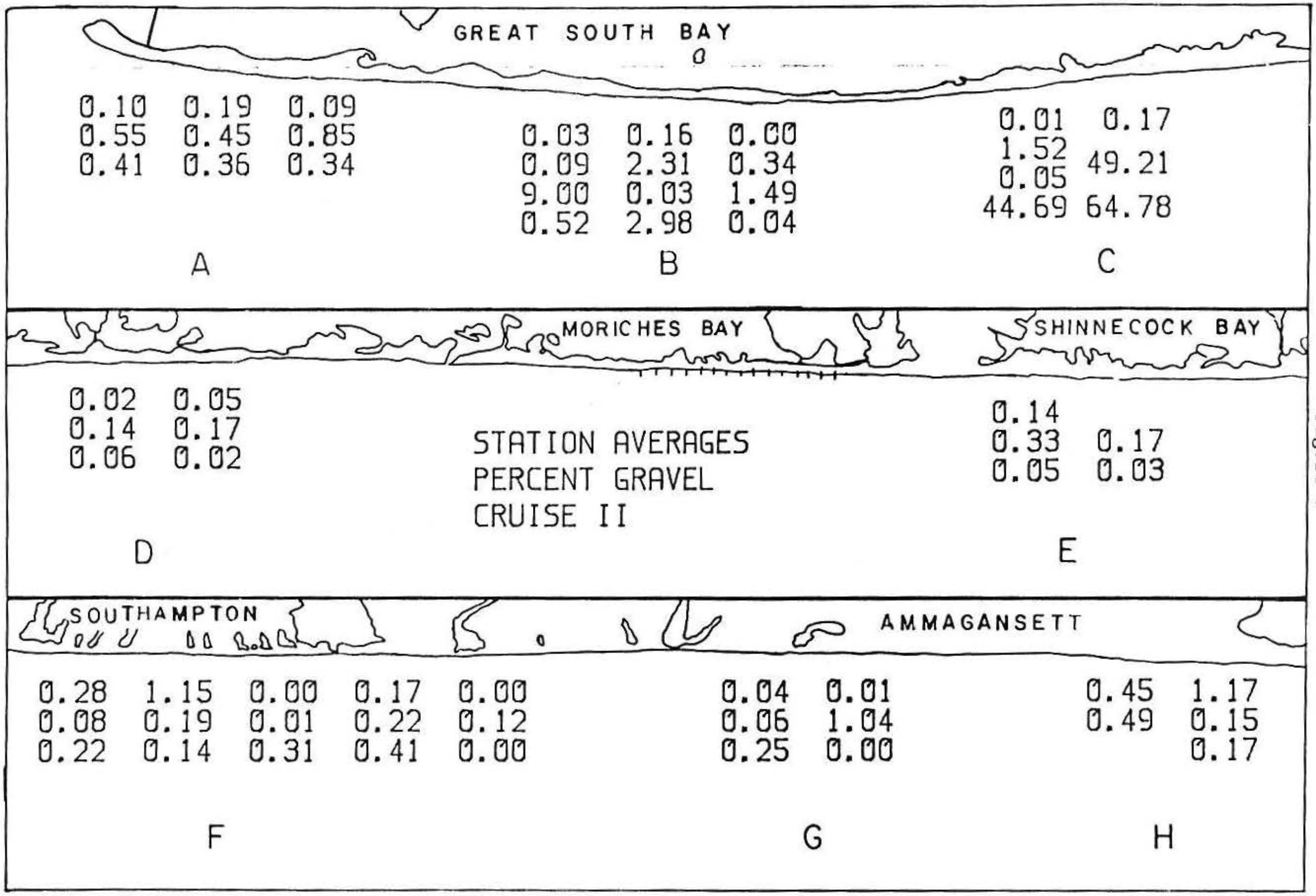

GREAT SOUTH BAY
0.10 0.19 0.09
0.55 0.45 0.85
0.41 0.36 0.34
A
0.03 0.16 0.00
0.09 2.31 0.34
9.00 0.03 1.49
0.52 2.98 0.04
B
0.01 0.17
1.52 49.21
0.05
44.69 64.78
C
MORICHES BAY
SHINNECOCK BAY
0.02 0.05
0.14 0.17
0.06 0.02
D
STATION AVERAGES
PERCENT GRAVEL
CRUISE II
0.14
0.33 0.17
0.05 0.03
E
SOUTHAMPTON
AMMAGANSETT
0.28 1.15 0.00 0.17 0.00
0.08 0.19 0.01 0.22 0.12
0.22 0.14 0.31 0.41 0.00
F
0.04 0.01
0.06 1.04
0.25 0.00
G
0.45 1.17
0.49 0.15
0.17
H

Figure 7

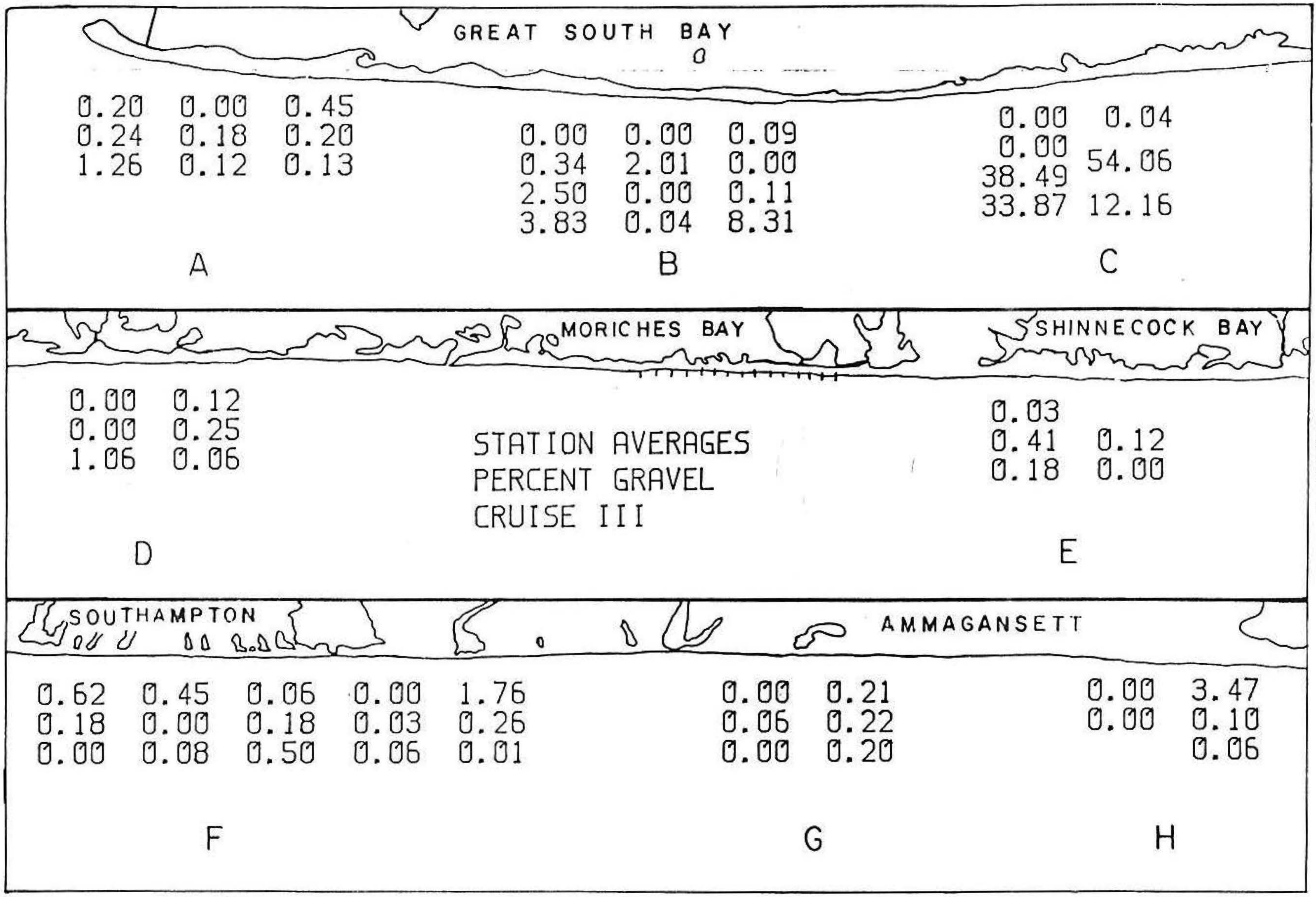

GREAT SOUTH BAY
0.20 0.00 0.45
0.24 0.18 0.20
1.26 0.12 0.13
A
0.00 0.00 0.09
0.34 2.01 0.00
2.50 0.00 0.11
3.83 0.04 8.31
B
0.00 0.04
0.00
38.49 54.06
33.87 12.16
C
MORICHES BAY
SHINNECOCK BAY
0.00 0.12
0.00 0.25
1.06 0.06
D
STATION AVERAGES
PERCENT GRAVEL
CRUISE III
0.03
0.41 0.12
0.18 0.00
E
SOUTHAMPTON
AMMAGANSETT
0.62 0.45 0.06 0.00 1.76
0.18 0.00 0.18 0.03 0.26
0.00 0.08 0.50 0.06 0.01
F
0.00 0.21
0.06 0.22
0.00 0.20
G
0.00 3.47
0.00 0.10
0.06
H

Figure 8

Figure 9

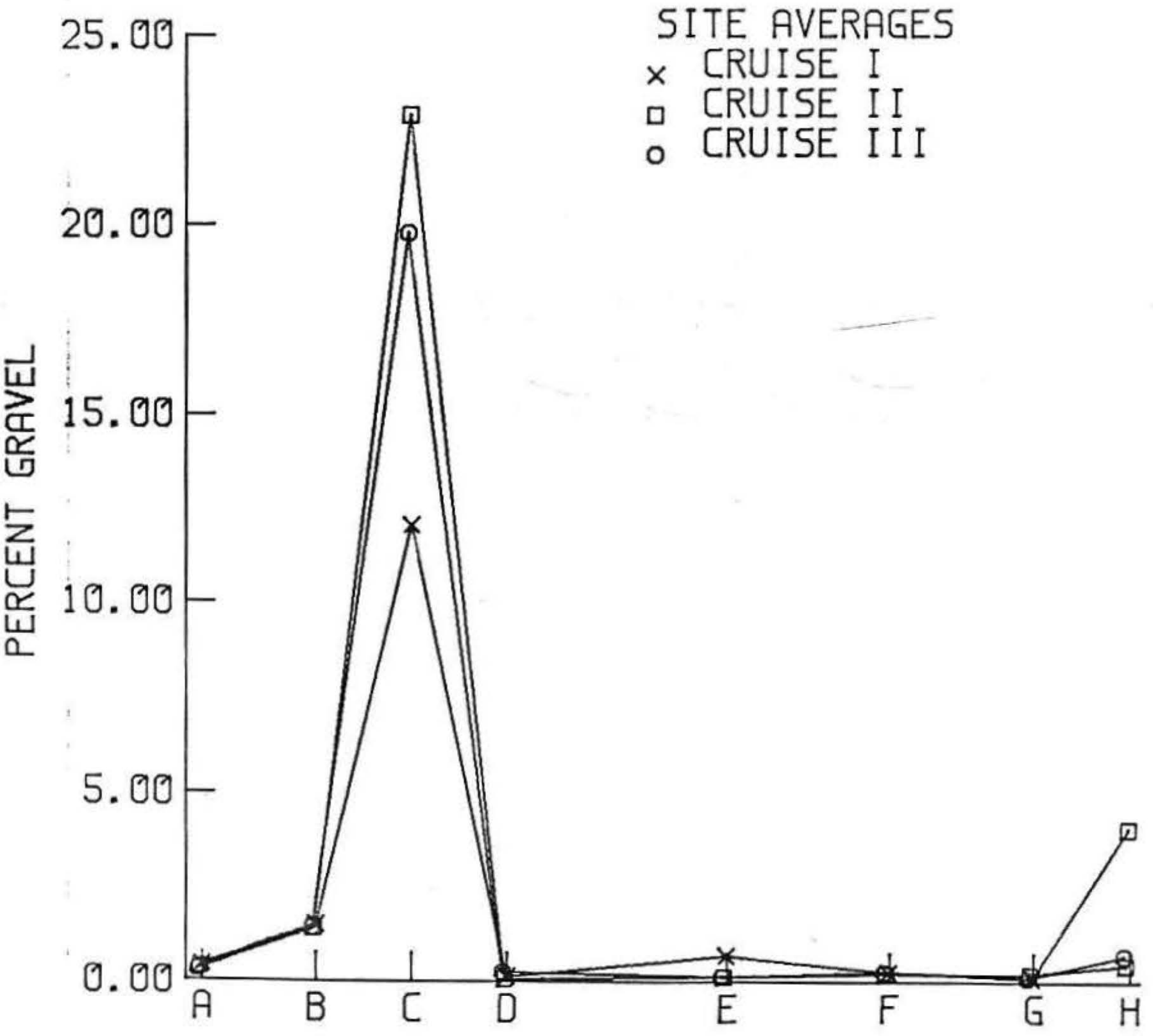

SITE AVERAGES
× CRUISE I
□ CRUISE II
o CRUISE III
25.00
20.00
15.00
10.00
5.00
0.00
PERCENT GRAVEL
A
B
C
D
E
F
G
H

Figure 10

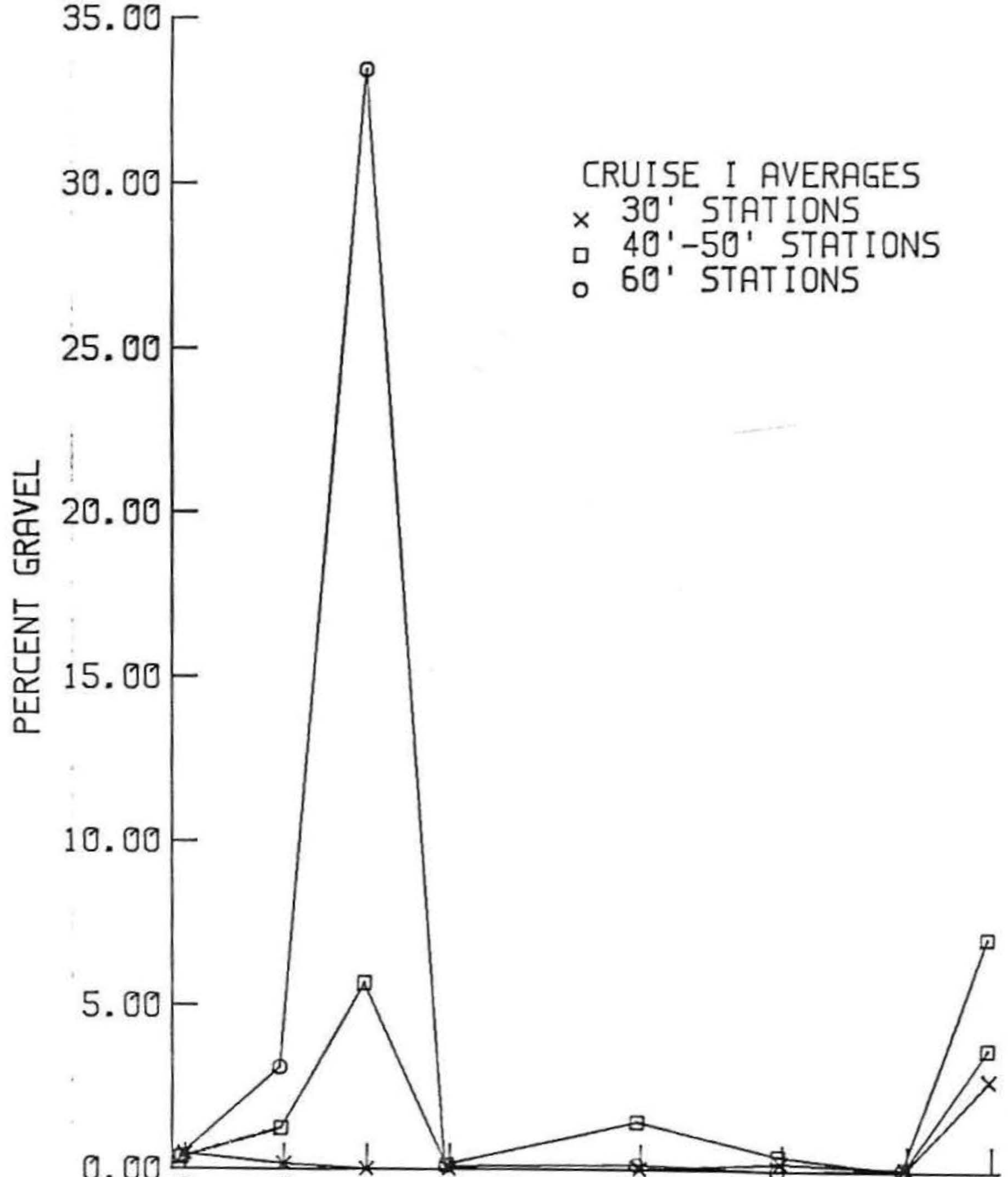

35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
PERCENT GRAVEL
CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
A
B
C
D
E
F
G
H

Figure 11

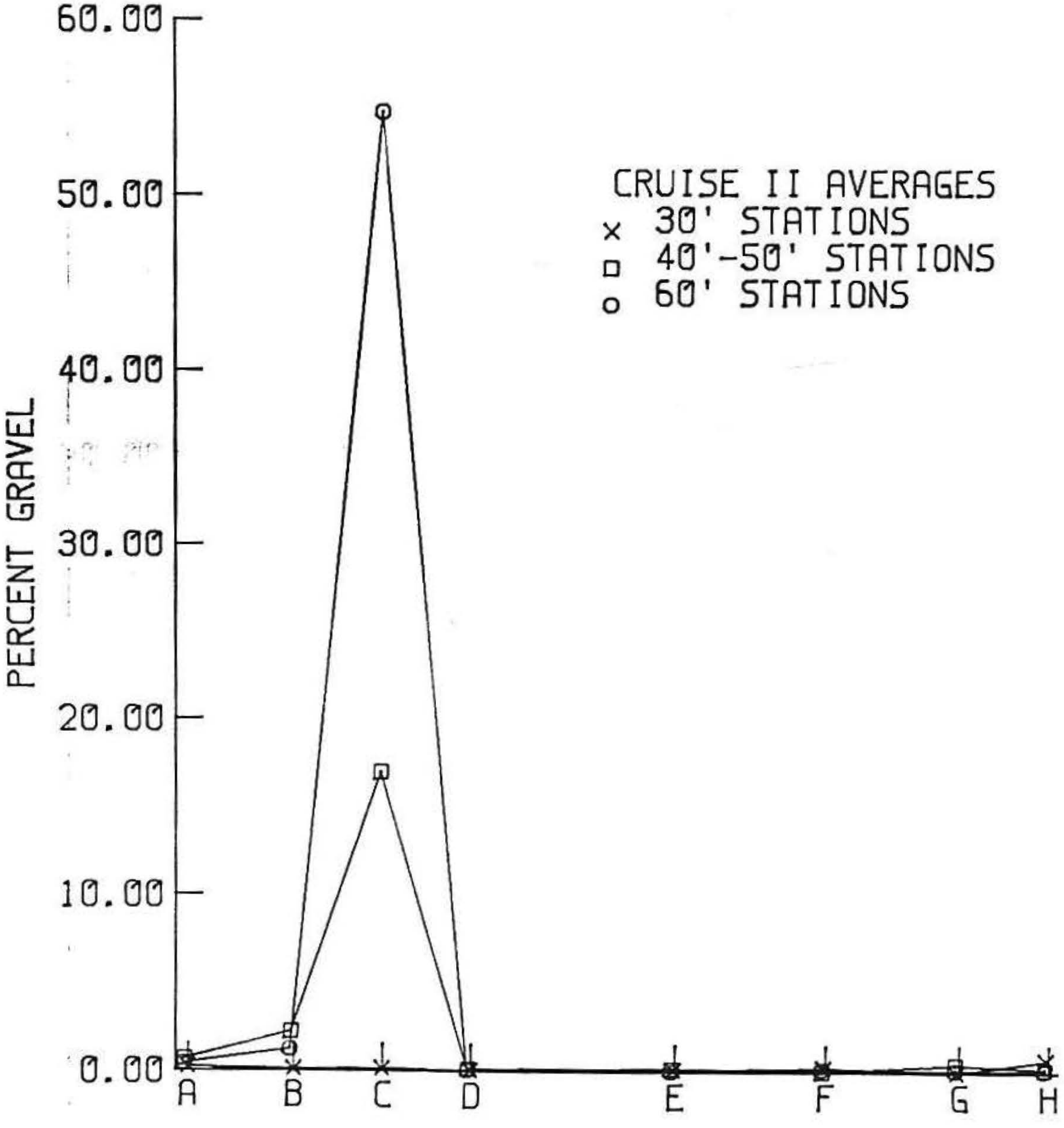

60.00
50.00
40.00
30.00
20.00
10.00
0.00
PERCENT GRAVEL
CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
A
B
C
D
E
F
G
H

Figure 12

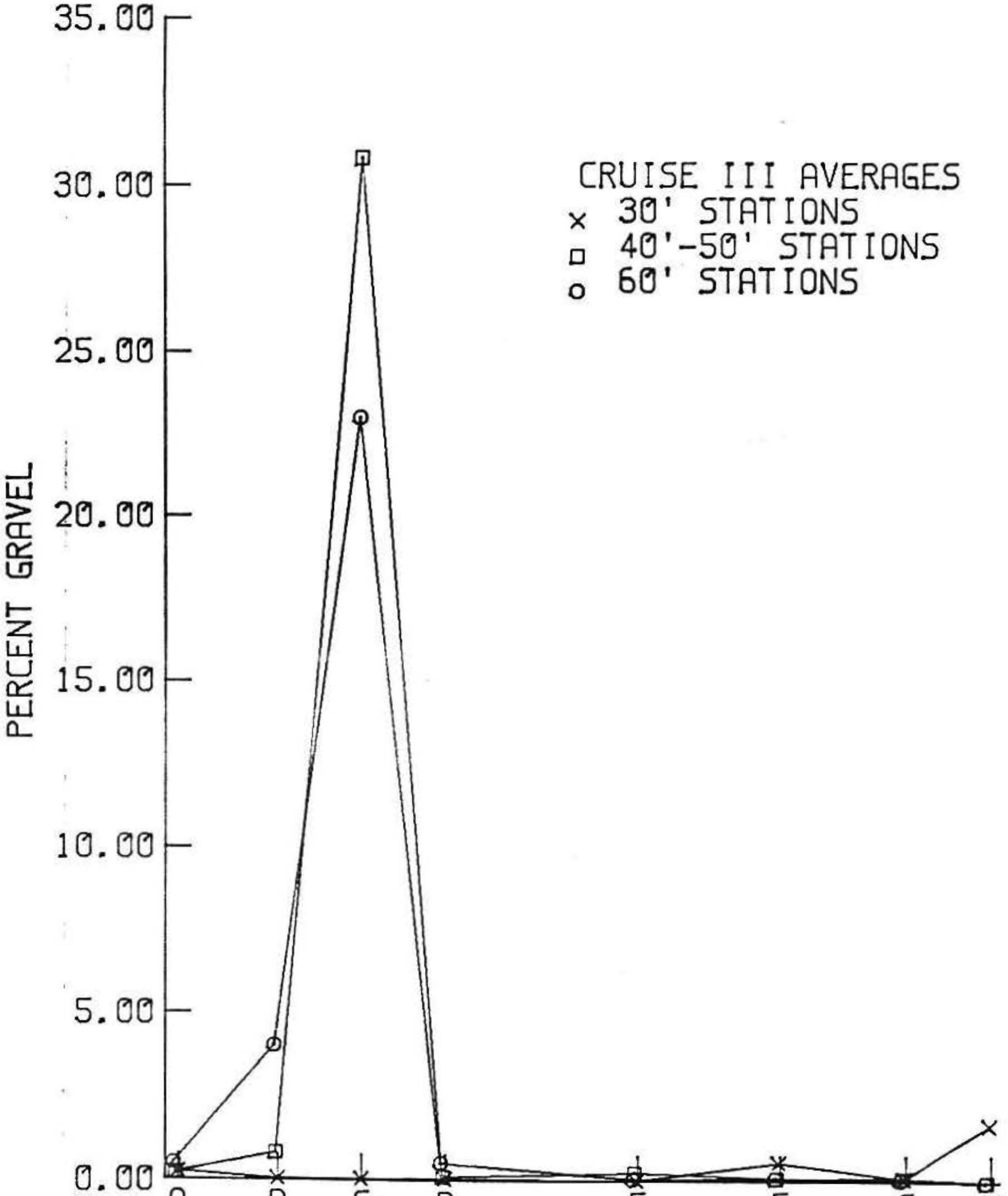

35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
PERCENT GRAVEL
CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
A
B
C
D
E
F
G
H

Figure 13

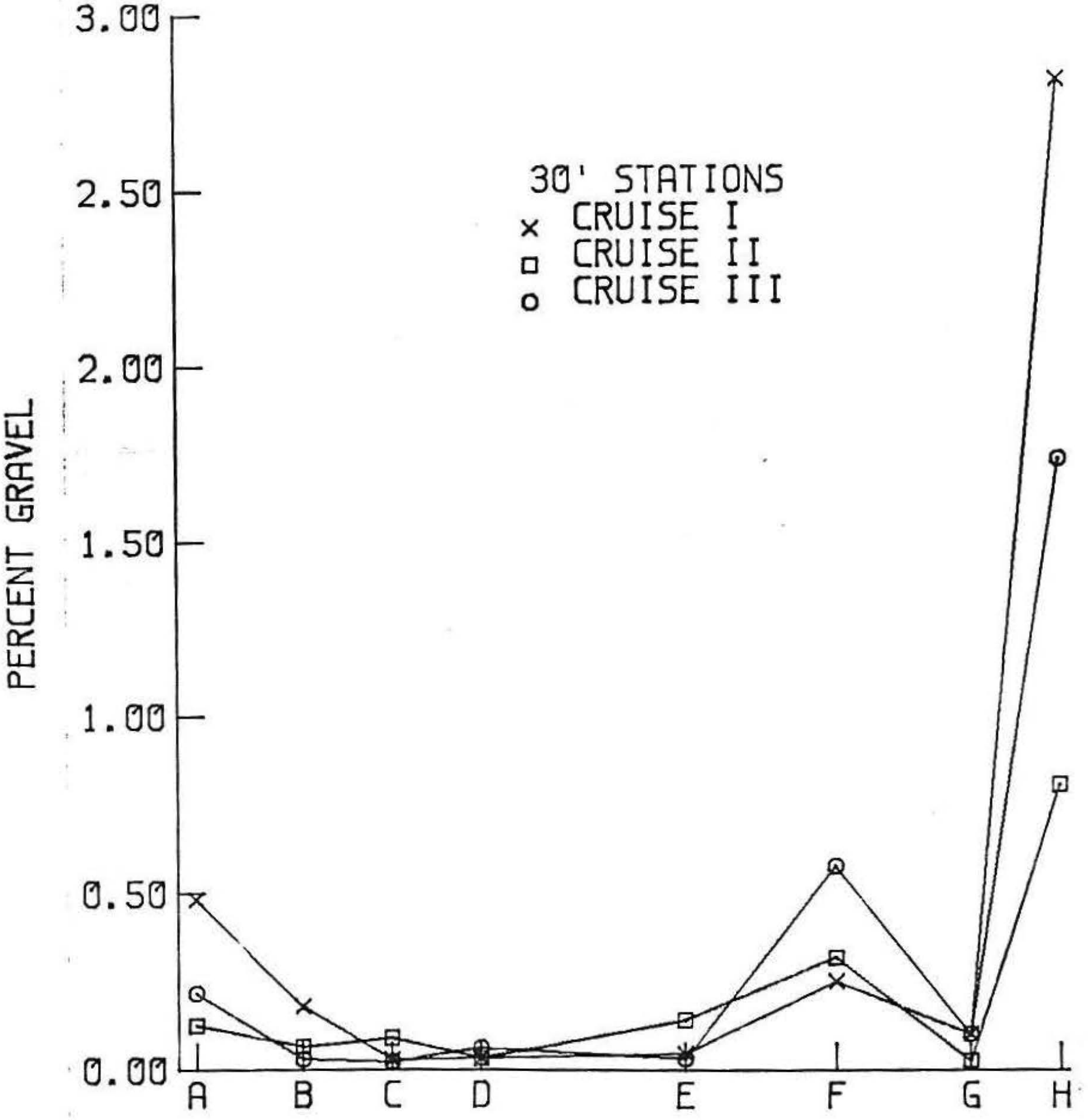

3.00
2.50
2.00
1.50
1.00
0.50
0.00
PERCENT GRAVEL
30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
A
B
C
D
E
F
G
H

Figure 14

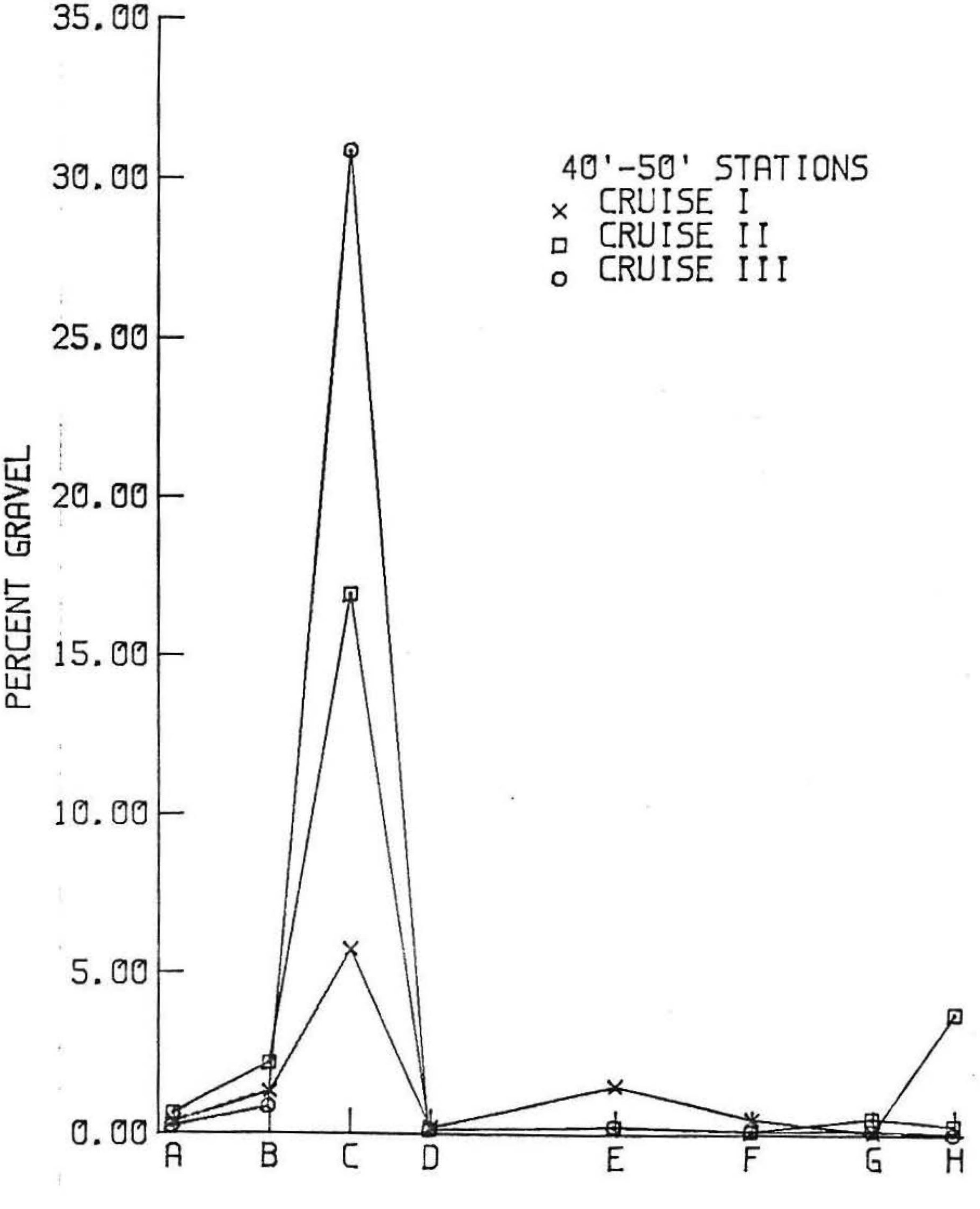
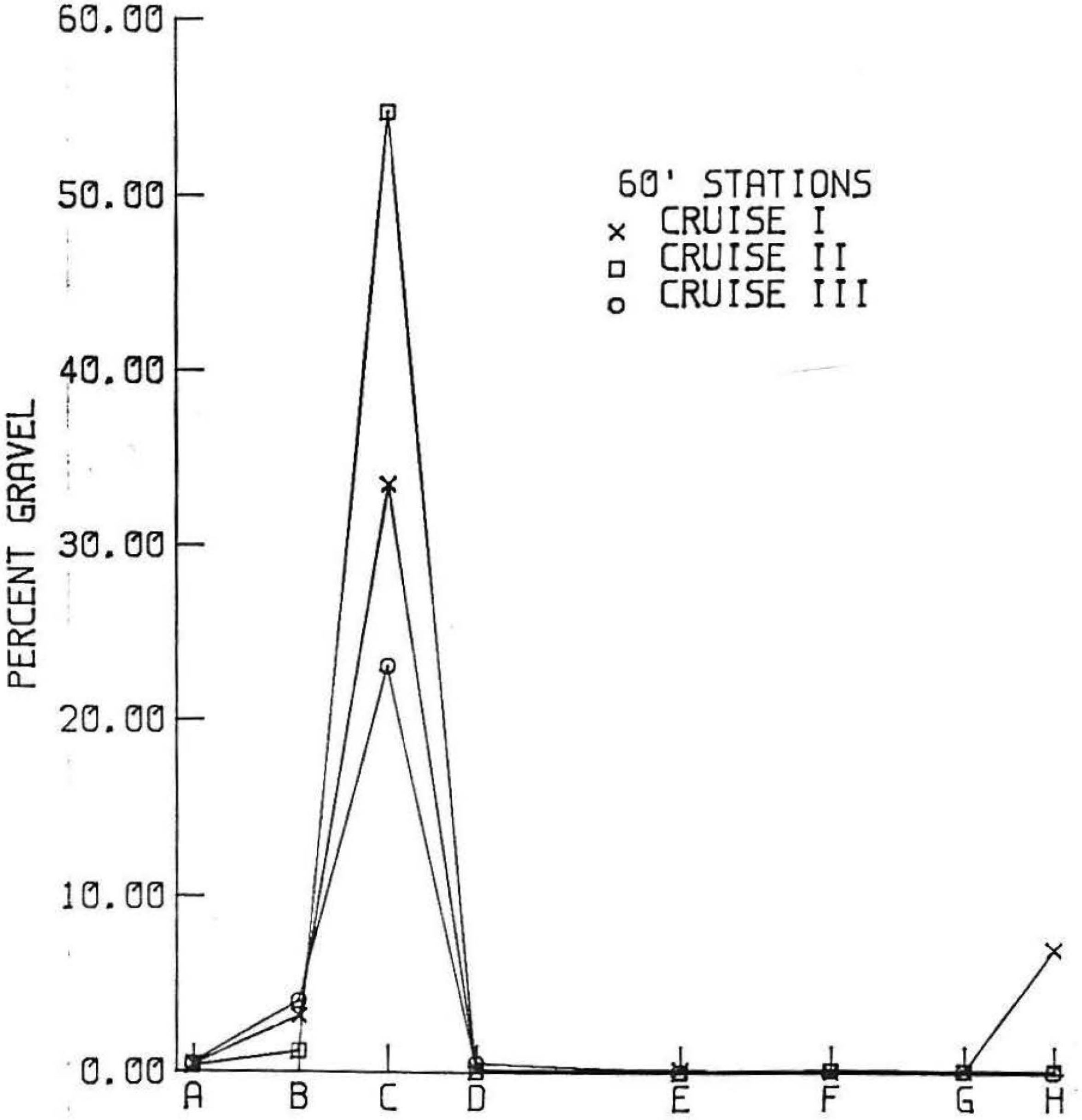

35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
PERCENT GRAVEL
40'-50' STATIONS
× CRUISE I
□ CRUISE II
o CRUISE III
A
B
C
D
E
F
G
H

Figure 15


60.00
50.00
40.00
30.00
20.00
10.00
0.00
PERCENT GRAVEL
A
B
C
D
E
F
G
H
60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

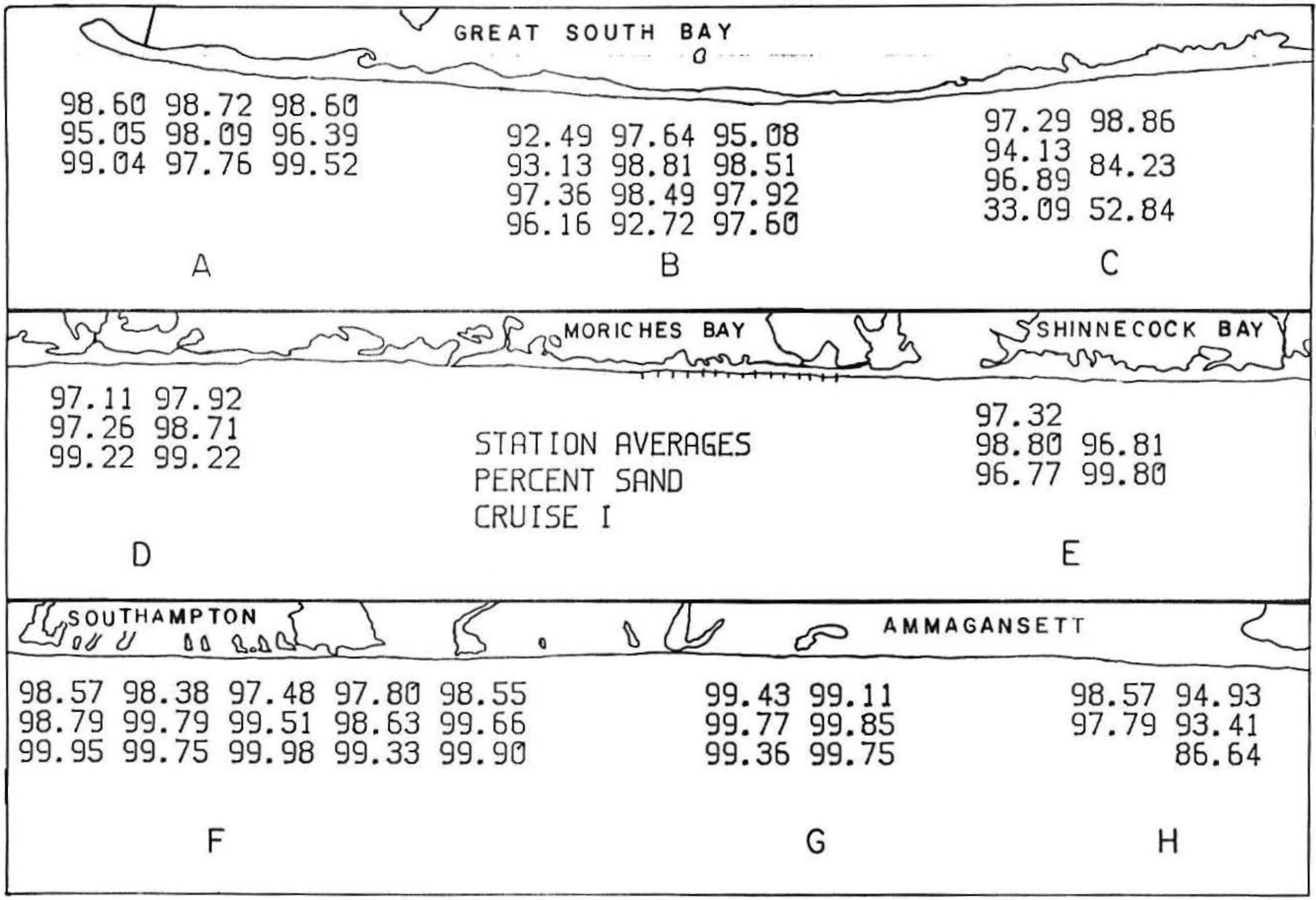

GREAT SOUTH BAY
98.60 98.72 98.60
95.05 98.09 96.39
99.04 97.76 99.52
A
92.49 97.64 95.08
93.13 98.81 98.51
97.36 98.49 97.92
96.16 92.72 97.60
B
97.29 98.86
94.13
96.89 84.23
33.09 52.84
C
MORICHES BAY
SHINNECOCK BAY
97.11 97.92
97.26 98.71
99.22 99.22
D
STATION AVERAGES
PERCENT SAND
CRUISE I
97.32
98.80 96.81
96.77 99.80
E
SOUTHAMPTON
AMMAGANSETT
98.57 98.38 97.48 97.80 98.55
98.79 99.79 99.51 98.63 99.66
99.95 99.75 99.98 99.33 99.90
F
99.43 99.11
99.77 99.85
99.36 99.75
G
98.57 94.93
97.79 93.41
86.64
H

Figure 16

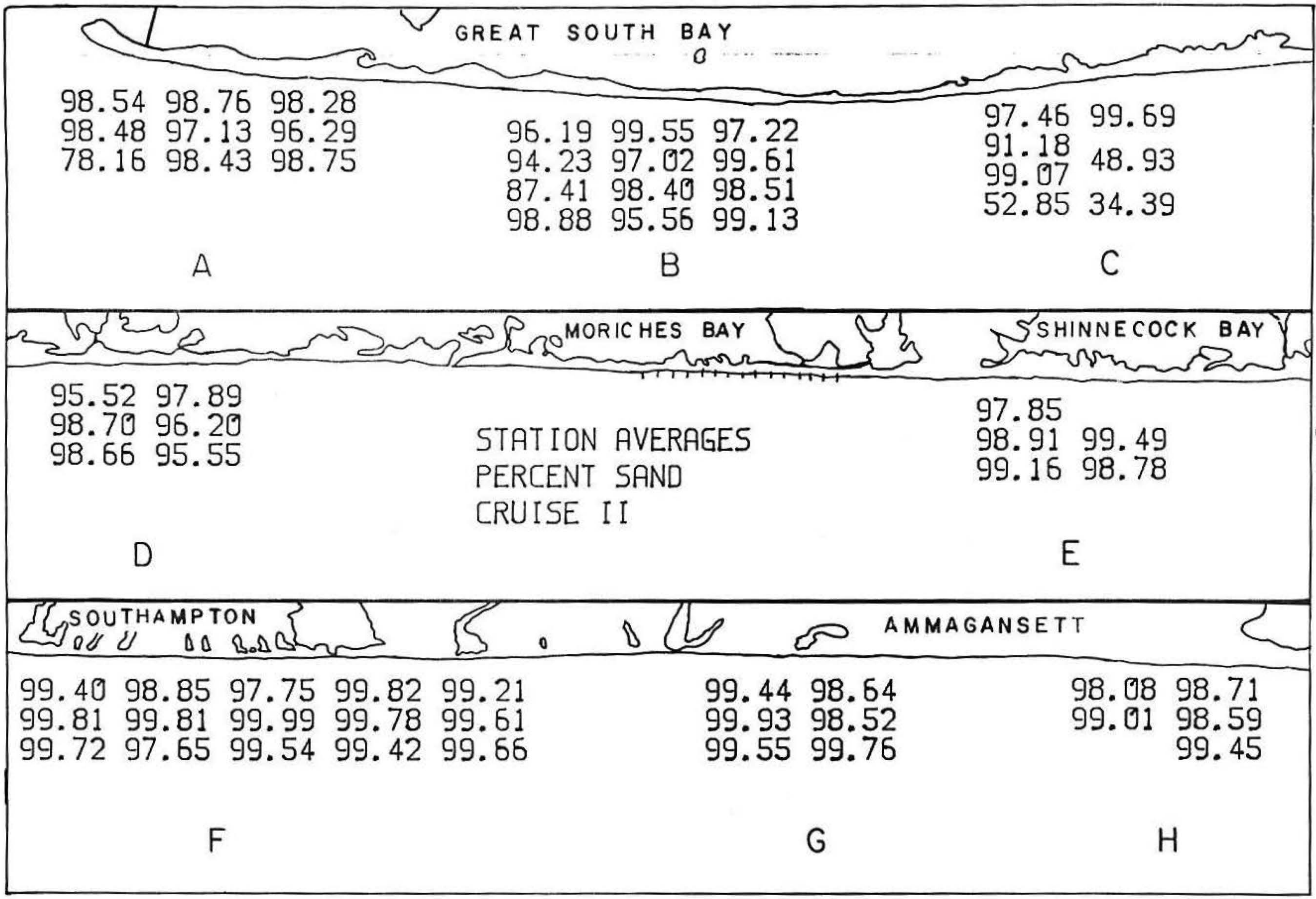

GREAT SOUTH BAY
98.54 98.76 98.28
98.48 97.13 96.29
78.16 98.43 98.75
A
96.19 99.55 97.22
94.23 97.02 99.61
87.41 98.40 98.51
98.88 95.56 99.13
B
97.46 99.69
91.18
99.07 48.93
52.85 34.39
C
MORICHES BAY
SHINNECOCK BAY
95.52 97.89
98.70 96.20
98.66 95.55
D
STATION AVERAGES
PERCENT SAND
CRUISE II
97.85
98.91 99.49
99.16 98.78
E
SOUTHAMPTON
AMMAGANSETT
99.40 98.85 97.75 99.82 99.21
99.81 99.81 99.99 99.78 99.61
99.72 97.65 99.54 99.42 99.66
F
99.44 98.64
99.93 98.52
99.55 99.76
G
98.08 98.71
99.01 98.59
99.45
H

Figure 17

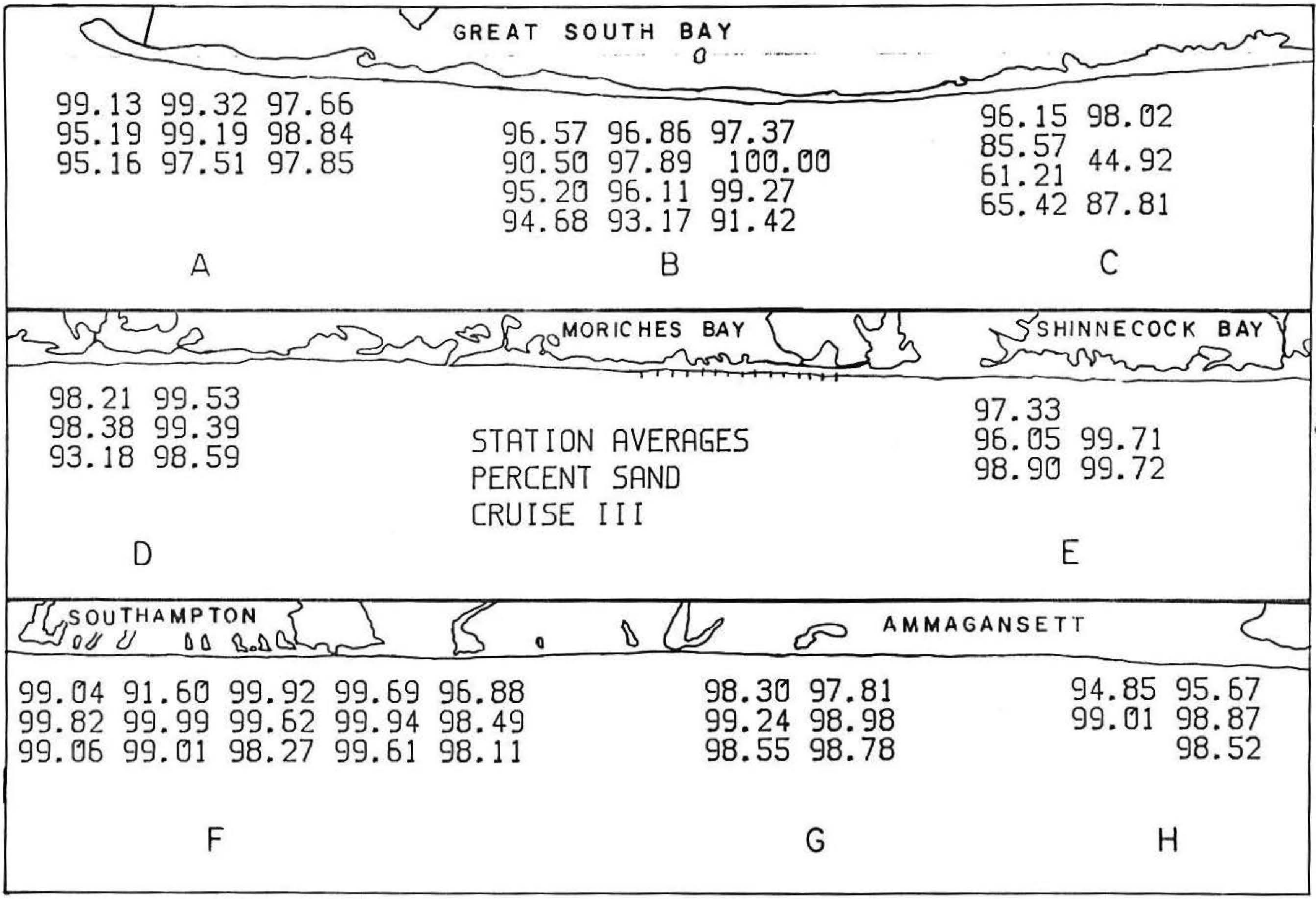

GREAT SOUTH BAY
99.13 99.32 97.66
95.19 99.19 98.84
95.16 97.51 97.85
A
96.57 96.86 97.37
90.50 97.89 100.00
95.20 96.11 99.27
94.68 93.17 91.42
B
96.15 98.02
85.57
44.92
61.21
65.42 87.81
C
MORICHES BAY
SHINNECOCK BAY
98.21 99.53
98.38 99.39
93.18 98.59
D
STATION AVERAGES
PERCENT SAND
CRUISE III
97.33
96.05 99.71
98.90 99.72
E
SOUTHAMPTON
AMMAGANSETT
99.04 91.60 99.92 99.69 96.88
99.82 99.99 99.62 99.94 98.49
99.06 99.01 98.27 99.61 98.11
F
98.30 97.81
99.24 98.98
98.55 98.78
G
94.85 95.67
99.01 98.87
98.52
H

Figure 18

Figure 19

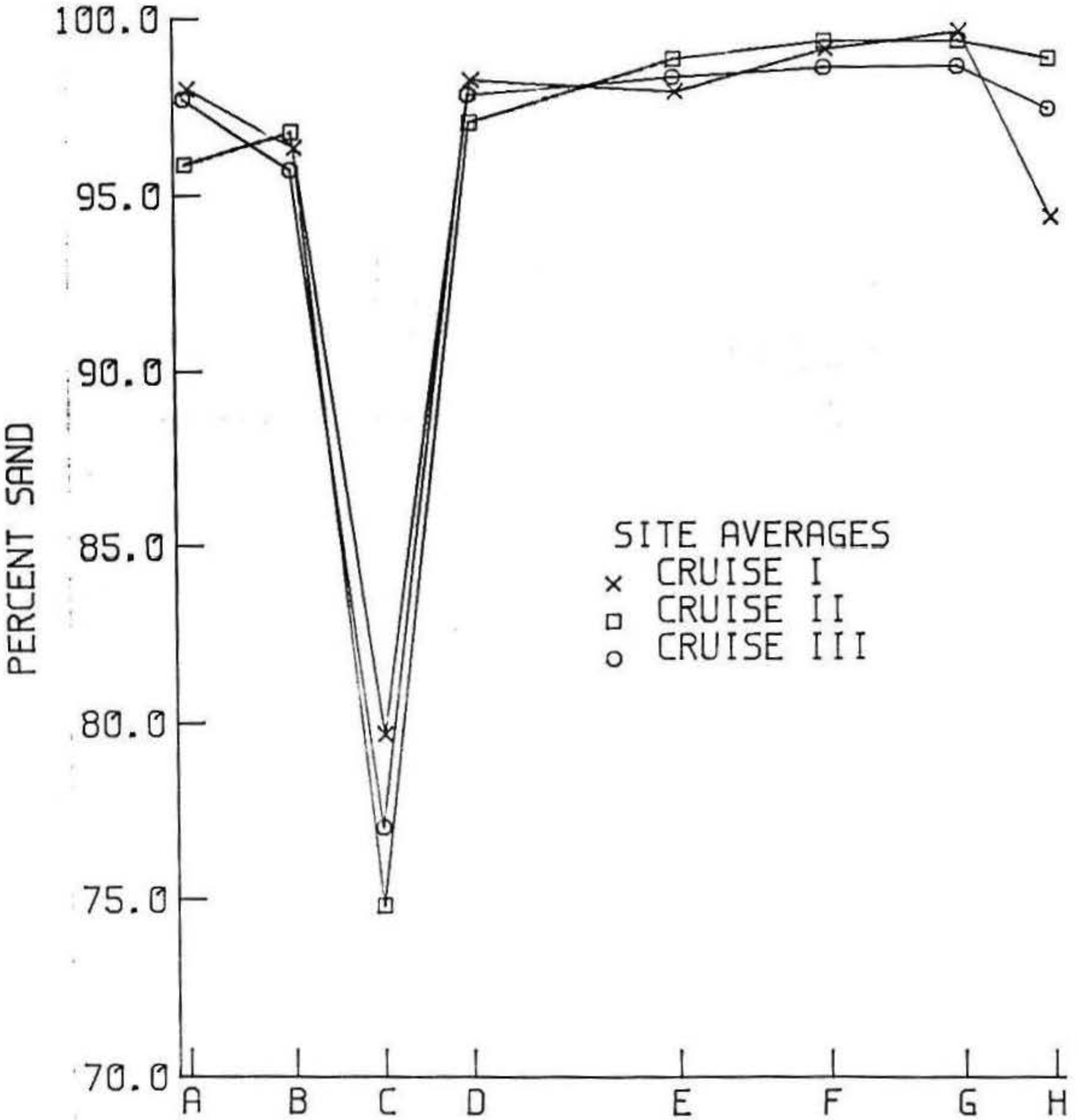

100.0
95.0
90.0
85.0
80.0
75.0
70.0
PERCENT SAND
A
B
C
D
E
F
G
H
SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 20

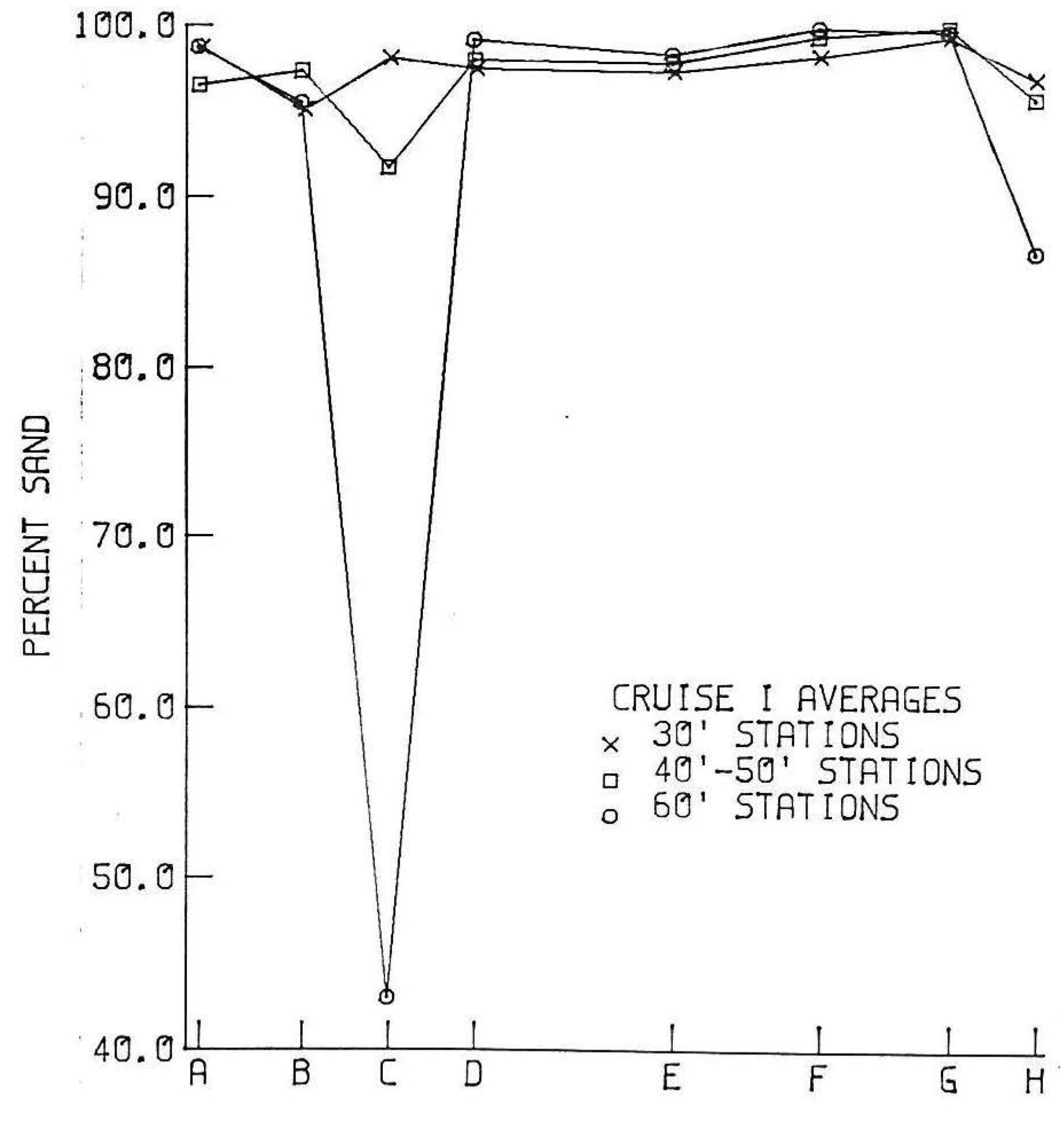
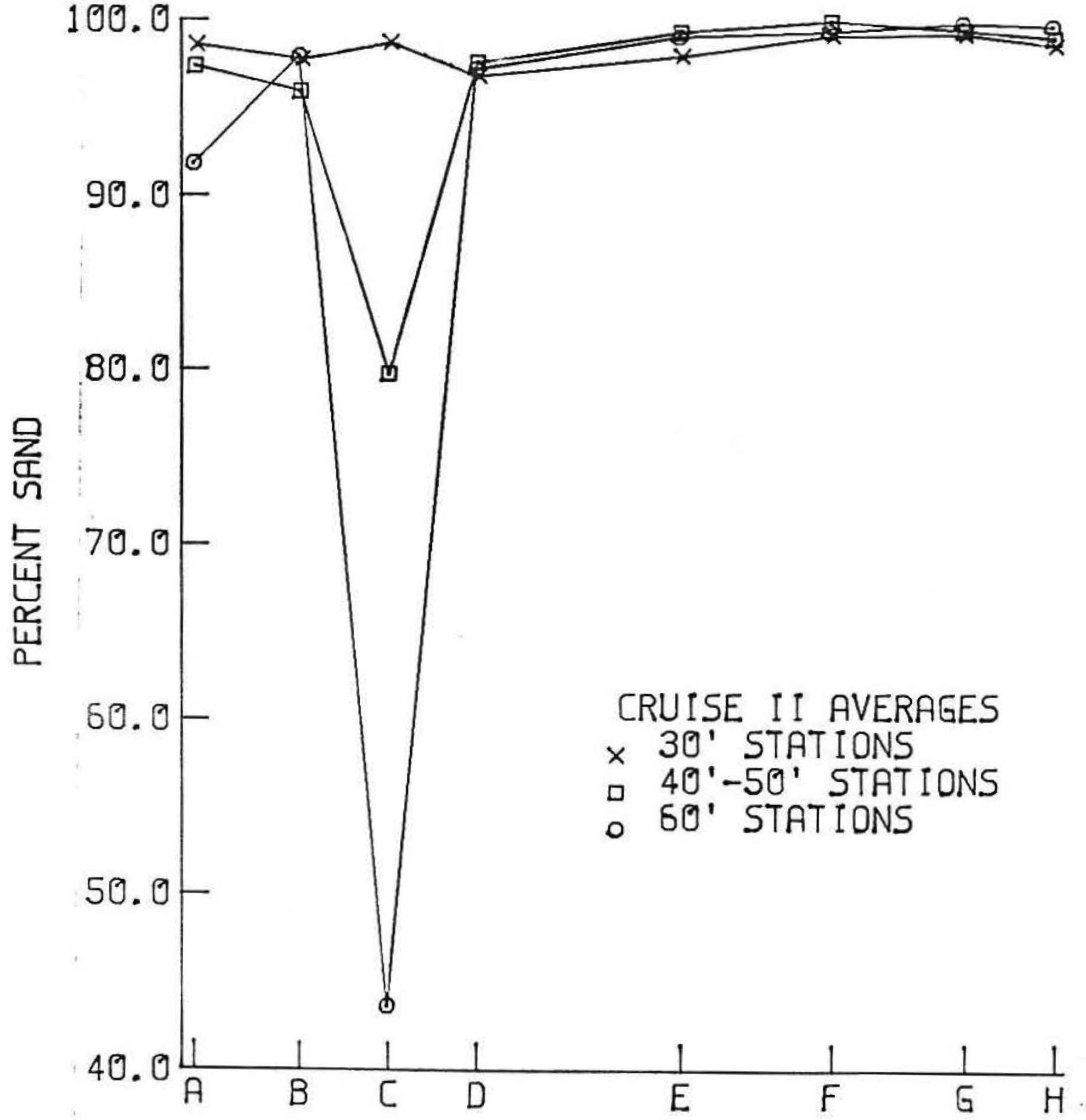

PERCENT SAND
100.0
90.0
80.0
70.0
60.0
50.0
40.0
A
B
C
D
E
F
G
H
CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS

Figure 21



100.0
90.0
80.0
70.0
60.0
50.0
40.0
PERCENT SAND
A
B
C
D
E
F
G
H
CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS

Figure 22

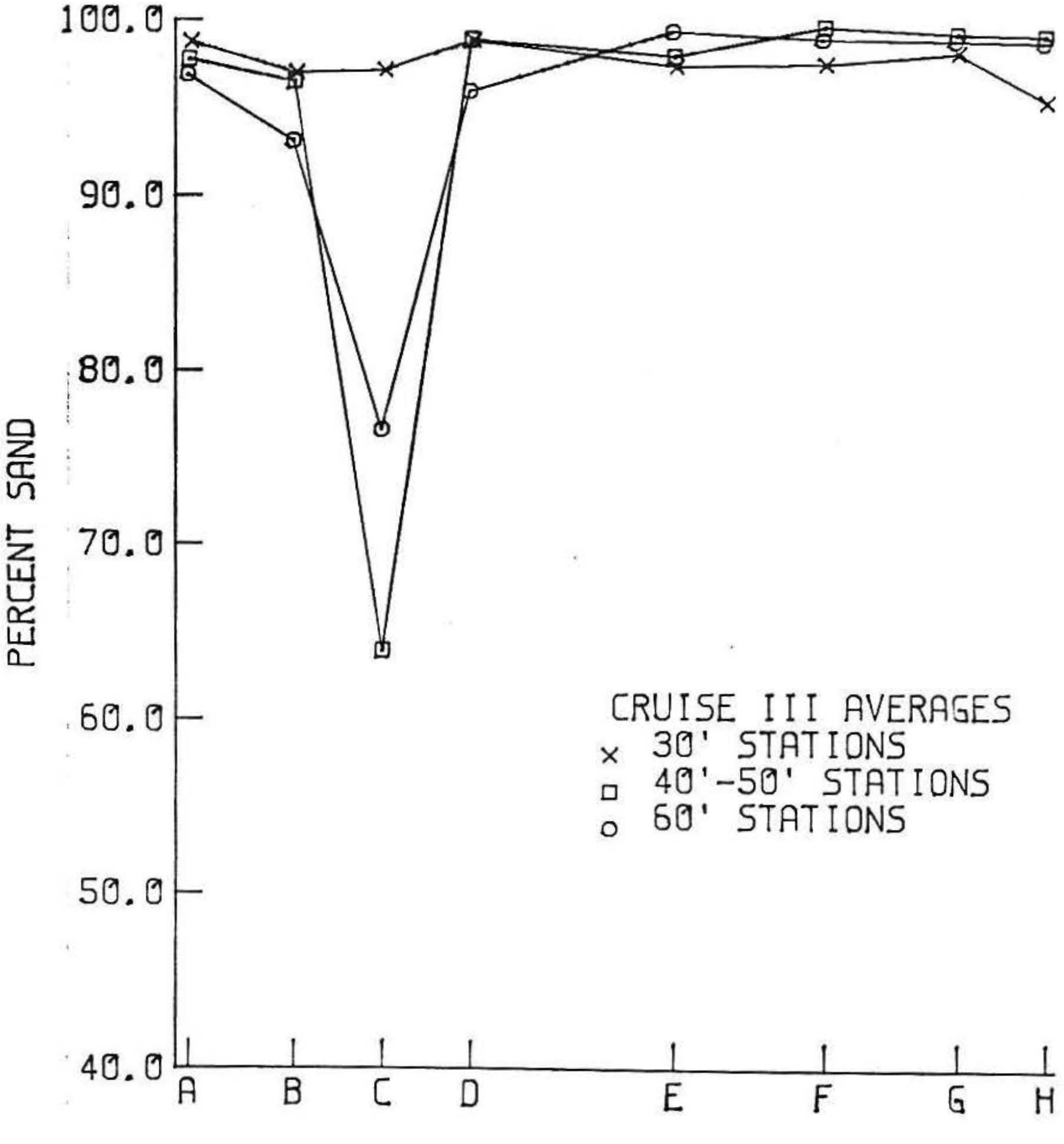

100.0
90.0
80.0
70.0
60.0
50.0
40.0
PERCENT SAND
A
B
C
D
E
F
G
H
CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS

Figure 23

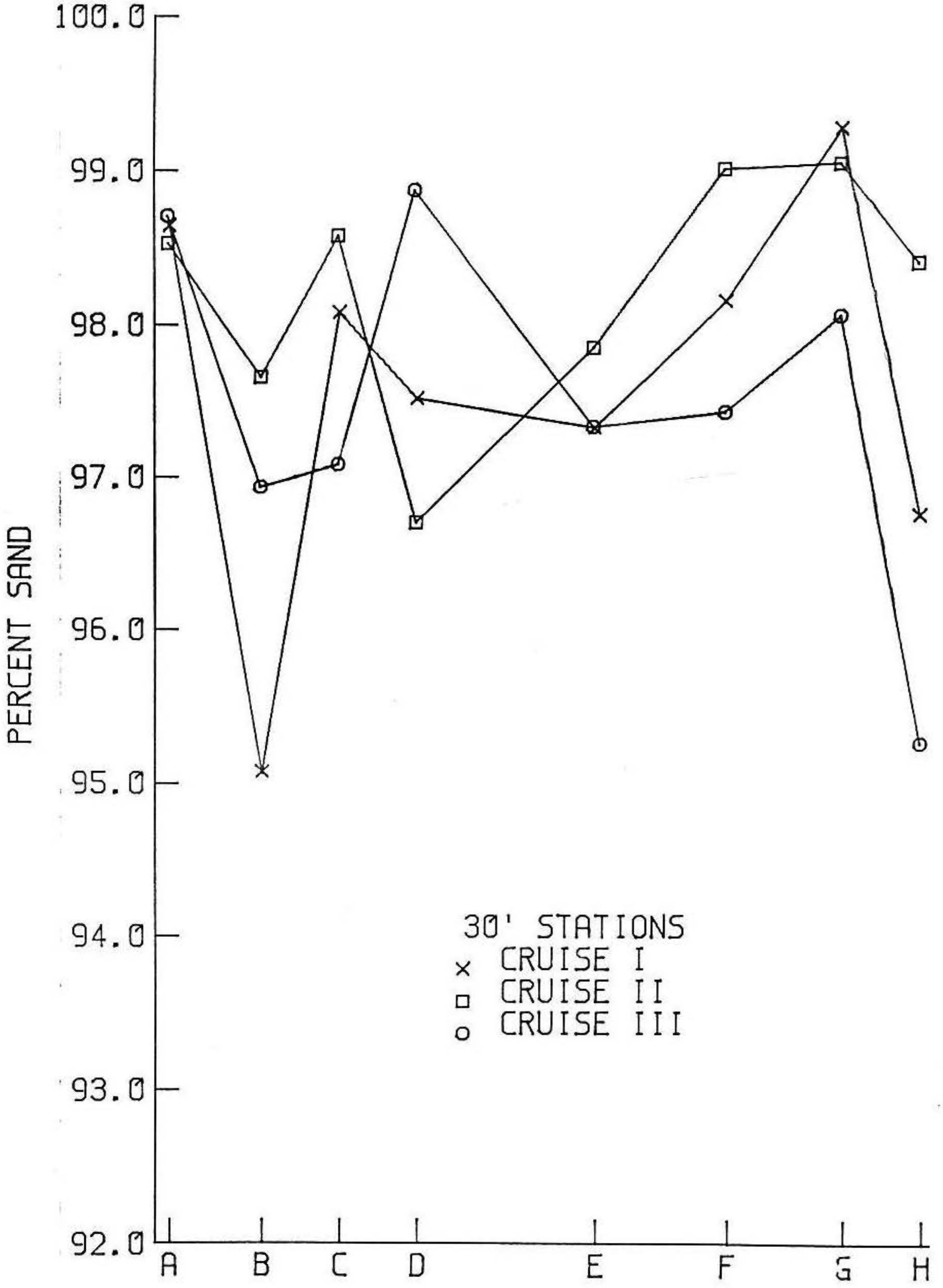

100.0
99.0
98.0
97.0
96.0
95.0
94.0
93.0
92.0
PERCENT SAND
A
B
C
D
E
F
G
H
30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 24

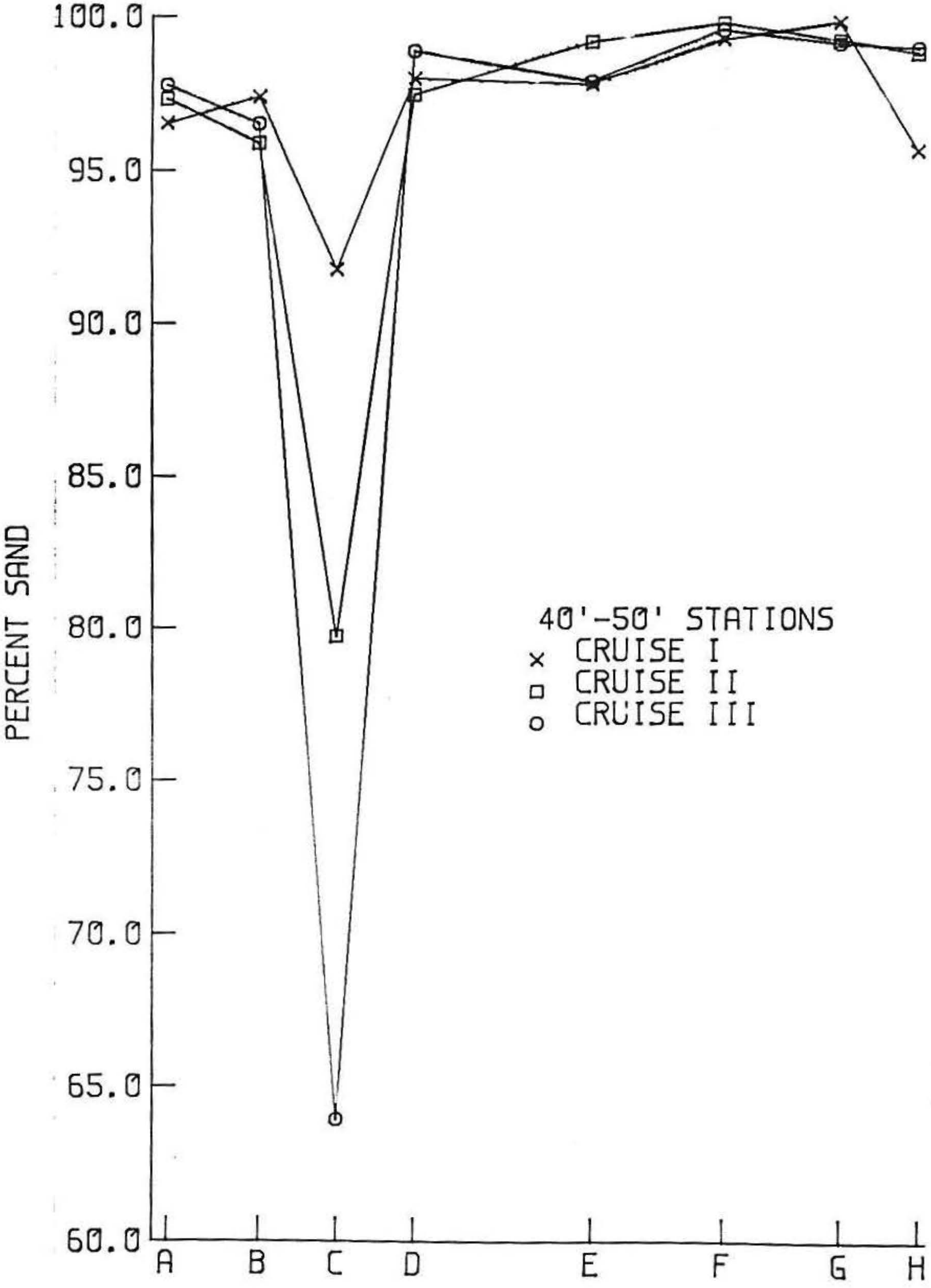
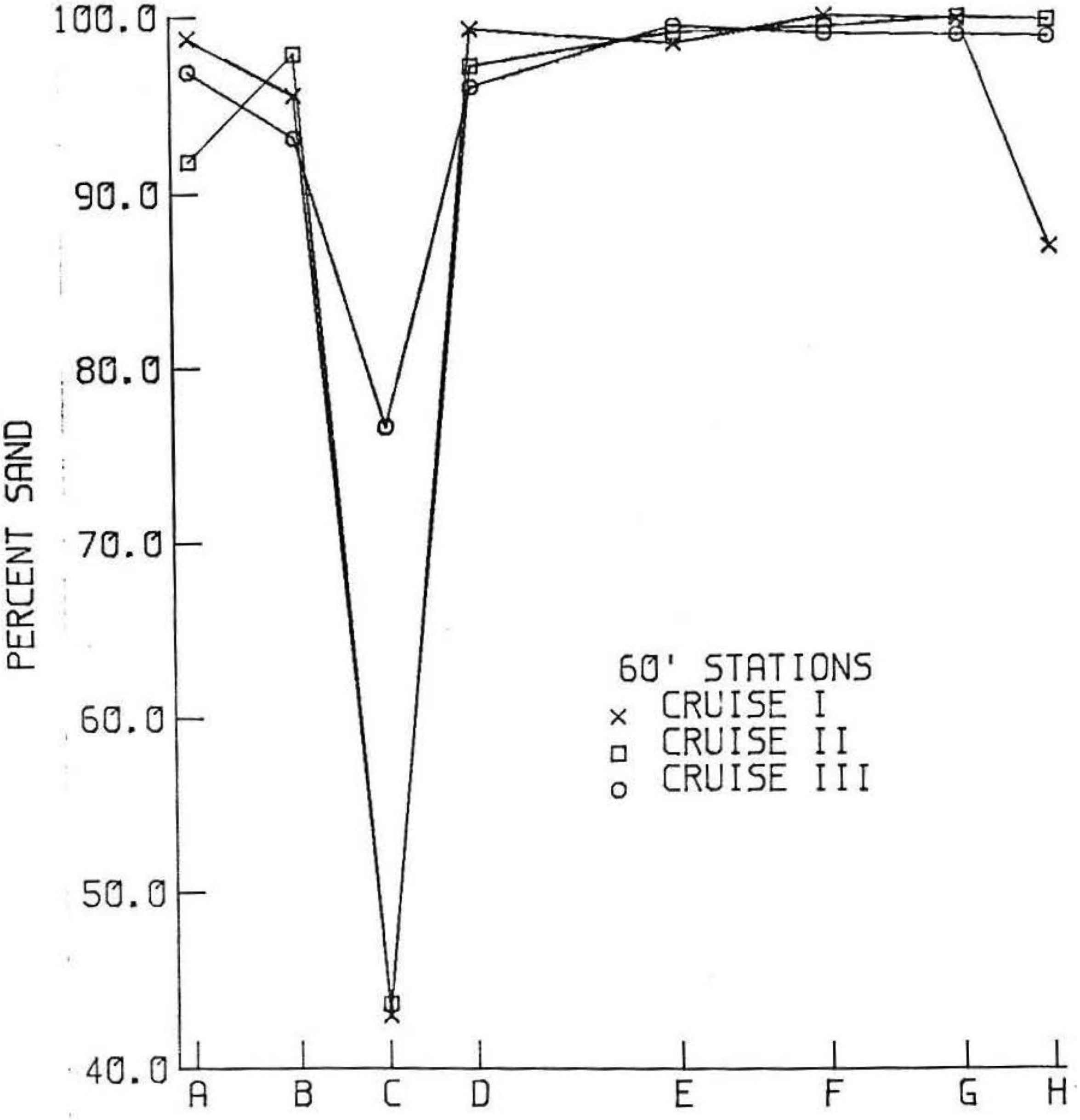

100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
PERCENT SAND
A
B
C
D
E
F
G
H
40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 25


100.0
90.0
80.0
70.0
60.0
50.0
40.0
PERCENT SAND
A
B
C
D
E
F
G
H
60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

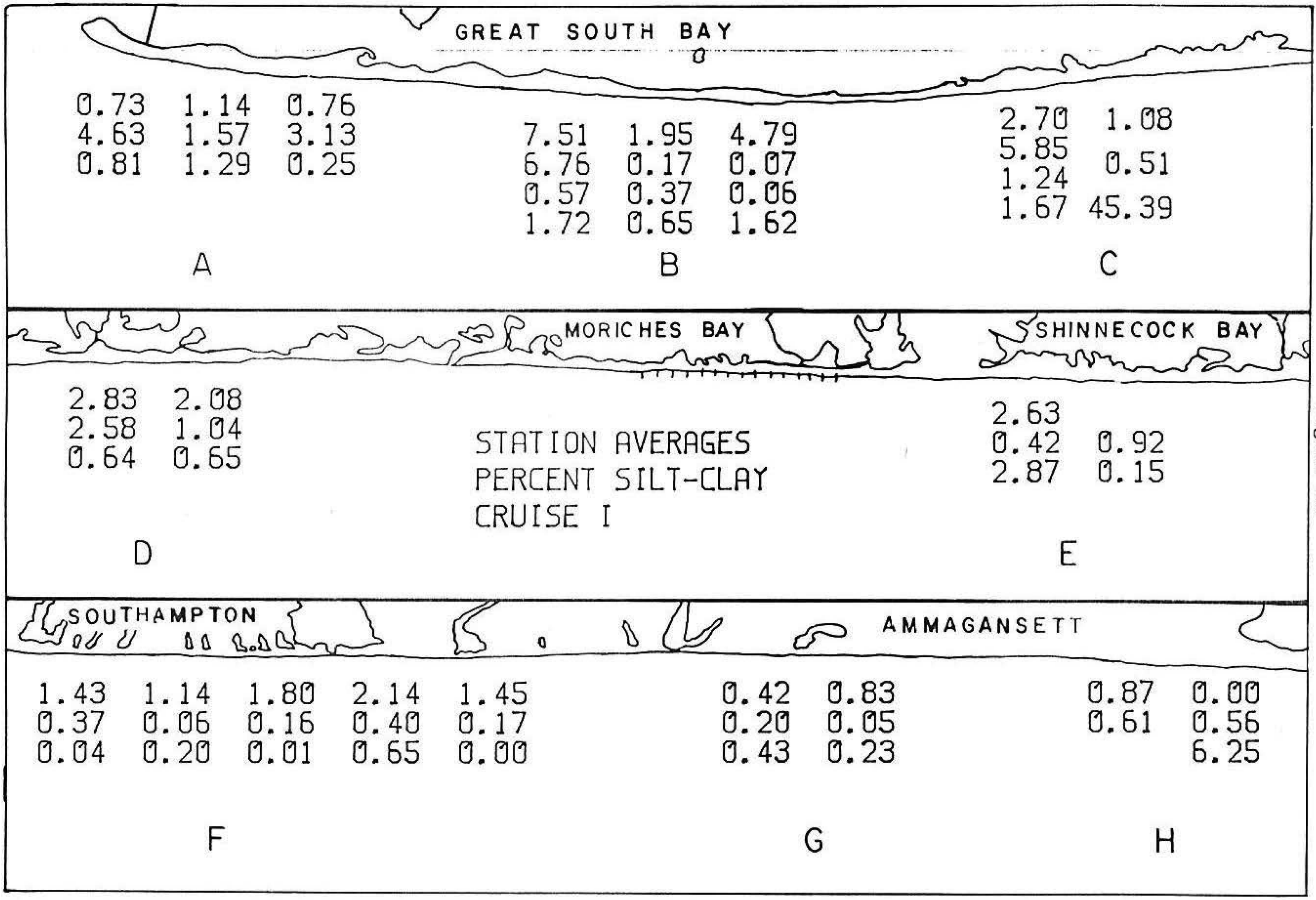

GREAT SOUTH BAY
0.73 1.14 0.76
4.63 1.57 3.13
0.81 1.29 0.25
A
7.51 1.95 4.79
6.76 0.17 0.07
0.57 0.37 0.06
1.72 0.65 1.62
B
2.70 1.08
5.85
1.24 0.51
1.67 45.39
C
MORICHES BAY
SHINNECOCK BAY
2.83 2.08
2.58 1.04
0.64 0.65
D
STATION AVERAGES
PERCENT SILT-CLAY
CRUISE I
2.63
0.42 0.92
2.87 0.15
E
SOUTHAMPTON
AMMAGANSETT
1.43 1.14 1.80 2.14 1.45
0.37 0.06 0.16 0.40 0.17
0.04 0.20 0.01 0.65 0.00
F
0.42 0.83
0.20 0.05
0.43 0.23
G
0.87 0.00
0.61 0.56
6.25
H

Figure 26

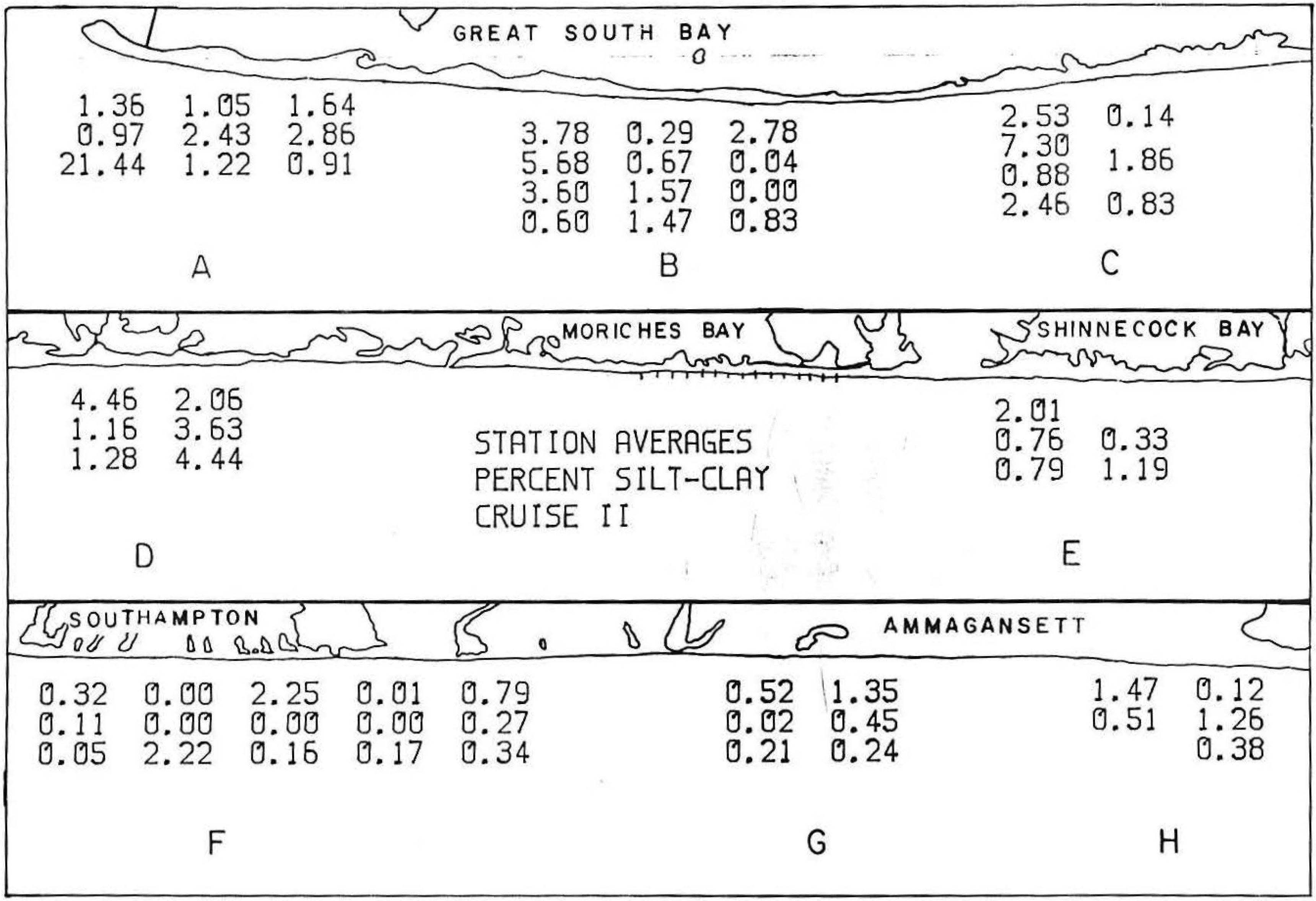

GREAT SOUTH BAY
1.36 1.05 1.64
0.97 2.43 2.86
21.44 1.22 0.91
A
3.78 0.29 2.78
5.68 0.67 0.04
3.60 1.57 0.00
0.60 1.47 0.83
B
2.53 0.14
7.30 1.86
0.88
2.46 0.83
C
MORICHES BAY
SHINNECOCK BAY
4.46 2.06
1.16 3.63
1.28 4.44
D
STATION AVERAGES
PERCENT SILT-CLAY
CRUISE II
2.01
0.76 0.33
0.79 1.19
E
SOUTHAMPTON
AMMAGANSETT
0.32 0.00 2.25 0.01 0.79
0.11 0.00 0.00 0.00 0.27
0.05 2.22 0.16 0.17 0.34
F
0.52 1.35
0.02 0.45
0.21 0.24
G
1.47 0.12
0.51 1.26
0.38
H

Figure 27

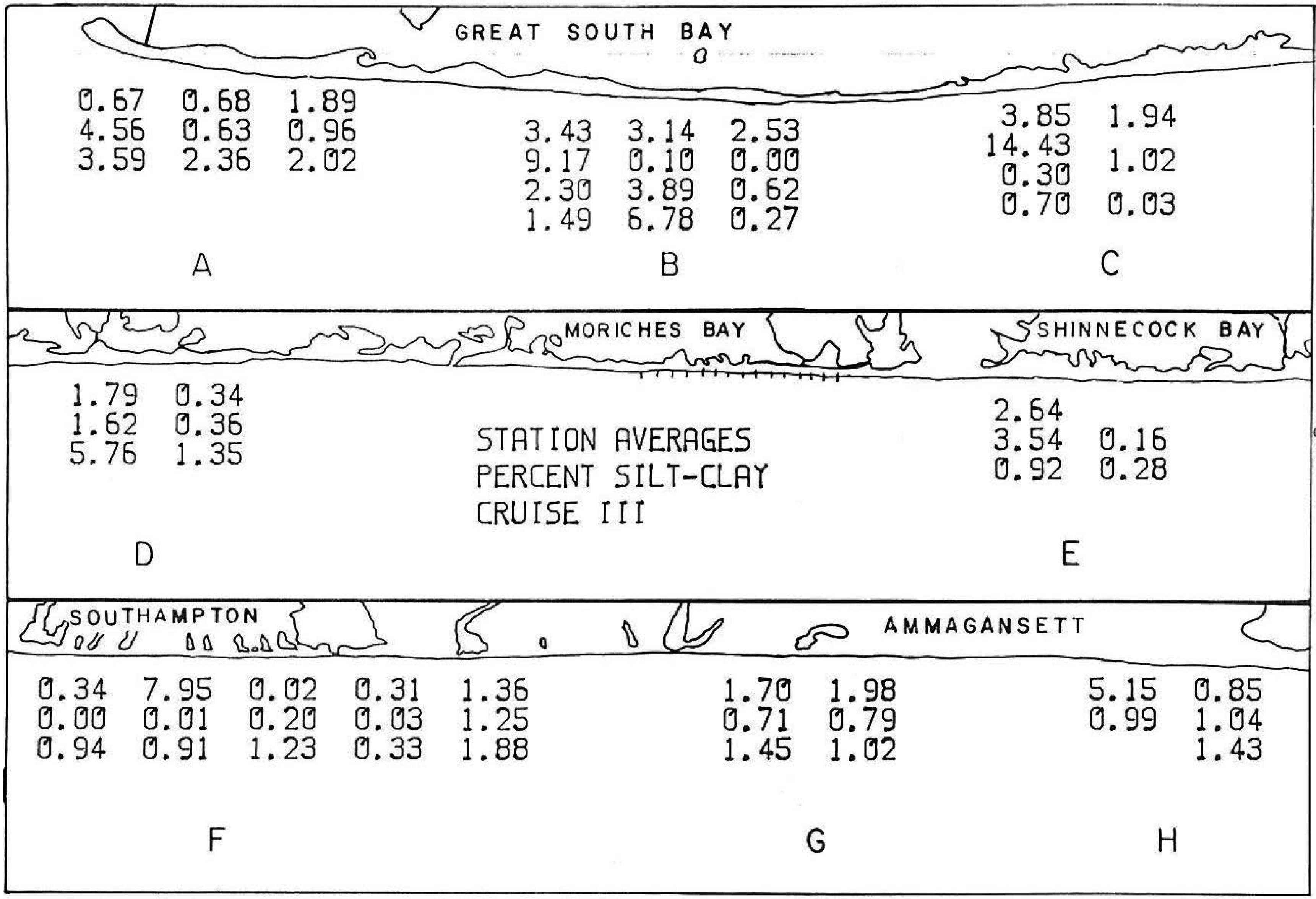

GREAT SOUTH BAY
0.67 0.68 1.89
4.56 0.63 0.96
3.59 2.36 2.02
A
3.43 3.14 2.53
9.17 0.10 0.00
2.30 3.89 0.62
1.49 6.78 0.27
B
3.85 1.94
14.43
1.02
0.30
0.70 0.03
C
MORICHES BAY
SHINNECOCK BAY
1.79 0.34
1.62 0.36
5.76 1.35
D
STATION AVERAGES
PERCENT SILT-CLAY
CRUISE III
2.64
3.54 0.16
0.92 0.28
E
SOUTHAMPTON
AMMAGANSETT
0.34 7.95 0.02 0.31 1.36
0.00 0.01 0.20 0.03 1.25
0.94 0.91 1.23 0.33 1.88
F
1.70 1.98
0.71 0.79
1.45 1.02
G
5.15 0.85
0.99 1.04
1.43
H

Figure 28

Figure 29

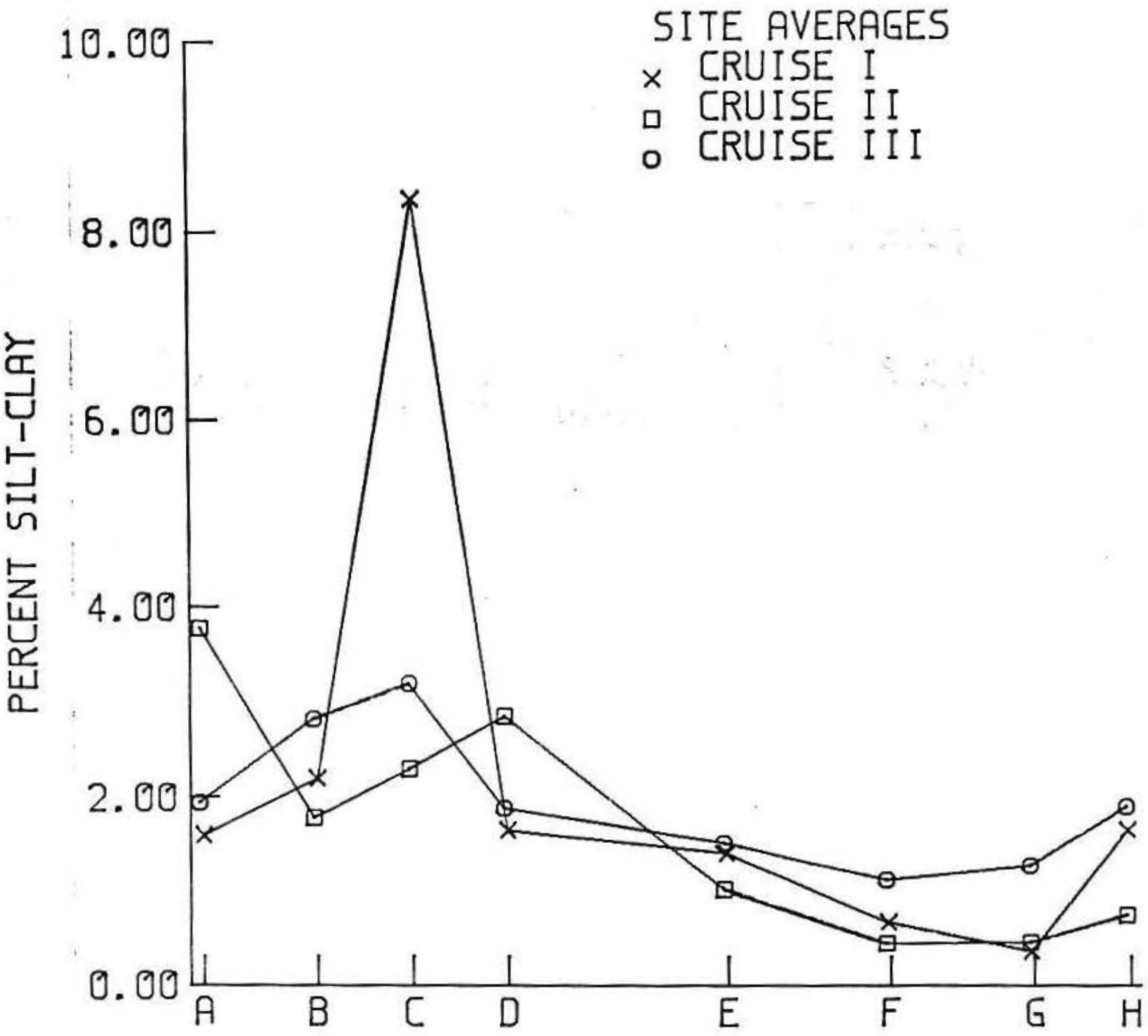

SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
PERCENT SILT-CLAY
10.00
8.00
6.00
4.00
2.00
0.00
A
B
C
D
E
F
G
H

Figure 30

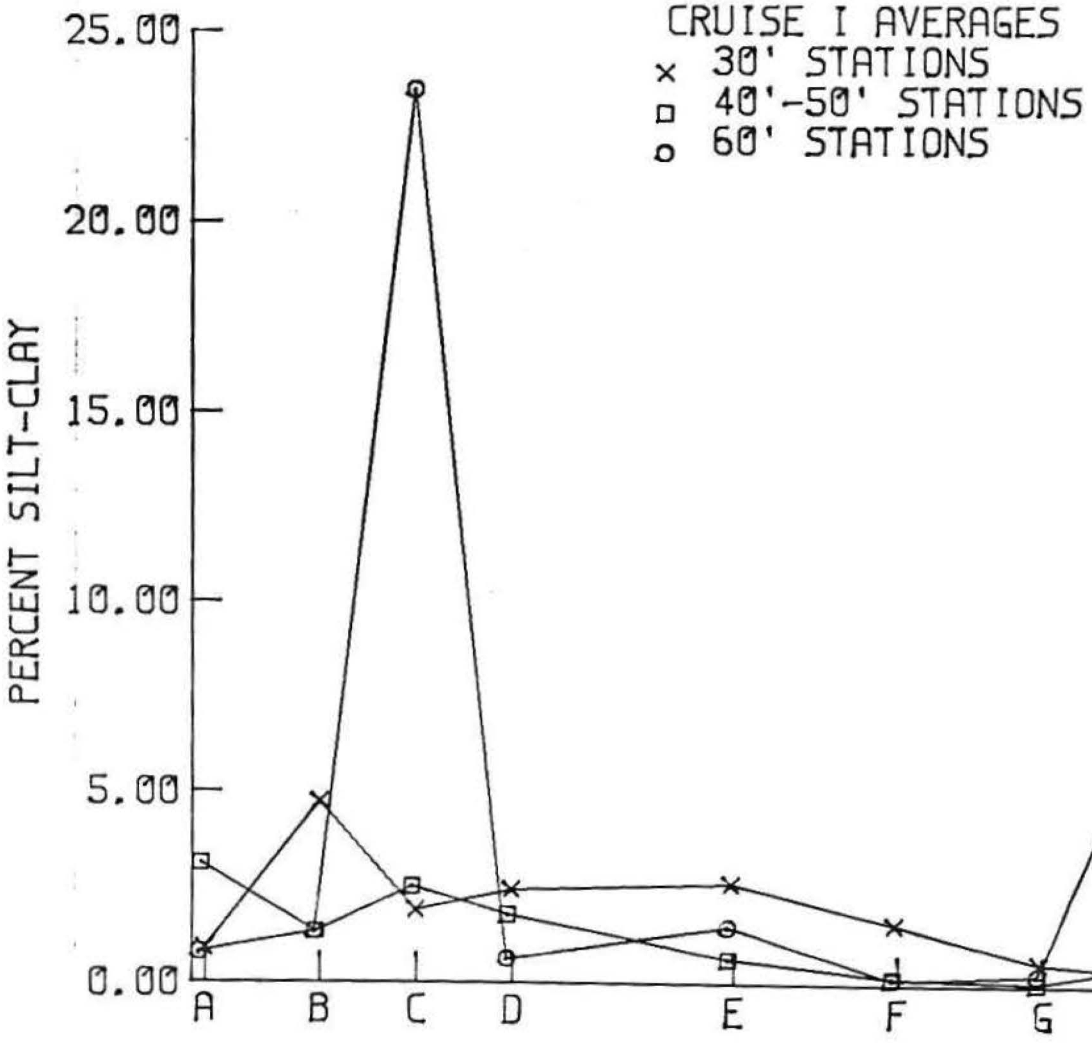

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
PERCENT SILT-CLAY
25.00
20.00
15.00
10.00
5.00
0.00
A
B
C
D
E
F
G
H

Figure 31

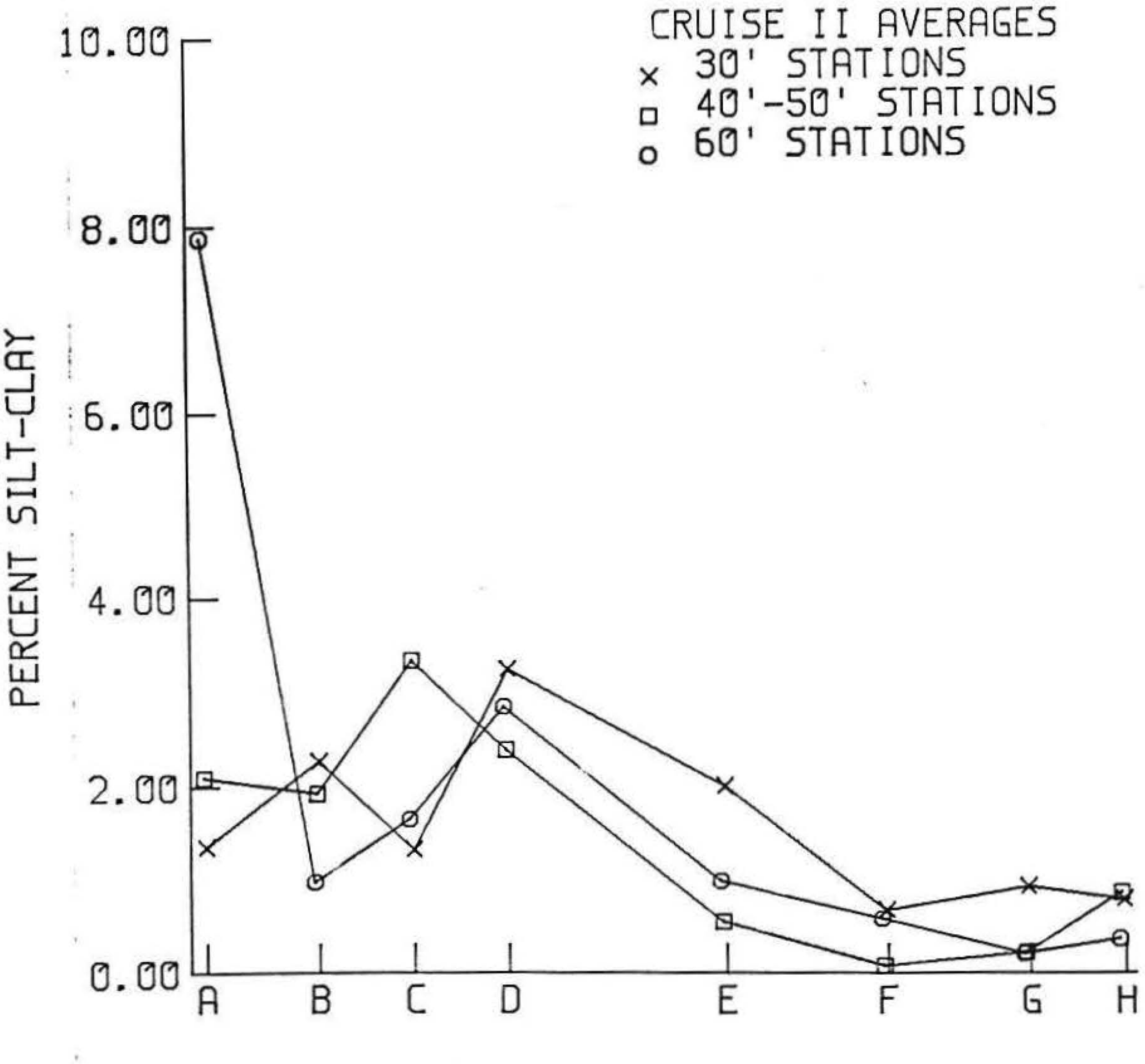

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
10.00
8.00
6.00
4.00
2.00
0.00
PERCENT SILT-CLAY
A
B
C
D
E
F
G
H

Figure 32

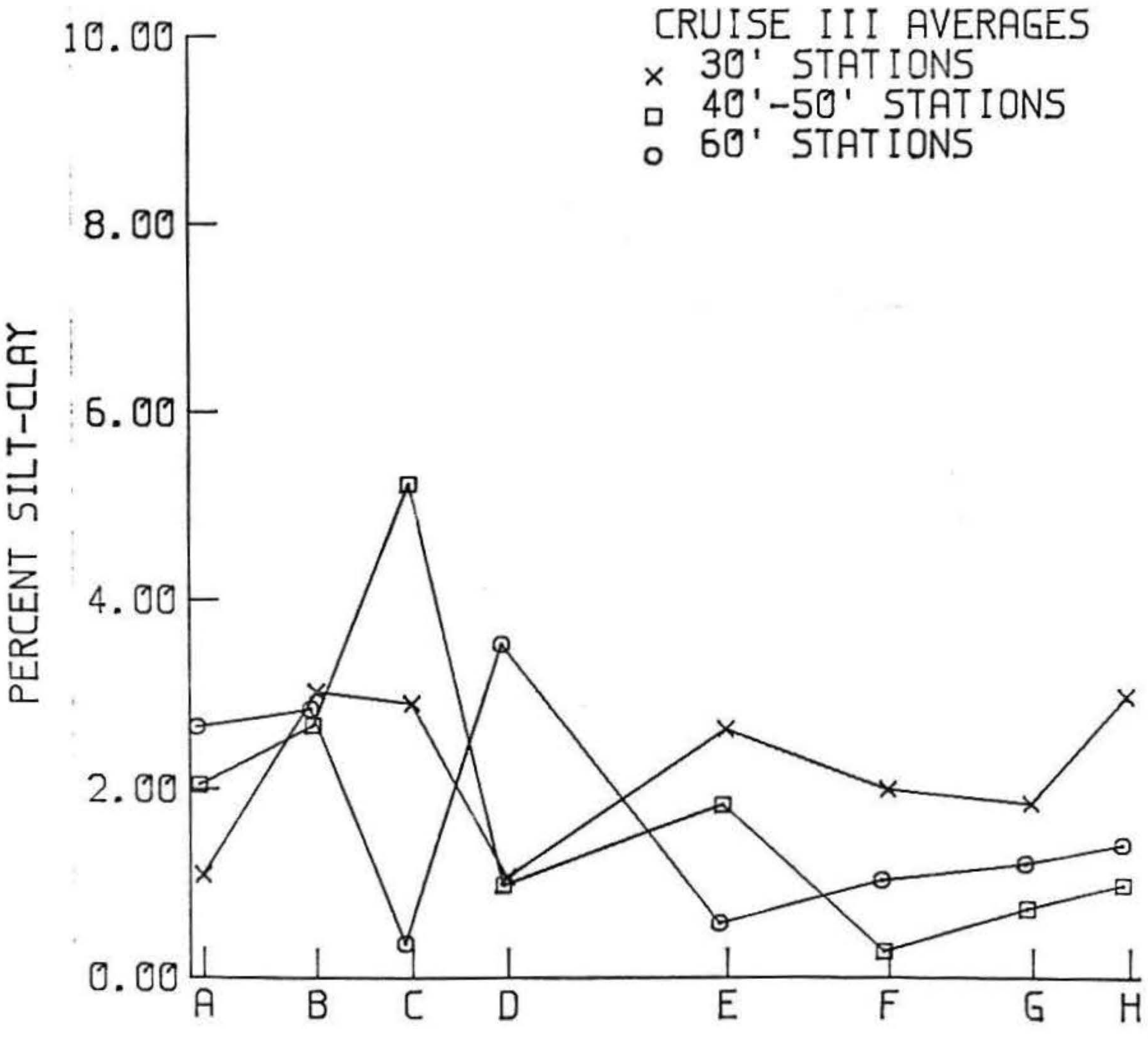

CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
PERCENT SILT-CLAY
10.00
8.00
6.00
4.00
2.00
0.00
A
B
C
D
E
F
G
H

Figure 33

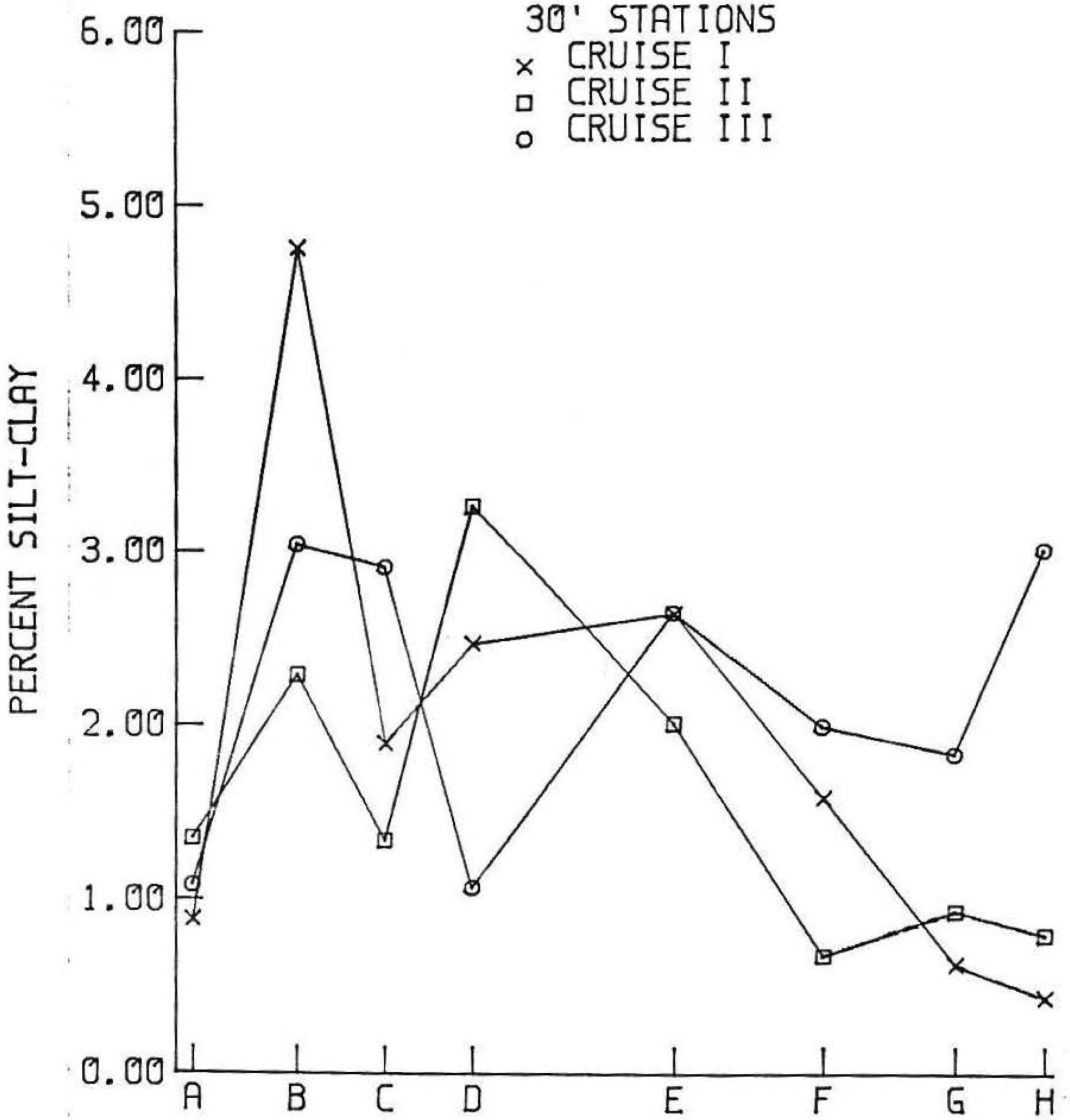

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
PERCENT SILT-CLAY
6.00
5.00
4.00
3.00
2.00
1.00
0.00
A
B
C
D
E
F
G
H

Figure 34

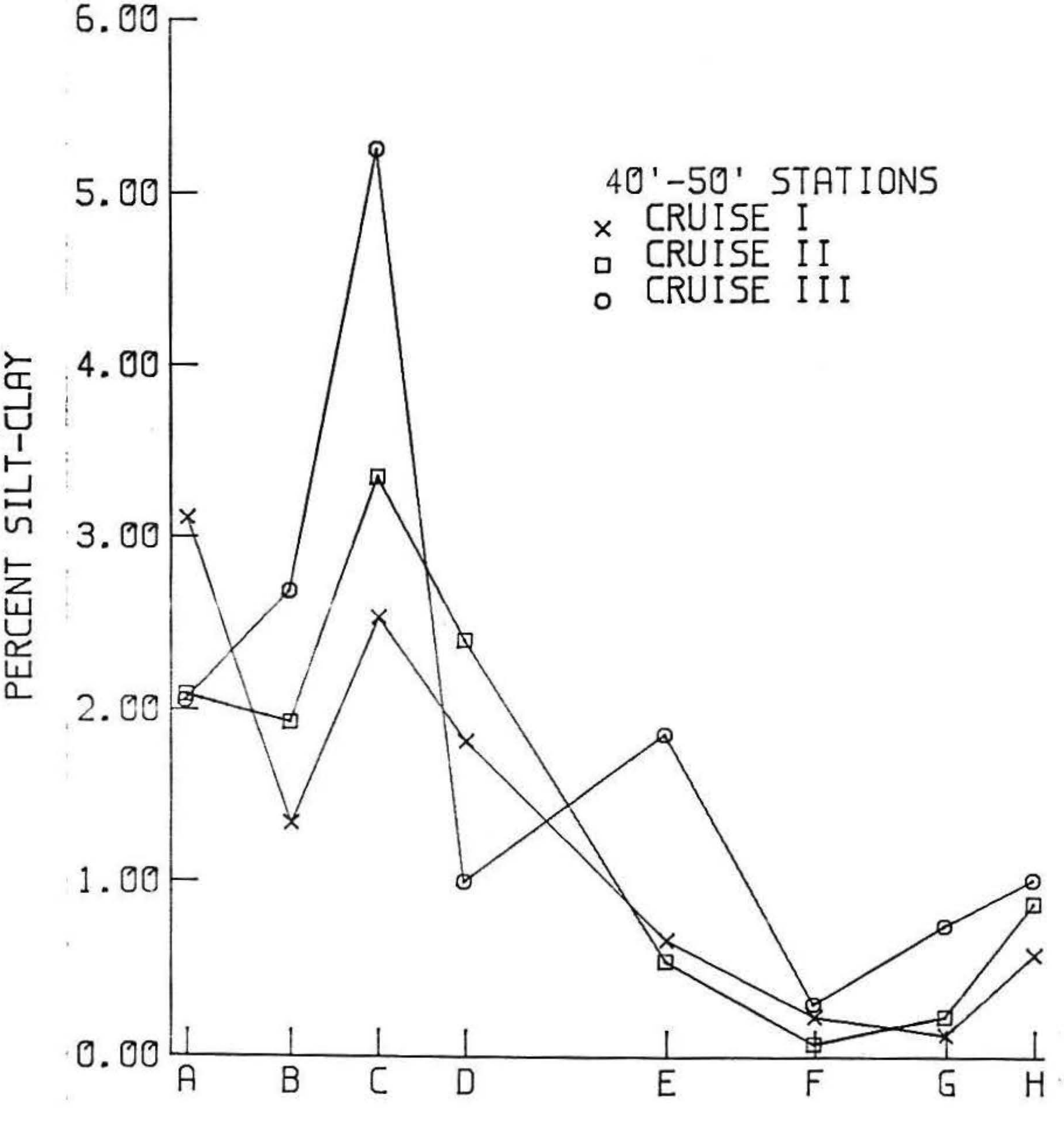
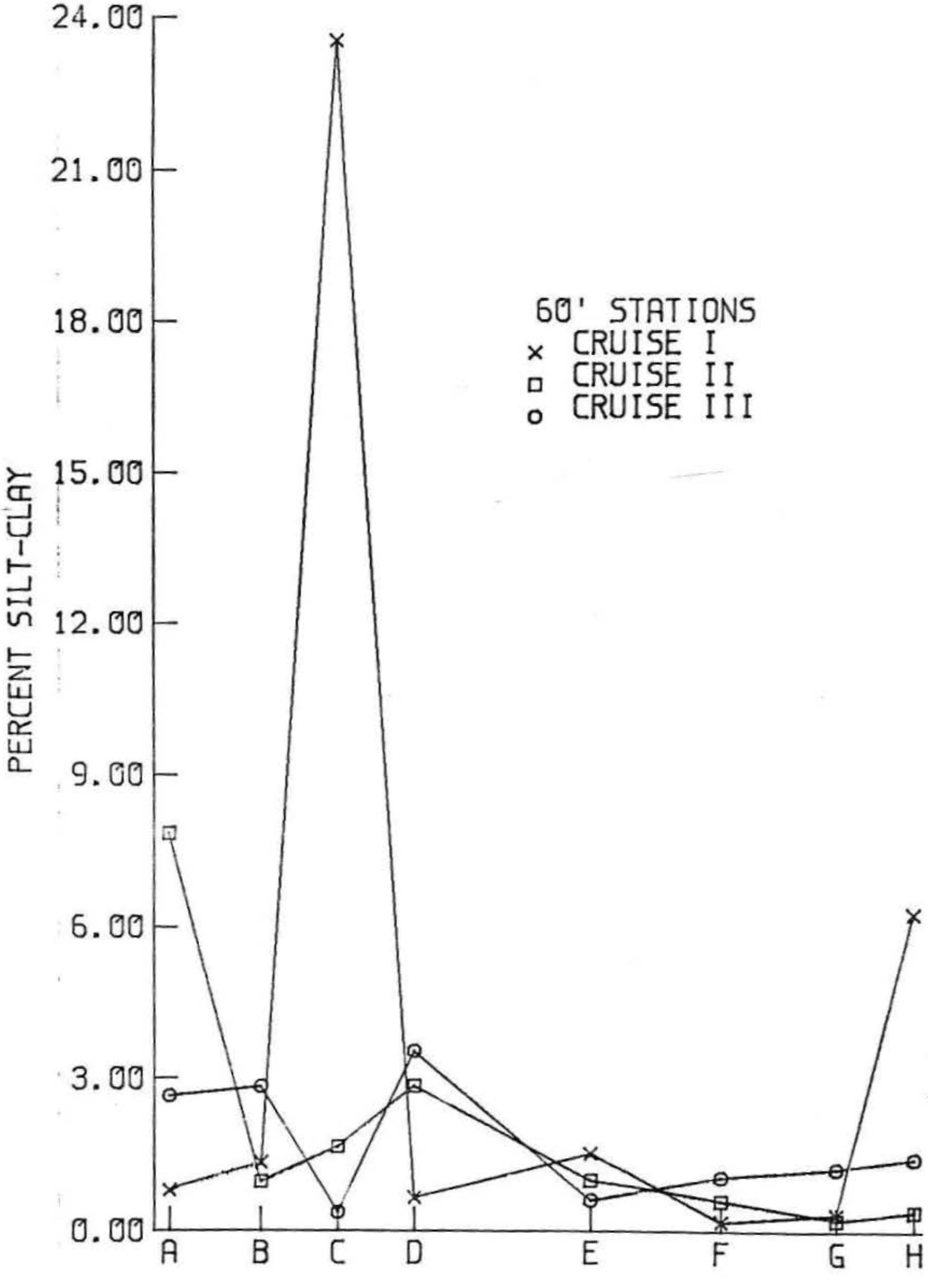

6.00
5.00
4.00
3.00
2.00
1.00
0.00
PERCENT SILT-CLAY
A
B
C
D
E
F
G
H
40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 35


24.00
21.00
18.00
15.00
12.00
9.00
6.00
3.00
0.00
PERCENT SILT-CLAY
60' STATIONS
× CRUISE I
□ CRUISE II
o CRUISE III
A
B
C
D
E
F
G
H

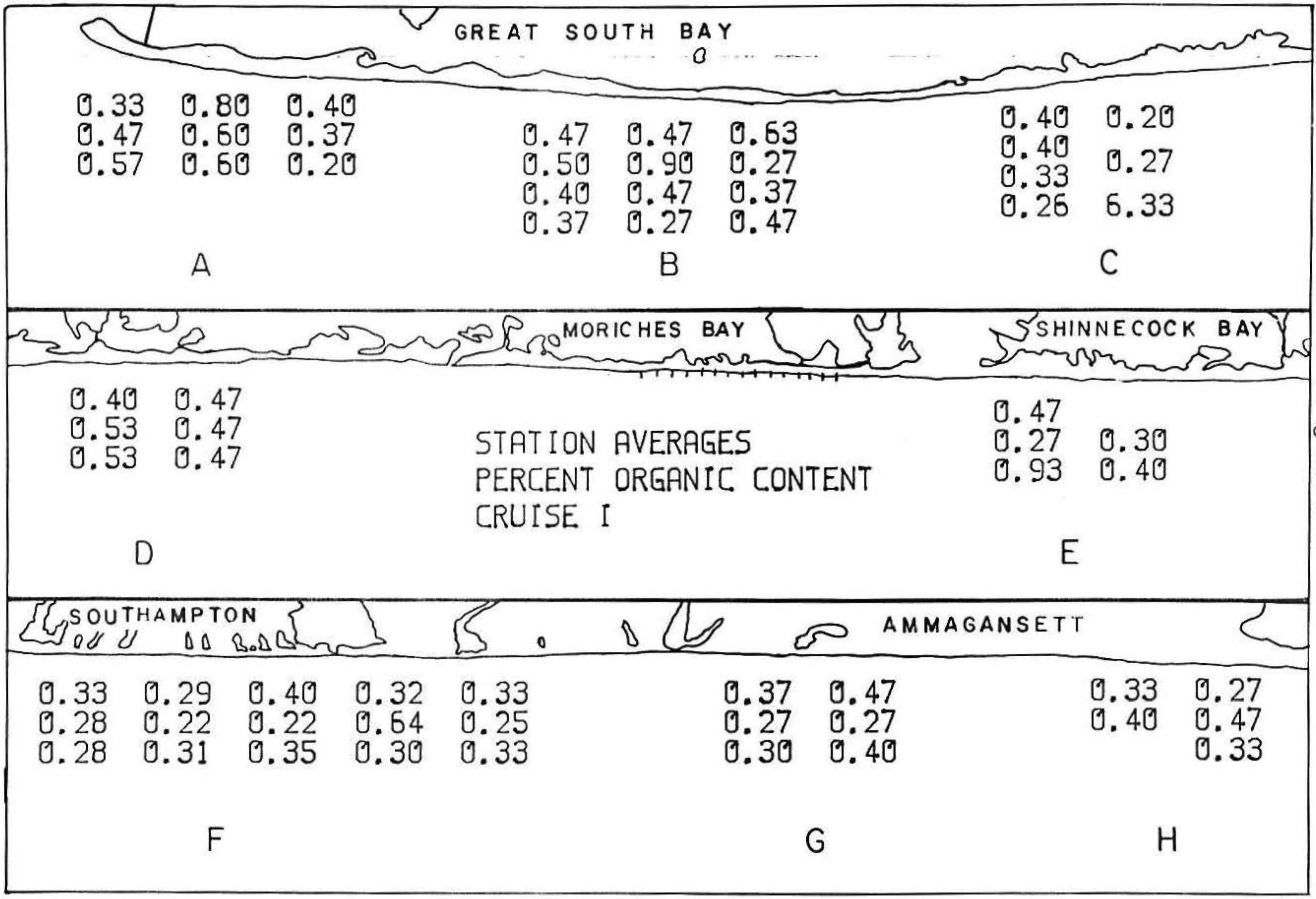

GREAT SOUTH BAY
0.33 0.80 0.40
0.47 0.60 0.37
0.57 0.60 0.20
A
0.47 0.47 0.63
0.50 0.90 0.27
0.40 0.47 0.37
0.37 0.27 0.47
B
0.40 0.20
0.40 0.27
0.33
0.26 6.33
C
MORICHES BAY
SHINNECOCK BAY
0.40 0.47
0.53 0.47
0.53 0.47
D
STATION AVERAGES
PERCENT ORGANIC CONTENT
CRUISE I
0.47
0.27 0.30
0.93 0.40
E
SOUTHAMPTON
AMMAGANSETT
0.33 0.29 0.40 0.32 0.33
0.28 0.22 0.22 0.64 0.25
0.28 0.31 0.35 0.30 0.33
F
0.37 0.47
0.27 0.27
0.30 0.40
G
0.33 0.27
0.40 0.47
0.33
H

Figure 36

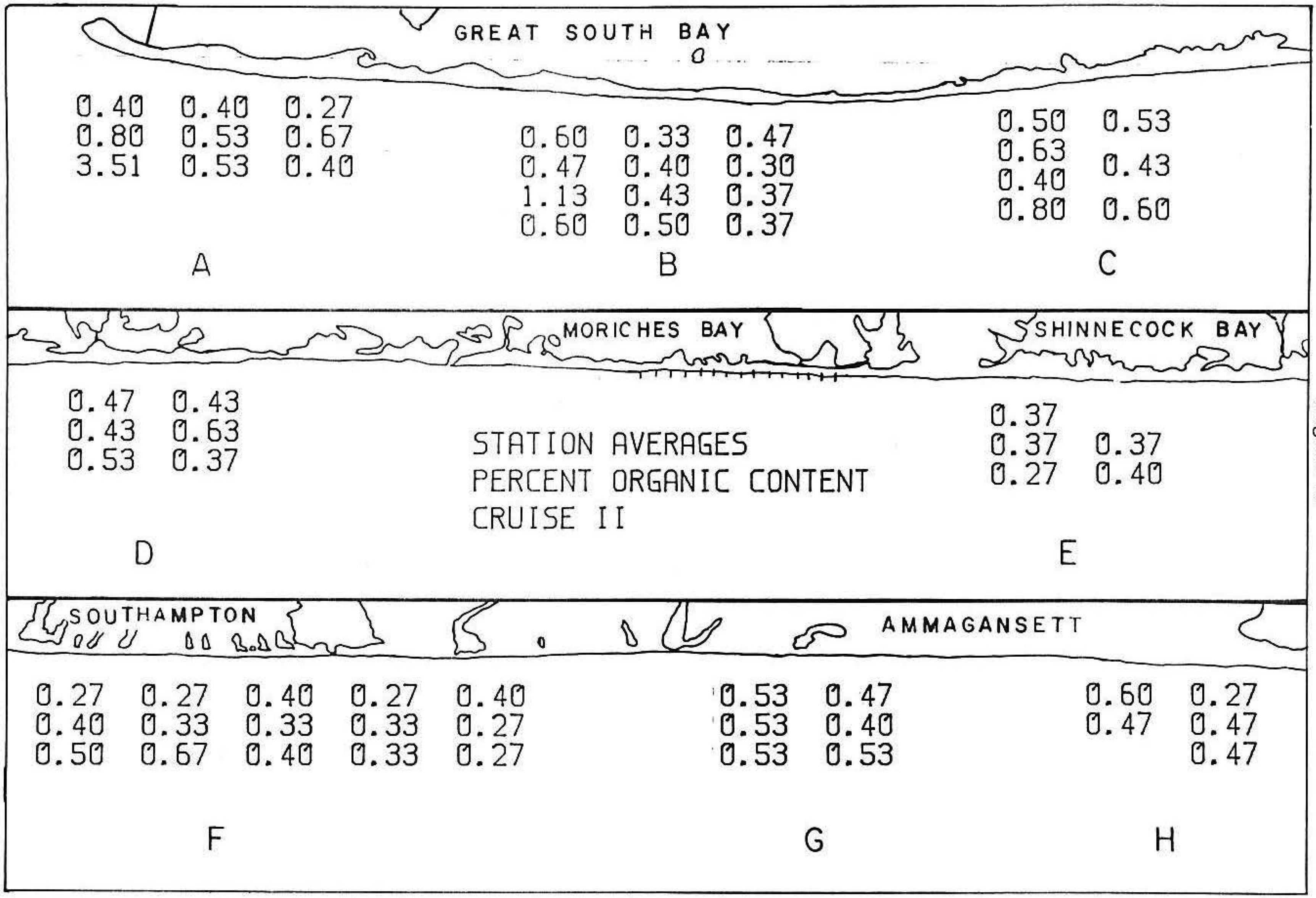

GREAT SOUTH BAY
0.40 0.40 0.27
0.80 0.53 0.67
3.51 0.53 0.40
A
0.60 0.33 0.47
0.47 0.40 0.30
1.13 0.43 0.37
0.60 0.50 0.37
B
0.50 0.53
0.63
0.40 0.43
0.80 0.60
C
MORICHES BAY
SHINNECOCK BAY
0.47 0.43
0.43 0.63
0.53 0.37
D
STATION AVERAGES
PERCENT ORGANIC CONTENT
CRUISE II
0.37
0.37 0.37
0.27 0.40
E
SOUTHAMPTON
AMMAGANSETT
0.27 0.27 0.40 0.27 0.40
0.40 0.33 0.33 0.33 0.27
0.50 0.67 0.40 0.33 0.27
F
0.53 0.47
0.53 0.40
0.53 0.53
G
0.60 0.27
0.47 0.47
0.47
H

Figure 37

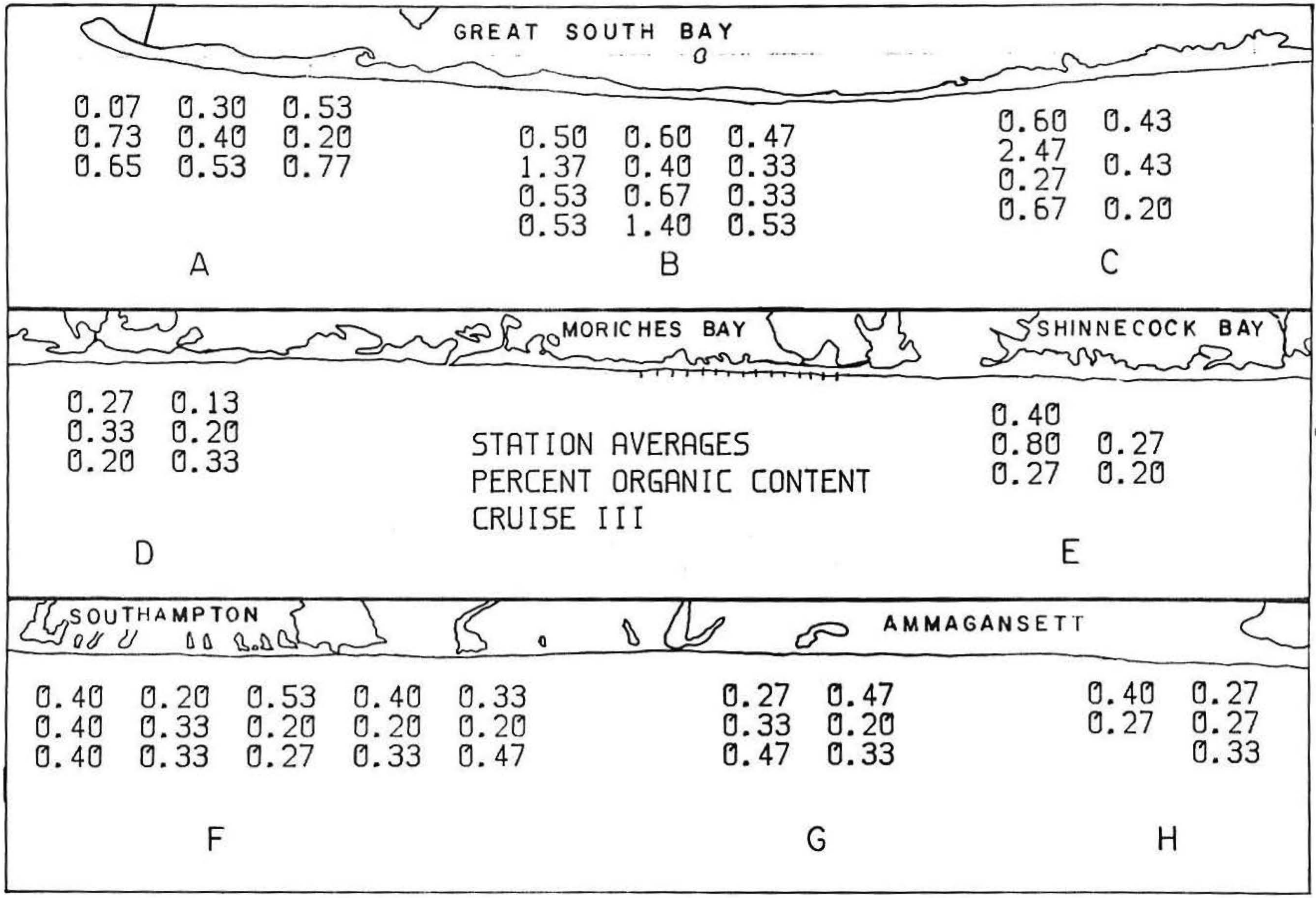

STATION AVERAGES
PERCENT ORGANIC CONTENT
CRUISE III

Figure 38

Figure 39

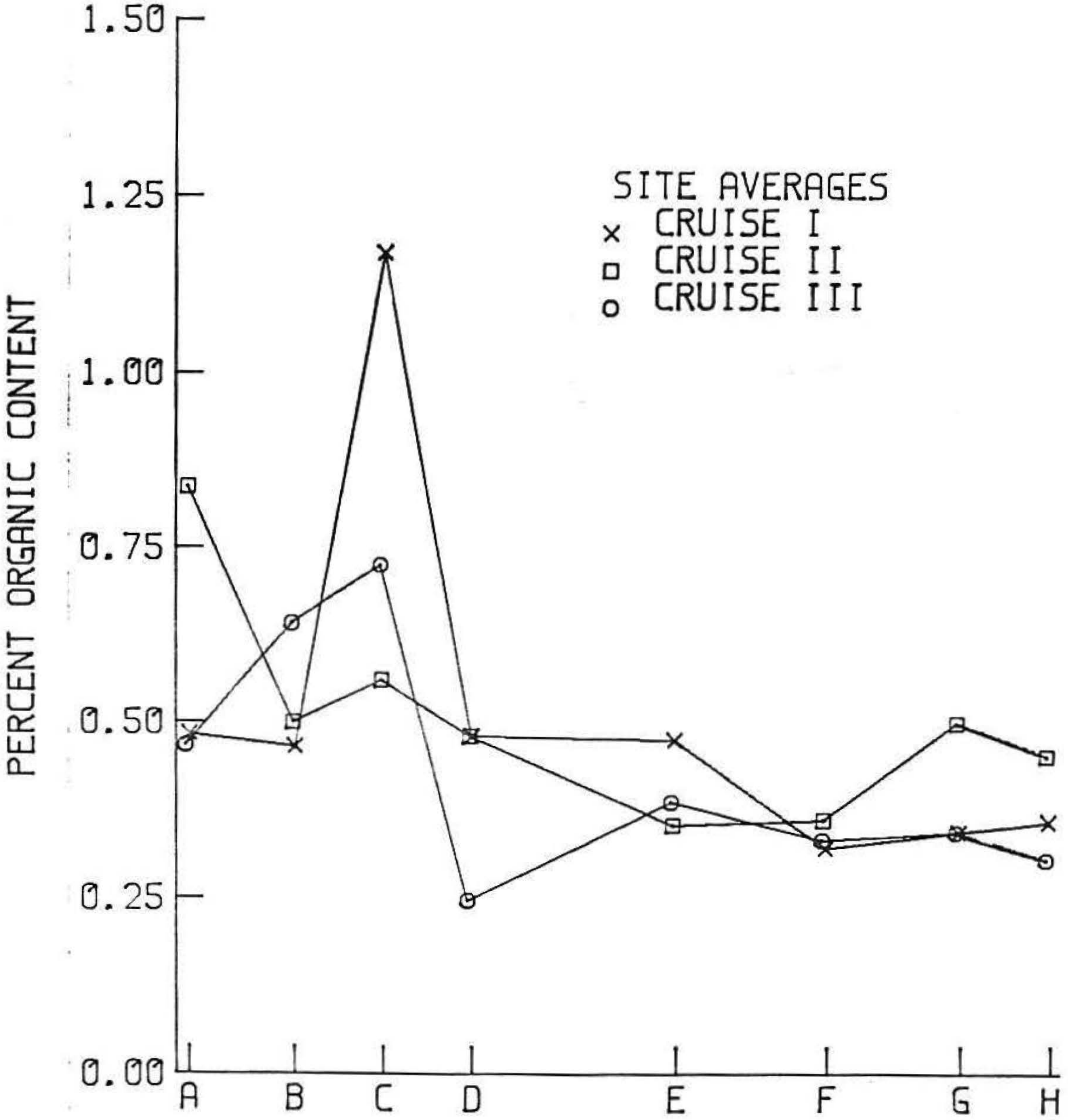

1.50
1.25
1.00
0.75
0.50
0.25
0.00
PERCENT ORGANIC CONTENT
SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
A
B
C
D
E
F
G
H

Figure 40

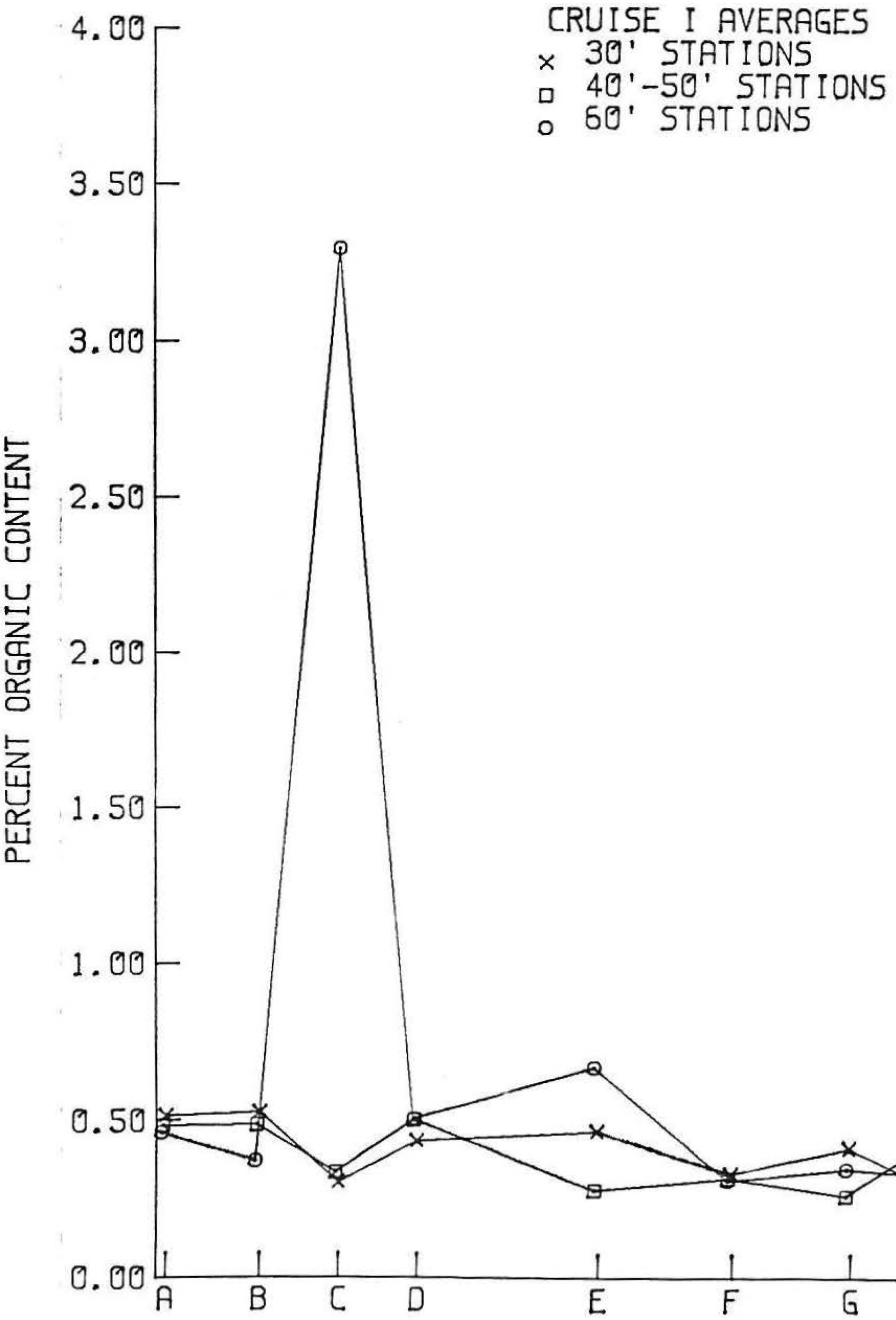

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
PERCENT ORGANIC CONTENT
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
A
B
C
D
E
F
G
H

Figure 41

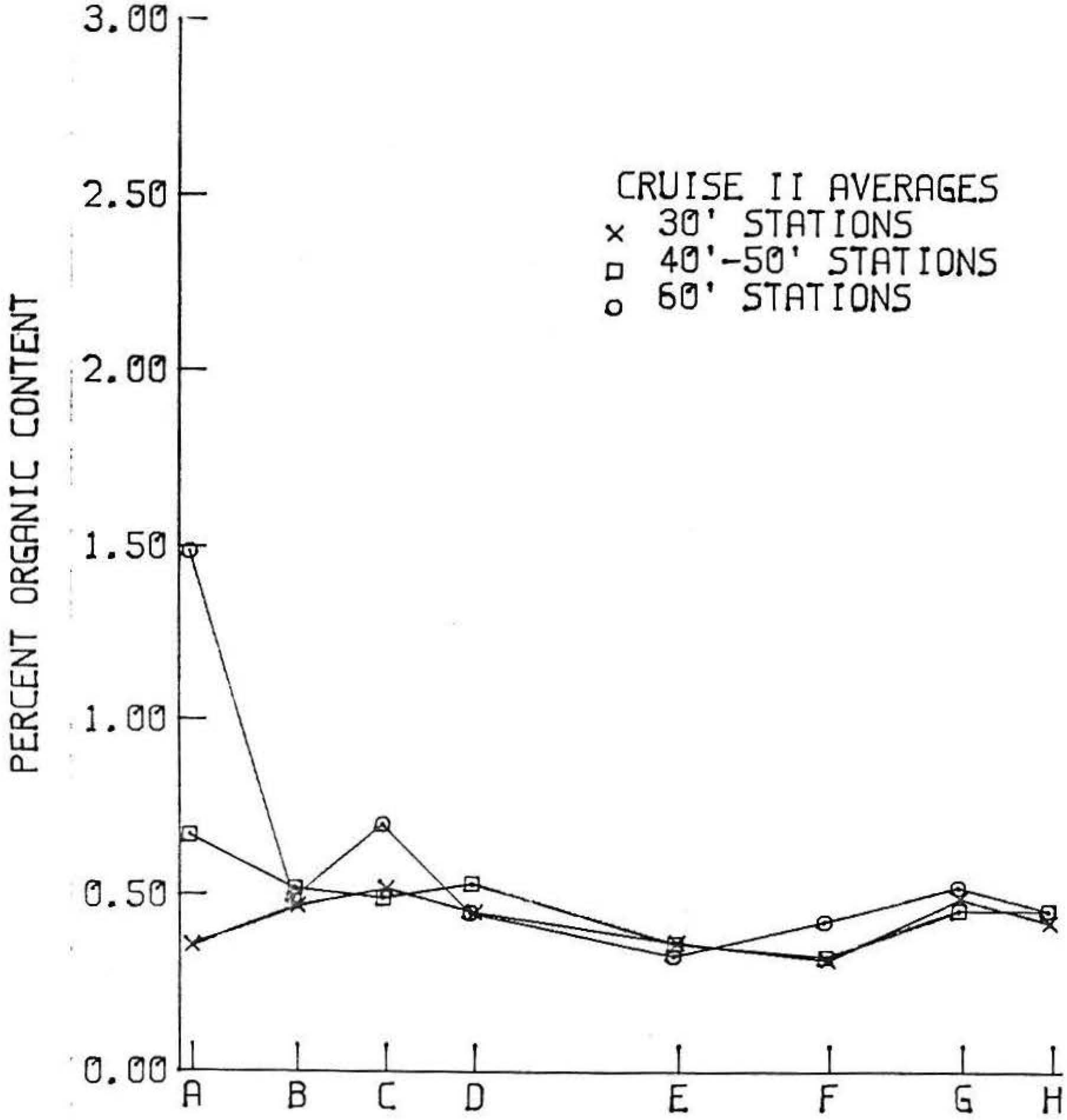

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
PERCENT ORGANIC CONTENT
3.00
2.50
2.00
1.50
1.00
0.50
0.00
A
B
C
D
E
F
G
H

Figure 42

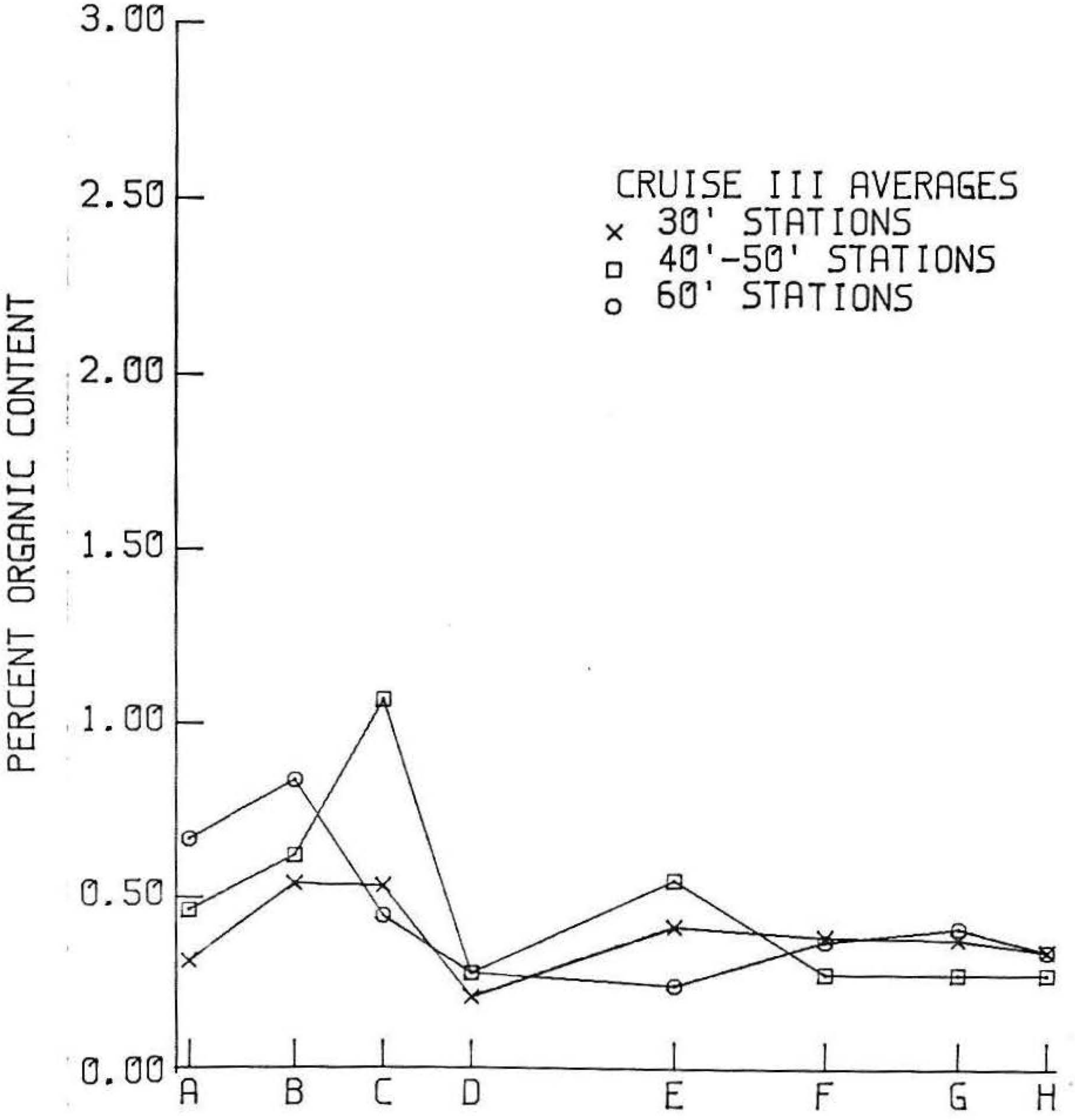

3.00
2.50
2.00
1.50
1.00
0.50
0.00
PERCENT ORGANIC CONTENT
CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
A
B
C
D
E
F
G
H

Figure 43

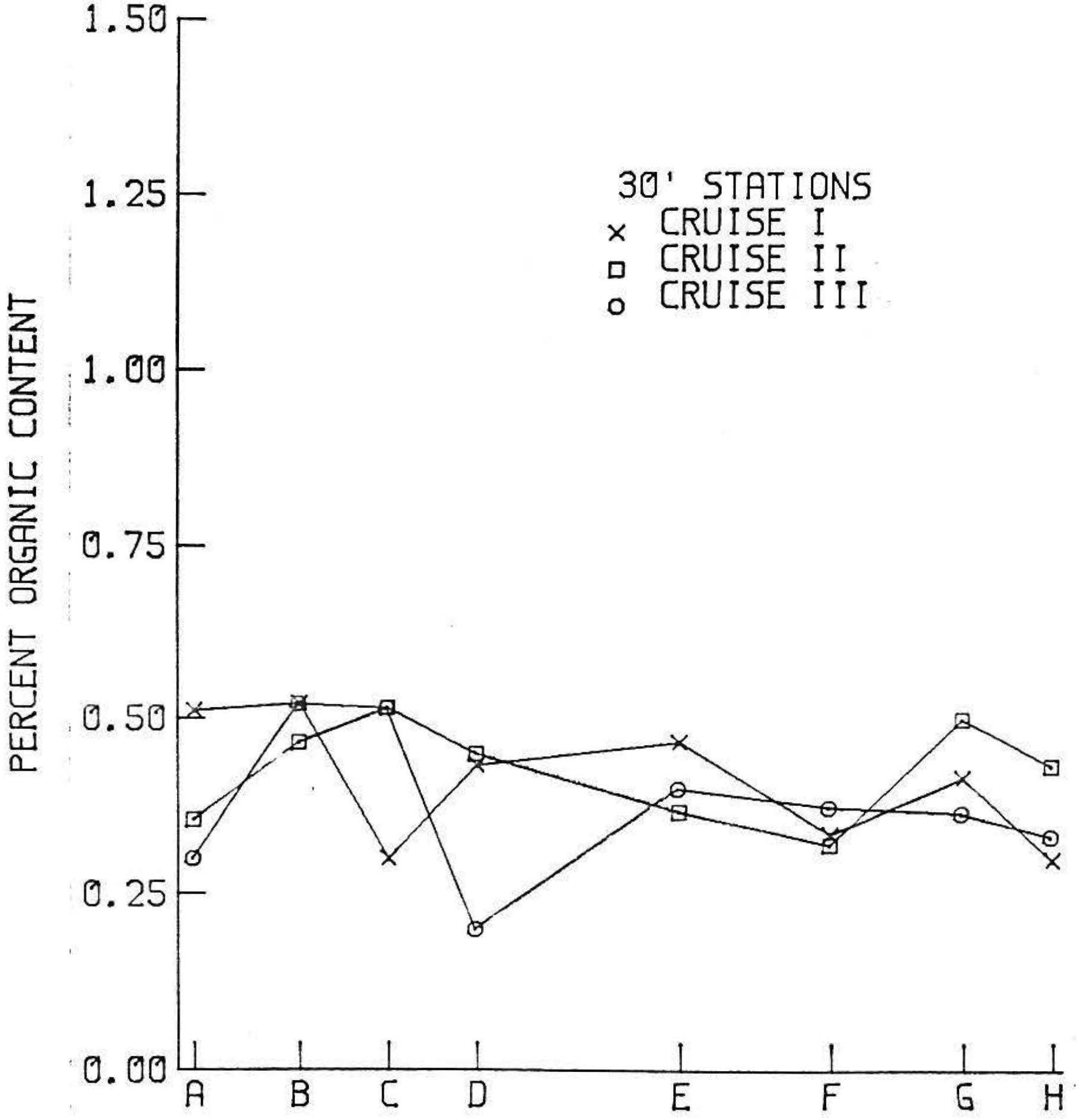

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
PERCENT ORGANIC CONTENT
1.50
1.25
1.00
0.75
0.50
0.25
0.00
A
B
C
D
E
F
G
H

Figure 44

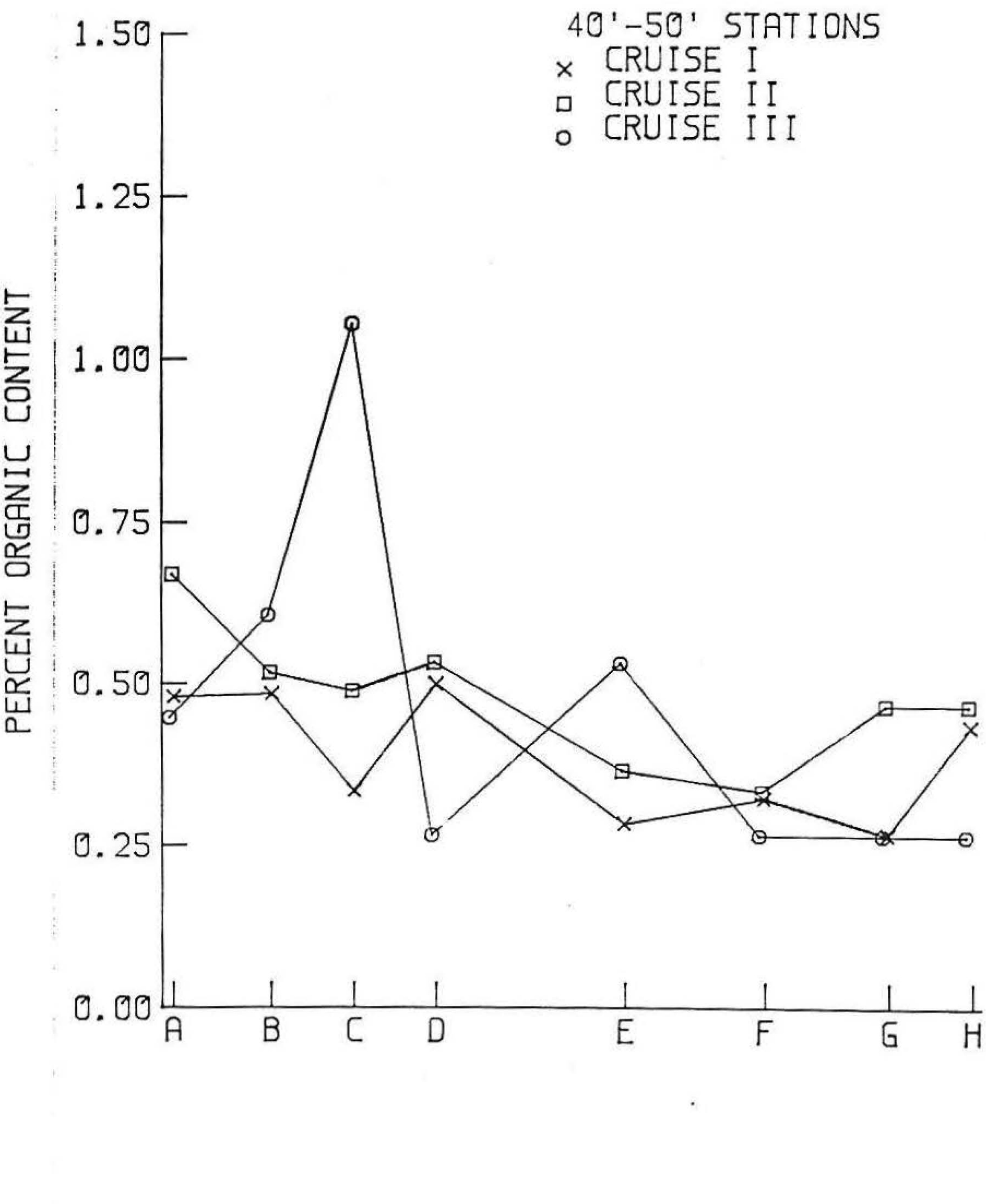
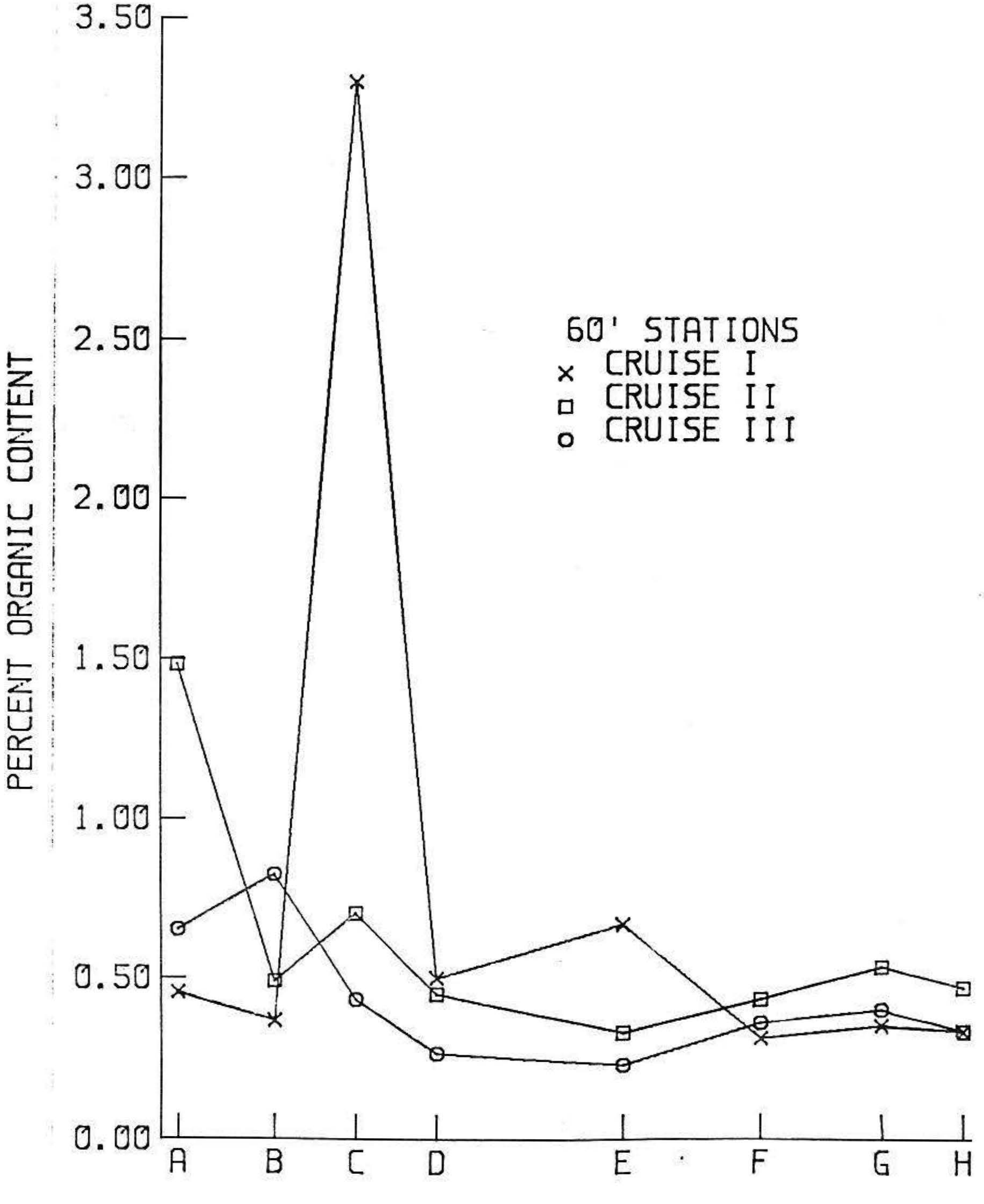

40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
PERCENT ORGANIC CONTENT
1.50
1.25
1.00
0.75
0.50
0.25
0.00
A
B
C
D
E
F
G
H

Figure 45


3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
PERCENT ORGANIC CONTENT
60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
A
B
C
D
E
F
G
H

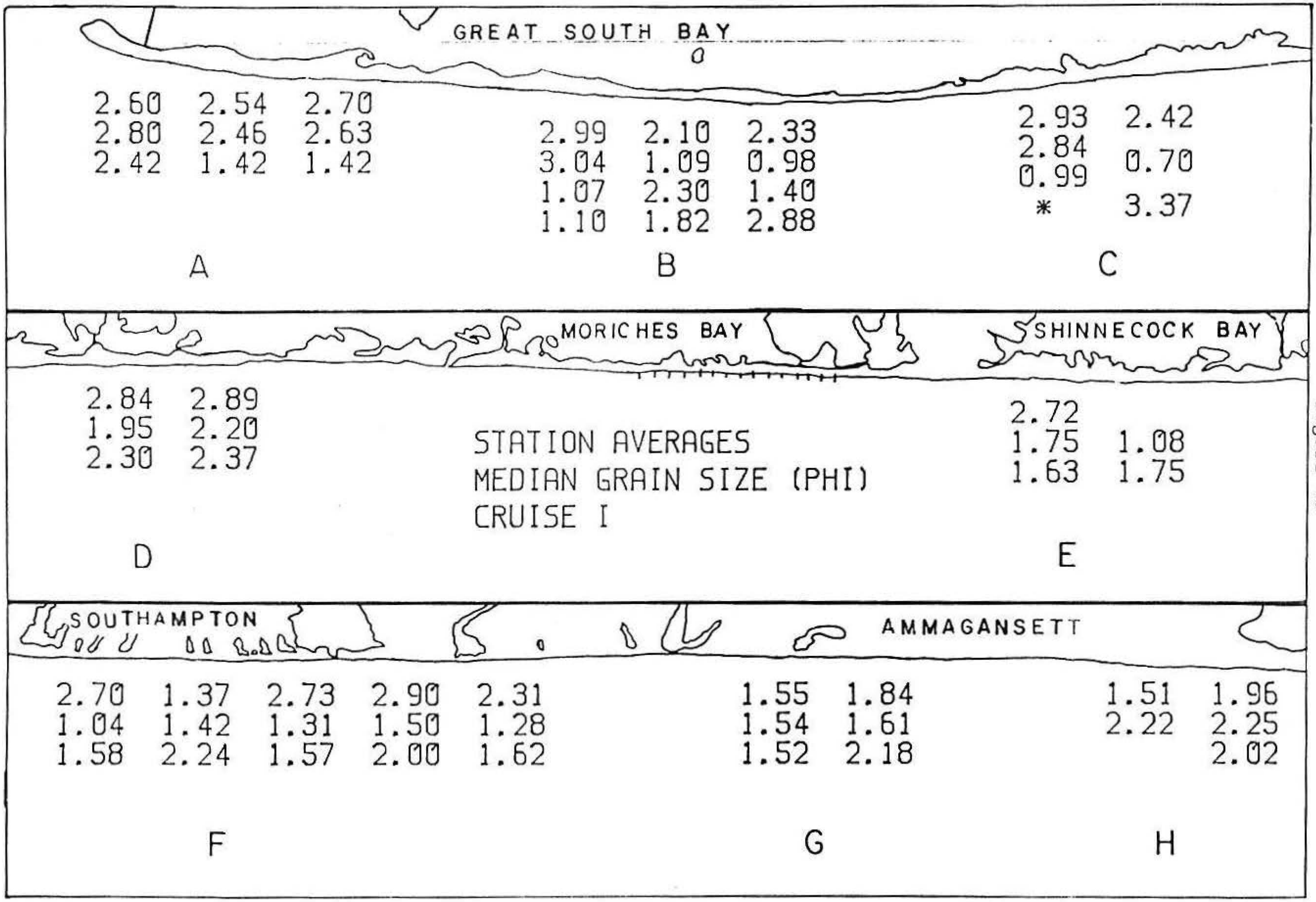

GREAT SOUTH BAY
2.60 2.54 2.70
2.80 2.46 2.63
2.42 1.42 1.42
A
2.99 2.10 2.33
3.04 1.09 0.98
1.07 2.30 1.40
1.10 1.82 2.88
B
2.93 2.42
2.84
0.99 0.70
* 3.37
C
MORICHES BAY
SHINNECOCK BAY
2.84 2.89
1.95 2.20
2.30 2.37
D
STATION AVERAGES
MEDIAN GRAIN SIZE (PHI)
CRUISE I
2.72
1.75 1.08
1.63 1.75
E
SOUTHAMPTON
AMMAGANSETT
2.70 1.37 2.73 2.90 2.31
1.04 1.42 1.31 1.50 1.28
1.58 2.24 1.57 2.00 1.62
F
1.55 1.84
1.54 1.61
1.52 2.18
G
1.51 1.96
2.22 2.25
2.02
H

Figure 46

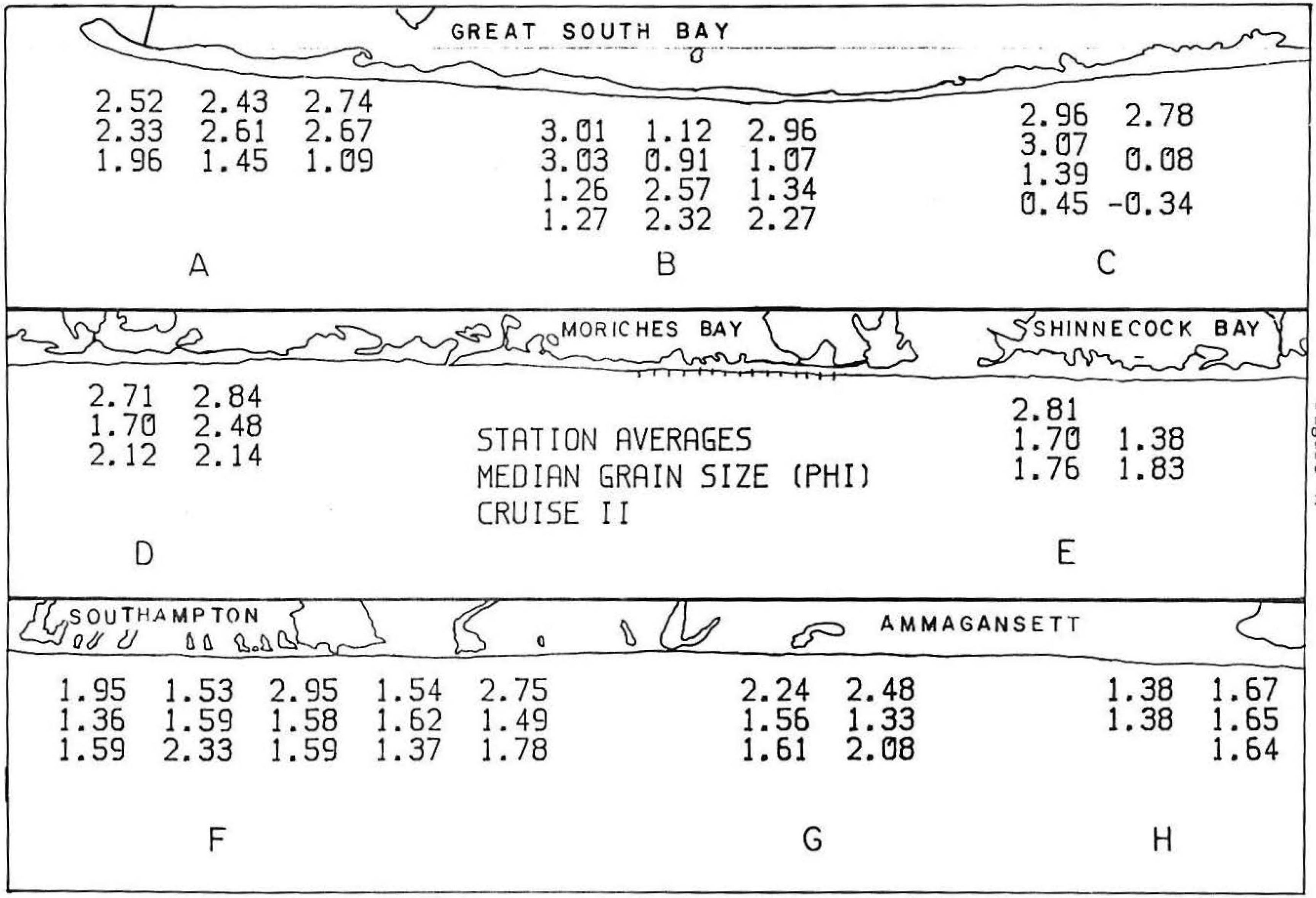

GREAT SOUTH BAY
2.52 2.43 2.74
2.33 2.61 2.67
1.96 1.45 1.09
A
3.01 1.12 2.96
3.03 0.91 1.07
1.26 2.57 1.34
1.27 2.32 2.27
B
2.96 2.78
3.07
1.39 0.08
0.45 -0.34
C
MORICHES BAY
SHINNECOCK BAY
2.71 2.84
1.70 2.48
2.12 2.14
D
STATION AVERAGES
MEDIAN GRAIN SIZE (PHI)
CRUISE II
2.81
1.70 1.38
1.76 1.83
E
SOUTHAMPTON
AMMAGANSETT
1.95 1.53 2.95 1.54 2.75
1.36 1.59 1.58 1.62 1.49
1.59 2.33 1.59 1.37 1.78
F
2.24 2.48
1.56 1.33
1.61 2.08
G
1.38 1.67
1.38 1.65
1.64
H

Figure 47

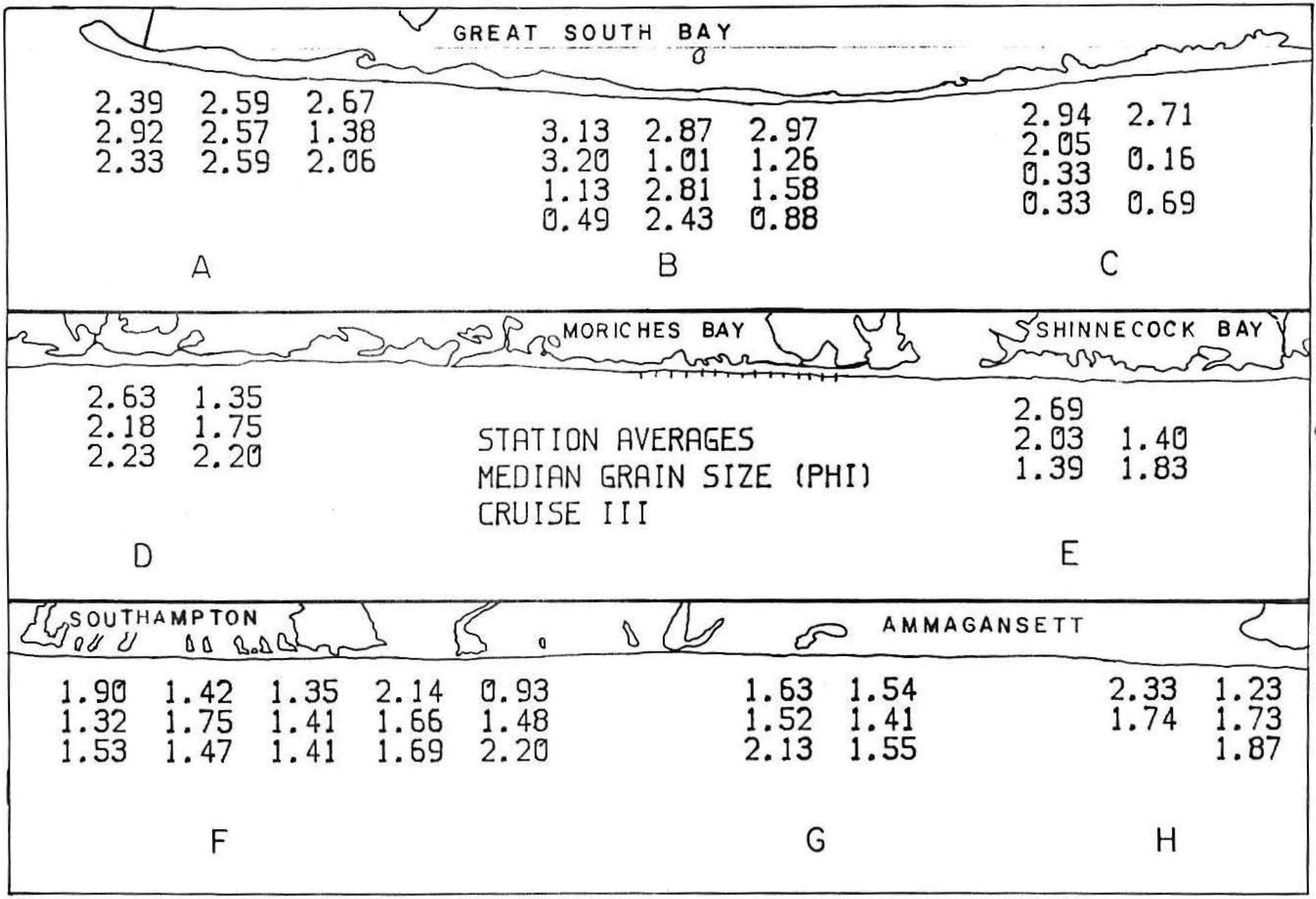

GREAT SOUTH BAY
2.39 2.59 2.67
2.92 2.57 1.38
2.33 2.59 2.06
A
3.13 2.87 2.97
3.20 1.01 1.26
1.13 2.81 1.58
0.49 2.43 0.88
B
2.94 2.71
2.05 0.16
0.33
0.33 0.69
C
MORICHES BAY
SHINNECOCK BAY
2.63 1.35
2.18 1.75
2.23 2.20
D
STATION AVERAGES
MEDIAN GRAIN SIZE (PHI)
CRUISE III
2.69
2.03 1.40
1.39 1.83
E
SOUTHAMPTON
AMMAGANSETT
1.90 1.42 1.35 2.14 0.93
1.32 1.75 1.41 1.66 1.48
1.53 1.47 1.41 1.69 2.20
F
1.63 1.54
1.52 1.41
2.13 1.55
G
2.33 1.23
1.74 1.73
1.87
H

Figure 48

Figure 49

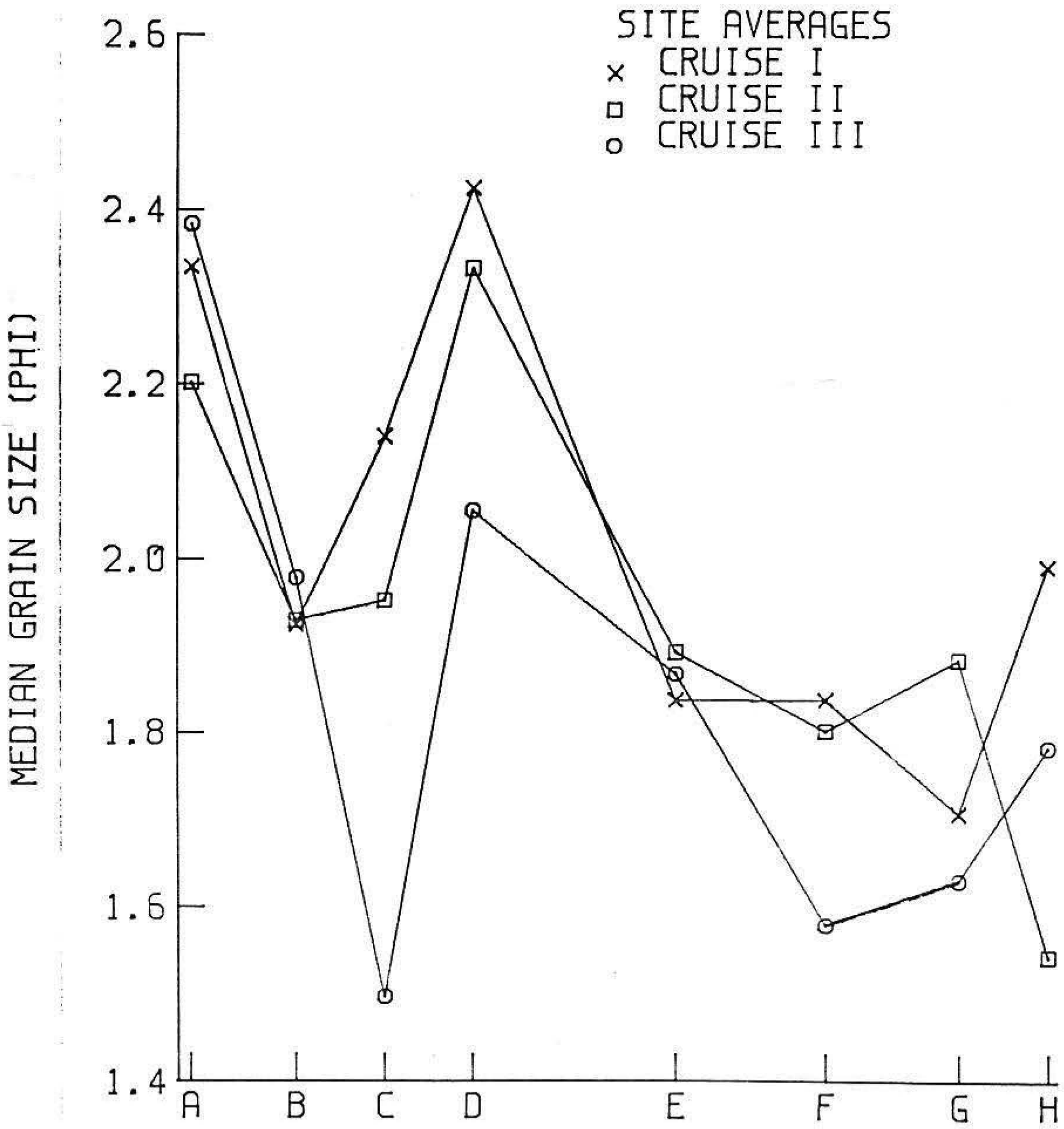

SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
MEDIAN GRAIN SIZE (PHI)
2.6
2.4
2.2
2.0
1.8
1.6
1.4
A
B
C
D
E
F
G
H

Figure 50

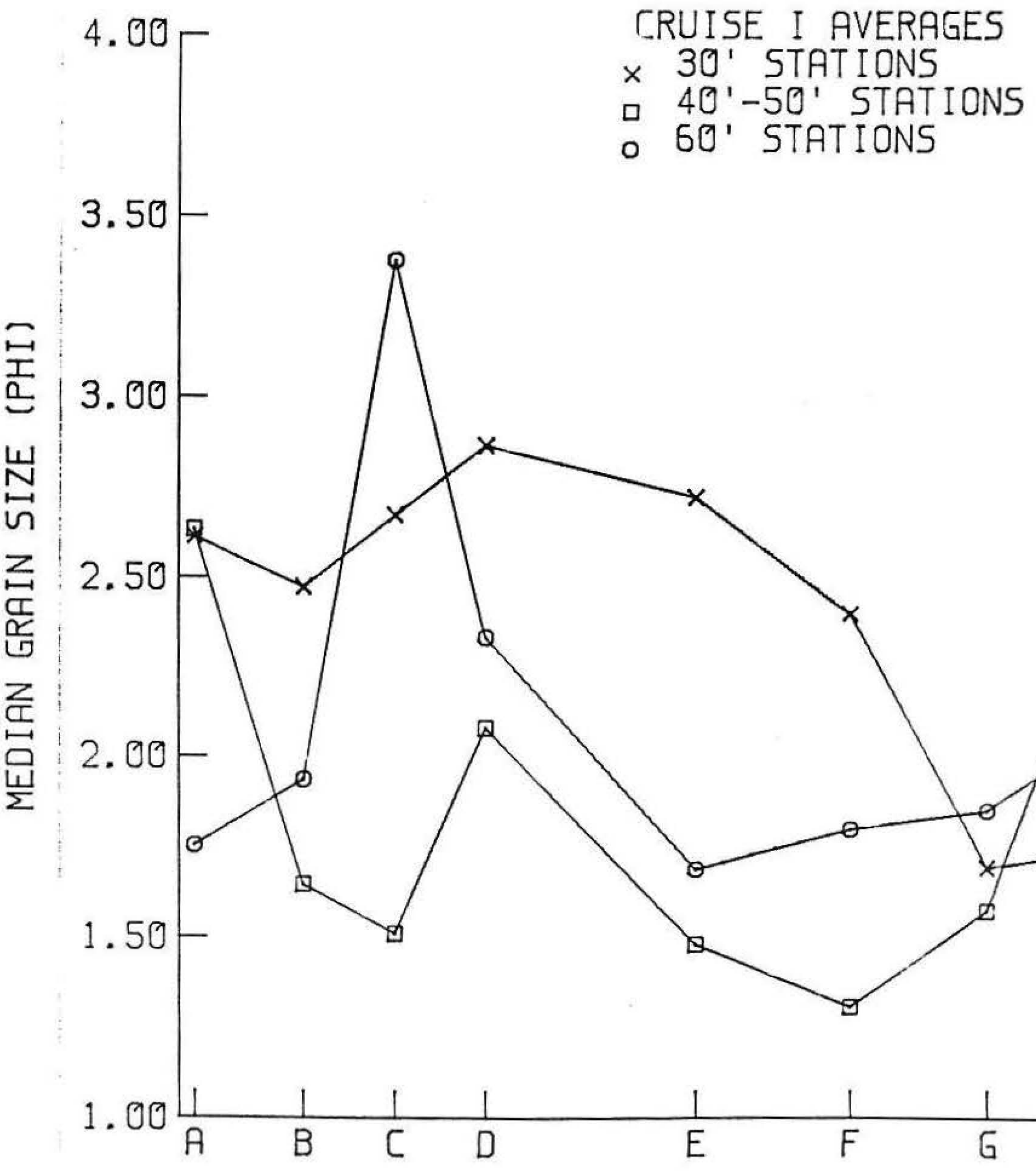

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
MEDIAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
A
B
C
D
E
F
G
H

Figure 51

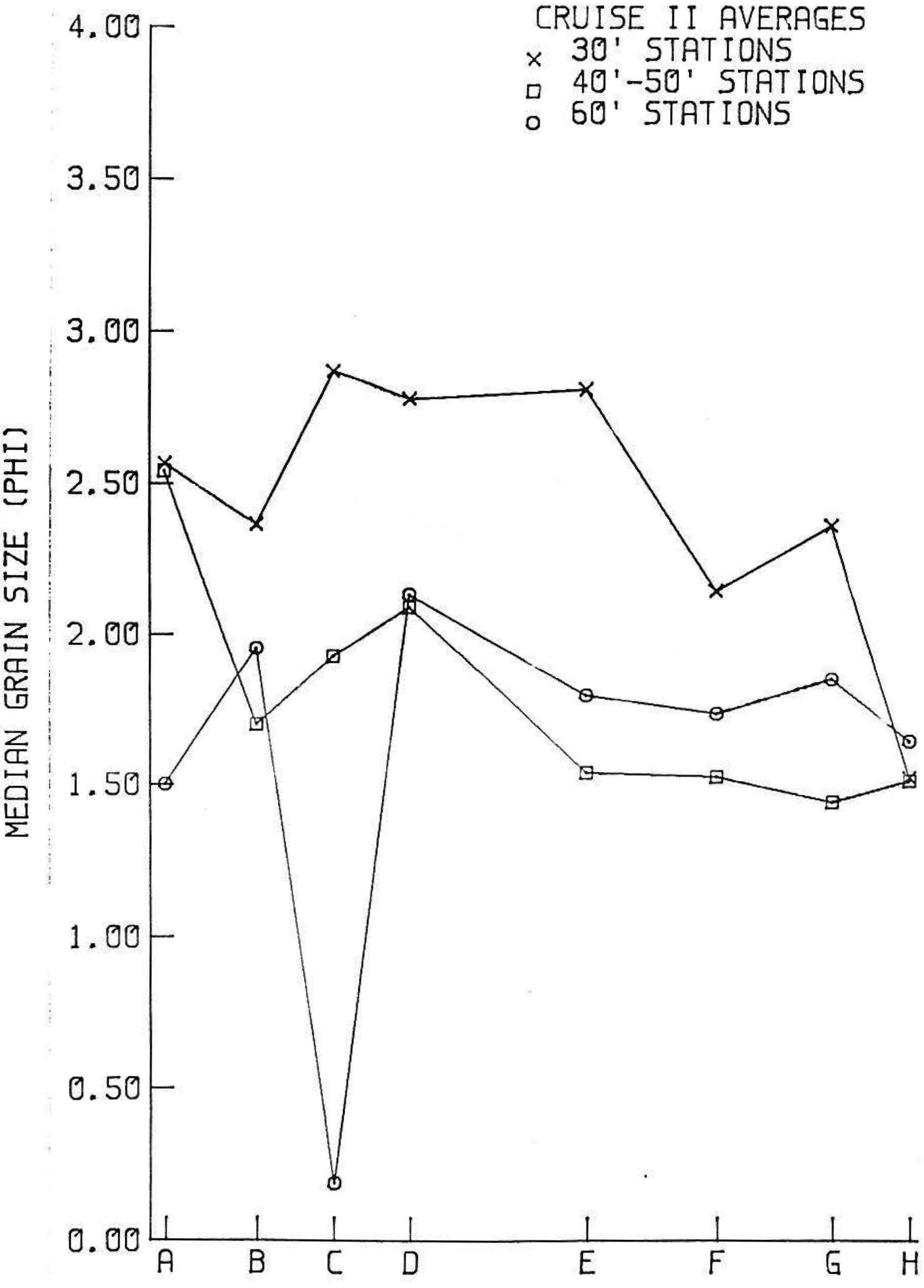

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
MEDIAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
A
B
C
D
E
F
G
H

Figure 52

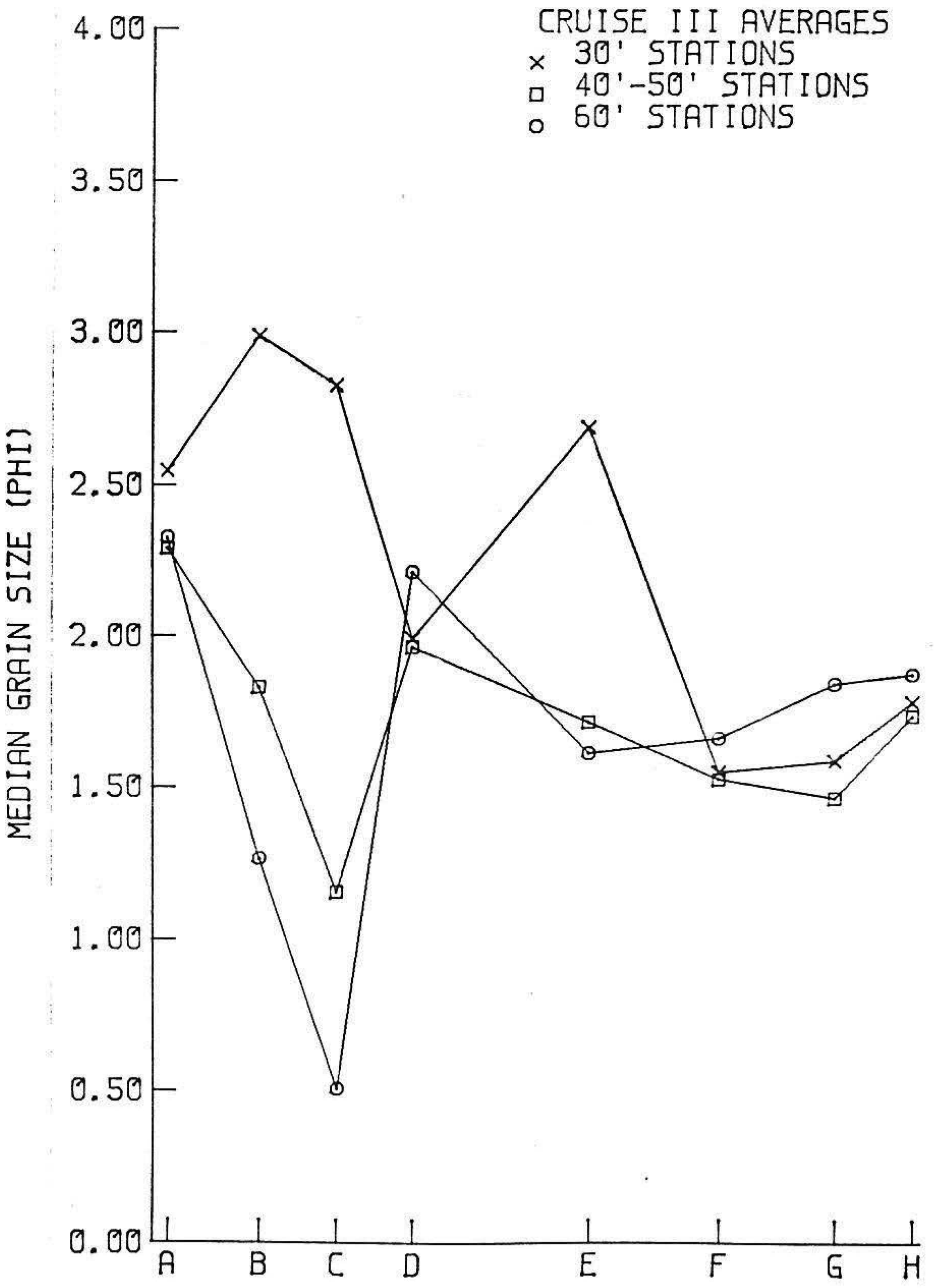

CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
MEDIAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
A
B
C
D
E
F
G
H

Figure 53

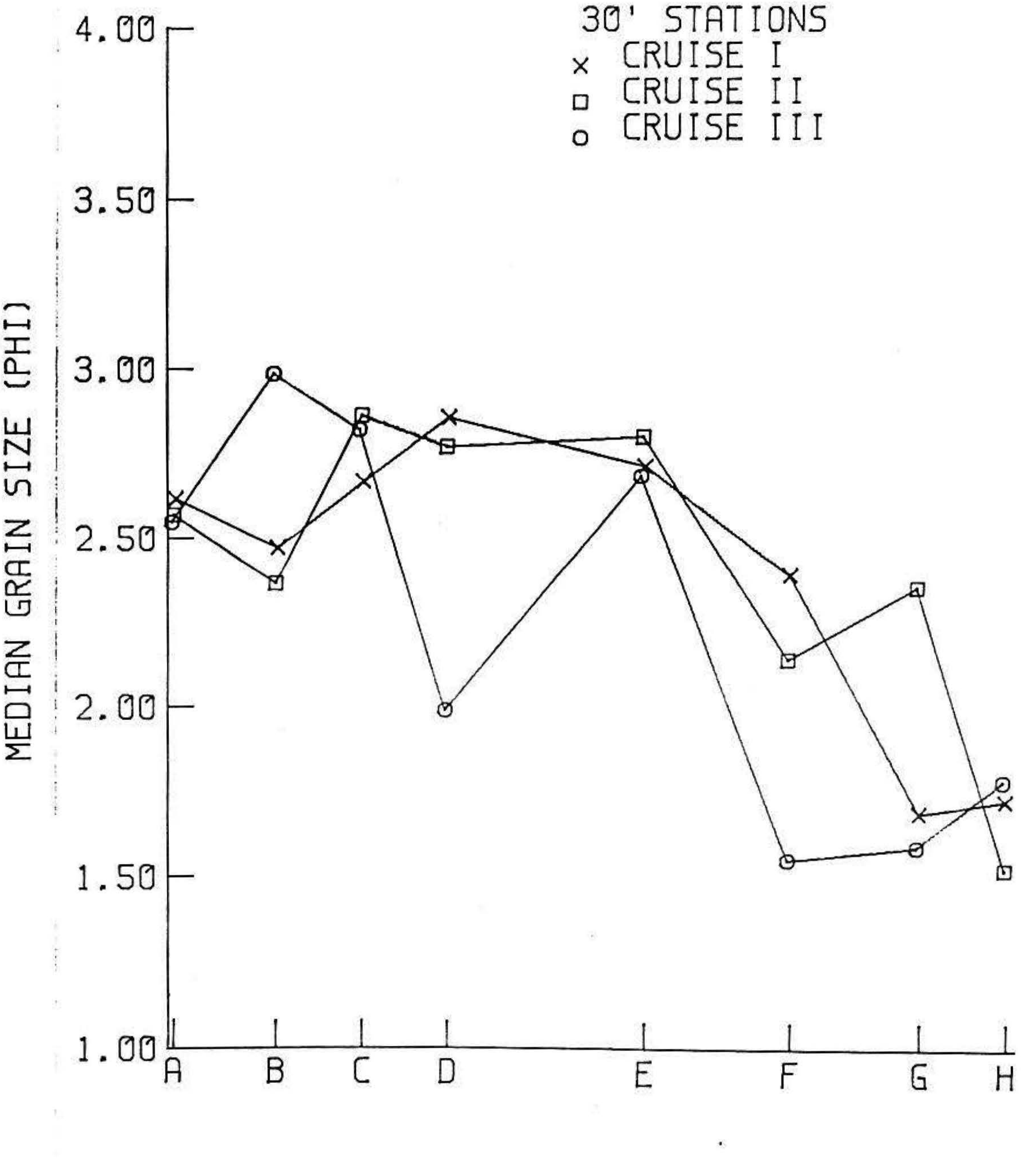

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
MEDIAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
A
B
C
D
E
F
G
H

Figure 54

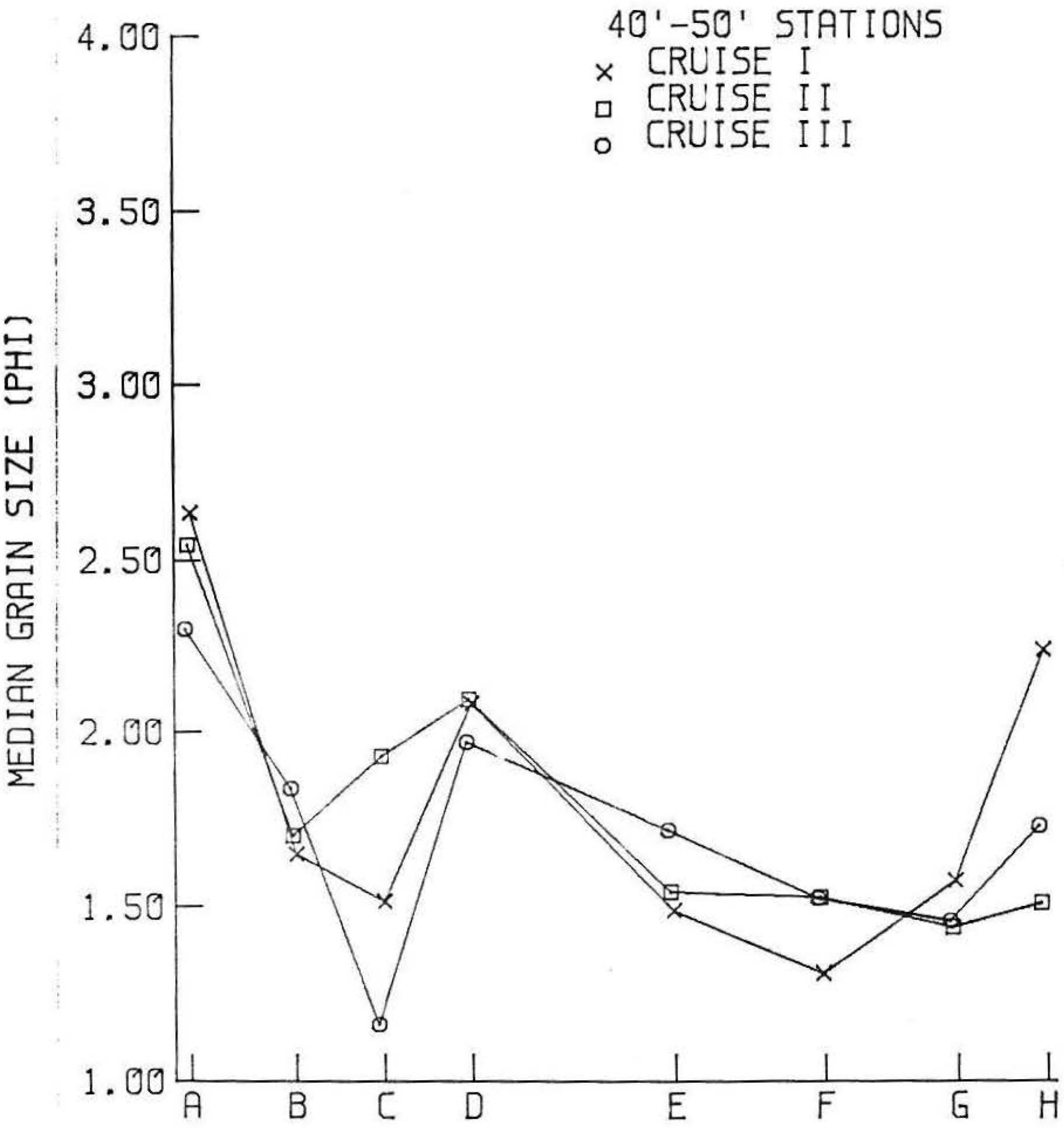
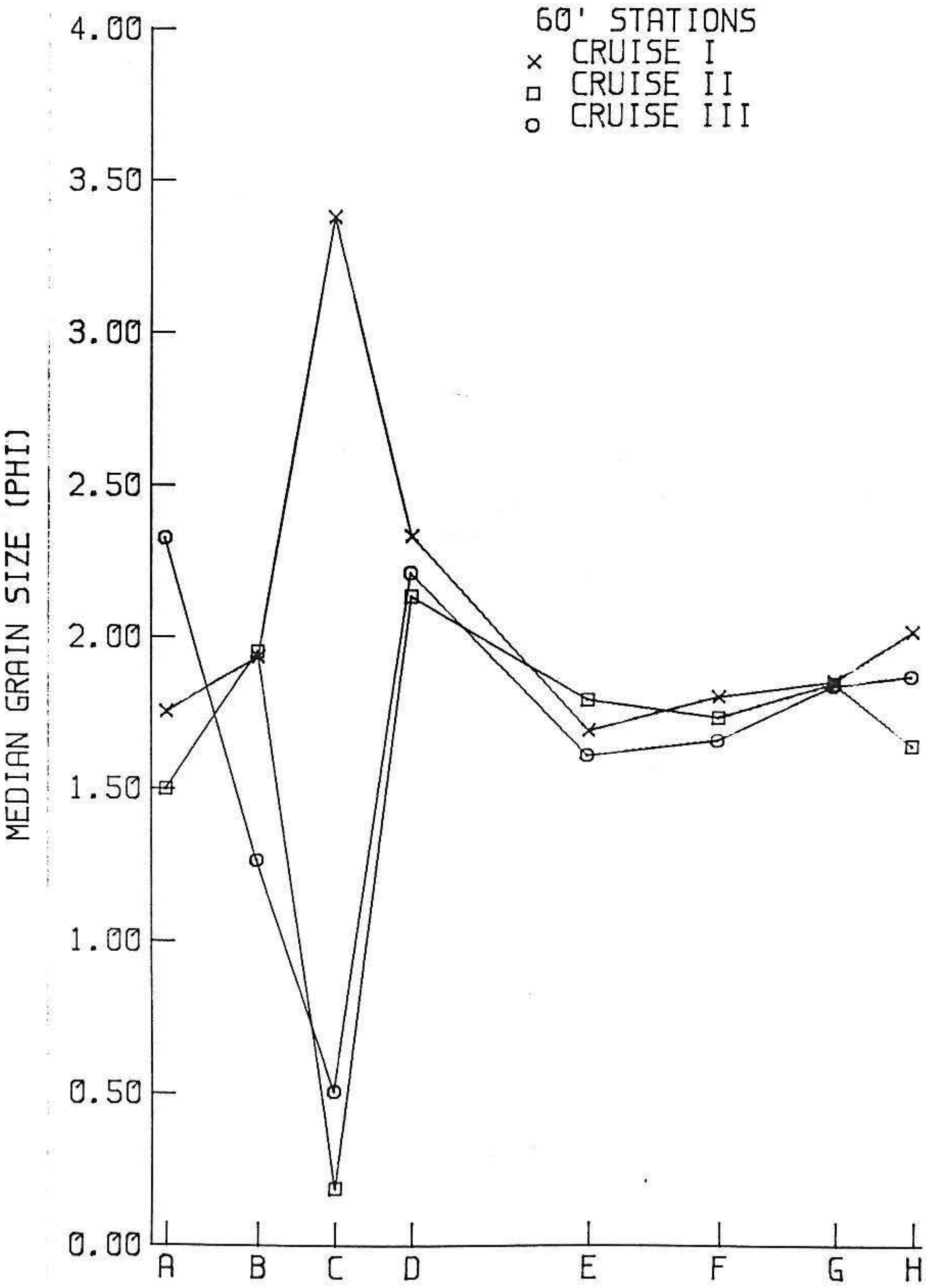

40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
MEDIAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
A
B
C
D
E
F
G
H

Figure 55


60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
MEDIAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
A
B
C
D
E
F
G
H

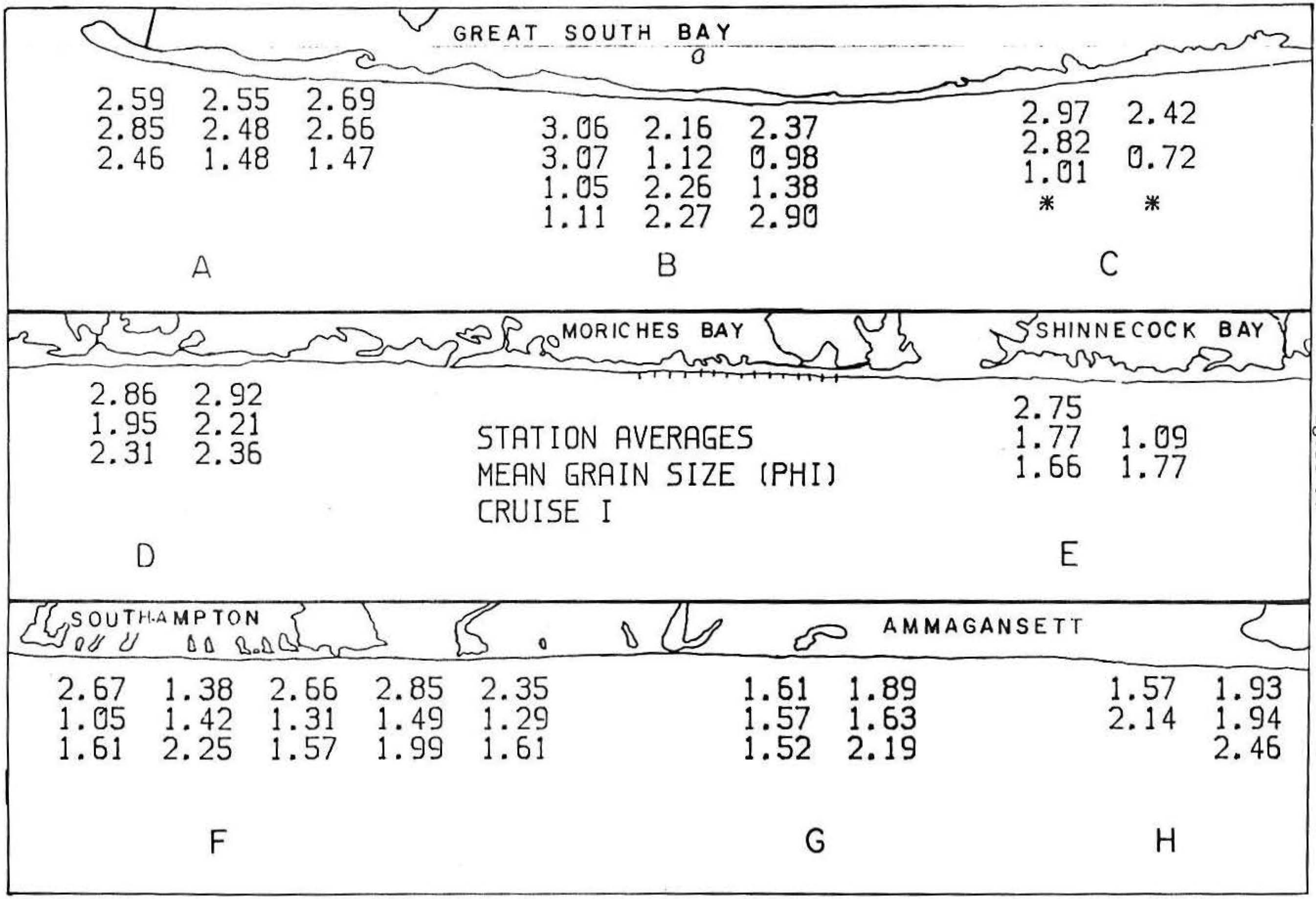

GREAT SOUTH BAY
2.59 2.55 2.69
2.85 2.48 2.66
2.46 1.48 1.47
A
3.06 2.16 2.37
3.07 1.12 0.98
1.05 2.26 1.38
1.11 2.27 2.90
B
2.97 2.42
2.82 0.72
1.01
* *
C
MORICHES BAY
SHINNECOCK BAY
2.86 2.92
1.95 2.21
2.31 2.36
D
STATION AVERAGES
MEAN GRAIN SIZE (PHI)
CRUISE I
2.75
1.77 1.09
1.66 1.77
E
SOUTHAMPTON
AMMAGANSETT
2.67 1.38 2.66 2.85 2.35
1.05 1.42 1.31 1.49 1.29
1.61 2.25 1.57 1.99 1.61
F
1.61 1.89
1.57 1.63
1.52 2.19
G
1.57 1.93
2.14 1.94
2.46
H

Figure 56

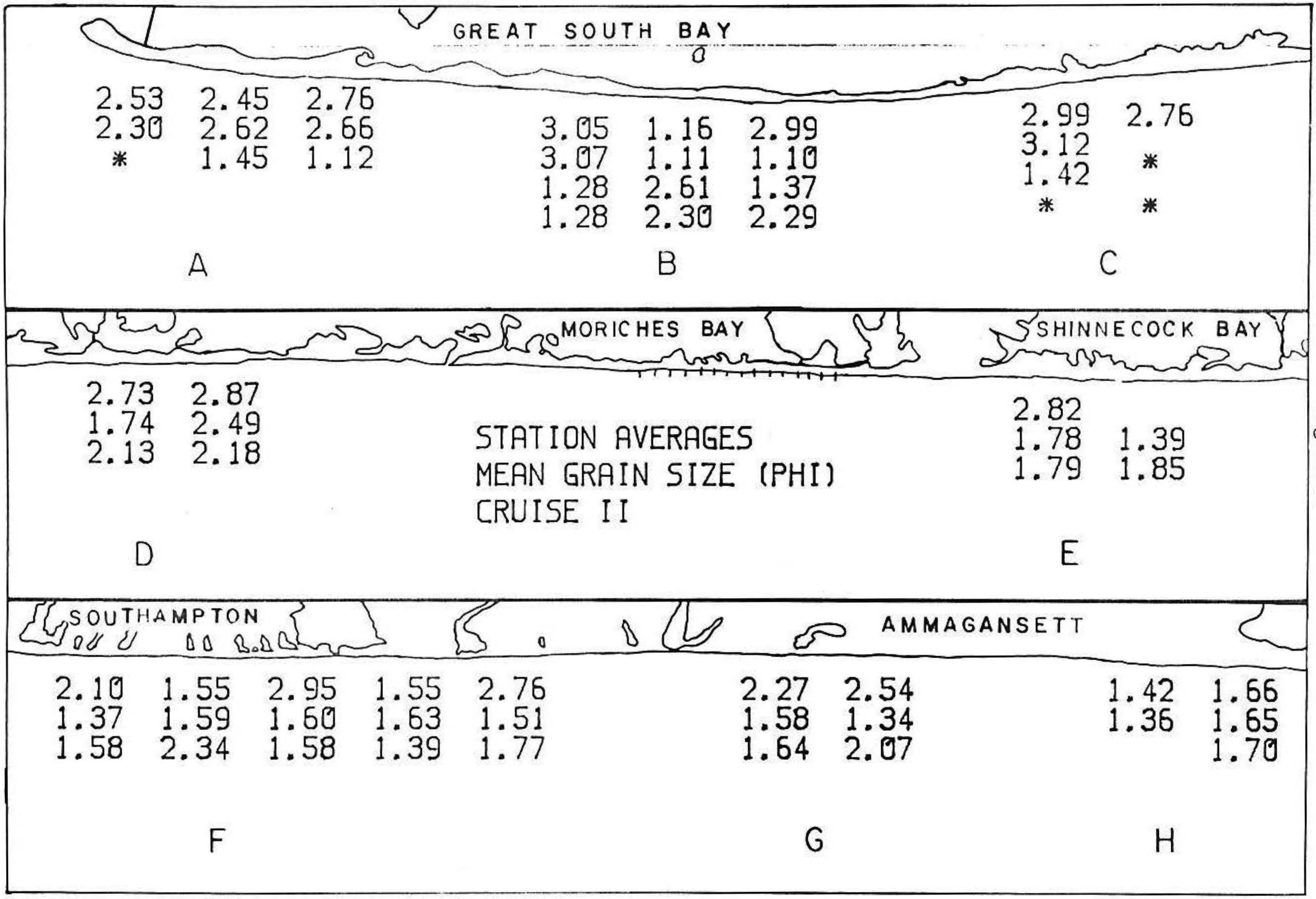

GREAT SOUTH BAY
2.53 2.45 2.76
2.30 2.62 2.66
* 1.45 1.12
A
3.05 1.16 2.99
3.07 1.11 1.10
1.28 2.61 1.37
1.28 2.30 2.29
B
2.99 2.76
3.12
1.42 *
* *
C
MORICHES BAY
SHINNECOCK BAY
2.73 2.87
1.74 2.49
2.13 2.18
D
STATION AVERAGES
MEAN GRAIN SIZE (PHI)
CRUISE II
2.82
1.78 1.39
1.79 1.85
E
SOUTHAMPTON
AMMAGANSETT
2.10 1.55 2.95 1.55 2.76
1.37 1.59 1.60 1.63 1.51
1.58 2.34 1.58 1.39 1.77
F
2.27 2.54
1.58 1.34
1.64 2.07
G
1.42 1.66
1.36 1.65
1.70
H

Figure 57

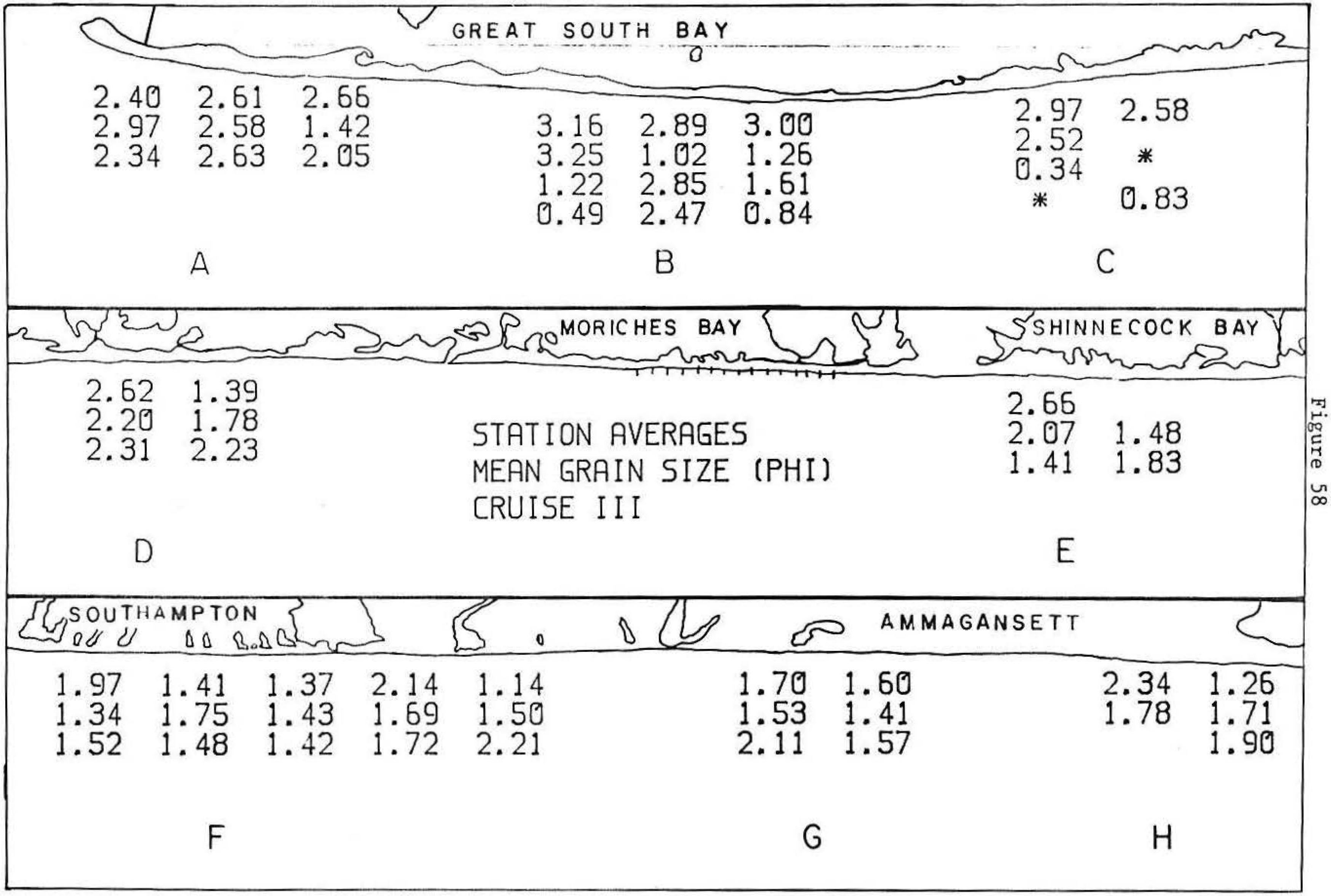

GREAT SOUTH BAY
2.40 2.61 2.66
2.97 2.58 1.42
2.34 2.63 2.05
A
3.16 2.89 3.00
3.25 1.02 1.26
1.22 2.85 1.61
0.49 2.47 0.84
B
2.97 2.58
2.52
0.34 *
* 0.83
C
MORICHES BAY
SHINNECOCK BAY
2.62 1.39
2.20 1.78
2.31 2.23
D
STATION AVERAGES
MEAN GRAIN SIZE (PHI)
CRUISE III
2.66
2.07 1.48
1.41 1.83
E
SOUTHAMPTON
AMMAGANSETT
1.97 1.41 1.37 2.14 1.14
1.34 1.75 1.43 1.69 1.50
1.52 1.48 1.42 1.72 2.21
F
1.70 1.60
1.53 1.41
2.11 1.57
G
2.34 1.26
1.78 1.71
1.90
H

Figure 58

Figure 59

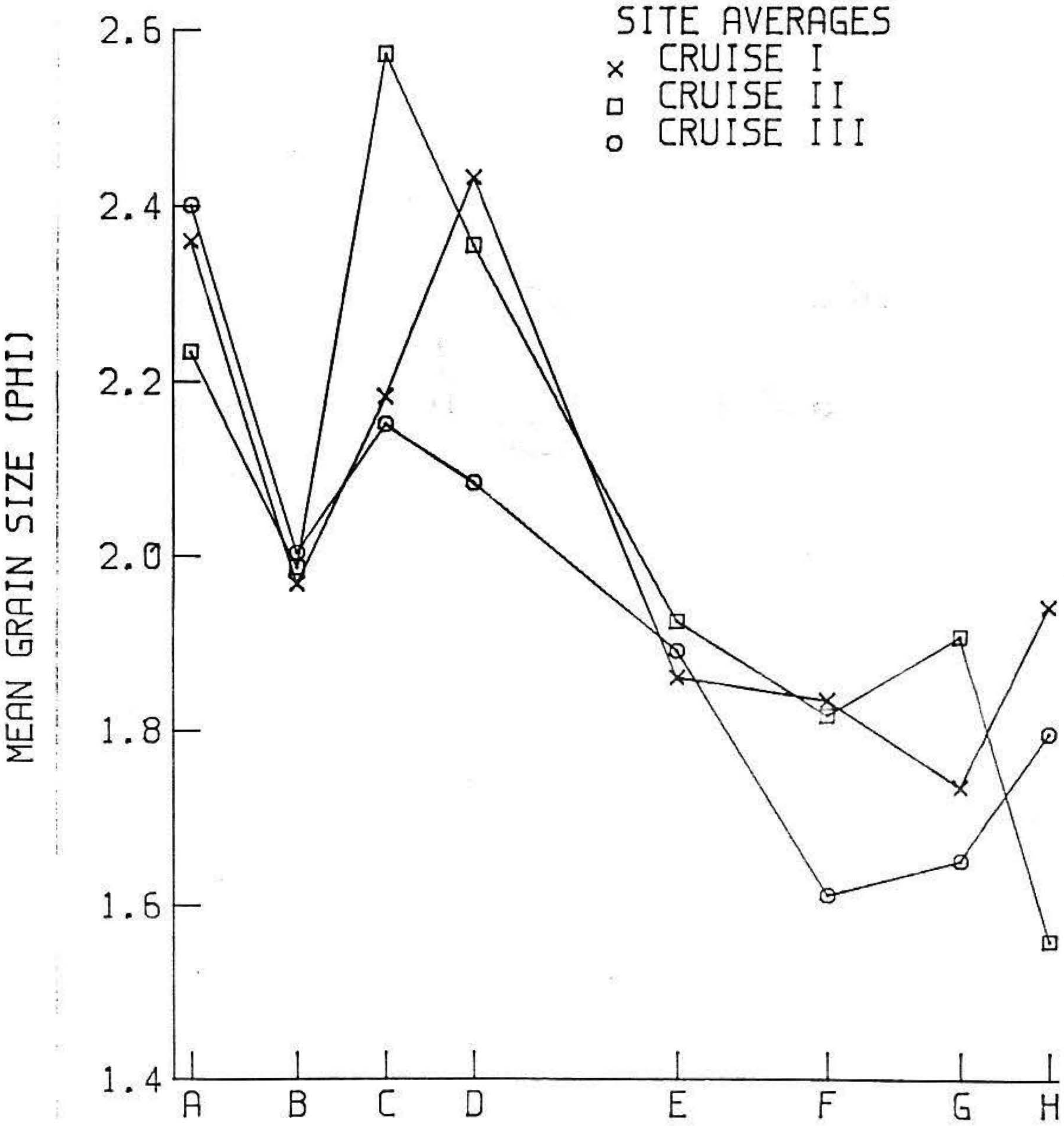

SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
MEAN GRAIN SIZE (PHI)
2.6
2.4
2.2
2.0
1.8
1.6
1.4
A
B
C
D
E
F
G
H

Figure 60

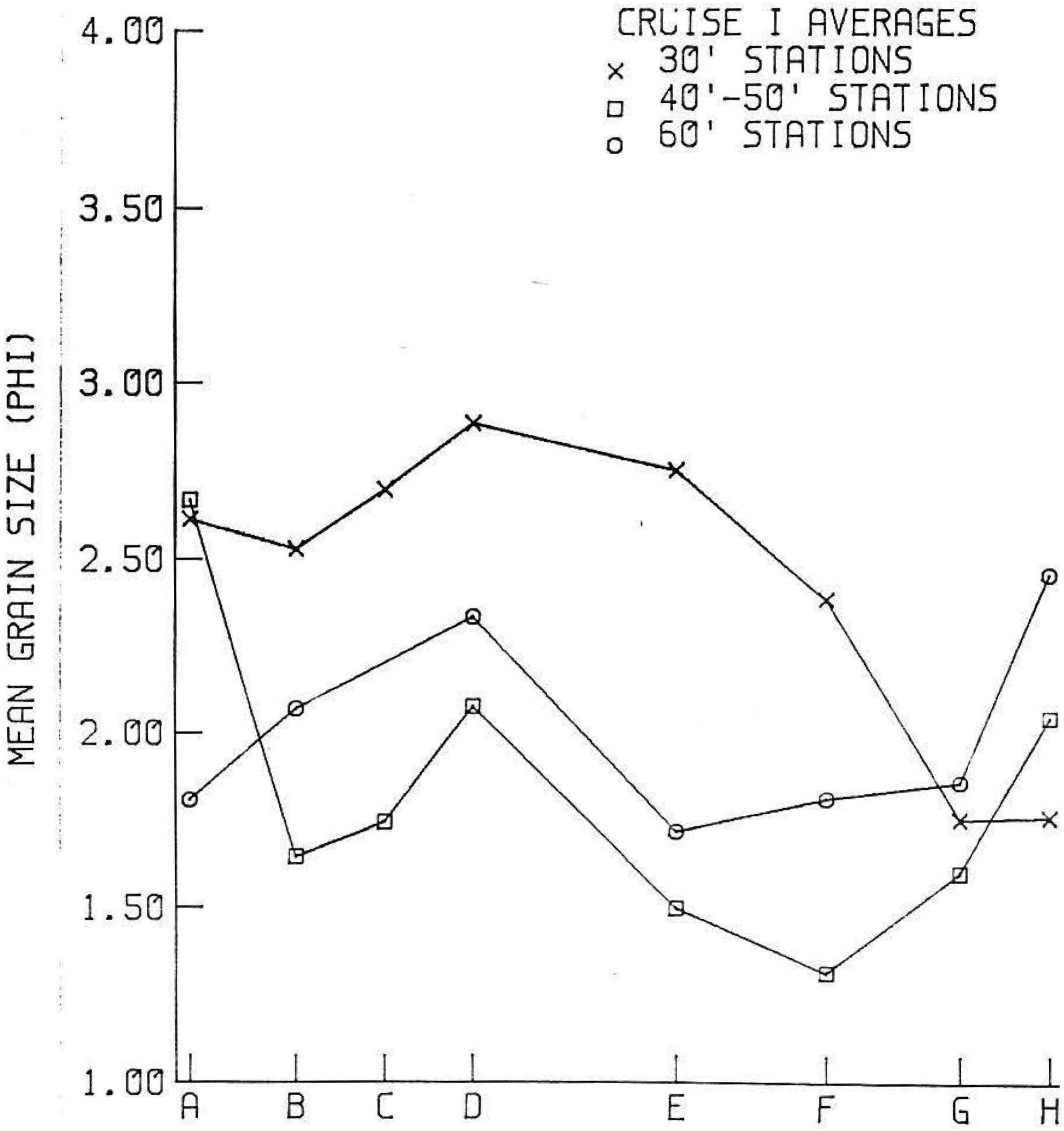

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
MEAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
A
B
C
D
E
F
G
H

Figure 61

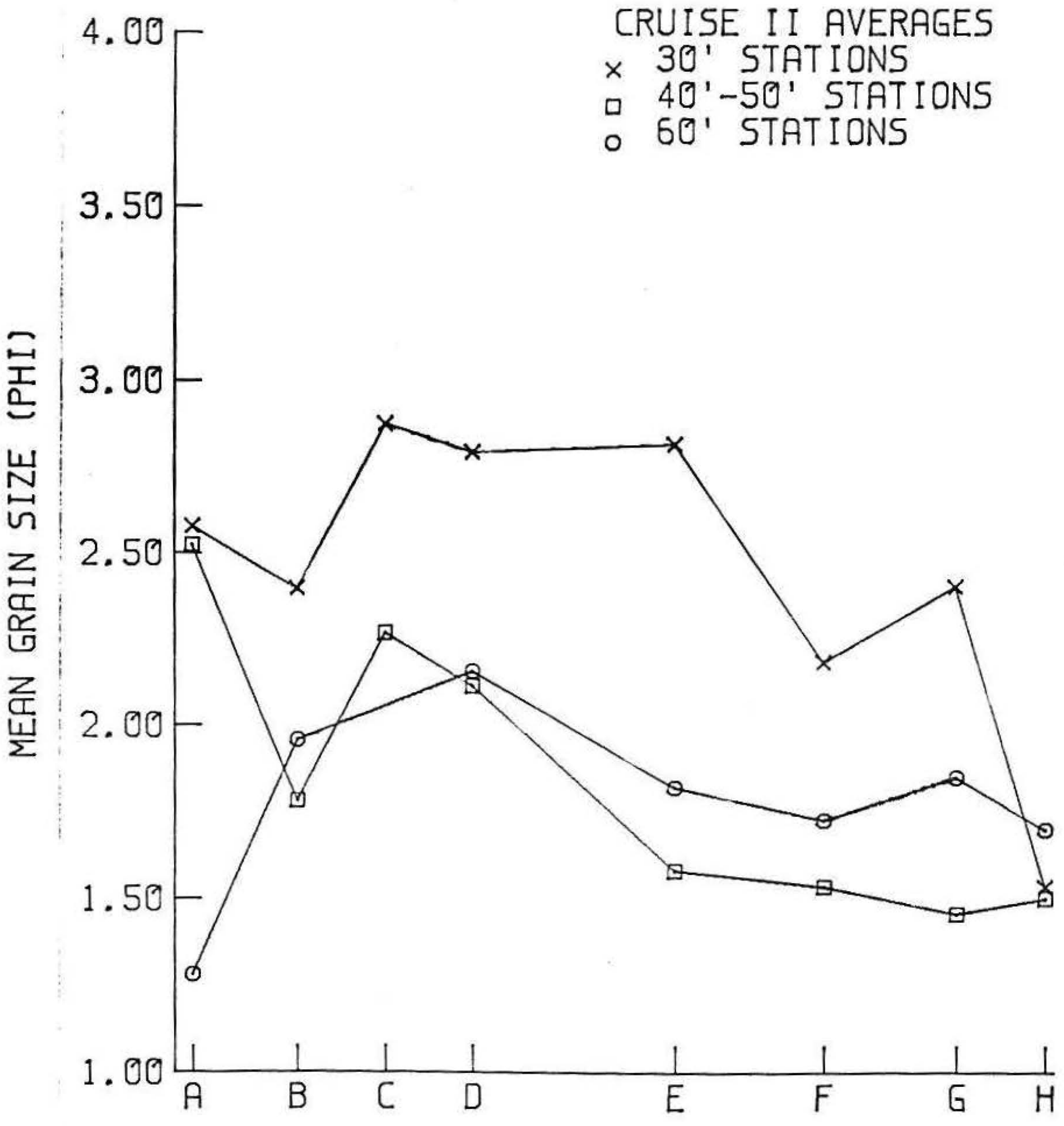

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
MEAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
A
B
C
D
E
F
G
H

Figure 62

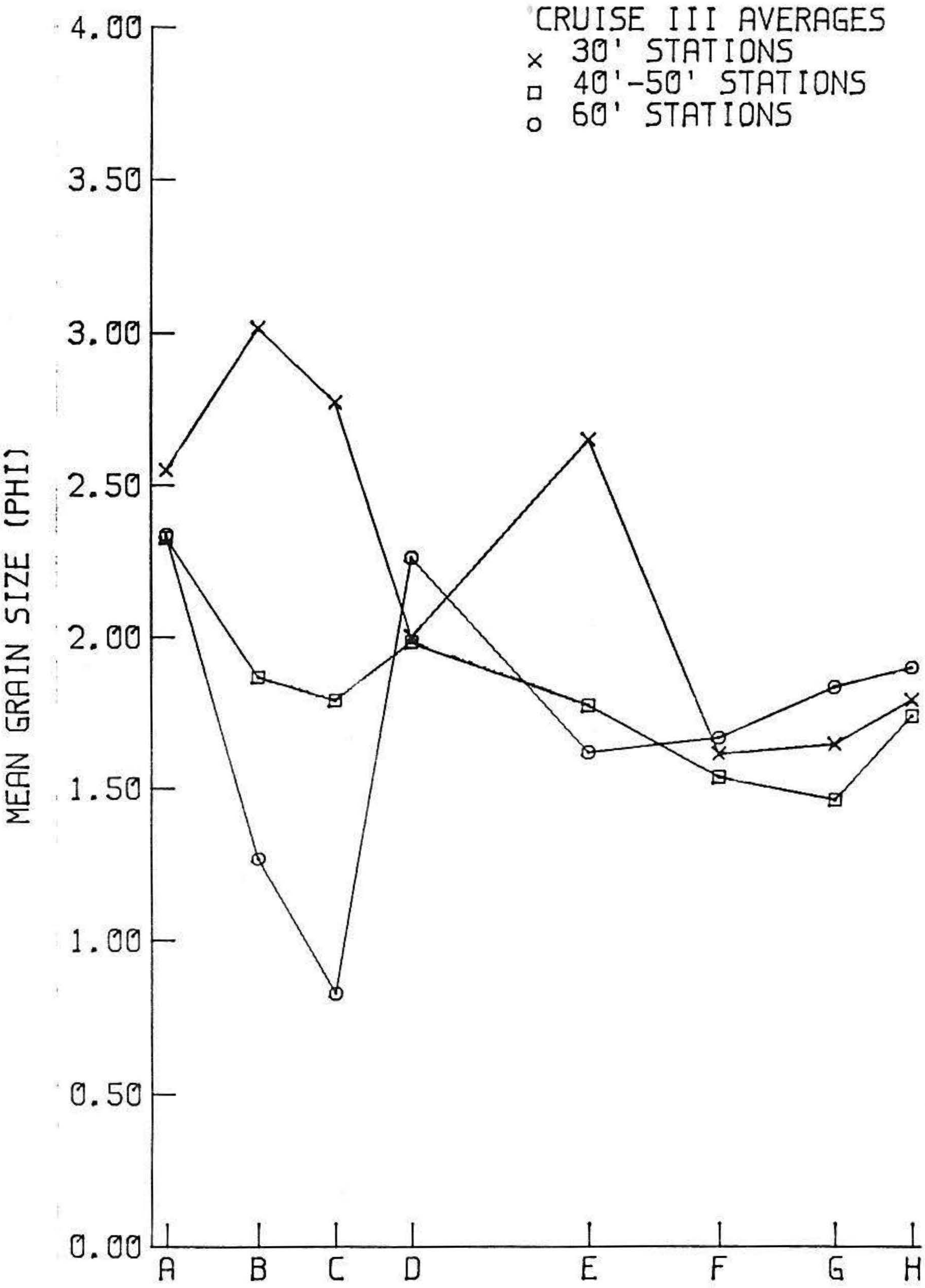

CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
MEAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
A
B
C
D
E
F
G
H

Figure 63

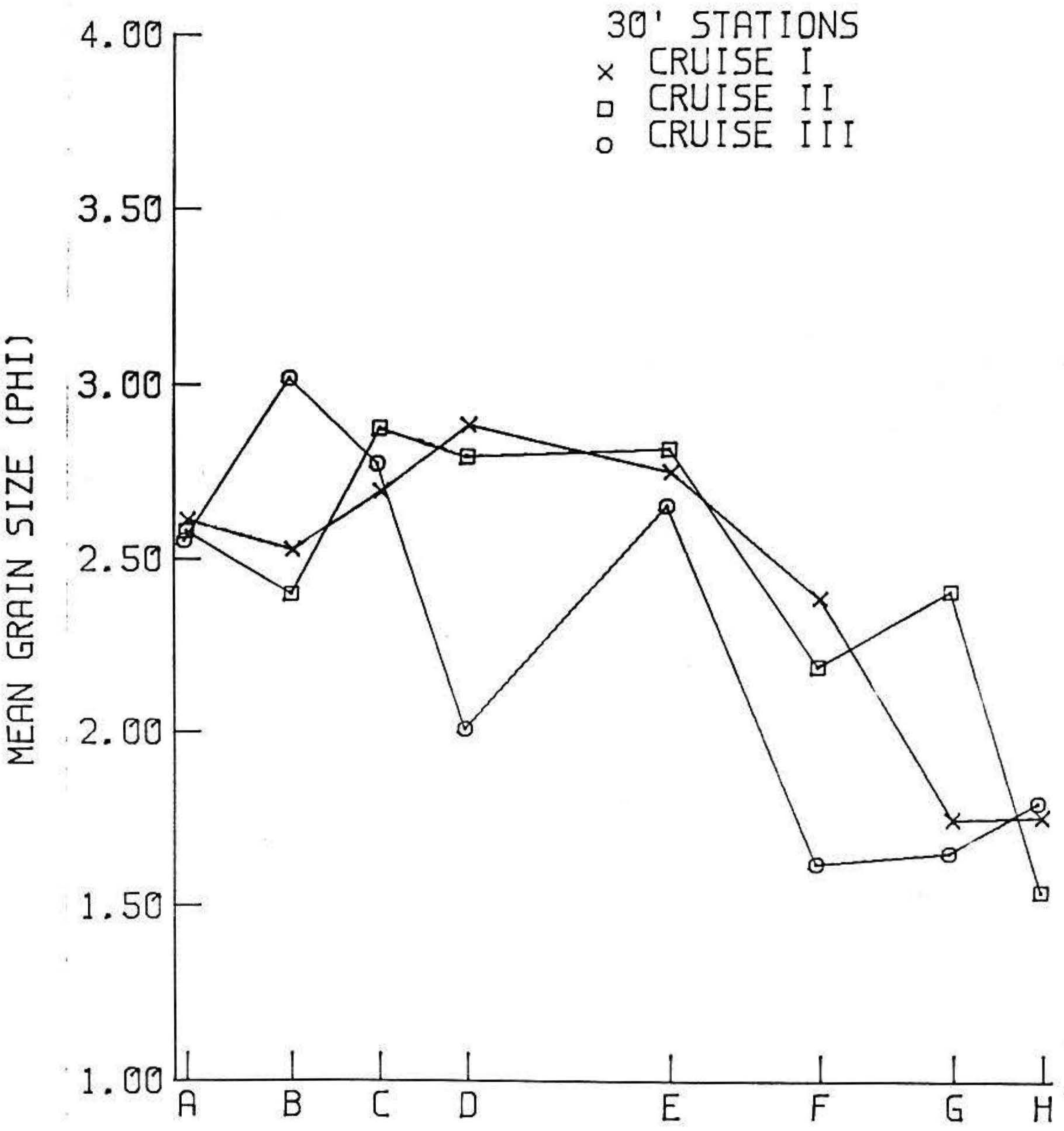

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
MEAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
A
B
C
D
E
F
G
H

Figure 64

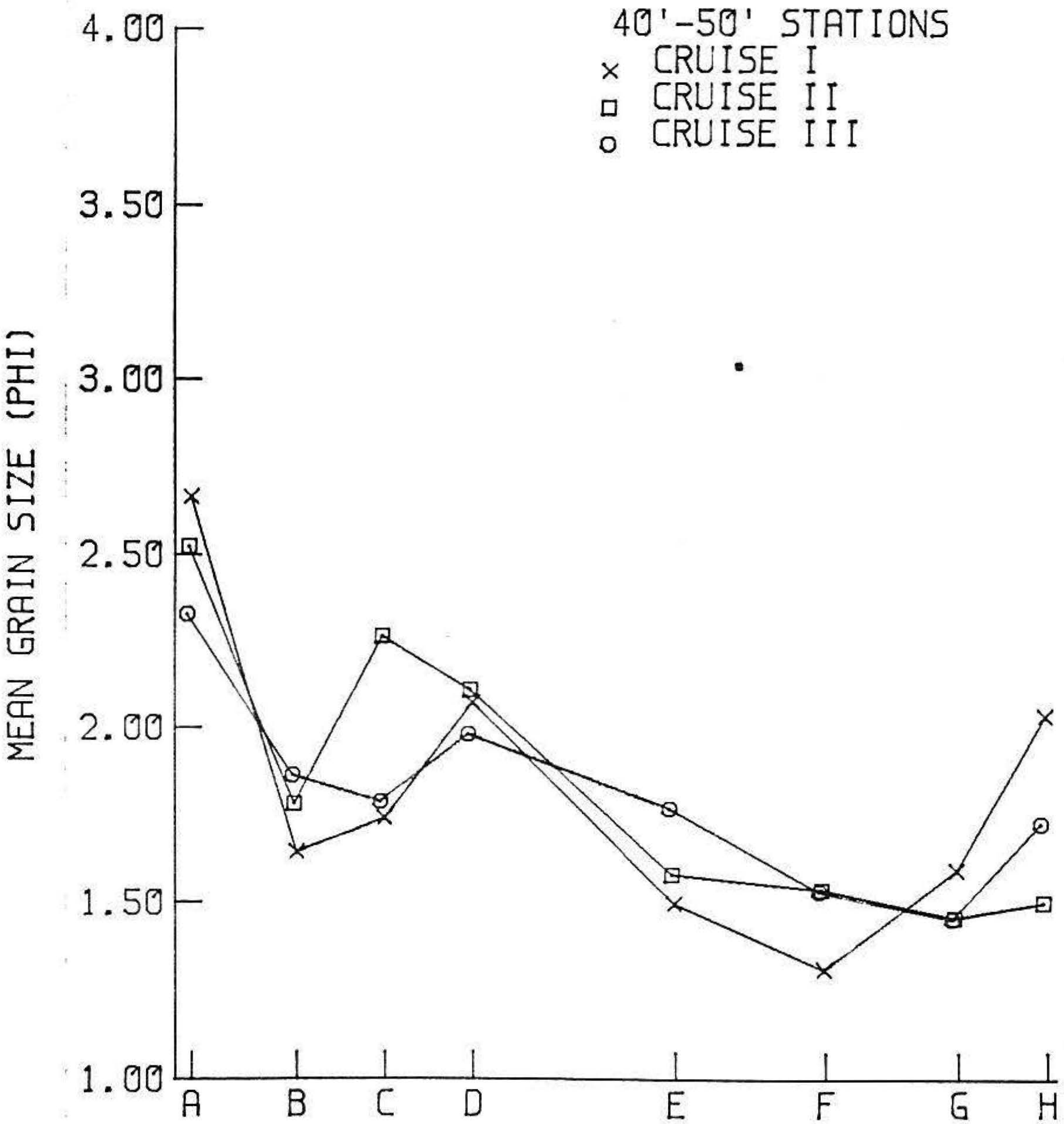
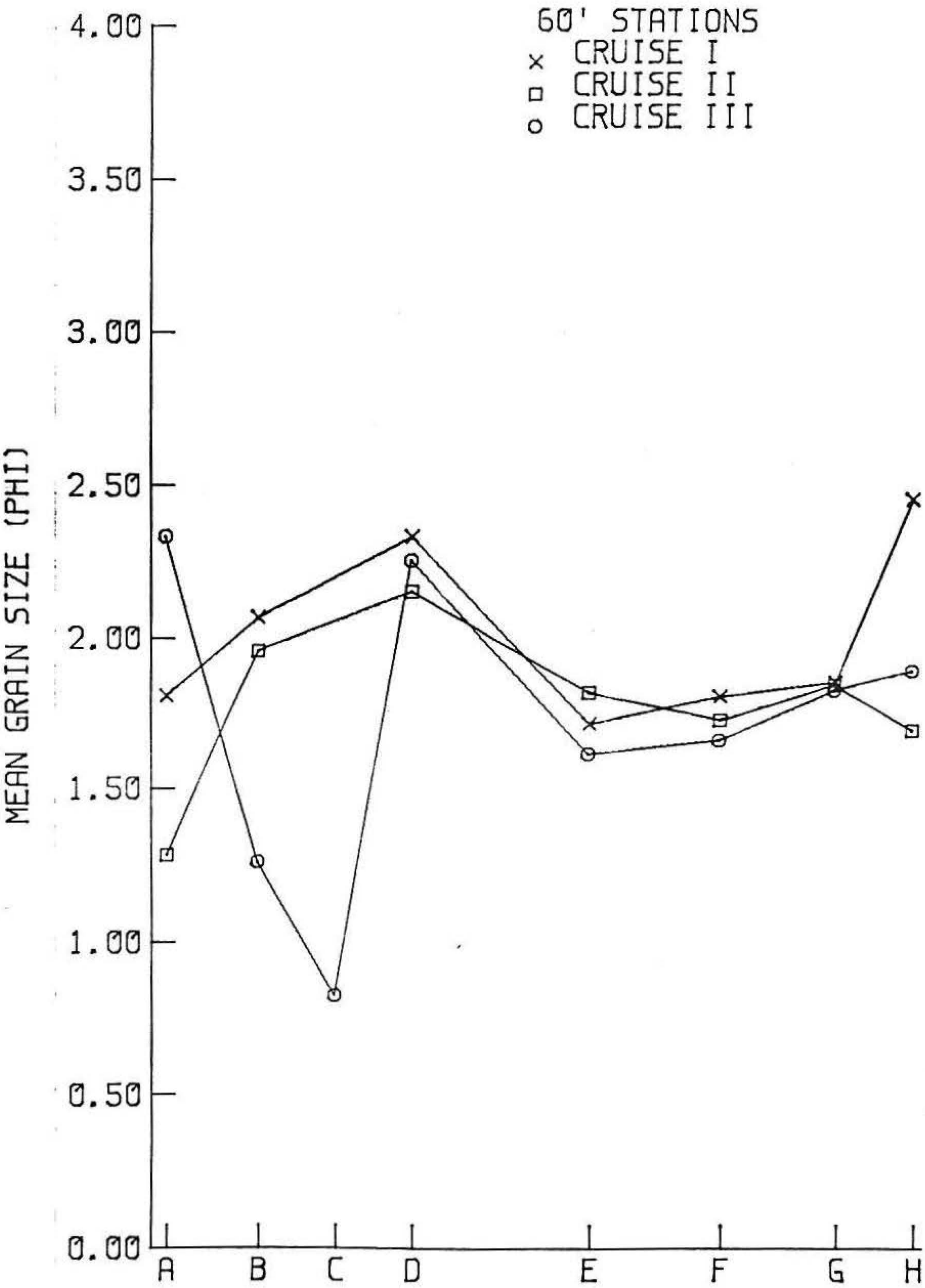

40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
MEAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
A
B
C
D
E
F
G
H

Figure 65


60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
MEAN GRAIN SIZE (PHI)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
A
B
C
D
E
F
G
H

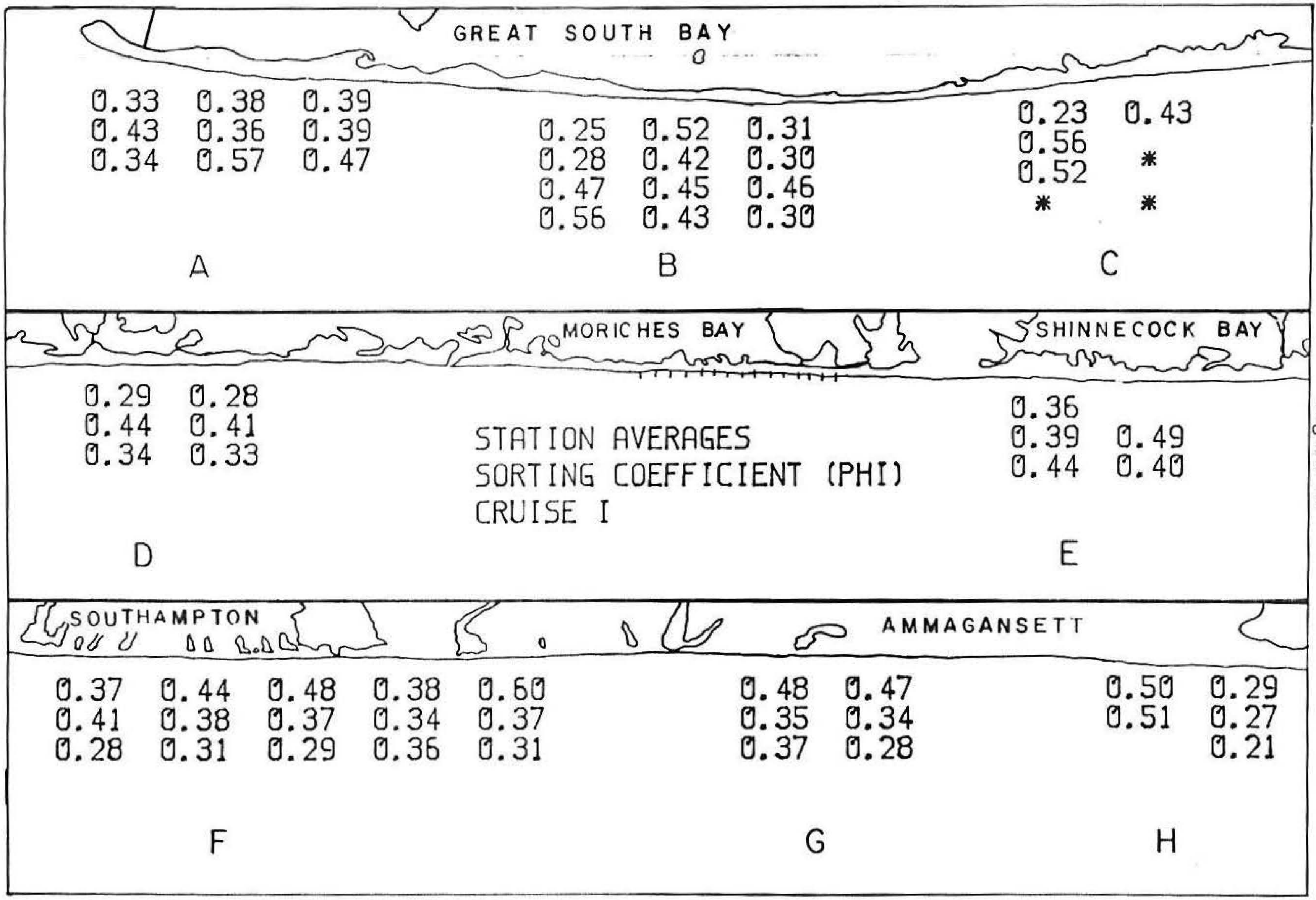

GREAT SOUTH BAY
0.33 0.38 0.39
0.43 0.36 0.39
0.34 0.57 0.47
A
0.25 0.52 0.31
0.28 0.42 0.30
0.47 0.45 0.46
0.56 0.43 0.30
B
0.23 0.43
0.56
0.52 *
* *
C
MORICHES BAY
SHINNECOCK BAY
0.29 0.28
0.44 0.41
0.34 0.33
D
STATION AVERAGES
SORTING COEFFICIENT (PHI)
CRUISE I
0.36
0.39 0.49
0.44 0.40
E
SOUTHAMPTON
AMMAGANSETT
0.37 0.44 0.48 0.38 0.60
0.41 0.38 0.37 0.34 0.37
0.28 0.31 0.29 0.36 0.31
F
0.48 0.47
0.35 0.34
0.37 0.28
G
0.50 0.29
0.51 0.27
0.21
H

Figure 66

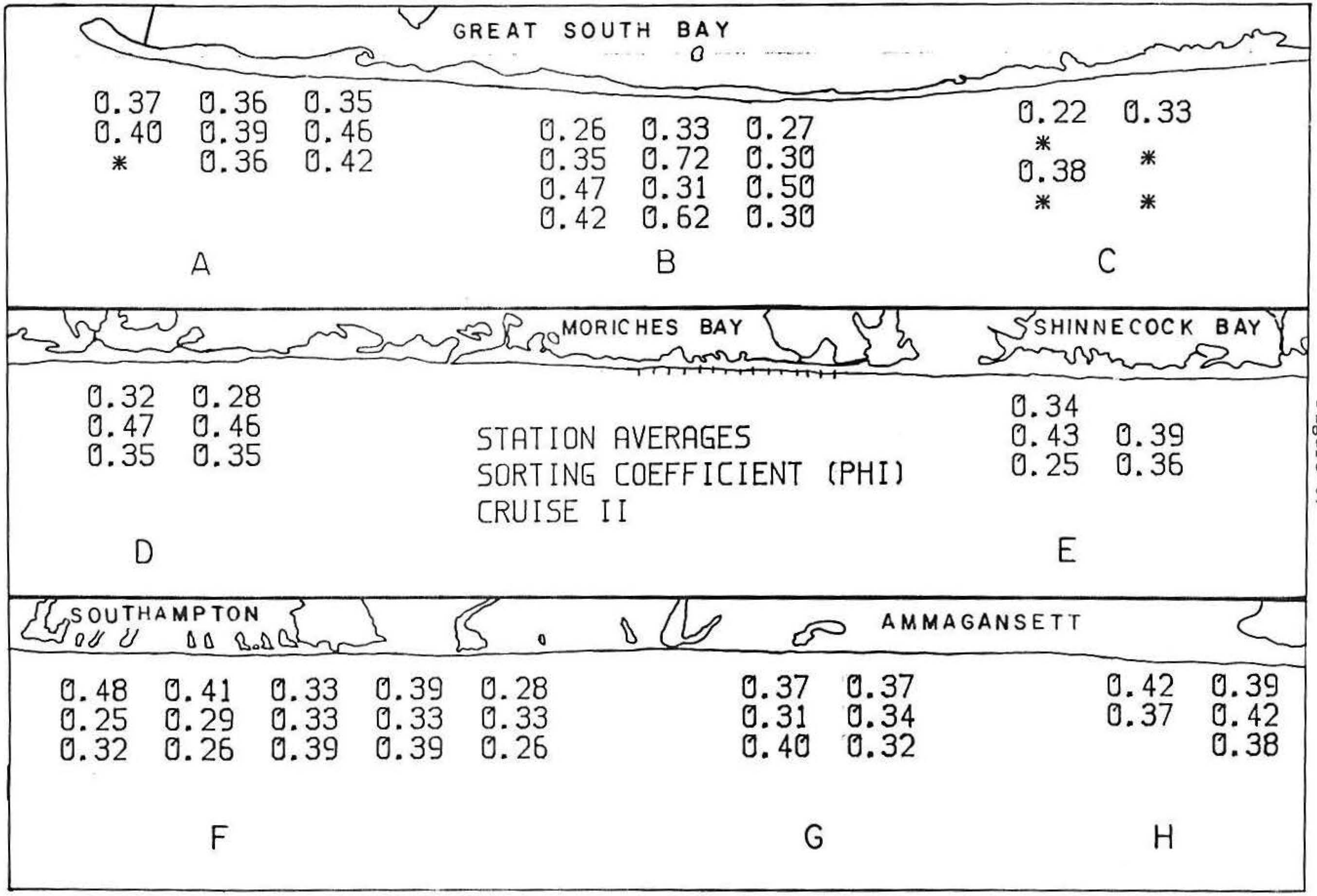

GREAT SOUTH BAY
0.37 0.36 0.35
0.40 0.39 0.46
* 0.36 0.42
A
0.26 0.33 0.27
0.35 0.72 0.30
0.47 0.31 0.50
0.42 0.62 0.30
B
0.22 0.33
*
0.38 *
* *
C
MORICHES BAY
SHINNECOCK BAY
0.32 0.28
0.47 0.46
0.35 0.35
D
STATION AVERAGES
SORTING COEFFICIENT (PHI)
CRUISE II
0.34
0.43 0.39
0.25 0.36
E
SOUTHAMPTON
AMMAGANSETT
0.48 0.41 0.33 0.39 0.28
0.25 0.29 0.33 0.33 0.33
0.32 0.26 0.39 0.39 0.26
F
0.37 0.37
0.31 0.34
0.40 0.32
G
0.42 0.39
0.37 0.42
0.38
H

Figure 67

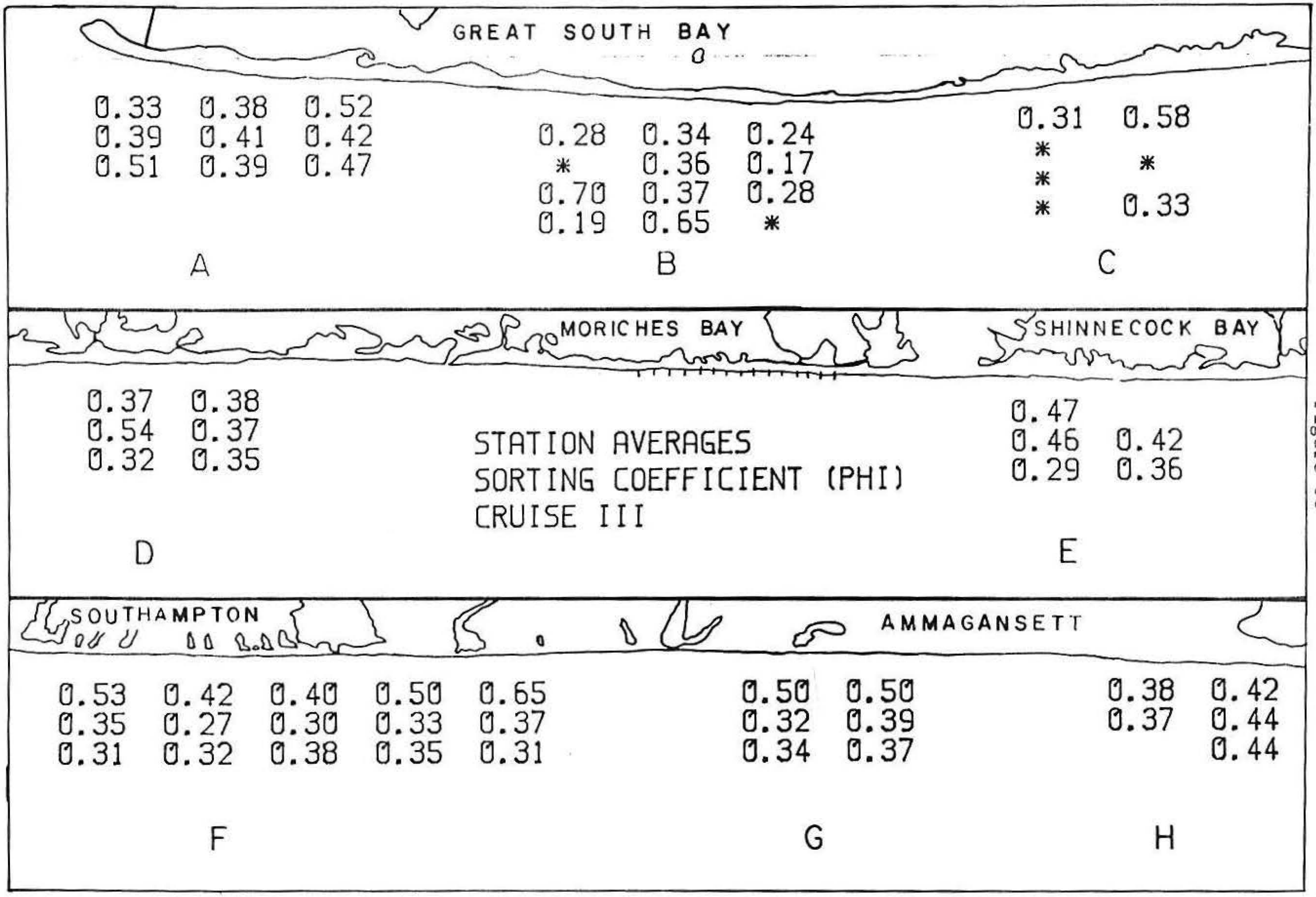

GREAT SOUTH BAY
0.33 0.38 0.52
0.39 0.41 0.42
0.51 0.39 0.47
A
0.28 0.34 0.24
* 0.36 0.17
0.70 0.37 0.28
0.19 0.65 *
B
0.31 0.58
* *
*
* 0.33
C
MORICHES BAY
SHINNECOCK BAY
0.37 0.38
0.54 0.37
0.32 0.35
D
STATION AVERAGES
SORTING COEFFICIENT (PHI)
CRUISE III
0.47
0.46 0.42
0.29 0.36
E
SOUTHAMPTON
AMMAGANSETT
0.53 0.42 0.40 0.50 0.65
0.35 0.27 0.30 0.33 0.37
0.31 0.32 0.38 0.35 0.31
F
0.50 0.50
0.32 0.39
0.34 0.37
G
0.38 0.42
0.37 0.44
0.44
H

Figure 68

Figure 69

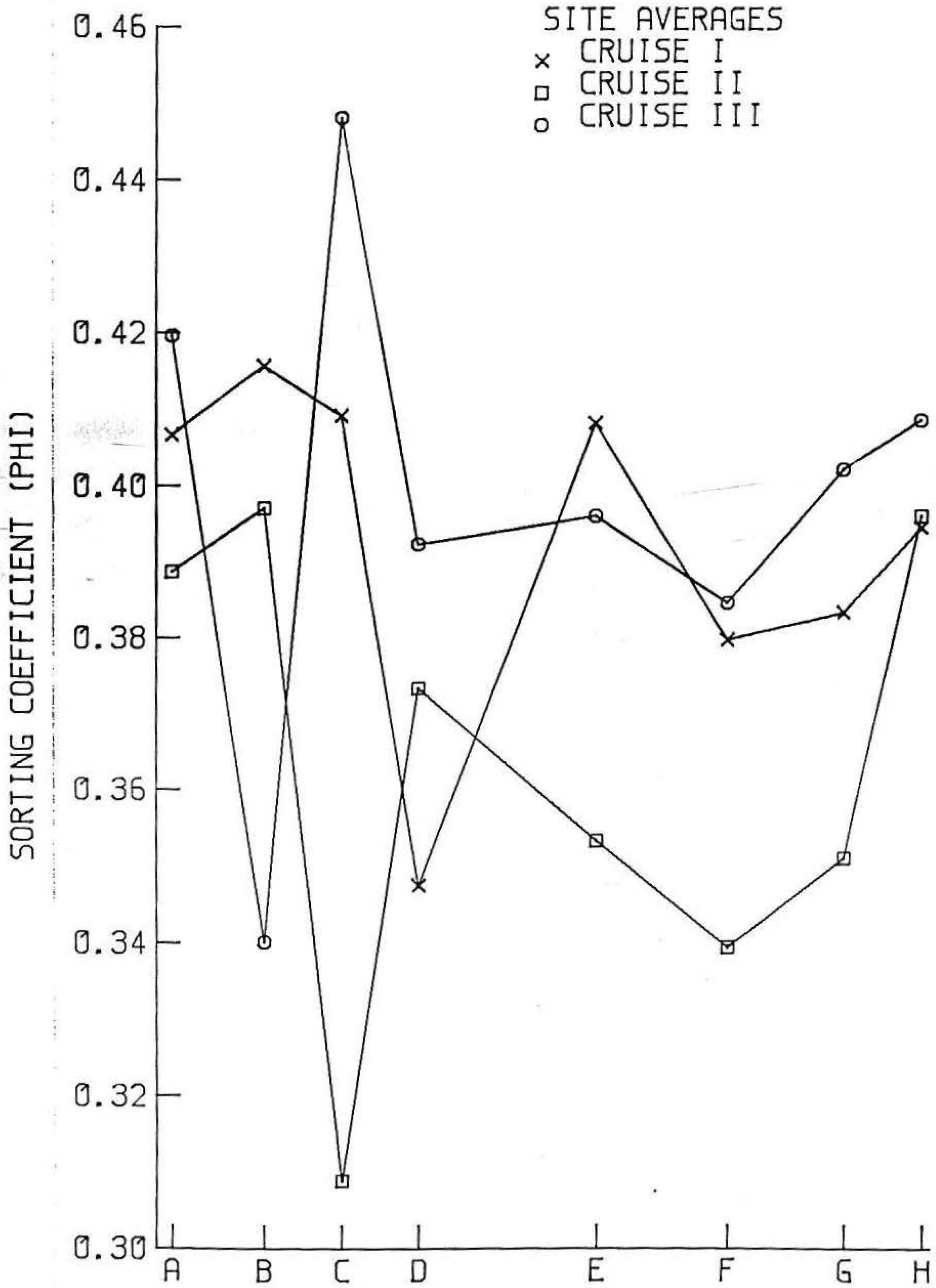

SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
SORTING COEFFICIENT (PHI)
0.46
0.44
0.42
0.40
0.38
0.36
0.34
0.32
0.30
A
B
C
D
E
F
G
H

Figure 70

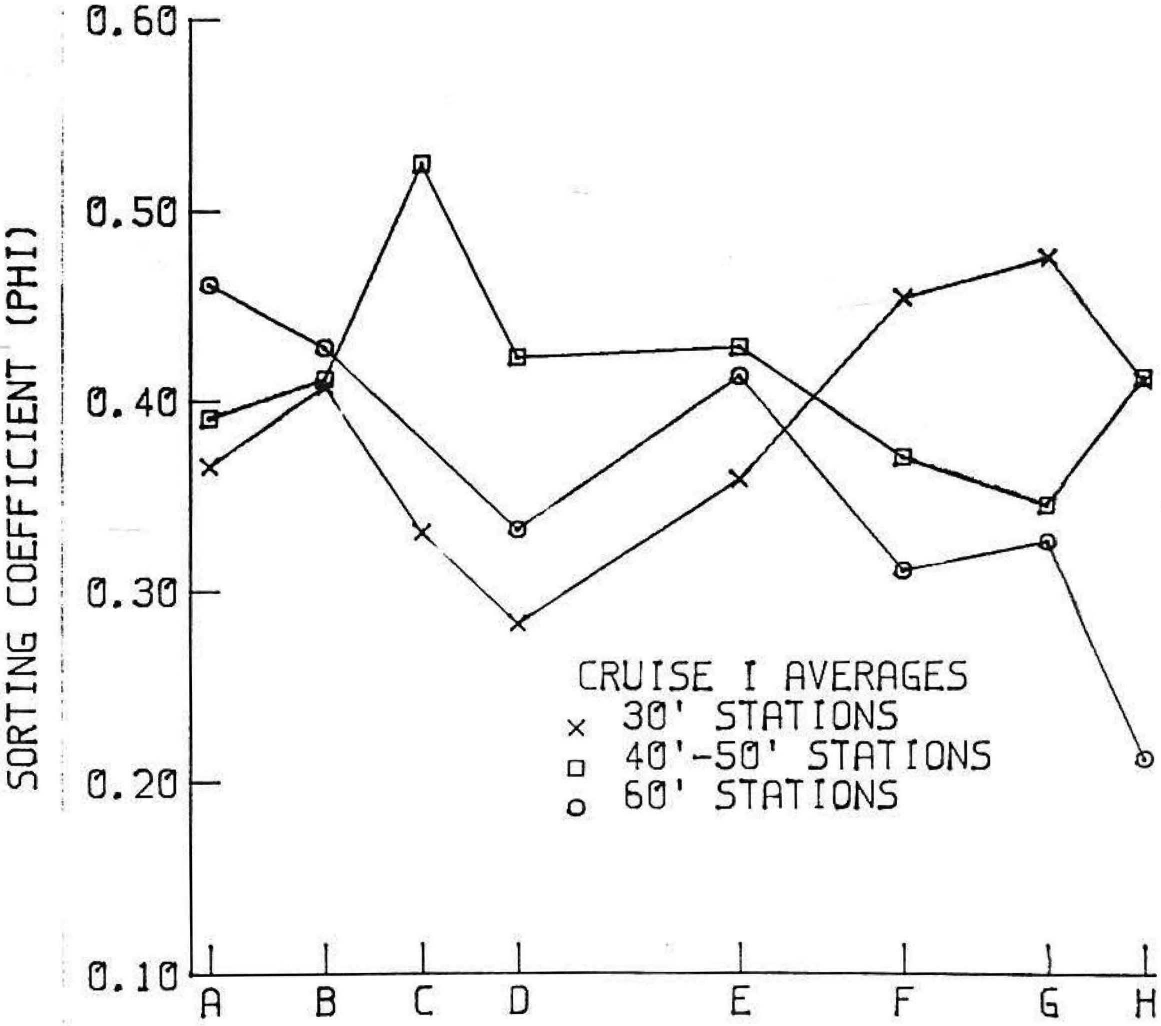

0.60
0.50
0.40
0.30
0.20
0.10
SORTING COEFFICIENT (PHI)
A
B
C
D
E
F
G
H
CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS

Figure 71

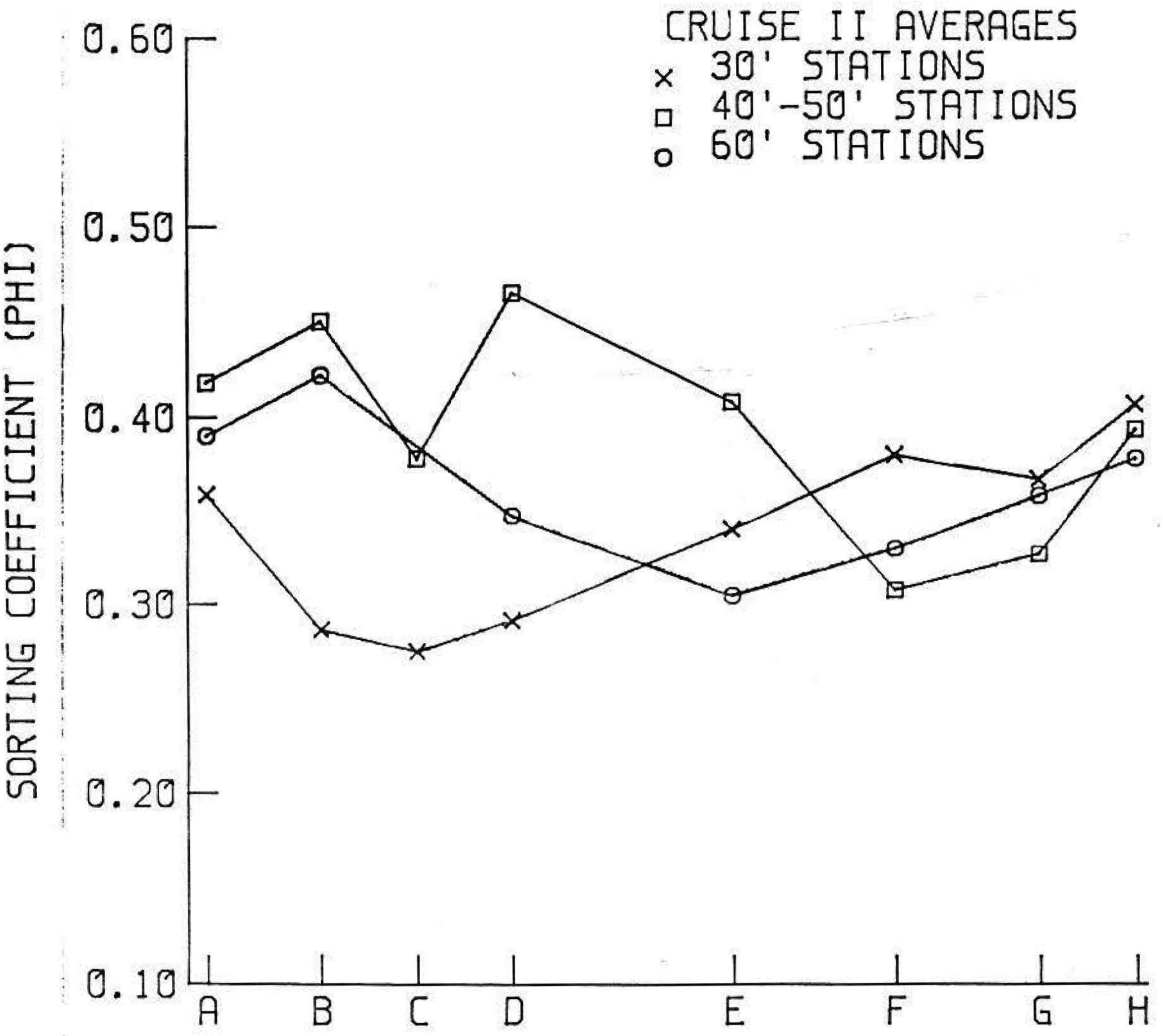

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
SORTING COEFFICIENT (PHI)
0.60
0.50
0.40
0.30
0.20
0.10
A
B
C
D
E
F
G
H

Figure 72

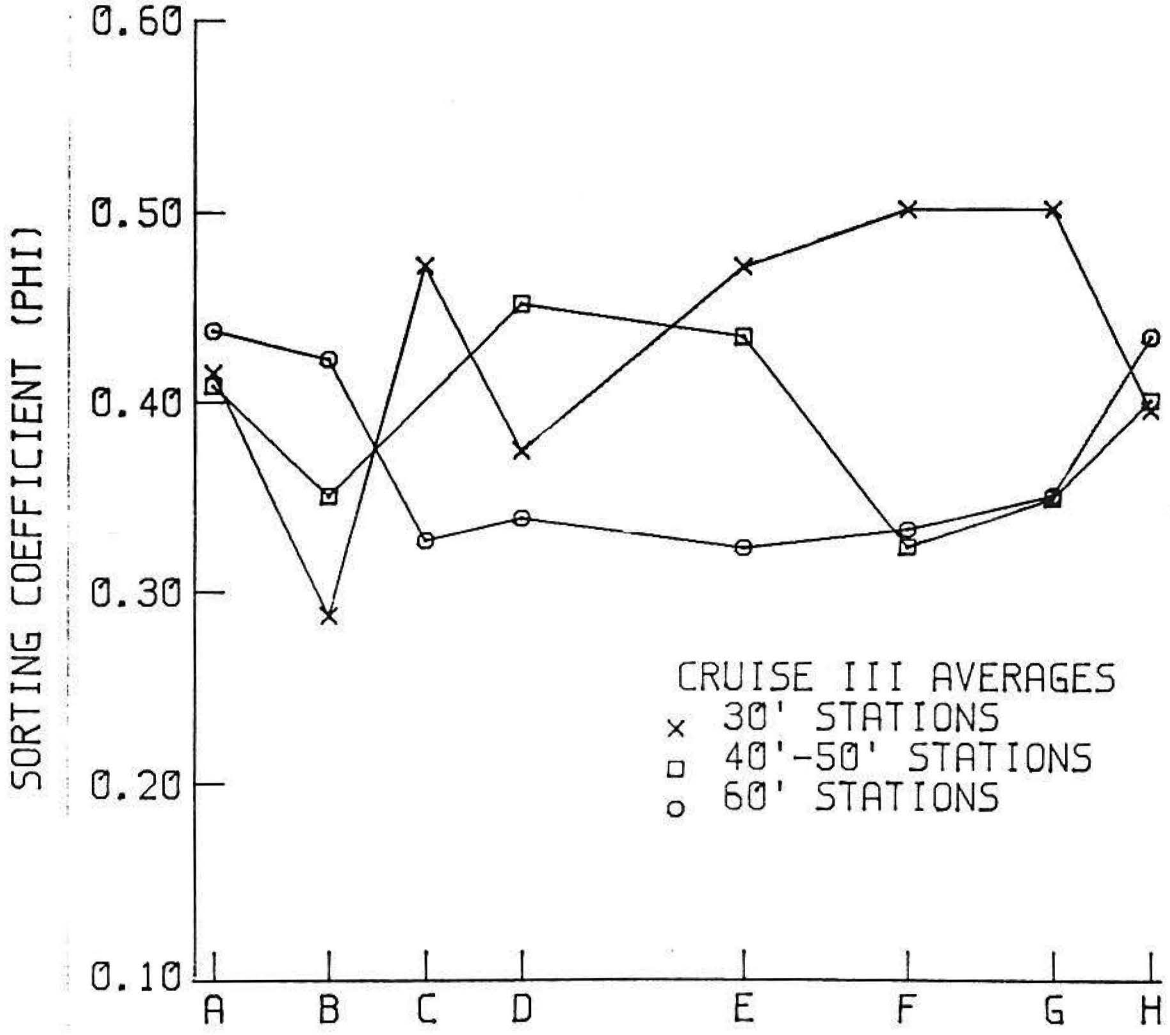

SORTING COEFFICIENT (PHI)
0.60
0.50
0.40
0.30
0.20
0.10
A
B
C
D
E
F
G
H
CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS

Figure 73

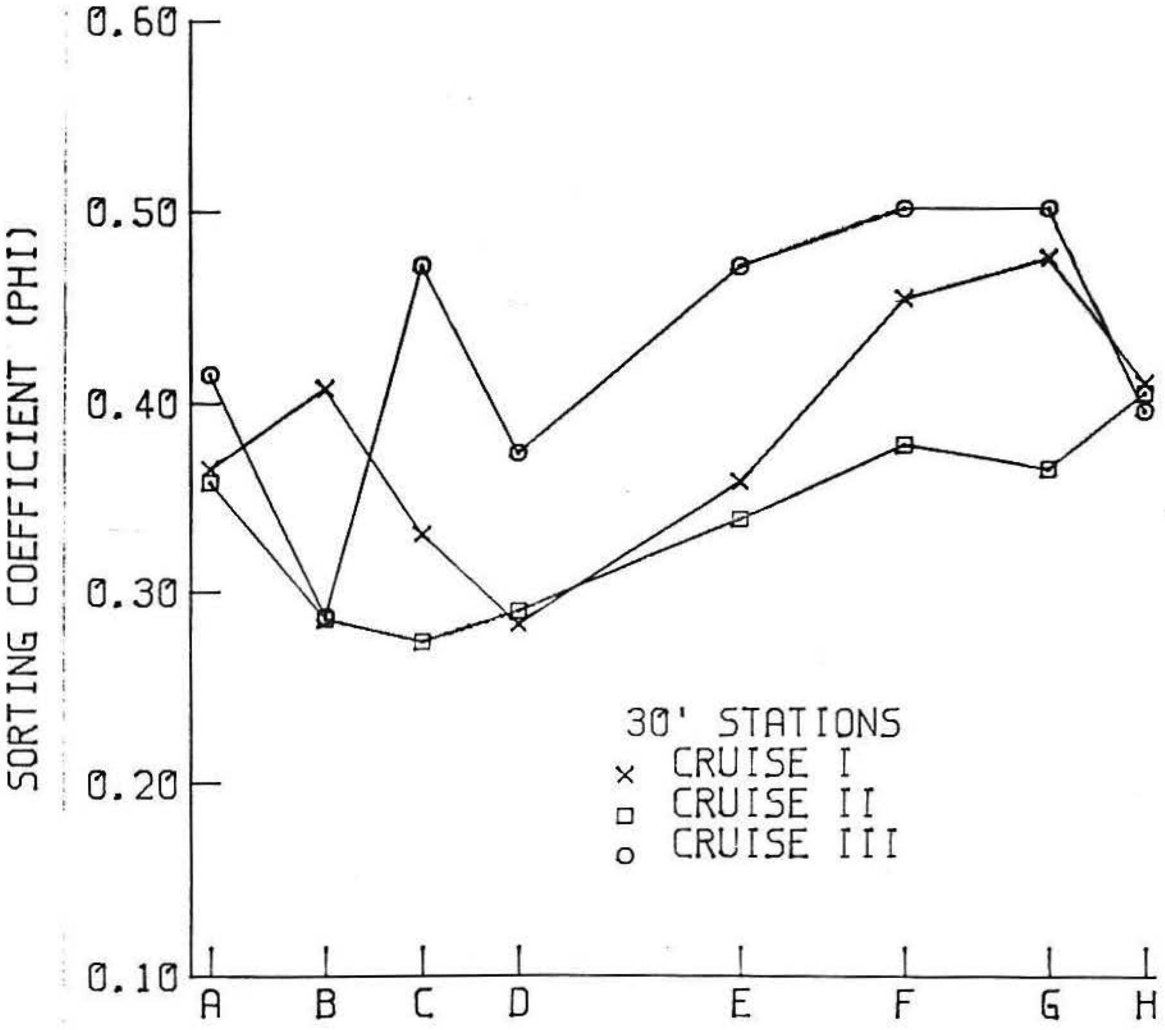

0.60
0.50
0.40
0.30
0.20
0.10
SORTING COEFFICIENT (PHI)
A
B
C
D
E
F
G
H
30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 74

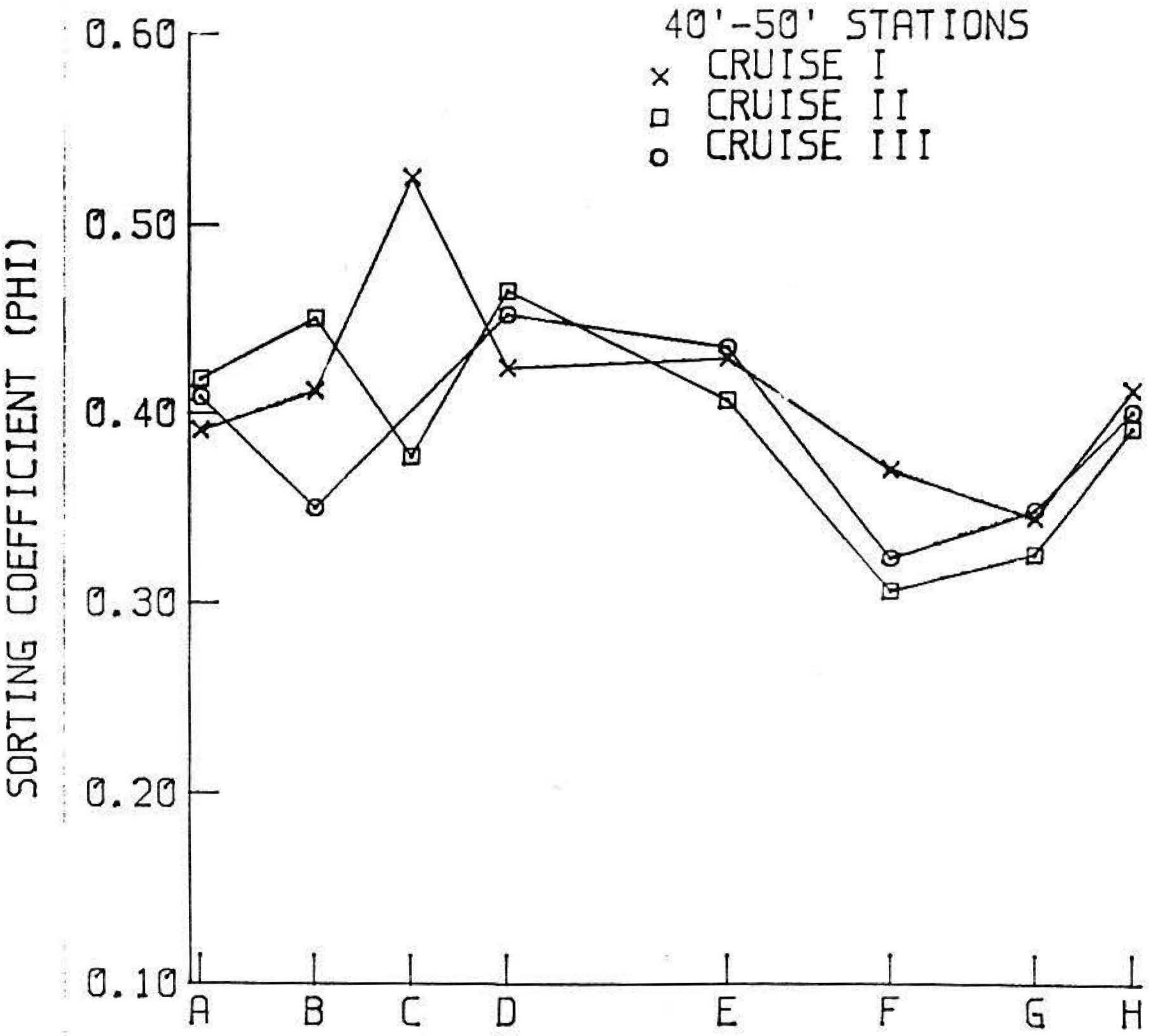
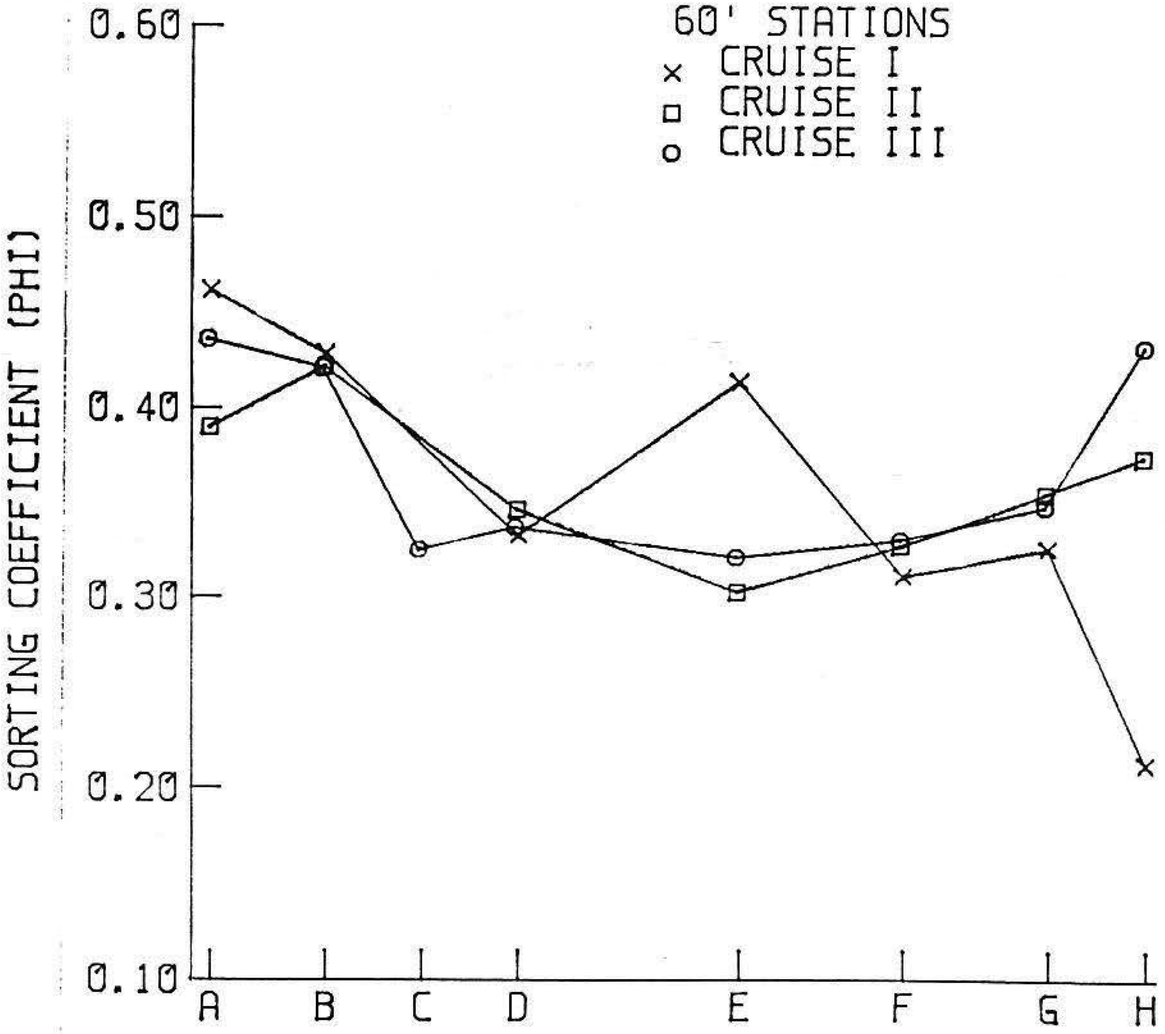

40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
SORTING COEFFICIENT (PHI)
0.60
0.50
0.40
0.30
0.20
0.10
A
B
C
D
E
F
G
H

Figure 75


60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
SORTING COEFFICIENT (PHI)
0.60
0.50
0.40
0.30
0.20
0.10
A
B
C
D
E
F
G
H

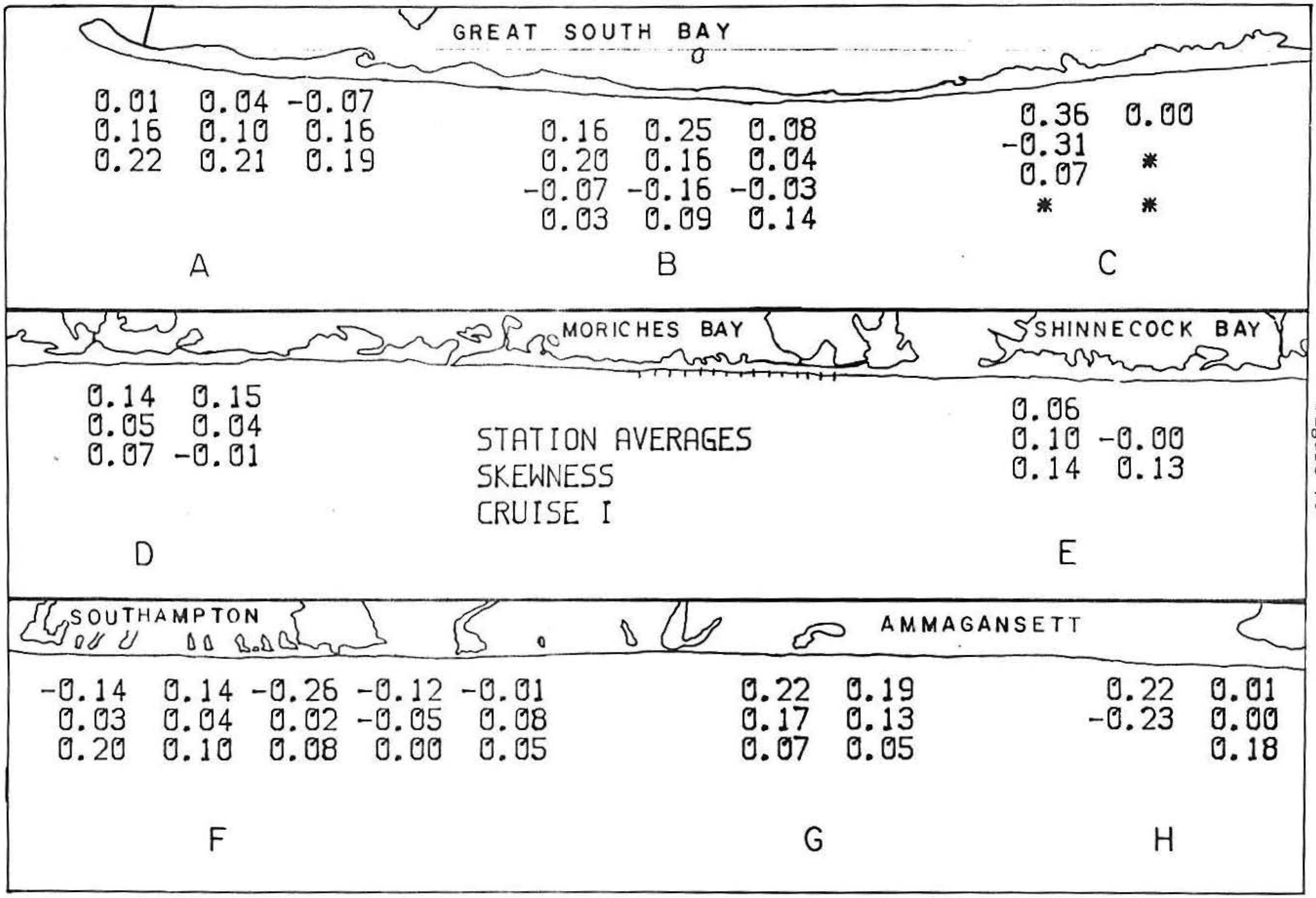

GREAT SOUTH BAY
0.01 0.04 -0.07
0.16 0.10 0.16
0.22 0.21 0.19
A
0.16 0.25 0.08
0.20 0.16 0.04
-0.07 -0.16 -0.03
0.03 0.09 0.14
B
0.36 0.00
-0.31 *
0.07 *
* *
C
MORICHES BAY
SHINNECOCK BAY
0.14 0.15
0.05 0.04
0.07 -0.01
D
STATION AVERAGES
SKEWNESS
CRUISE I
0.06
0.10 -0.00
0.14 0.13
E
SOUTHAMPTON
AMMAGANSETT
-0.14 0.14 -0.26 -0.12 -0.01
0.03 0.04 0.02 -0.05 0.08
0.20 0.10 0.08 0.00 0.05
F
0.22 0.19
0.17 0.13
0.07 0.05
G
0.22 0.01
-0.23 0.00
0.18
H

Figure 76

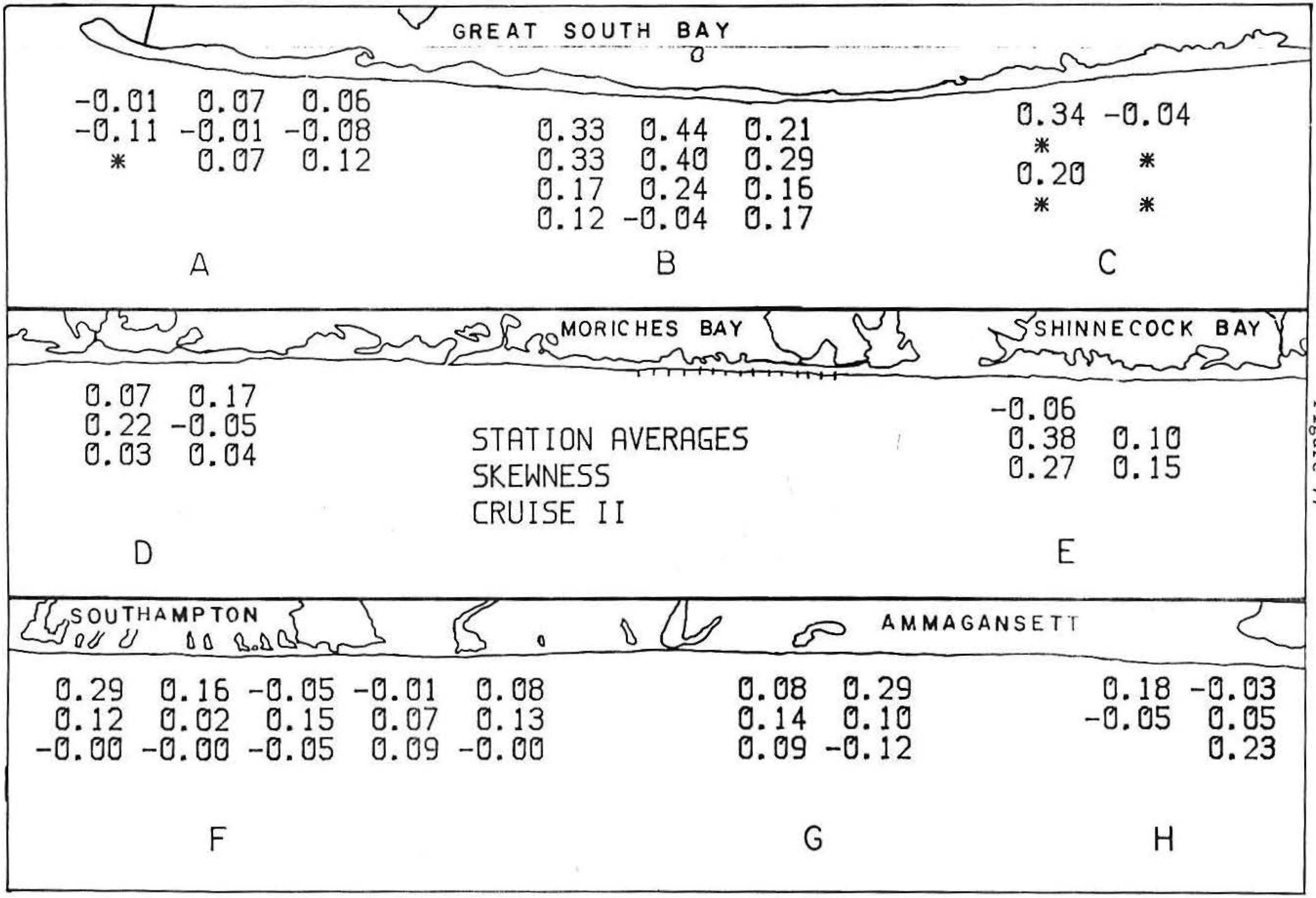

GREAT SOUTH BAY
-0.01 0.07 0.06
-0.11 -0.01 -0.08
* 0.07 0.12
A
0.33 0.44 0.21
0.33 0.40 0.29
0.17 0.24 0.16
0.12 -0.04 0.17
B
0.34 -0.04
*
0.20 *
* *
C
MORICHES BAY
SHINNECOCK BAY
0.07 0.17
0.22 -0.05
0.03 0.04
D
STATION AVERAGES
SKEWNESS
CRUISE II
-0.06
0.38 0.10
0.27 0.15
E
SOUTHAMPTON
AMMAGANSETT
0.29 0.16 -0.05 -0.01 0.08
0.12 0.02 0.15 0.07 0.13
-0.00 -0.00 -0.05 0.09 -0.00
F
0.08 0.29
0.14 0.10
0.09 -0.12
G
0.18 -0.03
-0.05 0.05
0.23
H

Figure 77

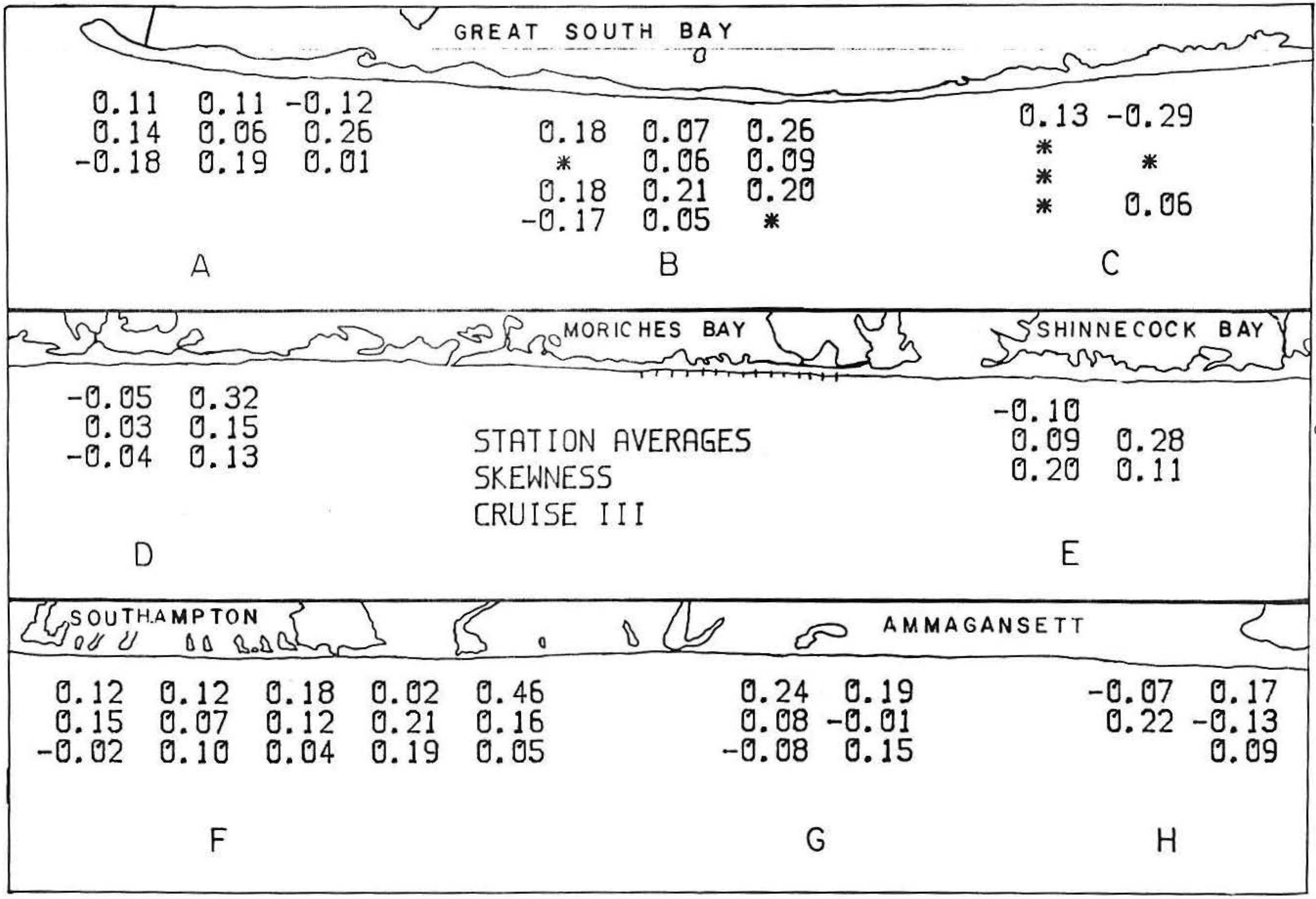

GREAT SOUTH BAY
0.11 0.11 -0.12
0.14 0.06 0.26
-0.18 0.19 0.01
A
0.18 0.07 0.26
* 0.06 0.09
0.18 0.21 0.20
-0.17 0.05 *
B
0.13 -0.29
*
* *
* 0.06
C
MORICHES BAY
SHINNECOCK BAY
-0.05 0.32
0.03 0.15
-0.04 0.13
D
STATION AVERAGES
SKEWNESS
CRUISE III
-0.10
0.09 0.28
0.20 0.11
E
SOUTHAMPTON
AMMAGANSETT
0.12 0.12 0.18 0.02 0.46
0.15 0.07 0.12 0.21 0.16
-0.02 0.10 0.04 0.19 0.05
F
0.24 0.19
0.08 -0.01
-0.08 0.15
G
-0.07 0.17
0.22 -0.13
0.09
H

Figure 78

Figure 79

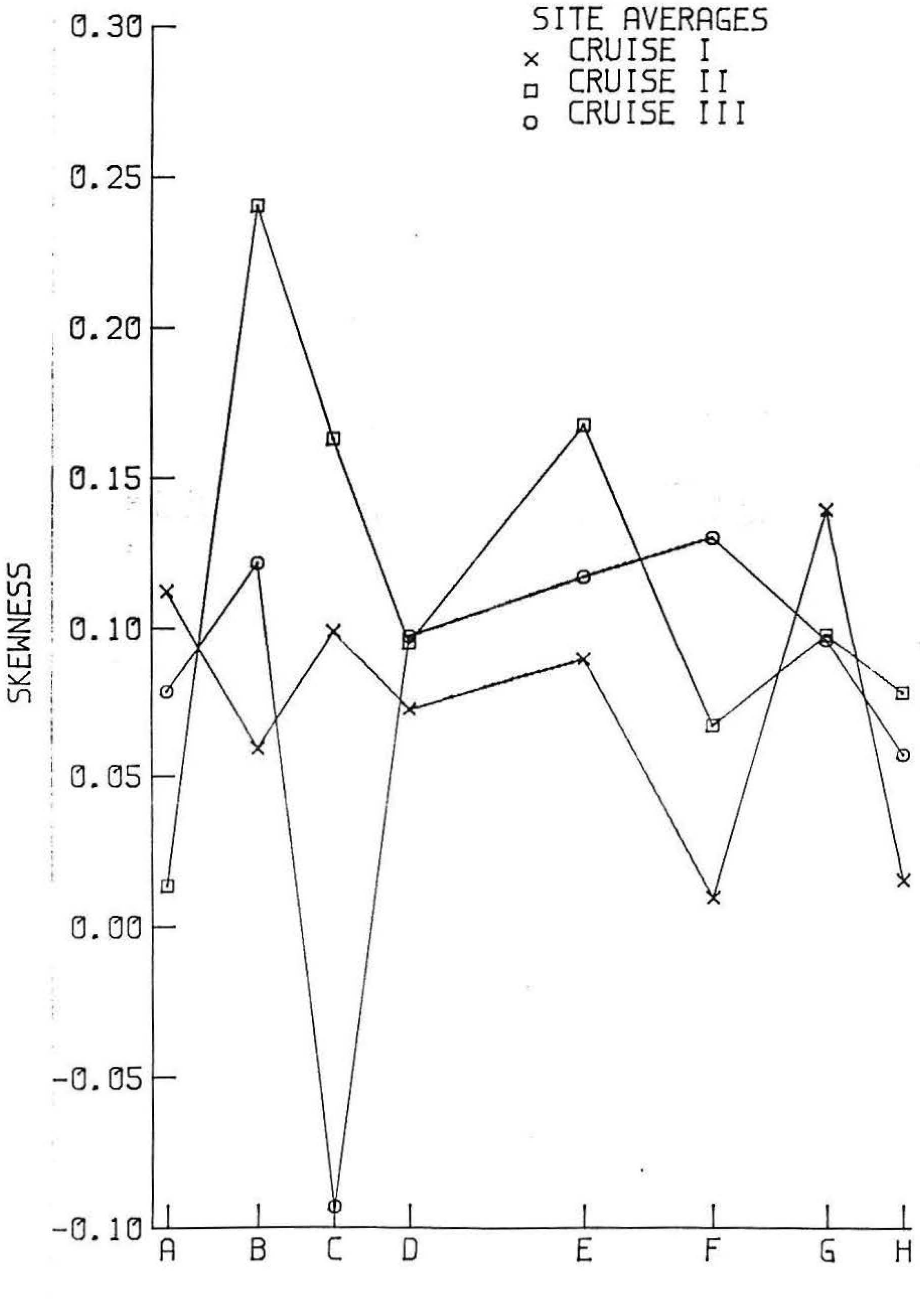

SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
SKEWNESS
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
A
B
C
D
E
F
G
H

Figure 80

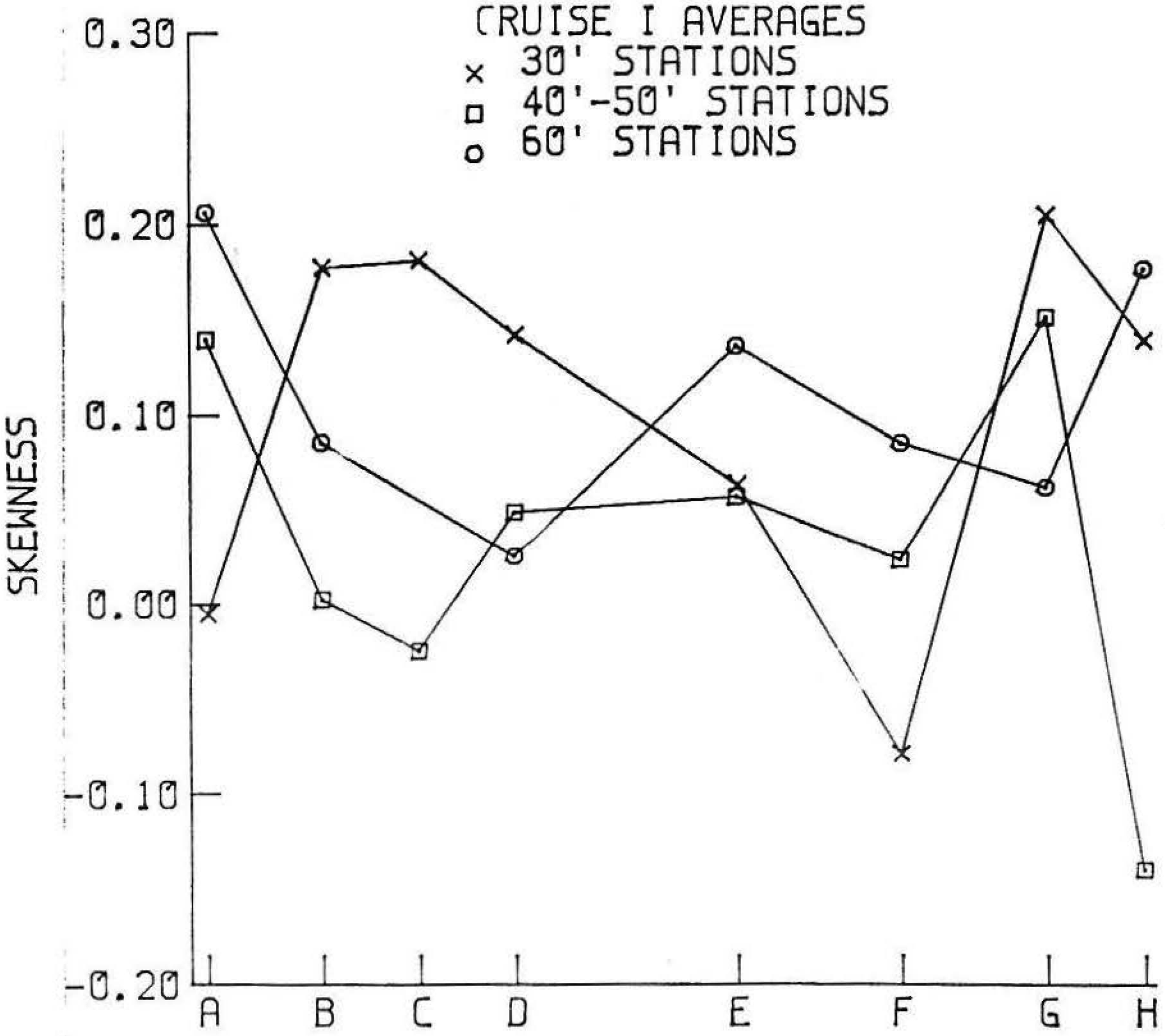

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
SKEWNESS
0.30
0.20
0.10
0.00
-0.10
-0.20
A
B
C
D
E
F
G
H

Figure 81

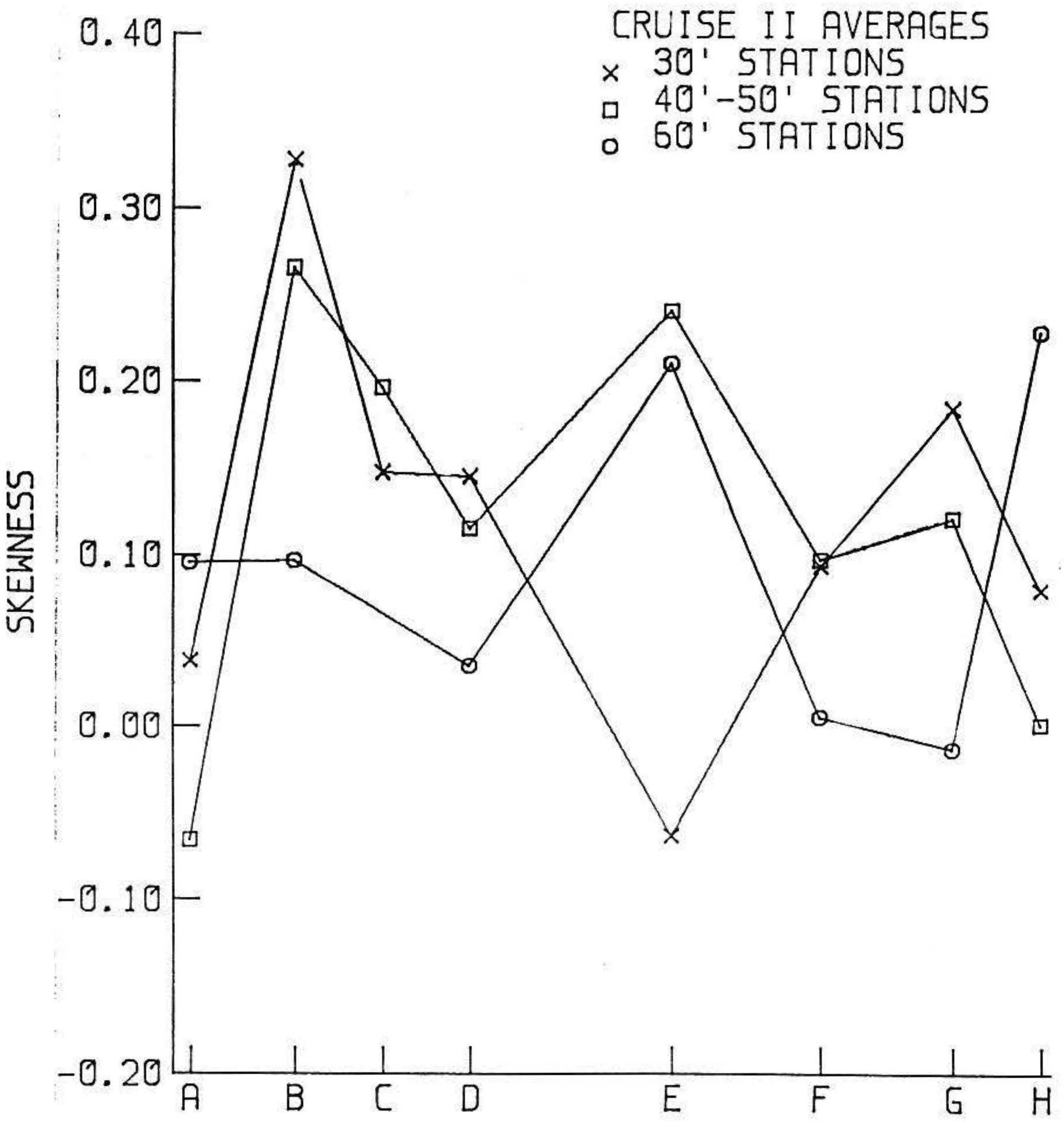

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
SKEWNESS
A
B
C
D
E
F
G
H

Figure 82

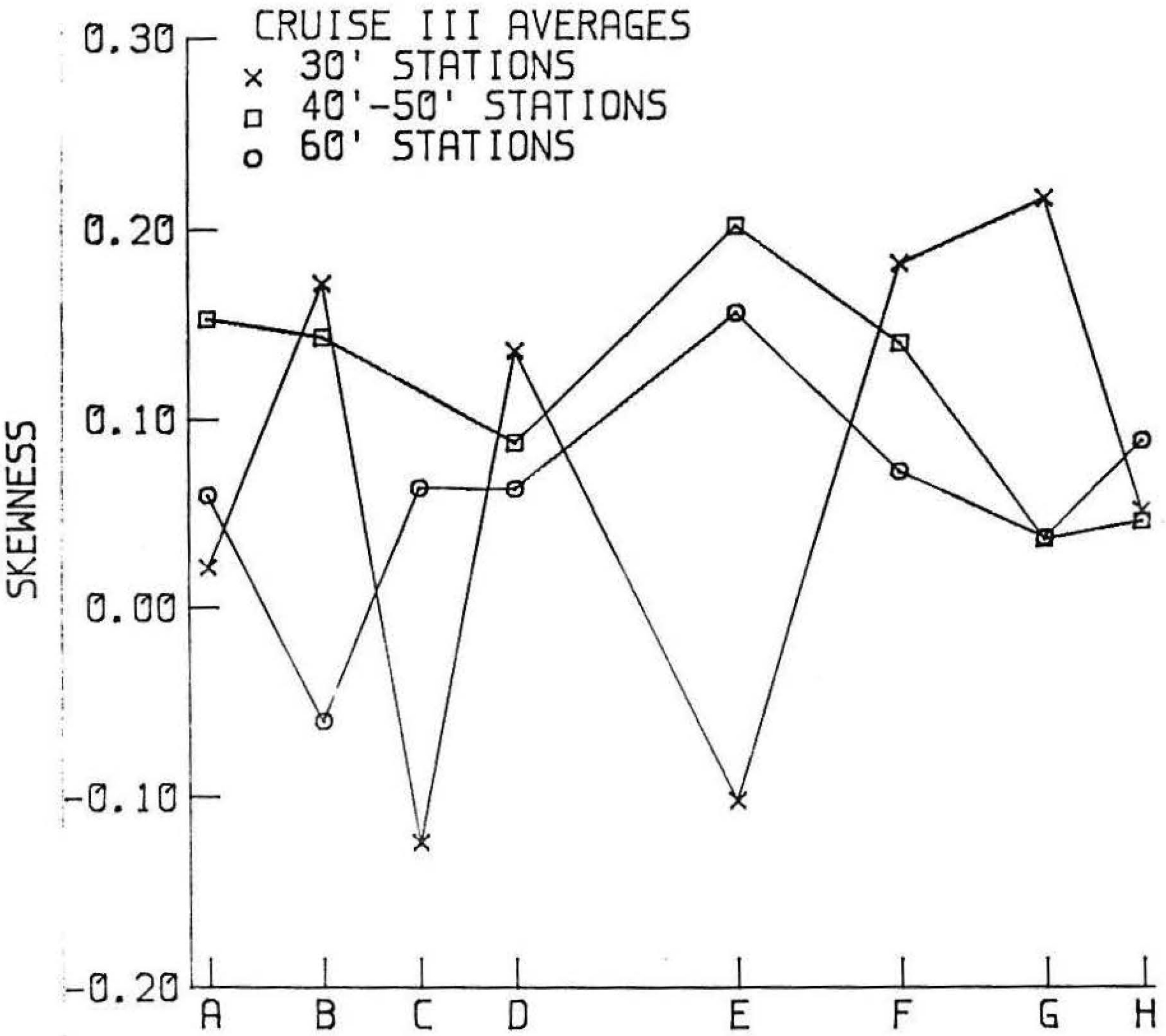

CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
SKEWNESS
0.30
0.20
0.10
0.00
-0.10
-0.20
A
B
C
D
E
F
G
H

Figure 83

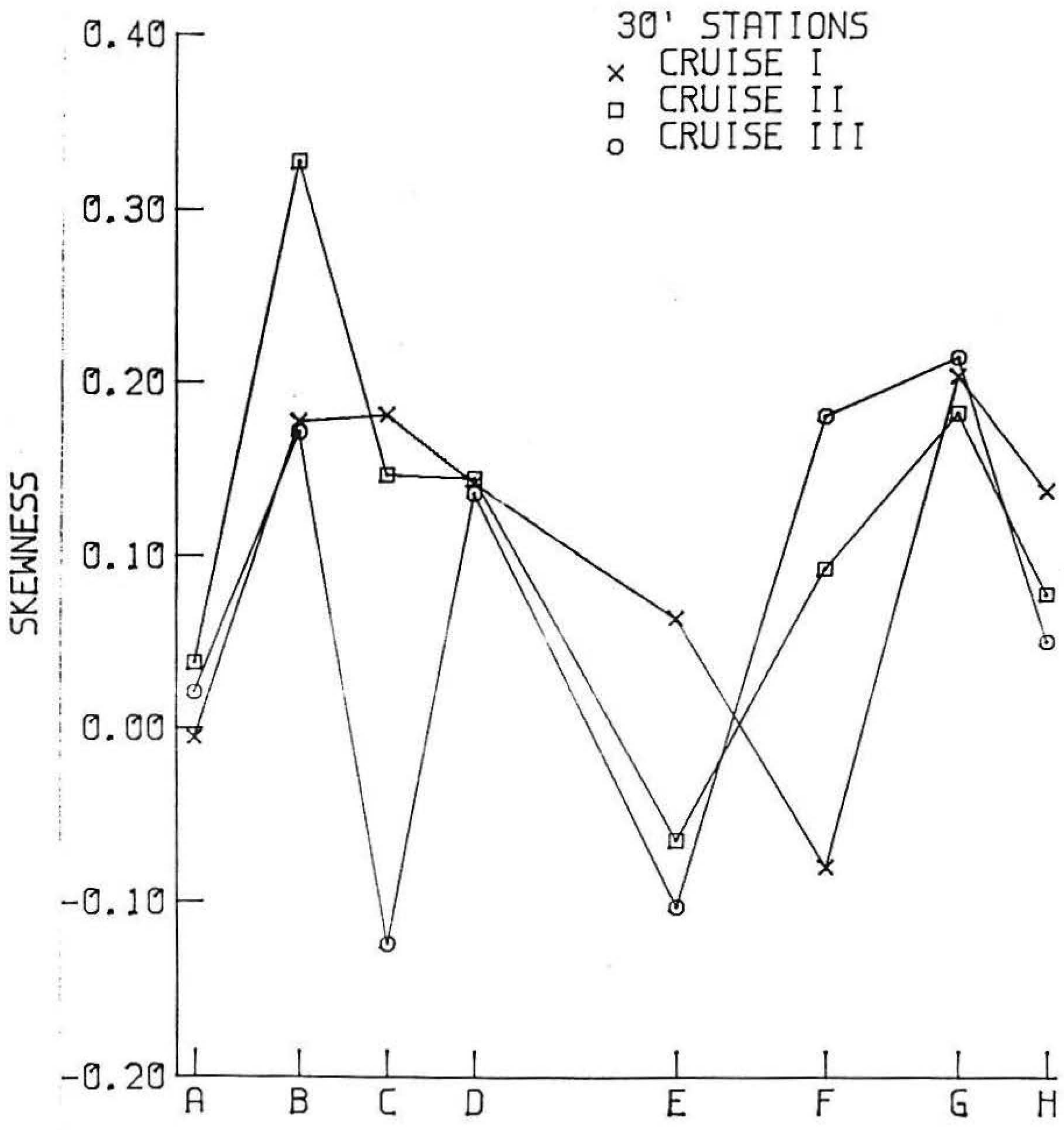

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
SKEWNESS
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
A
B
C
D
E
F
G
H

Figure 84

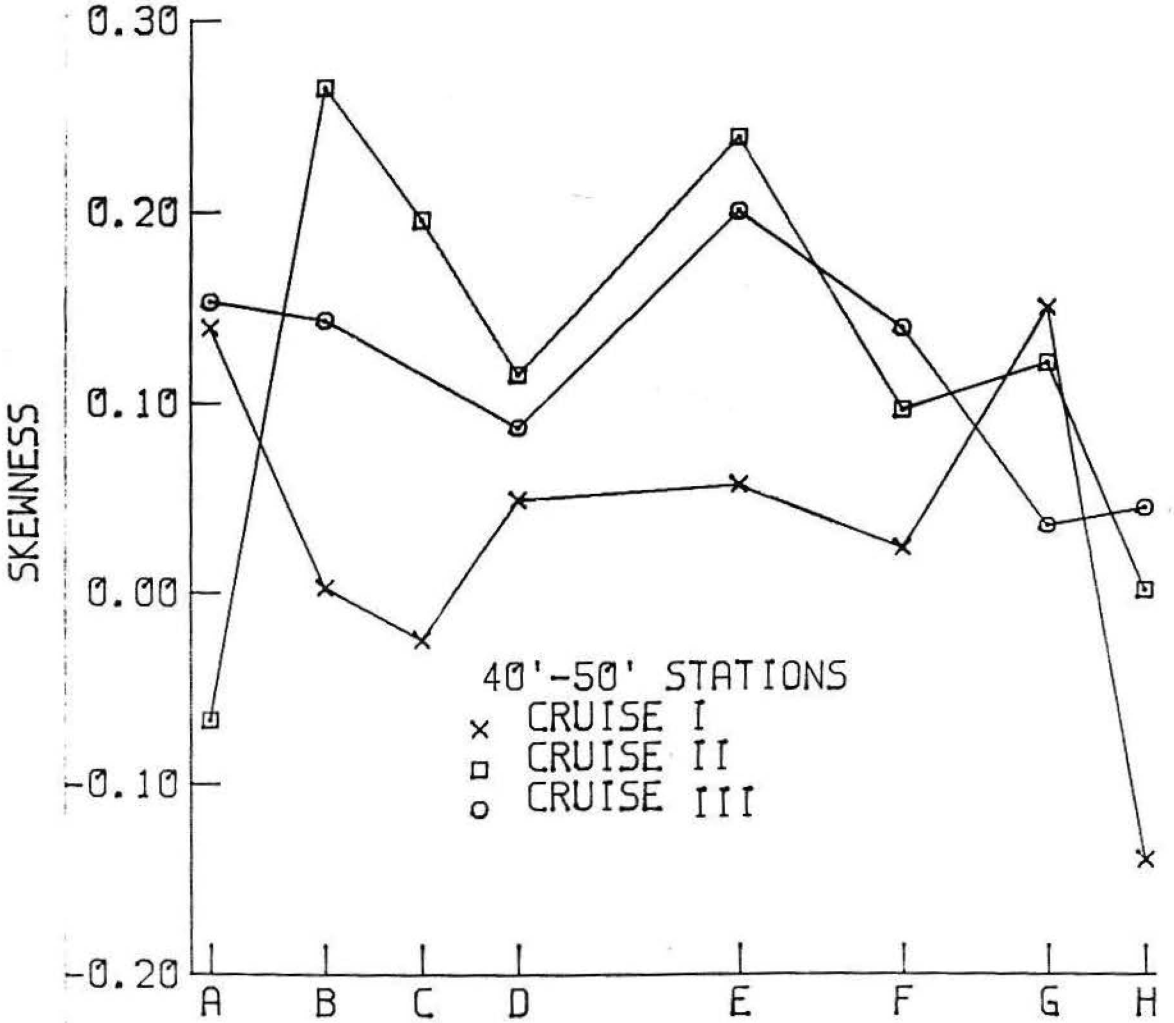
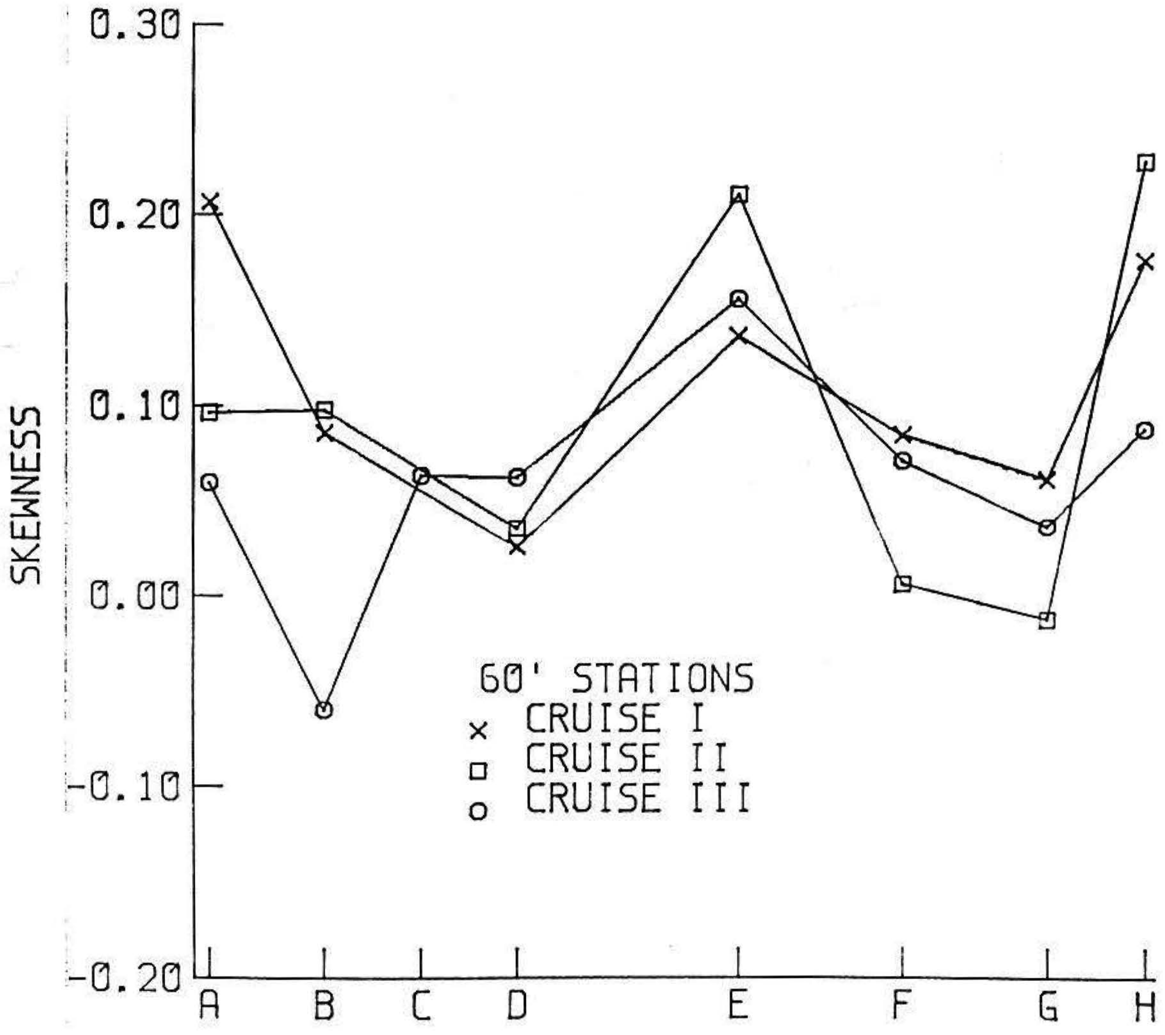

0.30
0.20
0.10
0.00
-0.10
-0.20
SKEWNESS
A
B
C
D
E
F
G
H
40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 85


0.30
0.20
0.10
0.00
-0.10
-0.20
SKEWNESS
A
B
C
D
E
F
G
H
60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

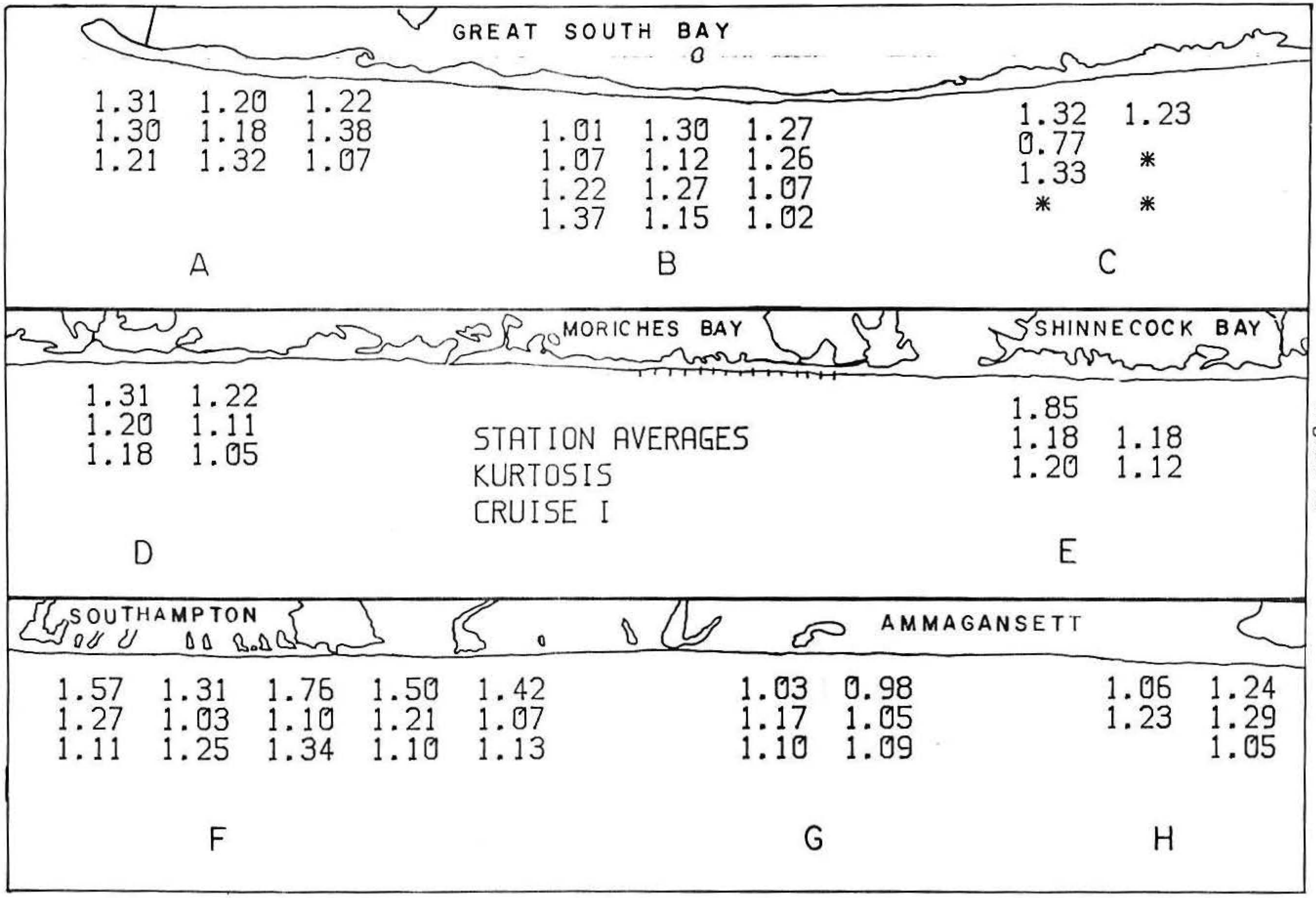

GREAT SOUTH BAY
MORICHES BAY
SHINNECOCK BAY
SOUTHAMPTON
AMMAGANSETT
STATION AVERAGES
KURTOSIS
CRUISE I
A
1.31 1.20 1.22
1.30 1.18 1.38
1.21 1.32 1.07
B
1.01 1.30 1.27
1.07 1.12 1.26
1.22 1.27 1.07
1.37 1.15 1.02
C
1.32 1.23
0.77
1.33 *
* *
D
1.31 1.22
1.20 1.11
1.18 1.05
E
1.85
1.18 1.18
1.20 1.12
F
1.57 1.31 1.76 1.50 1.42
1.27 1.03 1.10 1.21 1.07
1.11 1.25 1.34 1.10 1.13
G
1.03 0.98
1.17 1.05
1.10 1.09
H
1.06 1.24
1.23 1.29
1.05

Figure 86

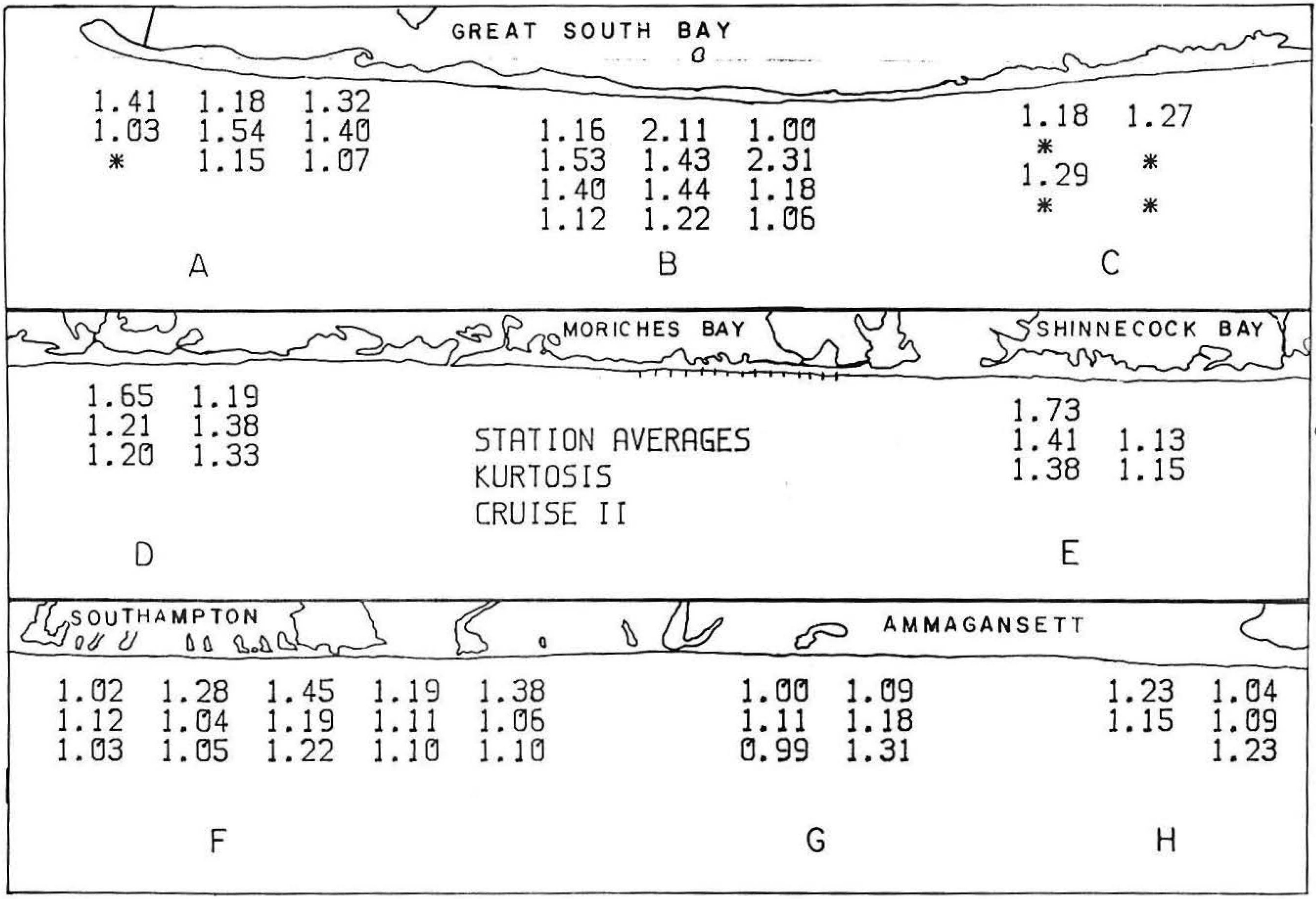

GREAT SOUTH BAY
1.41 1.18 1.32
1.03 1.54 1.40
* 1.15 1.07
A
1.16 2.11 1.00
1.53 1.43 2.31
1.40 1.44 1.18
1.12 1.22 1.06
B
1.18 1.27
*
1.29 *
* *
C
MORICHES BAY
SHINNECOCK BAY
1.65 1.19
1.21 1.38
1.20 1.33
D
STATION AVERAGES
KURTOSIS
CRUISE II
1.73
1.41 1.13
1.38 1.15
E
SOUTHAMPTON
AMMAGANSETT
1.02 1.28 1.45 1.19 1.38
1.12 1.04 1.19 1.11 1.06
1.03 1.05 1.22 1.10 1.10
F
1.00 1.09
1.11 1.18
0.99 1.31
G
1.23 1.04
1.15 1.09
1.23
H

Figure 87

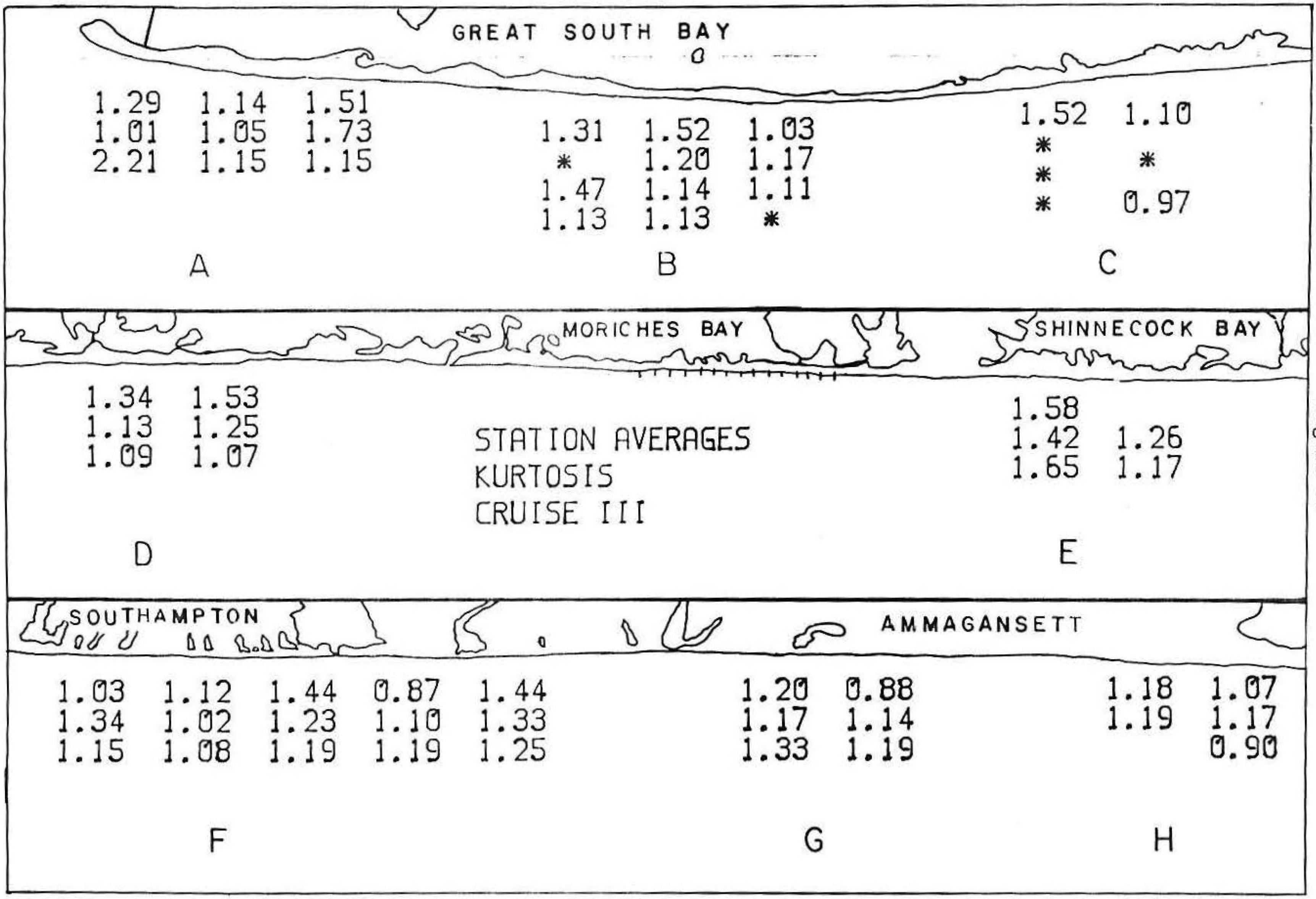

GREAT SOUTH BAY
1.29 1.14 1.51
1.01 1.05 1.73
2.21 1.15 1.15
A
1.31 1.52 1.03
* 1.20 1.17
1.47 1.14 1.11
1.13 1.13 *
B
1.52 1.10
* *
*
* 0.97
C
MORICHES BAY
SHINNECOCK BAY
1.34 1.53
1.13 1.25
1.09 1.07
D
STATION AVERAGES
KURTOSIS
CRUISE III
1.58
1.42 1.26
1.65 1.17
E
SOUTHAMPTON
AMMAGANSETT
1.03 1.12 1.44 0.87 1.44
1.34 1.02 1.23 1.10 1.33
1.15 1.08 1.19 1.19 1.25
F
1.20 0.88
1.17 1.14
1.33 1.19
G
1.18 1.07
1.19 1.17
0.90
H

Figure 88

Figure 89

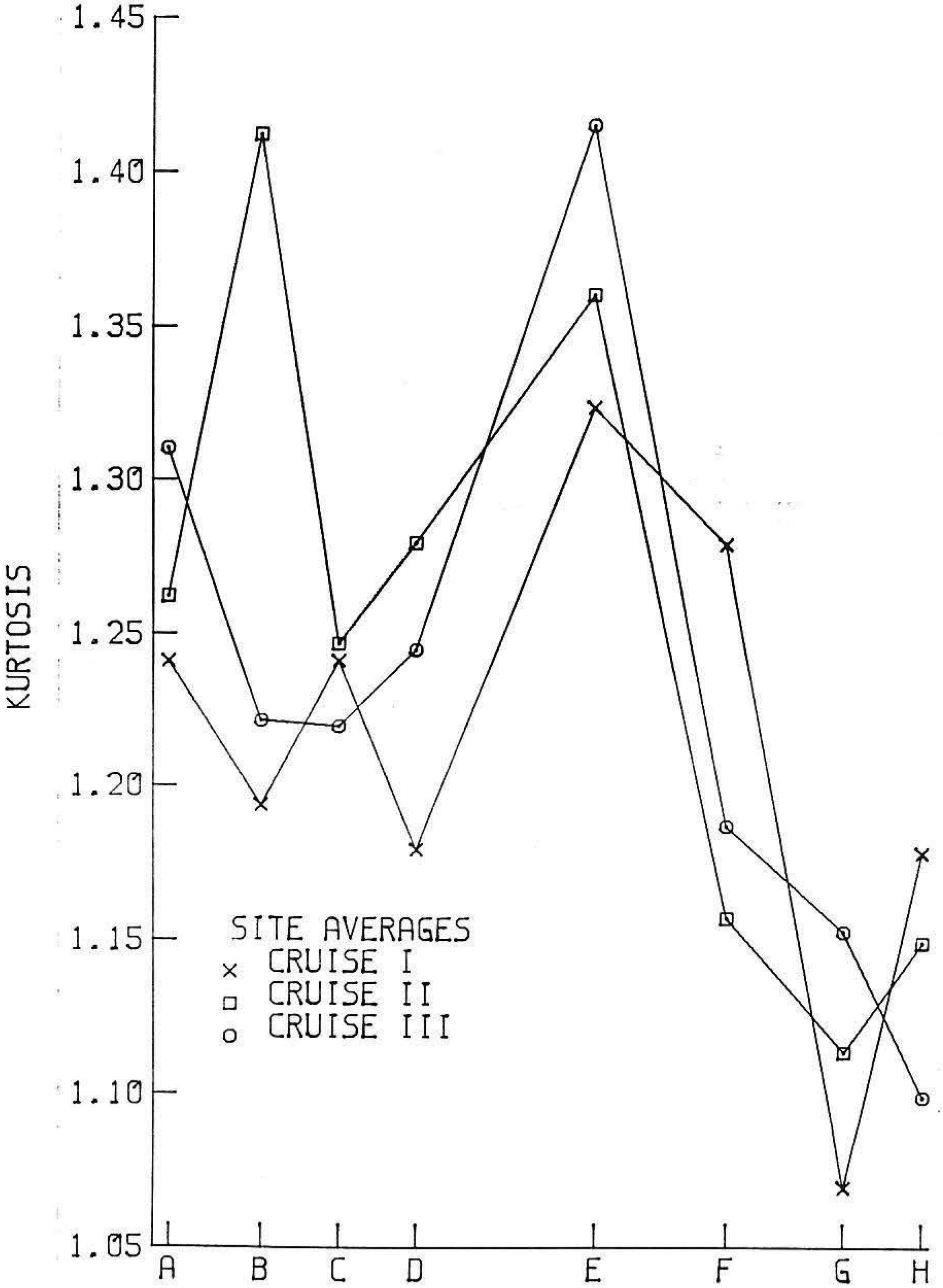

1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
KURTOSIS
A
B
C
D
E
F
G
H
SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 90

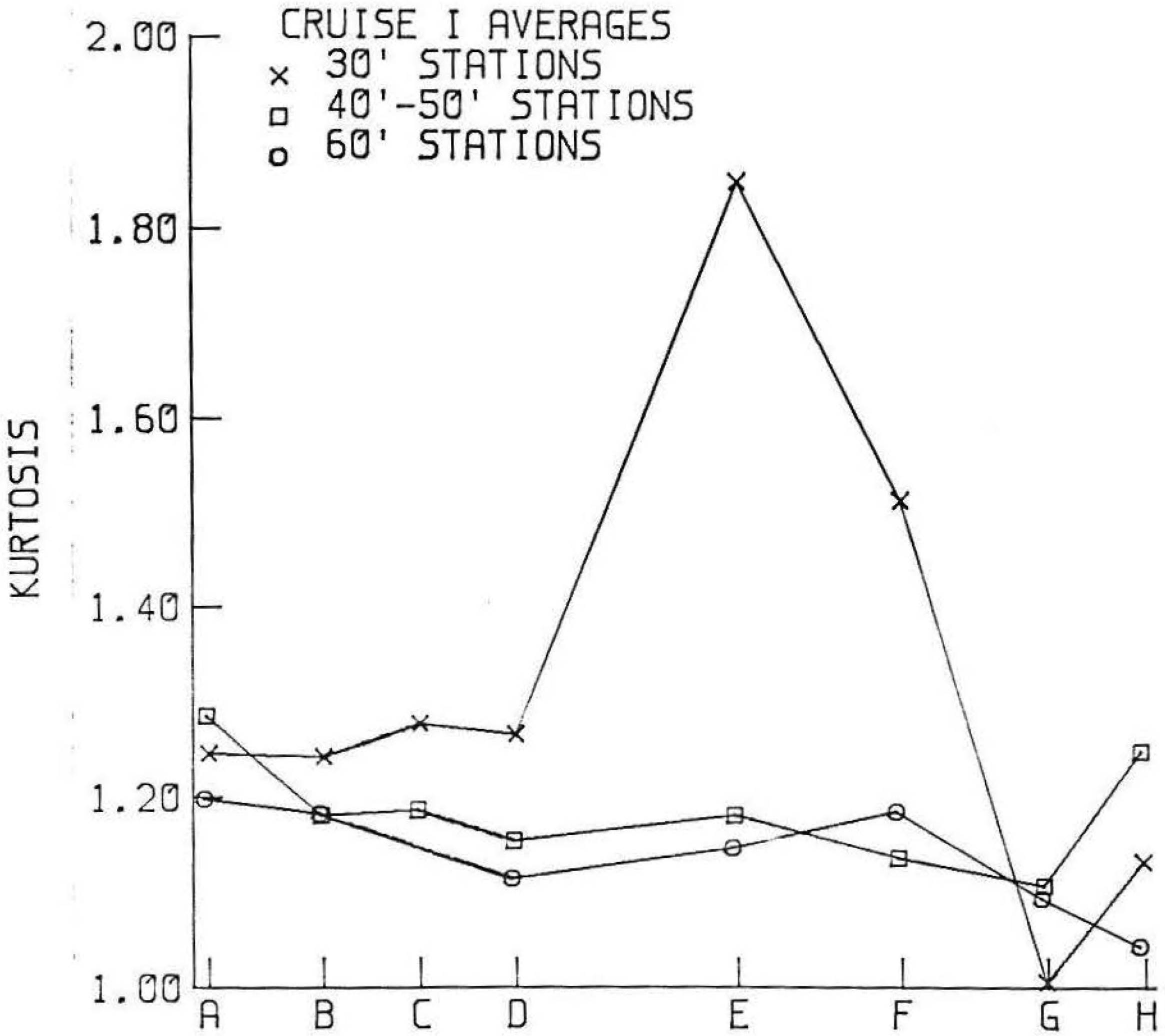

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
KURTOSIS
2.00
1.80
1.60
1.40
1.20
1.00
A
B
C
D
E
F
G
H

Figure 91

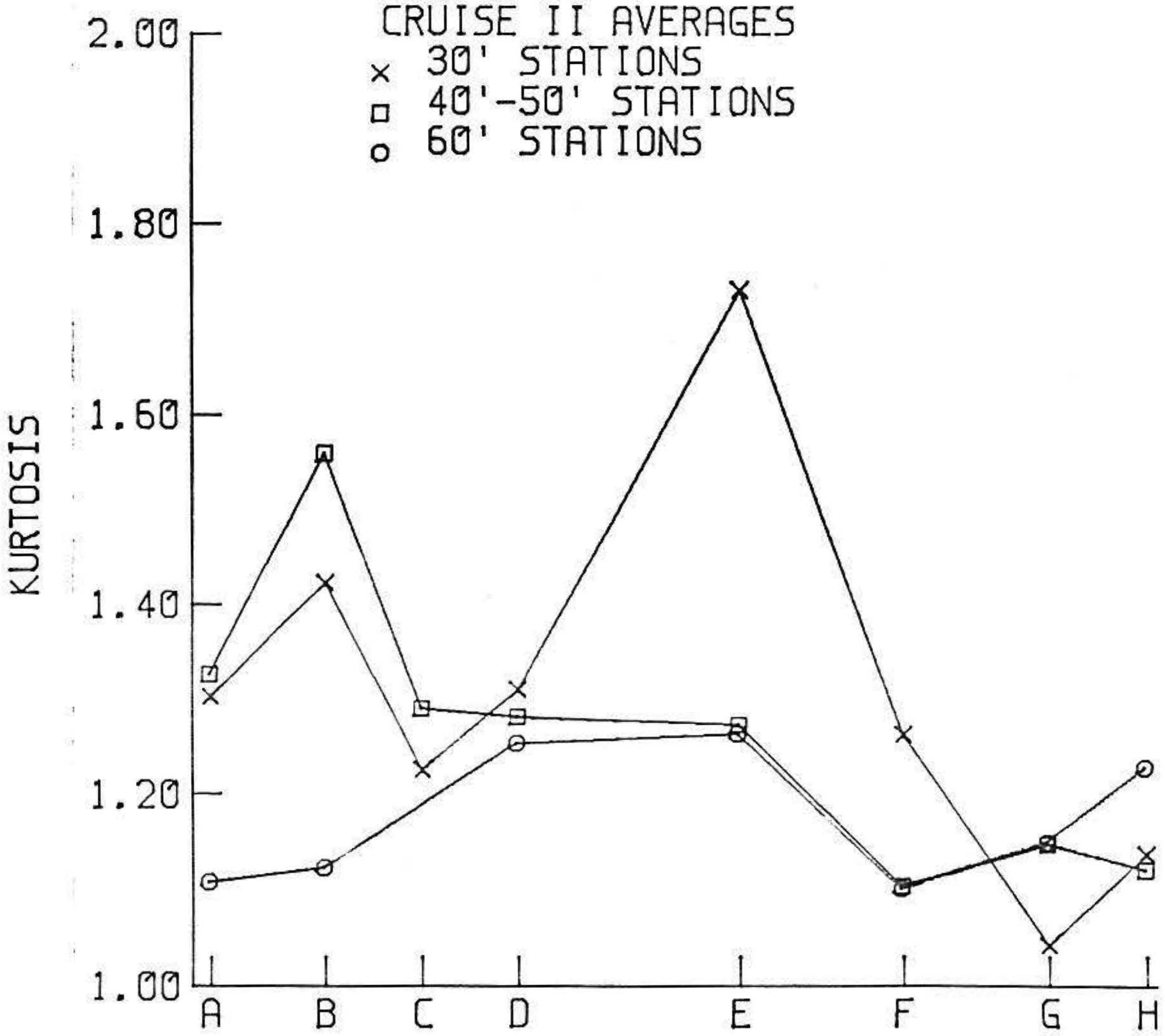

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
KURTOSIS
2.00
1.80
1.60
1.40
1.20
1.00
A
B
C
D
E
F
G
H

Figure 92

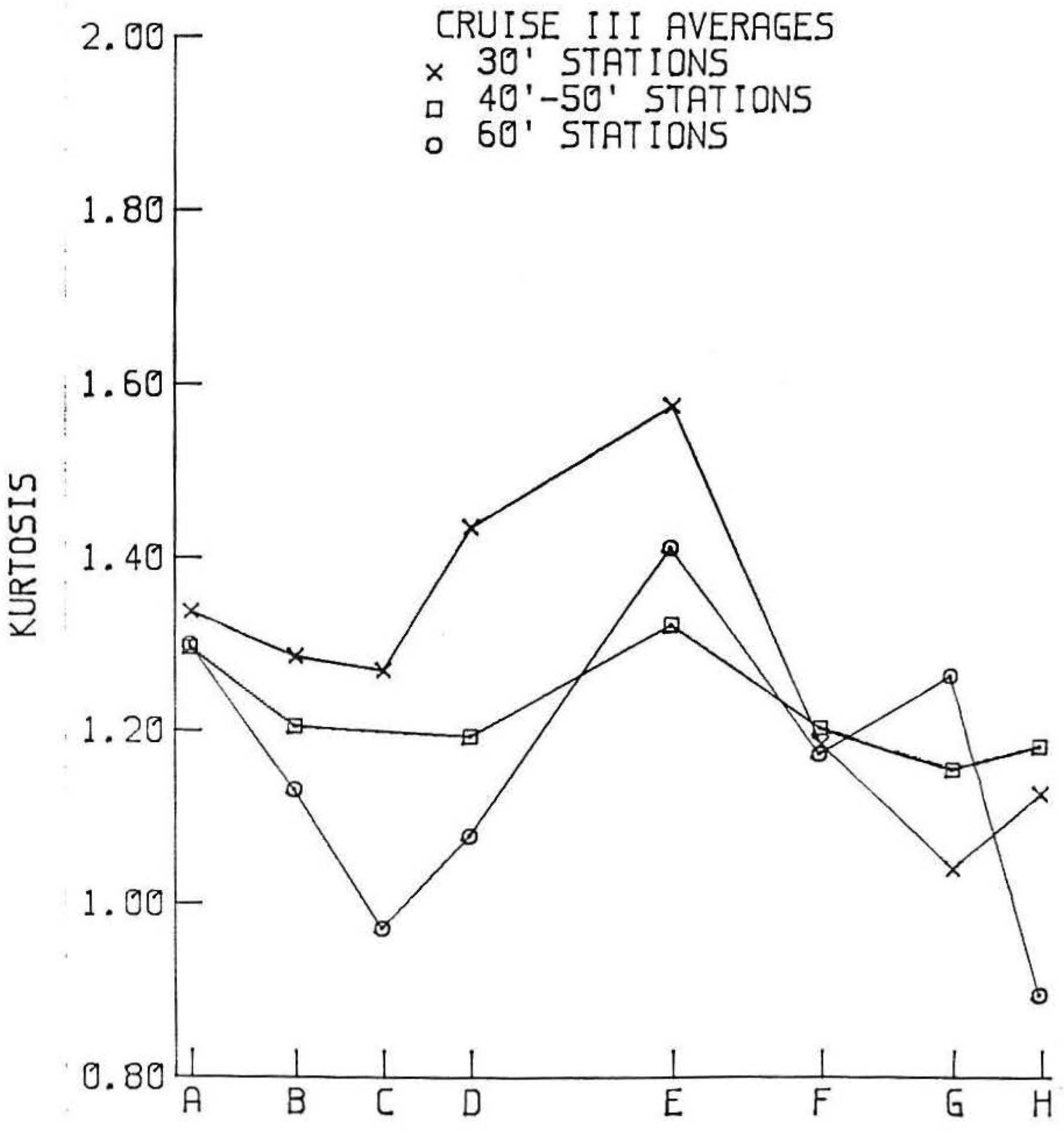

CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
KURTOSIS
2.00
1.80
1.60
1.40
1.20
1.00
0.80
A
B
C
D
E
F
G
H

Figure 93

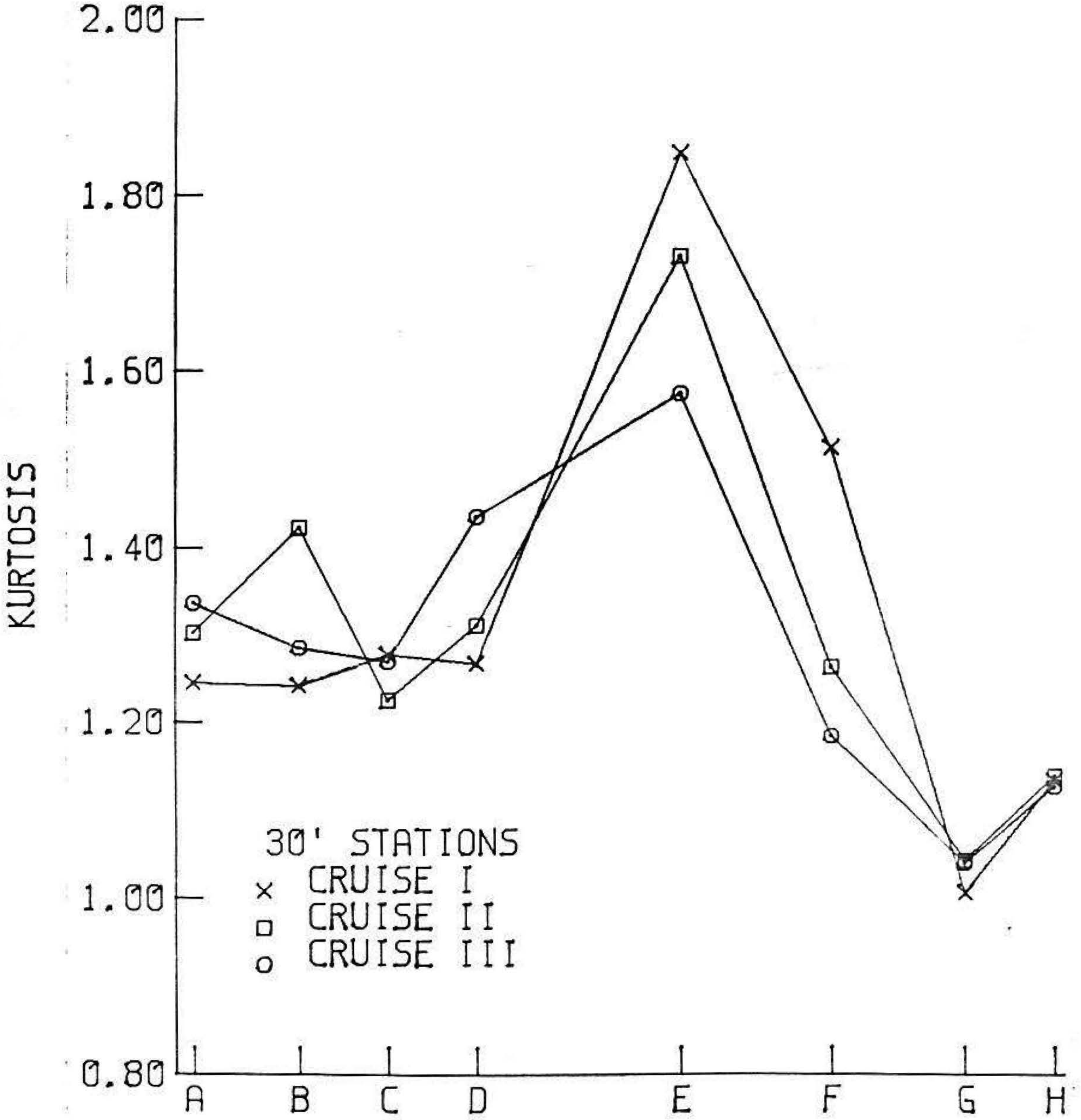

2.00
1.80
1.60
1.40
1.20
1.00
0.80
KURTOSIS
A
B
C
D
E
F
G
H
30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 94

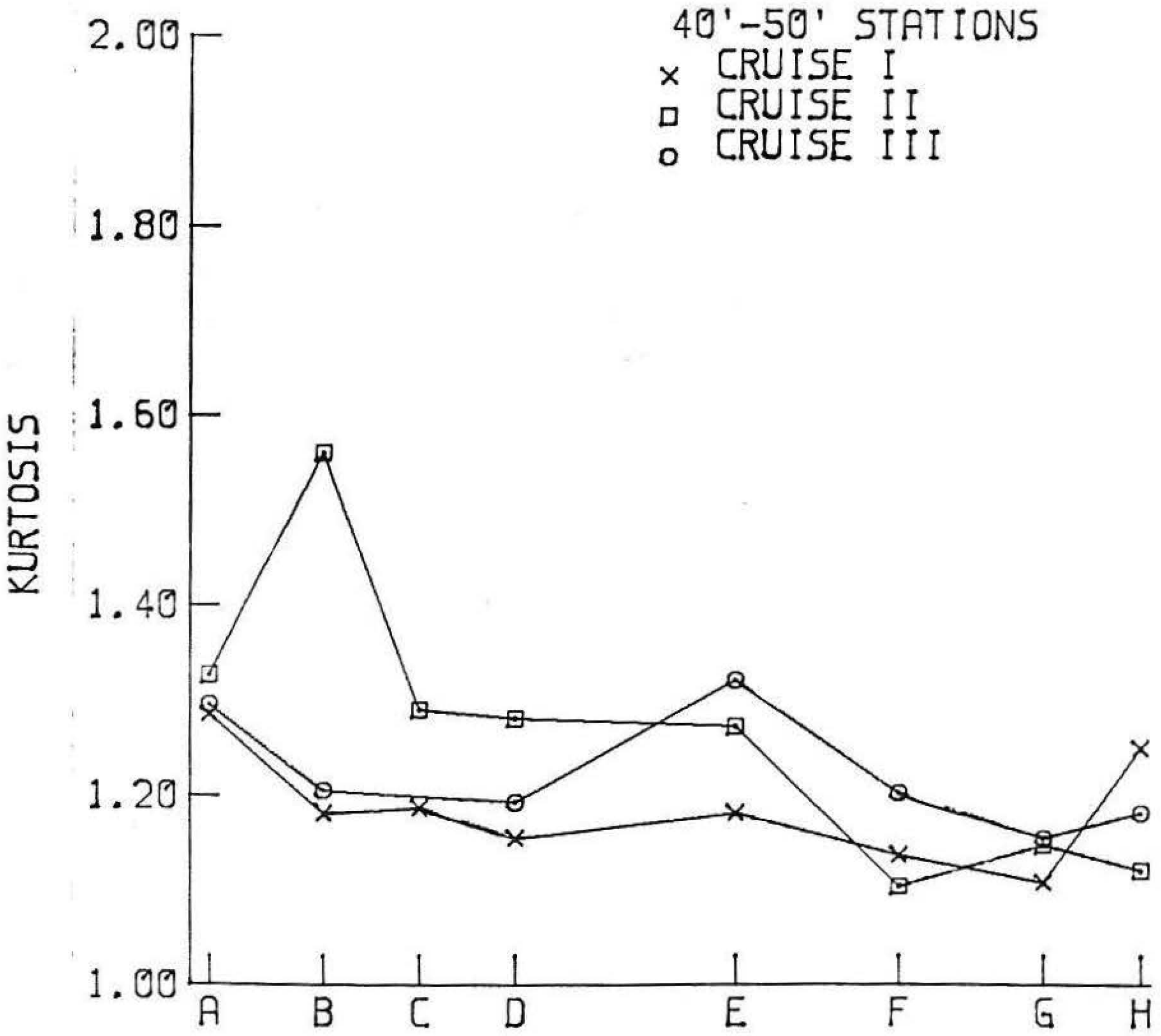
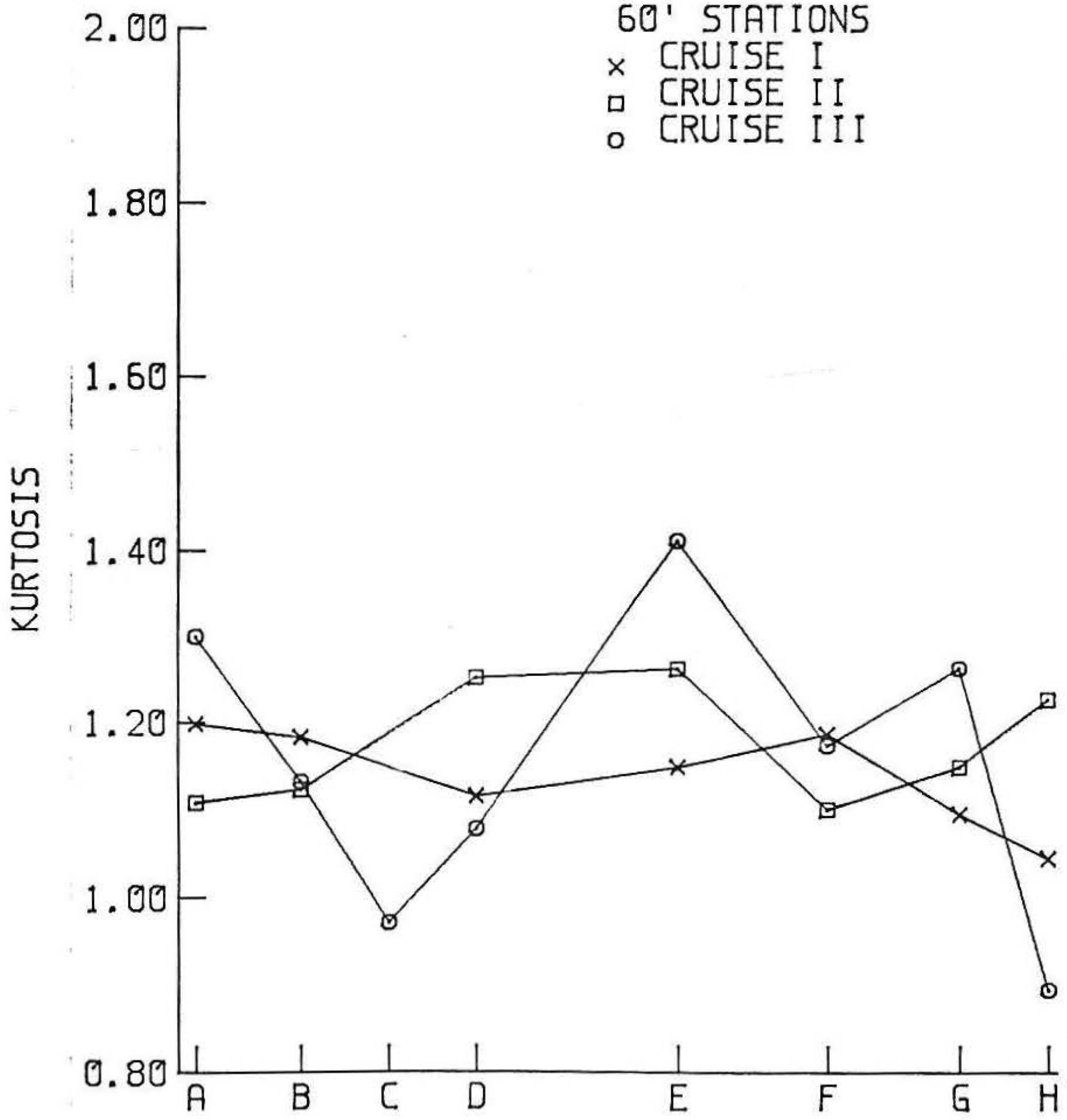

40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
KURTOSIS
2.00
1.80
1.60
1.40
1.20
1.00
A
B
C
D
E
F
G
H

Figure 95


60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
KURTOSIS
2.00
1.80
1.60
1.40
1.20
1.00
0.80
A
B
C
D
E
F
G
H

2. Benthic Fauna - Smith-McIntyre Grabs

A total of 96158 individuals representing 201 taxa were collected in Smith-McIntyre grab samples during the three cruises. A composite species list is given in Table 4. Of the 201 taxa, 77 (38%) were Polychaetes, 64 (32%) were Crustacea, 21 (10%) were Bivalves, and 14 (7%) were Gastropods. The remaining species were distributed amoung 15 other groups: Porifera, Anthozoa, Hydrozoa, Platyhelminthes, Nemertea, Nematoda, Sipunculida, Ectoprocta, Oligochaeta, Pycnogonida, Asteroidea, Echinoidea, Holothuroidea, Chaetognatha, and Chordata. Data from each Smith-McIntyre grab are tabulated in Appendix D. Sample volumes are listed in Appendix E.

a. Species Composition

During the spring cruise, a total of 136 species were collected in the Smith-McIntyre grab samples. The amphipod *Protohaustorius wigleyi* was the dominant species followed by the polychaete *Spiophanes bombyx*, nematodes, the bivalve *Tellina agilis*, and the polychaete *Asabellides oculata*. These four species plus nematodes comprised 55% of the fauna by abundance. *Spiophanes bombyx*, nematodes, and *Asabellides oculata* were common only at the western most sites (A, B, and C) while *Protohaustorius wigleyi* and *Tellina agilis* were abundant at all potential borrow sites.

For the summer cruise, 135 species were found. The dominant fauna consisted of *Protohaustorius wigleyi*, *Tellina agilis*, *Spiophanes bombyx*, the bivalve *Spisula solidissima*, and the polychaete *Magelona riojai*. These five species accounted for 56% of the total fauna by abundance. These species were generally found in high numbers at all sites with the exception of *Magelona riojai* which was not abundant at sites G and H. *Asabellides oculata*, a dominant species during the previous spring was found in low abundance during the summer. Nematodes were exceptionally abundant during the summer cruise only at site C.

During the fall cruise 158 species were collected. The amphipod *Gammarus annulatus* was the dominant species during this period. Other numerically dominant taxa include *Asabellides oculata*, *Tellina agilis*, nematodes, and *Spiophanes bombyx*. Only *Tellina agilis* was numerically important at all sites. *Gammarus annulatus* and *Asabellides oculata* were restricted to sites A, B, and C, nematodes to sites B and C, and *Spiophanes bombyx* to sites A through D.

b. Abundances

For the spring cruise, abundances ranged from 317 individuals per square meter at stations F11 and H1 to 6297 individuals per square meter at station A2 (Figure 96). Abundances during the summer ranged from 157 individuals per square meter at station B5 to 2723 individuals per square meter at station E1 (Figure 97). During the third cruise in the fall, densities were found to range from 163 individuals per square meter at station D4 to 37813 individuals per square meter at station B2 (Figure 98). Site averages for each cruise suggest a general pattern of decreasing abundance from west to east along the south shore of Long Island (Figure 99). Sites C through H show low seasonal variations in abundance. High seasonal variations were found at sites A and B and are mainly due to fluctuations in abundance of *Spiophanes bombyx*, *Gammarus annulatus*, *Asabellides oculata*, and nematodes.

Abundances were generally highest nearshore (30′) and middepth (40′-50′) at sites A, B, C, and E (Figures 100-102). At sites D, F, G, and H, however, highest densities were consistantly found at the 60′ stations (Figures 100-102). West-east and seasonal patterns in abundance at each depth were similar to those found in the overall site averages with the exception of the 60′ stations during cruise I (Figures 100-105).

c. Number of Species

The number of species at each station ranged from 13 to 41 during the spring cruise, from 10 to 41 in the summer, and from 13 to 47 in the fall (Figures 106-108). A pattern of decreasing number of species from west to east was found in the spring and fall with the exception of site C in the spring (Figure 109). During the summer, however, the greatest number of species was found at site E (Figure 109). Sites A, B, and C in the summer had lower numbers of species than during the spring or the fall (Figure 109).

With very few exceptions, the number of species increased with depth during each of the three cruises (Figures 110-112). In analyzing seasonal variations at a given depth, the greatest number of species were generally found in the spring or fall at the 30′ and 40′-50′ stations (Figures 113 and 114). At the 60′ stations, however, the opposite is true, that is, highest species numbers were more often found during the summer cruise (Figure 115).

d. Shannon-Wiener Diversity (H′)

Shannon-Wiener diversity values for each station are presented in Figures 116-118. Diversities ranged from 1.388 to 3.940 in the spring, from 1.834 to 4.194 in the summer, and from 1.050 to 4.321 in the fall. A trend of increasing diversity from west to east is clearly evident when the index is averaged by site (Figure 119). Diversity was somewhat depressed at site C during the spring. This site also had exceptionally low numbers of species at this time. Diversity values generally increased with depth (Figures 120-122). This trend was most clearly defined during the summer cruise (Figure 121). The 40′-50′ stations showed the least amount of seasonal change in diversity (Figures 123-125).

e. Equitability (V′)

Equitability values for each station are given in Figures 126-128. The equitability index ranged from 0.283 to 0.832 in the spring, from 0.458 to 0.867 in the summer, and from 0.232 to 0.922 in the fall. Equitability generally increased from west to east (Figure 129). No clearly defined trends with depth were found during any of the three cruises (Figures 130-132). The 40′-50′ stations showed the least amount of seasonal change in equitability (Figures 133-135).

f. Rarefaction Diversity

Rarefaction diversity is presented in Figures 136-145 as the expected number of species for a sample size of 100 individuals. Station values of the expected number of species for 100 individuals are given in Figures 136-138. A number of sampling stations did not yield a total of 100 individuals in the three replicate Smith-McIntyre grabs. For these stations, the number of species found is plotted in Figures 136-138 along with the symbol ">". It is assumed that had 100 individuals been collected at these stations, the number of species would have been greater than or equal to the number actually collected.

During the spring cruise, the expected number of species for 100 individuals as determined by the rarefaction method ranged from 9.1 at station F1 to >24.0 at station F11. The expected number of species for 100 individuals in the summer ranged from 8.2 at station E1 to 25.9 at station D6. During the fall cruise, the expected number of species for 100 individuals was found to range from 4.8 at station B2 to 27.1 at station G6.

Site averages of the expected number of species for a sample size of 100 individuals are presented in Figures 139-145. Only those stations which yielded a total of 100 individuals or more in the three replicate Smith-McIntyre grab samples were included in the computation. Site averages for each cruise suggest a general increase from west to east in the expected number of species (Figure 139). Sites D-F showed very low seasonal variations in rarefaction diversity (Figure 139). The expected number of species for 100 individuals was generally highest at the middepth (40′-50′) and offshore (60′) stations (Figures 140-142). With the exception of some of the westernmost sites, the expected number of species at the 30′ stations was distinctly lower than that found at either the 40′-50′ or 60′ stations (Figures 140-142). The 40′-50′ stations showed the least amount of seasonal change in rarefaction diversity (Figures 143-145).

g. Commercially and/or Recreationally Important Species

Of the 201 taxa collected in the Smith-McIntyre grab samples, only 7 species, the ocean quahog Arctica islandica, the surf clam Spisula solidissima, the blue mussel Mytilus edulis, the rock crab Cancer irroratus, the four-spotted flounder Paralicthys oblongus, the cunner Tautogolabrus adspersus, and the little skate Raja erinacea, are of commercial and/or recreational value. Four of these species, the ocean quahog, the four-spotted flounder, the cunner, and the little skate were rarely found in the Smith-McIntyre grabs. Mytilus edulis was common only in the spring as very small juveniles attached to floating pieces of detritus. Cancer irroratus was moderately abundant only during the summer cruise when it occurred at 24 of the 65 (37%) sampling stations (Figures 146-148).

Of the 7 commercially and/or recreationally important species collected in the Smith-McIntyre grab samples, only the surf clam was numerically abundant during all three cruises. Individuals of Spisula solidissima were generally quite small (<7 mm in anterior-posterior length). The size of individuals found is possibly more a function of the sampling device used than the actual size distribution of the population. The depth of penetration of the Smith-McIntyre grab is probably not great enough to collect the larger surf clams. Despite this sampling bias, surf clams were common at all eight potential borrow sites and were a numerically dominant species during the summer cruise.

Abundances of Spisula solidissima ranged from 0 to 337 individuals per square meter in the spring, from 0 to 500 individuals per square meter in the summer, and from 0 to 307 individuals per square meter during the fall cruise (Figures 149-151). Site averages suggest a general pattern of decreasing abundance from west to east (Figure 152). Highest abundances were generally found at the nearshore (30′) stations (Figures 153-155). The 30′ stations also showed the greatest amount of seasonal variations in abundance (Figures 156-158).

h. Animal-Sediment Associations

Correspondence between descriptive biological parameters (i.e., station abundances, number of species, diversity, and equitability) and sediment characteristics (i.e., station averaged percent gravel, percent sand, percent silt-clay, percent organic content, median grain size, mean grain size, sorting, skewness, and kurtosis) were analyzed graphically. In general, plots of a single biological parameter vs a single sediment characteristic were highly variable, and it was difficult to identify clear trends. Of the plots generated, those relating a biological parameter to either median or mean grain size displayed the strongest associations. Relationships between a biological parameter and other sediment characteristics (percent gravel, percent sand, percent silt-clay, percent organic content, sorting, skewness, and kurtosis) could not be clearly determined. While such relationships probably exist, multivariate statistical techniques would be required to identify them. Such an analysis is beyond the scope of this report.

Plots of a biological parameter vs either median or mean grain size are given in Figures 159-182. In these figures, a letter code designates stations from each potential borrow site (A-H). Linear regressions with the sediment characteristic as the independent variable and the biological parameter as the dependent variable were performed on these data. The resulting lines are plotted in Figures 159-182. These regressions were carried out to illustrate general associations and not with the intent of making quantitative predictions. Of the 24 regressions in Figures 159-182, 15 or 63% were significant at the 0.05 level. The fact that 9 or 37% were nonsignificant is indicative of the variability in the data.

Despite such variations, the qualitative patterns found between biological parameters and either median or mean grain size are fairly consistent. As shown in Figures 159-161 and 171-173, abundance tends to increase with increasing phi size (i.e., decreasing grain size). Conversely, the number of species, diversity, and equitability all tend to decrease with increasing phi size (Figures 162-170 and 174-182). Figure 174 is the only exception to this trend. Thus as median or mean grain size in mm decreases, greater numbers of animals per m^2 were found, with individuals more unevenly distributed amoung fewer species.

Table 4. Species List - Smith-McIntyre Grabs

PORIFERA
- Unidentified sponge spp.

CNIDARIA
- Anthozoa
  - Anemone sp. A
  - Anemone sp. E
  - Anemone sp. F
  - Anemone sp. G
  - Anemone sp. I
- Hydrozoa
  - Unidentified hydroid spp.

PLATYHELMINTHES
- Flatworm sp. A (horned)
- Flatworm sp. B (smooth)

NEMERTEA
- Unidentified nemertean spp.

NEMATODA
- Unidentified nematode spp.

SIPUNCULA
- Sipunculid sp. A
- Sipunculid sp. B

ECTOPROCTA
- Unidentified bryozoan spp.

ANNELIDA
- Oligochaeta
  - Tubificidae
    - Unidentified spp.
- Polychaeta
  - Unknown sp. Z
  - Ampharetidae
    - Ampharete acutifrons
    - Ampharete arctica
    - Asabellides oculata
  - Arabellidae
    - Drilonereis longa
  - Capitellidae
    - Capitella capitata
    - Heteromastus filiformes
  - Chaetopteridae
    - Spiochaetopterus oculatus
  - Cirratulidae
    - Chaetozone setosa
    - Cirratulas grandis
    - Tharyx acutus
  - Dorvilleidae
    - Protodorvillea kefersteini
    - Stauronereis caecus
  - Flabelligeridae
    - Flabelligera affinis
    - Pherusa affinis
  - Glyceridae
    - Glycera americana
    - Glycera dibranchiata
    - Hemipodus roseus
  - Goniadidae
    - Goniadella gracilis
  - Lumbrinereidae
    - Lumbrinerides acuta
    - Lumbrineris fragilis
    - Lumbrineris tenuis
  - Magelonidae
    - Magelona riojai
  - Maldanidae
    - Clymanella torquata
    - Clymenura dispar
  - Nephtyidae
    - Nephtys bucera
    - Nephtys caeca
    - Nephtys incisa
    - Nephtys picta
    - Nephtys spp. imm.
  - Nereidae
    - Nereis grayi
    - Nereis succina
    - Nereis spp.
  - Onuphidae
    - Diapatra cuprea
    - Hyalinoecia tubicola
    - Onuphis eremita
    - Onuphis opalina
  - Opheliidae
    - Travisia carnea
    - Ophelia denticulata
  - Orbiniidae
    - Hoploscoloplos acutus
    - Hoploscoloplos armiger
    - Hoploscoloplos fragilis
    - Hoploscoloplos robustus
    - Orbinia ornata
    - Orbinia swani
  - Oweniidae
    - Owenia fusiformis
  - Paraonidae
    - Aricidea catherinae
    - Aricidea wassi
    - Paradoneis lyra

Table 4 (continued)

Pectinariidae
  Pectinaria gouldi
Phyllodocidae
  Eteone flava
  Eteone heteropoda
  Eteone lactea
  Paranaites speciosa
  Phyllodoce arenae
  Phyllodoce mucosa
Pisionidae
  Pisione remota
Polynoidae
  Harmothoe extenuata
Sabellariidae
  Sabellaria vulgaris
Sigalionidae
  Pholoe minuta
  Sigalion arenicola
  Sthenelais limicola
Spionidae
  Dispio uncinata
  Malacoceros indicatus
  Polydora socialis
  Scolecolepides viridis
  Scoleoepis squamata
  Spio filicornis
  Spiophanes bombyx
Syllidae
  Autolytus spp.
  Exogone dispar
  Parapionosyllis longicirrata
  Sphaerosyllis hystrix
  Streptosyllis varians
  Syllis cornuta
  Unidentified spp.
Terebellidae
  Nicolea spp.
  Terebella spp.

MOLLUSCA
Gastropoda
  Gastropod larvae
Acteocinidae
  Acteocina canaliculata
Columbellidae
  Mitrella lunata
Crepidulidae
  Crepidula fornicata
  Crepidula plana
Haminoeidae
  Haminoea solitaria
Nassariidae
  Nassarius trivittatus
Naticidae
  Lunatia heros
  Lunatia triseriata
  Natica pusilla
Nudibranchia
  Unidentified nudibranch spp.
Pyramidellidae
  Pyramidella spp.
  Turbonilla bushina
  Turbonilla spp.
Retusidae
  Retusa spp.

Bivalvia
  Unidentified juvenile spp.
Arcticidae
  Arctica islandica
Astartidae
  Astarte castanea
Carditidae
  Microcardium peramabile
  Cerastoderma pinnulatum
Leptonidae
  Mysella planula
Lyonsiidae
  Lyonsia hyalina
Mactridae
  Spisula solidissima
Mytilidae
  Mytilus edulis
Nuculanidae
  Nuculana messanensis
  Yoldia limatula
  Yoldia thraciaeformis
Nuculidae
  Nucula delphinodonta
  Nucula proxima
  Nucula tenuis
Pandoridae
  Pandora gouldiana
Petricolidae
  Petricola pholadiformis
Pholadidae
  Cyrtopleura costata
Solenidae
  Ensis directus
  Siliqua costata
  Solen viridis
Tellinidae
  Tellina agilis

Table 4 (continued)

ARTHROPODA

- Pycnogonida
  - Phoxichilidium spp.

- Crustacea
  - Amphipoda
    - Ampeliscidae
      - Ampelisca abdita
      - Ampelisca verrilli
      - Byblis serata
    - Aoridae
      - Pseudunciola obliquua
      - Unciola irrorata
      - Unciola serrata
    - Caprellidae
      - Aeginina longicornis
      - Caprella linearis
      - Unidentified spp.
    - Corophiidae
      - Cerapus tubularis
      - Corophium crassicorne
    - Gammaridae
      - Gammarus annulatus
      - Gammarus lawrencianus
    - Haustoriidae
      - Acanthohaustorius bousfieldi
      - Acanthohaustorius intermedius
      - Acanthohaustorius millsi
      - Acanthohaustorius shoemakeri
      - Acanthohaustorius similis
      - Acanthohaustorius spinosus
      - Amphiporeia gigantea
      - Bathyporeia parkeri
      - Bathyporeia quoddyensis
      - Parahaustorius attenuatus
      - Parahaustorius holmesi
      - Parahaustorius longimerus
      - Protohaustorius wigleyi
      - Pseudohaustorius borealis
      - Pseudohaustorius carolinensis
    - Liljeborgiidae
      - Listriella barnardi
    - Lysianassidae
      - Hippomedon serratus
      - Orchomonella minuta
      - Orchomonella pinguis
      - Psammonyx nobilis
    - Oedicerotidae
      - Monoculodes edwardsi
    - Photidae
      - Microprotopus raneyi
      - Photis macrocoxa
    - Phoxocephalidae
      - Phoxocephalus holbolli
      - Rhepoxynuis epistomus

  - Copepoda
    - Unidentified copepod spp.

  - Cirripeidea
    - Unidentified barnacle spp.

  - Cumacea
    - Diastylis polita
    - Leptocuma minor
    - Oxyurostylis smithi

  - Decapoda
    - Cancer borealis
    - Cancer irroratus
    - Crangon septemspinosus
    - Ovalipes ocellatus
    - Pagurus acadianus
    - Pagurus longicarpus
    - Unidentified crab larvae spp.

  - Isopoda
    - Cirolana concharum
    - Cirolana polita
    - Chiridotea caeca
    - Chiridotea tuftsi
    - Cyathura polita
    - Edotea montosa
    - Idotea balthica
    - Ptilanthura tenuis

  - Mysidacea
    - Meterythrops robusta
    - Mysidiopsis bigelowi
    - Neomysis americana

  - Ostracoda
    - Unidentified ostracod spp.

  - Stomatopoda
    - Squilla sp. imm.

  - Tanaidacea
    - Leptognatha caeca
    - Tanaissus lilgeborgi

ECHINODERMATA

- Asteroidea
  - Asterias forbesii

Table 4 (continued)

Echinoidea
    Echinarachnius parma

Holothuroidea
    Unidentified holothurian spp.

CHAETOGNATHA
    Sagitta spp.

CHORDATA
Ascidiacea
    Unidentified tunicate spp.

Vertebrata
    Ammodytes americanus
    Paralicthys oblongus
    Raja erinacea
    Tautogolabrus adspersus

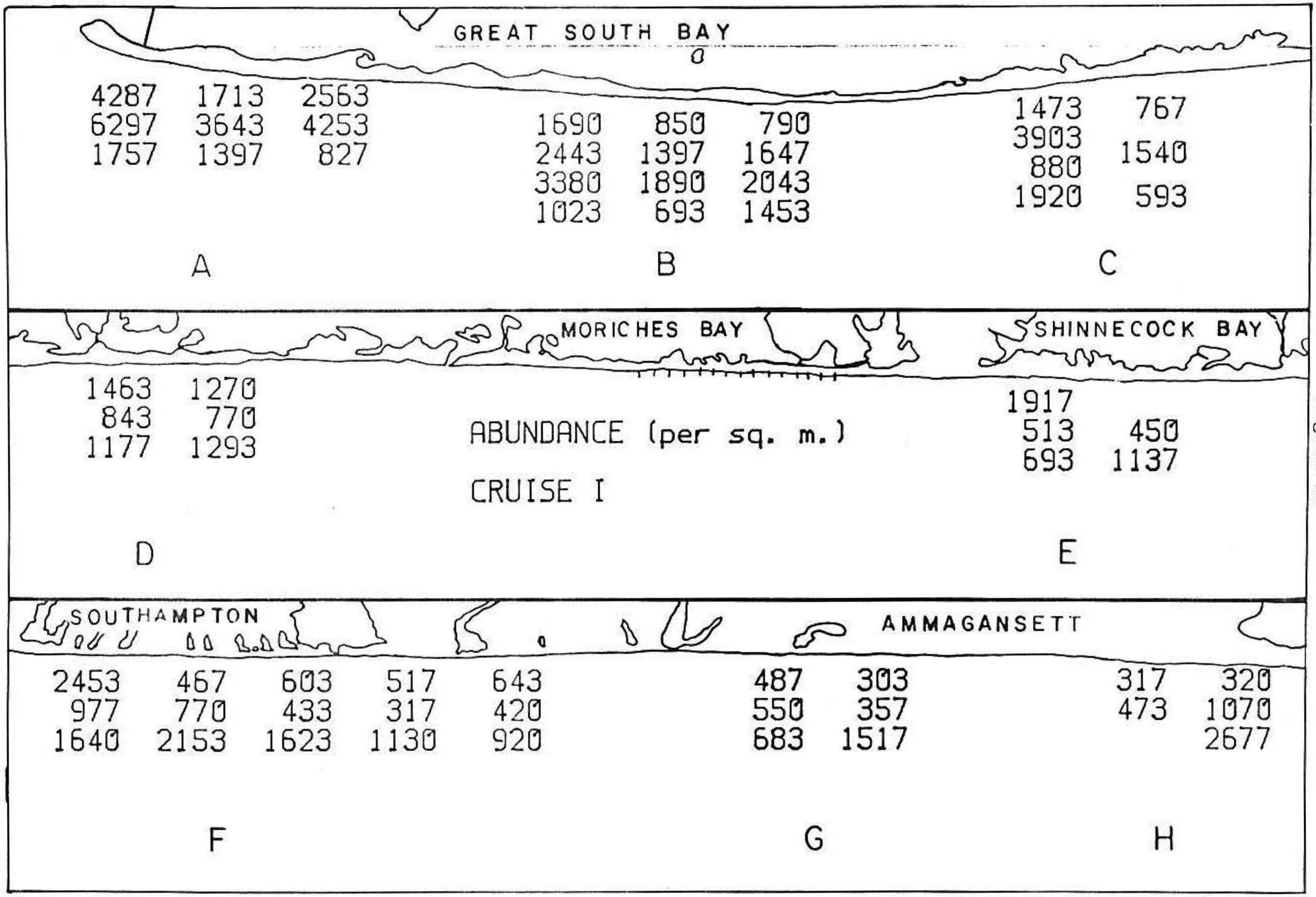

GREAT SOUTH BAY
4287 1713 2563
6297 3643 4253
1757 1397 827
A
1690 850 790
2443 1397 1647
3380 1890 2043
1023 693 1453
B
1473 767
3903 1540
880
1920 593
C
MORICHES BAY
SHINNECOCK BAY
1463 1270
843 770
1177 1293
D
ABUNDANCE (per sq. m.)
CRUISE I
1917
513 450
693 1137
E
SOUTHAMPTON
AMMAGANSETT
2453 467 603 517 643
977 770 433 317 420
1640 2153 1623 1130 920
F
487 303
550 357
683 1517
G
317 320
473 1070
2677
H

Figure 96

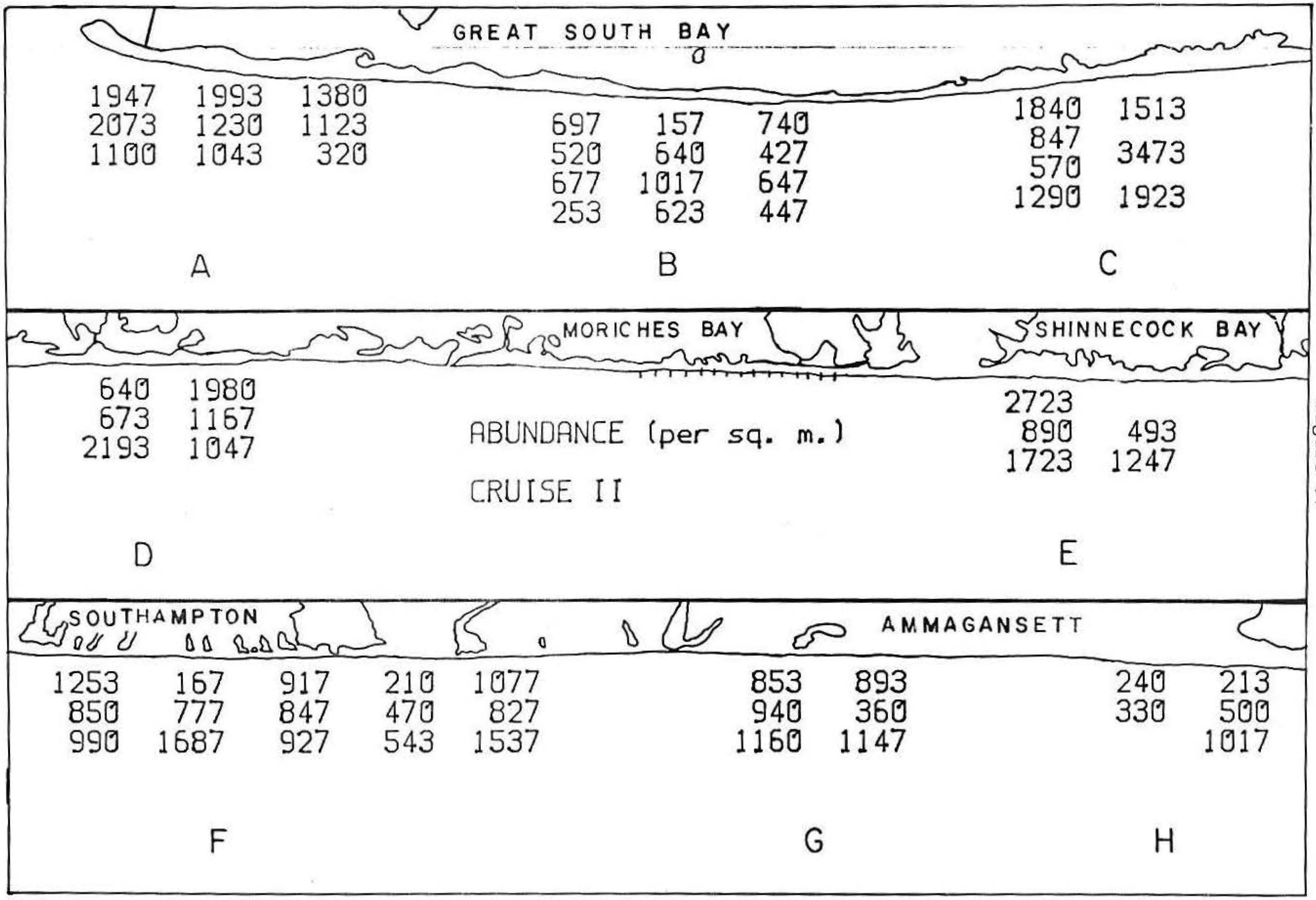

GREAT SOUTH BAY
1947 1993 1380
2073 1230 1123
1100 1043 320
A
697 157 740
520 640 427
677 1017 647
253 623 447
B
1840 1513
847
570 3473
1290 1923
C
MORICHES BAY
SHINNECOCK BAY
640 1980
673 1167
2193 1047
D
ABUNDANCE (per sq. m.)
CRUISE II
2723
890 493
1723 1247
E
SOUTHAMPTON
AMMAGANSETT
1253 167 917 210 1077
850 777 847 470 827
990 1687 927 543 1537
F
853 893
940 360
1160 1147
G
240 213
330 500
1017
H

Figure 97

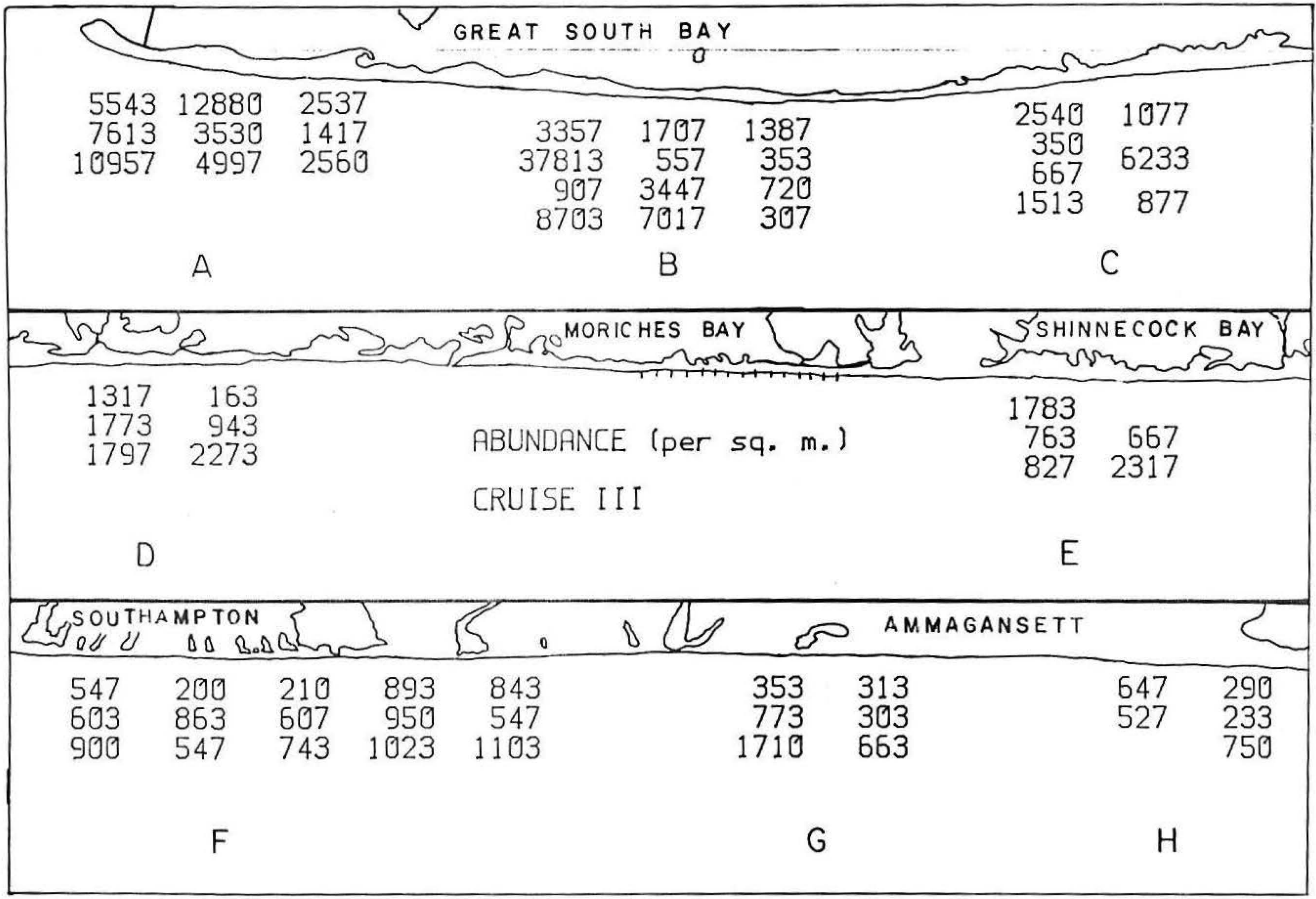

GREAT SOUTH BAY
5543 12880 2537
7613 3530 1417
10957 4997 2560
A
3357 1707 1387
37813 557 353
907 3447 720
8703 7017 307
B
2540 1077
350
667 6233
1513 877
C
MORICHES BAY
SHINNECOCK BAY
1317 163
1773 943
1797 2273
D
ABUNDANCE (per sq. m.)
CRUISE III
1783
763 667
827 2317
E
SOUTHAMPTON
AMMAGANSETT
547 200 210 893 843
603 863 607 950 547
900 547 743 1023 1103
F
353 313
773 303
1710 663
G
647 290
527 233
750
H

Figure 98

Figure 99

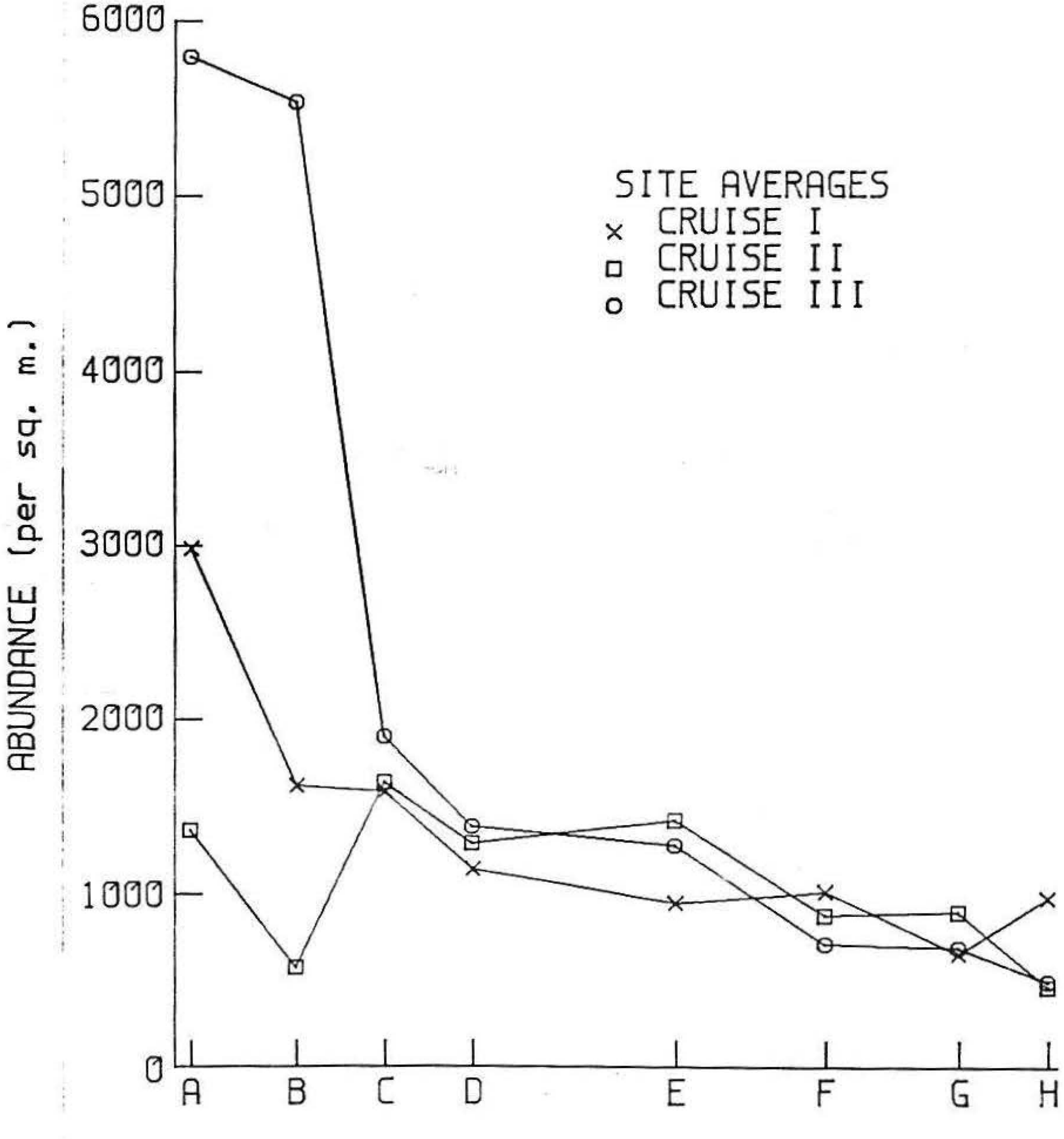

ABUNDANCE (per sq. m.)
6000
5000
4000
3000
2000
1000
0
A
B
C
D
E
F
G
H
SITE AVERAGES
× CRUISE I
□ CRUISE II
o CRUISE III

Figure 100

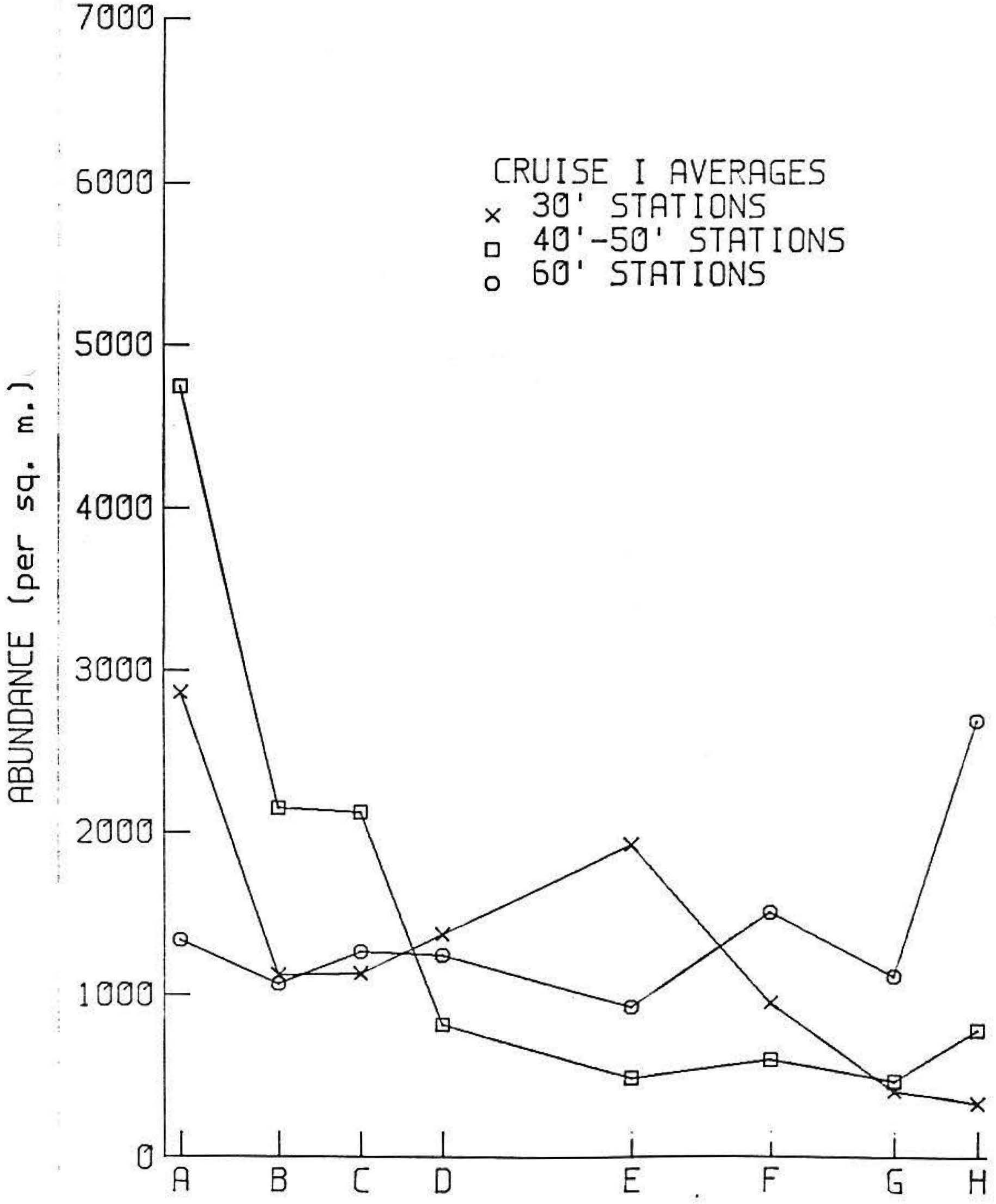

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
ABUNDANCE (per sq. m.)
7000
6000
5000
4000
3000
2000
1000
0
A
B
C
D
E
F
G
H

Figure 101

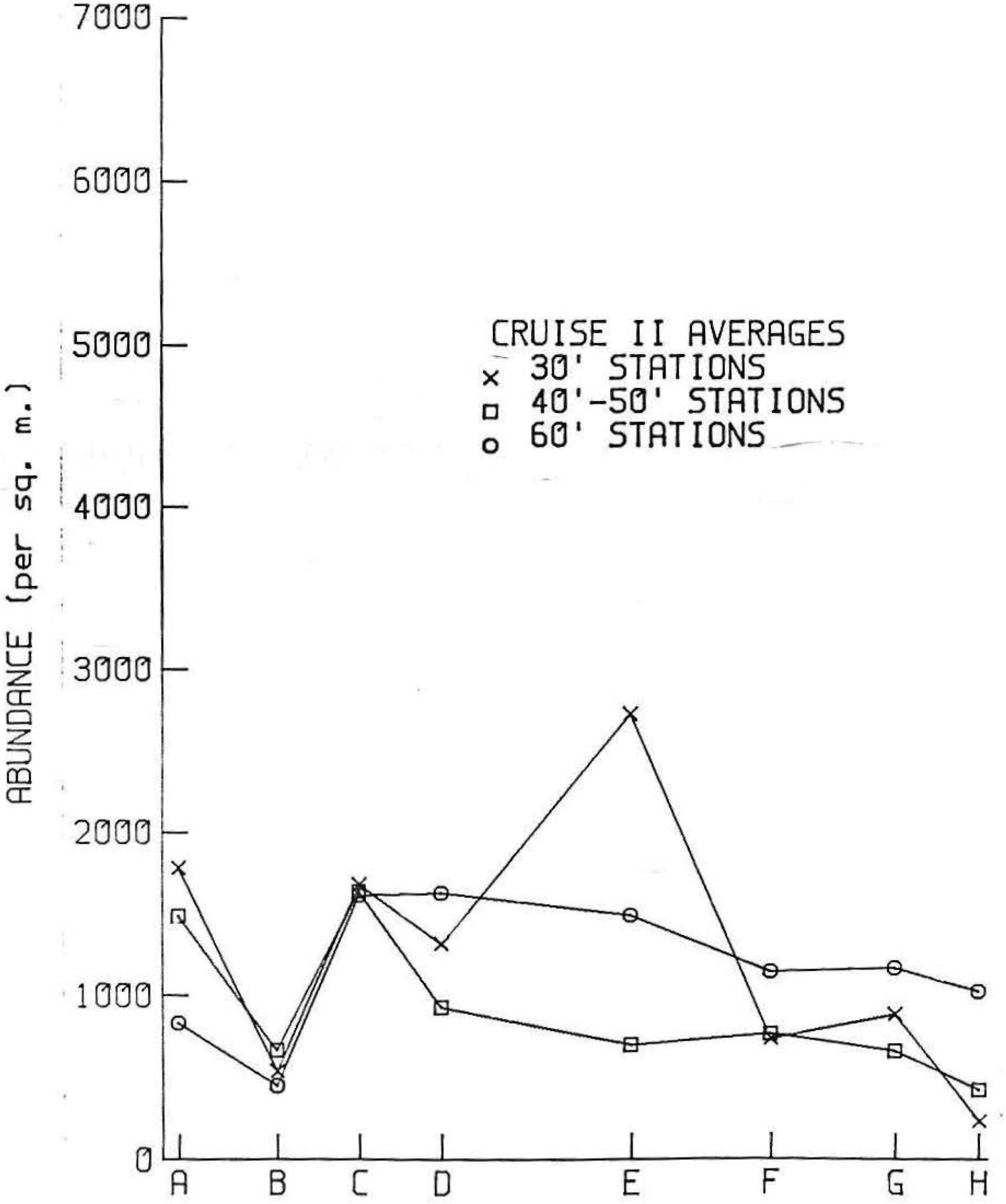
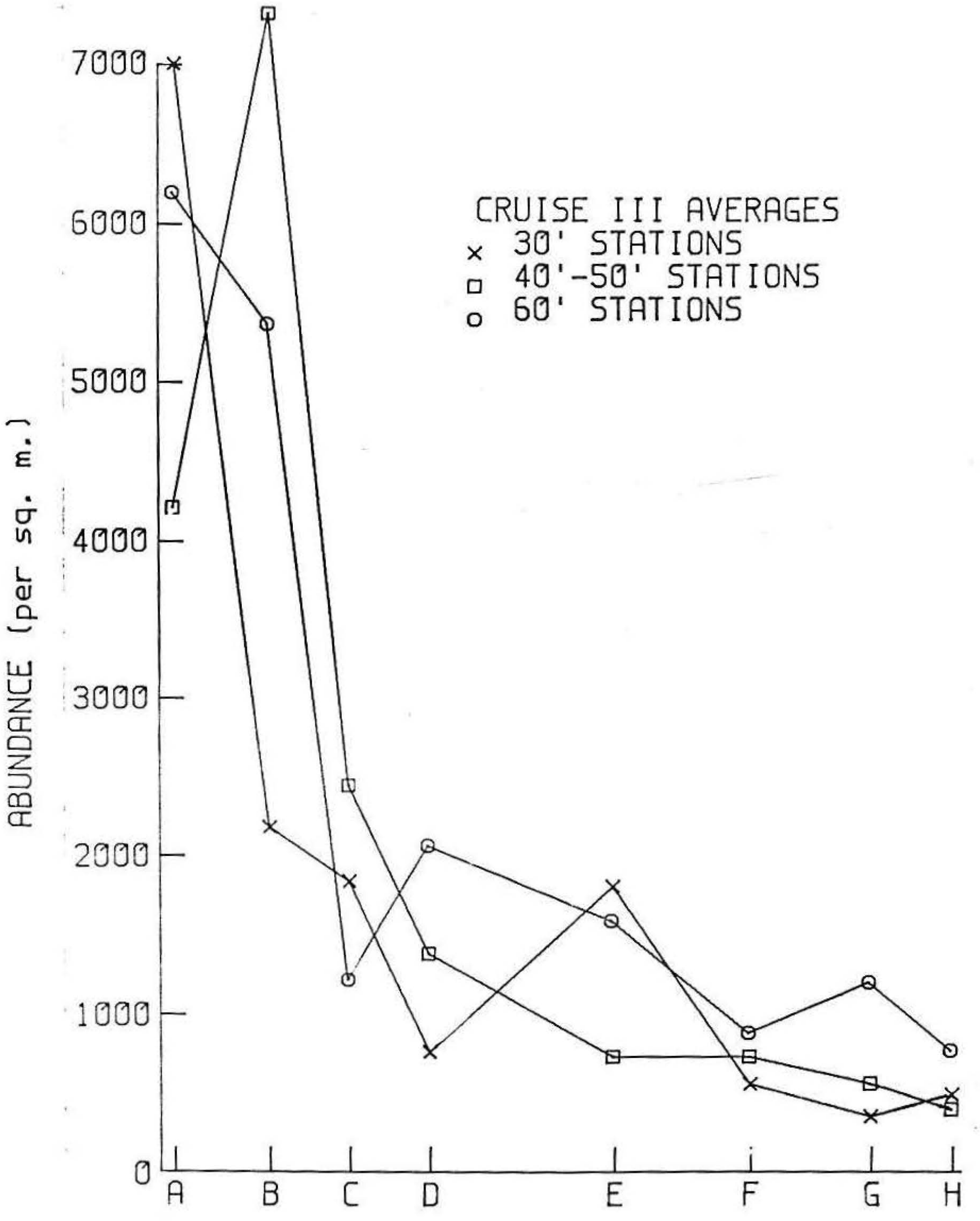

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
ABUNDANCE (per sq. m.)
7000
6000
5000
4000
3000
2000
1000
0
A
B
C
D
E
F
G
H

Figure 102



CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
ABUNDANCE (per sq. m.)
7000
6000
5000
4000
3000
2000
1000
0
A
B
C
D
E
F
G
H

Figure 103

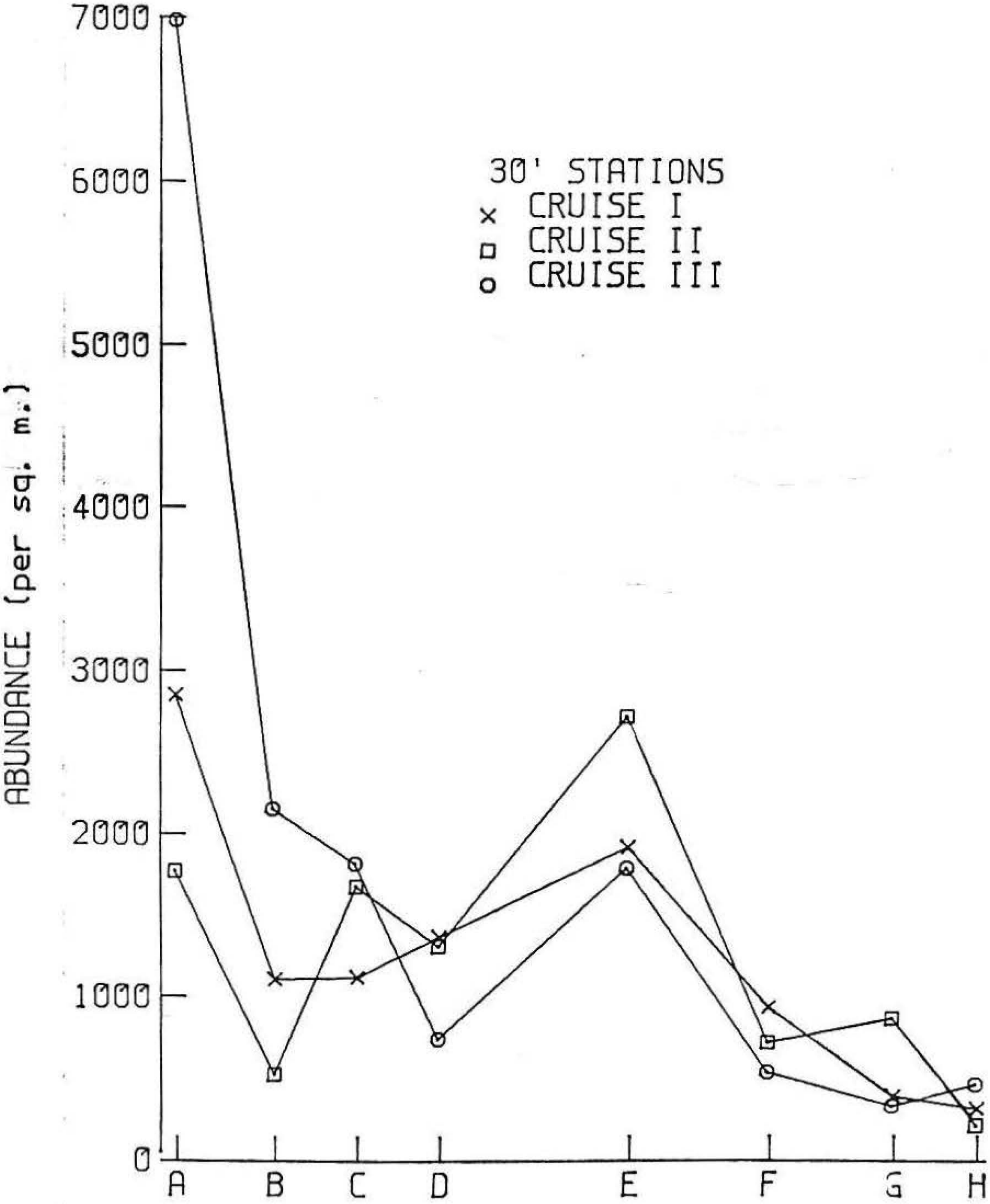

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
ABUNDANCE (per sq. m.)
7000
6000
5000
4000
3000
2000
1000
0
A
B
C
D
E
F
G
H

Figure 104

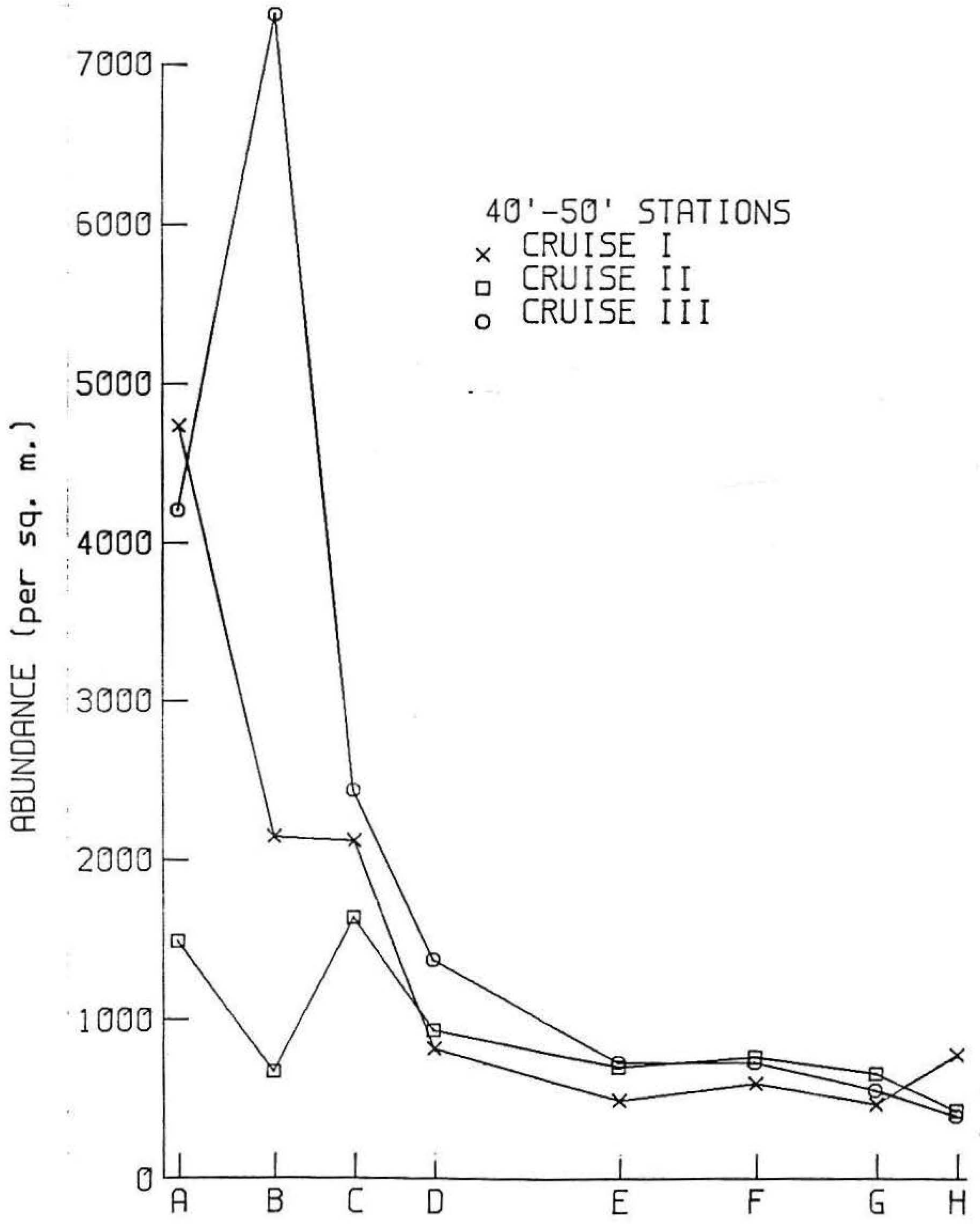
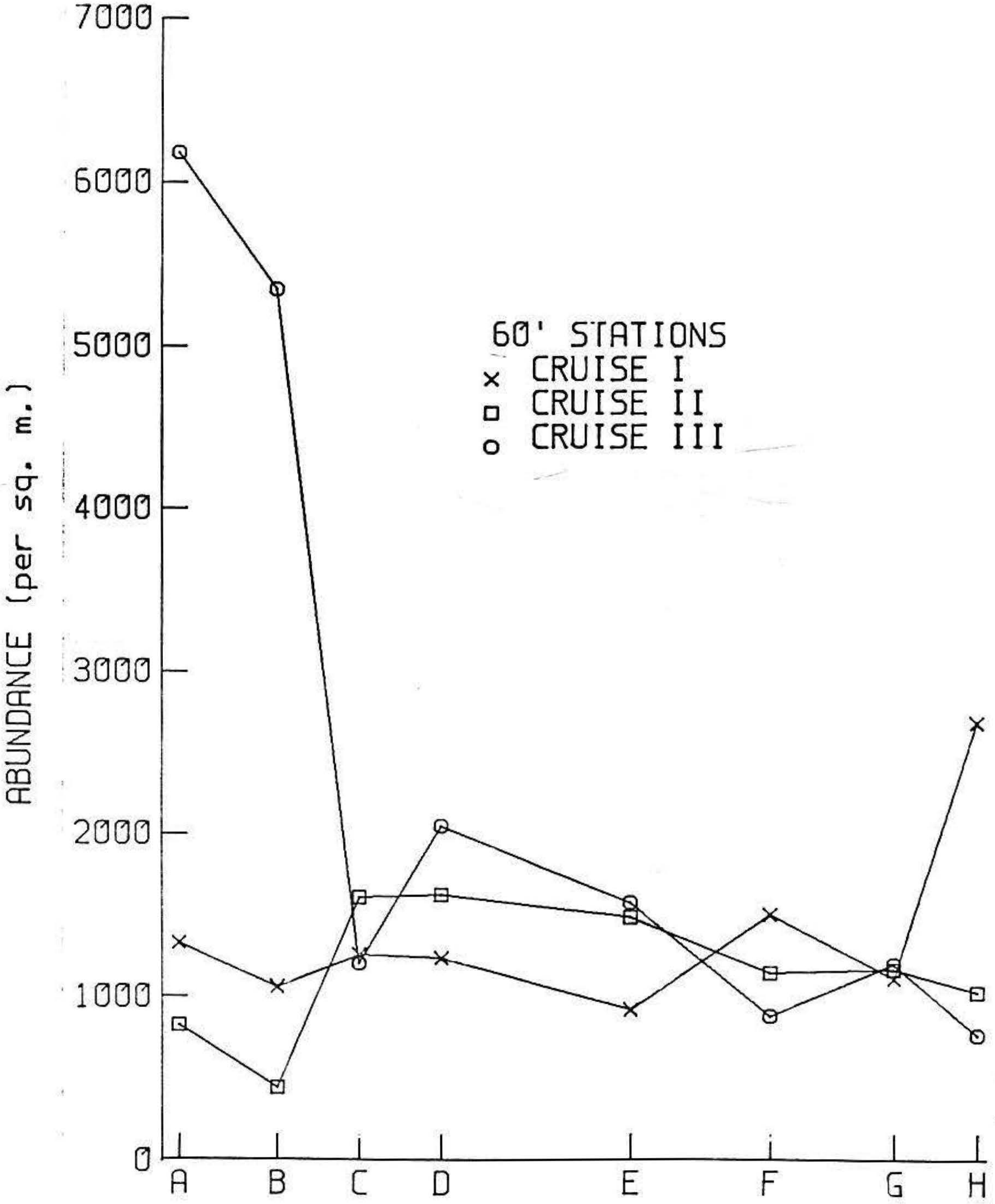

40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
ABUNDANCE (per sq. m.)
7000
6000
5000
4000
3000
2000
1000
0
A
B
C
D
E
F
G
H

Figure 105


7000
6000
5000
4000
3000
2000
1000
0
ABUNDANCE (per sq. m.)
60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
A
B
C
D
E
F
G
H

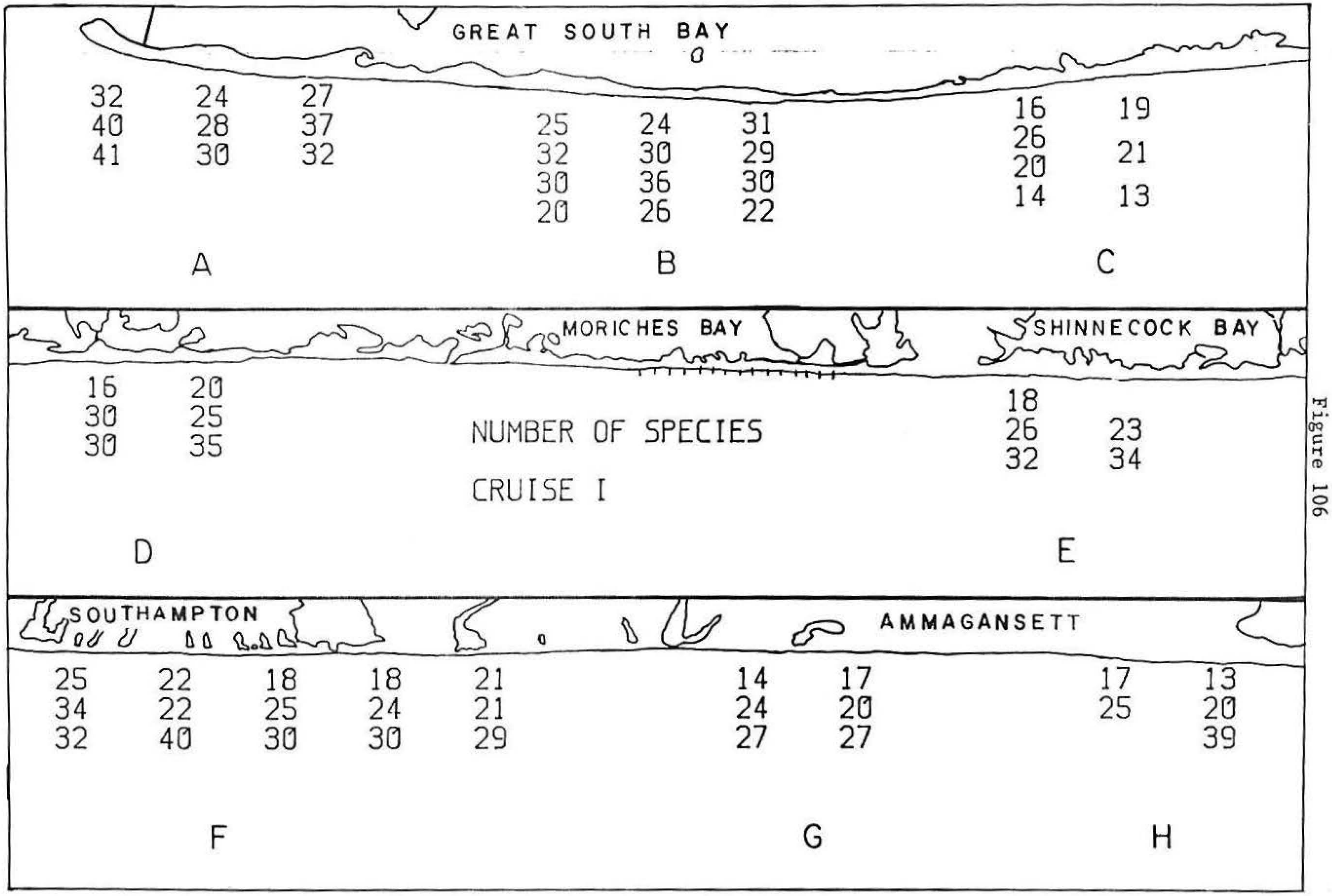

GREAT SOUTH BAY
32
40
41
24
28
30
27
37
32
25
32
30
20
24
30
36
26
31
29
30
22
16
26
20
14
19
21
13
A
B
C
MORICHES BAY
SHINNECOCK BAY
16
30
30
20
25
35
NUMBER OF SPECIES
CRUISE I
18
26
32
23
34
D
E
SOUTHAMPTON
AMMAGANSETT
25
34
32
22
22
40
18
25
30
18
24
30
21
21
29
14
24
27
17
20
27
17
25
13
20
39
F
G
H

Figure 106

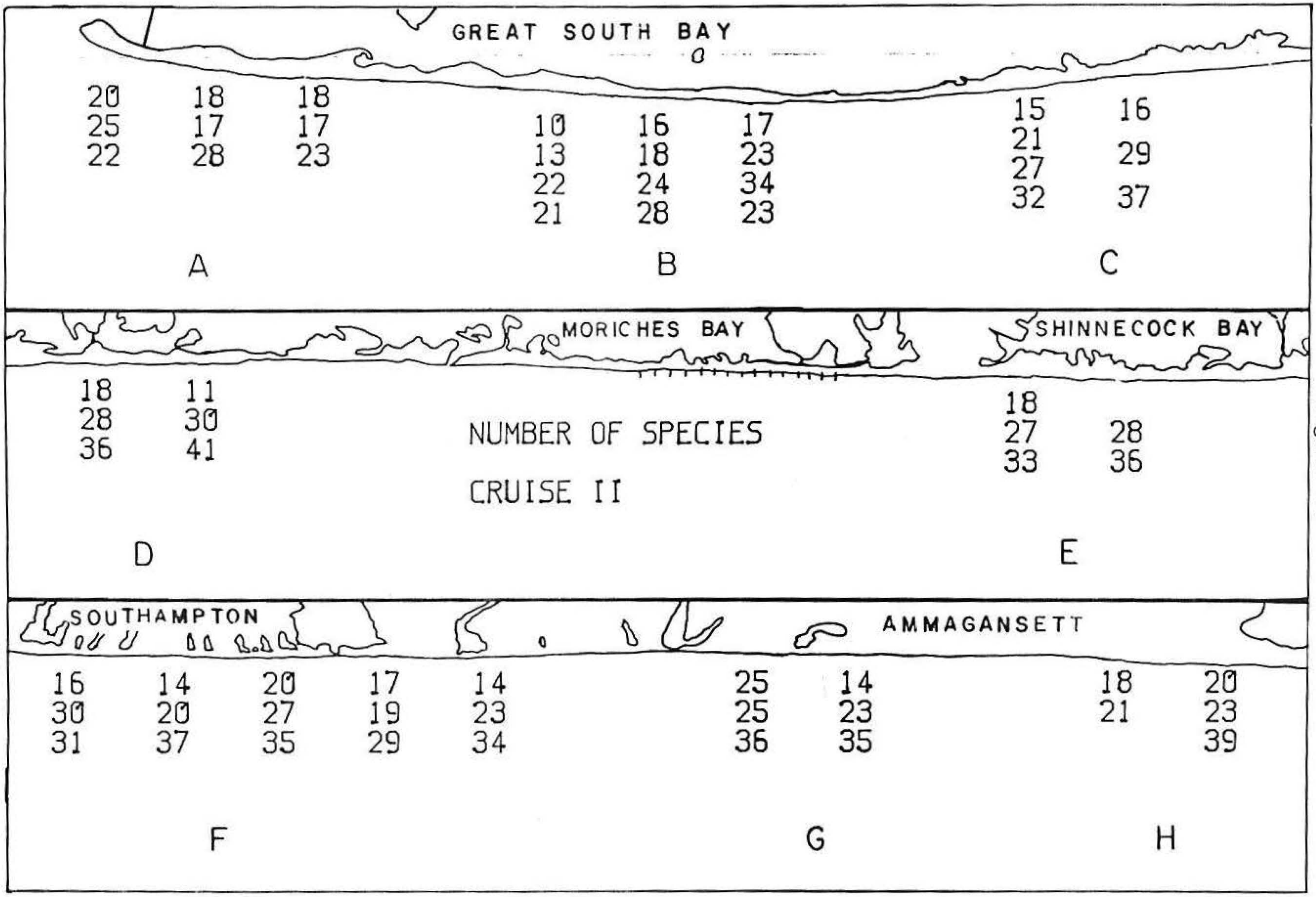

GREAT SOUTH BAY
20 25 22
18 17 28
18 17 23
10 13 22 21
16 18 24 28
17 23 34 23
15 21 27 32
16 29 37
A
B
C
MORICHES BAY
SHINNECOCK BAY
18 28 36
11 30 41
NUMBER OF SPECIES
CRUISE II
18 27 33
28 36
D
E
SOUTHAMPTON
AMMAGANSETT
16 30 31
14 20 37
20 27 35
17 19 29
14 23 34
25 25 36
14 23 35
18 21
20 23 39
F
G
H

Figure 107

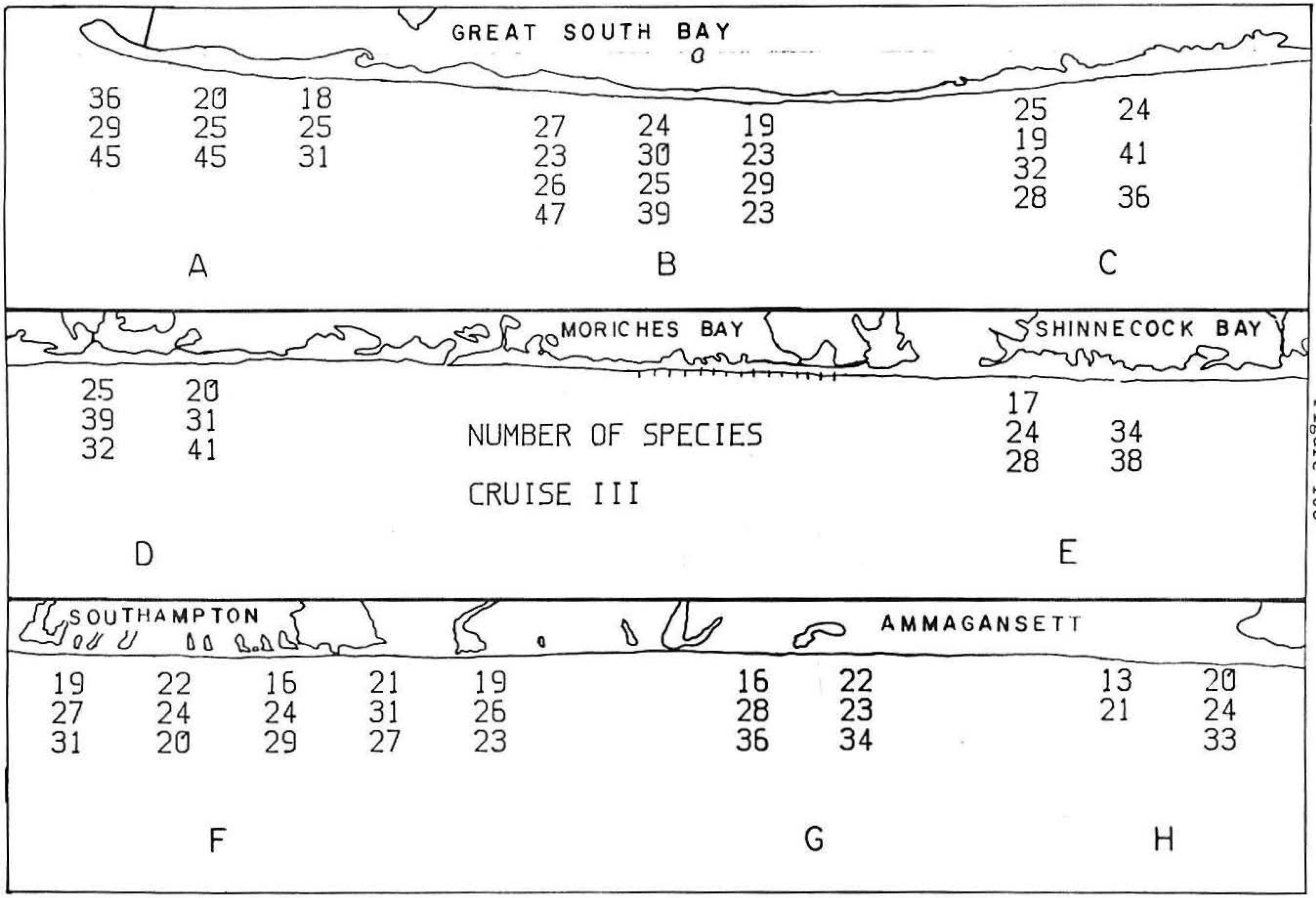

GREAT SOUTH BAY
36
29
45
20
25
45
18
25
31
27
23
26
47
24
30
25
39
19
23
29
23
25
19
32
28
24
41
36
A
B
C
MORICHES BAY
SHINNECOCK BAY
25
39
32
20
31
41
NUMBER OF SPECIES
CRUISE III
17
24
28
34
38
D
E
SOUTHAMPTON
AMMAGANSETT
19
27
31
22
24
20
16
24
29
21
31
27
19
26
23
16
28
36
22
23
34
13
21
20
24
33
F
G
H

Figure 108

Figure 109

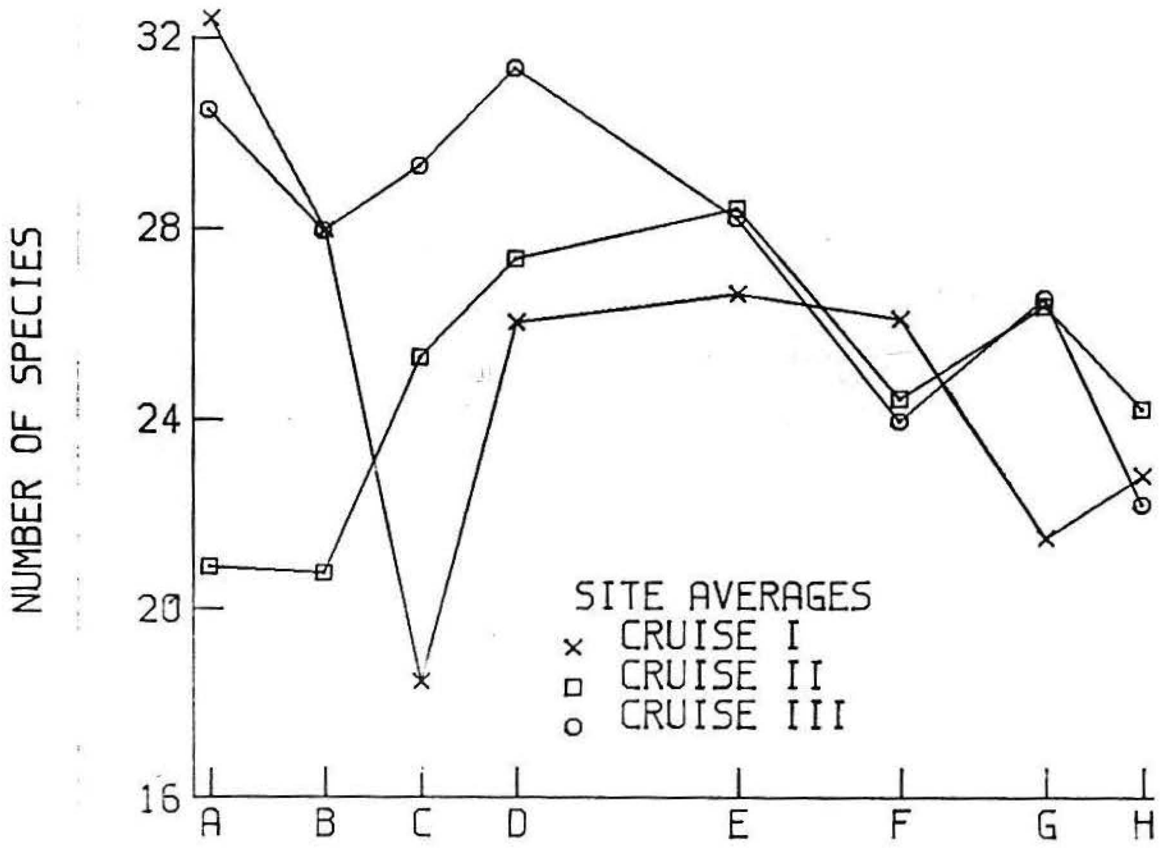

32
28
24
20
16
NUMBER OF SPECIES
A
B
C
D
E
F
G
H
SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 110

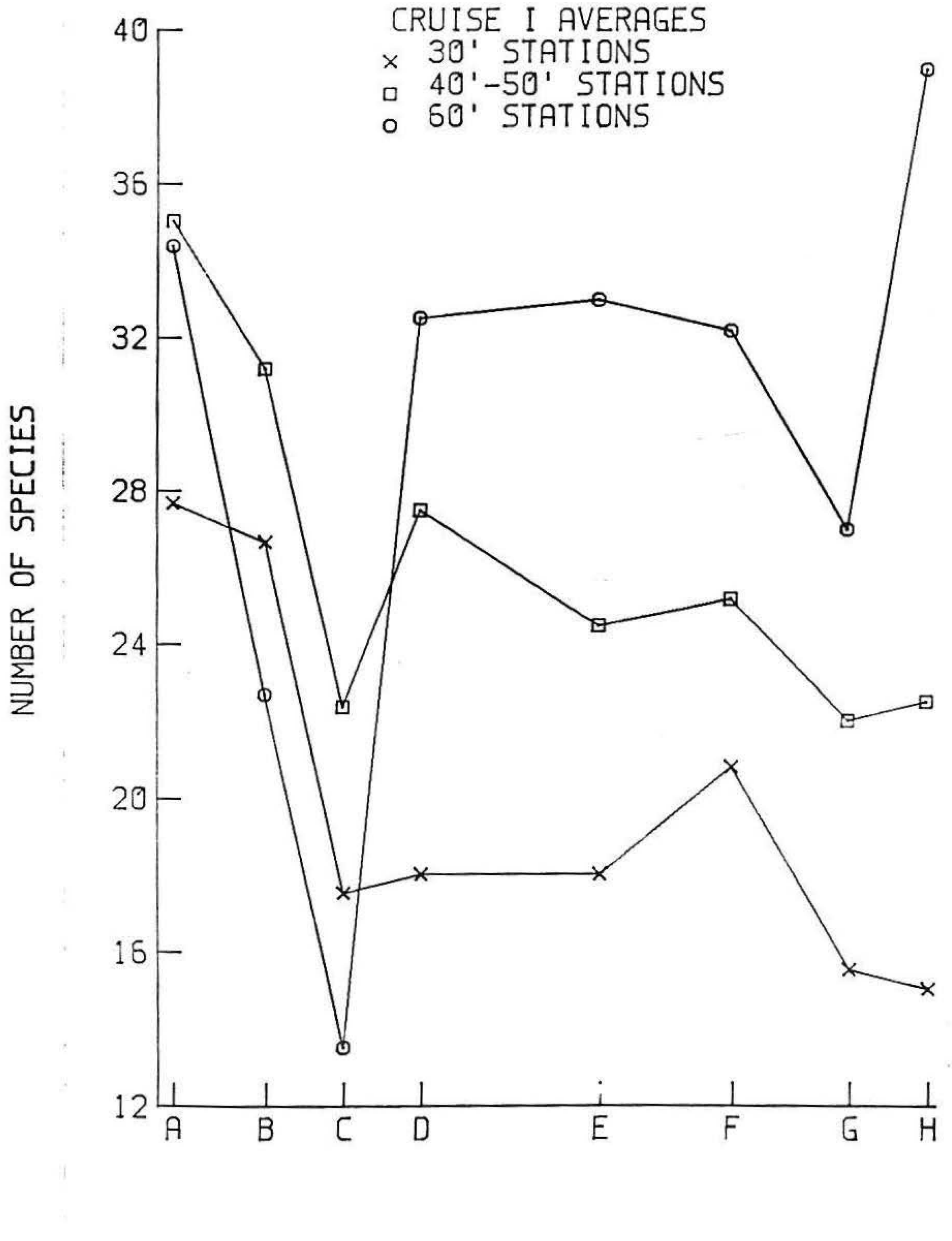

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
NUMBER OF SPECIES
40
36
32
28
24
20
16
12
A
B
C
D
E
F
G
H

Figure 111

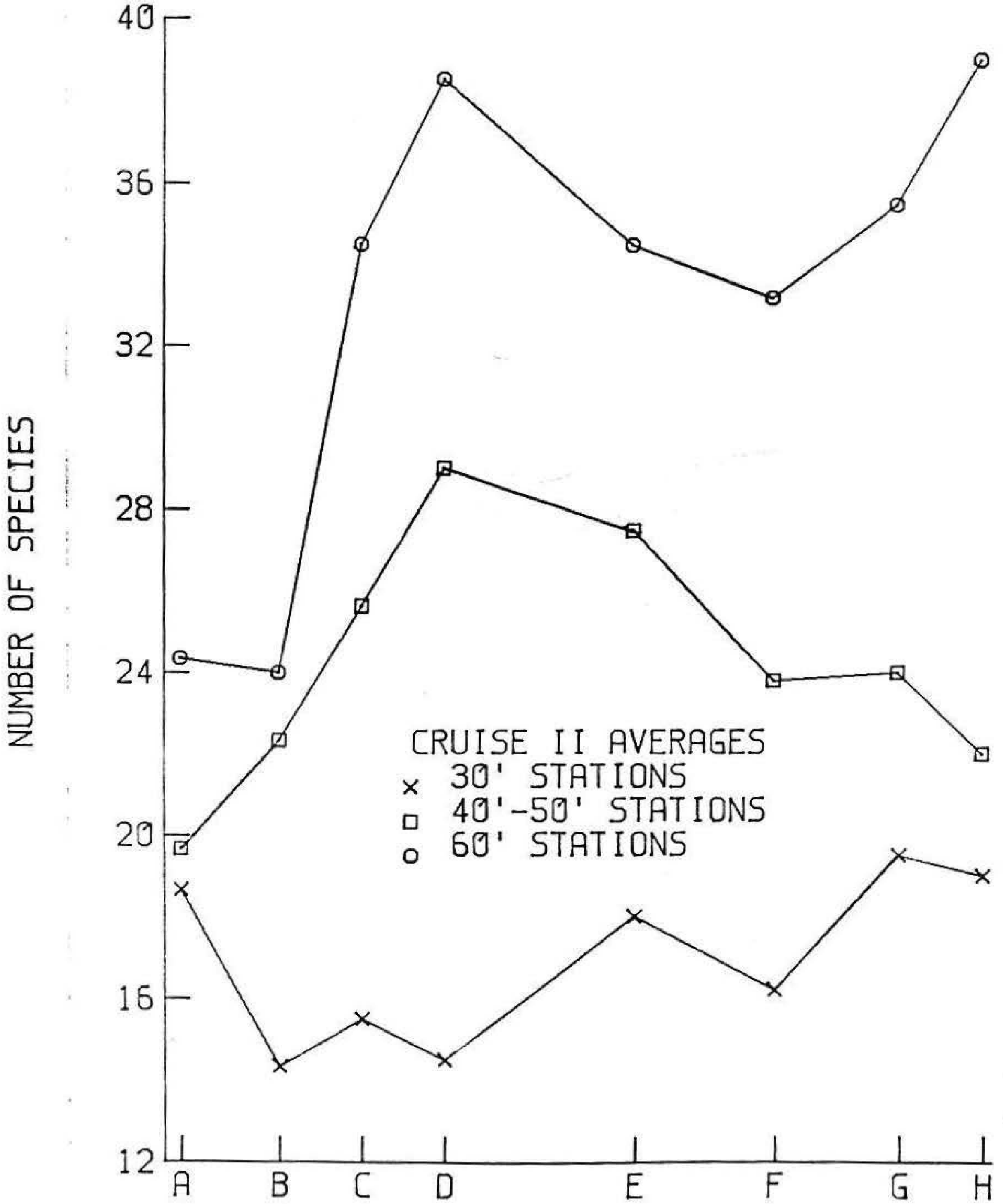

40
36
32
28
24
20
16
12
NUMBER OF SPECIES
A
B
C
D
E
F
G
H
CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS

Figure 112

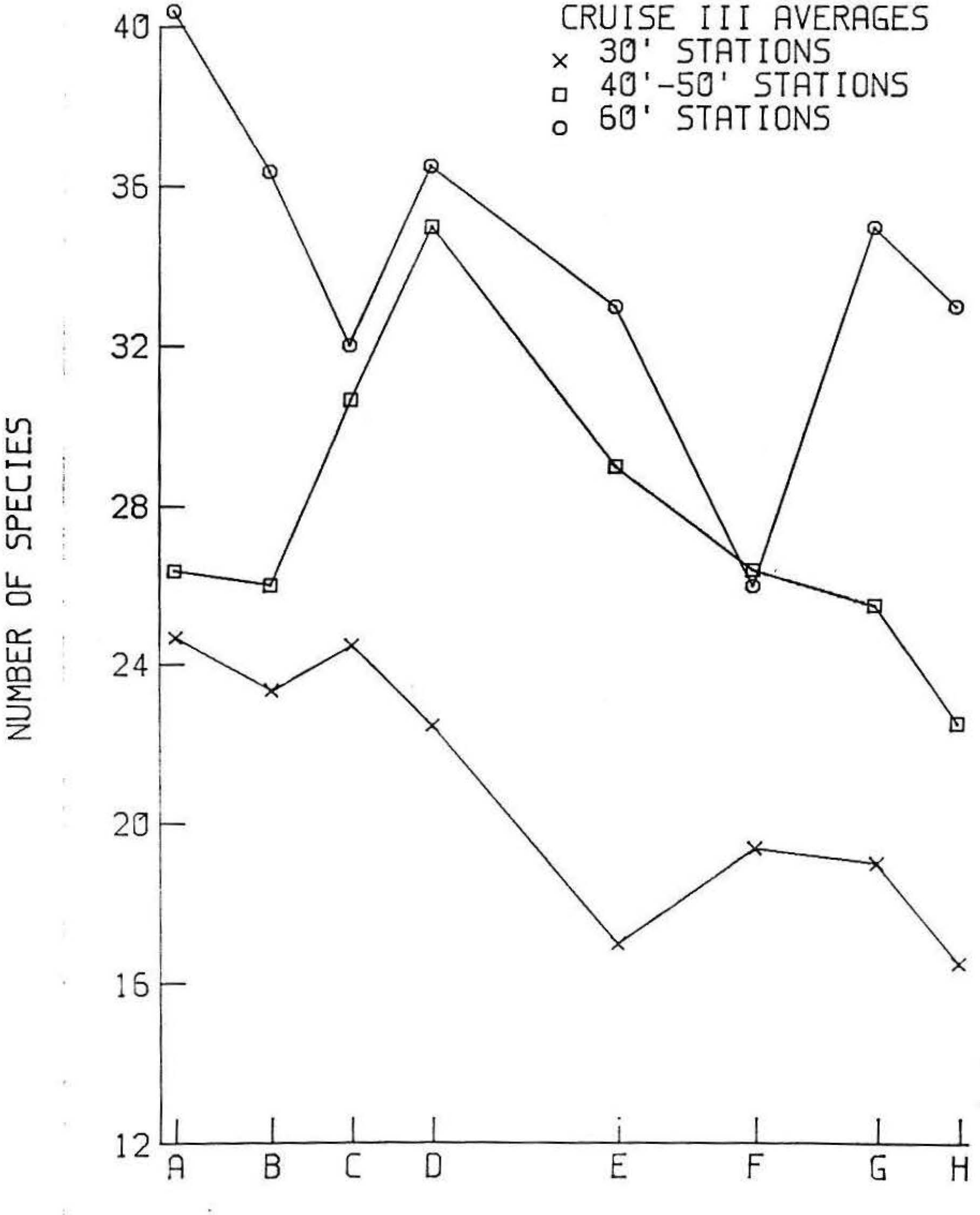

CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
NUMBER OF SPECIES
40
36
32
28
24
20
16
12
A
B
C
D
E
F
G
H

Figure 113

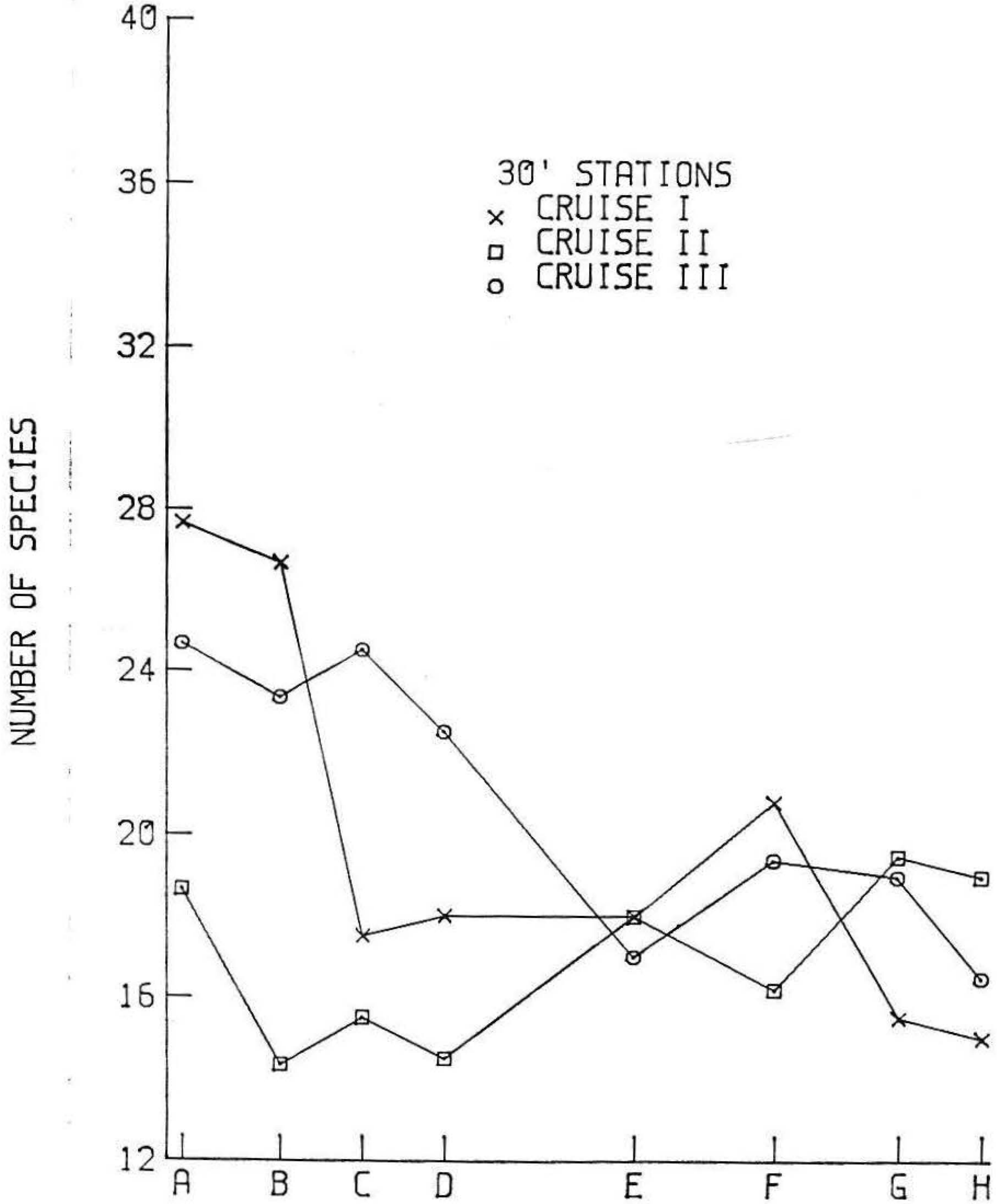
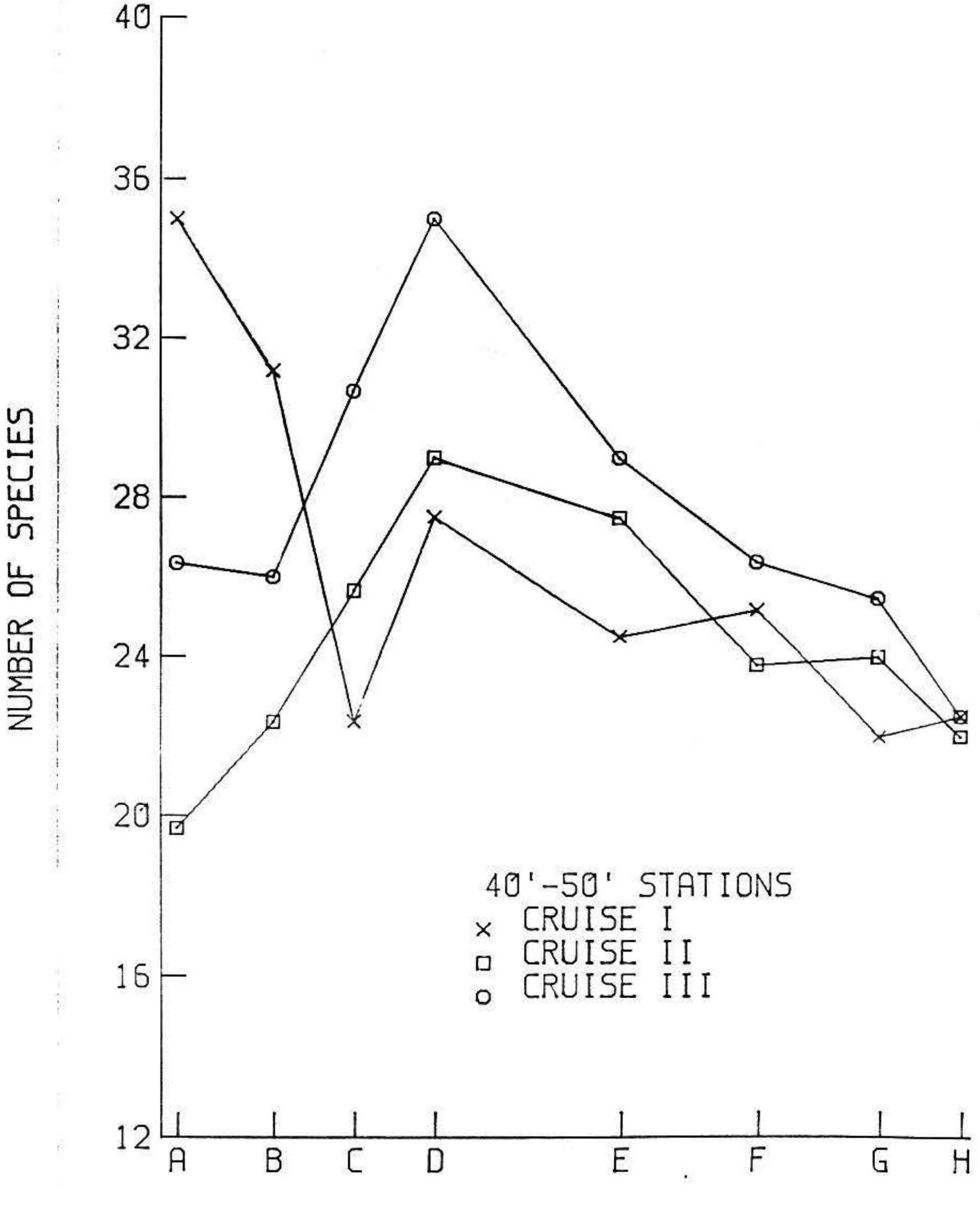
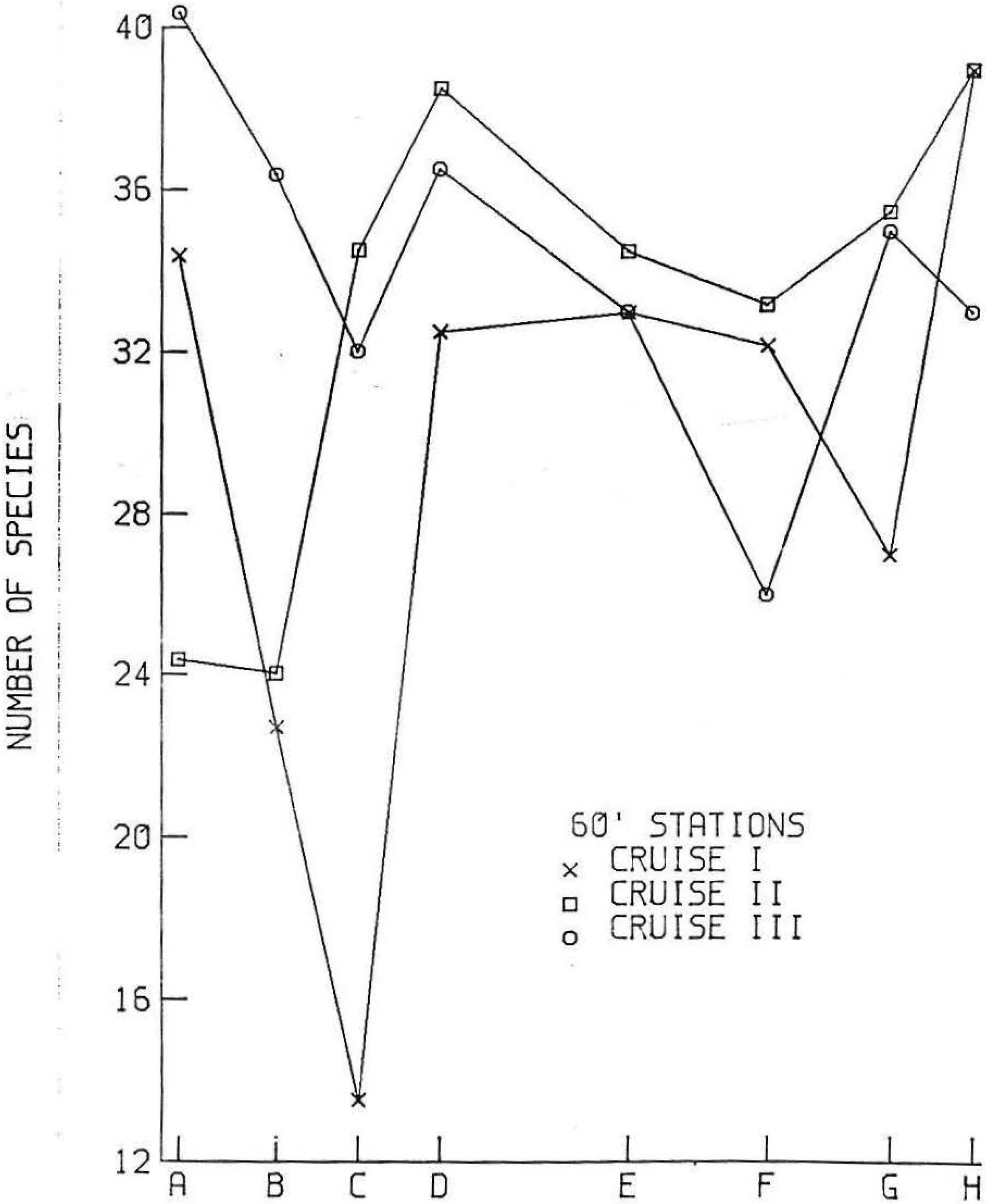

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
NUMBER OF SPECIES
40
36
32
28
24
20
16
12
A
B
C
D
E
F
G
H

Figure 114



40
36
32
28
24
20
16
12
NUMBER OF SPECIES
A
B
C
D
E
F
G
H
40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 115


NUMBER OF SPECIES
40
36
32
28
24
20
16
12
A
B
C
D
E
F
G
H
60' STATIONS
× CRUISE I
□ CRUISE II
o CRUISE III

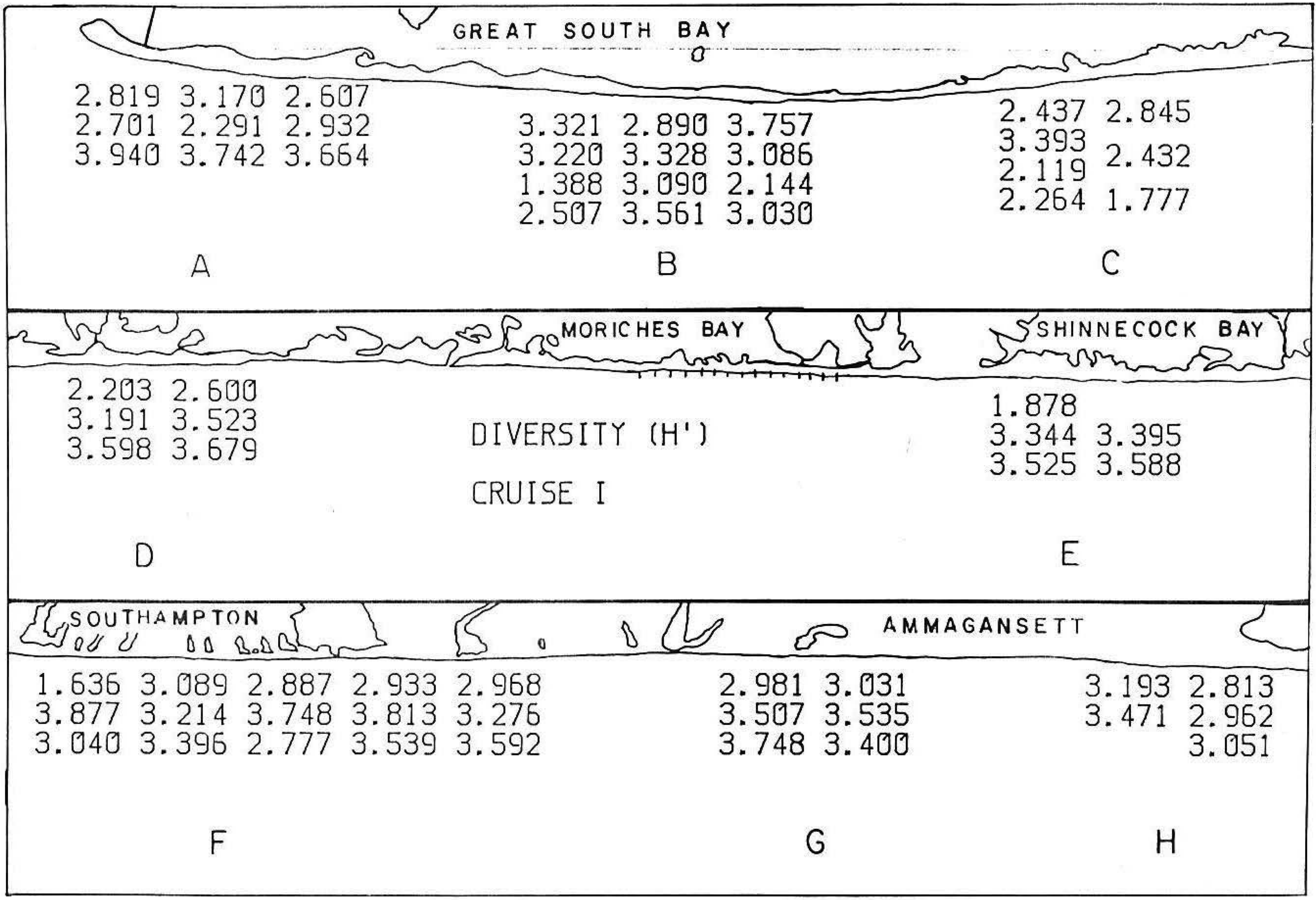

GREAT SOUTH BAY
2.819 3.170 2.607
2.701 2.291 2.932
3.940 3.742 3.664
A
3.321 2.890 3.757
3.220 3.328 3.086
1.388 3.090 2.144
2.507 3.561 3.030
B
2.437 2.845
3.393 2.432
2.119
2.264 1.777
C
MORICHES BAY
SHINNECOCK BAY
2.203 2.600
3.191 3.523
3.598 3.679
D
DIVERSITY (H')
CRUISE I
1.878
3.344 3.395
3.525 3.588
E
SOUTHAMPTON
AMMAGANSETT
1.636 3.089 2.887 2.933 2.968
3.877 3.214 3.748 3.813 3.276
3.040 3.396 2.777 3.539 3.592
F
2.981 3.031
3.507 3.535
3.748 3.400
G
3.193 2.813
3.471 2.962
3.051
H

Figure 116

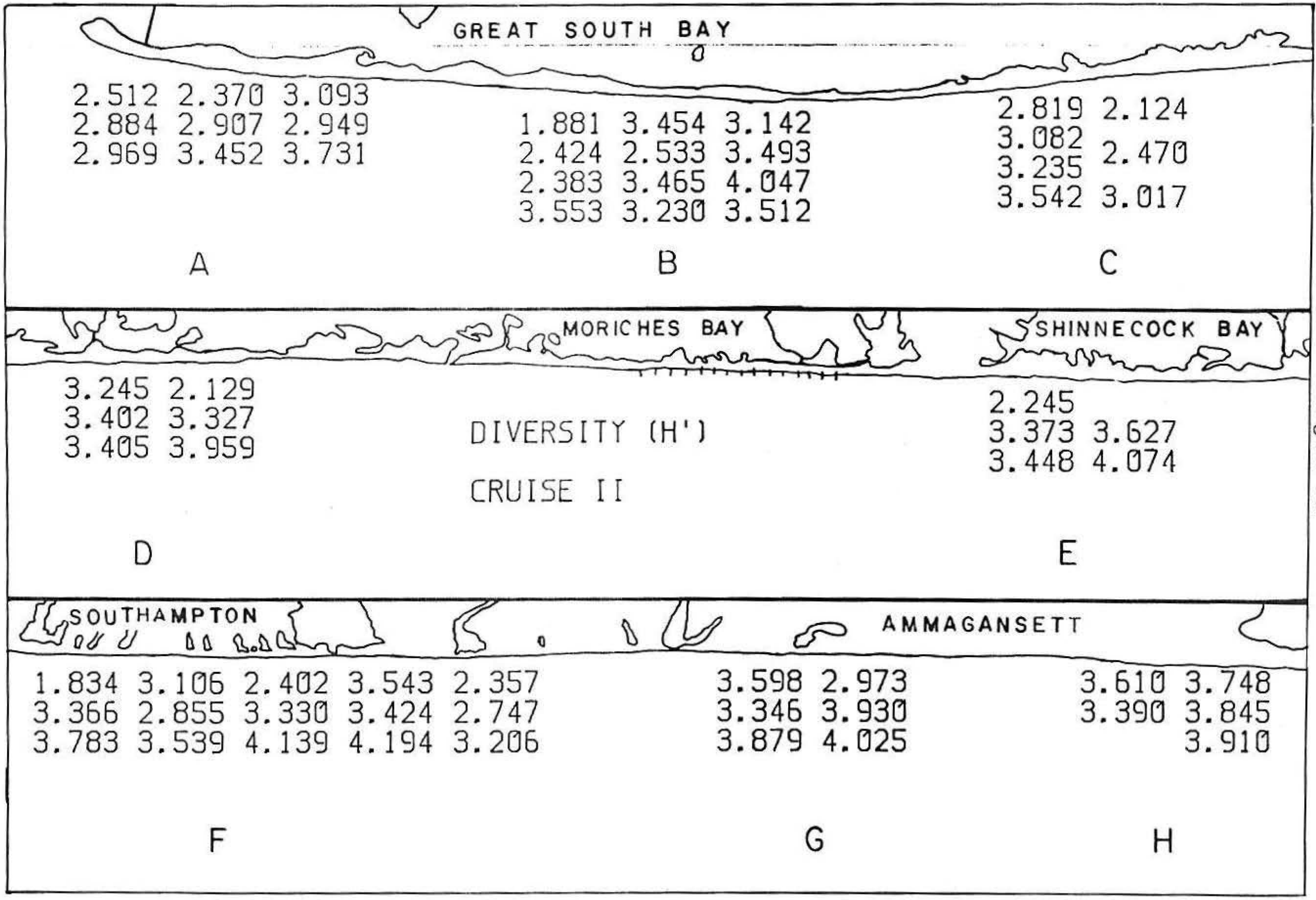

GREAT SOUTH BAY
2.512 2.370 3.093
2.884 2.907 2.949
2.969 3.452 3.731
A
1.881 3.454 3.142
2.424 2.533 3.493
2.383 3.465 4.047
3.553 3.230 3.512
B
2.819 2.124
3.082
3.235 2.470
3.542 3.017
C
MORICHES BAY
SHINNECOCK BAY
3.245 2.129
3.402 3.327
3.405 3.959
D
DIVERSITY (H')
CRUISE II
2.245
3.373 3.627
3.448 4.074
E
SOUTHAMPTON
AMMAGANSETT
1.834 3.106 2.402 3.543 2.357
3.366 2.855 3.330 3.424 2.747
3.783 3.539 4.139 4.194 3.206
F
3.598 2.973
3.346 3.930
3.879 4.025
G
3.610 3.748
3.390 3.845
3.910
H

Figure 117

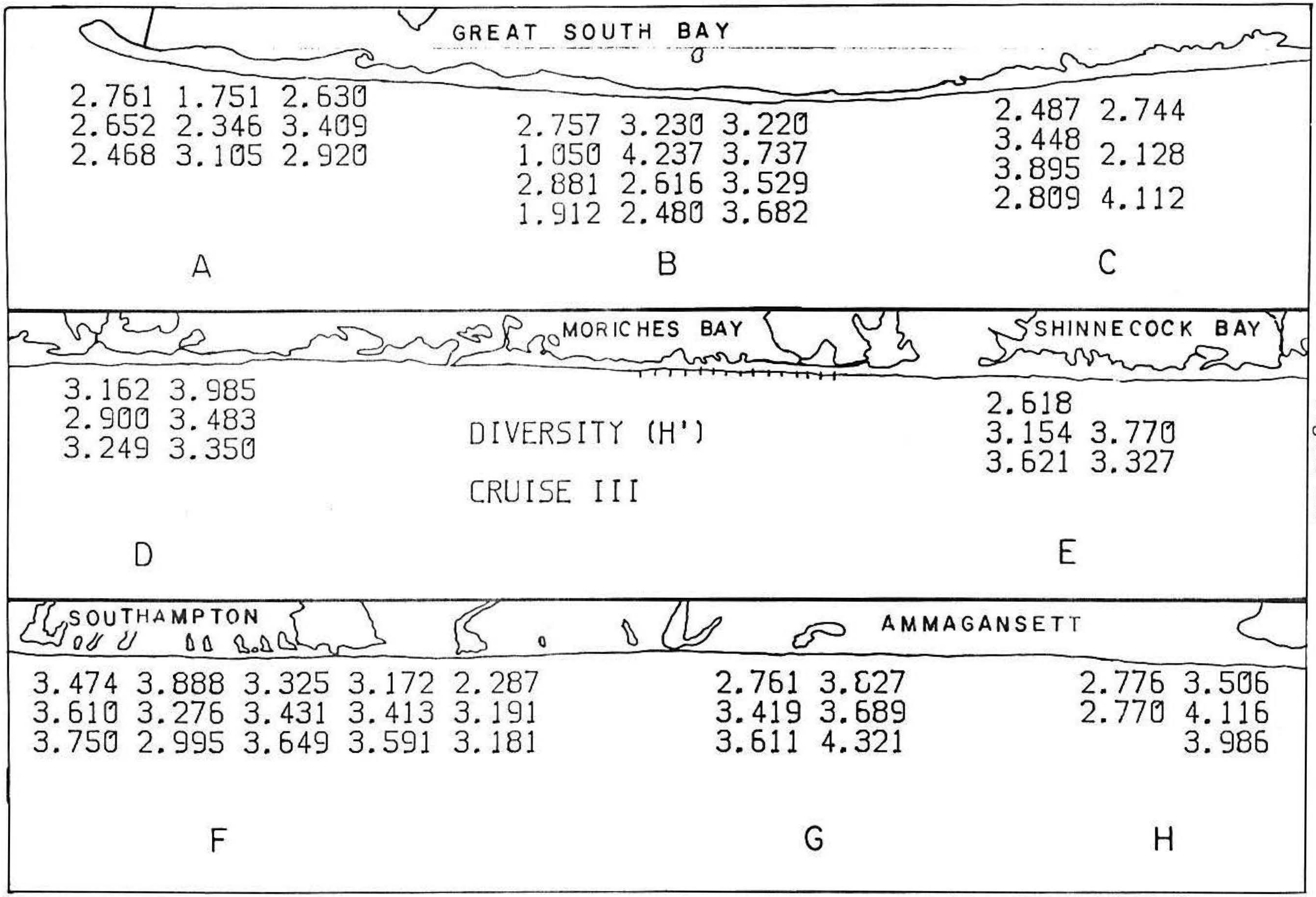

GREAT SOUTH BAY
2.761 1.751 2.630
2.652 2.346 3.409
2.468 3.105 2.920
A
2.757 3.230 3.220
1.050 4.237 3.737
2.881 2.616 3.529
1.912 2.480 3.682
B
2.487 2.744
3.448
3.895 2.128
2.809 4.112
C
MORICHES BAY
SHINNECOCK BAY
3.162 3.985
2.900 3.483
3.249 3.350
D
DIVERSITY (H')
CRUISE III
2.618
3.154 3.770
3.621 3.327
E
SOUTHAMPTON
AMMAGANSETT
3.474 3.888 3.325 3.172 2.287
3.610 3.276 3.431 3.413 3.191
3.750 2.995 3.649 3.591 3.181
F
2.761 3.827
3.419 3.689
3.611 4.321
G
2.776 3.506
2.770 4.116
3.986
H

Figure 118

Figure 119

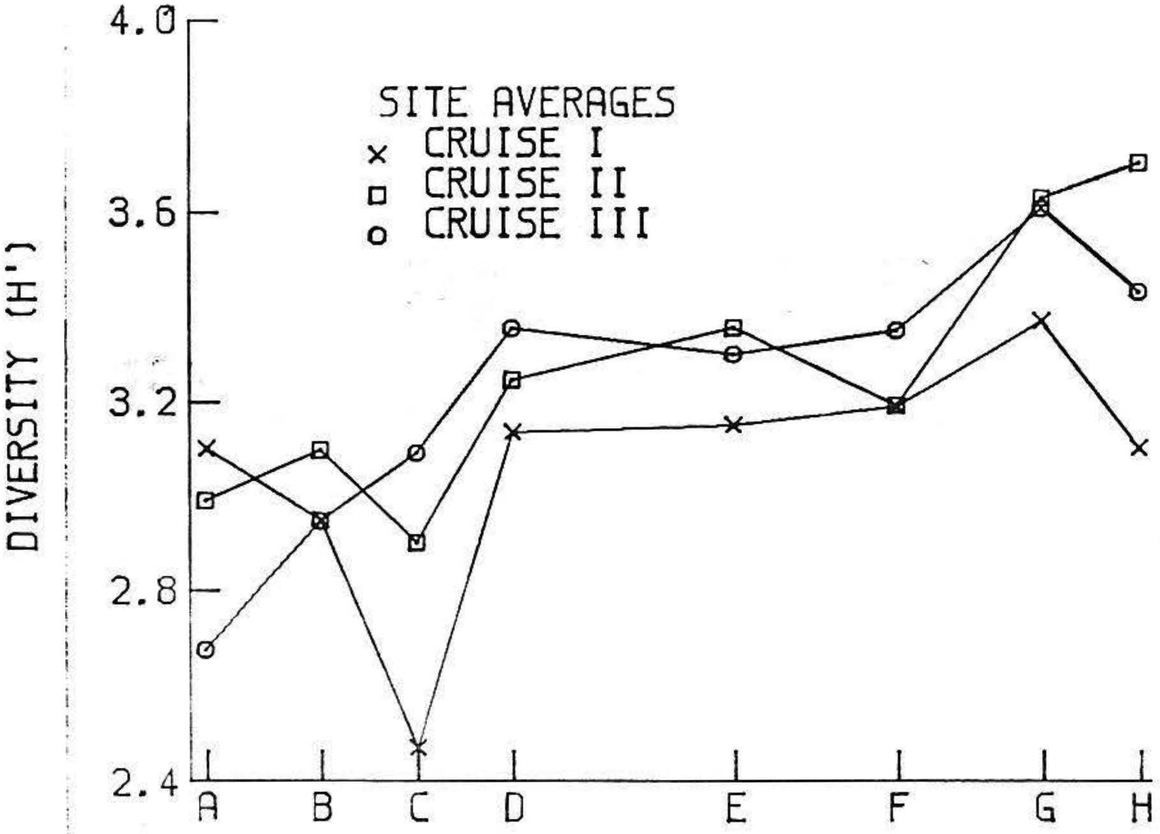

4.0
3.6
3.2
2.8
2.4
DIVERSITY (H')
SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
A
B
C
D
E
F
G
H

Figure 120

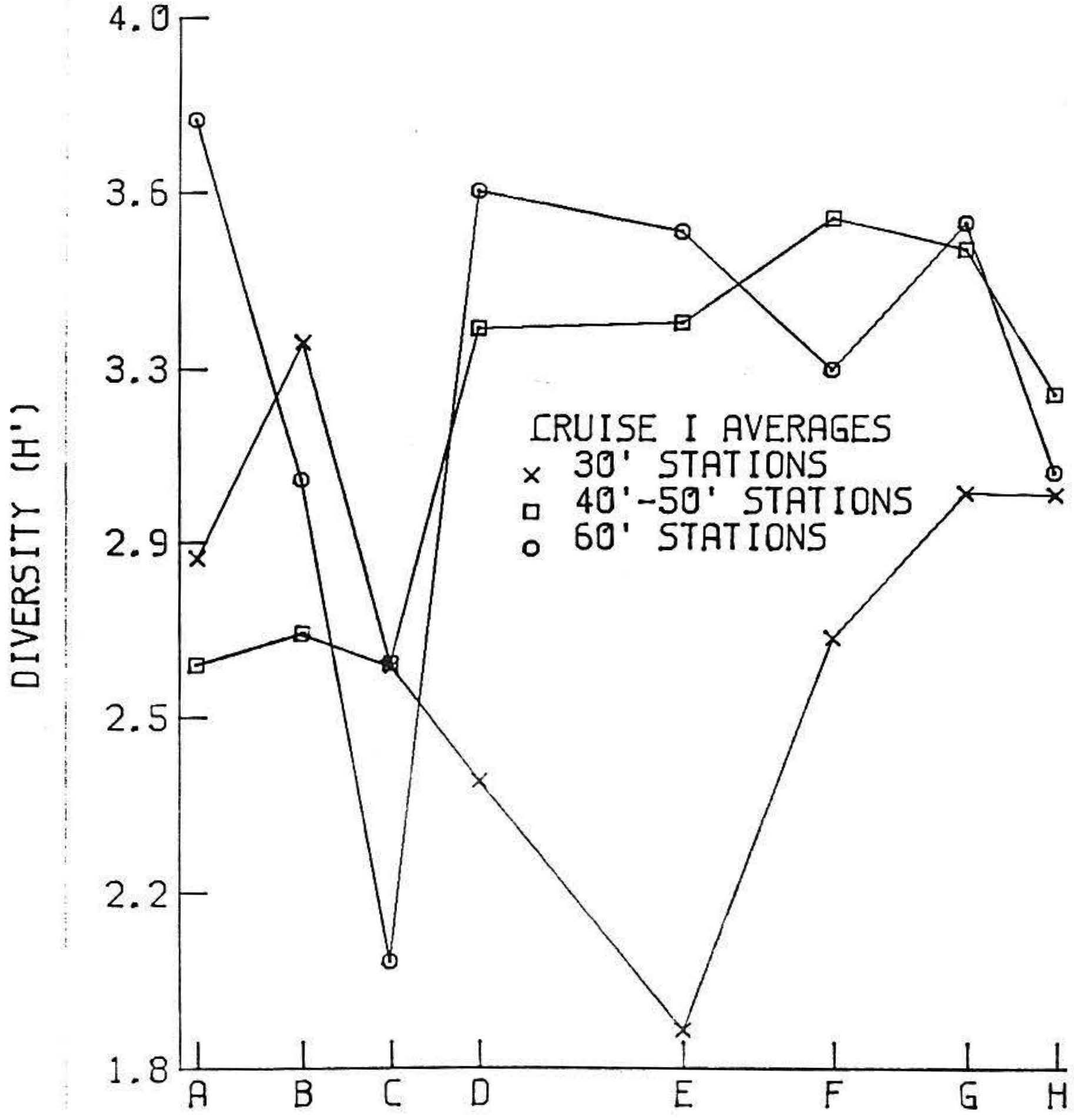

4.0
3.6
3.3
2.9
2.5
2.2
1.8
DIVERSITY (H')
A
B
C
D
E
F
G
H
CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS

Figure 121

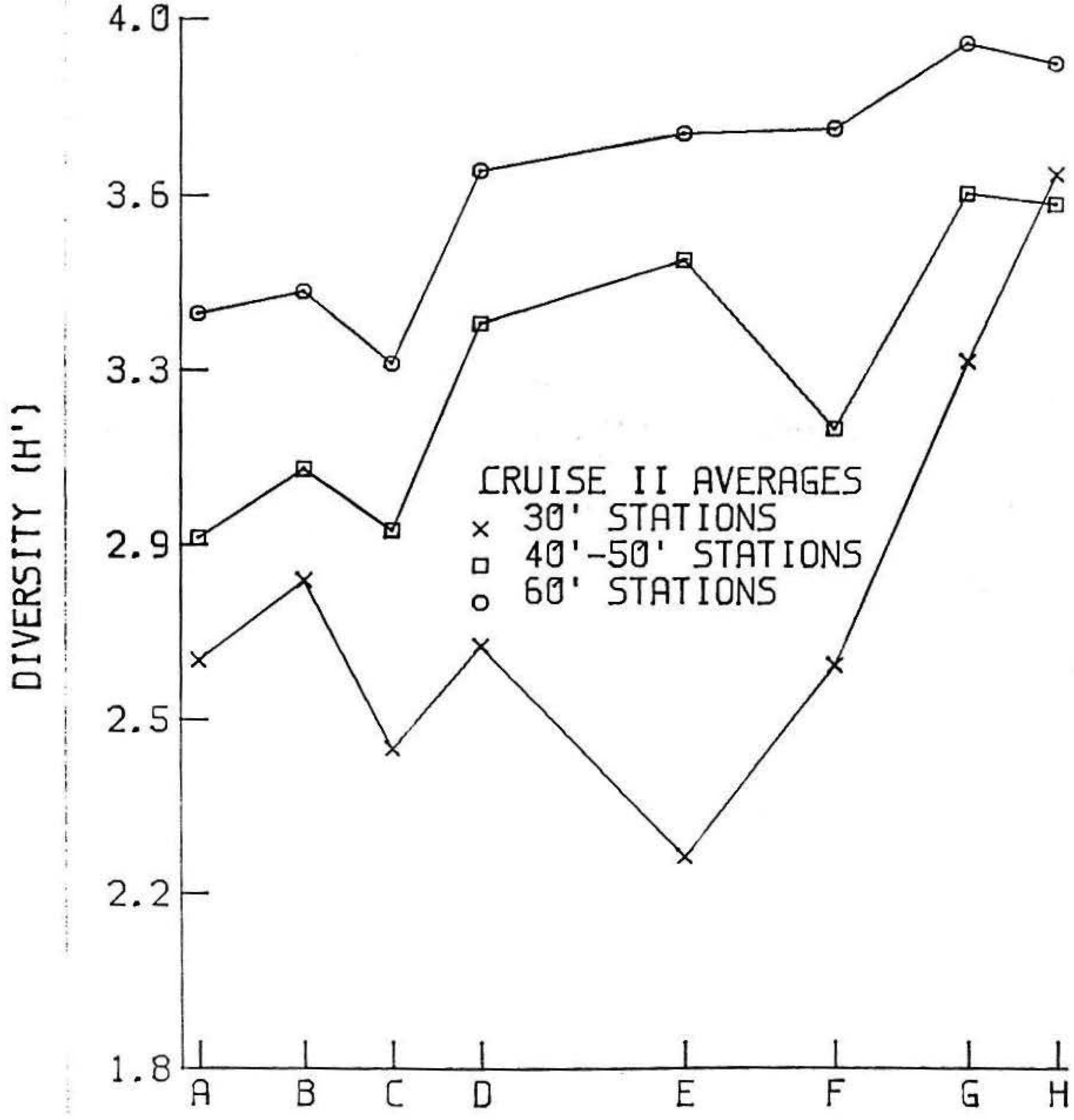

4.0
3.6
3.3
2.9
2.5
2.2
1.8
DIVERSITY (H')
CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
A
B
C
D
E
F
G
H

Figure 122

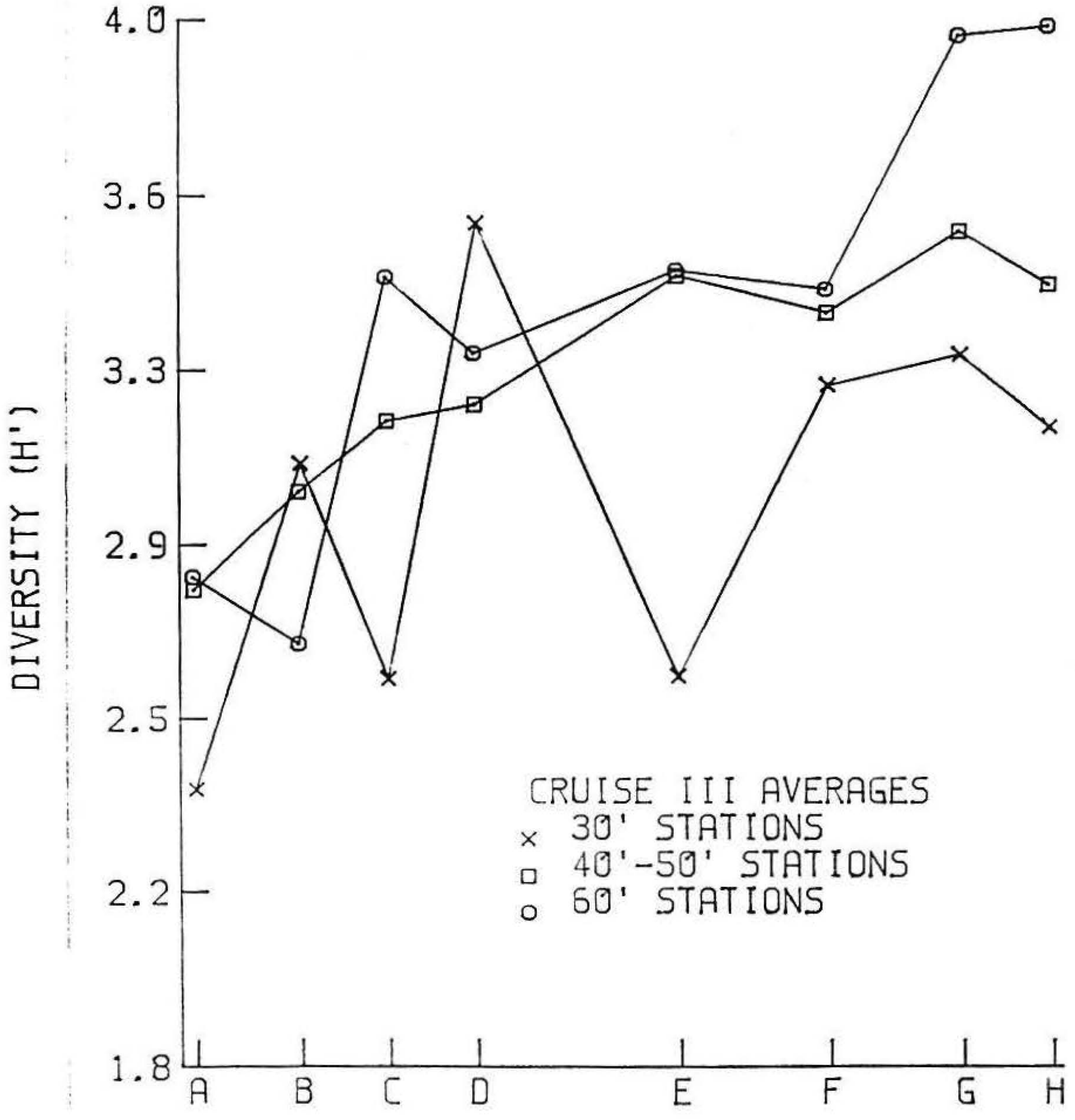

4.0
3.6
3.3
2.9
2.5
2.2
1.8
DIVERSITY (H')
A
B
C
D
E
F
G
H
CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS

Figure 123

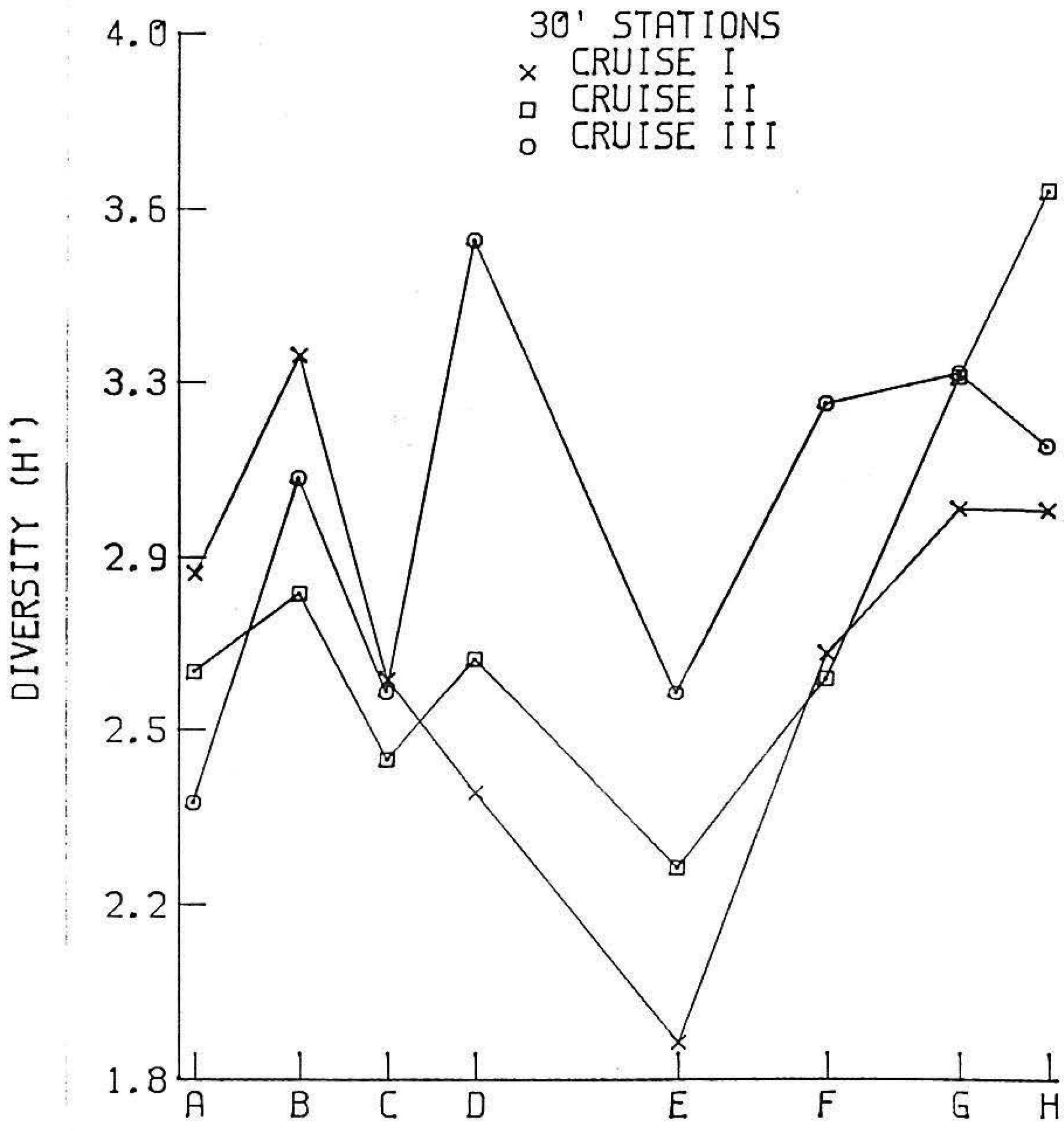

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
DIVERSITY (H')
4.0
3.6
3.3
2.9
2.5
2.2
1.8
A
B
C
D
E
F
G
H

Figure 124

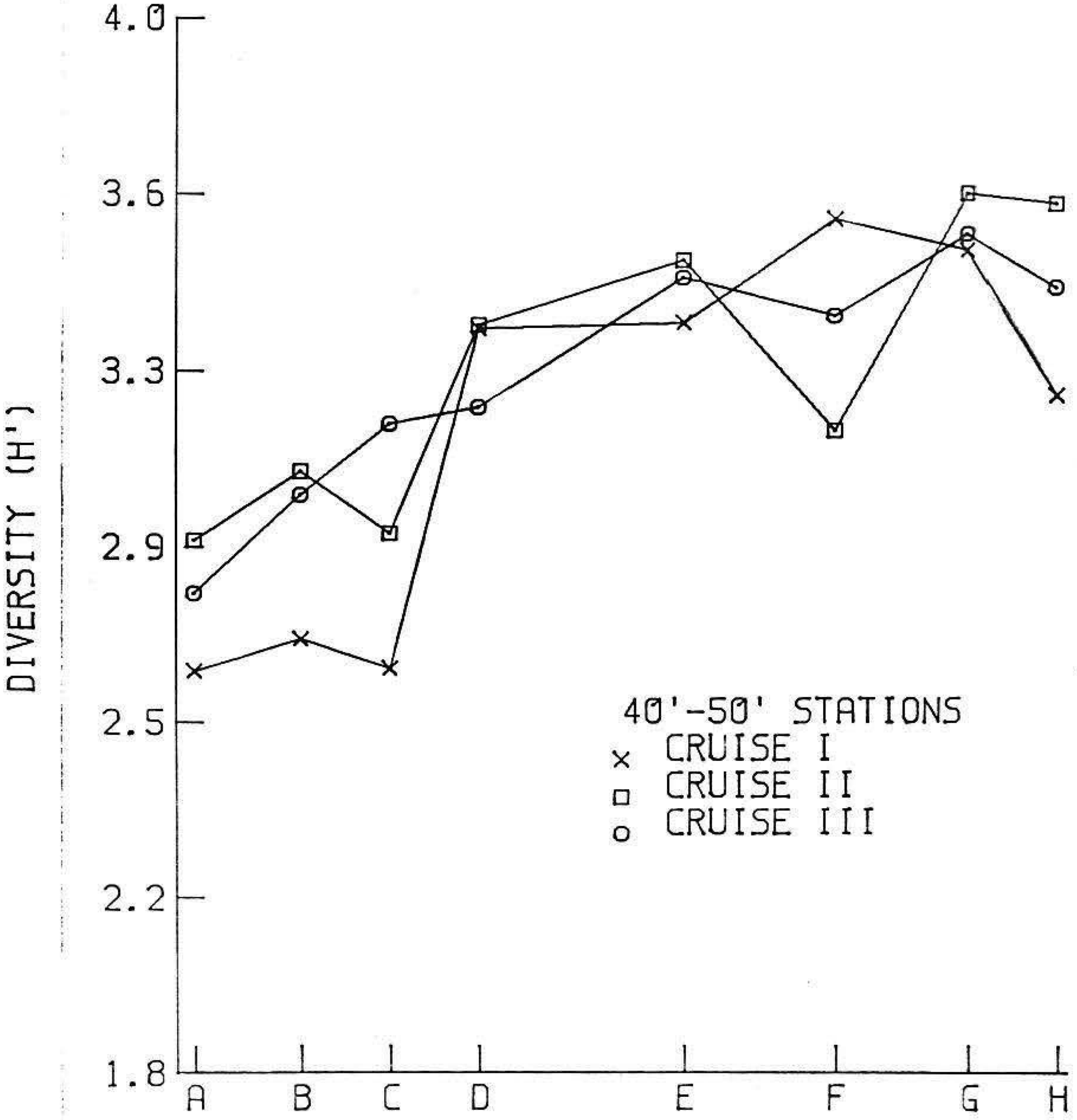
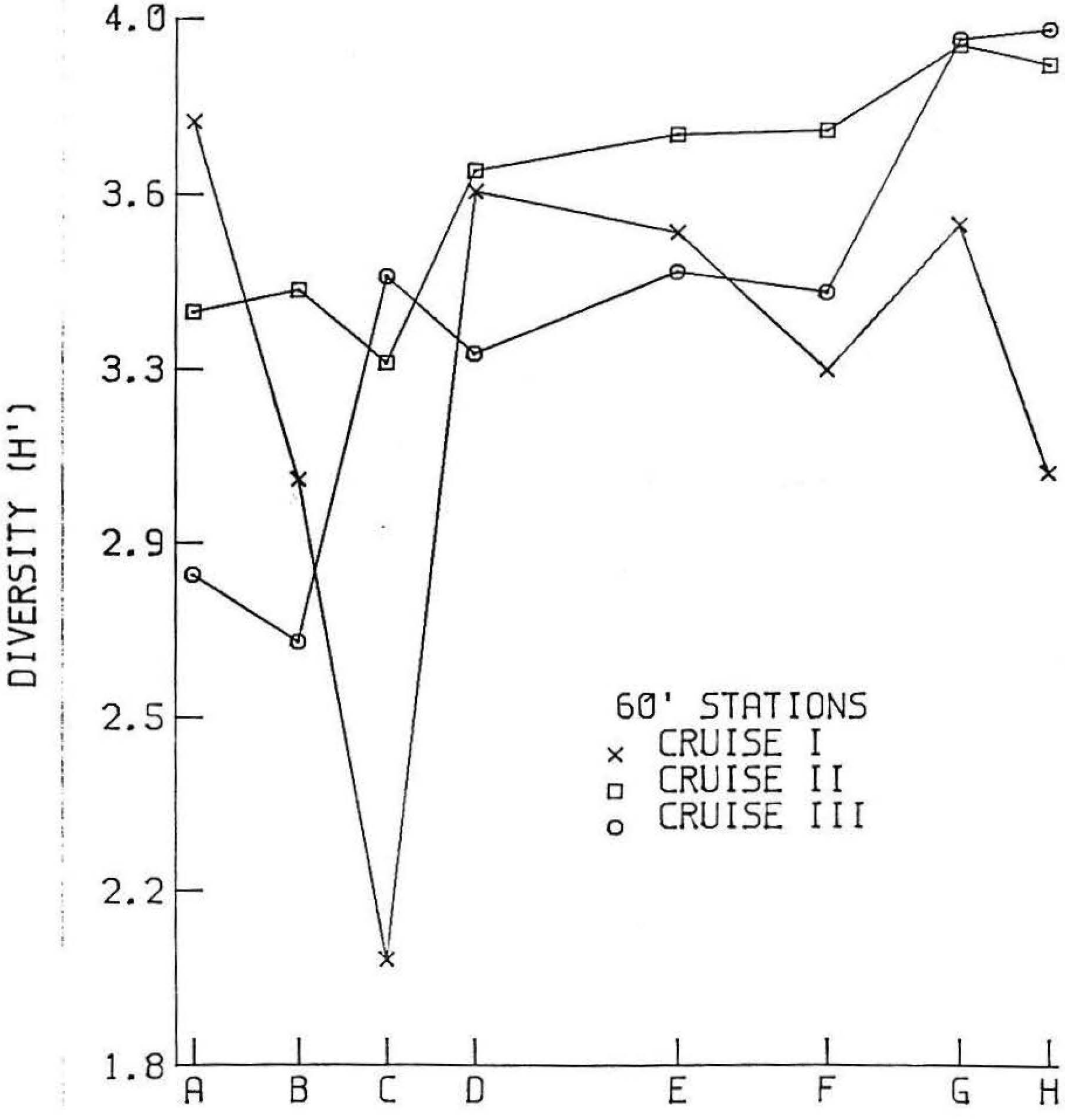

4.0
3.6
3.3
2.9
2.5
2.2
1.8
DIVERSITY (H')
A
B
C
D
E
F
G
H
40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

Figure 125


DIVERSITY (H')
4.0
3.6
3.3
2.9
2.5
2.2
1.8
A
B
C
D
E
F
G
H
60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

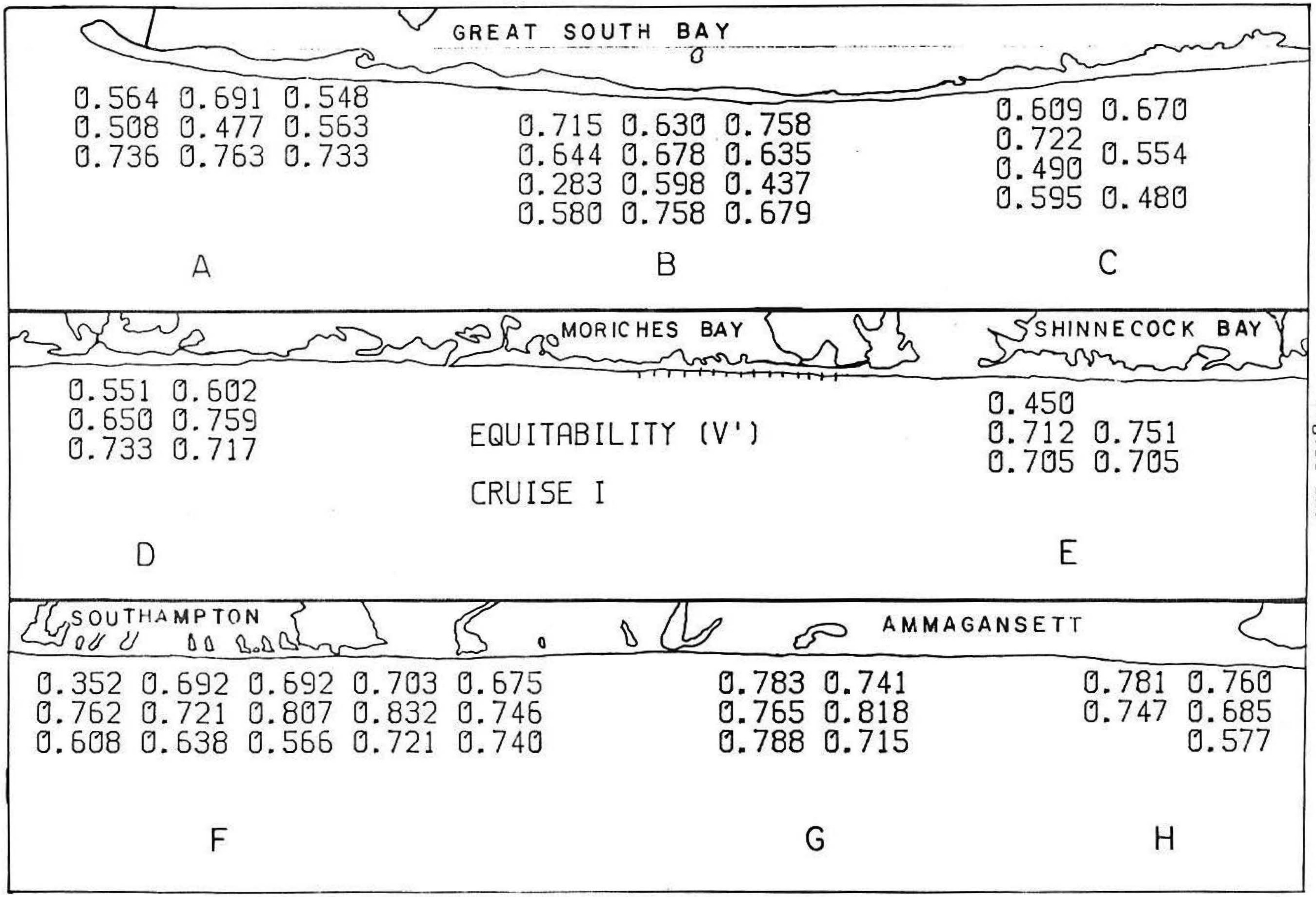

GREAT SOUTH BAY
0.564 0.691 0.548
0.508 0.477 0.563
0.736 0.763 0.733
0.715 0.630 0.758
0.644 0.678 0.635
0.283 0.598 0.437
0.580 0.758 0.679
0.609 0.670
0.722
0.490 0.554
0.595 0.480
A
B
C
MORICHES BAY
SHINNECOCK BAY
0.551 0.602
0.650 0.759
0.733 0.717
EQUITABILITY (V')
CRUISE I
0.450
0.712 0.751
0.705 0.705
D
E
SOUTHAMPTON
AMMAGANSETT
0.352 0.692 0.692 0.703 0.675
0.762 0.721 0.807 0.832 0.746
0.608 0.638 0.566 0.721 0.740
0.783 0.741
0.765 0.818
0.788 0.715
0.781 0.760
0.747 0.685
0.577
F
G
H

Figure 126

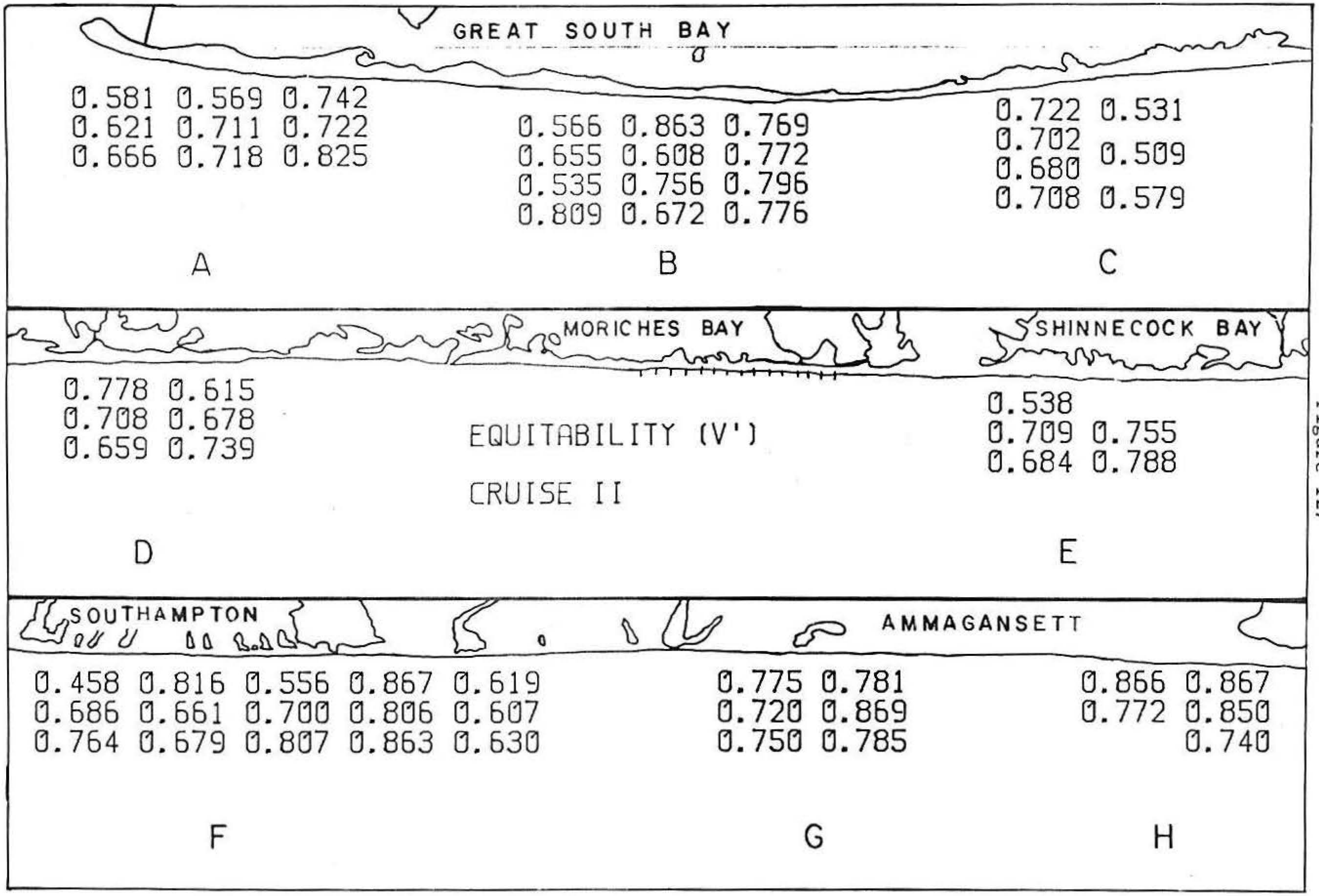

GREAT SOUTH BAY
0.581 0.569 0.742
0.621 0.711 0.722
0.666 0.718 0.825
A
0.566 0.863 0.769
0.655 0.608 0.772
0.535 0.756 0.796
0.809 0.672 0.776
B
0.722 0.531
0.702
0.680 0.509
0.708 0.579
C
MORICHES BAY
SHINNECOCK BAY
0.778 0.615
0.708 0.678
0.659 0.739
D
EQUITABILITY (V')
CRUISE II
0.538
0.709 0.755
0.684 0.788
E
SOUTHAMPTON
AMMAGANSETT
0.458 0.816 0.556 0.867 0.619
0.686 0.661 0.700 0.806 0.607
0.764 0.679 0.807 0.863 0.630
F
0.775 0.781
0.720 0.869
0.750 0.785
G
0.866 0.867
0.772 0.850
0.740
H

Figure 127

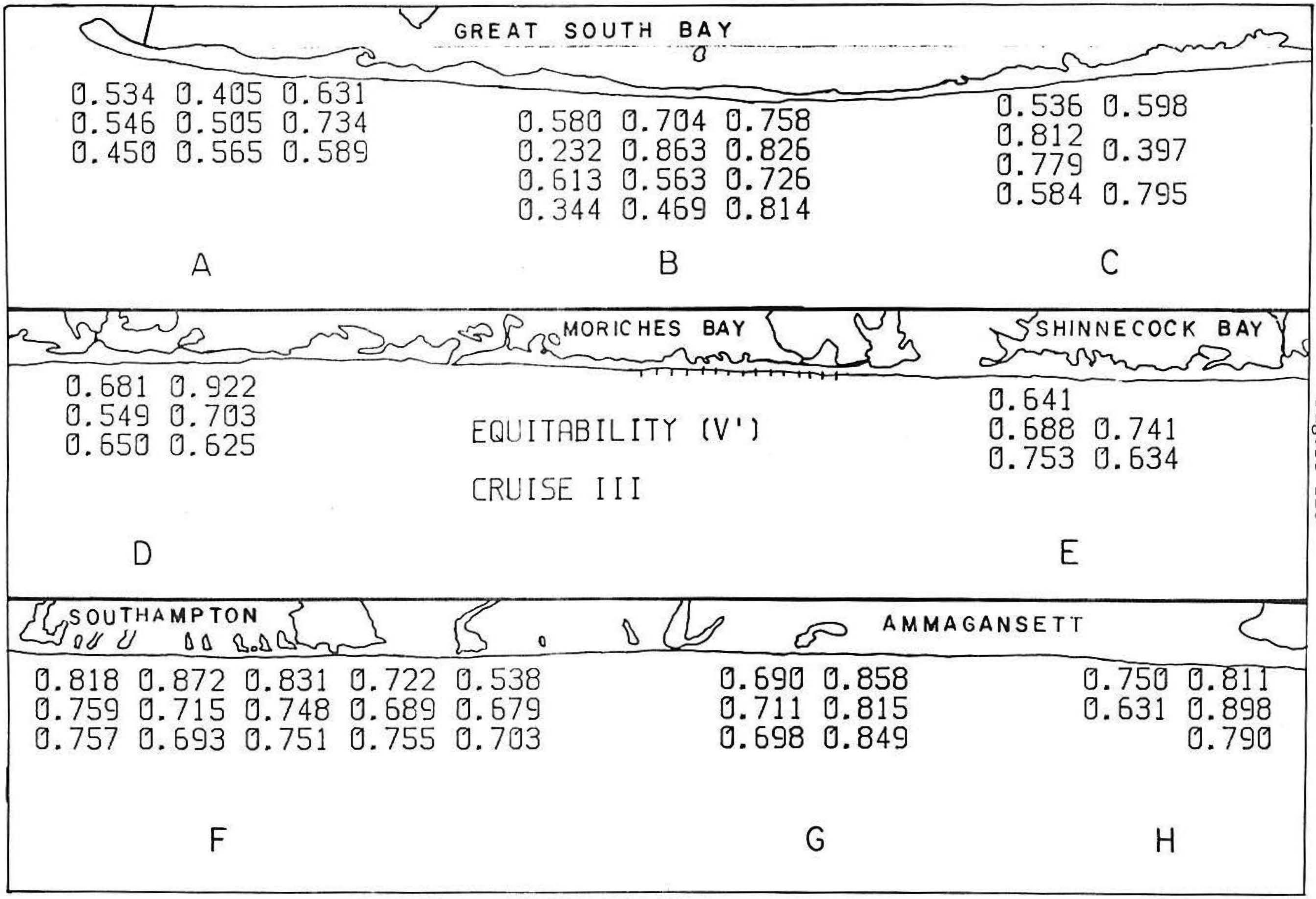

GREAT SOUTH BAY
0.534 0.405 0.631
0.546 0.505 0.734
0.450 0.565 0.589
A
0.580 0.704 0.758
0.232 0.863 0.826
0.613 0.563 0.726
0.344 0.469 0.814
B
0.536 0.598
0.812
0.779 0.397
0.584 0.795
C
MORICHES BAY
SHINNECOCK BAY
0.681 0.922
0.549 0.703
0.650 0.625
D
EQUITABILITY (V')
CRUISE III
0.641
0.688 0.741
0.753 0.634
E
SOUTHAMPTON
AMMAGANSETT
0.818 0.872 0.831 0.722 0.538
0.759 0.715 0.748 0.689 0.679
0.757 0.693 0.751 0.755 0.703
F
0.690 0.858
0.711 0.815
0.698 0.849
G
0.750 0.811
0.631 0.898
0.790
H

Figure 128

Figure 129

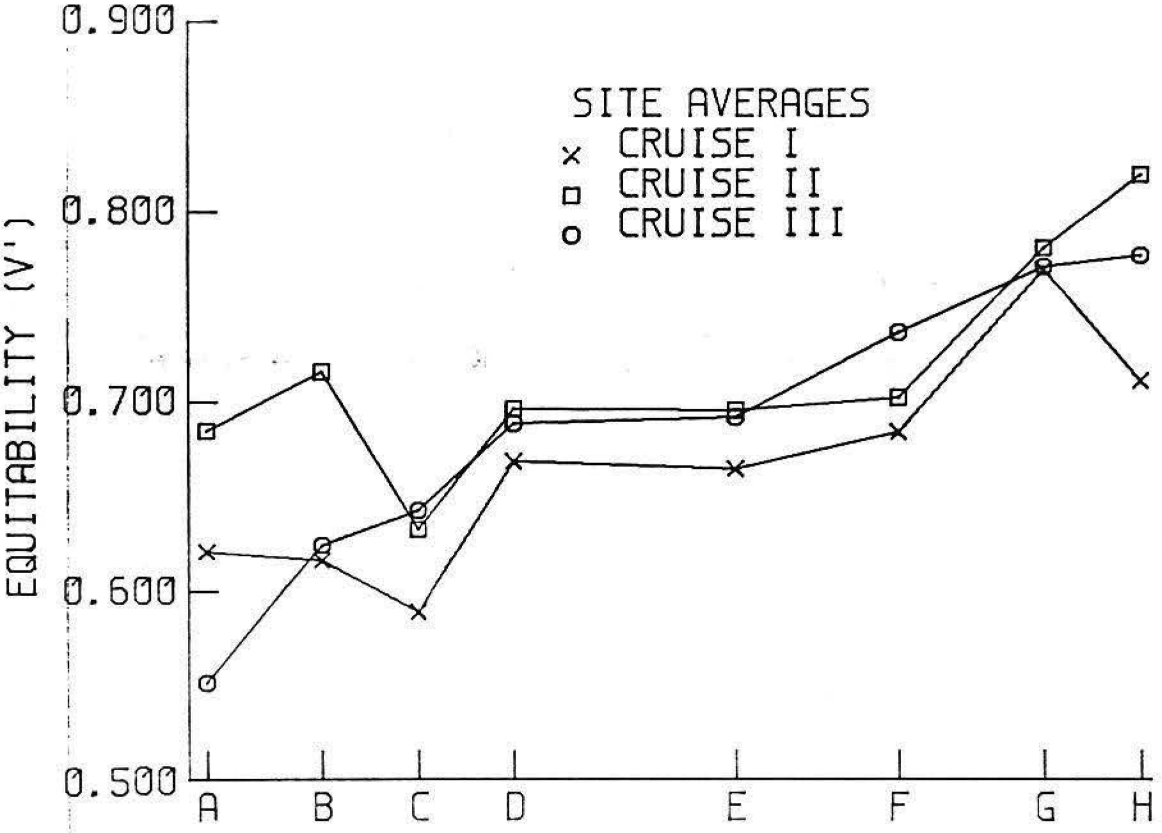

0.900
0.800
0.700
0.600
0.500
EQUITABILITY (V')
SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
A
B
C
D
E
F
G
H

Figure 130

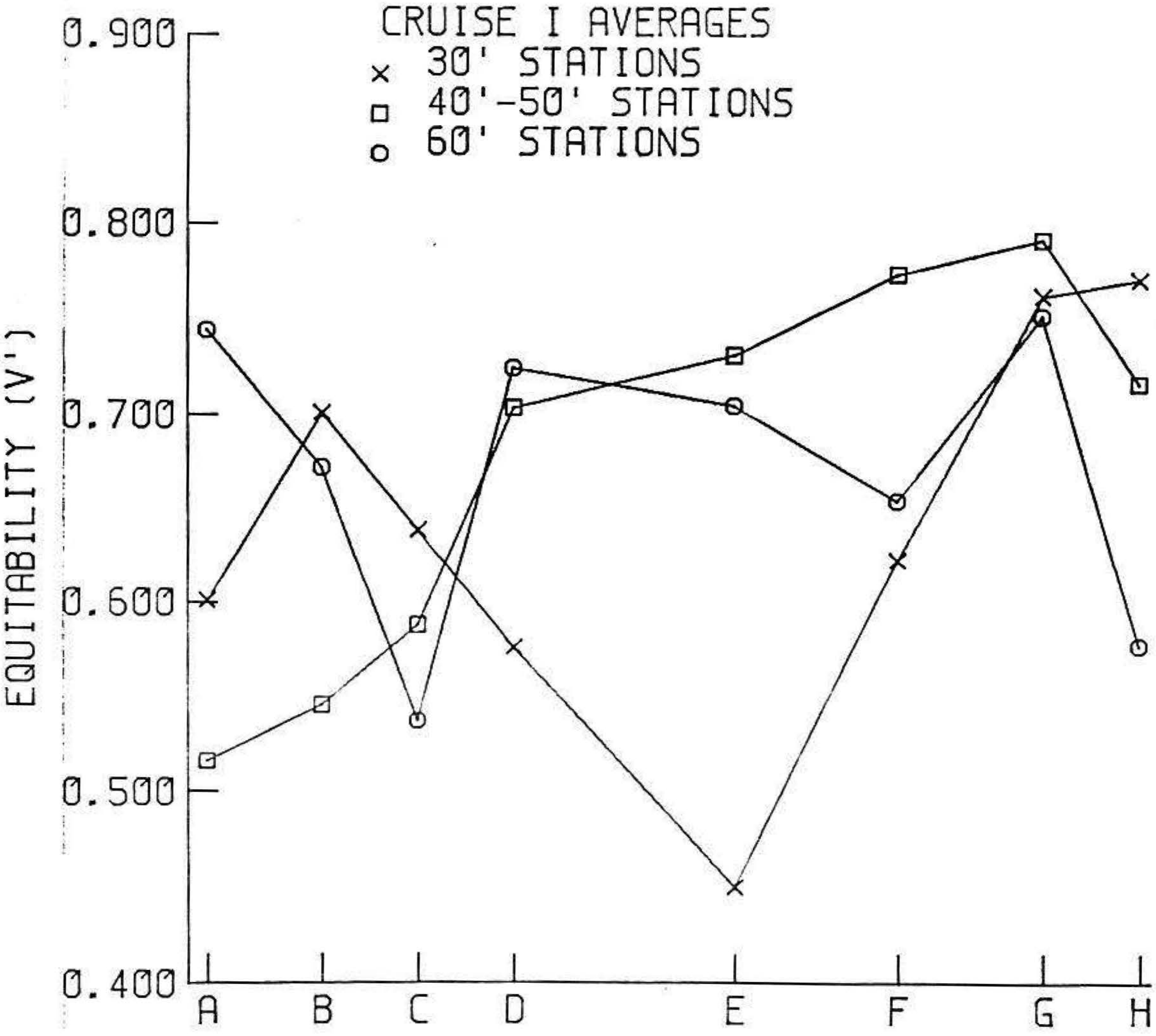

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
EQUITABILITY (V')
0.900
0.800
0.700
0.600
0.500
0.400
A
B
C
D
E
F
G
H

Figure 131

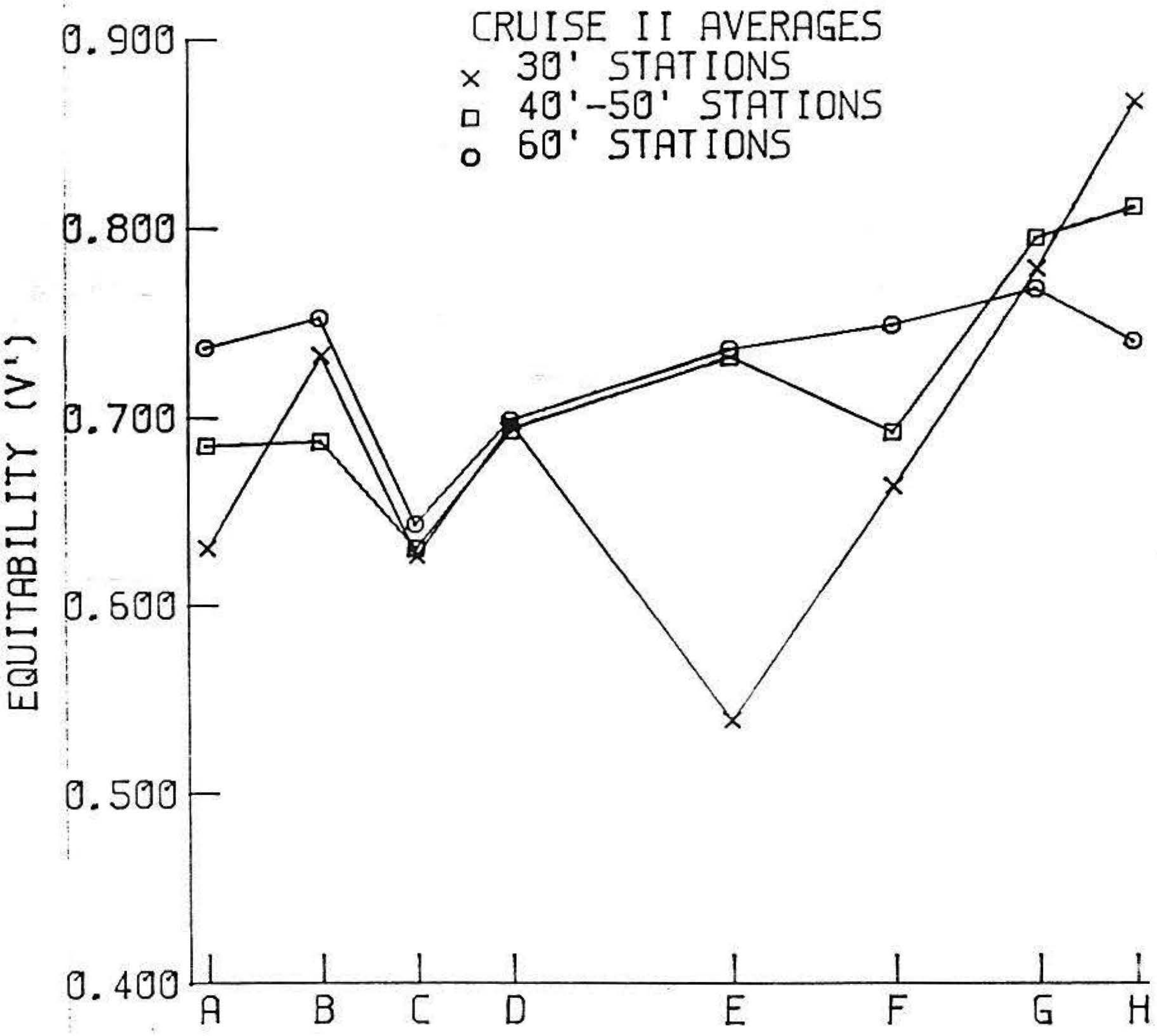

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
EQUITABILITY (V')
0.900
0.800
0.700
0.600
0.500
0.400
A
B
C
D
E
F
G
H

Figure 132

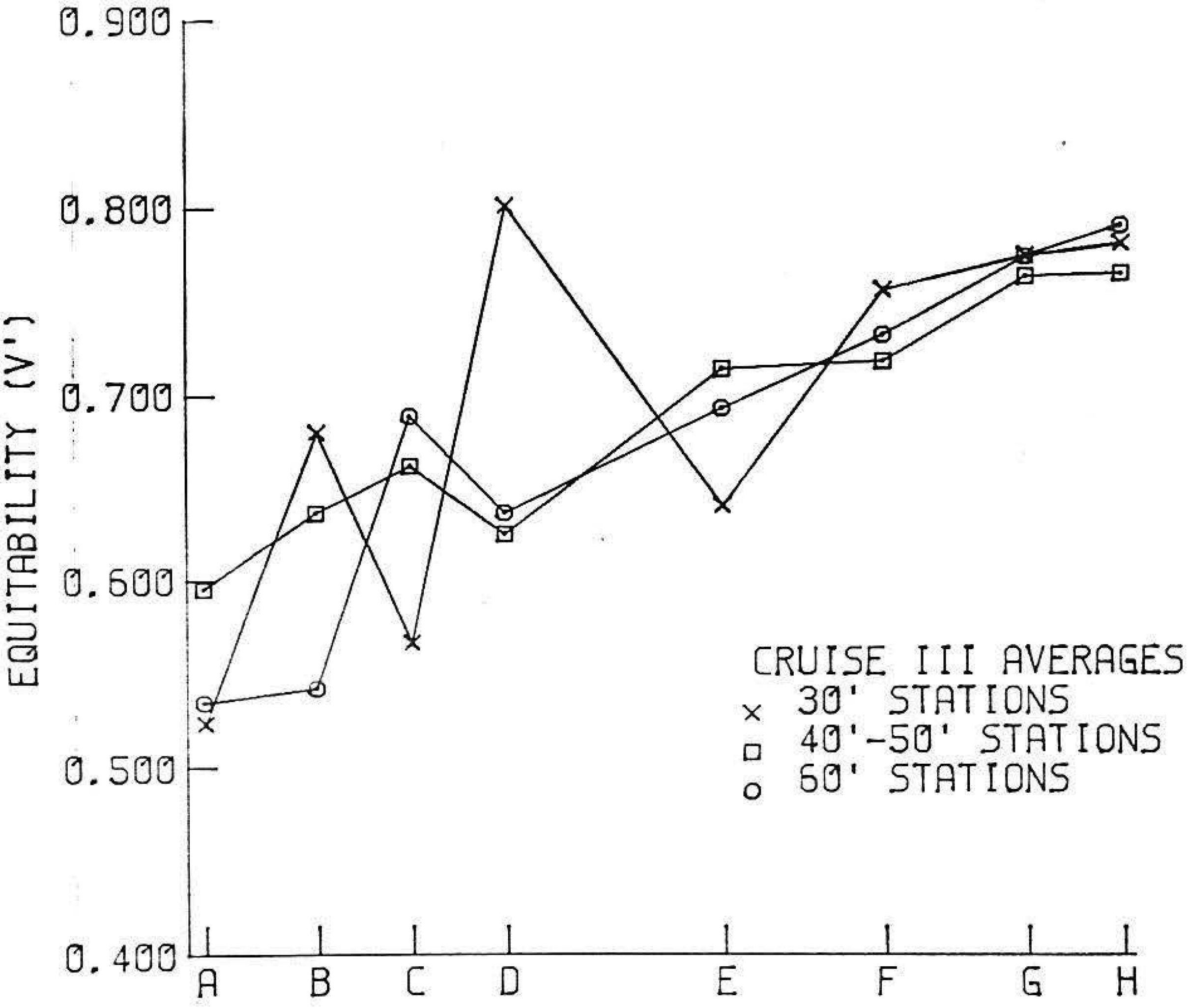

0.900
0.800
0.700
0.600
0.500
0.400
EQUITABILITY (V')
A
B
C
D
E
F
G
H
CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS

Figure 133

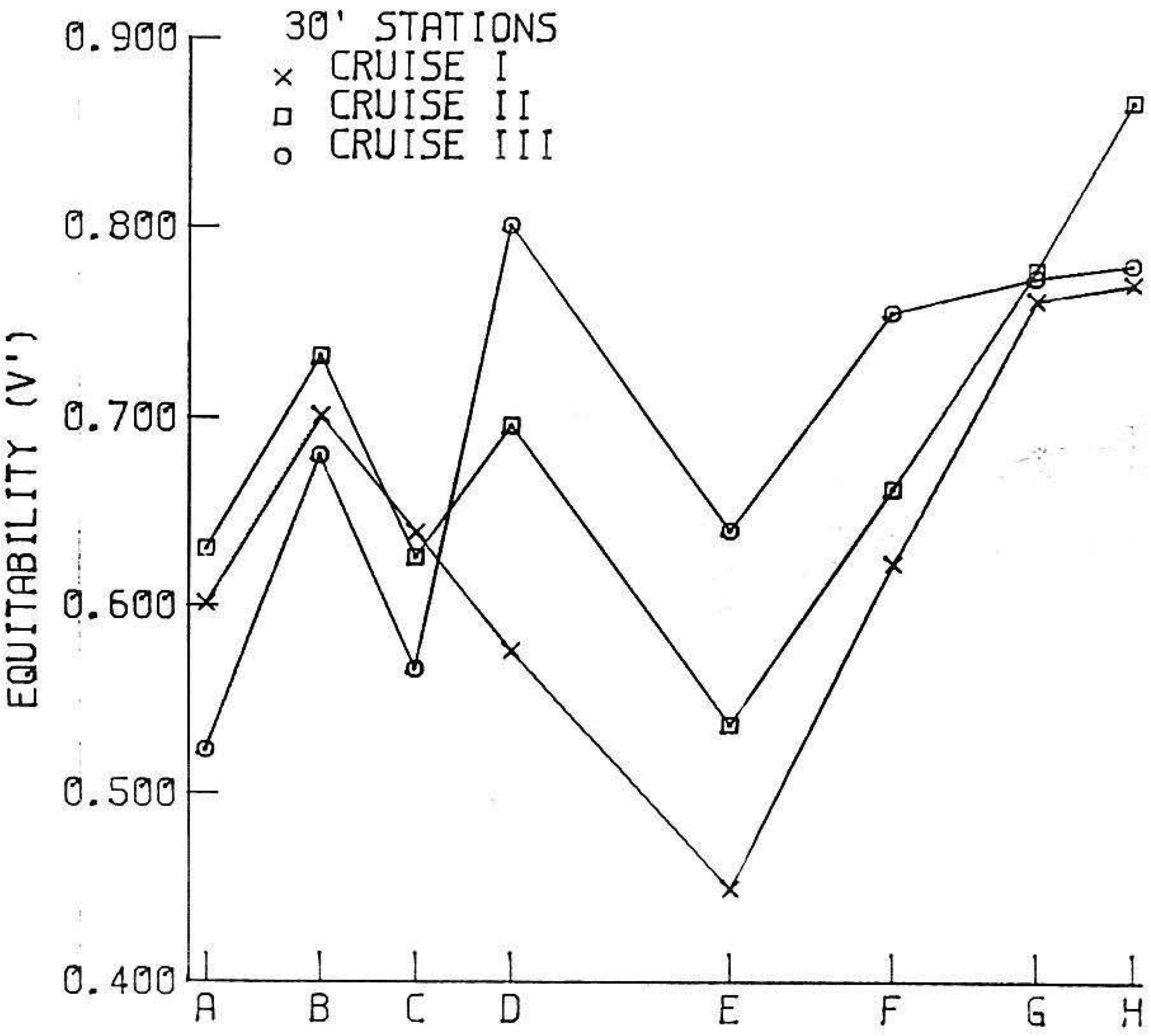

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
EQUITABILITY (V')
0.900
0.800
0.700
0.600
0.500
0.400
A
B
C
D
E
F
G
H

Figure 134

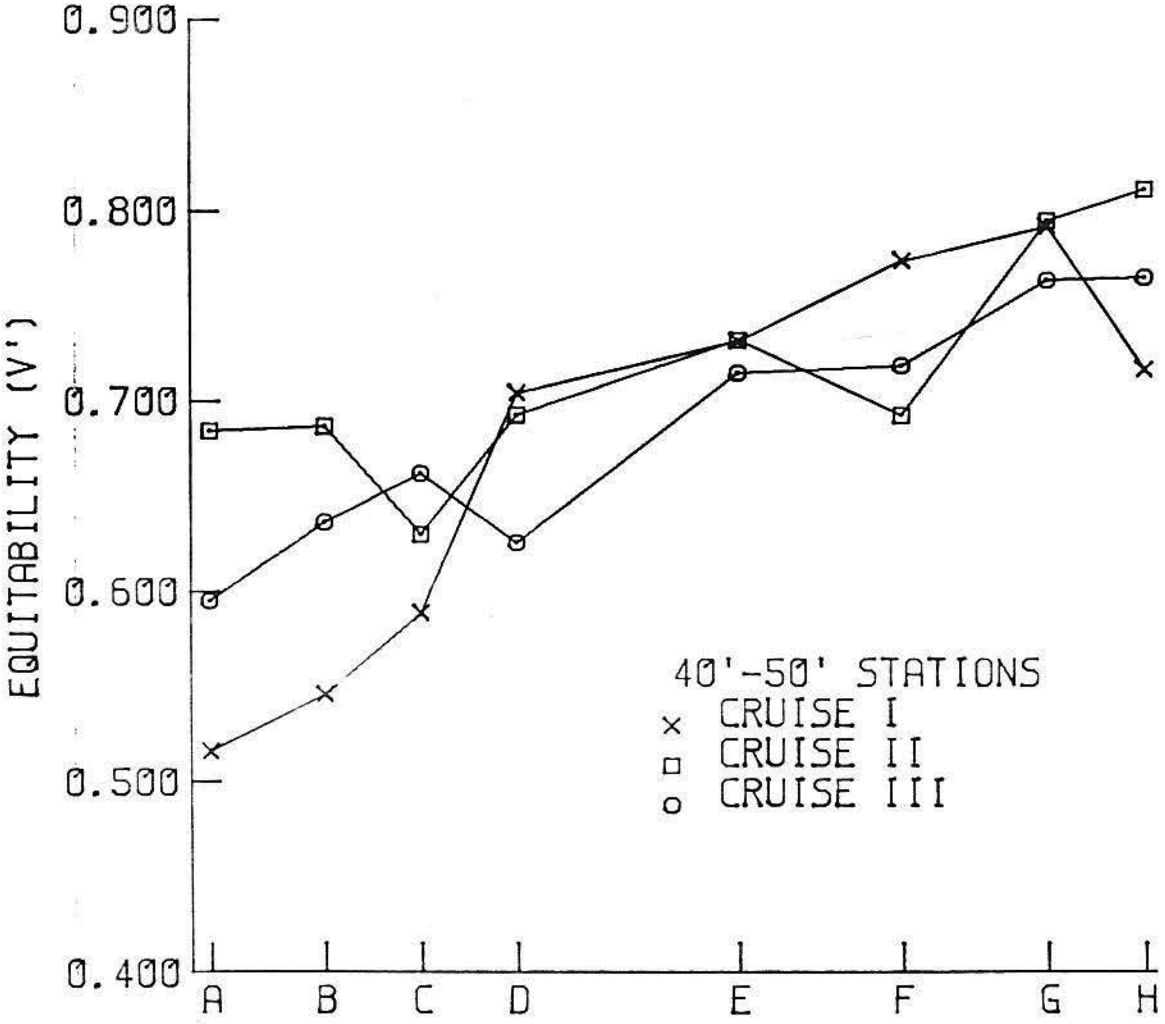
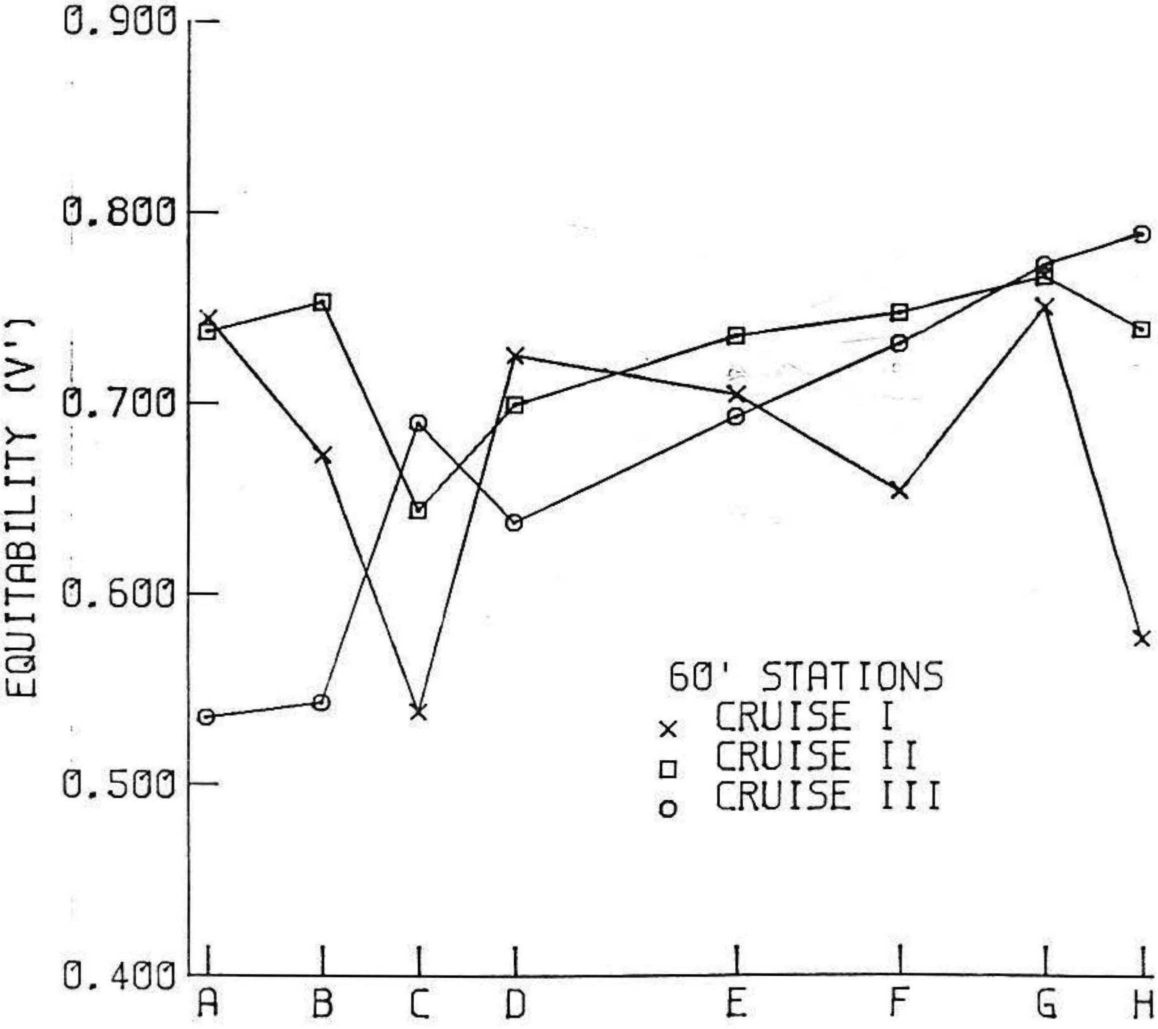

0.900
0.800
0.700
0.600
0.500
0.400
EQUITABILITY (V')
A
B
C
D
E
F
G
H
40'-50' STATIONS
× CRUISE I
□ CRUISE II
o CRUISE III

Figure 135


0.900
0.800
0.700
0.600
0.500
0.400
EQUITABILITY (V')
A
B
C
D
E
F
G
H
60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III

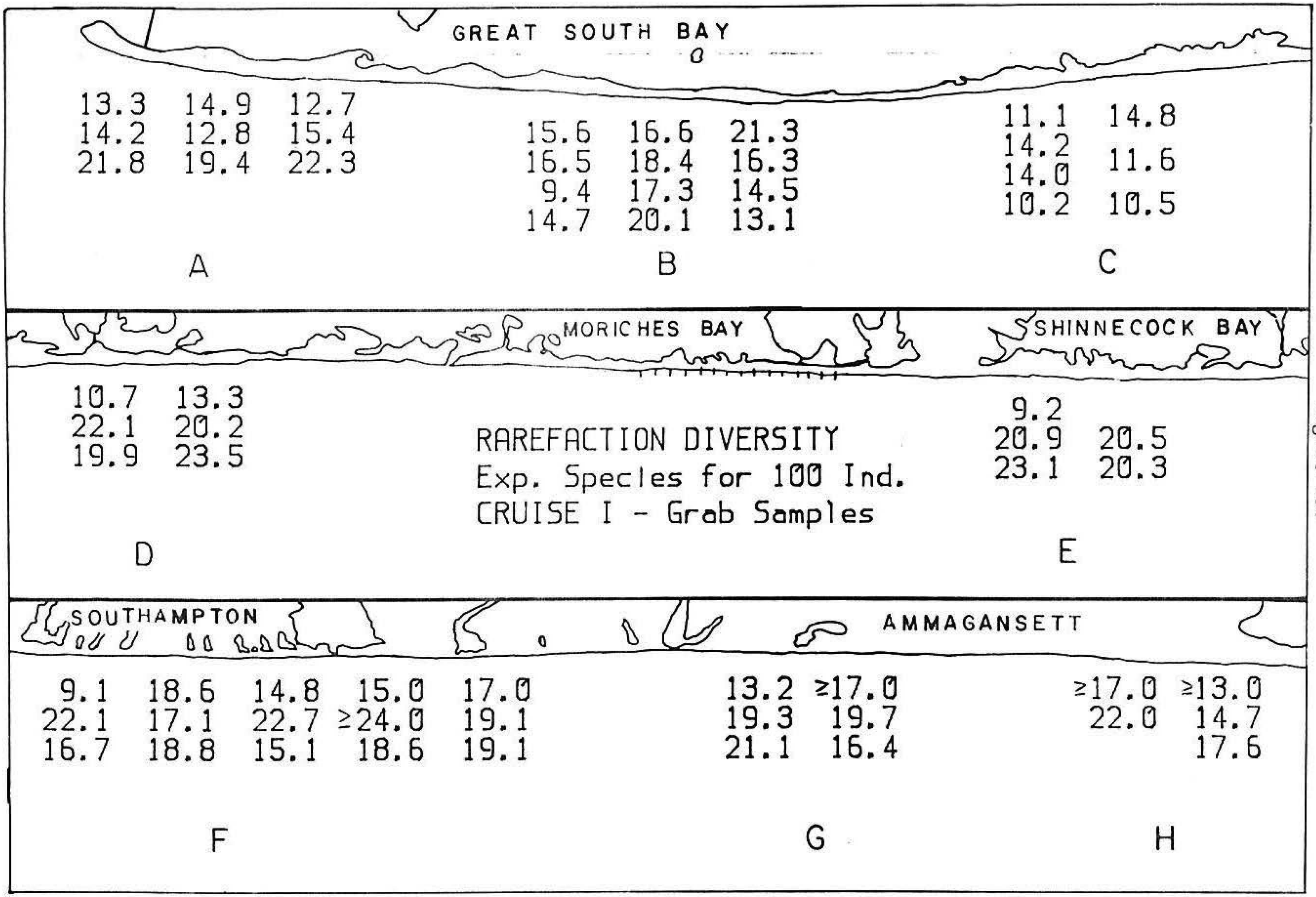
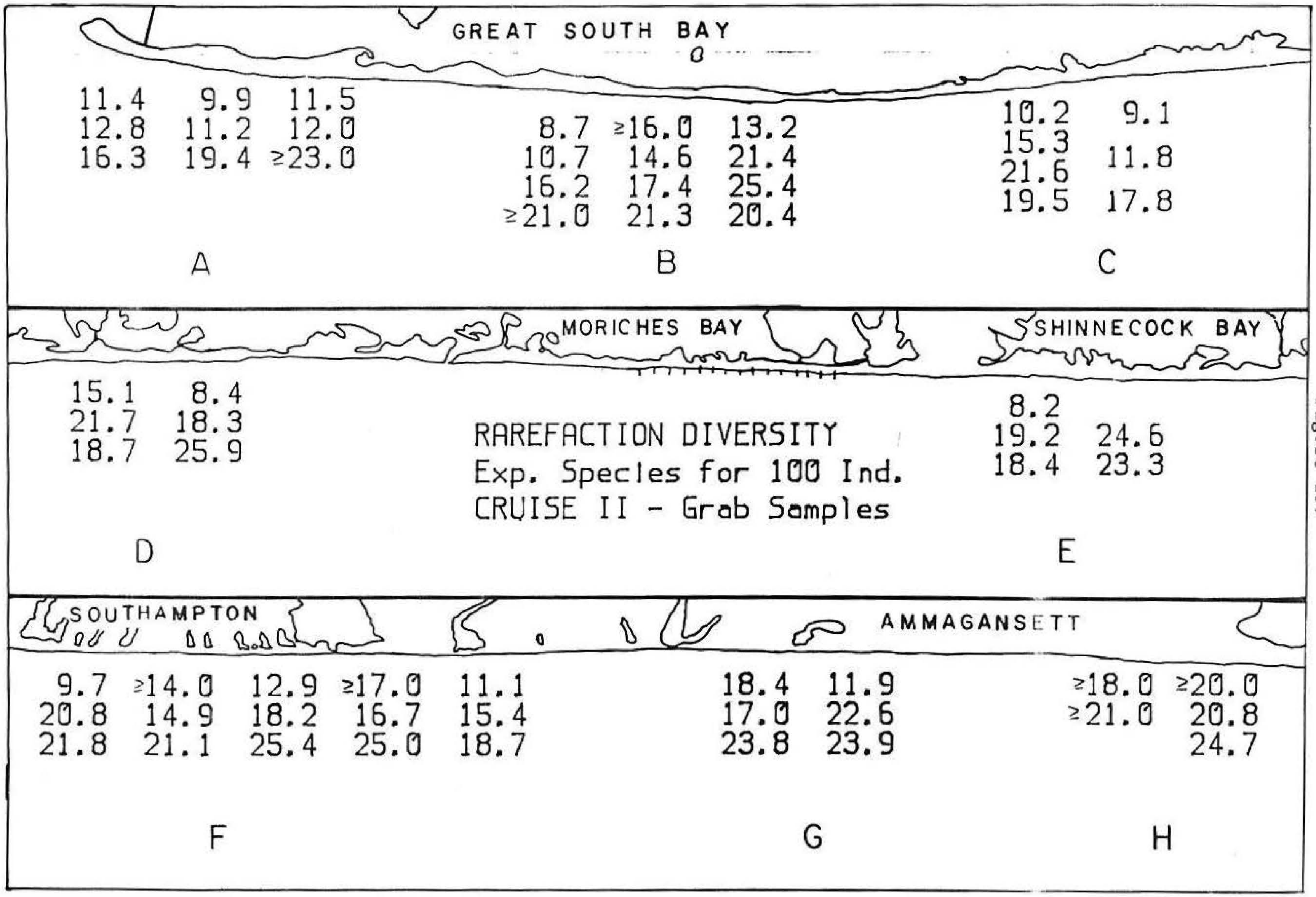

GREAT SOUTH BAY
13.3 14.9 12.7
14.2 12.8 15.4
21.8 19.4 22.3
A
15.6 16.6 21.3
16.5 18.4 16.3
9.4 17.3 14.5
14.7 20.1 13.1
B
11.1 14.8
14.2
14.0 11.6
10.2 10.5
C
MORICHES BAY
SHINNECOCK BAY
10.7 13.3
22.1 20.2
19.9 23.5
D
RAREFACTION DIVERSITY
Exp. Species for 100 Ind.
CRUISE I - Grab Samples
9.2
20.9 20.5
23.1 20.3
E
SOUTHAMPTON
AMMAGANSETT
9.1 18.6 14.8 15.0 17.0
22.1 17.1 22.7 ≥24.0 19.1
16.7 18.8 15.1 18.6 19.1
F
13.2 ≥17.0
19.3 19.7
21.1 16.4
G
≥17.0 ≥13.0
22.0 14.7
17.6
H

Figure 136



RAREFACTION DIVERSITY
Exp. Species for 100 Ind.
CRUISE II - Grab Samples

Figure 137

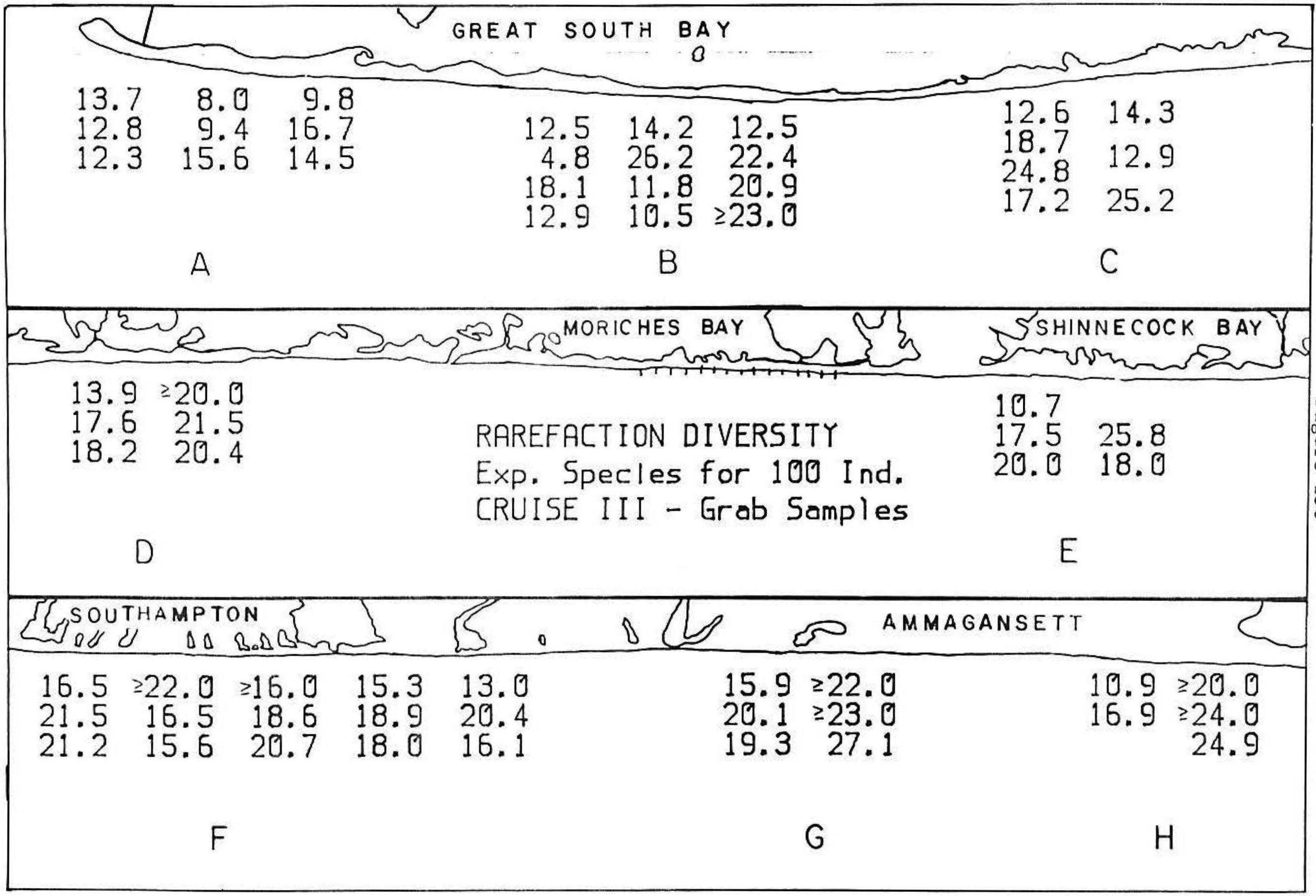

GREAT SOUTH BAY
13.7 8.0 9.8
12.8 9.4 16.7
12.3 15.6 14.5
A
12.5 14.2 12.5
4.8 26.2 22.4
18.1 11.8 20.9
12.9 10.5 ≥23.0
B
12.6 14.3
18.7
24.8 12.9
17.2 25.2
C
MORICHES BAY
SHINNECOCK BAY
13.9 ≥20.0
17.6 21.5
18.2 20.4
D
RAREFACTION DIVERSITY
Exp. Species for 100 Ind.
CRUISE III - Grab Samples
10.7
17.5 25.8
20.0 18.0
E
SOUTHAMPTON
AMMAGANSETT
16.5 ≥22.0 ≥16.0 15.3 13.0
21.5 16.5 18.6 18.9 20.4
21.2 15.6 20.7 18.0 16.1
F
15.9 ≥22.0
20.1 ≥23.0
19.3 27.1
G
10.9 ≥20.0
16.9 ≥24.0
24.9
H

Figure 138

Figure 139

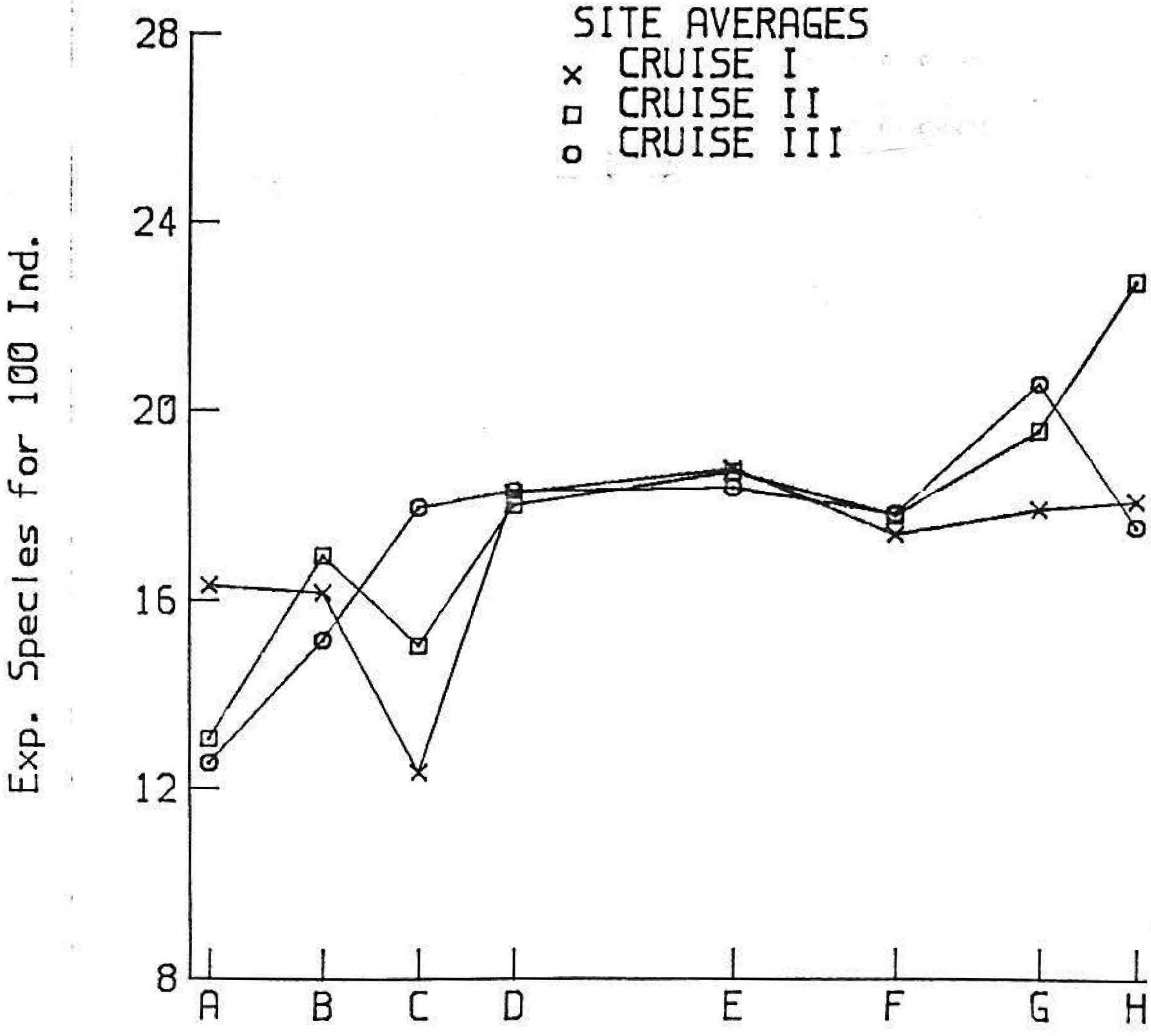

SITE AVERAGES
× CRUISE I
□ CRUISE II
○ CRUISE III
Exp. Species for 100 Ind.
28
24
20
16
12
8
A
B
C
D
E
F
G
H

Figure 140

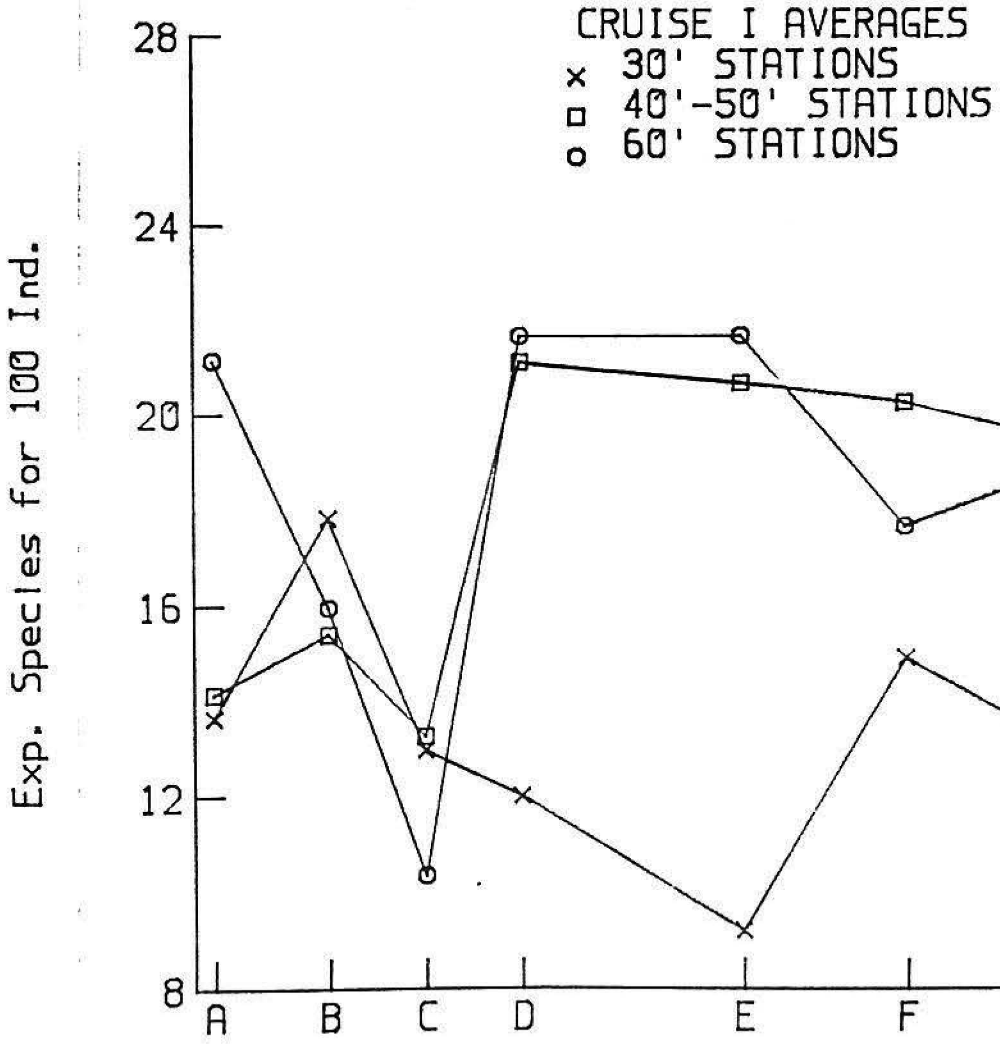

CRUISE I AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
Exp. Species for 100 Ind.
28
24
20
16
12
8
A
B
C
D
E
F
G
H

Figure 141

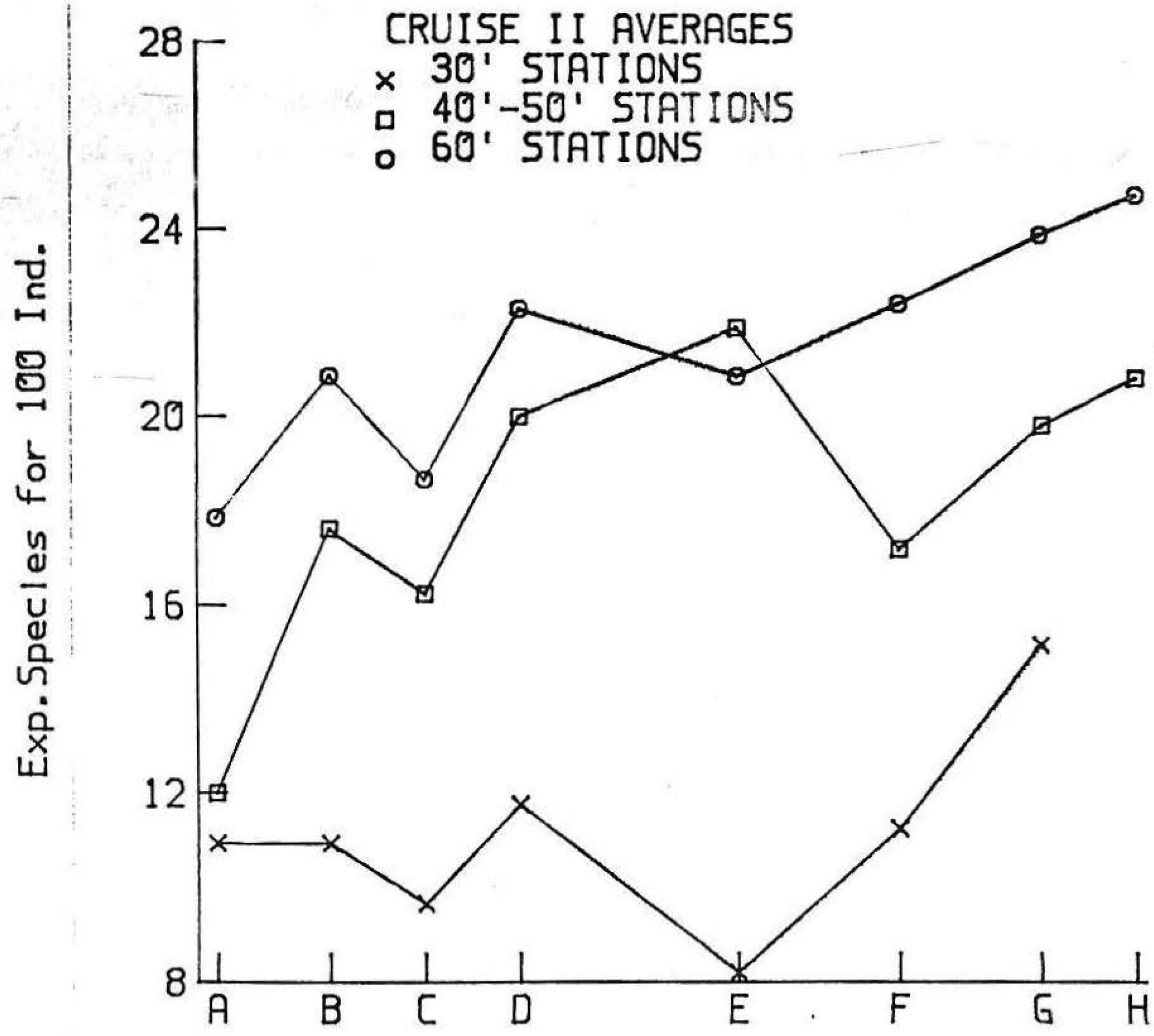

CRUISE II AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
Exp.Species for 100 Ind.
28
24
20
16
12
8
A
B
C
D
E
F
G
H

Figure 142

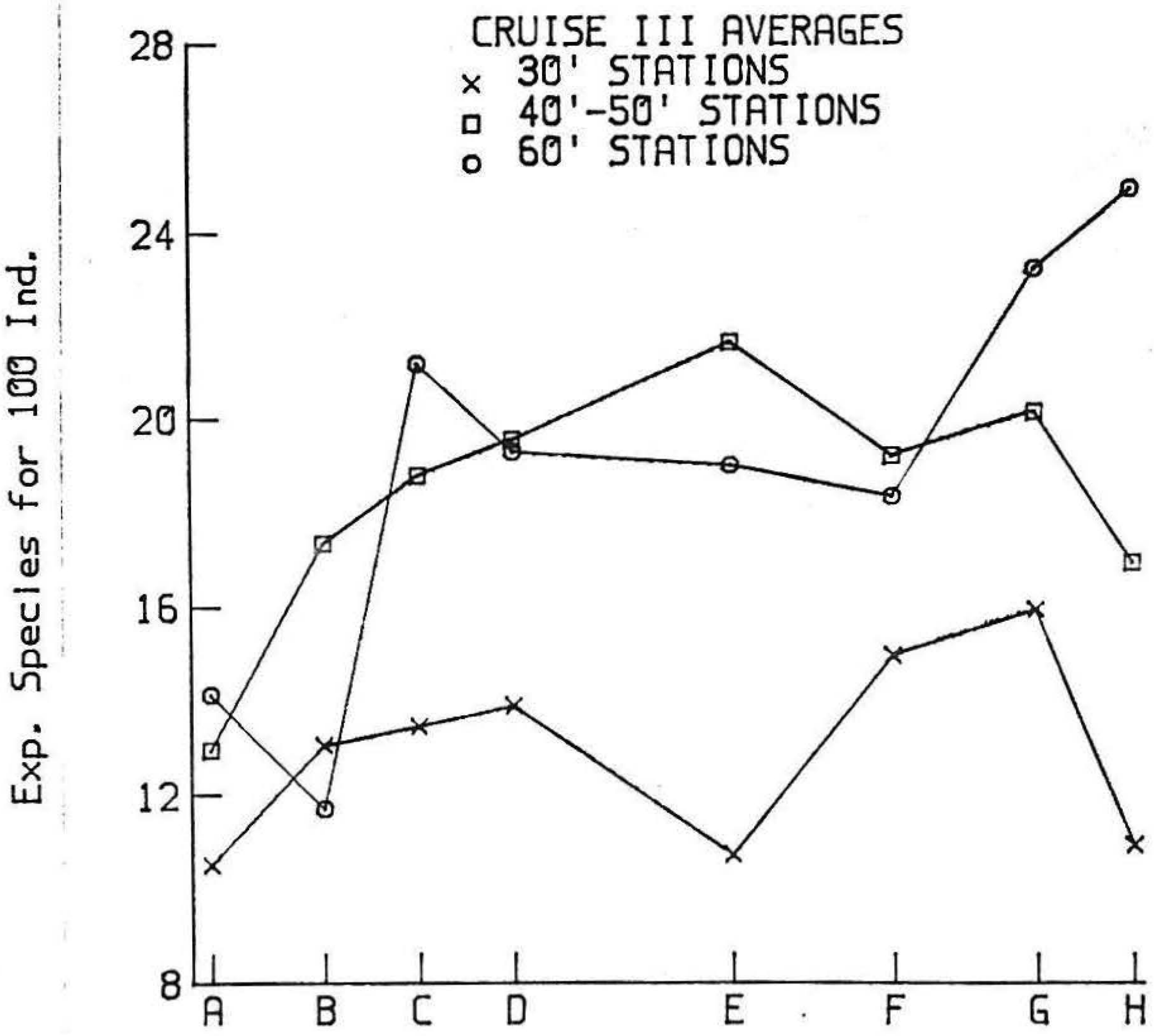

CRUISE III AVERAGES
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
Exp. Species for 100 Ind.
28
24
20
16
12
8
A
B
C
D
E
F
G
H

Figure 143

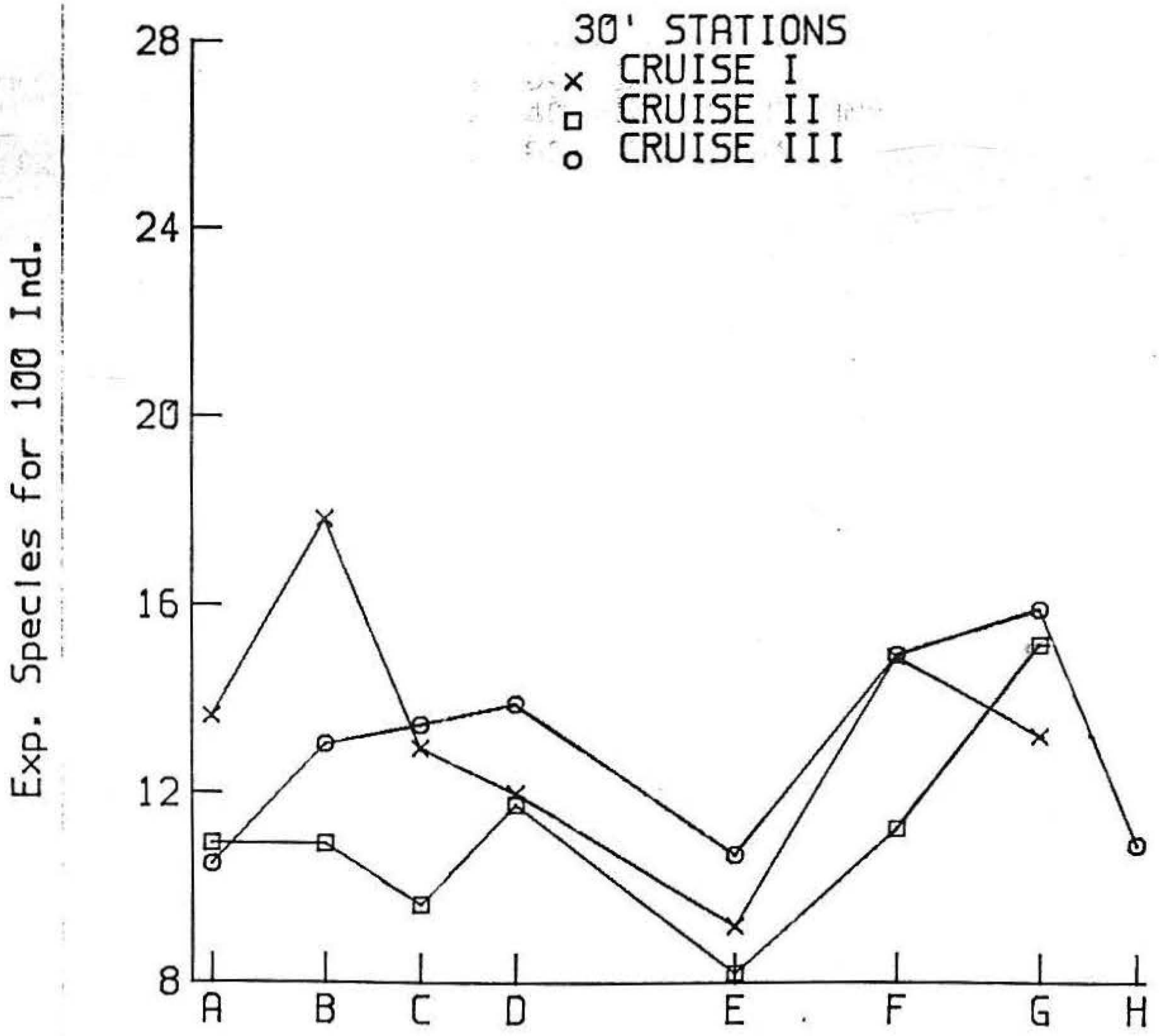

30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
Exp. Species for 100 Ind.
28
24
20
16
12
8
A
B
C
D
E
F
G
H

Figure 144

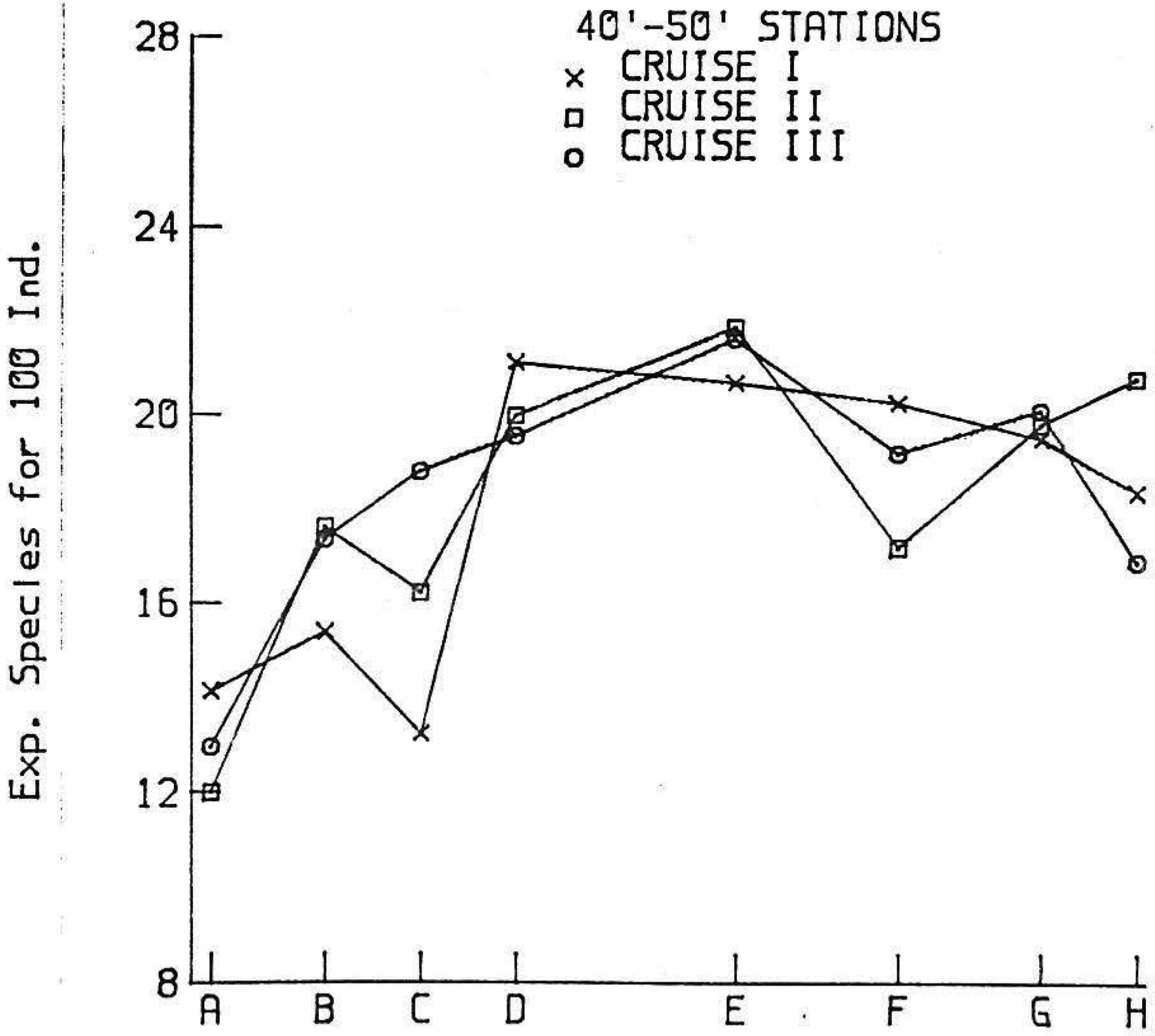
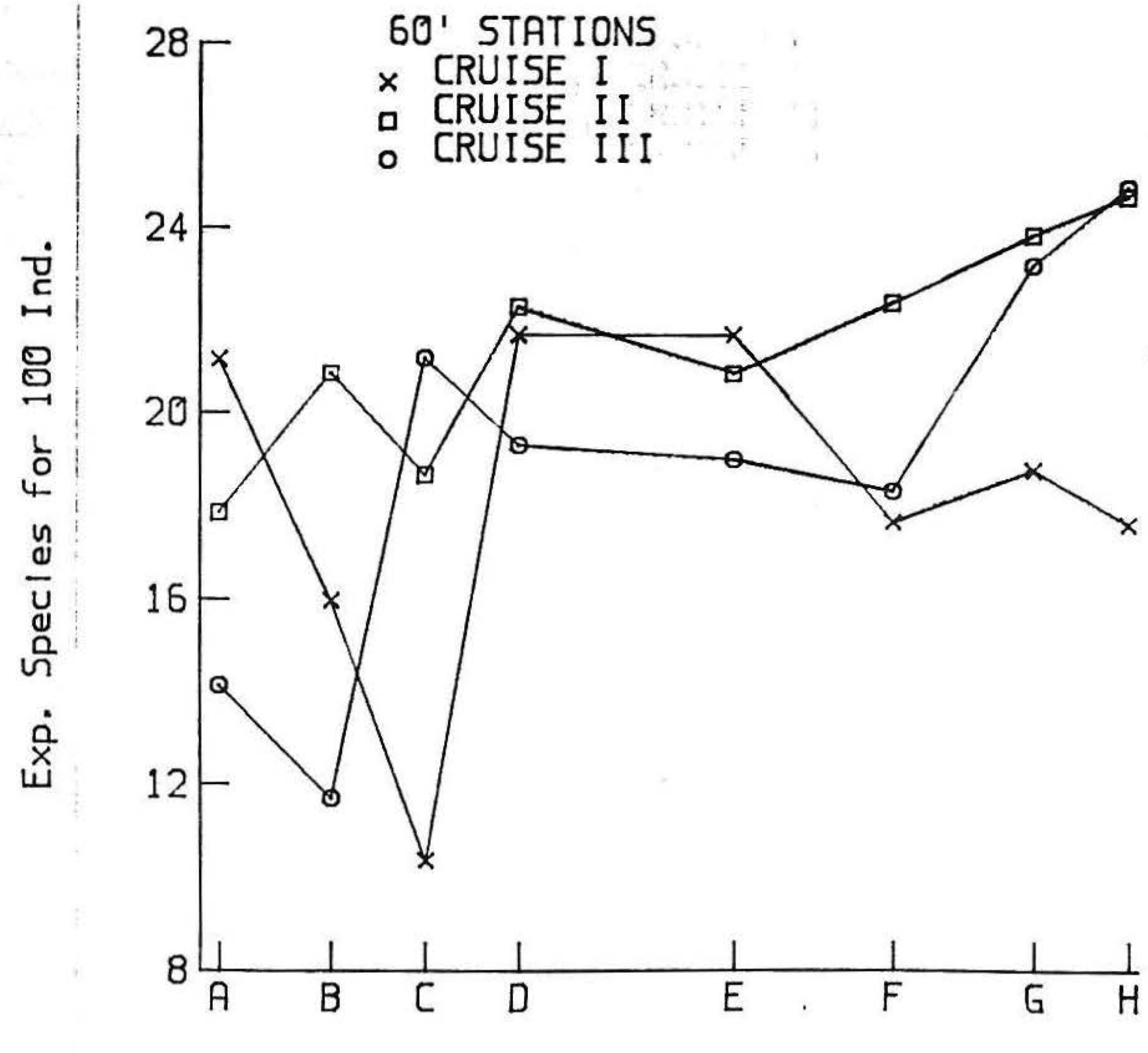

40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
Exp. Species for 100 Ind.
28
24
20
16
12
8
A
B
C
D
E
F
G
H

Figure 145


60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
Exp. Species for 100 Ind.
28
24
20
16
12
8
A
B
C
D
E
F
G
H

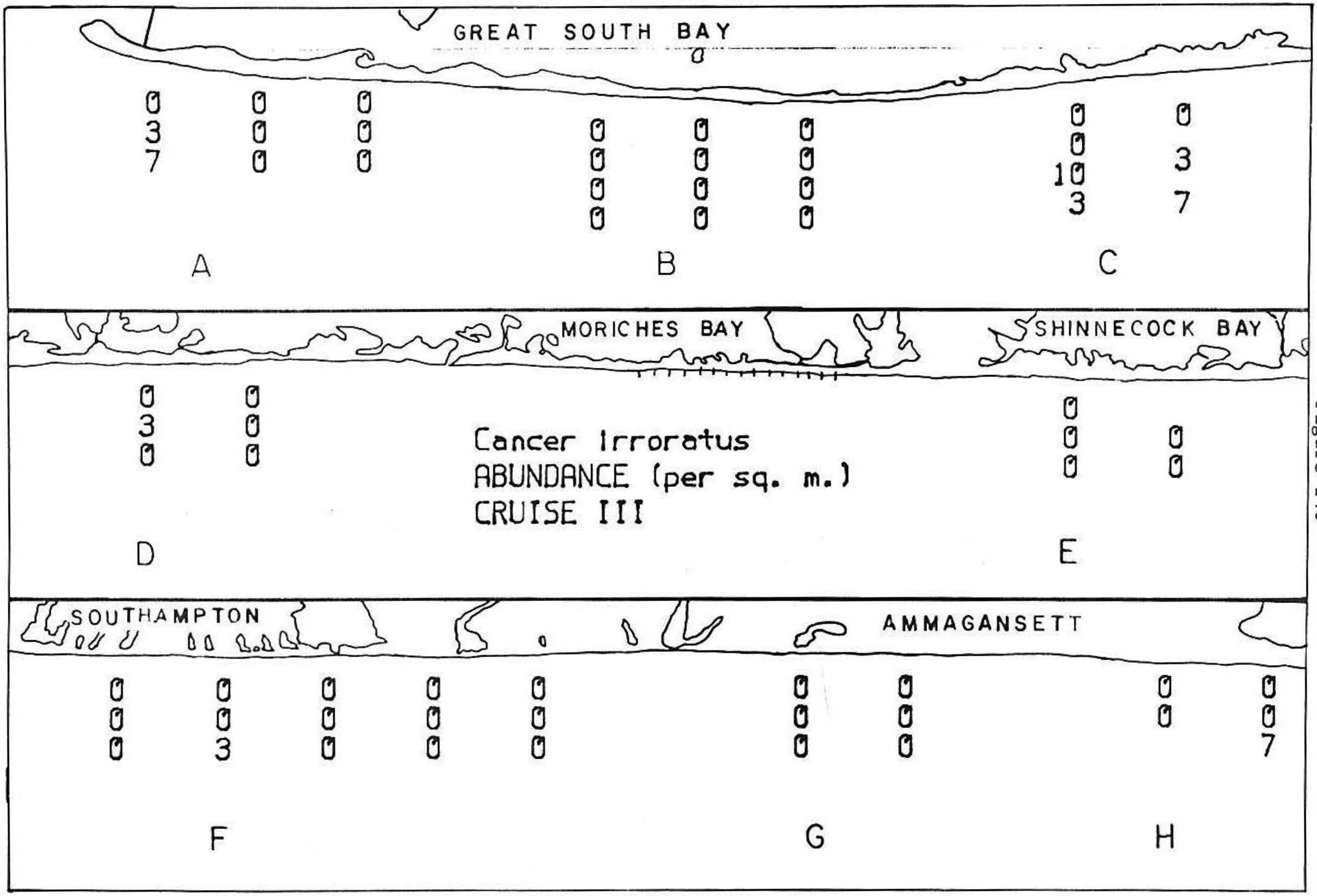

GREAT SOUTH BAY
0
3
7
0
0
0
0
0
0
A
0
0
0
0
0
0
0
0
0
0
0
0
B
0
0
10
3
0
3
7
C
MORICHES BAY
SHINNECOCK BAY
0
3
0
0
0
0
D
Cancer Irroratus
ABUNDANCE (per sq. m.)
CRUISE III
0
0
0
0
0
E
SOUTHAMPTON
AMMAGANSETT
0
0
0
0
0
3
0
0
0
0
0
0
0
0
0
F
0
0
0
0
0
0
G
0
0
0
0
7
H

Figure 146

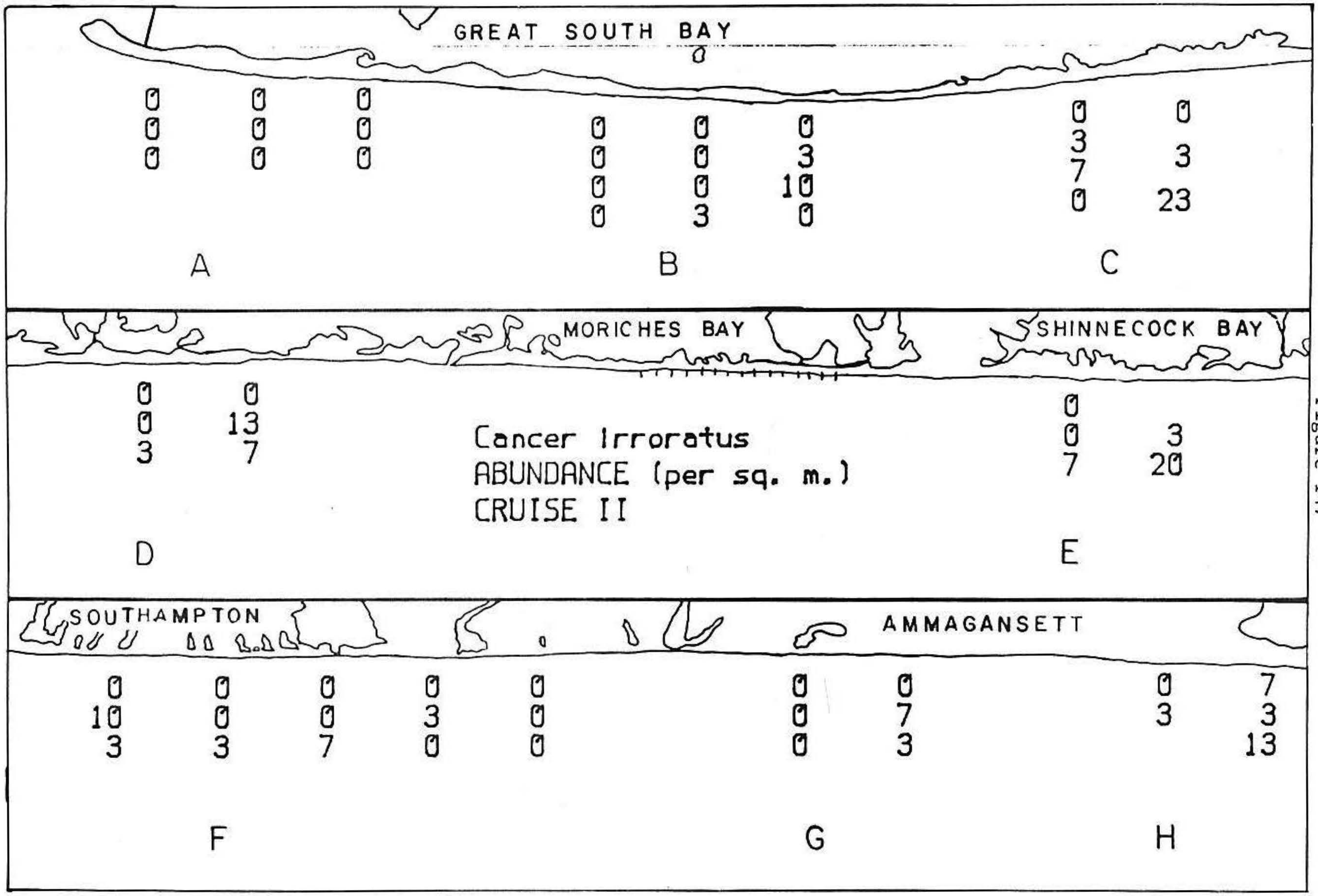

GREAT SOUTH BAY
0
0 0 0
0 0 0
0 0 0
A
0 0 0
0 0 3
0 0 10
0 3 0
B
0 0
3 3
7
0 23
C
MORICHES BAY
SHINNECOCK BAY
0 0
0 13
3 7
D
Cancer Irroratus
ABUNDANCE (per sq. m.)
CRUISE II
0
0 3
7 20
E
SOUTHAMPTON
AMMAGANSETT
0 0 0 0 0
10 0 0 3 0
3 3 7 0 0
F
0 0
0 7
0 3
G
0 7
3 3
13
H

Figure 147

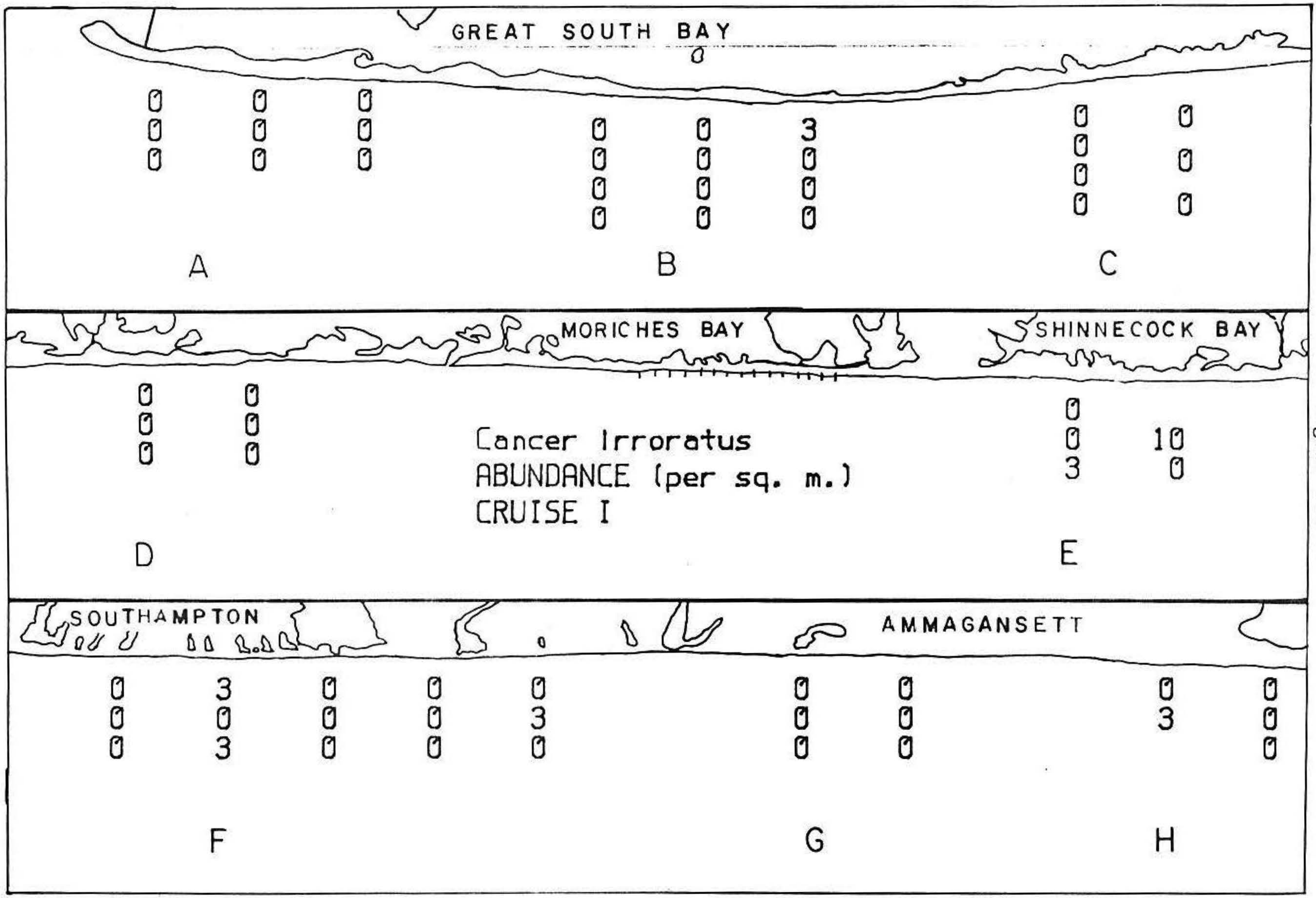
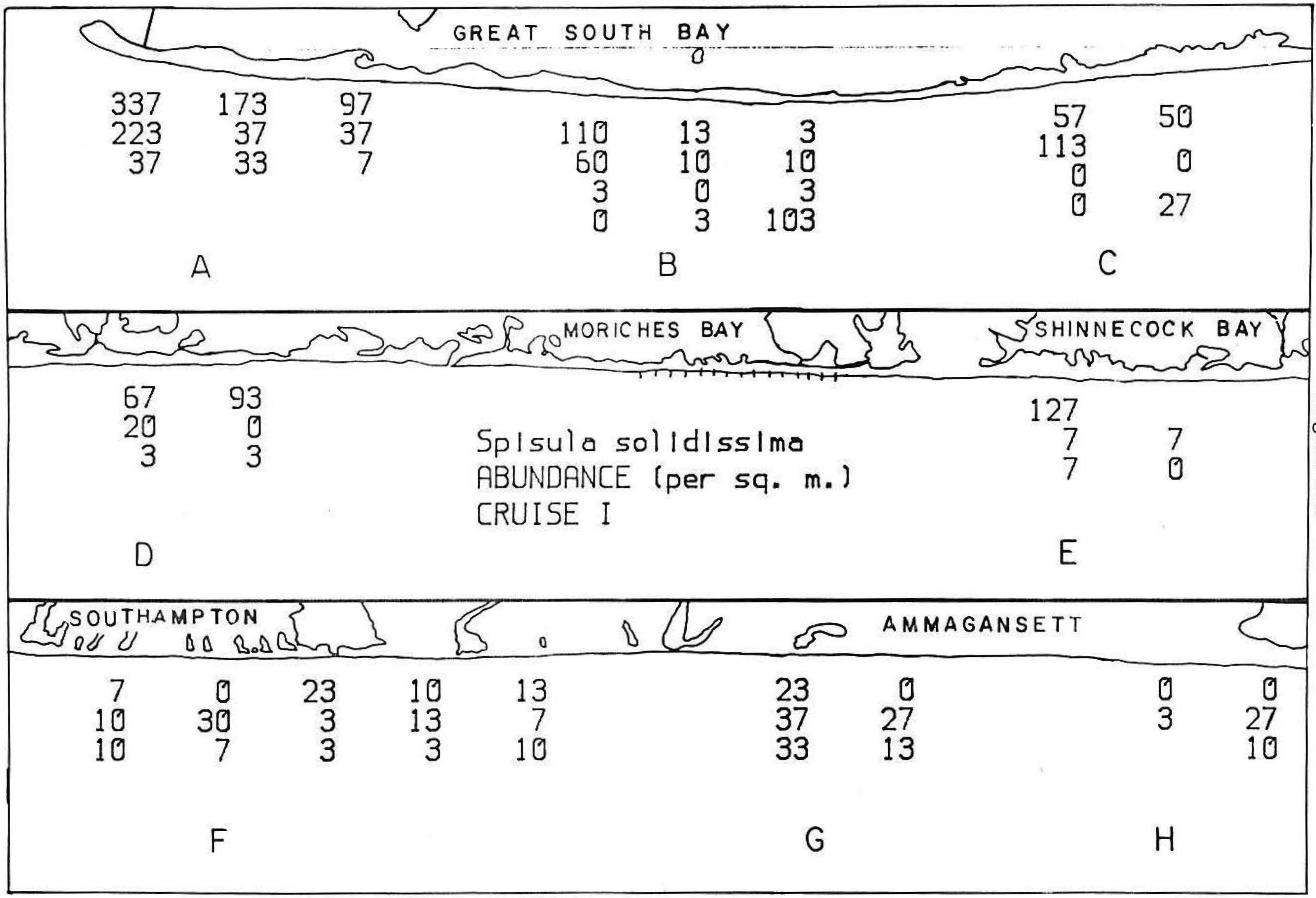

GREAT SOUTH BAY
0
0 0 0
0 0 0
0 0 0
0 0 3
0 0 0
0 0 0
0 0 0
0 0
0
0 0
0
A
B
C
MORICHES BAY
SHINNECOCK BAY
0 0
0 0
0 0
Cancer Irroratus
ABUNDANCE (per sq. m.)
CRUISE I
0
0 10
3 0
D
E
SOUTHAMPTON
AMMAGANSETT
0 3 0 0 0 0 0 0 0
0 0 0 0 3 0 0 3 0
0 3 0 0 0 0 0 0 0
F
G
H

Figure 148



Spisula solidissima
ABUNDANCE (per sq. m.)
CRUISE I

Figure 149

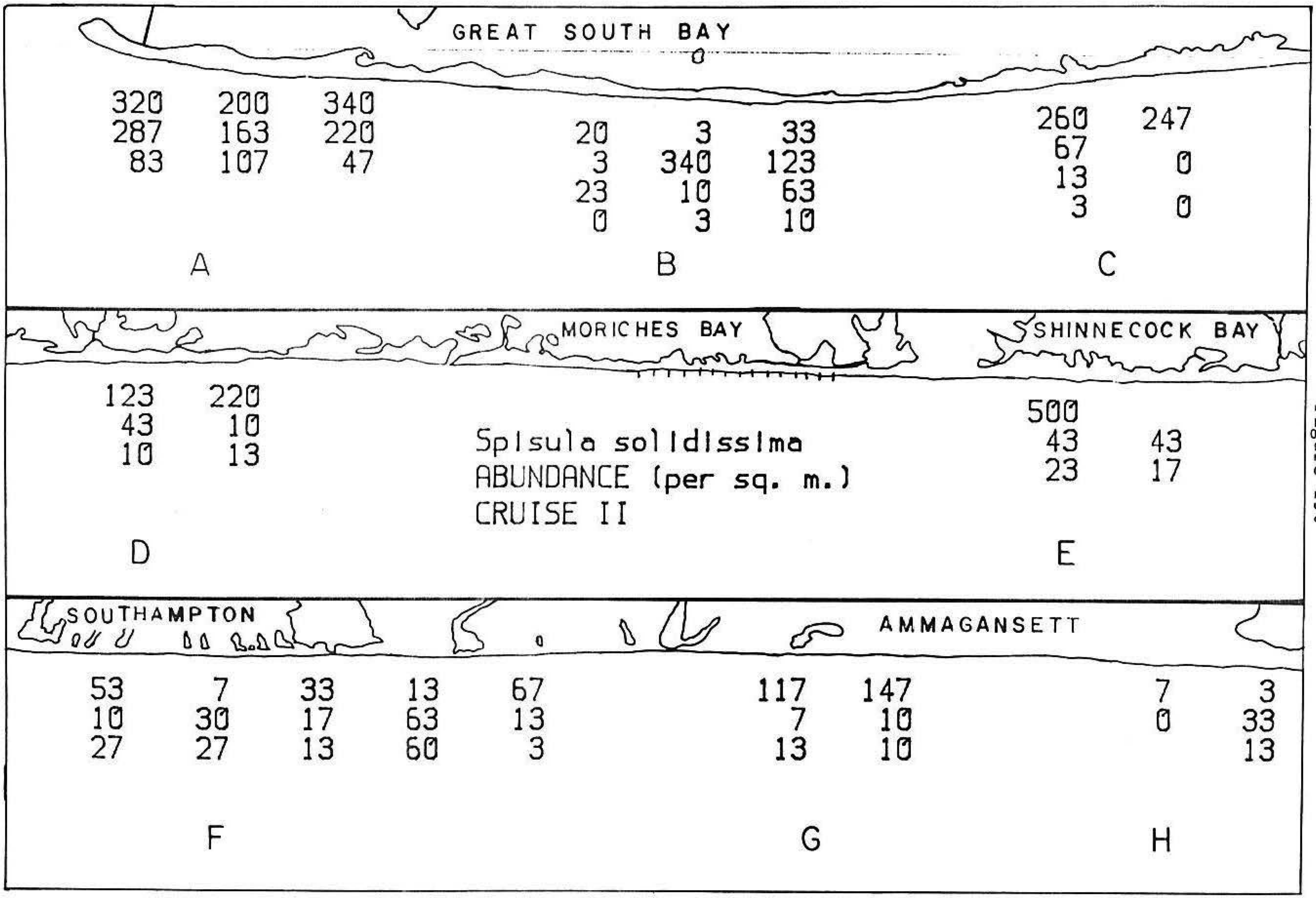

GREAT SOUTH BAY
320 287 83
200 163 107
340 220 47
20 3 23 0
3 340 10 3
33 123 63 10
260 67 13 3
247 0 0
A
B
C
MORICHES BAY
SHINNECOCK BAY
123 43 10
220 10 13
Spisula solidissima
ABUNDANCE (per sq. m.)
CRUISE II
500 43 23
43 17
D
E
SOUTHAMPTON
AMMAGANSETT
53 10 27
7 30 27
33 17 13
13 63 60
67 13 3
117 7 13
147 10 10
7 0
3 33 13
F
G
H

Figure 150

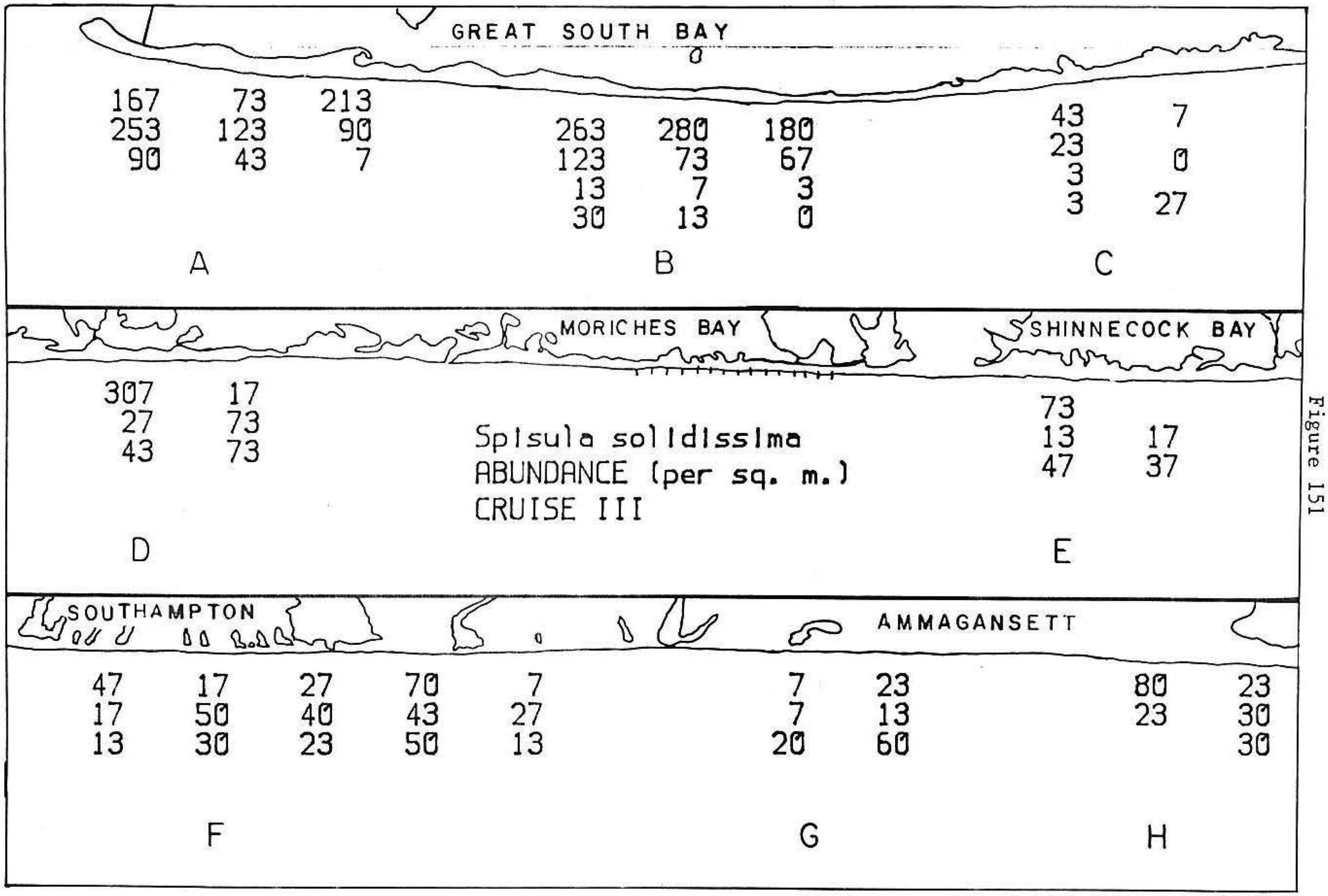

GREAT SOUTH BAY
167 73 213
253 123 90
90 43 7
263 280 180
123 73 67
13 7 3
30 13 0
43 7
23
3 0
3 27
A
B
C
MORICHES BAY
SHINNECOCK BAY
307 17
27 73
43 73
Spisula solidissima
ABUNDANCE (per sq. m.)
CRUISE III
73
13 17
47 37
D
E
SOUTHAMPTON
AMMAGANSETT
47 17 27 70 7
17 50 40 43 27
13 30 23 50 13
7 23
7 13
20 60
80 23
23 30
30
F
G
H

Figure 151

Figure 152

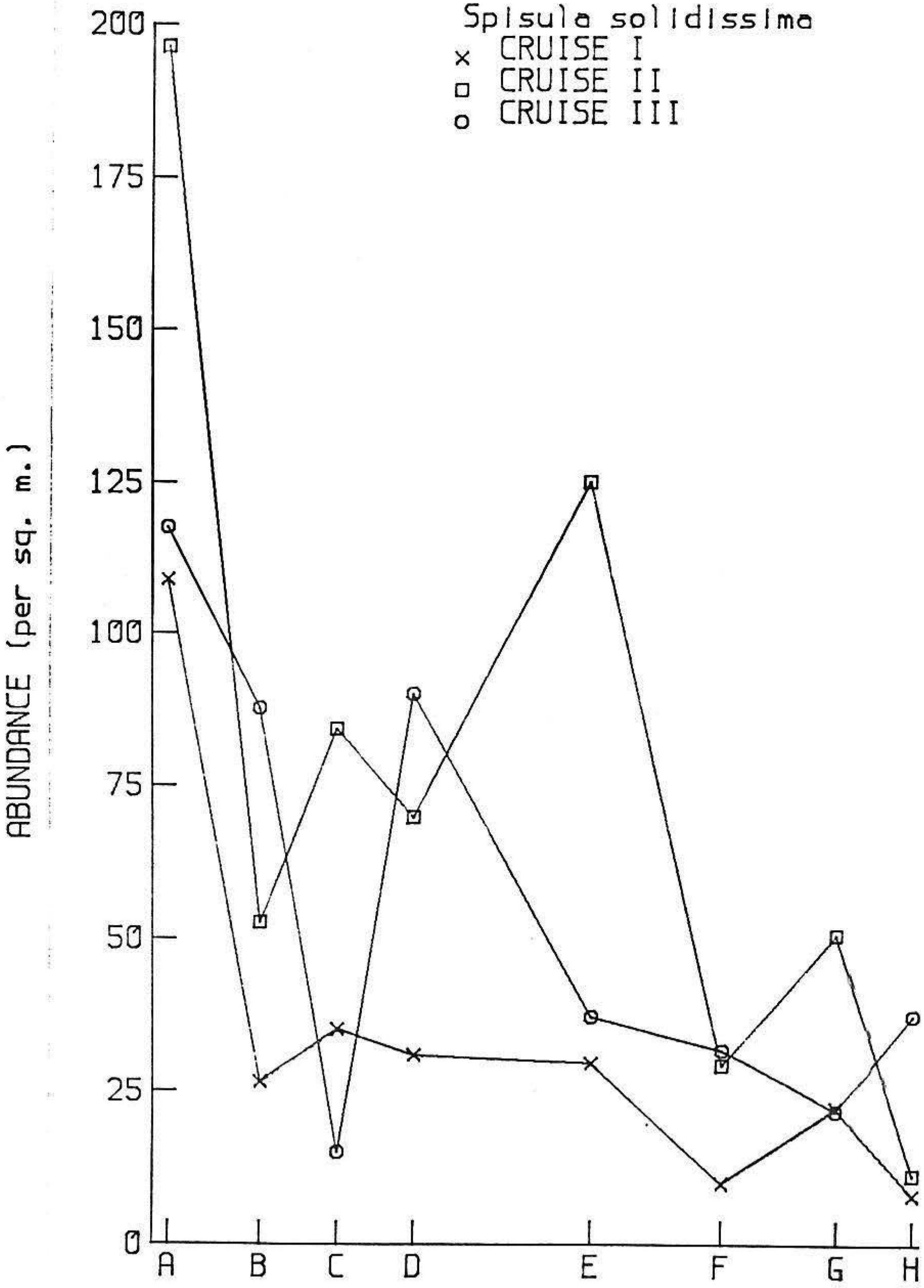

Spisula solidissima
× CRUISE I
□ CRUISE II
○ CRUISE III
ABUNDANCE (per sq. m.)
200
175
150
125
100
75
50
25
0
A
B
C
D
E
F
G
H

Figure 153

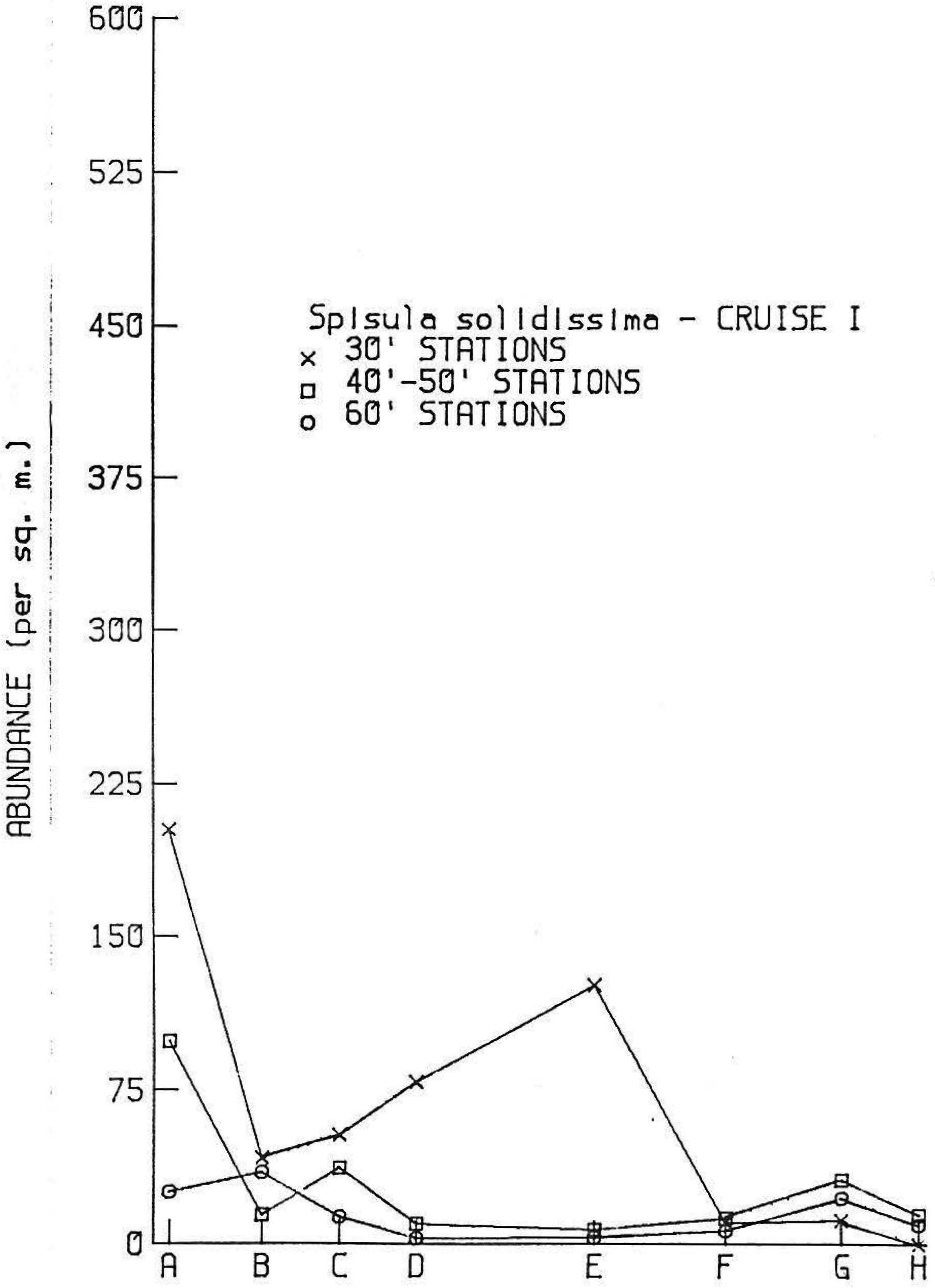

600
525
450
375
300
225
150
75
0
ABUNDANCE (per sq. m.)
Spisula solidissima - CRUISE I
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
A
B
C
D
E
F
G
H

Figure 154

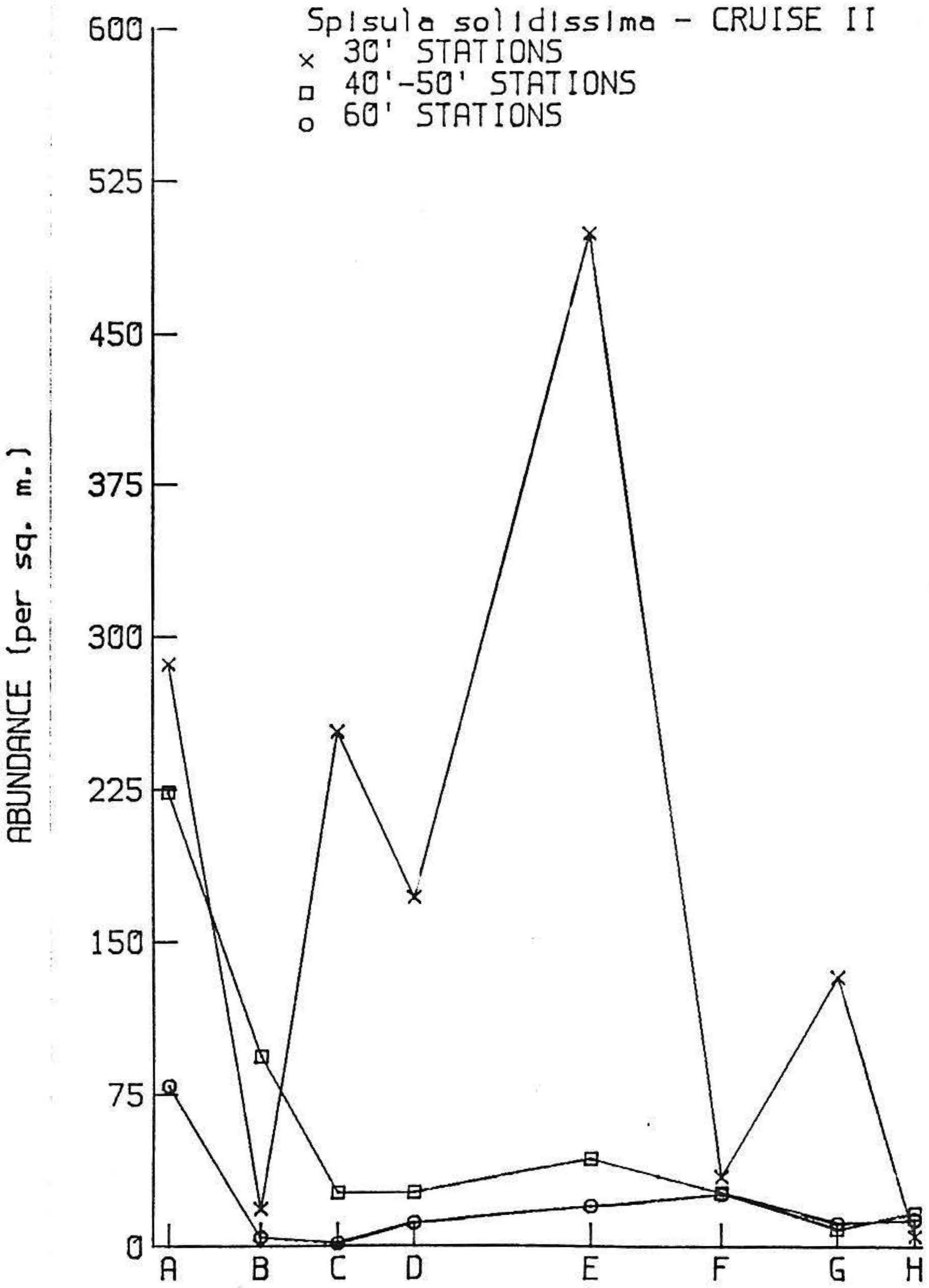

Spisula solidissima - CRUISE II
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
ABUNDANCE (per sq. m.)
600
525
450
375
300
225
150
75
0
A
B
C
D
E
F
G
H

Figure 155

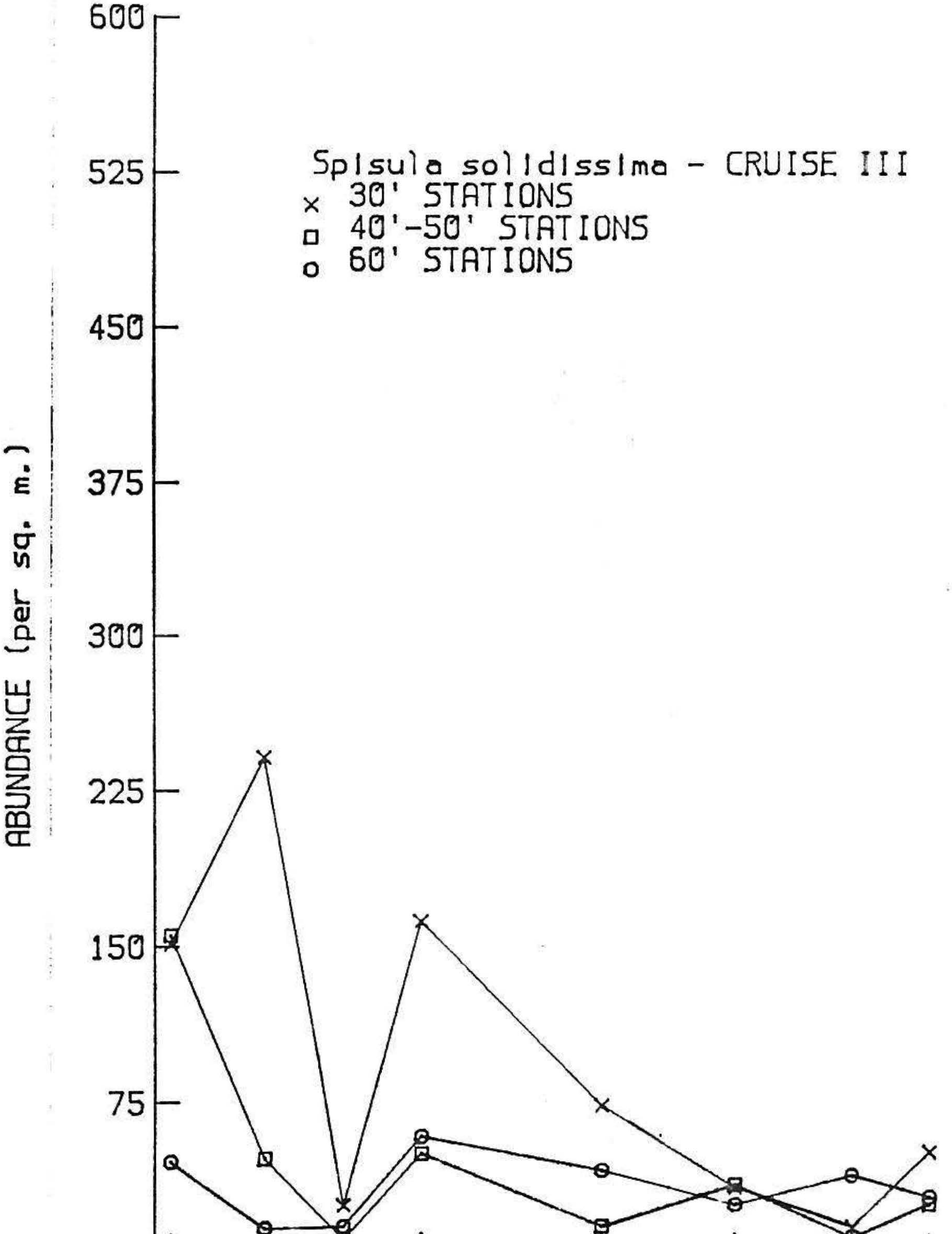

Spisula solidissima - CRUISE III
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
ABUNDANCE (per sq. m.)
600
525
450
375
300
225
150
75
0
A
B
C
D
E
F
G
H

Figure 156

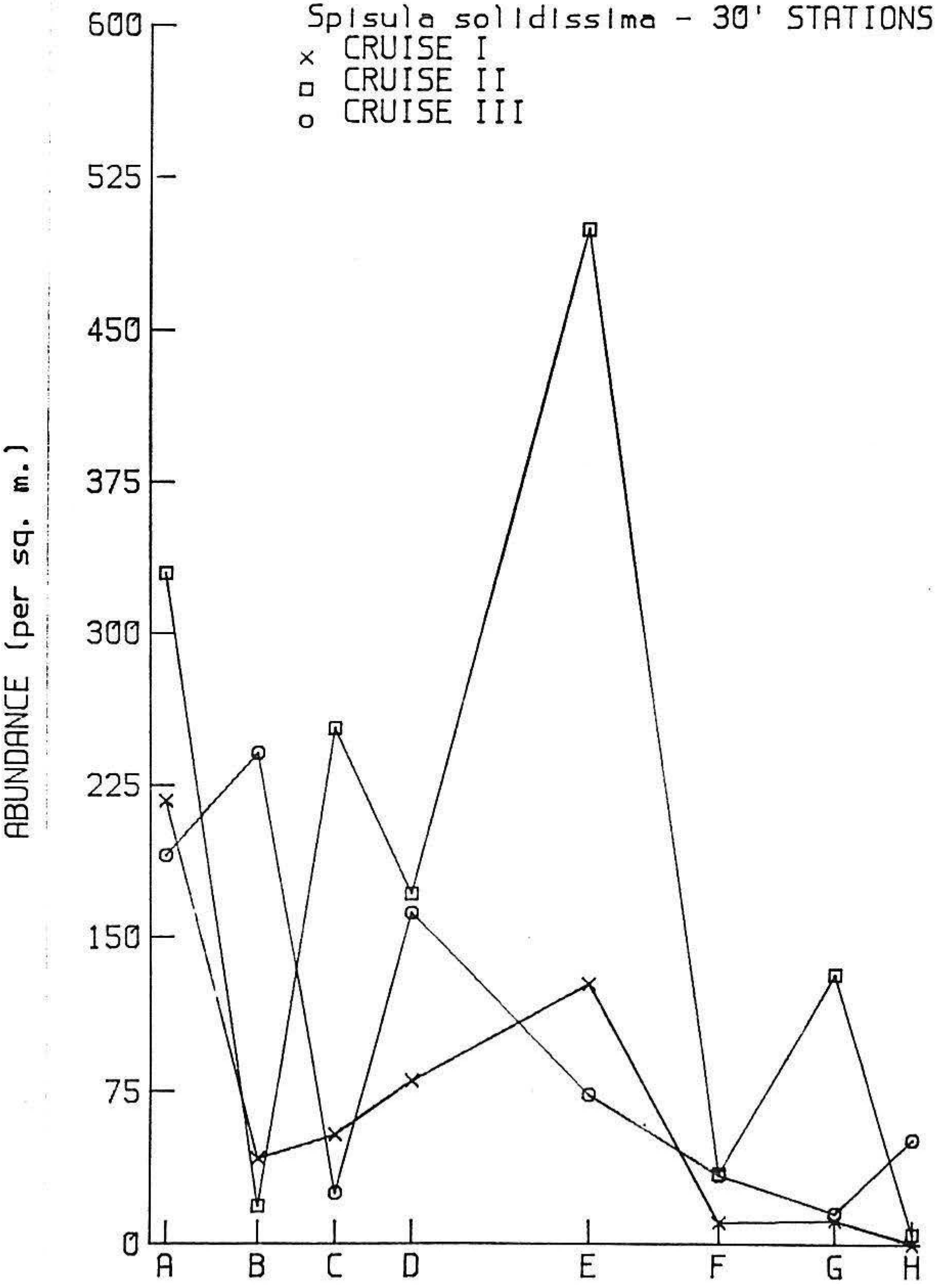

Spisula solidissima - 30' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
ABUNDANCE (per sq. m.)
600
525
450
375
300
225
150
75
0
A
B
C
D
E
F
G
H

Figure 157

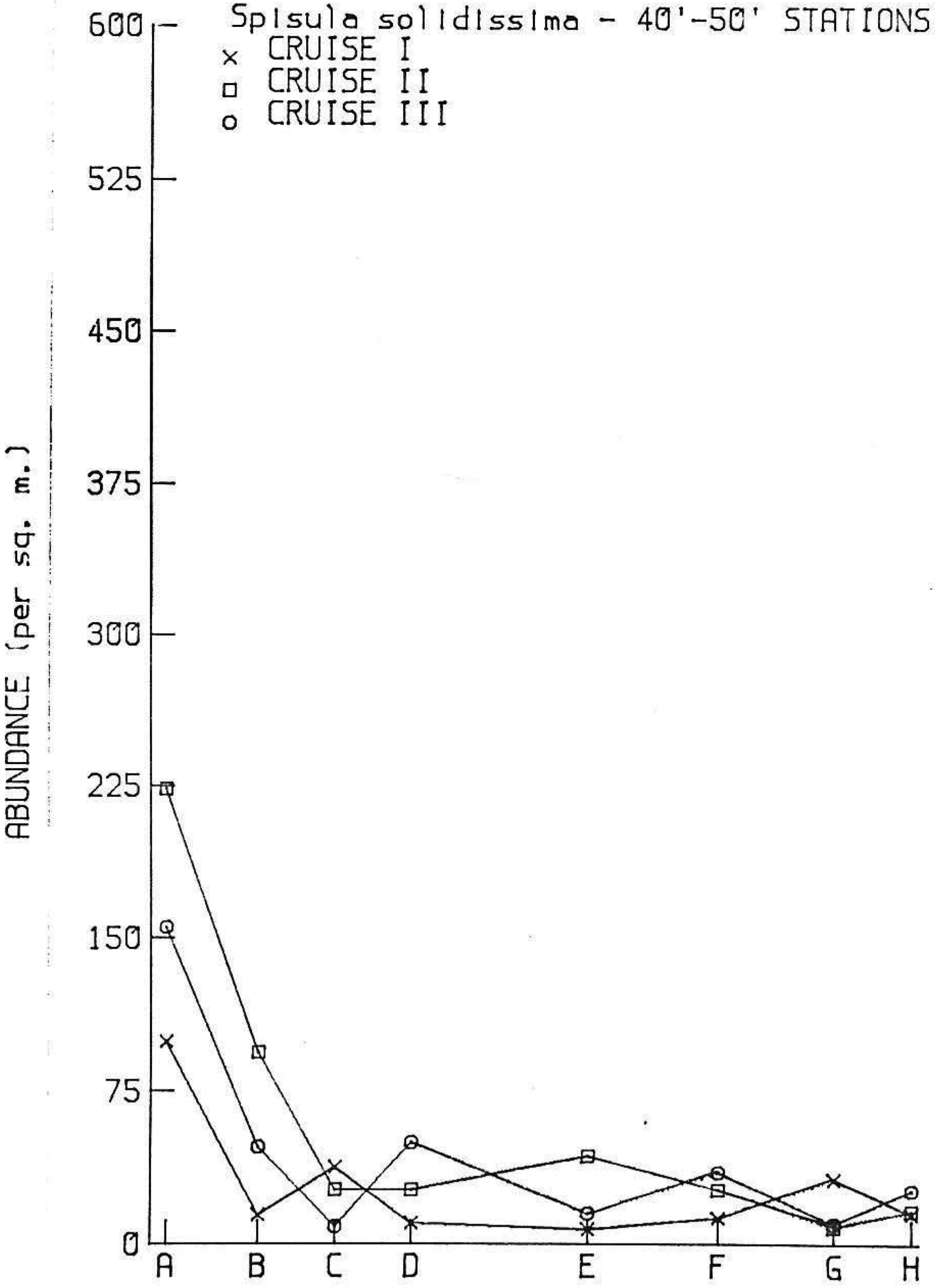

Spisula solidissima - 40'-50' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
ABUNDANCE (per sq. m.)
600
525
450
375
300
225
150
75
0
A
B
C
D
E
F
G
H

Figure 158

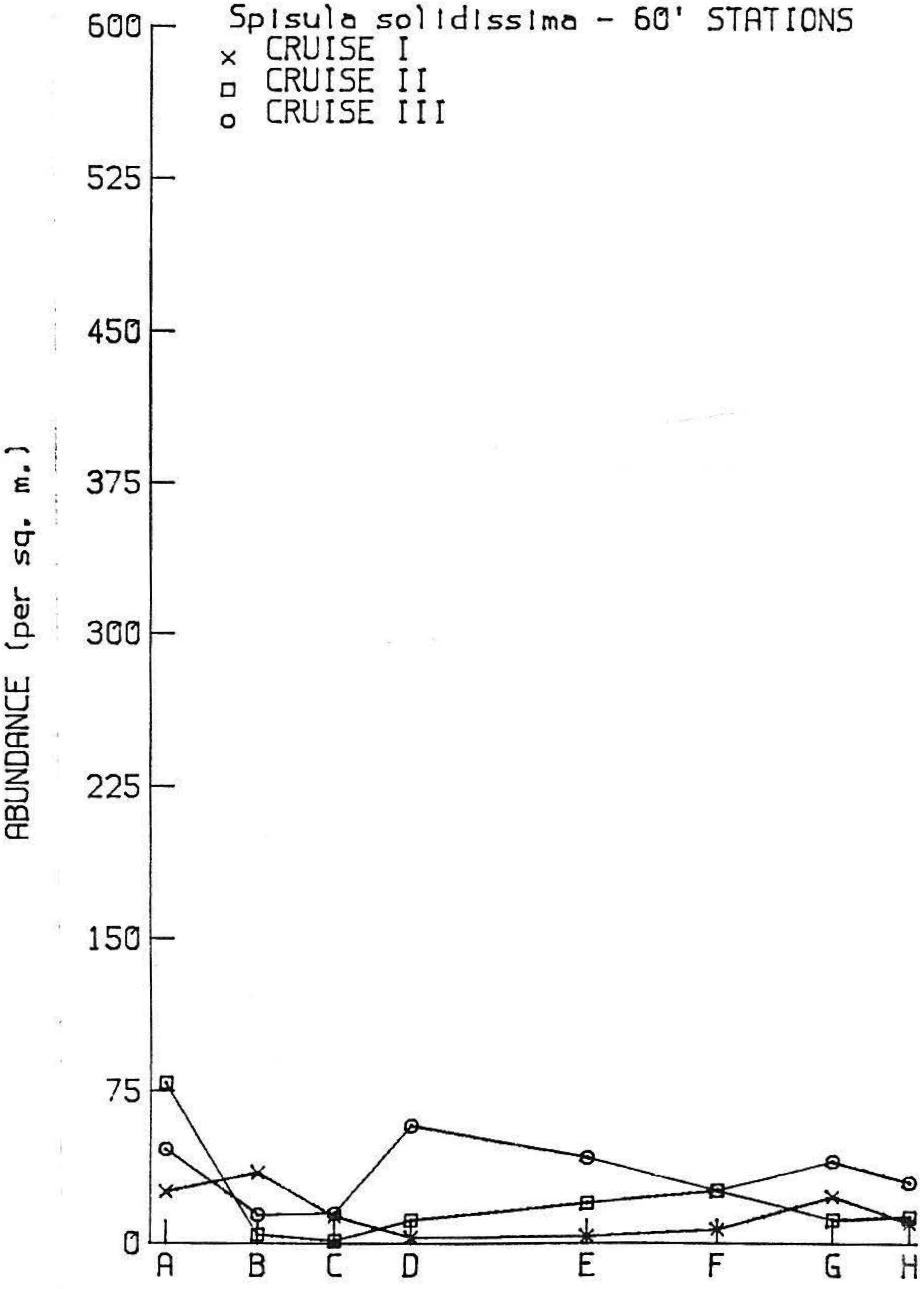

Spisula solidissima - 60' STATIONS
× CRUISE I
□ CRUISE II
○ CRUISE III
ABUNDANCE (per sq. m.)
600
525
450
375
300
225
150
75
0
A
B
C
D
E
F
G
H

Figure 159

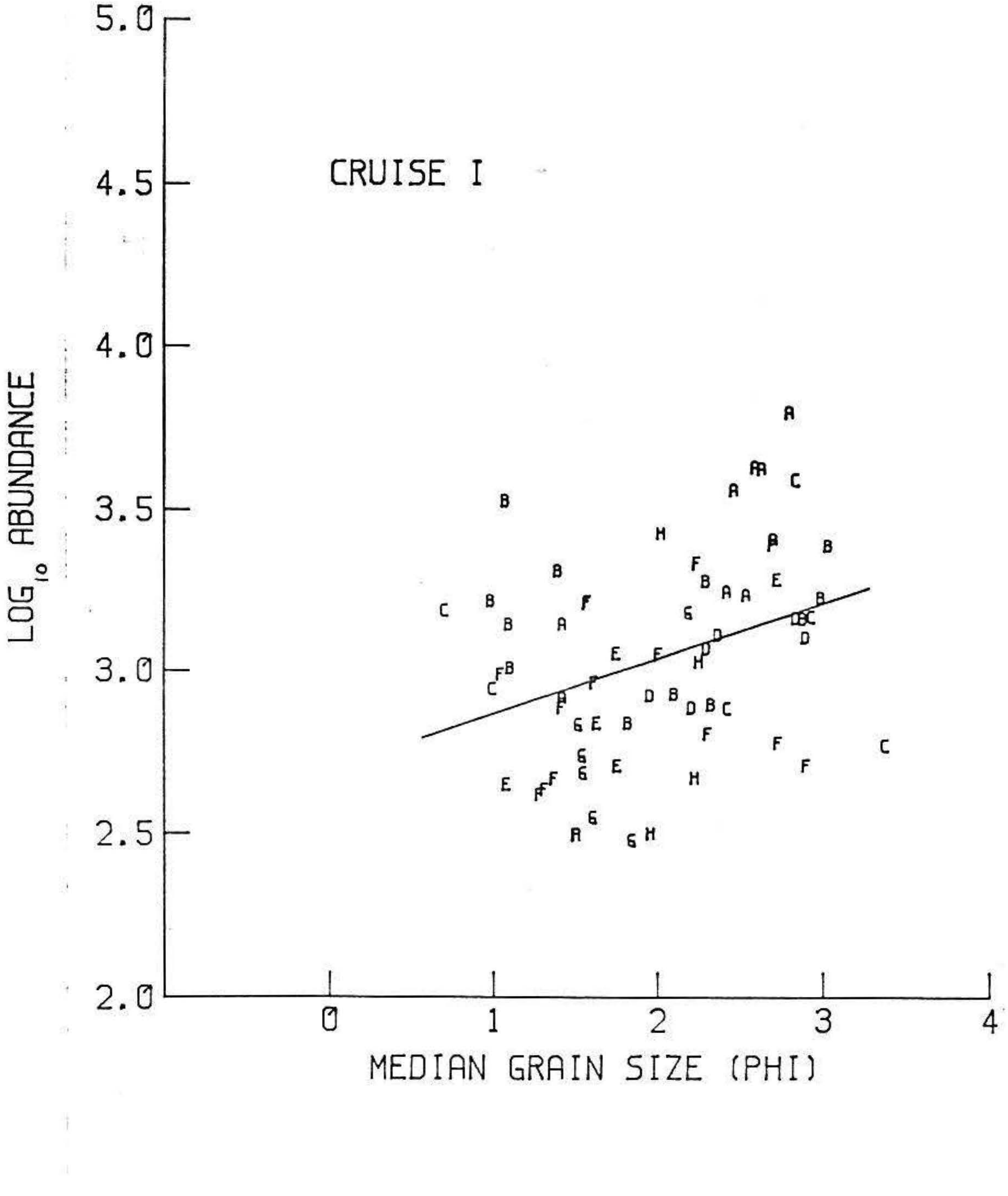

CRUISE I
LOG10 ABUNDANCE
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0
1
2
3
4
MEDIAN GRAIN SIZE (PHI)

Figure 160

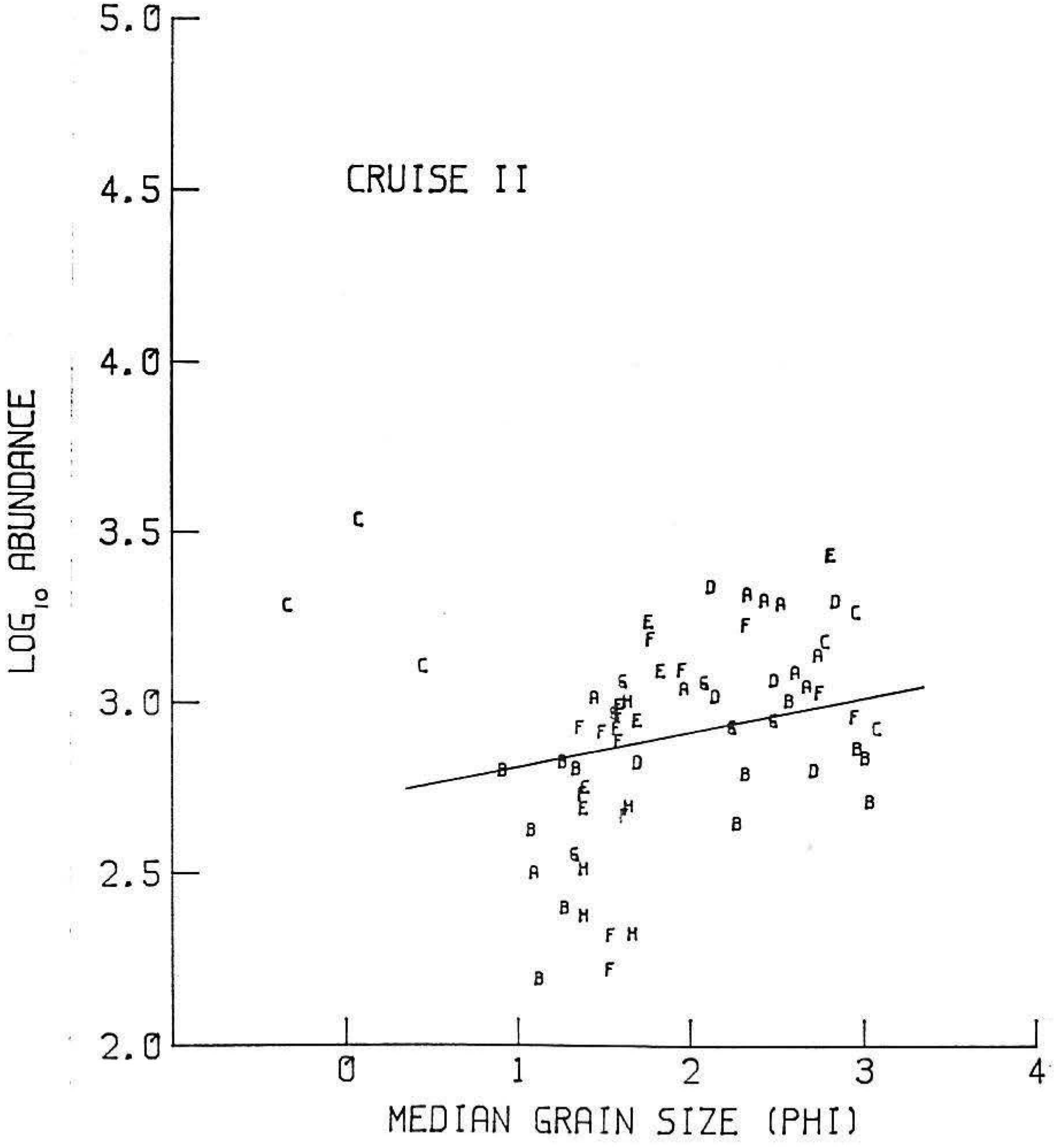

CRUISE II
LOG10 ABUNDANCE
MEDIAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0
1
2
3
4

Figure 161

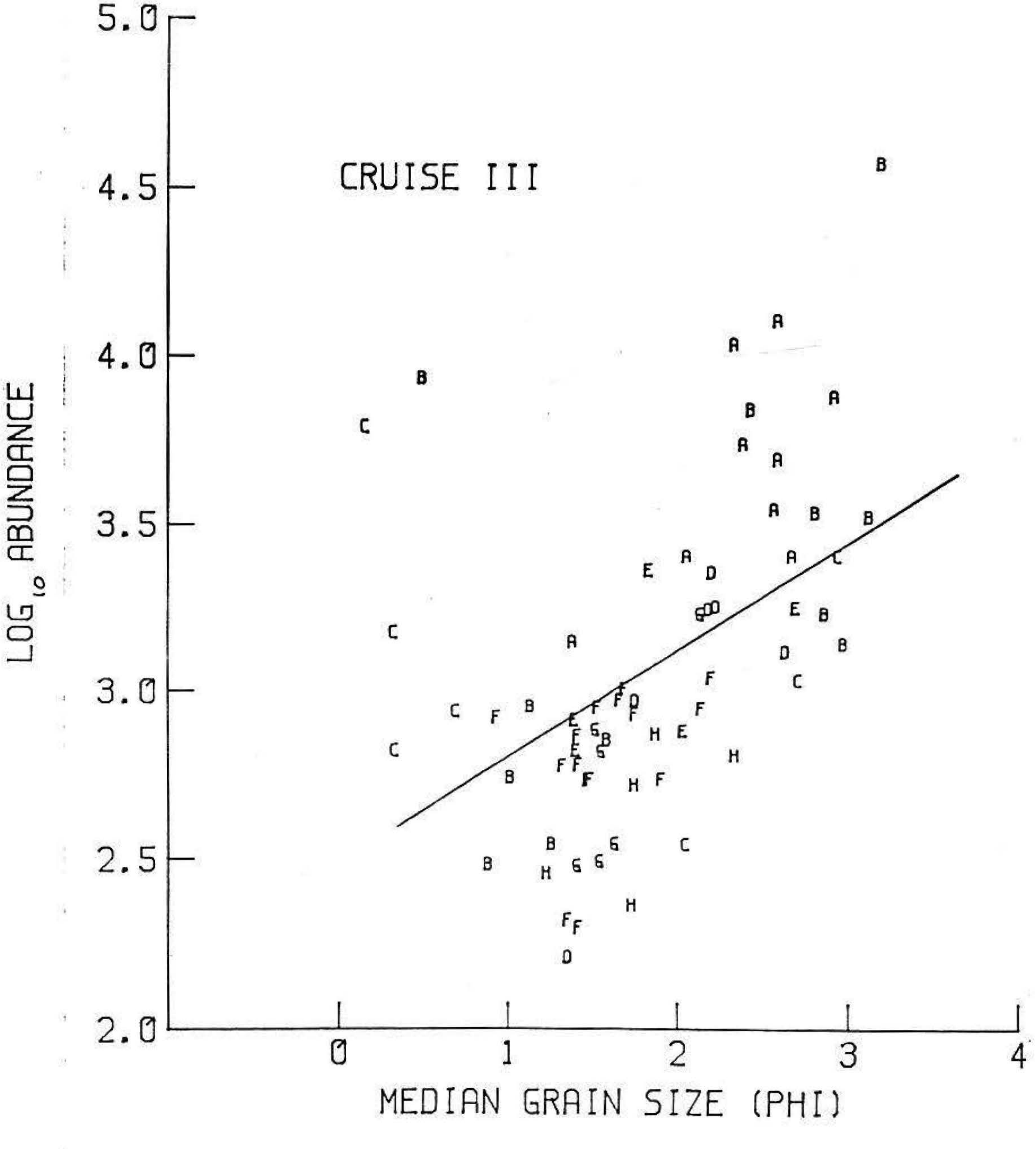

CRUISE III
LOG10 ABUNDANCE
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0
1
2
3
4
MEDIAN GRAIN SIZE (PHI)
A
B
C
D
E
F
G
H

Figure 162

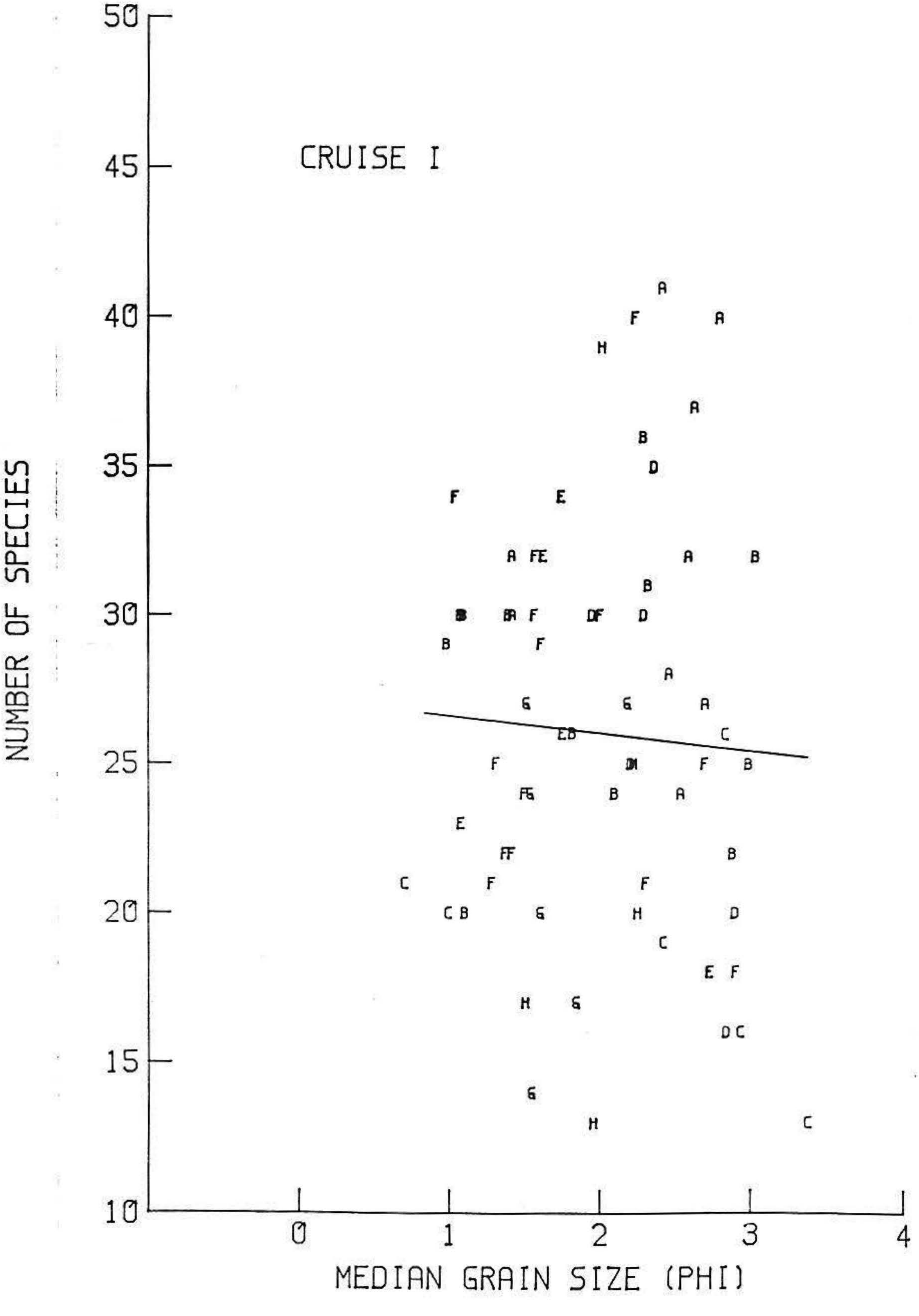

CRUISE I
NUMBER OF SPECIES
50
45
40
35
30
25
20
15
10
0
1
2
3
4
MEDIAN GRAIN SIZE (PHI)

Figure 163

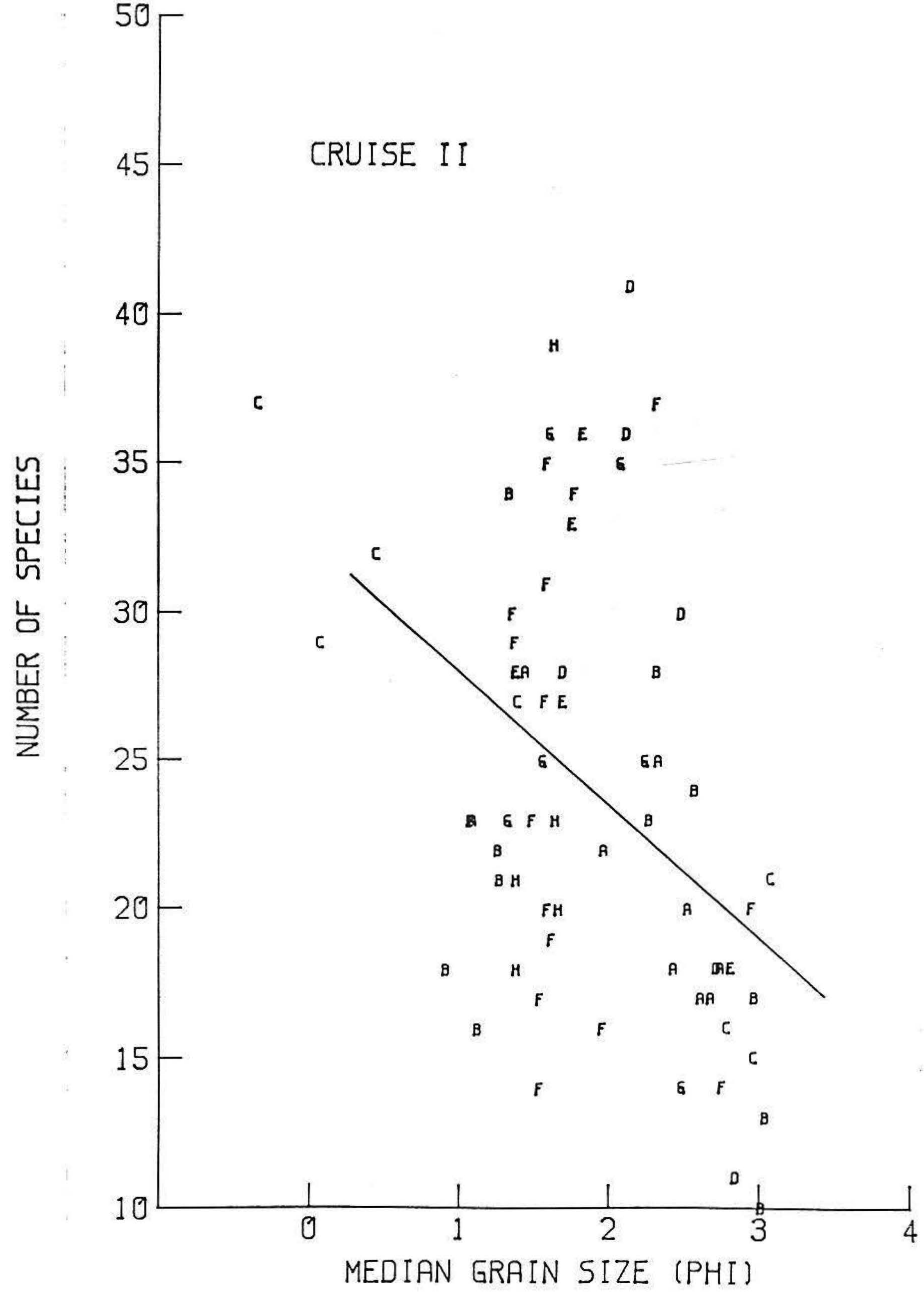

CRUISE II
NUMBER OF SPECIES
MEDIAN GRAIN SIZE (PHI)
50
45
40
35
30
25
20
15
10
0
1
2
3
4

Figure 164

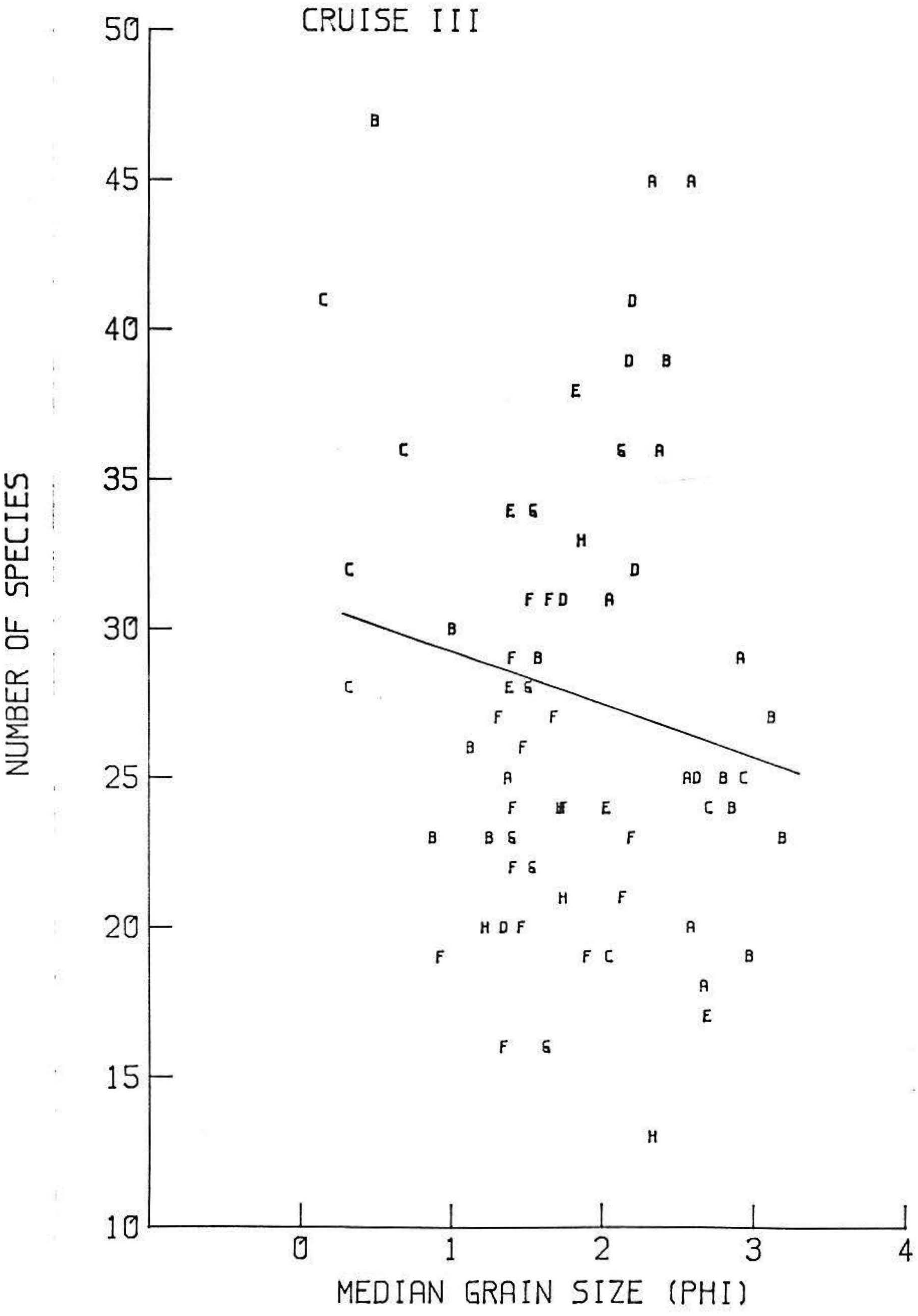

CRUISE III
NUMBER OF SPECIES
MEDIAN GRAIN SIZE (PHI)
50
45
40
35
30
25
20
15
10
0
1
2
3
4

Figure 165

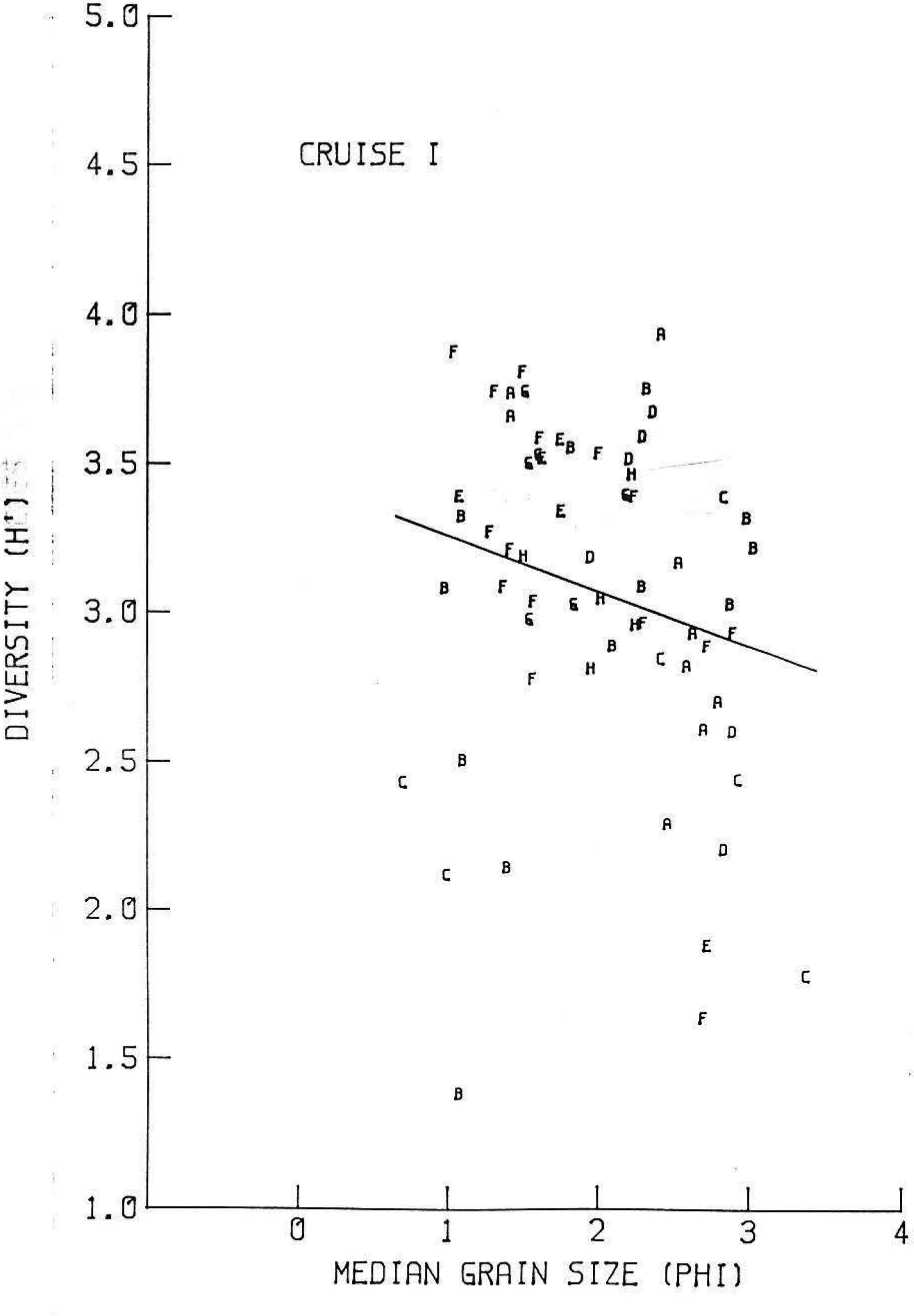

CRUISE I
DIVERSITY (H')
MEDIAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
1
2
3
4

Figure 166

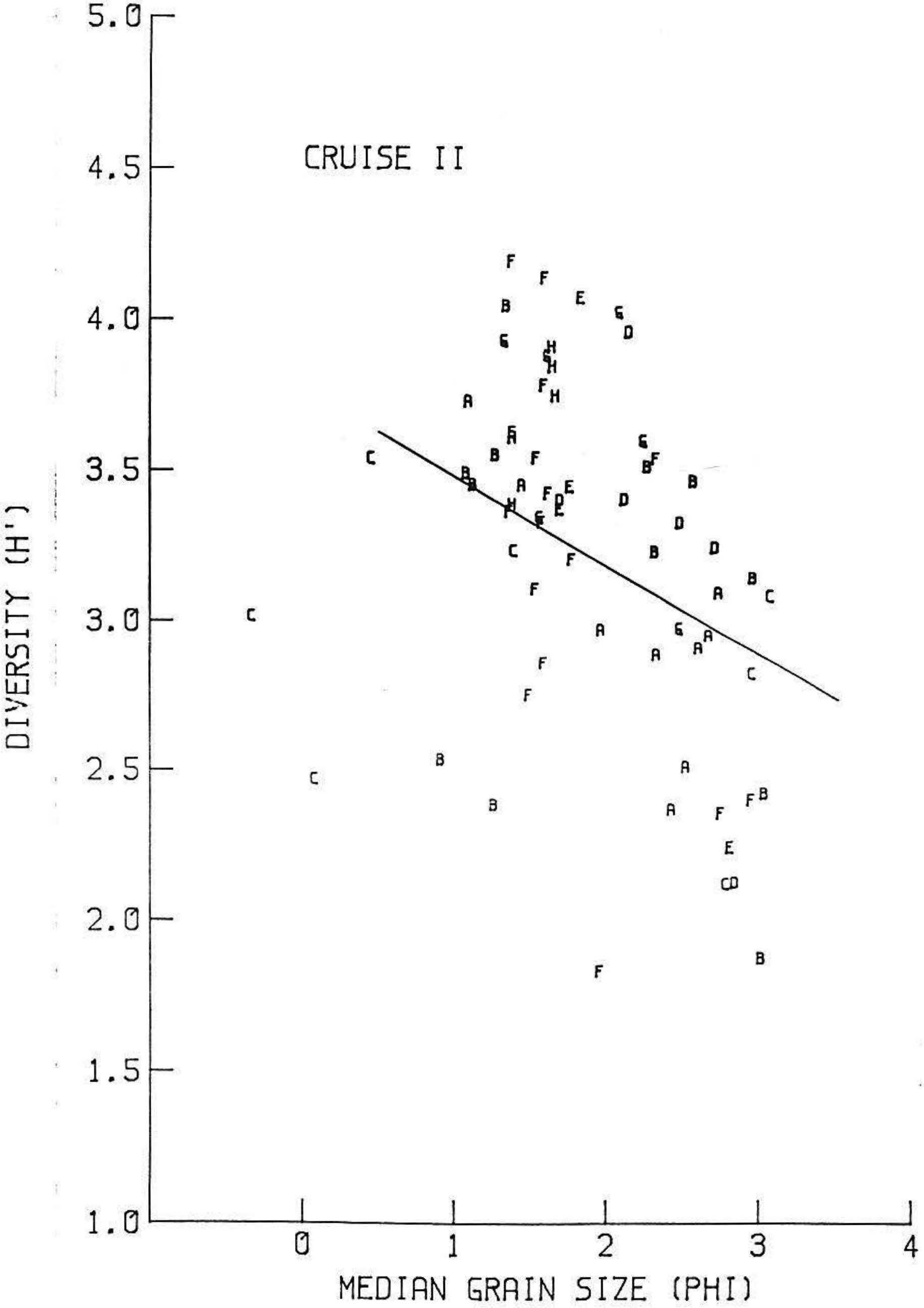

CRUISE II
DIVERSITY (H')
MEDIAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
1
2
3
4

Figure 167

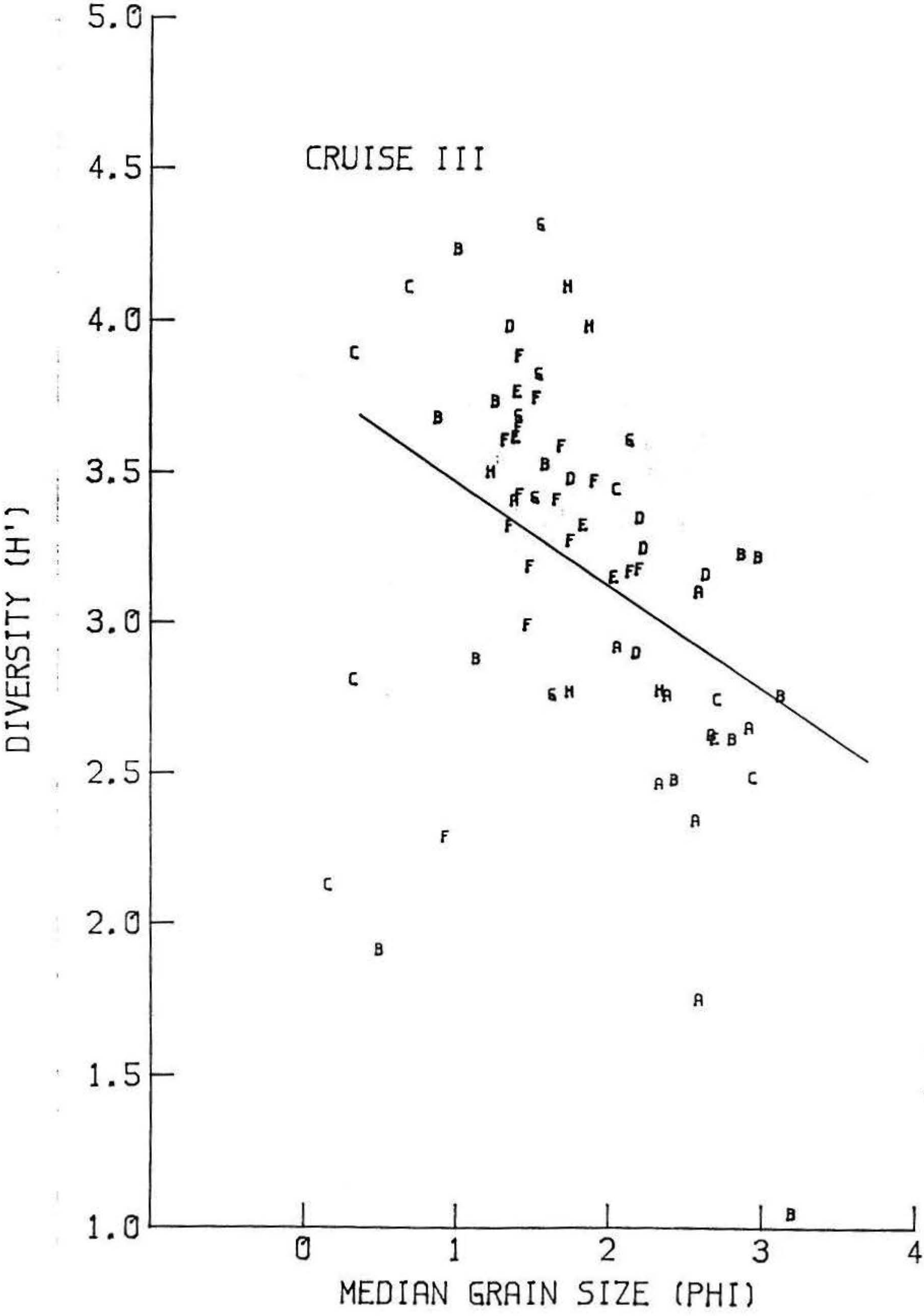

CRUISE III
DIVERSITY (H')
MEDIAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
1
2
3
4

Figure 168

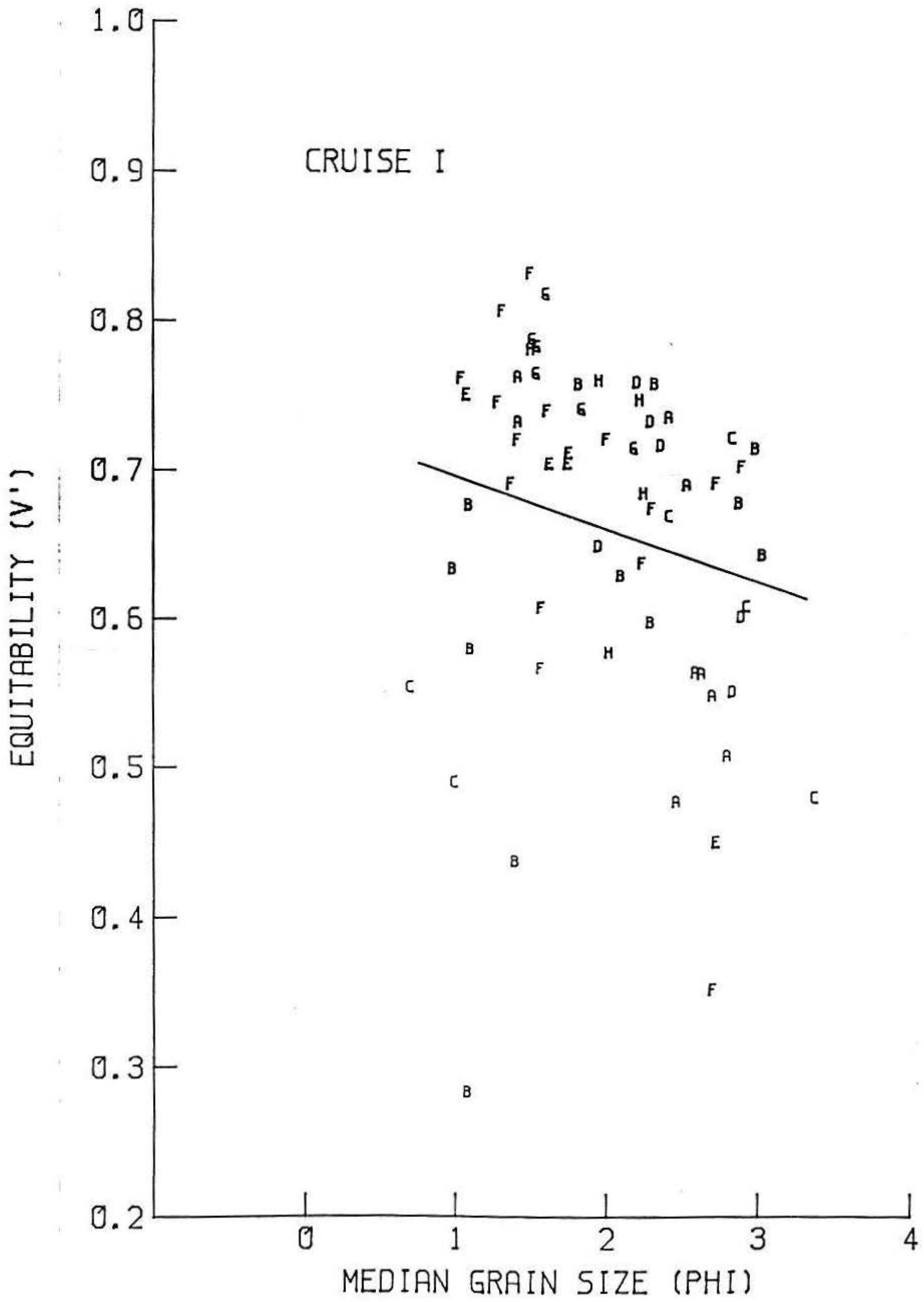

CRUISE I
EQUITABILITY (V')
MEDIAN GRAIN SIZE (PHI)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4

Figure 169

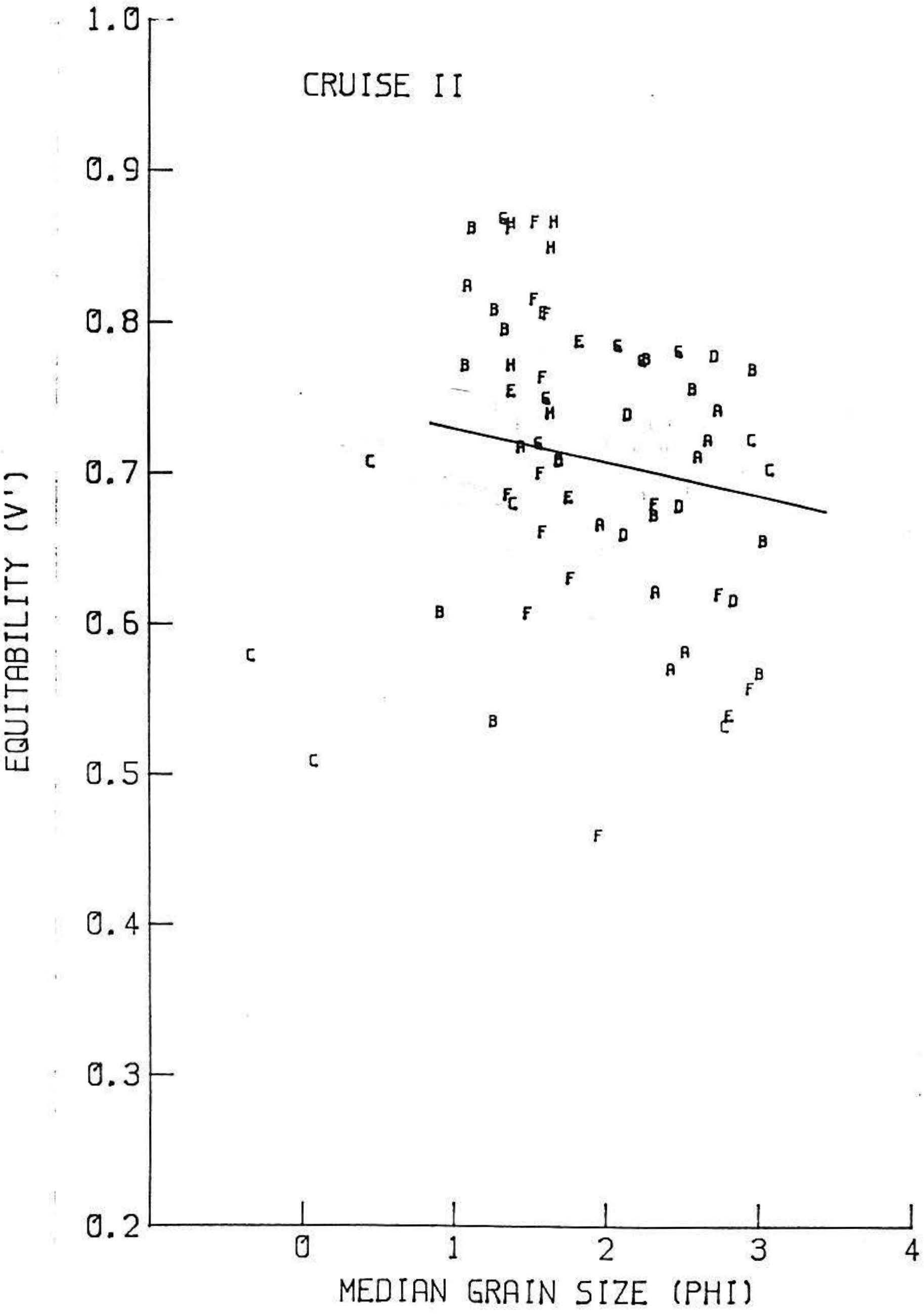

CRUISE II
EQUITABILITY (V')
MEDIAN GRAIN SIZE (PHI)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4

Figure 170

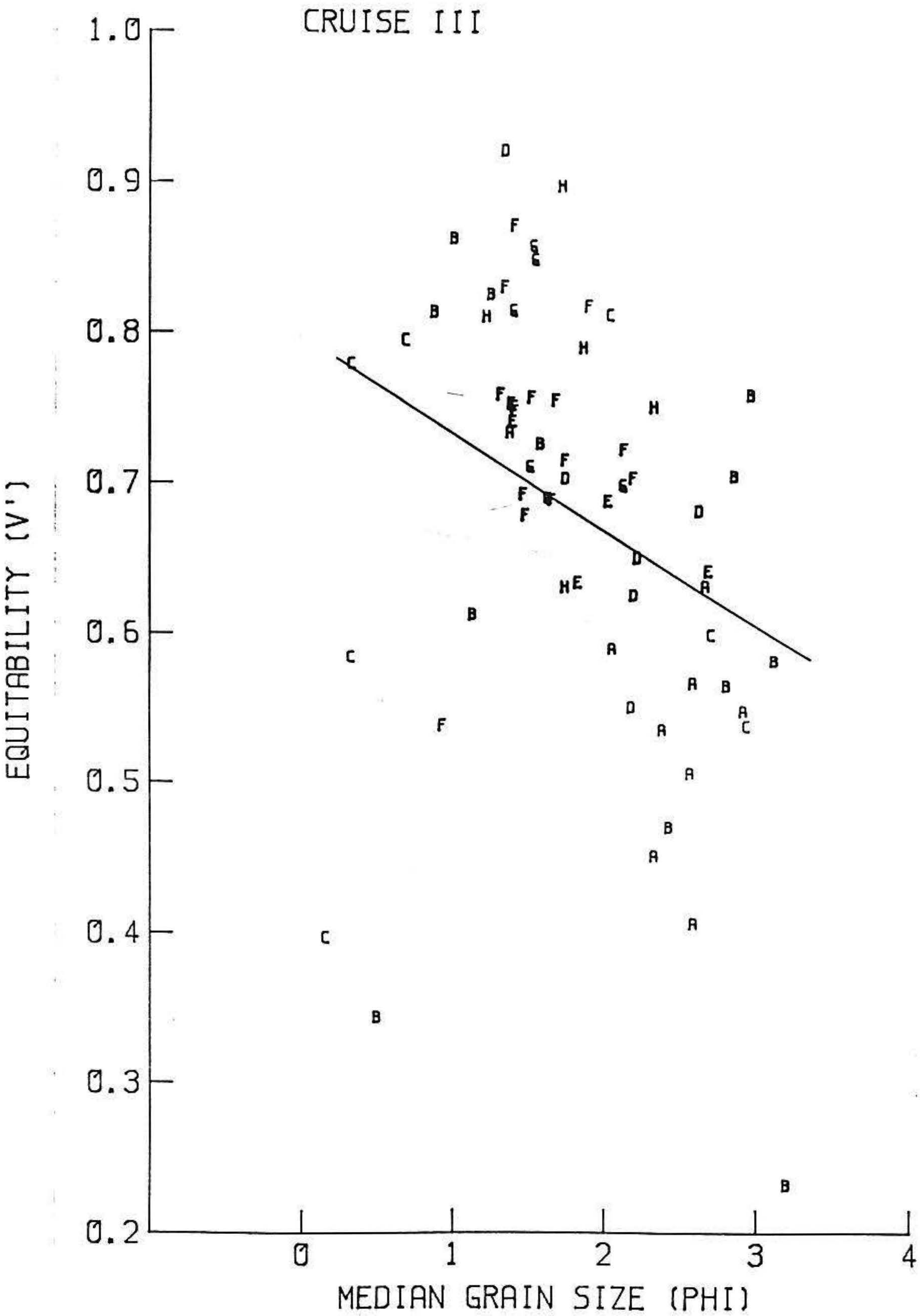

CRUISE III
EQUITABILITY (V')
MEDIAN GRAIN SIZE (PHI)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
A
B
C
D
E
F
G
H

Figure 171

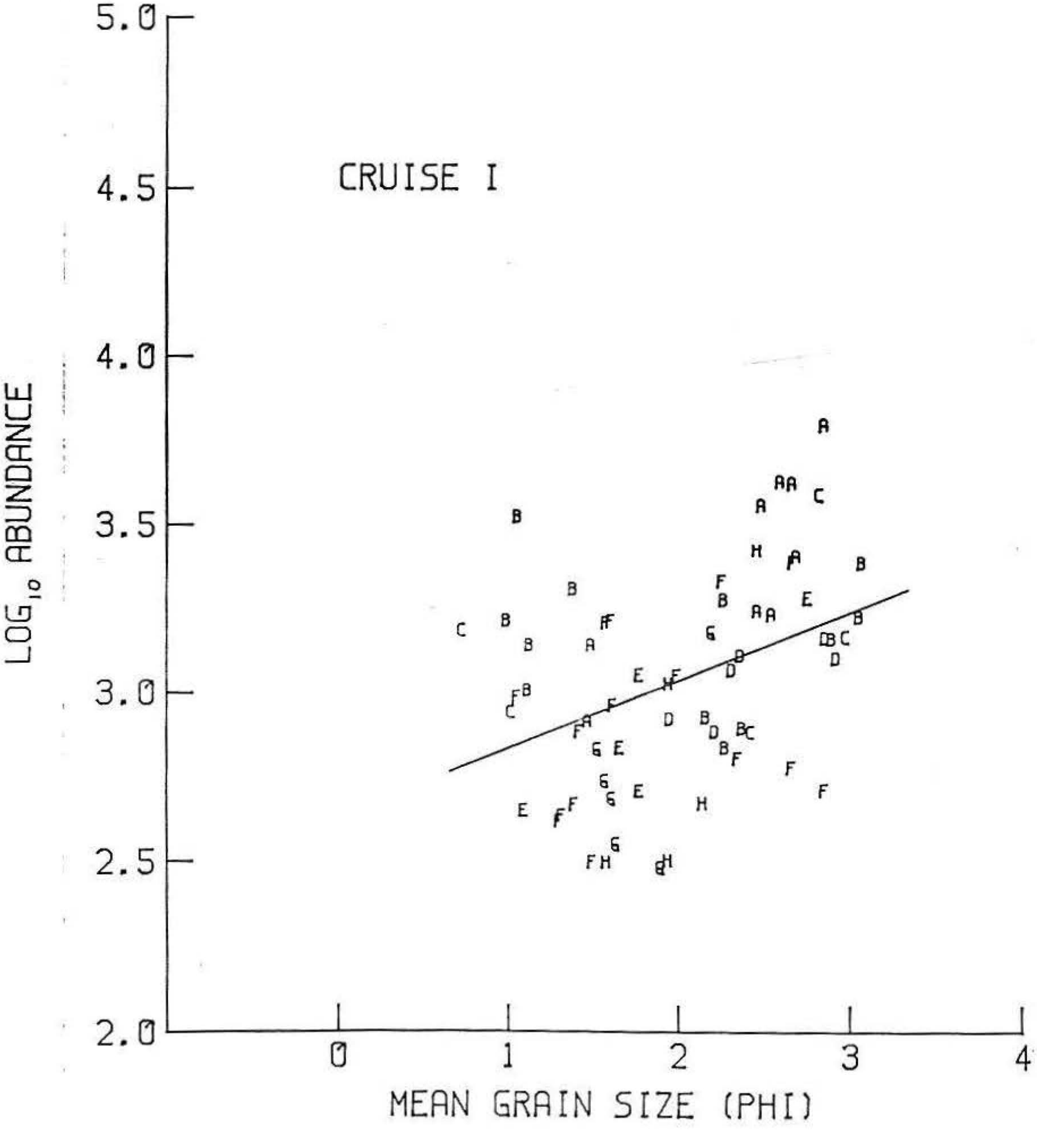

CRUISE I
LOG10 ABUNDANCE
MEAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0
1
2
3
4

Figure 172

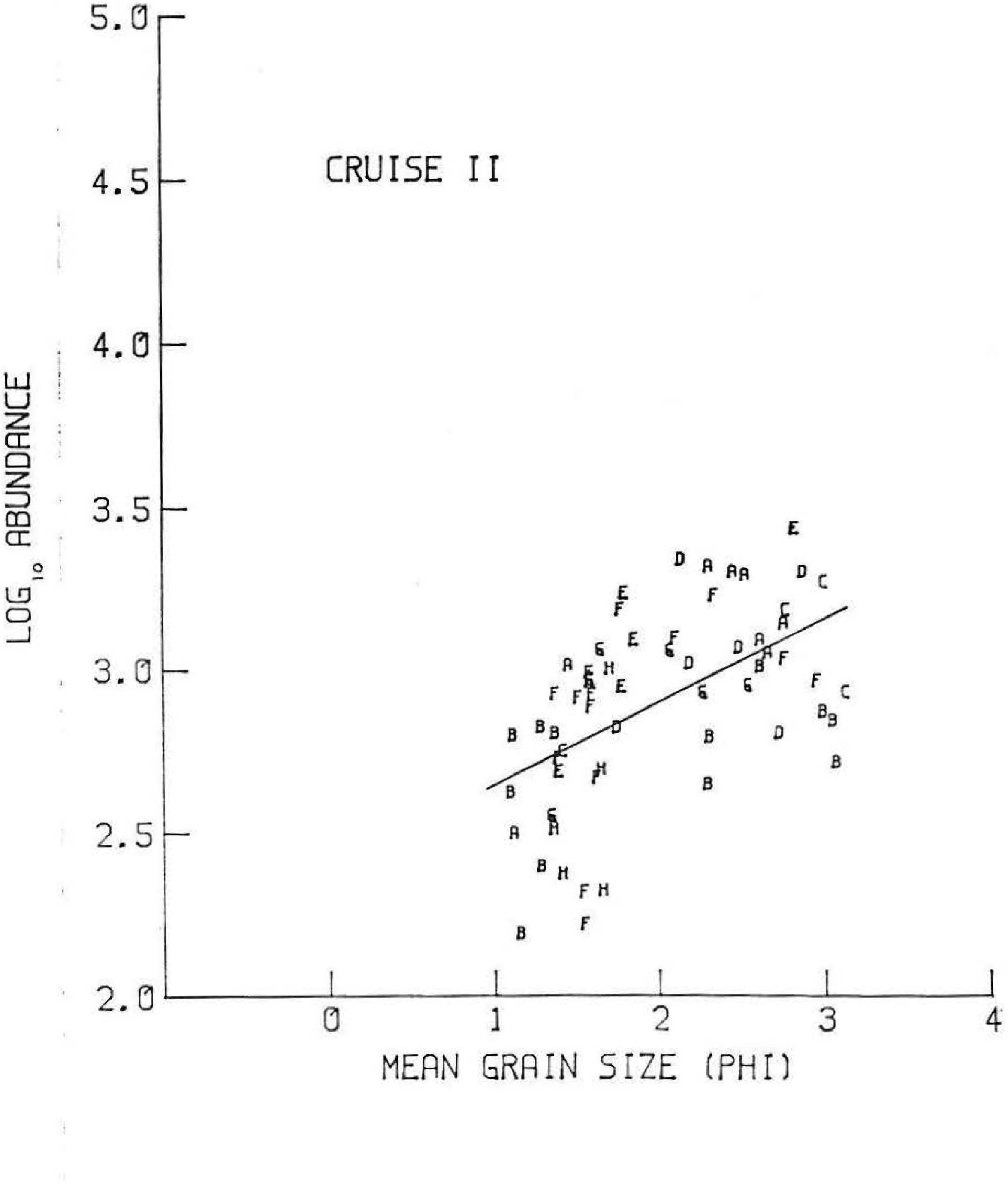

CRUISE II
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LOG$_{10}$ ABUNDANCE
0
1
2
3
4
MEAN GRAIN SIZE (PHI)

Figure 173

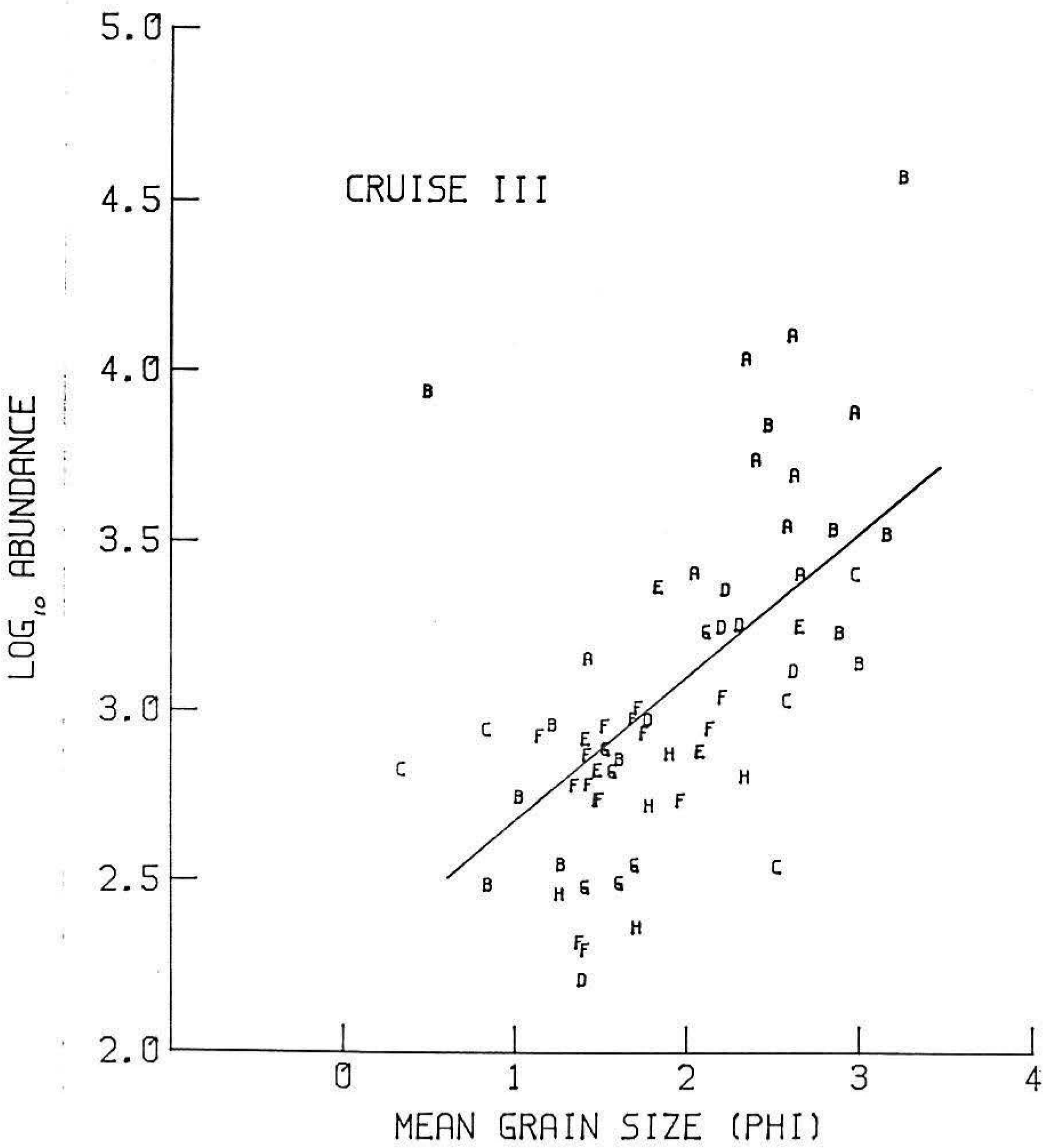

CRUISE III
LOG10 ABUNDANCE
MEAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0
1
2
3
4

Figure 174

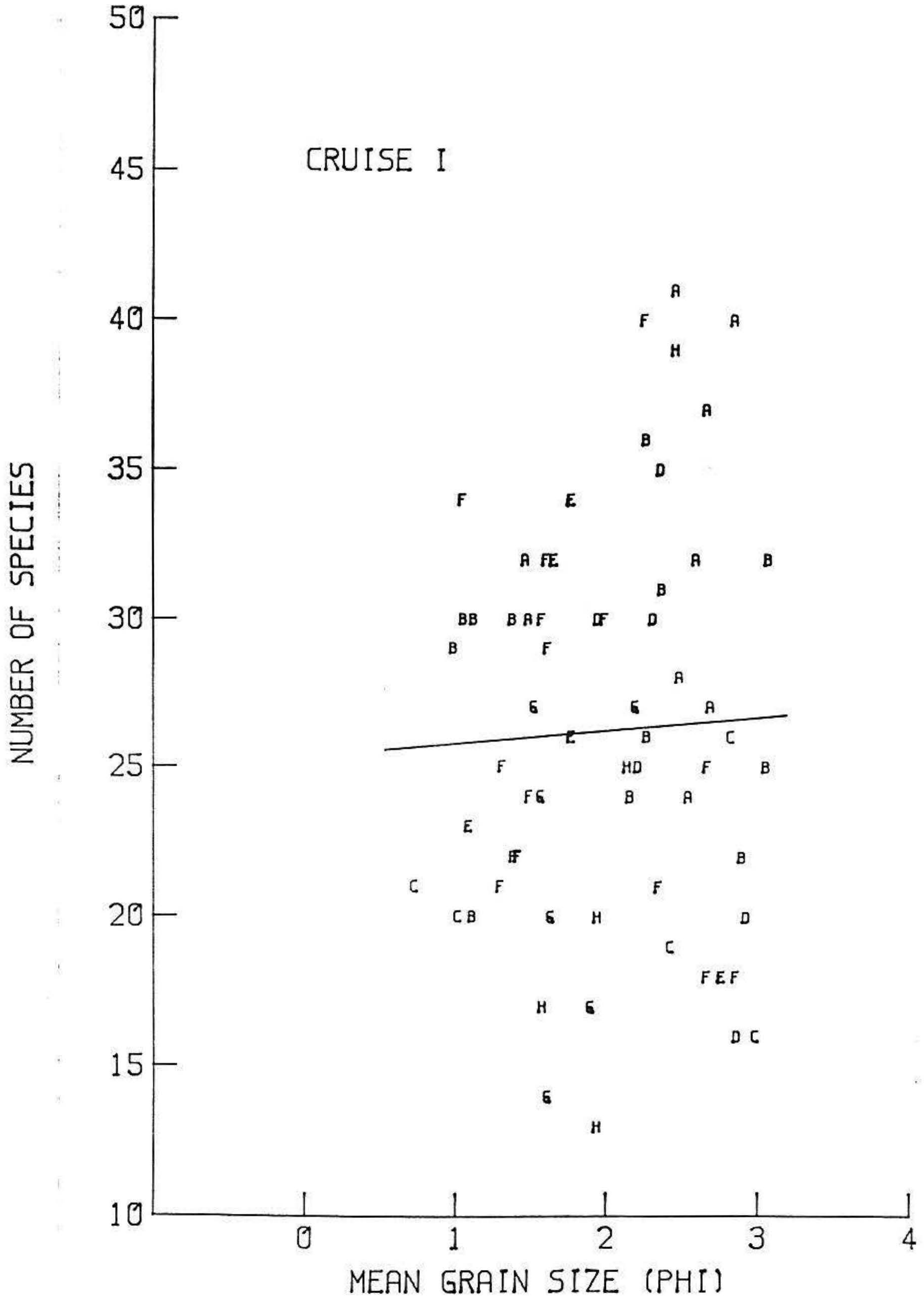

CRUISE I
NUMBER OF SPECIES
50
45
40
35
30
25
20
15
10
0
1
2
3
4
MEAN GRAIN SIZE (PHI)

Figure 175

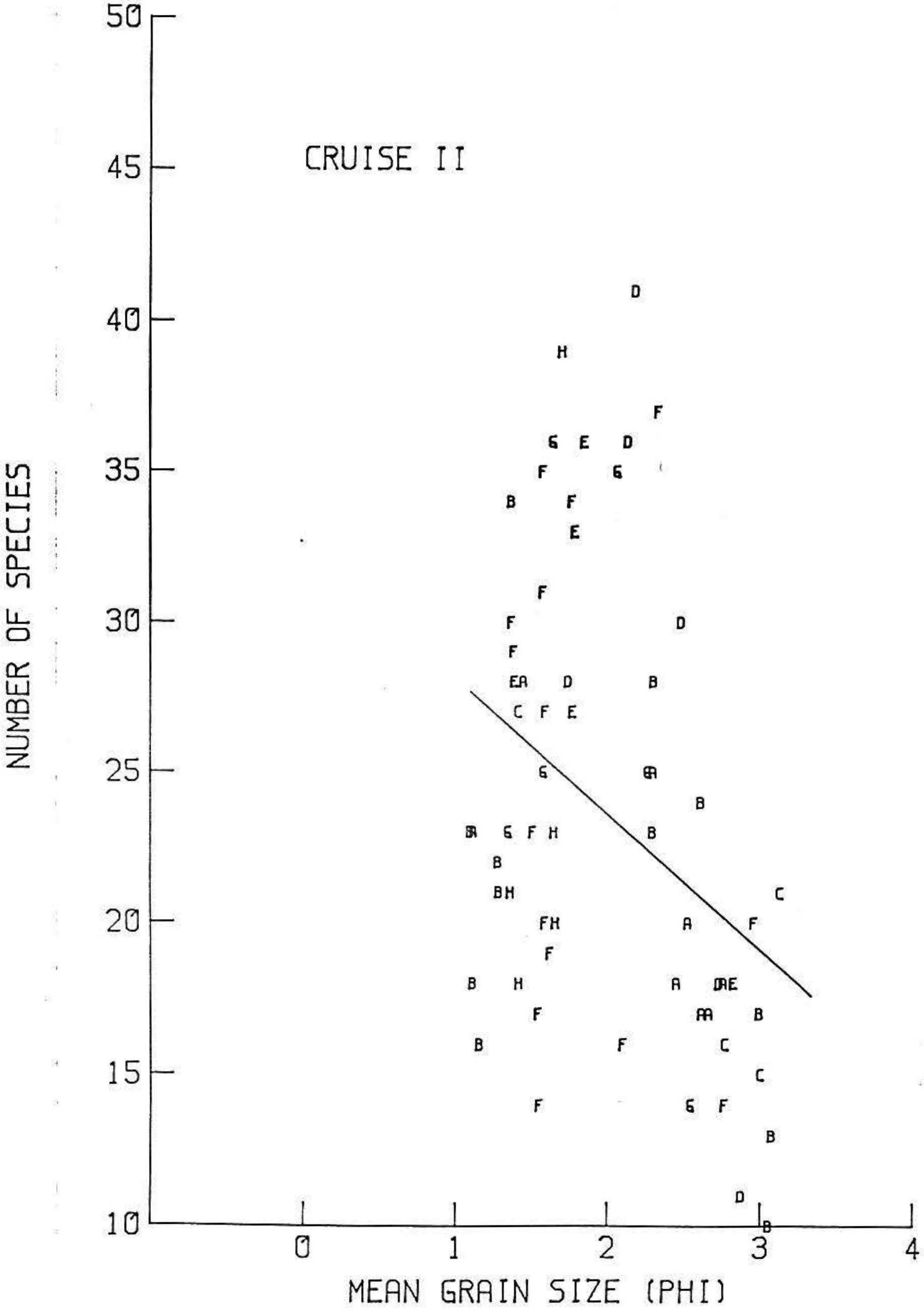

CRUISE II
NUMBER OF SPECIES
MEAN GRAIN SIZE (PHI)
50
45
40
35
30
25
20
15
10
0
1
2
3
4

Figure 176

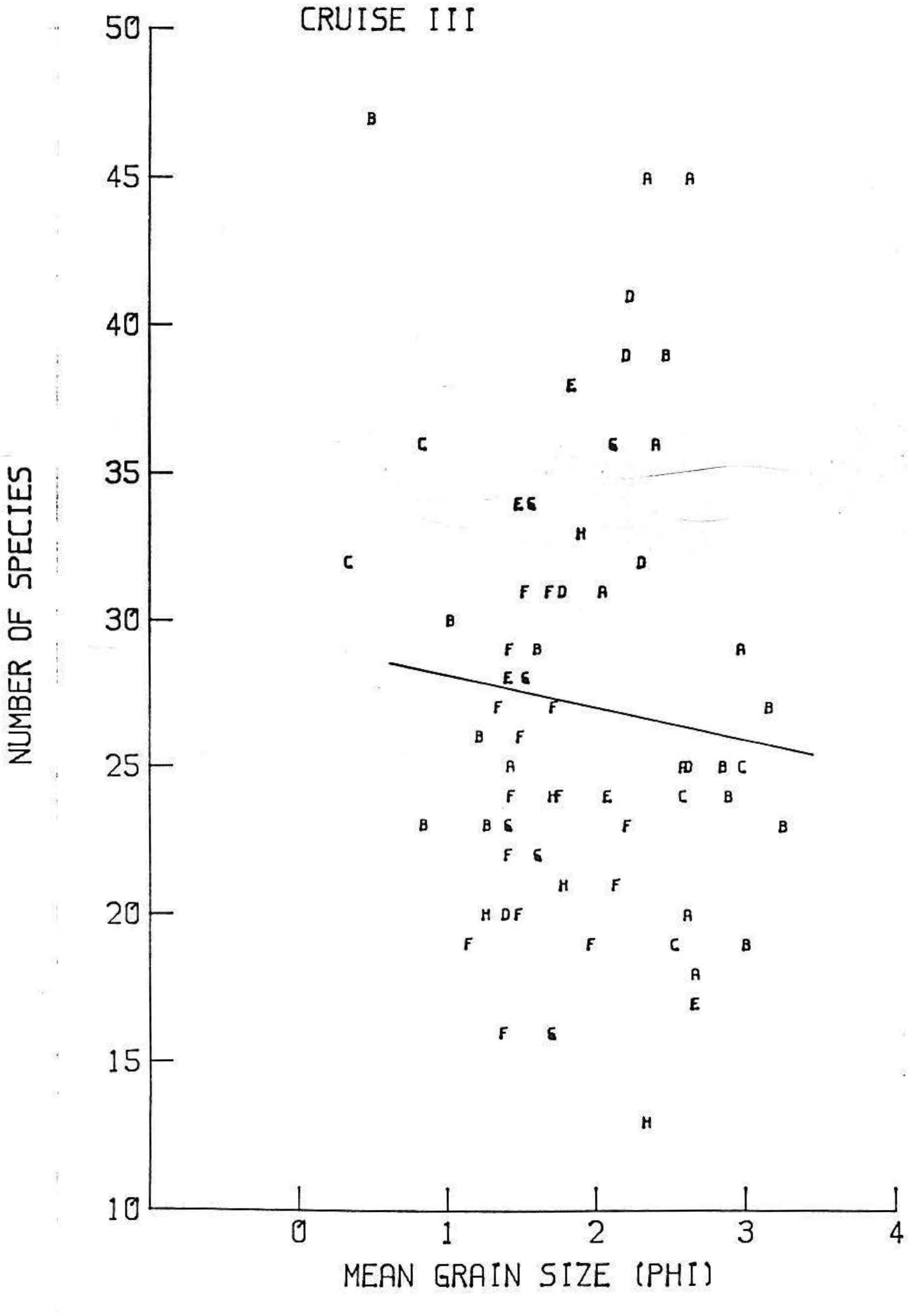

CRUISE III
NUMBER OF SPECIES
MEAN GRAIN SIZE (PHI)
50
45
40
35
30
25
20
15
10
0
1
2
3
4

Figure 177

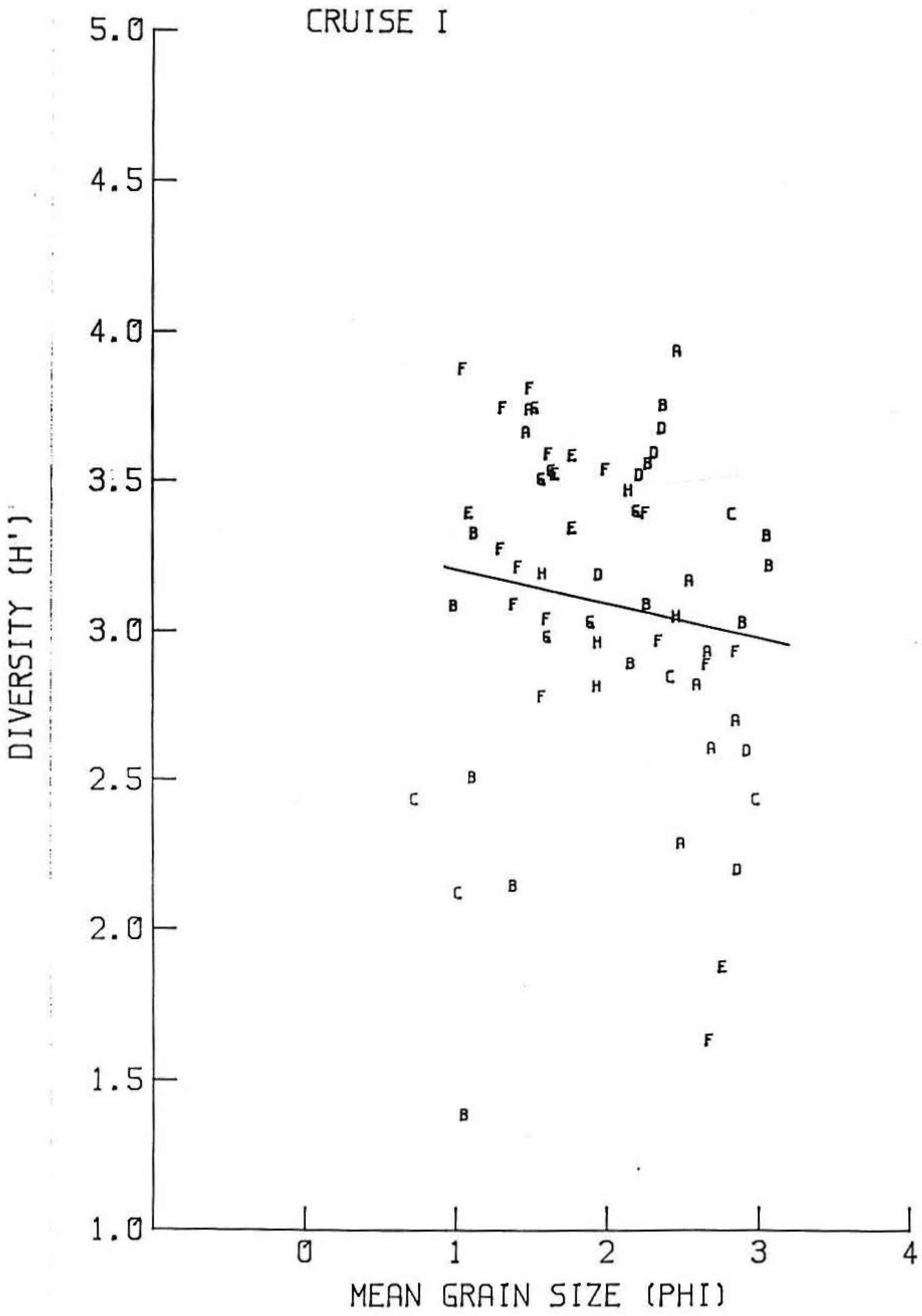

CRUISE I
DIVERSITY (H')
MEAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
1
2
3
4

Figure 178

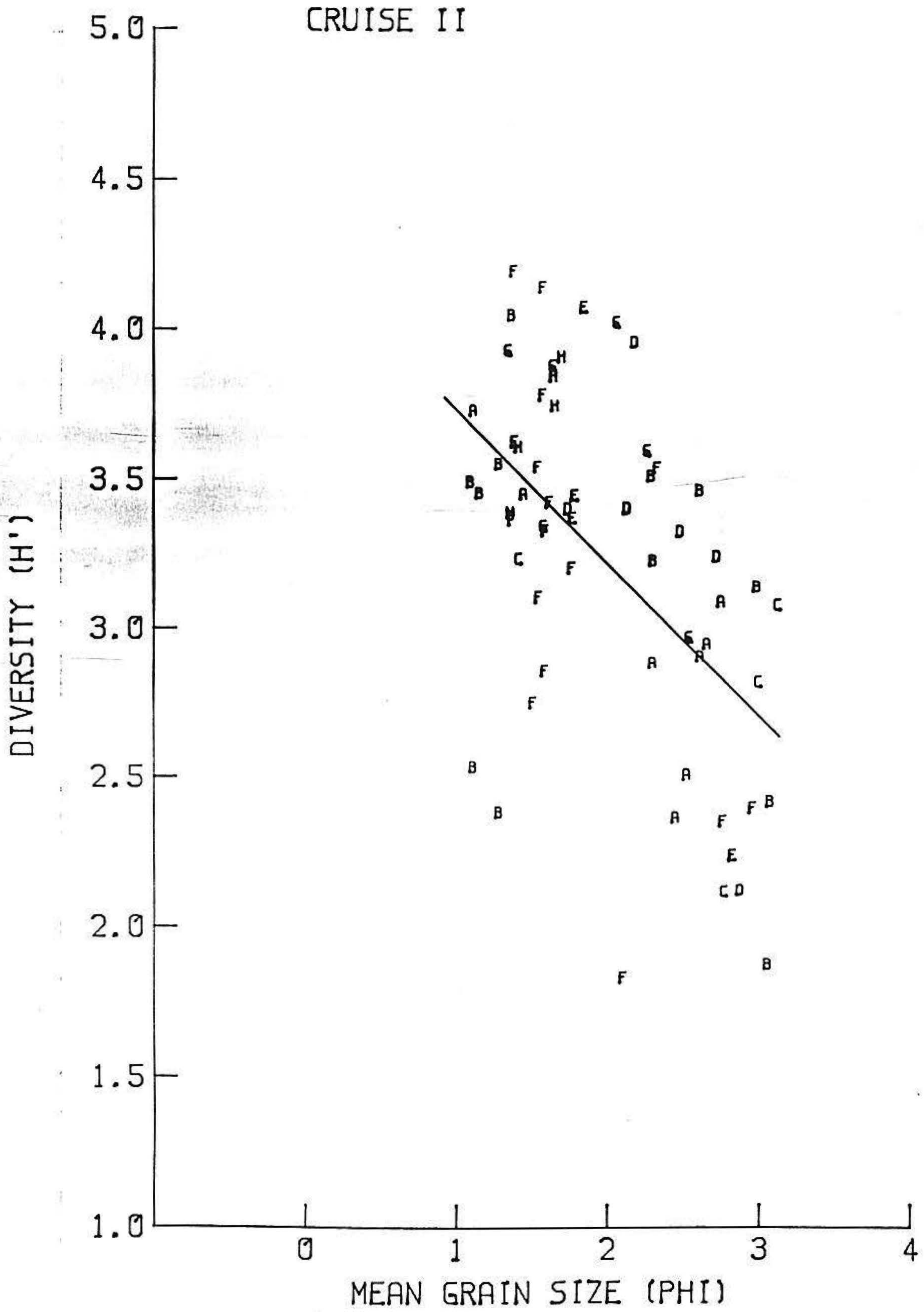

CRUISE II
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
DIVERSITY (H')
0
1
2
3
4
MEAN GRAIN SIZE (PHI)

Figure 179

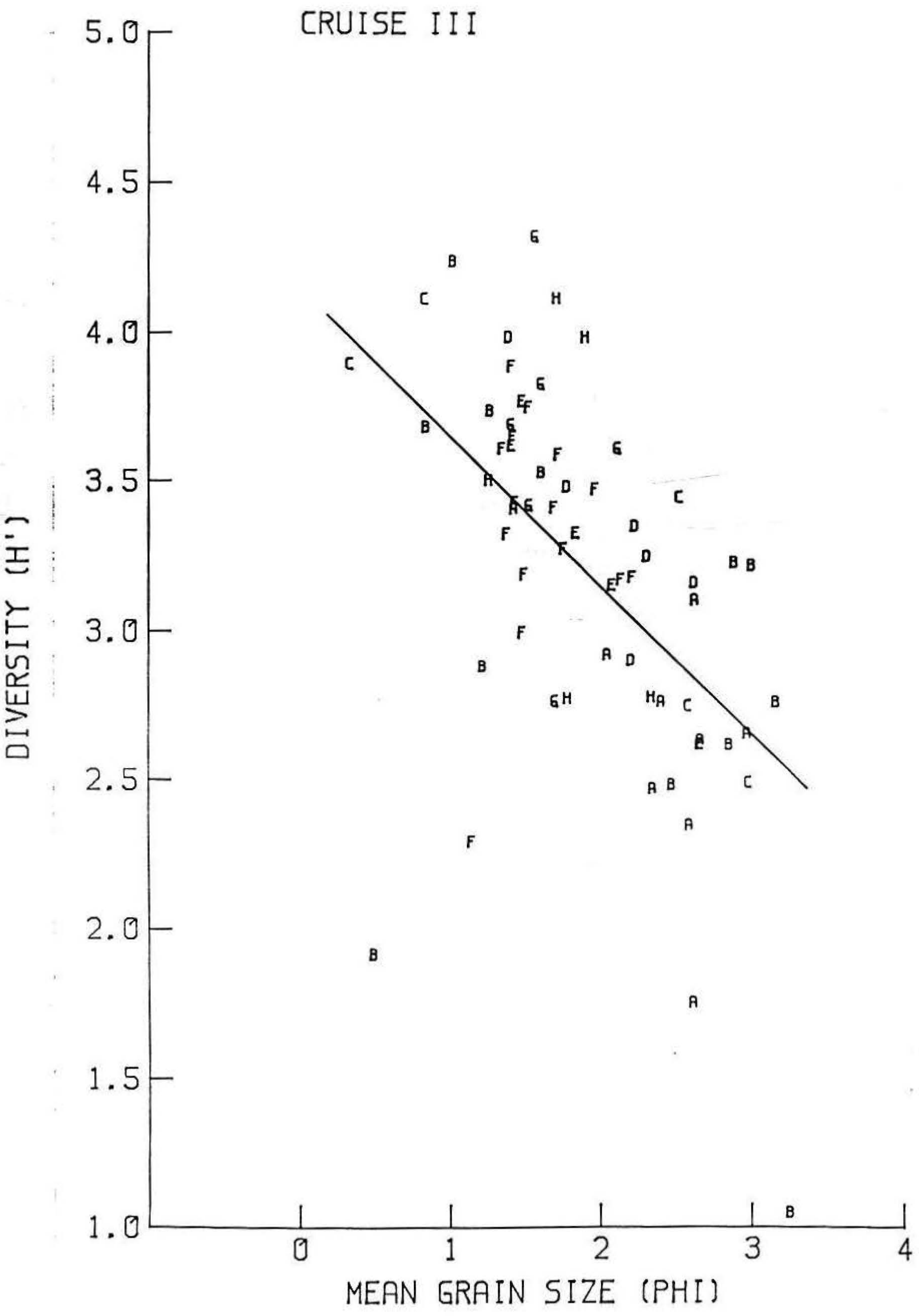

CRUISE III
DIVERSITY (H')
MEAN GRAIN SIZE (PHI)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
1
2
3
4

Figure 180

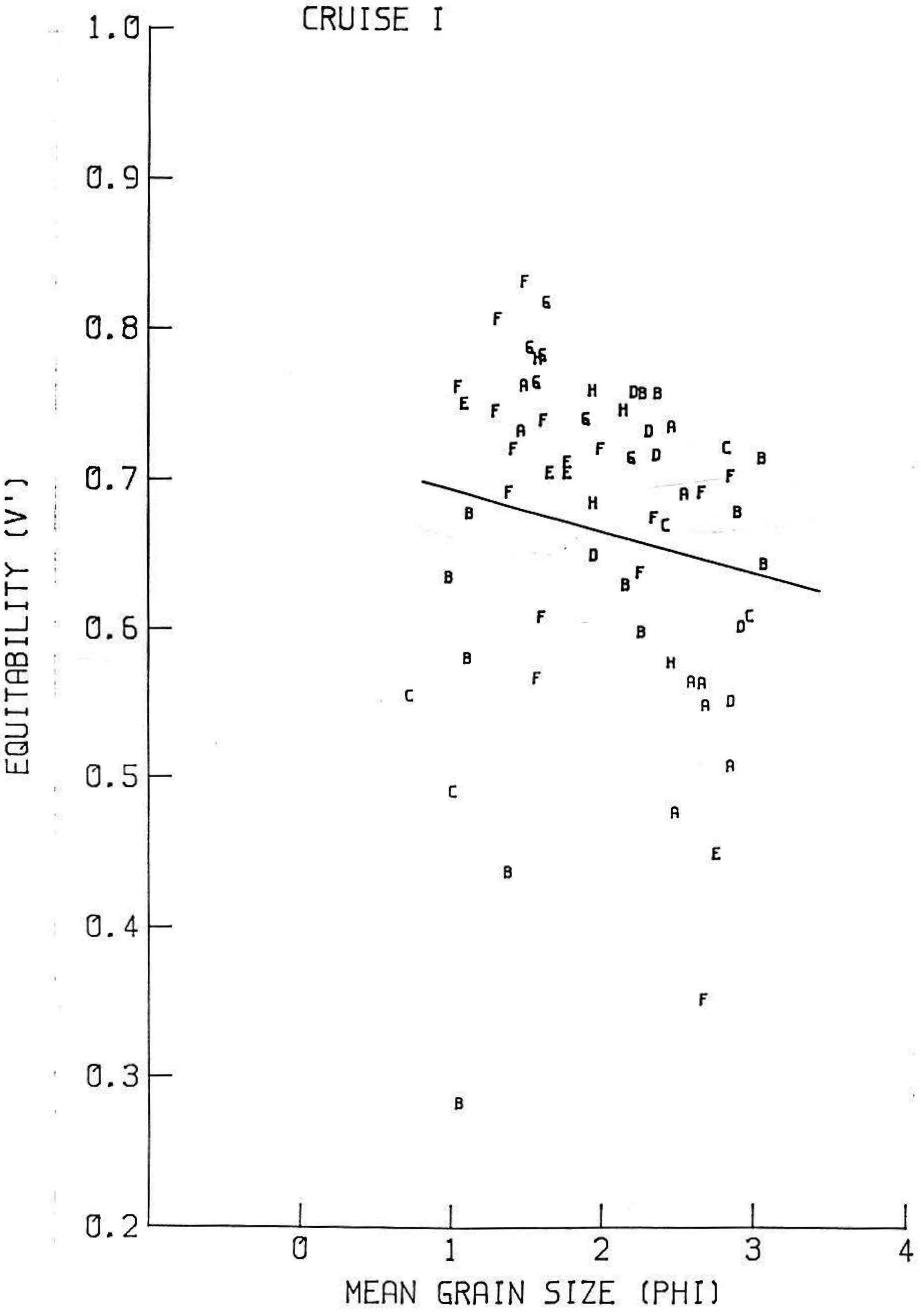

CRUISE I
EQUITABILITY (V')
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
MEAN GRAIN SIZE (PHI)
0
1
2
3
4

Figure 181

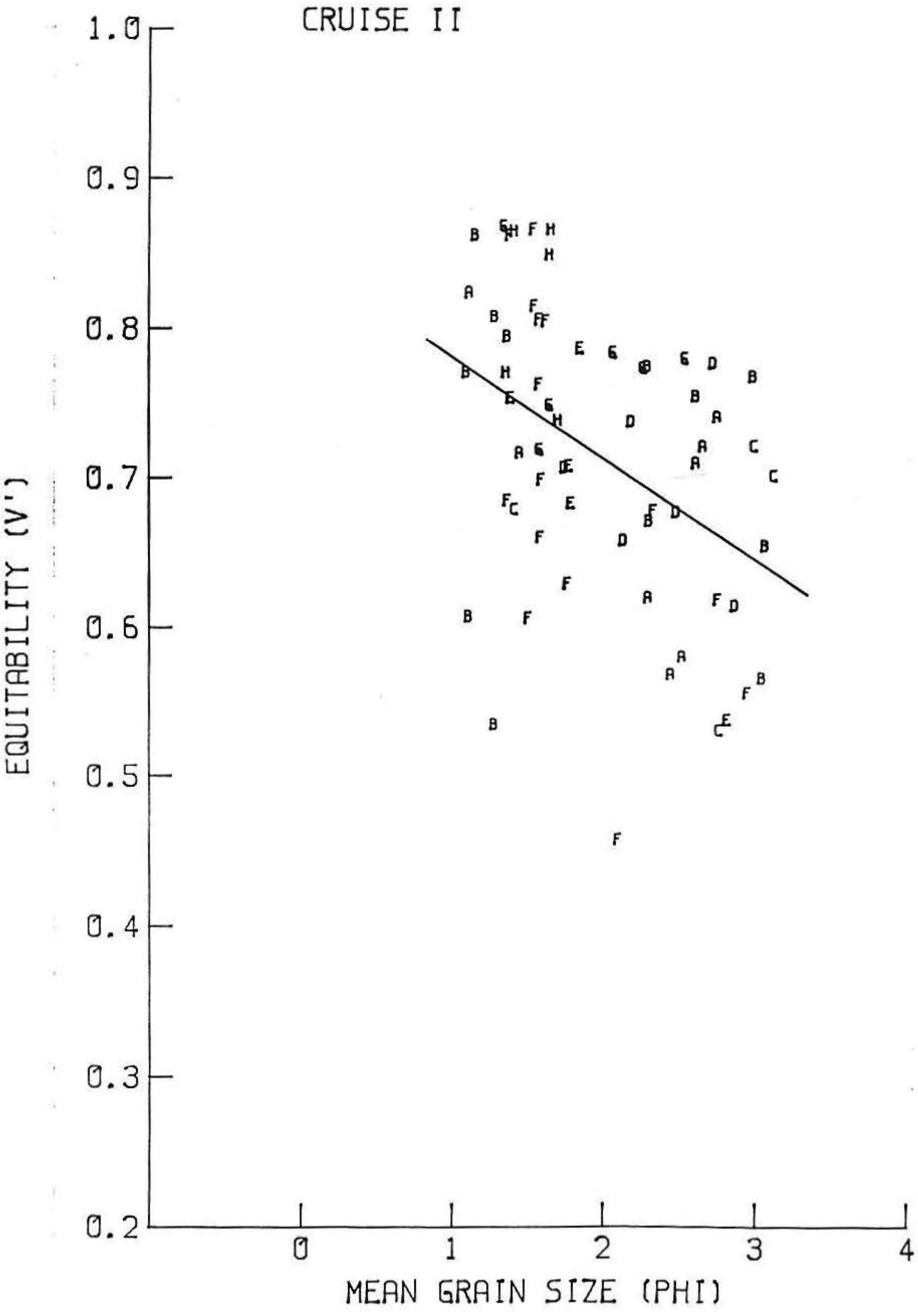
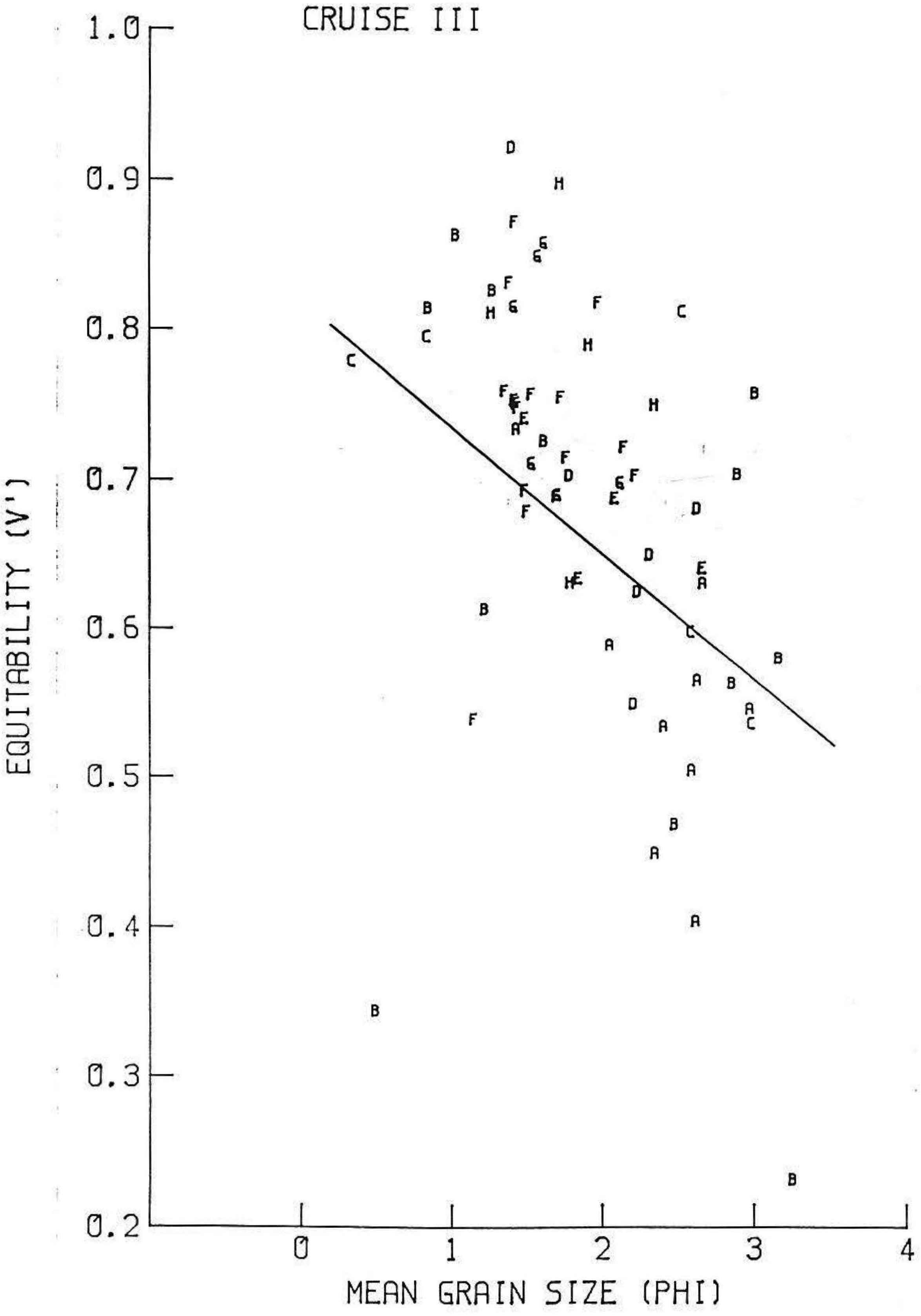

CRUISE II
EQUITABILITY (V')
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
MEAN GRAIN SIZE (PHI)

Figure 182


CRUISE III
EQUITABILITY (V')
MEAN GRAIN SIZE (PHI)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4

3. Benthic Fauna - Epibenthic Sled Tows

A total of 141319 individuals representing 151 taxa were collected in epibenthic sled tows during the three cruises. A composite species list is given in Table 5. Of the 151 taxa, 35 (23%) were Polychaetes, 35 (23%) were Crustacea, 25 (17%) were Chordates, and 15 (10%) were Bivalves. The remaining species were distributed amoung 14 other groups: Porifera, Anthozoa, Hydrozoa, Nemertea, Nematoda, Sipunculida, Ectoprocta, Gastropoda, Cephalopoda, Xiphosura, Hoplocardia, Asteroidea, Echinoidea, and Holothuroidea. Data for each sled tow are tabulated in Appendix F.

a. Species Composition

For the spring cruise, the sand dollar *Echinarachnius parma*, the ampharetid polychaete *Asabellides oculata*, the chestnut clam *Astarte castenea*, and the sand shrimp *Crangon septemspinosa* accounted for 92% of the individuals collected in the sled tows. *Echinarachnius parma* was found at all sites but was especially common in samples collected at the easternmost areas (E-H). *Asabellides oculata*, on the other hand, was restricted to the westernmost sites (A-C). *Astarte castanea* was found at all sites with the exception of D, and the sand shrimp *Crangon septemspinosa* was collected at all potential borrow sites.

During the summer, three species, *Echinarachnius parma*, the lady crab *Ovalipes ocellatus*, and *Crangon septemspinosa* made up 86% of the individuals collected in the sled tows. Highest numbers of individuals of *Echinarachnius parma* were found at site B and sites E through H. *Ovalipes ocellatus* and *Crangon septemspinosa* were collected at all sites but were especially common in sled tows taken at sites A-C.

For the fall cruise, *Asabellides oculata*, *Echinarachnius parma*, and *Crangon septemspinosa* accounted for 96% of the individuals collected in the sled tows. *Asabellides oculata* was restricted to the westernmost sites (A-D). As in the previous cruises, *Echinarachnius parma* was especially common in tows collected at sites E through H. *Crangon septemspinosa* was found at all potential borrow sites.

A number of species were found in epibenthic sled tows but were not collected in Smith-McIntyre grab samples. Table 6 lists these species. Notably, a large number of fish species appears on this list.

b. Number of Species

The number of species in each sled tow ranged from 1 to 29 in the spring, from 9 to 28 in the summer, and from 6 to 32 during the fall (Figures 183-185). A pattern of decreasing number of species per tow from west to east was observed in the spring and fall cruises (Figure 186). During the summer cruise, the average number of species per tow was relatively constant from west to east, except at site A (Figure 186). The average number of species in a tow was highest during the summer cruise for six of the eight potential borrow sites (C-H).

The number of species per tow was generally highest either at the mid-depth (40′-50′) or offshore (60′) stations during all three cruises (Figures 187-189). At all depths, the greatest number of species per tow often occurred during the summer months (Figures 190-192).

c. Commercially and/or Recreationally Important Species

Of the 151 taxa collected in the epibenthic sled tow samples, only 16 species were of commercial and/or recreational value. They are: the ocean quahog *Arctica islandica*, the surf clam *Spisula solidissima*, the blue mussel *Mytilus edulis*, the rock crab *Cancer irroratus*, the cod *Gadus morhua*, the yellowtail flounder *Limnada ferruginea*, the silver hake *Murluccius bilinearis*, the summer flounder *Paralichtys dentatus*, the fourspotted flounder *Paralichtys oblongus*, the butterfish *Poronotus triacanthus*, the winter flounder *Pseudopleuronectes americanus*, the little skate *Raja erinacea*, the thorny skate *Raja radiata*, the scup *Stenotomus chrysops*, the cunner *Tautogolabrus adspersus*, and the squirrel hake *Urophycis chuss*.

The majority (10) of the commercial and/or recreational species were rare and were collected in less than 20% of the sled tows during any of the three cruises (Table 7). *Mytilus edulis* was present in greater than 20% of the tows during the spring and summer cruises as very small juveniles attached to floating pieces of detritus. *Paralichtys oblongus* was common only during the summer where it occured in 24 of the 39 sled tows (62%). The little skate *Raja erinacea* was found in more than 20% of the sled tows during the summer cruise. *Urophysis chuss* was found in 33% and 26% of the tows during the spring and summer cruises, respectively. Finally, only two species, *Spisula solidissima* and *Cancer irroratus*, were found in greater than 20% of the tows during all three cruises (Table 7).

Table 5. Species List - Epibenthic Sled Tows

PORIFERA
- Suberites spp.

CNIDARIA
- Anthozoa
  - anemone sp. A
  - anemone sp. B
  - anemone sp. C
  - anemone sp. D
  - anemone sp. G

- Hydrozoa
  - Abietinaria filicula
  - Hydrallmania falcata
  - Hydractinia echinata
  - Obelia commisuralis
  - Obelia flabellata
  - Obelia spp.
  - Pennaria tiarella
  - Podocoryne carnea
  - Tubularia spp.

NEMATODA
- Unidentified nematode spp.

NEMERTEA
- Unidentified nemertean spp.

SIPUNCULA
- Unidentified sipunculid spp.

ECTOPROCTA
- Alcyonidium spp.
- Bulgula turrita
- Bulgula spp.
- Callopora craticula
- Callopora spp.
- Electra pilosa
- Eucratea loricata
- Hippoporina spp.
- Membranipora tenuis
- Microporella ciliata

ANNELIDA
- Polychaeta
  - Ampharetidae
    - Ampharete artica
    - Asabellides oculata
  - Arabellidae
    - Drilonereis longa
    - Unidentified spp.
  - Capitellidae
    - Capitella capitata
  - Cirratulidae
    - Tharyx acutus
  - Flabelligeridae
    - Pherusa affinis
  - Glyceridae
    - Glycera americana
    - Glycera dibranchata
    - Glycera robusta
    - Glycera spp.
    - Hemipodus roseus
  - Goniadidae
    - Goniadella gracilis
  - Lumbrinereidae
    - Lumbrineris fragilis
    - Lumbrineris tenuis
    - Lumbrineris spp.
  - Magelonidae
    - Magelona riojai
  - Nephtyidae
    - Nephtys bucera
    - Nephtys picta
    - Nephtys spp. imm.
  - Nereidae
    - Nereis succinea
  - Onuphidae
    - Diapatra cuprea
    - Onuphis opalina
  - Opheliidae
    - Ophelia denticulata
  - Orbiniidae
    - Scoloplos acutus
  - Paraonidae
    - Aricidea catherinae
  - Pectinariidae
    - Pectinaria gouldii
  - Phyllodocidae
    - Eteone spp.
    - Phyllodoce arenae
    - Phyllodoce spp.
  - Polynoidae
    - Harmothoe extenuata
  - Sigalionidae
    - Sigalion arenicola
    - Sthenelais limicola
  - Spionidae
    - Polydora socialis
    - Spio filicornis
    - Spiophanes bombyx
    - Spionidae spp.

Table 5 (continued)

MOLLUSCA
- Gastropoda
  - Nassariidae
    - Nassarius trivittata
  - Crepidulidae
    - Crepidula fornicata
    - Crepidula plana
  - Naticidae
    - Lunatia heros
    - Lunatia heros eggs
  - Nudibranchia
    - Unidentified nudibranch spp.

- Bivalva
  - Arcticidae
    - Arctica islandica
  - Astartidae
    - Astarte castenea
  - Carditidae
    - Cerastoderma pinnulatum
  - Lyonsiidae
    - Lyonsia hyalina
  - Mactridae
    - Spisula solidissima
  - Mytilidae
    - Mytilus edulis
  - Nuculanidae
    - Yolida limulata
  - Pandoridae
    - Pandora gouldiana
  - Petricolidae
    - Petricola pholadiformis
  - Pholadidae
    - Crytopleura costata
  - Solenidae
    - Ensis directus
    - Siliqua costata
    - Solen viridis
  - Tellinidae
    - Tellina agilis
  - Veneridae
    - Pitar morrhuana

- Cephalopoda
    - Iliex illacebrosus

ARTHROPODA
- Xiphosura
    - Limulus polyphemus

- Crustacea
  - Amphipoda
    - Ampeliscidae
      - Byblis serrata
    - Aoridae
      - Pseudunciola obliquua
      - Unciola irrorata
    - Caprellidae
      - Agenia longcornis
      - Caprella linearis
      - Caprella unica
      - Unidentified spp.
    - Corophiidae
      - Cerapus tubularis
      - Corophium acherusicum
      - Corophium crassicorne
    - Gammaridae
      - Gammarus annulatus
      - Gammarus lawrencianus
    - Haustoriidae
      - Parahaustorius attenuatus
      - Parahaustorius holmesi
      - Protohaustorius wiglyei
      - Pseudohaustorius borealis
    - Lysiannasidae
      - Hippomedon serratus
      - Psammonyx nobilis
    - Oecicerotidae
      - Monoculodes edwardsi
    - Photidae
      - Photis macrocoxa

  - Cirripidea
      - Balanus amphitrite

  - Cumacea
      - Diastylis polita
      - Leptocuma minor

  - Decapoda
      - Cancer irroratus
      - Crangon septimspinosus
      - Eualis pusiolus
      - Libinia dubia
      - Pagurus acadianus
      - Pagarus longicarpus
      - Pagarus pollicaris
      - Pagarus spp.
      - Ovalipes ocellatus
      - Unidentified crab larvae spp.

Table 5 (continued)

- Isopoda
  - Chiridotea caeca
  - Cirolana polita
  - Edotea montosa

- Mysidacea
  - Neomysis americana

- Stomatopoda
  - Unidentified hoplocarid spp.

ECHINODERMATA

- Asteroidea
  - Asterias forbesii

- Echinoidea
  - Echinarachnius parma

- Holothuroidea
  - Unidentified holothurian spp

CHORDATA

- Ascidacea
  - Cnemidocarpa mollis
  - Unidentified tunicate spp.

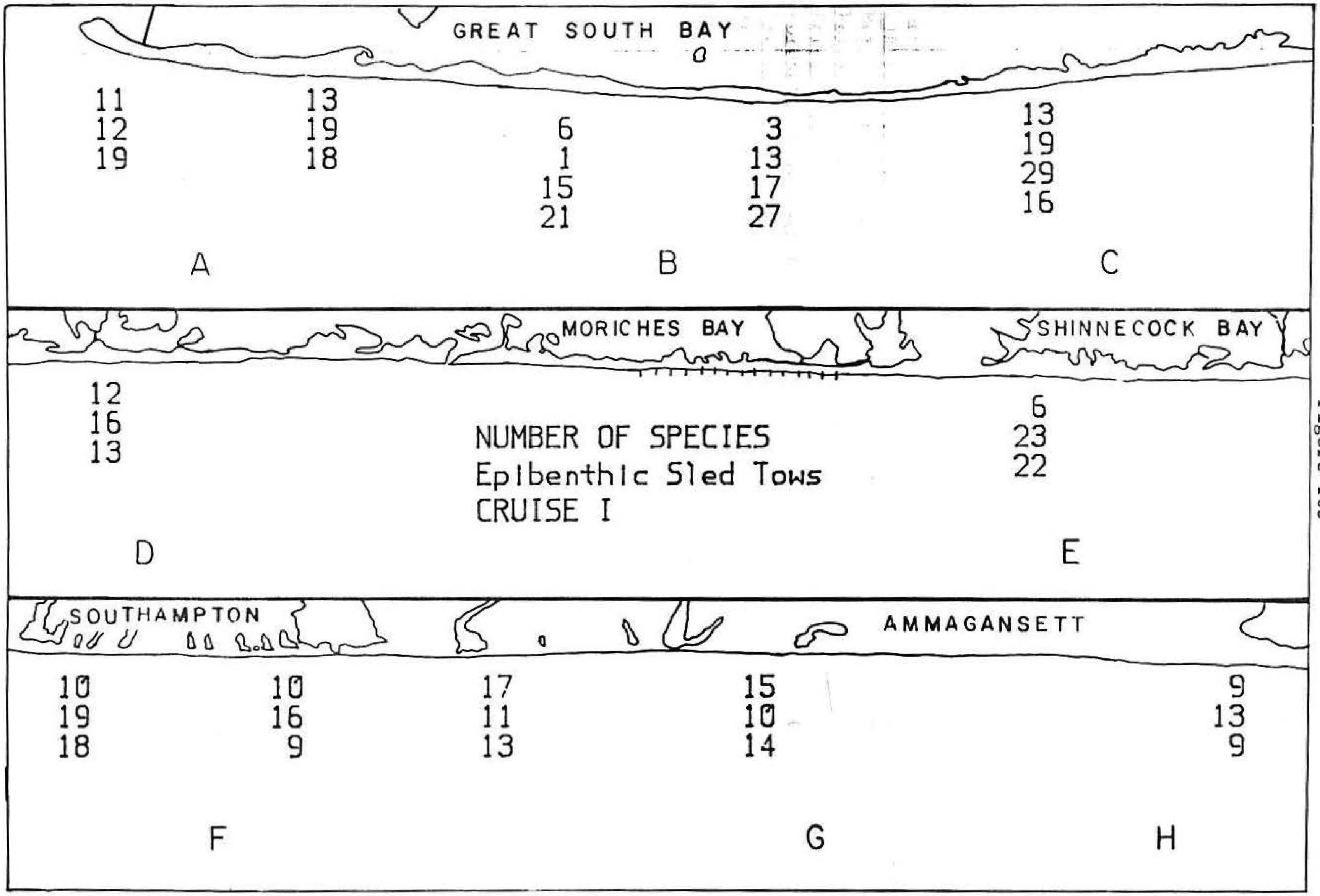
- Vertebrata
  - Ammodytes americanus
  - Enchelyopus cimbrius
  - Etropus microstomus
  - Gadus morhua
  - Hippocampus hudsonius
  - Limnada ferruginea
  - Lophopestta maculata
  - Merluccius bilinearis
  - Moxocephalus aenus
  - Paralichtys dentatus
  - Paralichtys oblongus
  - Poronotus tricanthus
  - Priontus evolans
  - Pseudopleuronectes americanus
  - Raja erinacea
  - Raja ocellata
  - Raja radiata
  - Scophthalmus aquosus
  - Sphaeroides maculatus
  - Stenotomus chrysops
  - Syngnathus fuscus
  - Tautogolabrus adspersus
  - Urophycis chuss
  - Unidentified fish larvae
  - Unidentified fish eggs

Table 6. List of Species Found in Sled Tows But Not Found in Smith-McIntyre Grabs

- Anthozoa
  - sp. B
  - sp. C
  - sp. D
- Hydrozoa
  - Abietinaria filicula
  - Hydrallmania falcata
  - Hydractinia echinata
  - Obelia commisuralis
  - Obelia flabellata
  - Obelia spp.
  - Pennaria tiarella
  - Podocoryne carnea
  - Tubularia spp.
- Ectoprocta
  - Alcyonidium spp.
  - Bulgula turrita
  - Bulgula spp.
  - Callopora craticula
  - Callopora spp.
  - Electra pilosa
  - Eucratea loricata
  - Hippoporina sp.1
  - Hippoporina sp.2
  - Membranipora tenuis
  - Microporella ciliata
- Polychaeta
  - Neanthes succinea
  - Scoloplos acutus
  - Glycera robusta
- Cephalopoda
  - Iliex illacebrosus
- Bivalva
  - Pitar morrhuana
- Crustacea
  - Eualis pusioulus
  - Pagurus pollicaris
  - Balanus amphitrite
  - Libinia dubia
- Xiphosura
  - Limulus polyphemus
- Chordata
  - Cnemidocarpa mollis
  - Enchelyopus cimbrius
  - Etropus microstomus
  - Gadus morhua
  - Hippocampus hudsonius
  - Limnada ferruginea
  - Lophopestta maculata
  - Merluccius bilinearis
  - Moxocephalus aenus
  - Paralichtys oblongus
  - Poronotus tricanthus
  - Priontus evolans
  - Pseudopleuronectes americanus
  - Raja ocellata
  - Raja radiata
  - Scophthalmus aquosus
  - Sphaeroides maculatus
  - Stenotomus chrysops
  - Syngnathus fuscus
  - Urophycis chuss

Table 7. Percent Occurrence in Sled Tows of Commercial and/or Recreational Species

	CRUISE I	CRUISE II	CRUISE III
Bivalvia			
Artica islandica	0	13	10
Mytilus edulis	21	23	3
Spisula solidissima	59	54	72
Crustacea			
Cancer irroratus	85	77	80
Vertebrata			
Gadus morhua	5	0	0
Limnada ferruginea	5	8	3
Murluccius bilinearis	3	0	3
Paralichtys dentatus	5	5	5
Paralichtys oblongus	3	62	8
Porbnotus triacanthus	0	3	0
Pseudopleuronectes americanus	3	3	0
Raja erinacea	39	5	10
Raja radiata	8	0	0
Stenotomus chrysops	0	0	3
Tautogloabrus adspensus	0	15	3
Urophysis chuss	33	15	26



NUMBER OF SPECIES
Epibenthic Sled Tows
CRUISE I

Figure 183

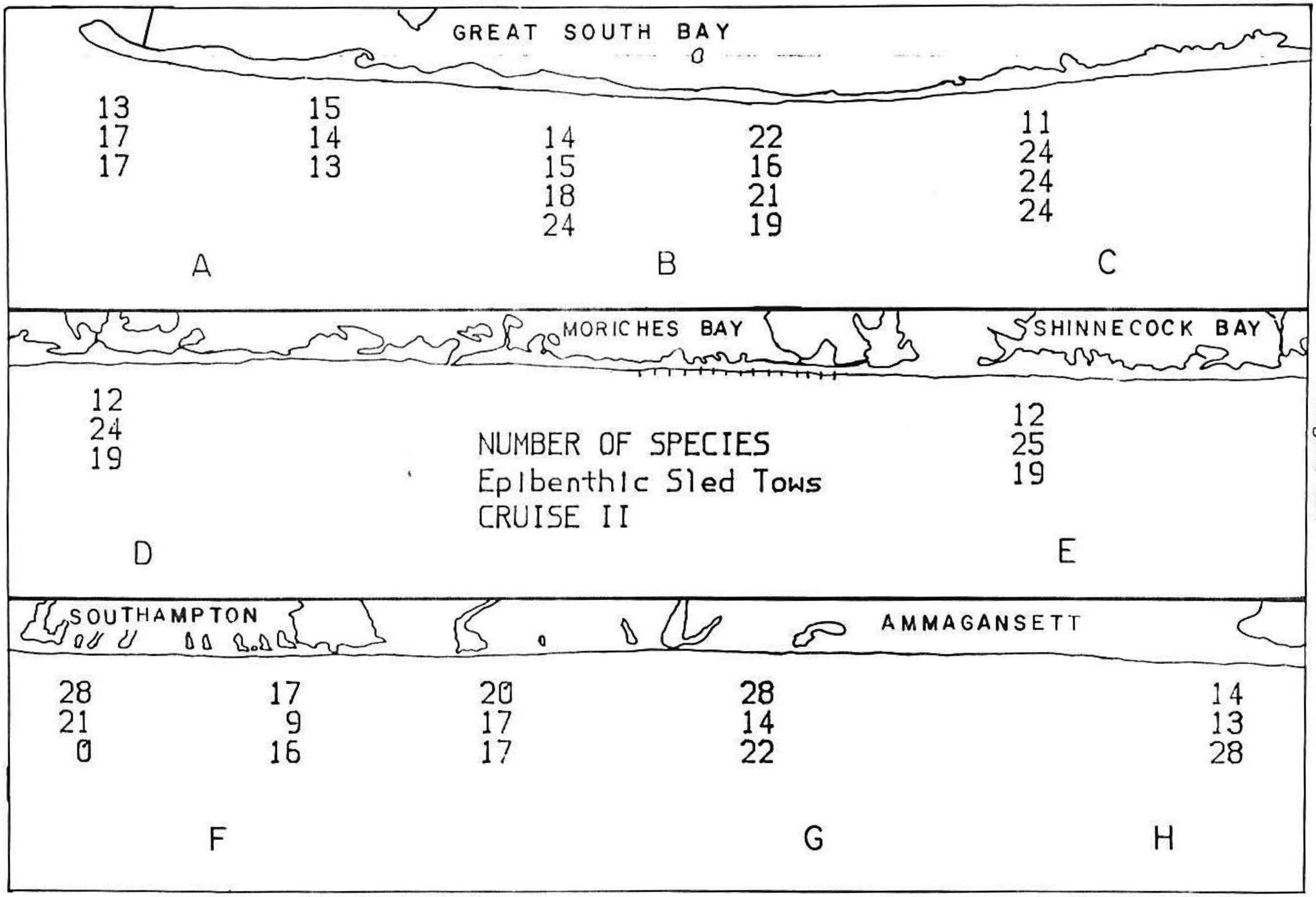

GREAT SOUTH BAY
13
17
17
15
14
13
14
15
18
24
22
16
21
19
11
24
24
24
A
B
C
MORICHES BAY
SHINNECOCK BAY
12
24
19
NUMBER OF SPECIES
Epibenthic Sled Tows
CRUISE II
12
25
19
D
E
SOUTHAMPTON
AMMAGANSETT
28
21
0
17
9
16
20
17
17
28
14
22
14
13
28
F
G
H

Figure 184

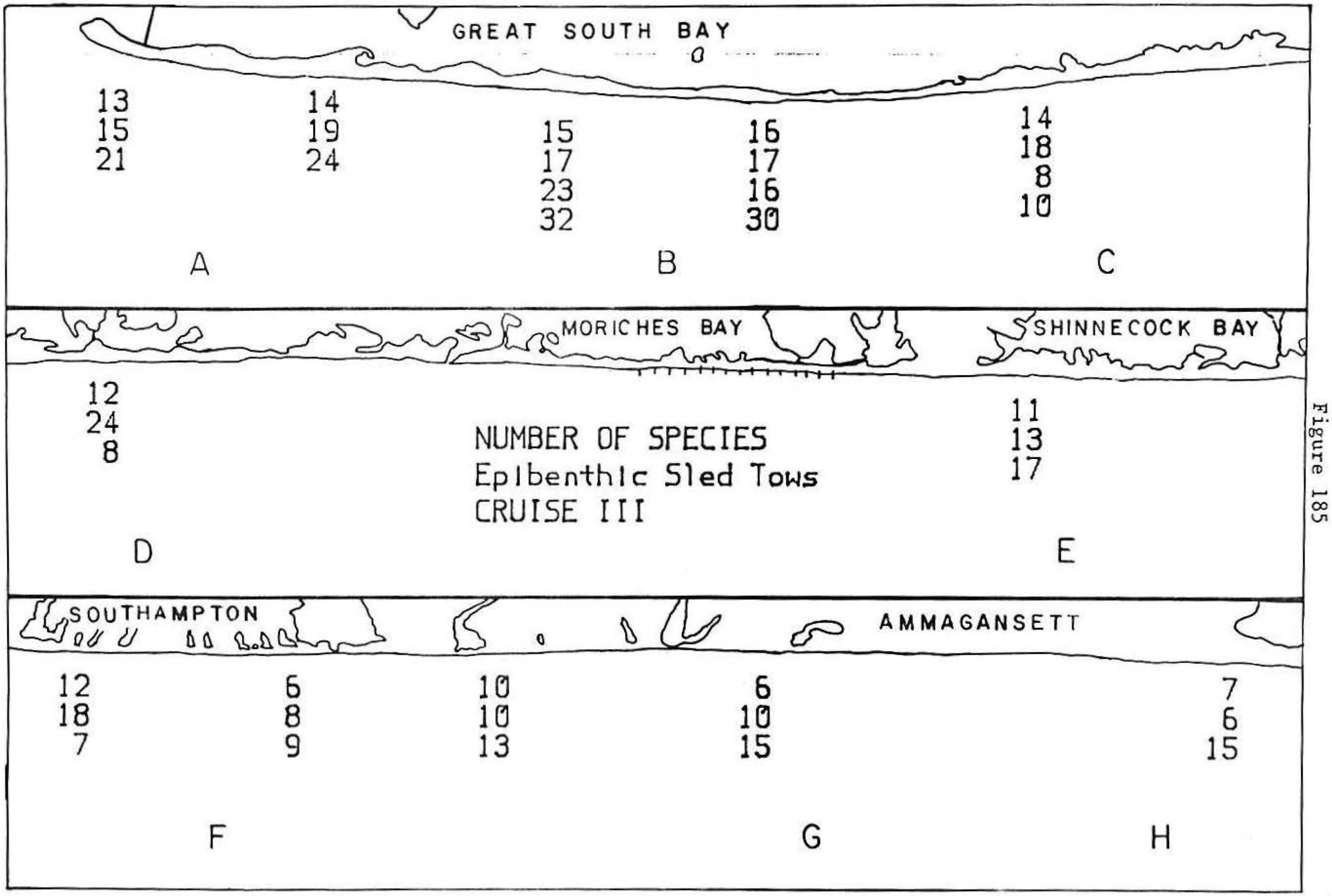

GREAT SOUTH BAY
13
15
21
14
19
24
15
17
23
32
16
17
16
30
14
18
8
10
A
B
C
MORICHES BAY
SHINNECOCK BAY
12
24
8
NUMBER OF SPECIES
Epibenthic Sled Tows
CRUISE III
11
13
17
D
E
SOUTHAMPTON
AMMAGANSETT
12
18
7
6
8
9
10
10
13
6
10
15
7
6
15
F
G
H

Figure 185

Figure 186

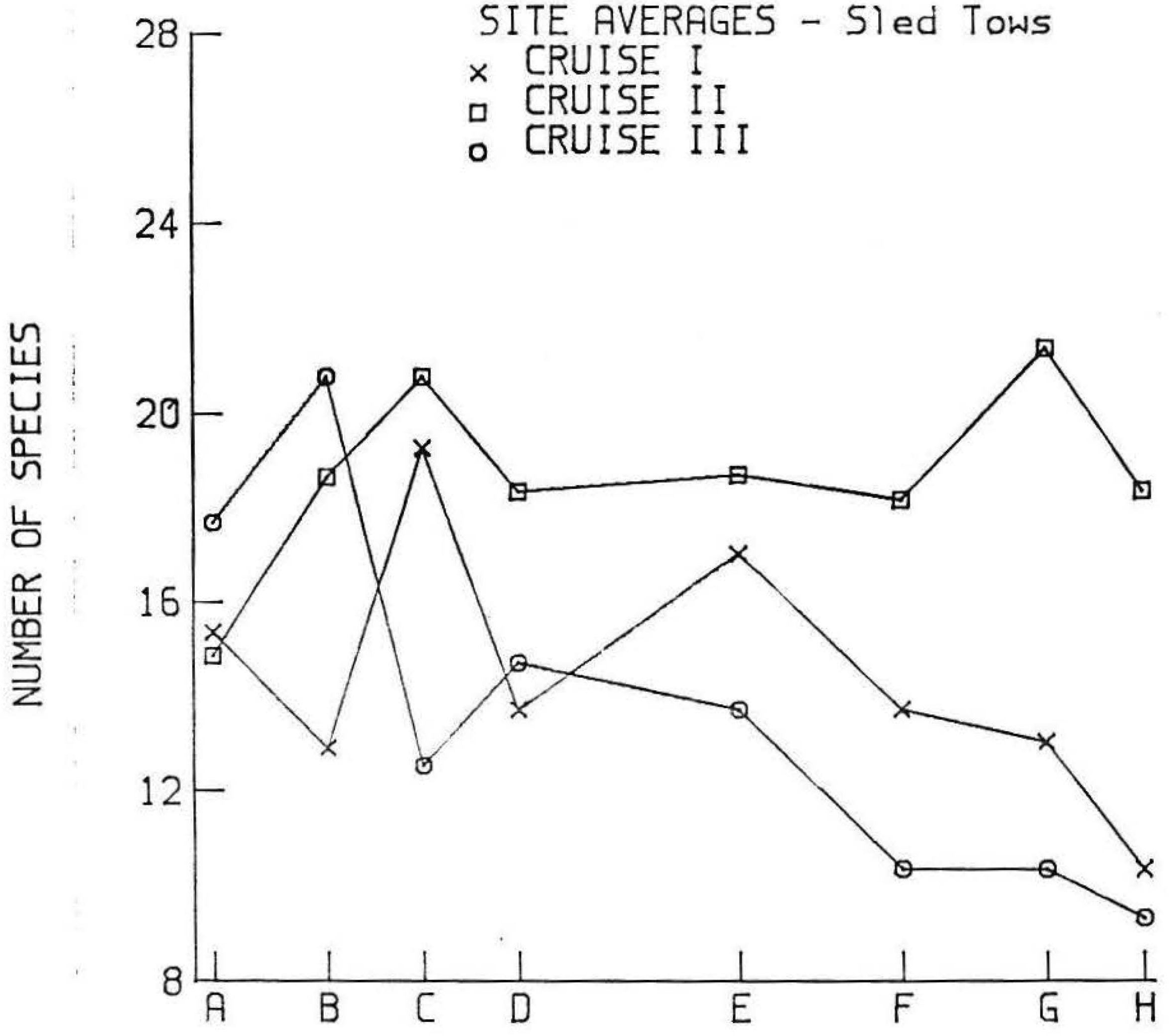

SITE AVERAGES - Sled Tows
× CRUISE I
□ CRUISE II
o CRUISE III
28
24
20
16
12
8
NUMBER OF SPECIES
A
B
C
D
E
F
G
H

Figure 187

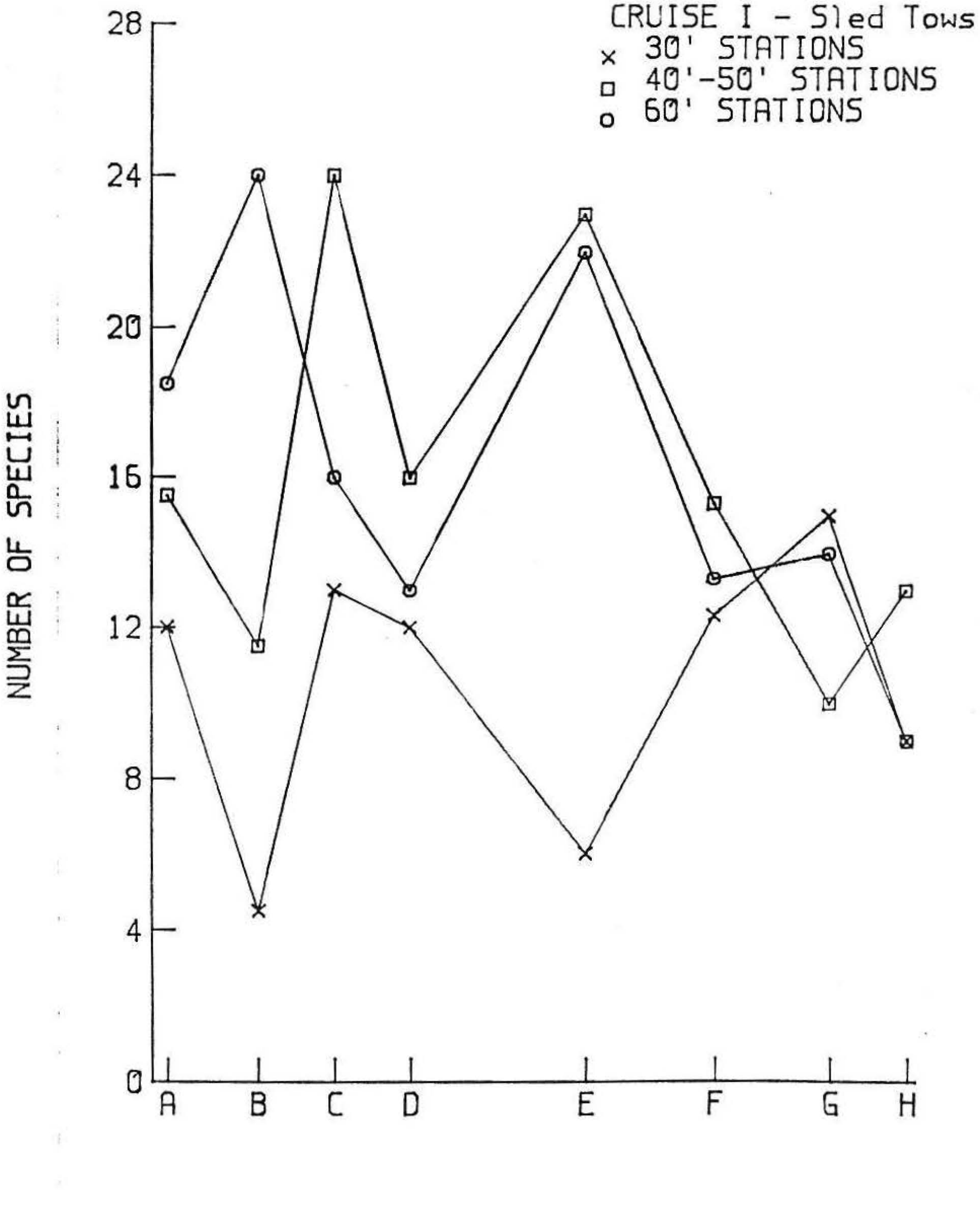

CRUISE I - Sled Tows
× 30' STATIONS
□ 40'-50' STATIONS
o 60' STATIONS
NUMBER OF SPECIES
28
24
20
16
12
8
4
0
A
B
C
D
E
F
G
H

Figure 188

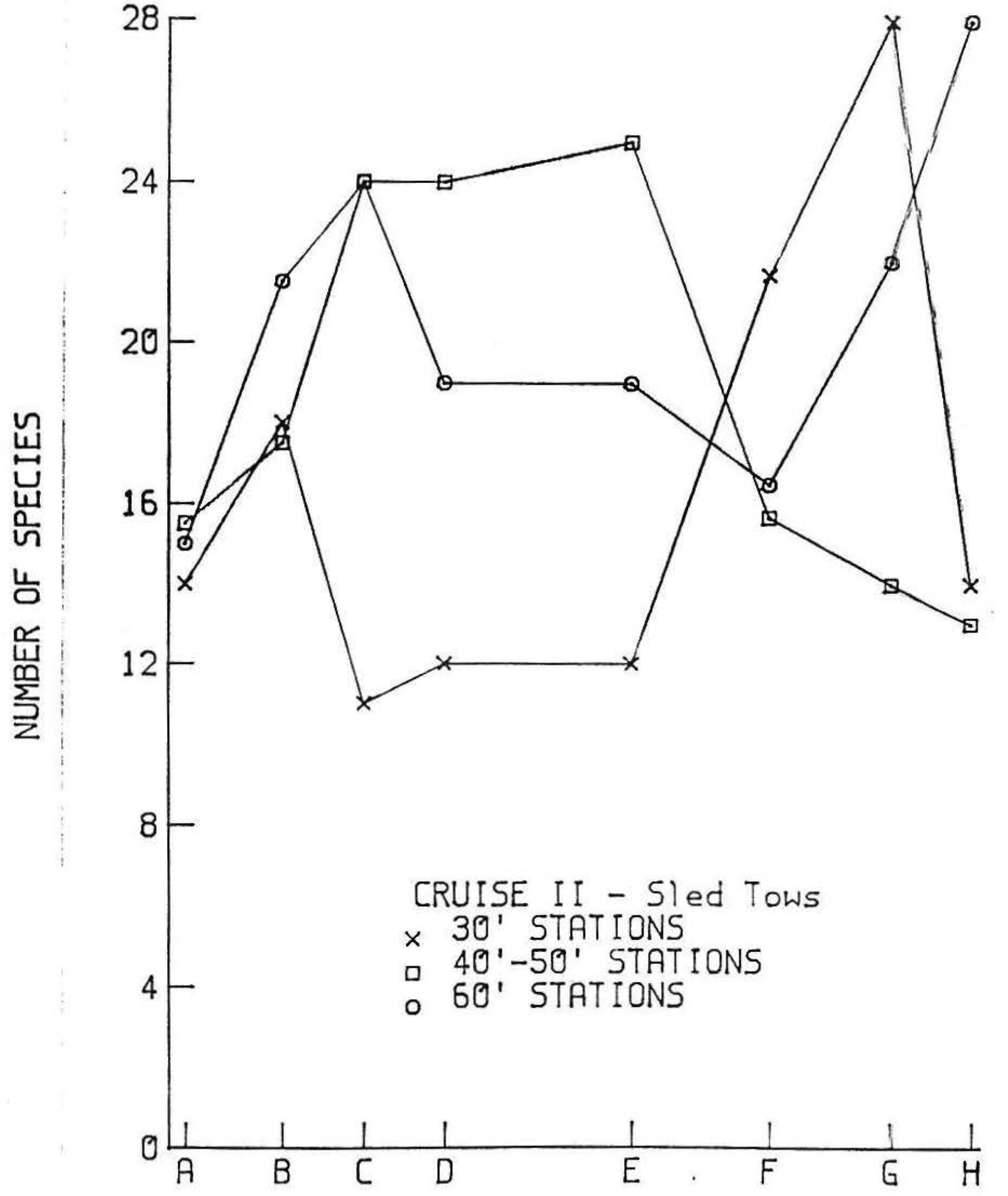

NUMBER OF SPECIES
28
24
20
16
12
8
4
0
A
B
C
D
E
F
G
H
CRUISE II - Sled Tows
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS

Figure 189

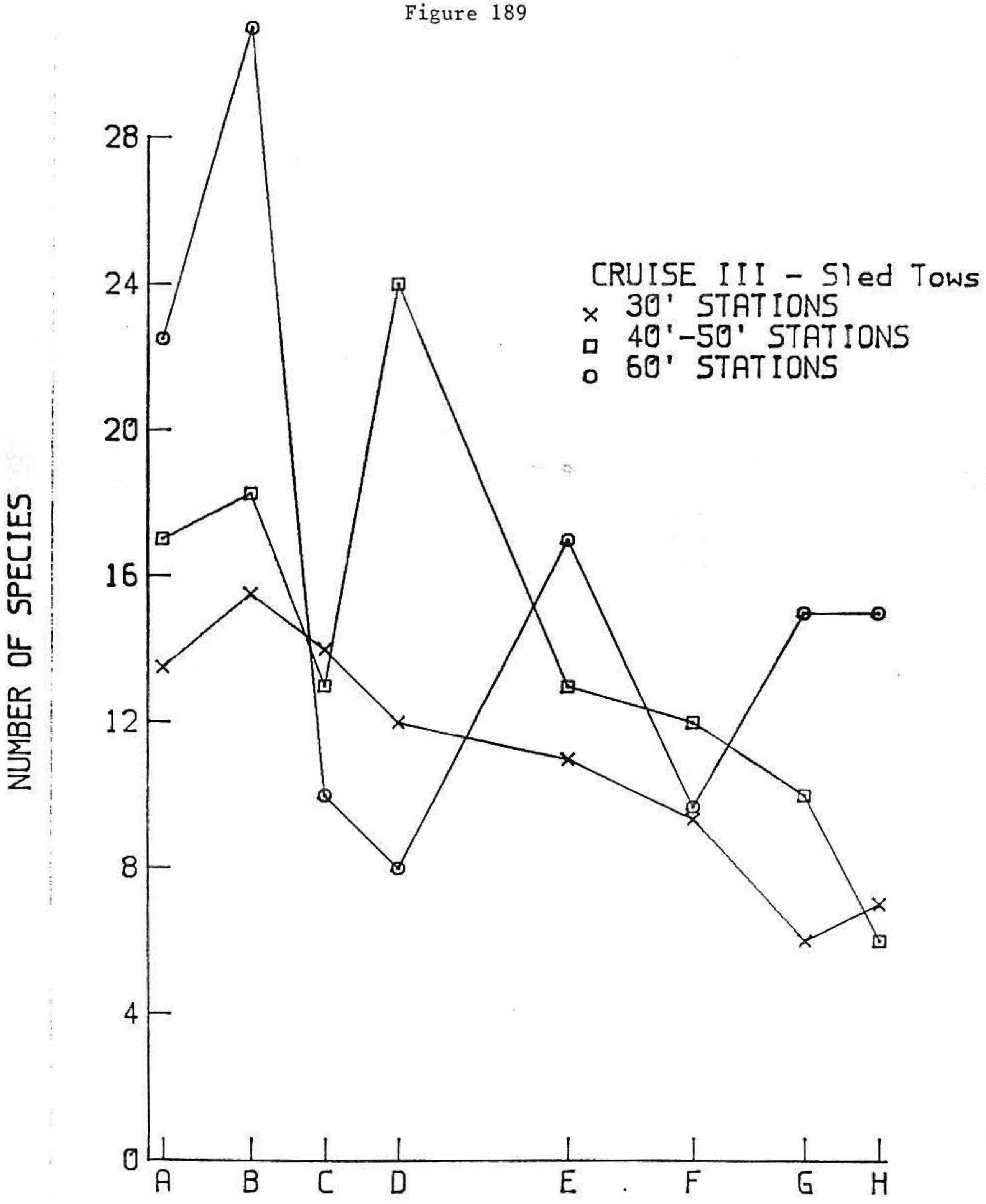

CRUISE III - Sled Tows
× 30' STATIONS
□ 40'-50' STATIONS
○ 60' STATIONS
NUMBER OF SPECIES
28
24
20
16
12
8
4
0
A
B
C
D
E
F
G
H

Figure 190

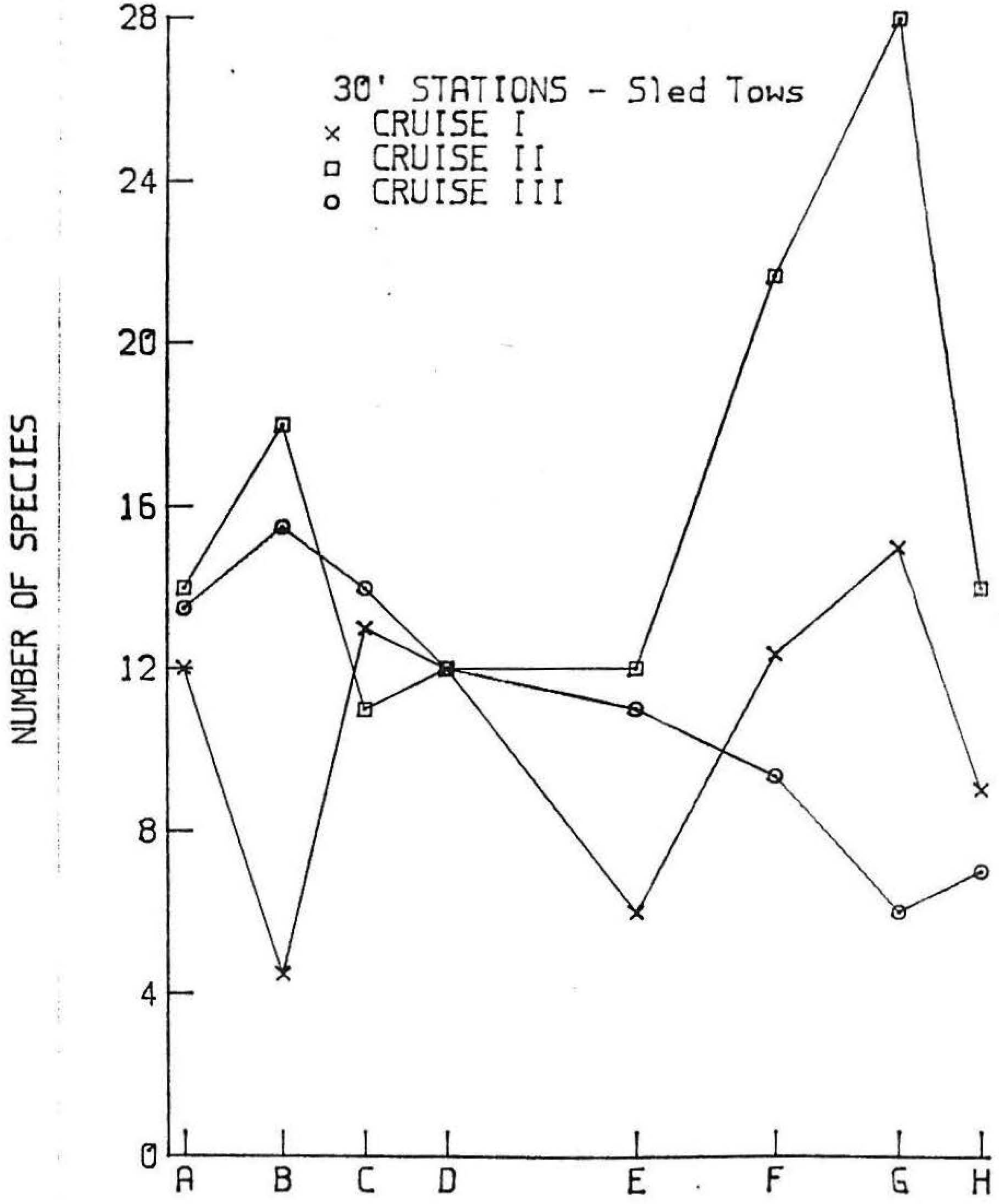

30' STATIONS - Sled Tows
× CRUISE I
□ CRUISE II
○ CRUISE III
NUMBER OF SPECIES
0
4
8
12
16
20
24
28
A
B
C
D
E
F
G
H

Figure 191

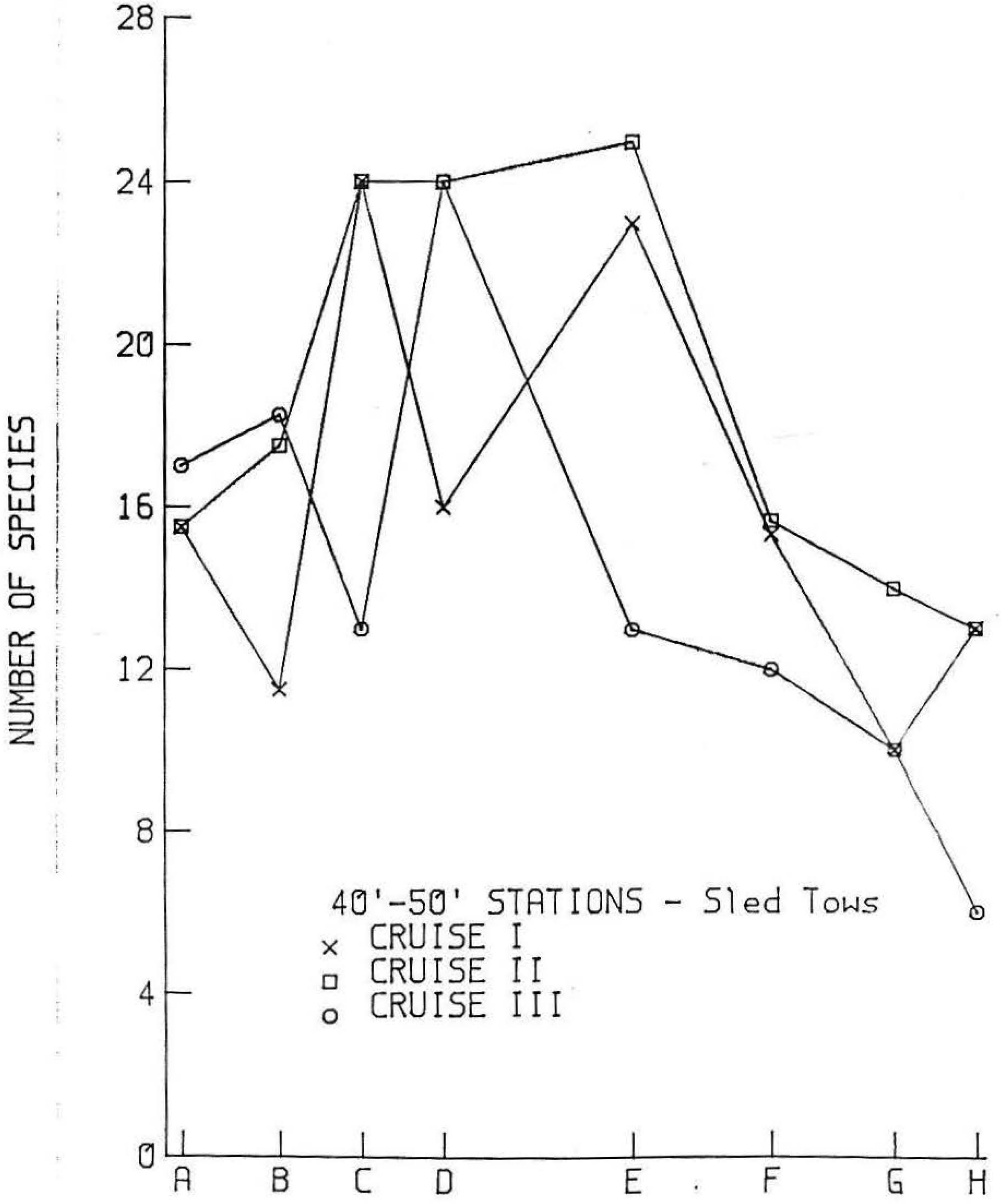
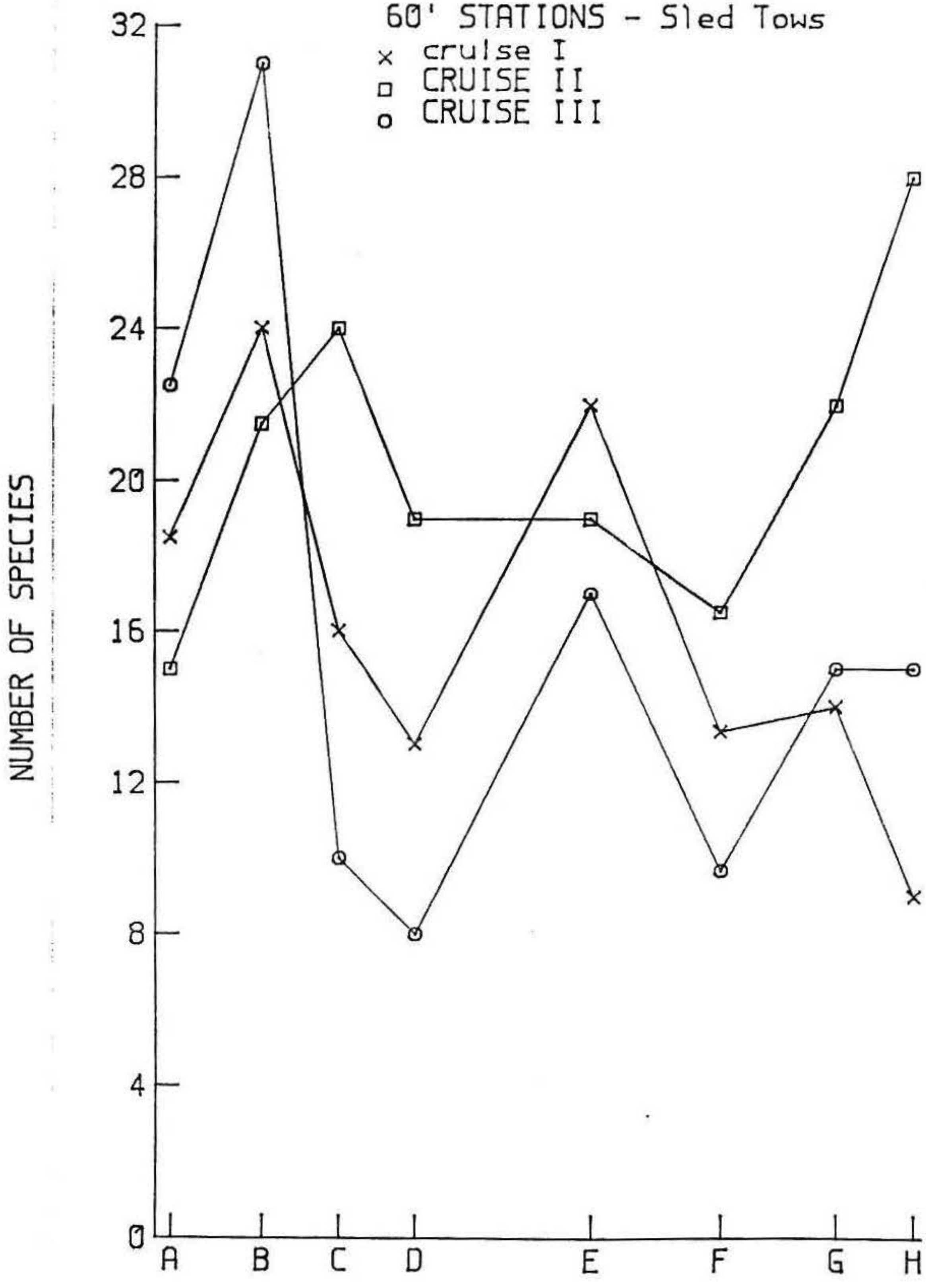

NUMBER OF SPECIES
28
24
20
16
12
8
4
0
A
B
C
D
E
F
G
H
40'-50' STATIONS - Sled Tows
× CRUISE I
□ CRUISE II
o CRUISE III

Figure 192


60' STATIONS - Sled Tows
× cruise I
□ CRUISE II
o CRUISE III
NUMBER OF SPECIES
32
28
24
20
16
12
8
4
0
A
B
C
D
E
F
G
H

IV. DISCUSSION

a. General Sediment Characteristics

The results of the sediment analysis suggest a number of general trends along the South Shore of Long Island. Surface sediments at the eight potential borrow sites were mainly fine to medium grained sands (3 to 1 phi). In fact, sand content exceeded 95% in most of the samples collected. With the exception of Sites C and D, median and mean grain size increased from west to east when these sediment parameters were averaged by site. This west to east gradient in median and mean grain size, however, changed with depth. The gradient was best defined for the 30′ stations, less evident for the middepth stations, and not discernable at 60′. The finest grained sediments within borrow areas were found nearshore at Sites A-F and offshore for sites G-H. Organic content in the surface sediments rarely exceeded 1%, and this parameter decreased slightly from west to east in the study area.

Several of the observed trends have been noted in previous studies. Both Taney (1961) and Williams (1976) noted that the sediments along the South Shore consist primarily of fine to medium grain sands. Taney (1961) reported that median grain size increased from west to east. A similar trend was found by Williams (1976) for mean grain size. Taney (1961) stated that this west to east pattern was not monotonic but fluctuated, especially near inlets. Because sampling was restricted to eight sites in the current study, insufficient data were available to confirm this observation.

Using station transects normal to the shoreline and excluding data from the vicinity of Montauk Point, Taney (1961) found a peak in median grain size in the zone from mean tide to just below mean low water. Beyond this zone, median grain size decreased to a depth of 30′. Between 30′ and 50′, surface sediments became coarser and Taney (1961) felt that this offshore material was similar to that found in the mean tide zone. This led Taney (1961) to postulate the existance of a nearshore-offshore transport mechanism. The current study, although restricted to depths between 30′ and 60′, tends to substantiate his observations.

b. General Faunal Characteristics

The results of the benthos study suggest a number of faunal trends along the South Shore of Long Island. Abundance and number of species generally decreased from west to east, while Shannon-Wiener diversity, equitability, and rarefaction diversity (i.e., the expected number of species for 100 individuals) generally increased toward Montauk Point when stations were averaged by site. Number of species, Shannon-Wiener diversity, and rarefaction diversity consistently increased with depth at many potential borrow sites. This pattern was most clearly defined during the summer cruise. Distinct seasonal changes in abundance were found at Sites A and B. In general, however, most biotic parameters did not vary substantially between cruises when data from borrow areas were represented as site averages.

c. Commercial and/or Recreational Species

Study results indicate a total of 16 species of commercial and/or recreational value. Table 8 lists landing and use data for each species. Of the 16 species, 10 were rare and found in less than 20% of the biological samples during all three cruises. The remaining 6 species (Mytilus edulis, Spisula solidissima, Paralicthys oblongus, Raja erinacea, Urophysis chuss, and Cancer irroratus) were common during at least one of the three seasonal cruises.

Half of the common species are felt to be of little significance for a variety of reasons. The blue mussel, Mytilus edulis, was common in the spring and summer only as very small juveniles attached to floating pieces of detritus. Both the four-spotted flounder, Paralictys oblongus, and the little skate, Raja erinacea, were common during the summer, but they have minor commercial or recreational value (Bigelow and Schroeder, 1953; Thomson, et al., 1978).

Two of the remaining common species are of moderate value. The squirrel hake, Urophycis chuss, is used primarily in the manufacture of fishmeal and animal food (McHugh and Ginter, 1978). In the present study, this species was found in >20% of the sled tows during the spring and summer cruises. The rock crab, Cancer irroratus, was found in greater than 20% of the sled tows during all three cruises. This species is taken as a bycatch by pot fisherman in the study area (Briggs and Mushacke, 1980).

The most important commercial species found in the study area was the surf clam, Spisula solidissima. Smith-McIntyre grab data suggest a general pattern of decreasing abundance from west to east for this species. In addition, highest abundances were found at the nearshore (30′) stations. Both abundance patterns have previously been observed by Franz (1976).

All individuals of Spisula collected in the Smith-McIntyre grabs were small (<7mm). This sampling device does not penetrate the sediments deeply enough to collect larger individuals. The small surf clams collected in the Smith-McIntyre grabs were less than 1 year old, based on growth data in Franz (1977). Larger surf clams and surf clam siphons were often collected in the epibenthic sled tows, but abundance estimates cannot be made using this sampling device.

Of the commercial-size clams, Franz (1976) indicates that about 90% of the standing stock east of Fire Island Inlet was made up of individuals greater than 9 years old. Franz (1976) further reflects that this indicates poor recruitment of young animals into the commercial-size subpopulation. This information suggests that dredging at a potential borrow site would probably remove that area from the commercial surf clam fishery for a considerable period of time.

In terms of importance, Franz (1976) indicates that the surf clam resource supports a small commercial fishery along the South Shore of Long Island. Landings in New York waters during 1976 are given in Table 8. Surf clams in the study area may be of value, however, for another reason. Surf clams have planktonic larvae which spend a fair amount of time in the water column and can disperse over great distances (Ropes, 1978). Because of this and considering the dominant southward-flowing currents along the Mid-Atlantic region, Franz (1976) suggests that the Long Island surf clam populations may supply larvae to the major commercial fishery areas off southern New Jersey, Maryland, and Virginia.

Finally, it is important to note that lobsters (Homarus americanus) were not collected in the present study. This result is probably a function of the sampling gear used and does not reflect information on the actual distribution and abundance of this species. The South Shore does support a lobster fishery. Briggs and Mushacke (1980) studied the inshore pot fishery between Fire Island Inlet and Montauk Point. In their study, 1962 trap hauls were made yielding a total of 2617 lobsters.

d. Animal-Sediment Associations

Animal-sediment associations were not examined in detail in the current study. A simple graphical analysis did, however, show a number of interesting patterns. For example, abundance was found to increase with decreasing grain size. Conversely, number of species, diversity, and equitability all tended to decrease in finer grained sediments. No explanation of these patterns will be provided here because the analysis was carried out in a cursory fashion. Further examination of the data set is warranted.

e. Recovery Following Dredging

Colonization of shallow water marine sediments after a physical disturbance such as that created by dredging or dredge spoil disposal has been shown to follow a distinct pattern (e.g., Saila, et al., 1972; Scheibel, 1974; Kaplan, et al., 1975; Boesch, Diaz, and Virnstein, 1976; Boesch, Wass, and Virnstein, 1976; Oliver, et al., 1977; Wolff, et al., 1977; Rhoads, et al., 1978; Rhoads and Boyer, 1982). This pattern, generally termed ecological succession, involves both changes in species structure and community processes with time (Rhoads and Boyer, 1982). Species with strong colonization and reproductive abilities are the first to invade a newly disturbed habitat. These pioneering species are usually small, tubiculous, opportunistic polychaetes and amphipods (McCall, 1978; Rhoads, et al., 1978; Rhoads and Boyer, 1982). As time passes, other, highly competitive species enter, and if the area remains undisturbed, a complex, equilibrium stage eventually develops.

Dredging and dredge spoil disposal operations are not the only sources of physical disturbances in shallow water. The seafloor may also be disturbed naturally by, for example, storm waves, strong longshore and rip currents, and tidal scour. The probability of natural environmental perturbations is high nearshore (Johnson, 1970, 1971, and 1972; Oliver, et al., 1977; Rhoads, et al., 1978; Rhoads and Boyer, 1982). Communities in shallow areas are, therefore, maintained at lower order, pioneering stages and should recover from a dredging operation faster than those in deeper areas. As a specific example, Rhoads, et al. (1978) estimated recovery at two sites in Long Island Sound. One site, located in 14 m of water and in an area frequently disturbed by storms, recovered from an experimental disturbance in less than one year. The second site, a dump site in 20 m of water and rarely perturbed by storm turbulence, was estimated to require several years for recovery.

Estimates of the time to recovery after dredging or dredge spoil disposal in shallow water areas range from less than one year to greater than ten years (e.g., Drobek, 1970; Harper, 1973; Rogers and Darnell, 1973; Saila, 1976; Oliver, et al., 1977; Rhoads, et al., 1978; Saloman, et al., 1982; Culter and Mahadevan, 1982; Turbeville and Marsh, 1982). In the current study, the potential borrow sites all lie within a shallow, fairly high energy environment. Colonization after dredging should be rapid, and the time to recovery should be at the lower end of the above range. This estimate is made, however, with two important qualifications.

The first qualification is that not all species in the study area are pioneers able to quickly colonize after dredging. Vermeij (1978) has noted that some species do not fit the pioneer-to-equilibrium classification scheme. He includes an additional end-member adaptive type called a stress tolerant species. Stress tolerant species inhabit physiologically stressed areas such as the intertidal zone. These species are long lived and may be slow to recover from severe disturbances. The most important commercial species in the study area, Spisula solidissima, may belong to this group. As noted earlier, a considerable period of time would be required for this species to recover to pre-dredging levels.

The second qualification is that this recovery estimate assumes no long term changes in habitat as a result of dredging. If dredged substantially below the seafloor, pits created by a dredging operation may persist in time. The environment at the bottom of a borrow pit may differ from ambient conditions in several ways. Firstly, reduced flushing in dredge holes has been found to result in temperature and dissolved oxygen stratification (Taylor and Saloman, 1968; Murawski, 1969; Swartz and Brinkhuis, 1978). Secondly, the substrate within a pit may not be similar to pre-mining conditions. A dredging operation may uncover material differing in character than existing surficial sediments. Dredge holes are also effective traps for fine grained sediments (Taylor and Saloman, 1968; Sykes and Hall, 1970; Rodgers and Darnell, 1973; Saloman, et al., 1982; Bokuniewicz,, 1983) and the pit bottom may change from sand to mud over time. Finally, borrow pits may accumulate substantial quantities of organic matter (Taylor and Saloman, 1968; Murawski, 1969; Saloman, et al., 1982). It is not known whether any of these conditions would occur in pits along the South Shore of Long Island, but habitat alterations would affect both the rate of recovery and the eventual community composition.

Table 8. New York landings during 1976 and use data for commercial and/or recreational species collected in the current study.

Scientific Name	Commercial Landings in 1976 (thousand pounds)	(thousand dollars)	Use
Artica islandica	-	-	Food
Mytilus edulis	85	37	Food
Spisula solidissima	3455	1089	Food
Cancer irroratus	-	-	Food
Gadus morhua	686	200	Food
Limnada ferruginea	595	168	Food
Merluccius bilinearis	-	-	Primarily Industrial
Paralichtys dentatus	3203	1500	Food
Paralichtys oblongus	-	-	Food
Poronotus triacanthus	960	274	Food
Pseudopleuronectes americanus	712	144	Food
Raja erinacea and R. radiata	49	8	Bait
Stenotomus sp. and Calamus sp.	2468	580	Food
Tautogolabrus adspersus	<500	<500	Food
Urophycis chuss	309	26	Primarily Industrial

Sources: Thomson, et al. (1978)
McHugh and Ginter (1978)
National Marine Fisheries Service (1980)

Note: 1976 is the latest published New York landings summary available.

V. SUMMARY

A seasonal survey was conducted of surficial sediments and benthic macrofauna at eight potential borrow sites along the South Shore of Long Island. Sixty-five stations were sampled from these sites during each of three seasonal cruises. Stations were located along nearshore-offshore, open ocean transects at depths ranging from 30 to 60 feet. Samples were collected from 20 April to 24 April 1981, from 27 July to 4 August 1981, and from 5 October to 23 October 1981.

A total of 580 sediment samples collected using a Smith-McIntyre grab were analyzed for grain size distribution and organic content. Substrata within the borrow sites consisted mainly of fine to medium grained sands (3 to 1 phi). Sand content exceeded 95% in most of the samples collected. Median and mean grain size generally increased from west to east along the South Shore. Finest grained sediments within borrow areas were found nearshore at all but the two easternmost sites. Organic content in the surficial sediments rarely exceeded 1%.

A total of 583 Smith-Mcintyre and 117 epibenthic sled tows were analyzed for macrobenthos. For the Smith-McIntyre grabs, 96158 individuals representing 201 taxa were collected during the three cruises. Station abundances ranged from a low of 157 individuals per square meter obtained during the summer to a high of 37813 individuals per square meter in the fall cruise. The fewest number of species (10) collected at a station occurred in the summer and the greatest number (47) was found in the fall. West to east trends in the site data were apparent with abundance and number of species decreasing while Shannon-Wiener diversity, equitability, and rarefaction diversity increased toward Montauk Point. At many potential borrow sites, number of species, Shannon-Wiener diversity, and rarefaction diversity increased with depth. The most important commercial and/or recreational species found in the study area was the surf clam Spisula solidissima. Highest abundances for this species were observed in shallow water (30′), and surf clam abundance generally decreased toward Montauk Point.

In the epibenthic sled tows, 141319 individuals from 151 taxa were collected during the three cruises. The number of species in each sled tow ranged from a low of 1 in the spring to a high of 32 during the fall cruise. Number of species per tow decreased from west to east during the spring and fall but was relatively uniform in the summer. Within a borrow site, number of species per tow was often greatest at either mid-depth (40′-50′) or offshore (60′).

Literature estimates of recovery after dredging or dredge spoil disposal range from less than one year to greater than ten years. Since all potential borrow sites lie within a shallow, fairly high energy environment, colonization after dredging should be rapid, and recovery should be, in general, at the low end of the above time scale. Two important qualifications must be considered with this estimate. Firstly, some long lived species, such as the surf clam, will require many years to reestablish adult populations at predredging levels. Secondly, long term changes in the habitat as a result of dredging are possible and would affect both the rate of recovery and the eventual community composition.

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APPENDIX A

Derivations and Descriptions of Sediment Analysis Techniques

1. Derivation of the Volumetric Method for Silt-Clay Weight Determination

In the methods section, a procedure was described for determining the weight of the silt-clay fraction of the sediment sample. The basis for this technique will be given here. The equation which will be derived relates the weight of the silt-clay fraction to the values obtained by two successive weighings. For the first weighing, the sediment sample was put into the flask and distilled water was added to bring the volume up to the capacity line. For this step, we have

$$(1) \qquad V_{s-g} + V_{s-c} + V_w = V_{flask}$$

$$(2) \qquad W_{s-g} + W_{s-c} + W_w + W_{flask} = x_1$$

where

V_{s-g} = volume of the sand-gravel fraction
V_{s-c} = volume of the silt-clay fraction
V_w = volume of distilled water added to flask
V_{flask} = flask volume (100 ml)

W_{s-g} = weight of the sand-gravel fraction
W_{s-c} = weight of the silt-clay fraction
W_w = weight of the distilled water added to flask
W_{flask} = flask weight
x_1 = result of the first weighing.

Note that x_1 represents the combined weight of the sediment sample, the added water, and the flask.

The contents of the volumetric flask was next washed into a 0.0625 mm screen and thoroughly wet sieved to remove the silt-clay fraction. The sand-gravel fraction was carefully transferred back into the flask, and distilled water was added to bring the volume up to the capacity line. For the second step, we have

$$(3) \qquad V_{s-g} + \Delta V_w + V_w = V_{flask}$$

$$(4) \qquad W_{s-g} + \Delta W_w + W_w + W_{flask} = x_2$$

where

ΔV_w = volume increment of water added because the silt-clay fraction was removed

ΔW_w = weight increment of water added because the silt-clay fraction was removed
x_2 = result of the second weighing

Note that x_2 represents the combined weight of the sand-gravel fraction, the water, and the flask.

Combining equations (1) and (3) to eliminate V_{flask}, we obtain

$$V_{s-g} + V_{s-c} + V_w = V_{s-g} + \Delta V_w + V_w$$

or

$$(5) \qquad V_{s-c} = \Delta V_w .$$

By definition, $V_{s-c} = W_{s-c}/g\,\rho_{s-c}$ and $\Delta V_w = \Delta W_w/g\,\rho_w$, where ρ_{s-c}=2.65 g/cc and ρ_w = 1.0 g/cc, and g = acceleration due to gravity. Substituting these relations into equation (5), we obtain

$$W_{s-c}/g\,\rho_{s-c} = \Delta W_w/g\,\rho_w$$

or

$$(6) \qquad \Delta W_w = W_{s-c}\,\rho_w/\,\rho_{s-c} .$$

Equations (2) and (4) can also be combined to eliminate W_{s-c}, W_w, and W_{flask}. This combination yields

$$(7) \qquad x_1 - W_{s-c} = x_2 - \Delta W_w .$$

Substituting equation (6) into (7) and rearranging terms gives

$$(8) \qquad W_{s-c} = \frac{(x_1 - x_2)}{(1 - \rho_w/\,\rho_{s-c})} .$$

2. Accuracy of the Volumetric Method for Determining the Weight of the Silt-Clay Fraction

The accuracy of the volumetric method was determined empirically prior to its use in the study. A large volume of sediments were wet sieved through a 0.0625 mm screen to partition the material into silt-clay and sand-gravel fractions. These two fractions were placed into beakers and dried at 60° C. After drying, the silt-clay fraction was disaggregated with a mortar and pestle, and dry sieved through a 0.0625 mm screen. Varying amounts of each fraction were then weighed and mixed together. Thus sediment test material of precisely known dry weight was prepared. These test samples were processed using the volumetric method and yielded the following:

Test Sample (dry weight in grams)					
Sand-Gravel	Silt-Clay	Total	Calculated (Ws-c)	d=(obser. -cal.)	$\left(\frac{\lvert d\rvert}{Total}\right)100$
48.15	0.90	49.05	0.88	0.02	0.04%
53.52	0.50	54.02	0.63	-0.13	0.24%
48.75	1.55	50.30	1.56	-0.01	0.24%
47.63	2.26	49.89	2.23	0.03	0.06%
43.58	3.00	46.58	2.81	0.19	0.41%
33.07	8.41	41.48	8.38	0.03	0.07%
21.03	13.61	34.64	13.23	0.38	1.10%
39.39	2.26	41.65	2.31	-0.05	0.12%
50.49	1.10	51.59	1.06	0.04	0.08%
39.64	0.36	40.00	0.66	-0.30	0.75%
49.26	0.00	49.26	0.00	0.00	0.00%
57.72	0.00	57.72	0.03	-0.03	0.05%
					Ave = 0.25%

Based on this test, percent silt-clay can be determined to within 0.25% on the average.

3. Sand Grain Size Analysis - Description of the Settling Column

The grain size distribution of the sand fraction of the sediment samples was determined on a settling column. Particles fall through a medium such as water with velocities that depend on their size, density, and shape. Knowing the settling velocity of a particle, it is possible to compute the particle´s sedimentation diameter. Sedimentation diameter is defined as "...the diameter of a sphere having the same density as the given particle and having a settling velocity identical to that of the particle in a given media" (Gibbs, et al., 1971). Gibbs, et al. (1971) present an empirical equation which relates sedimentation diameter to settling velocity.

The settling column used for this study was a 3 m tall, PVC tube with an inside diameter of 15.24 cm. The tube was filled with distilled water, and a sample collection pan, 13.97 cm in diameter, was suspended inside the column using four lenghths of dacron coated fly line. The diameter of the pan was 1.27 cm less than the inside diameter of the settling column so that any particles interacting with the walls of the tube would be excluded from collection. The dacron coated lines were attached to a balsa wood yoke which was, in turn, suspended from a strain guage (Gould Statham Universal Transducing Cell, Model UC2, and Microscale Accessory, Model UL5). Weights were added to the strain guage to counter balance the yoke and the collection pan. The analog output from the strain guage was first amplified (Gould Statham Bidirectional Amplifier, Model SC1105) and then converted to an 8-bit digital signal. Data acquisition and storage was accomplished using a Sinclair ZX81 microcomputer.

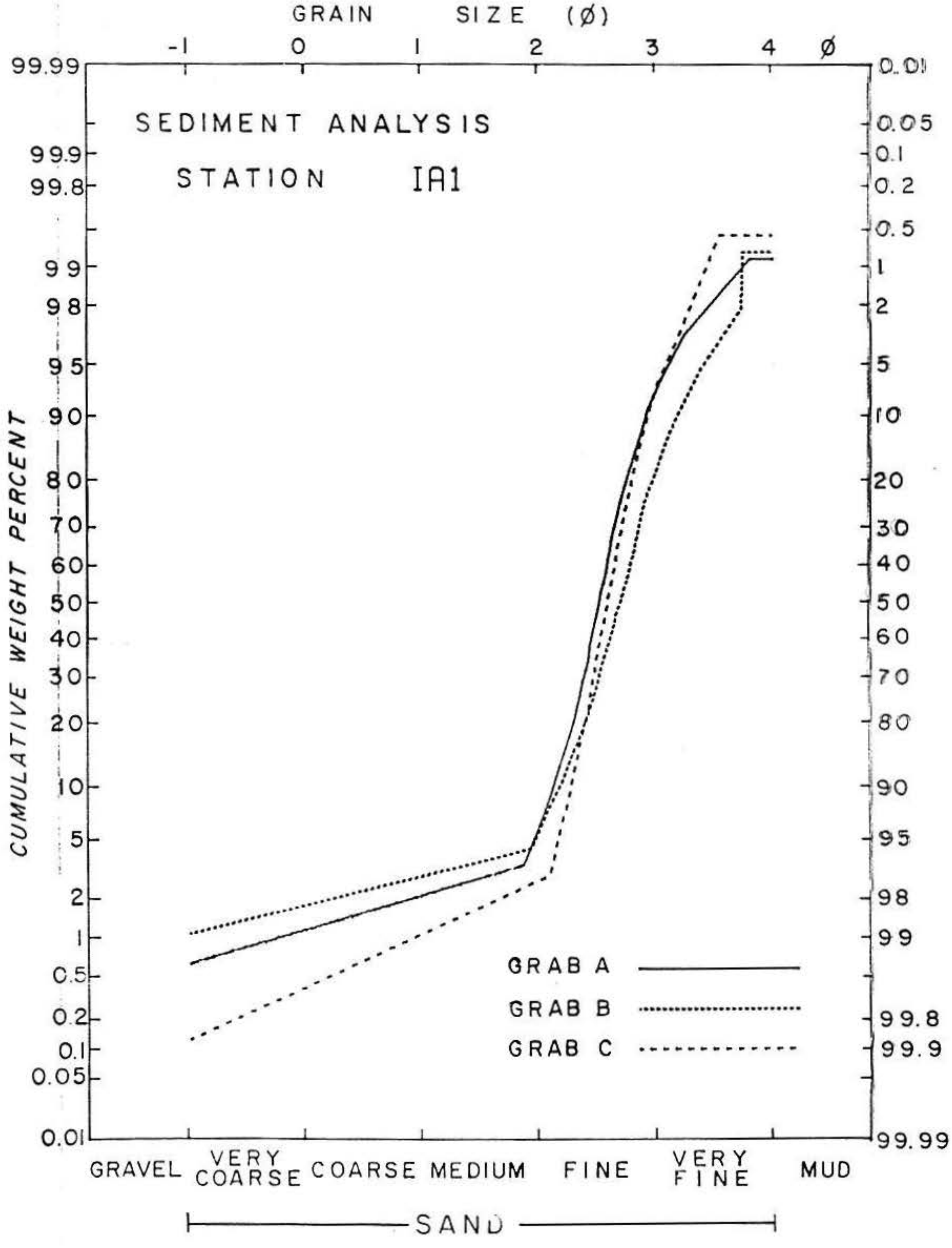
The device used to introduce a sample into the settling column consisted of a 10 cm watchglass cemented to a plexiglass disc. The watchglass was sprayed with distilled water, and a small amount of the sand fraction (1.5 grams) was distributed over the surface. Surface tension holds the grains to the watchglass as it is inverted and placed within the column. The watchglass is then slowly lowered towards the water surface with the sand layer facing downward. When the watchglass comes in contact with the surface of the water, the sand grains are released and fall through the column.

The analog/digital convertor in this system contained both a zero adjust and a gain control. Prior to initiating a run, the digital output was set to zero. The sensitivity of the data collecting device to changes in the weight of material accumulating on the pan was determined empirically by test runs at different gain settings. During a sample run, the elapsed time from the beginning of the run was stored by the microcomputer in an array whenever the digital output increased by 1.96% (i.e., 5 digital units out of 255). The actual number of data points collected during a sample run depended on the gain setting, the initial sample weight, and the fraction of particles interacting with the wall of the column and, therefore, not accumulating on the pan. For this study, 34 elapsed time records were collected during an average run. The microcomputer also recorded the final digital output value at the end of a run.

Data obtained from the microcomputer were in the form of cumulative weight vs. elapsed time. For this study, the settling distance, i.e., the distance between the water surface and the collecting pan, was set at 150 cm. Settling velocities were computed by dividing the settling distance by each elapsed time record. The temperature of the water in the settling column was recorded prior to each run. Knowing settling velocity and water temperature, the sedimentation diameter for each recorded point in a run was calculated using the equation in Gibbs, et al. (1971). The final outcome of this conversion yields cumulative weight vs. particle diameter.

APPENDIX B

Sediment Grain Size Distributions


GRAIN SIZE (Ø)
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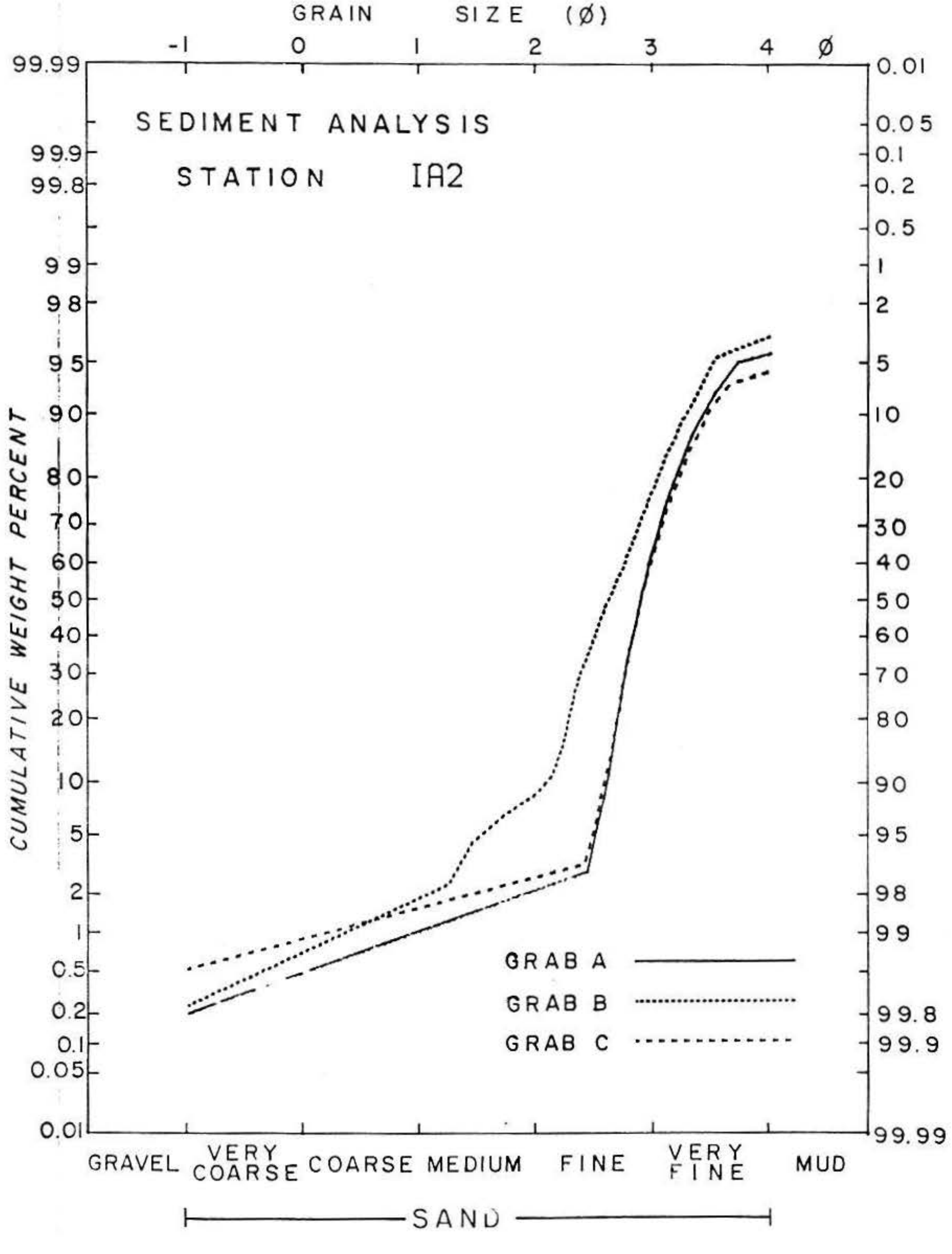
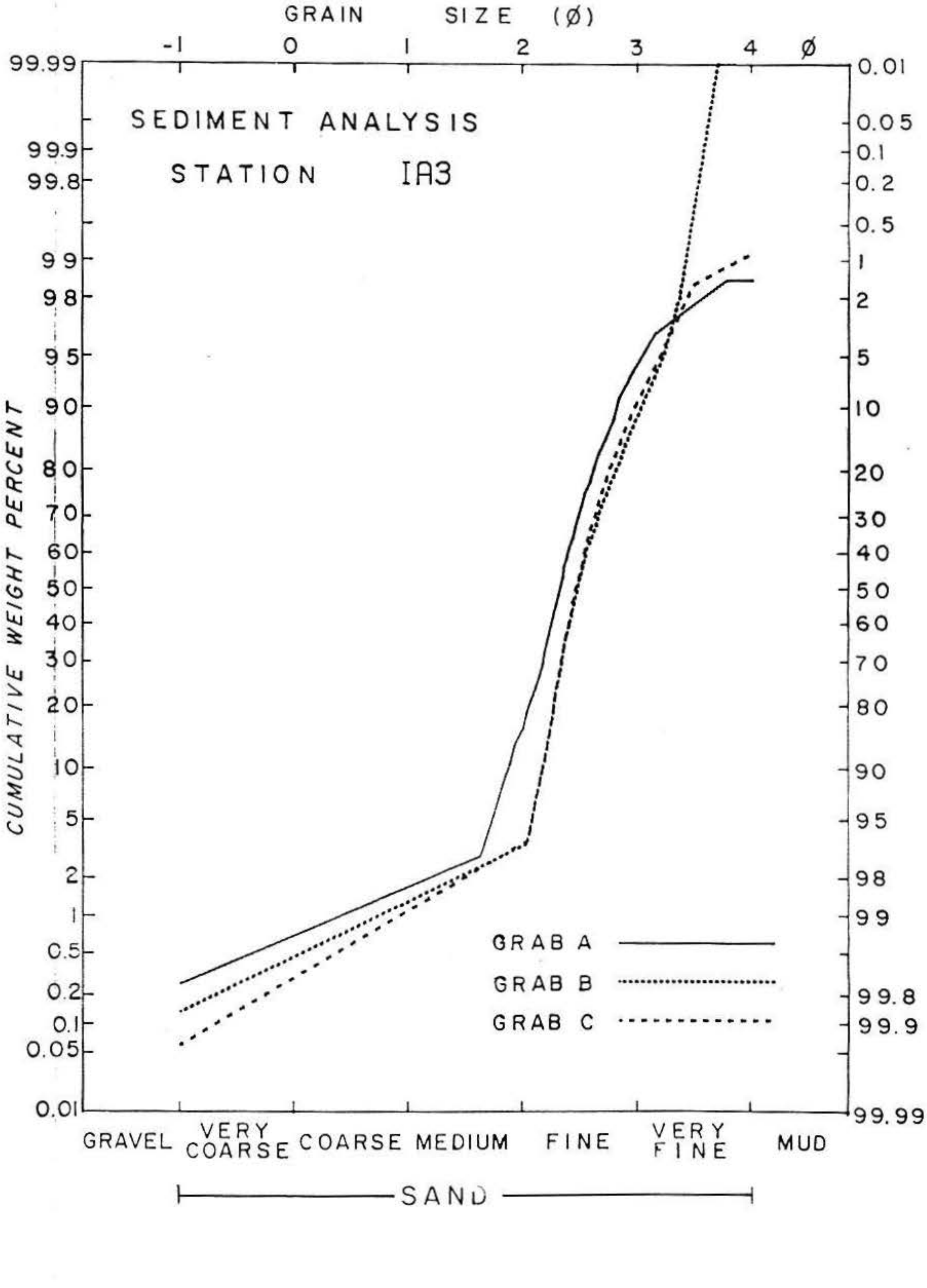
0
1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IA1
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
-1
0
1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IA2
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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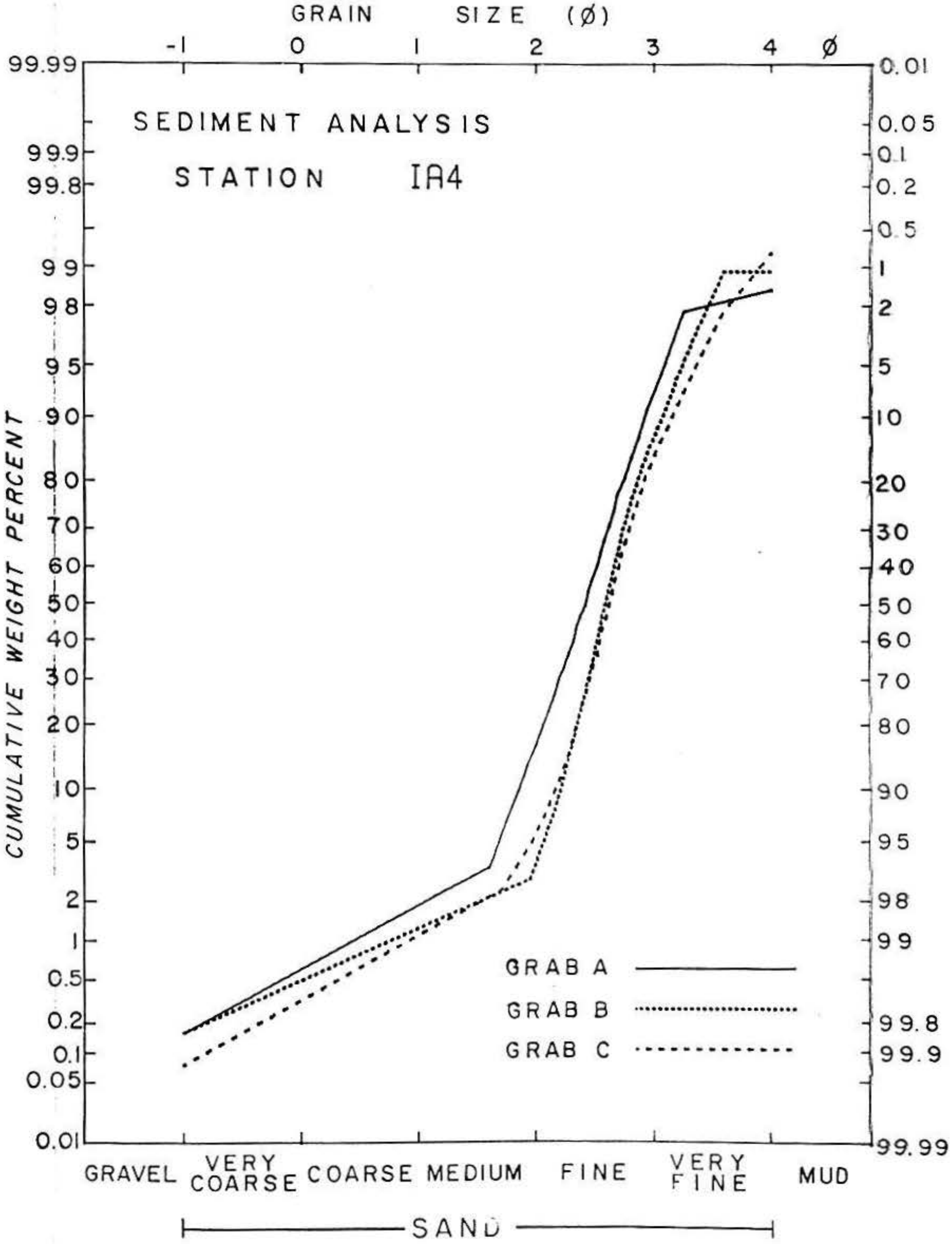
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IA3
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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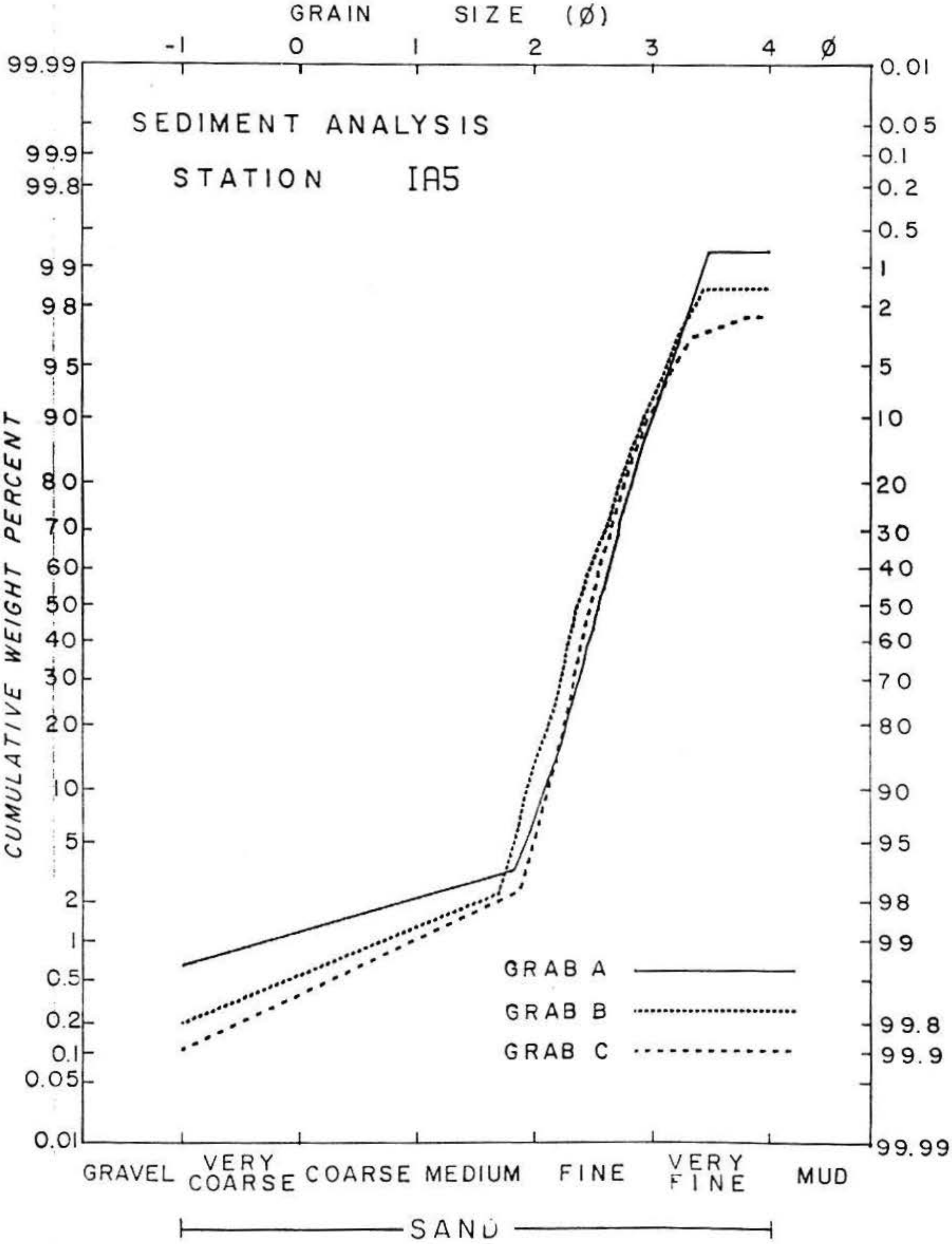
0
1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IA4
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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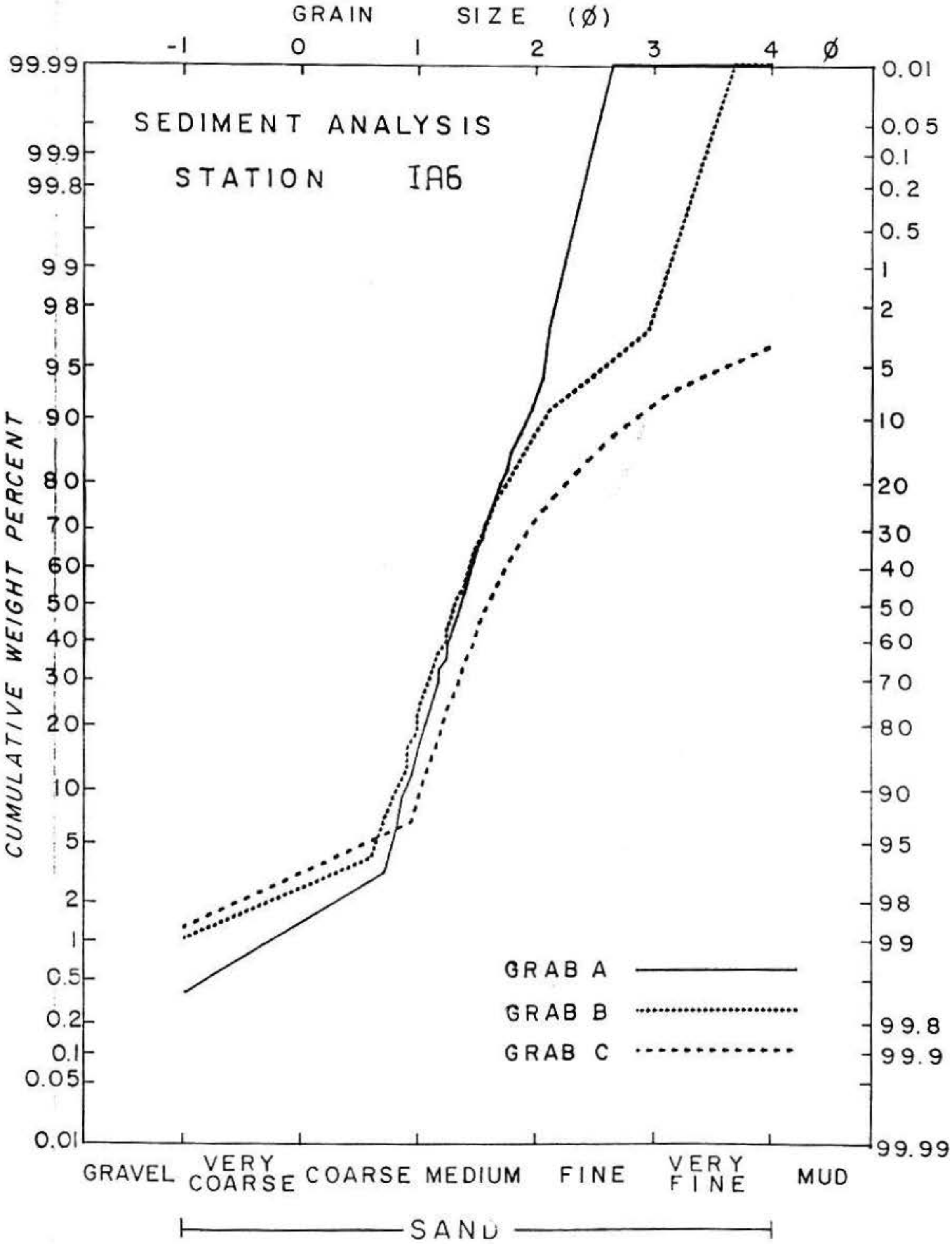
0
1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IA5
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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0
1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IA6
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
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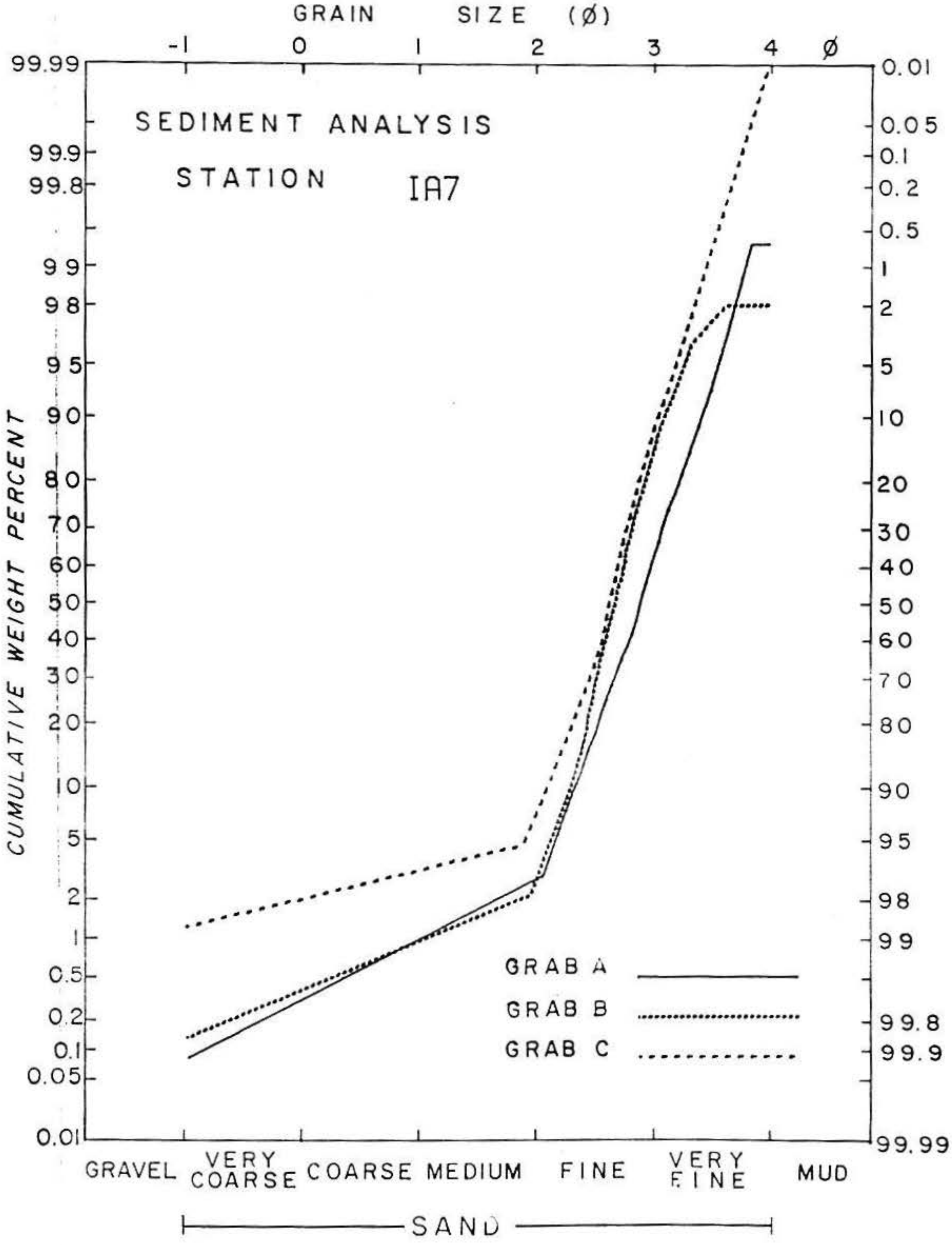
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND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2
3
4
Ø
SEDIMENT ANALYSIS
STATION IA7
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.05
0.1
0.2
0.5
1
2
5
10
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30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
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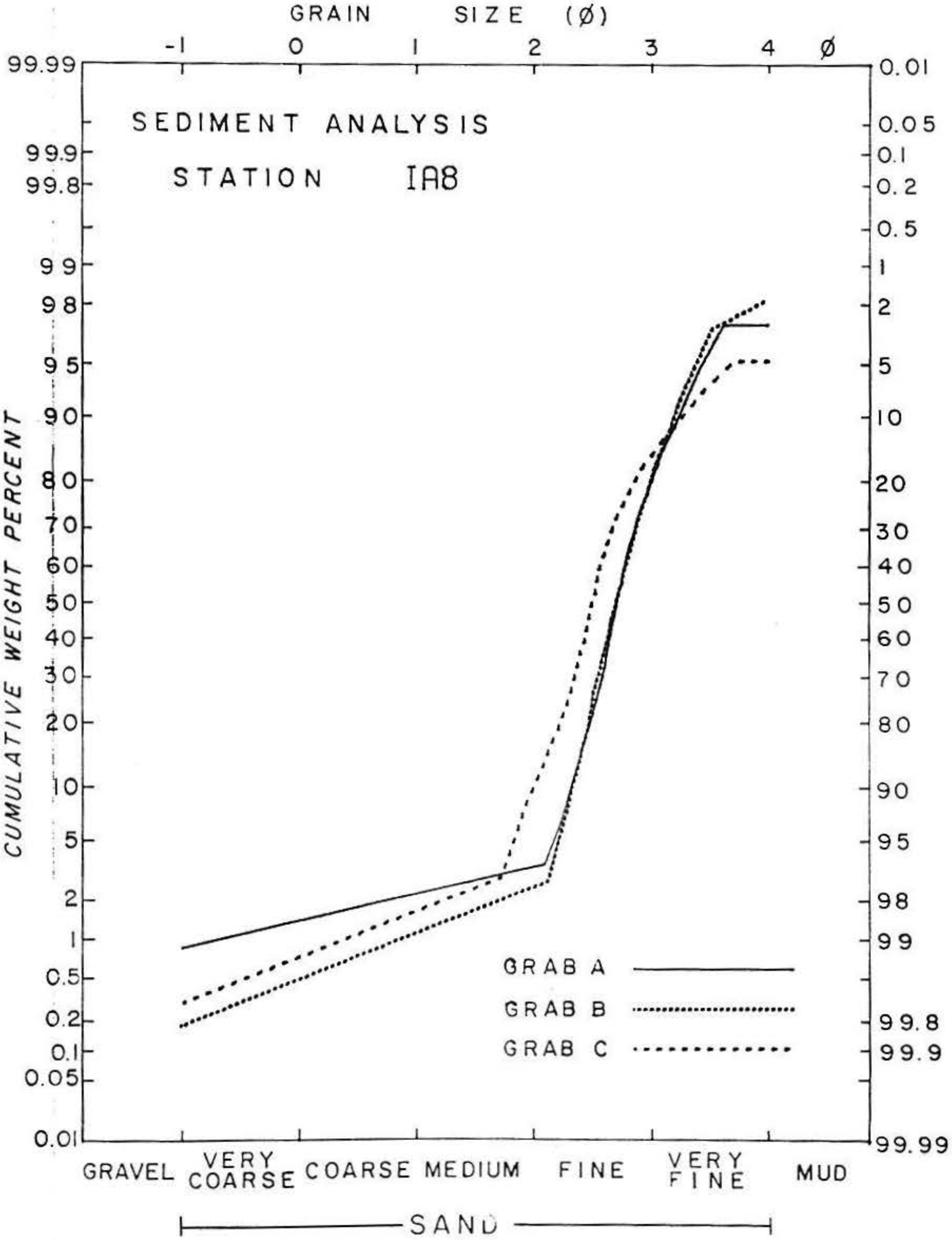
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND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STATION IA8
CUMULATIVE WEIGHT PERCENT
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99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
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5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
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GRAB C
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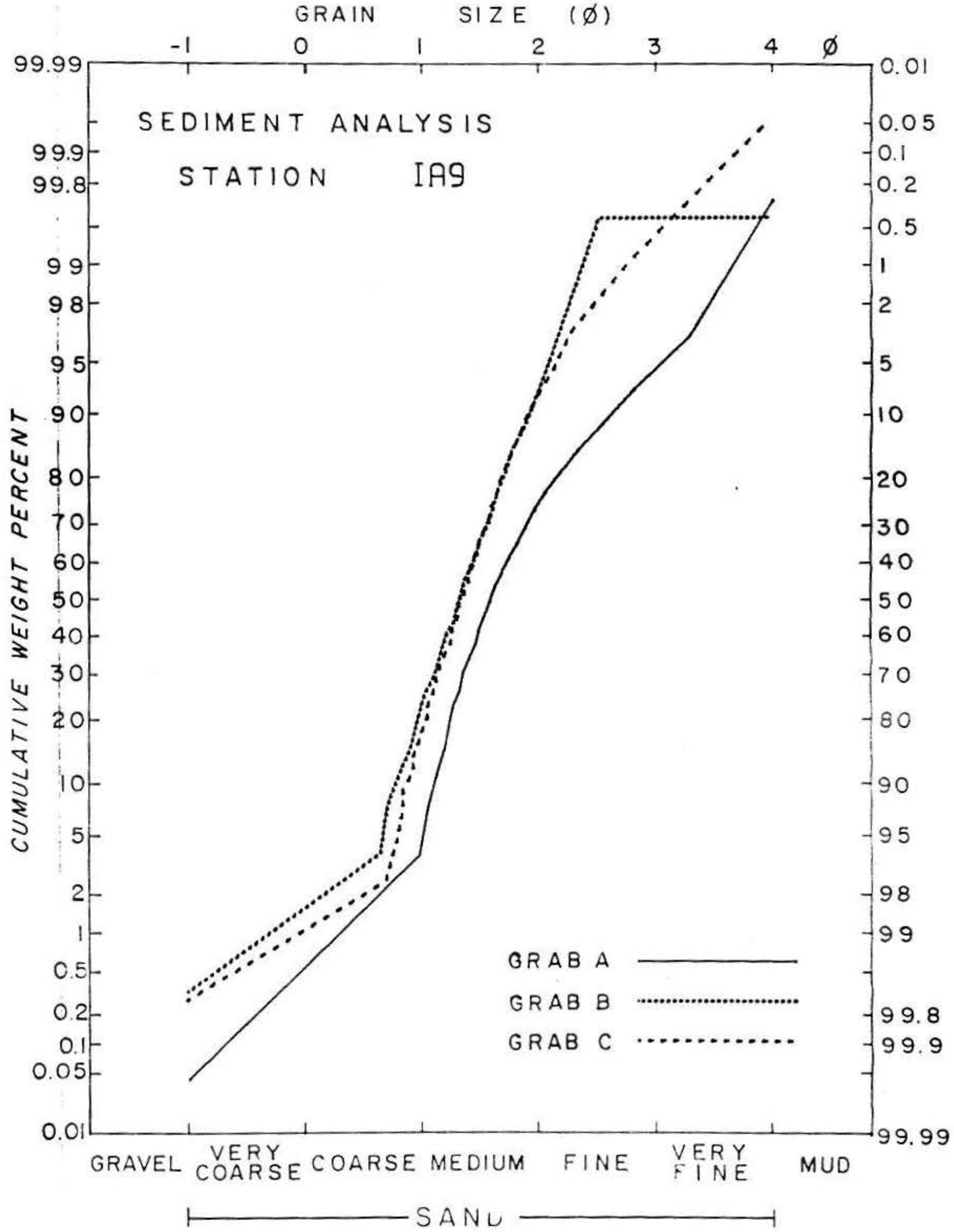
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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4
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SEDIMENT ANALYSIS
STATION IA9
CUMULATIVE WEIGHT PERCENT
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99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
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5
2
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0.5
0.2
0.1
0.05
0.01
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80
90
95
98
99
99.8
99.9
99.99
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GRAB C
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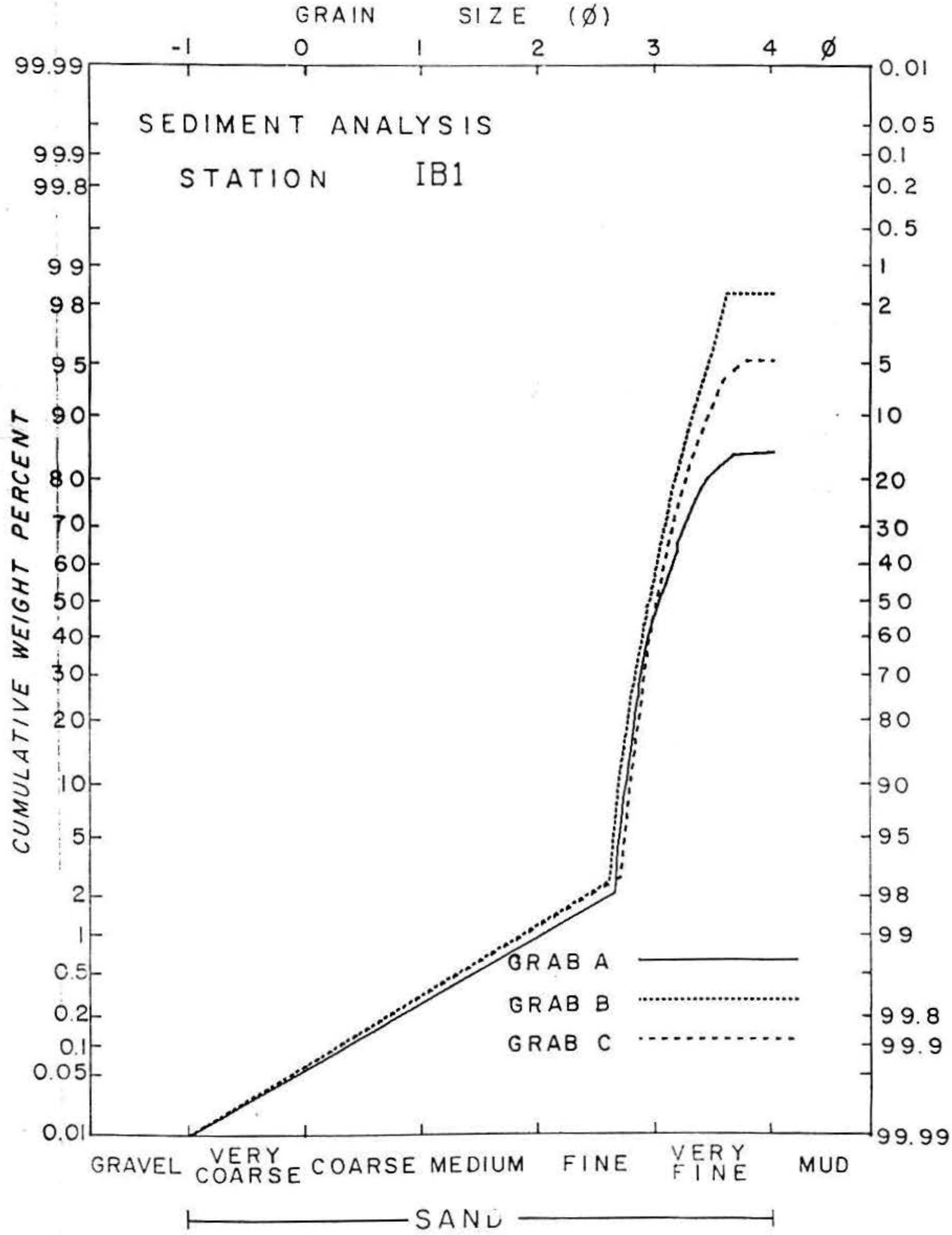
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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4
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SEDIMENT ANALYSIS
STATION IB1
CUMULATIVE WEIGHT PERCENT
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99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
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90
95
98
99
99.8
99.9
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GRAB B
GRAB C
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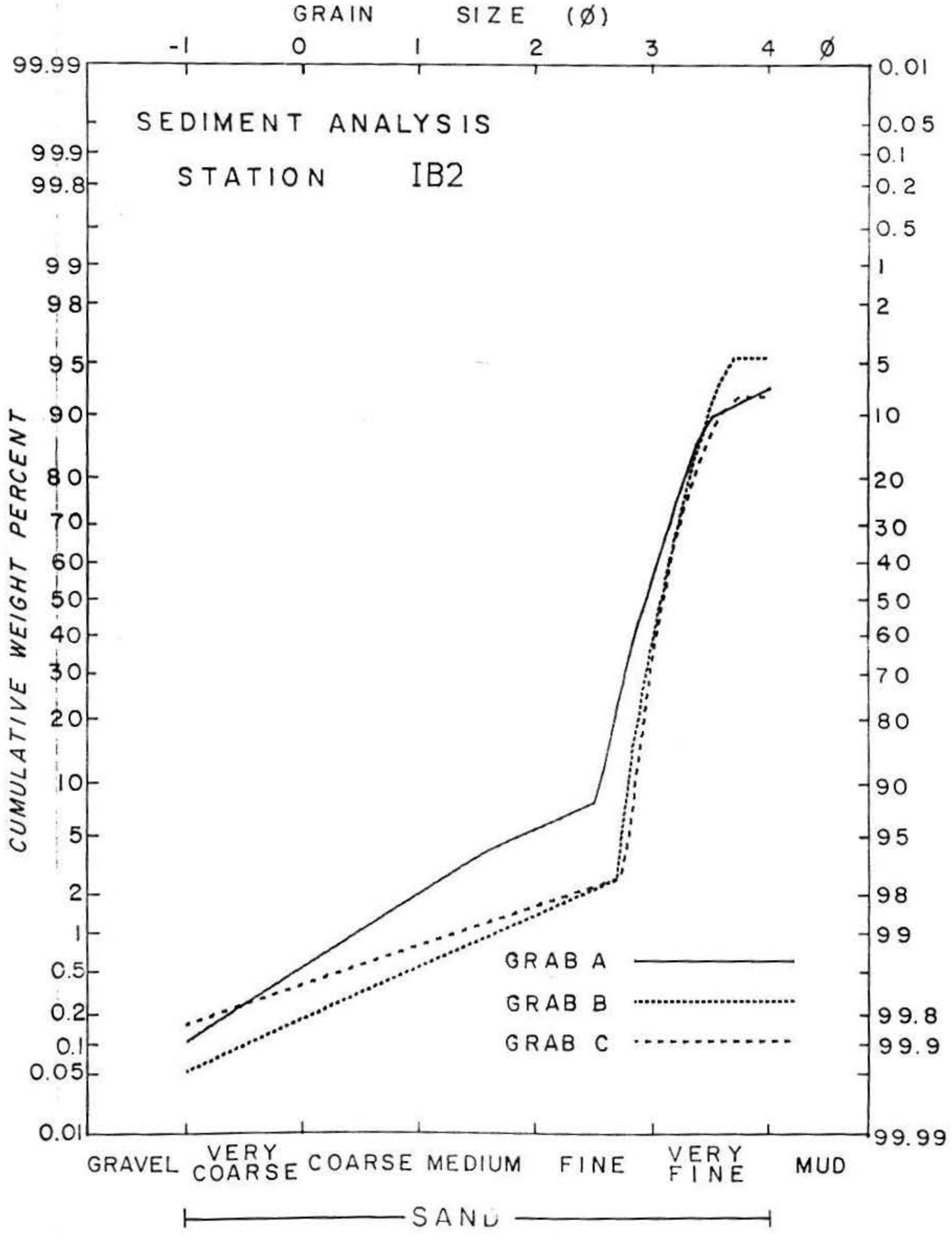
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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2
3
4
Ø
SEDIMENT ANALYSIS
STATION IB2
CUMULATIVE WEIGHT PERCENT
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99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
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50
60
70
80
90
95
98
99
99.8
99.9
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GRAB B
GRAB C
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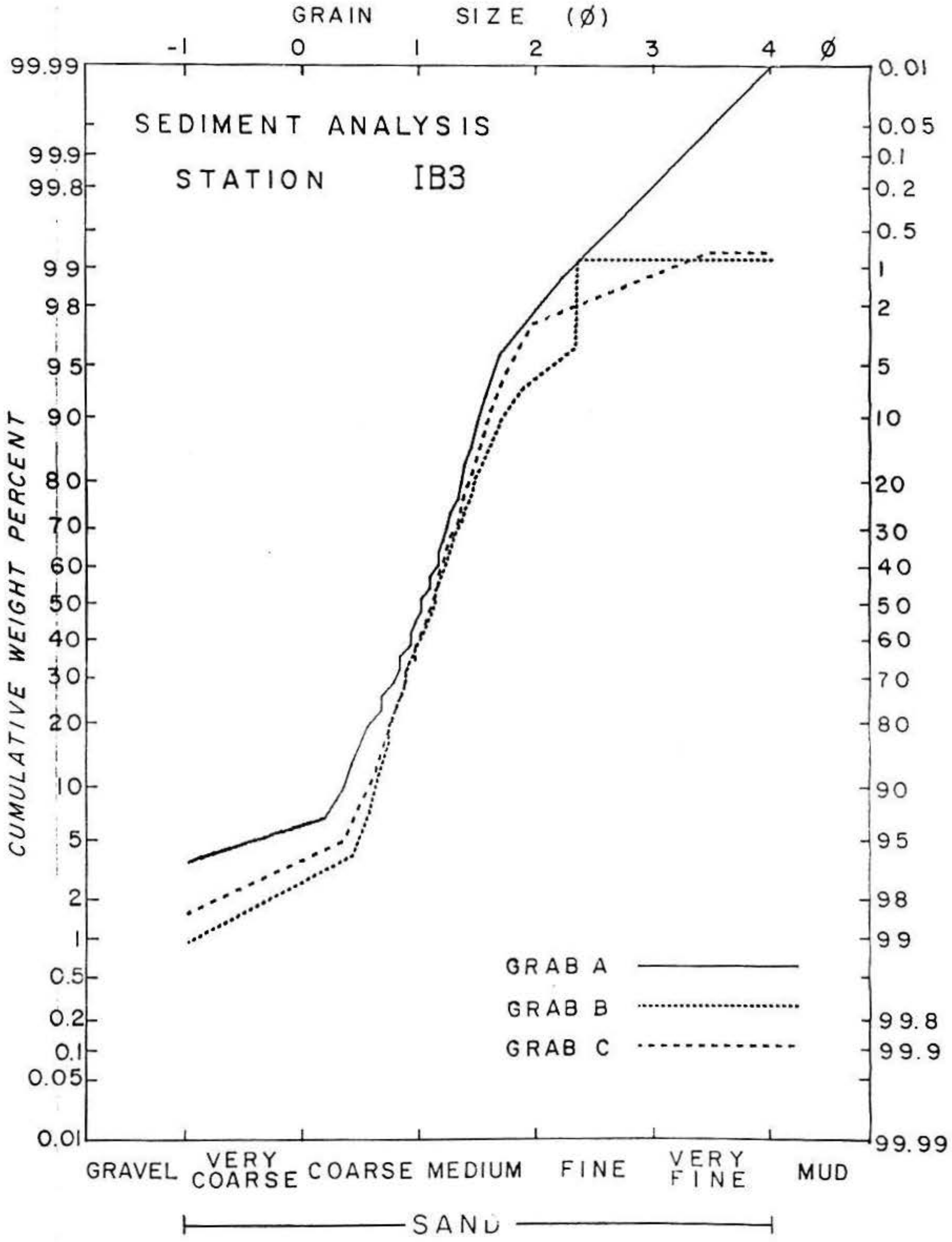
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IB3
CUMULATIVE WEIGHT PERCENT
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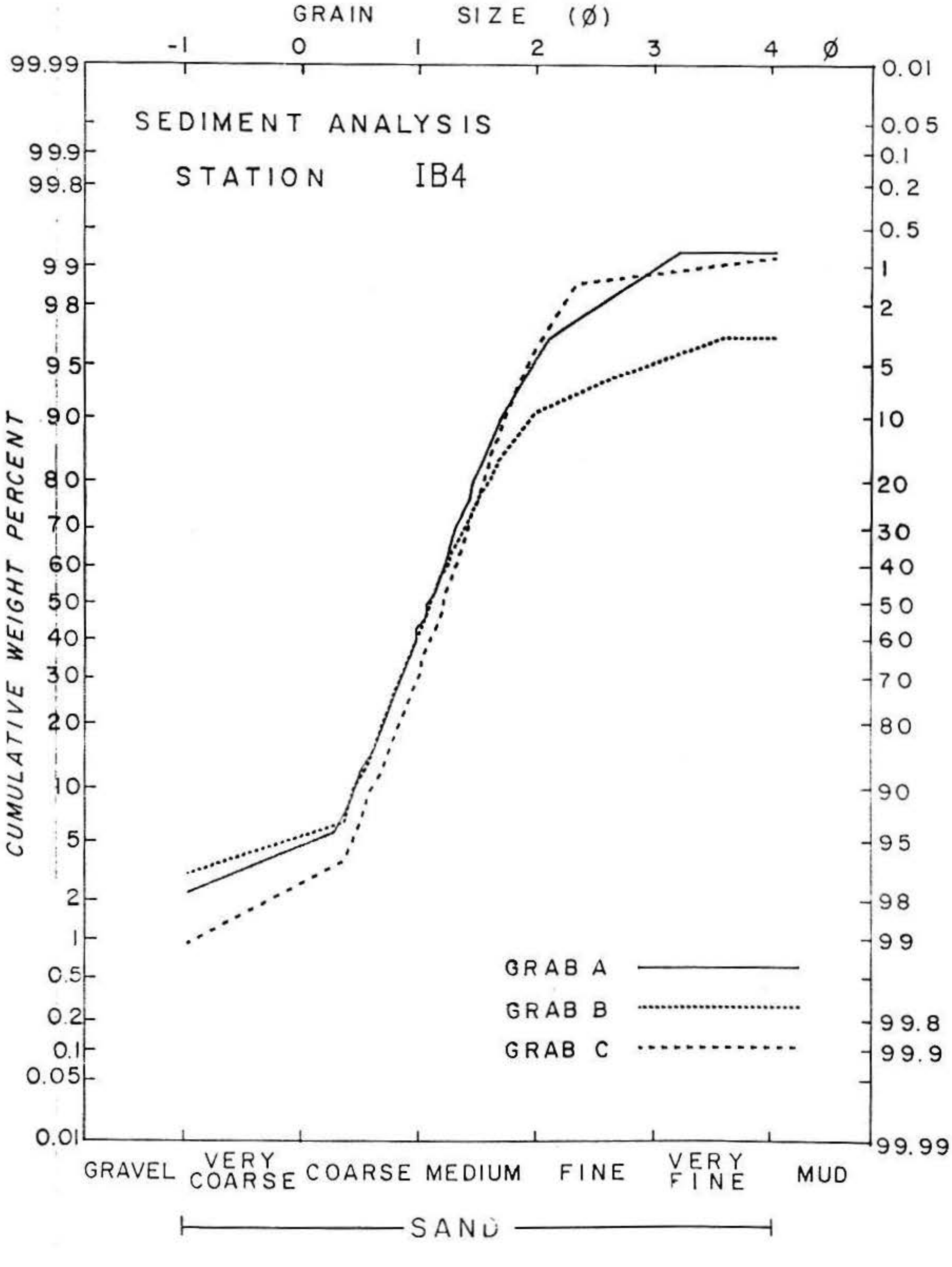
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND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3
4
0
SEDIMENT ANALYSIS
STATION IB4
CUMULATIVE WEIGHT PERCENT
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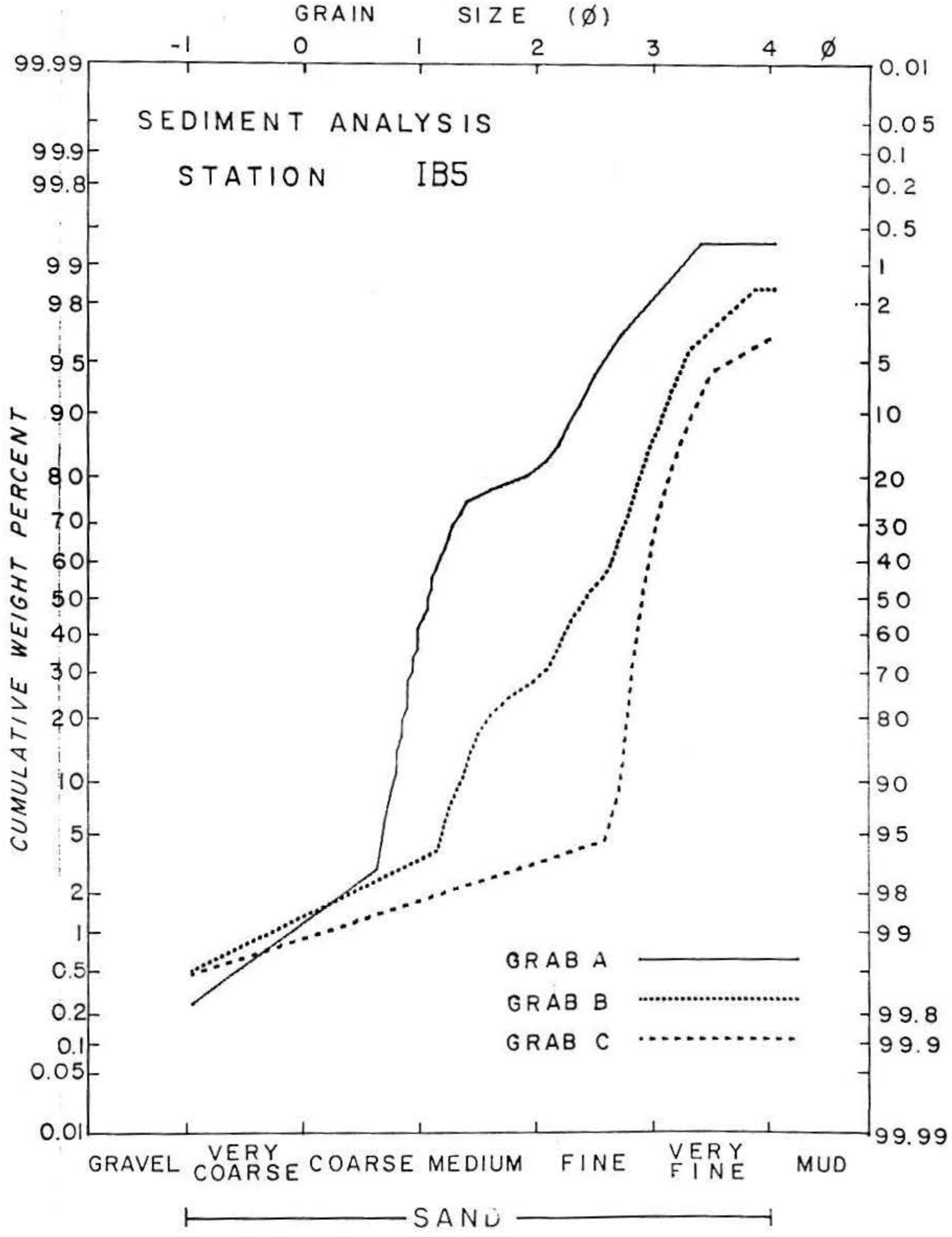
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IB5
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
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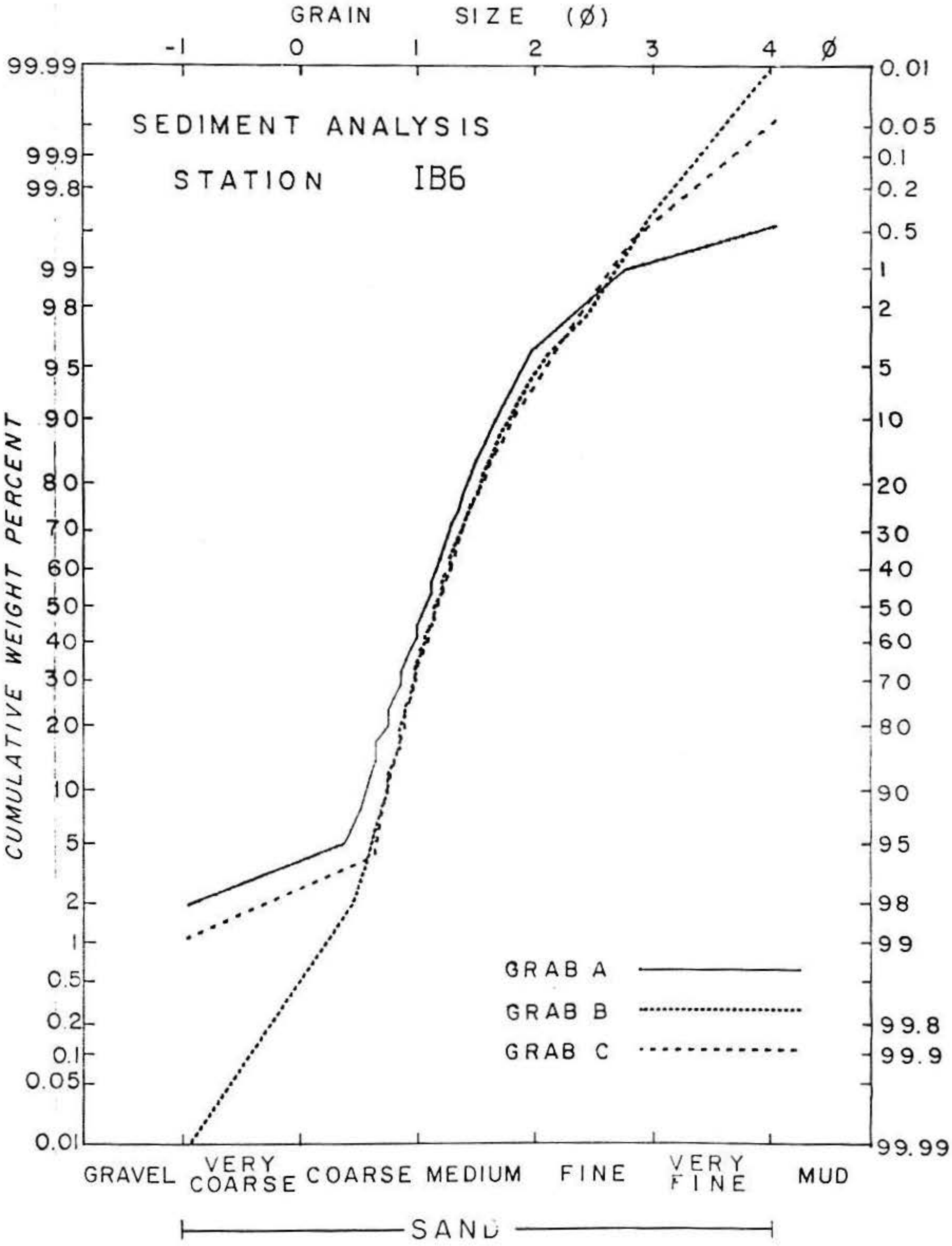
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
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3
4
Ø
SEDIMENT ANALYSIS
STATION IB6
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
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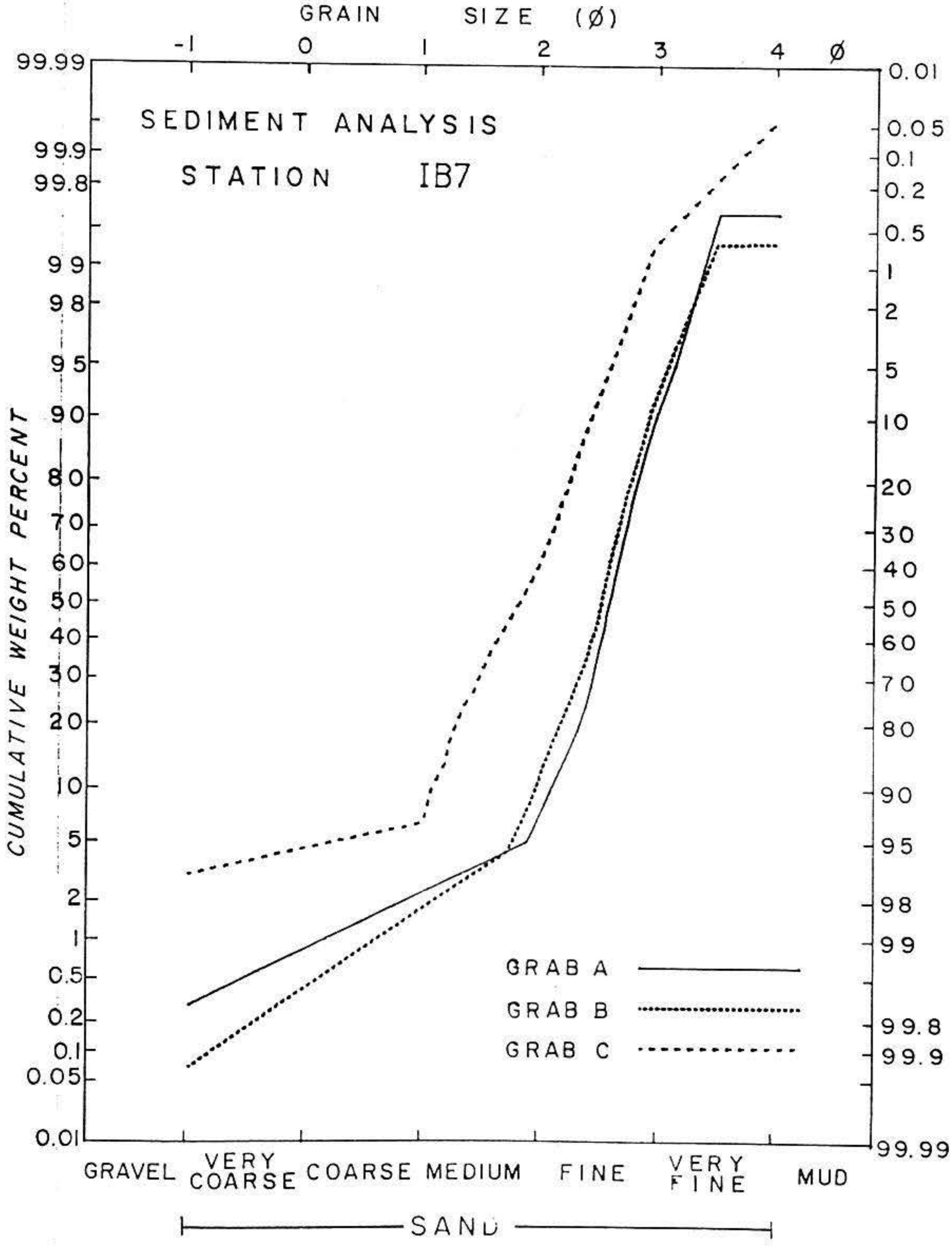
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND


GRAIN SIZE (Ø)
-1
0
1
2
3
4
Ø
SEDIMENT ANALYSIS
STATION IB7
CUMULATIVE WEIGHT PERCENT
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
GRAB A
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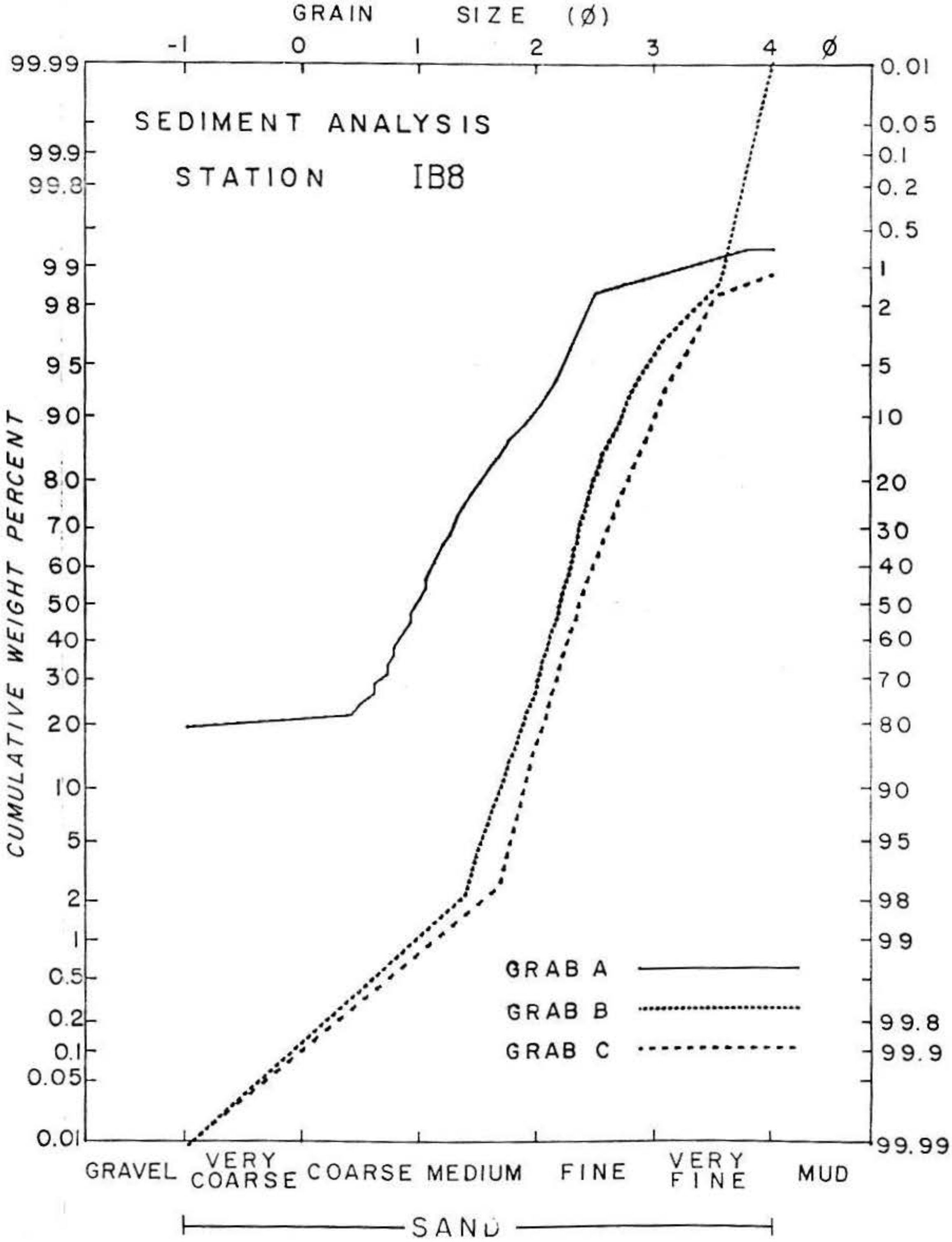
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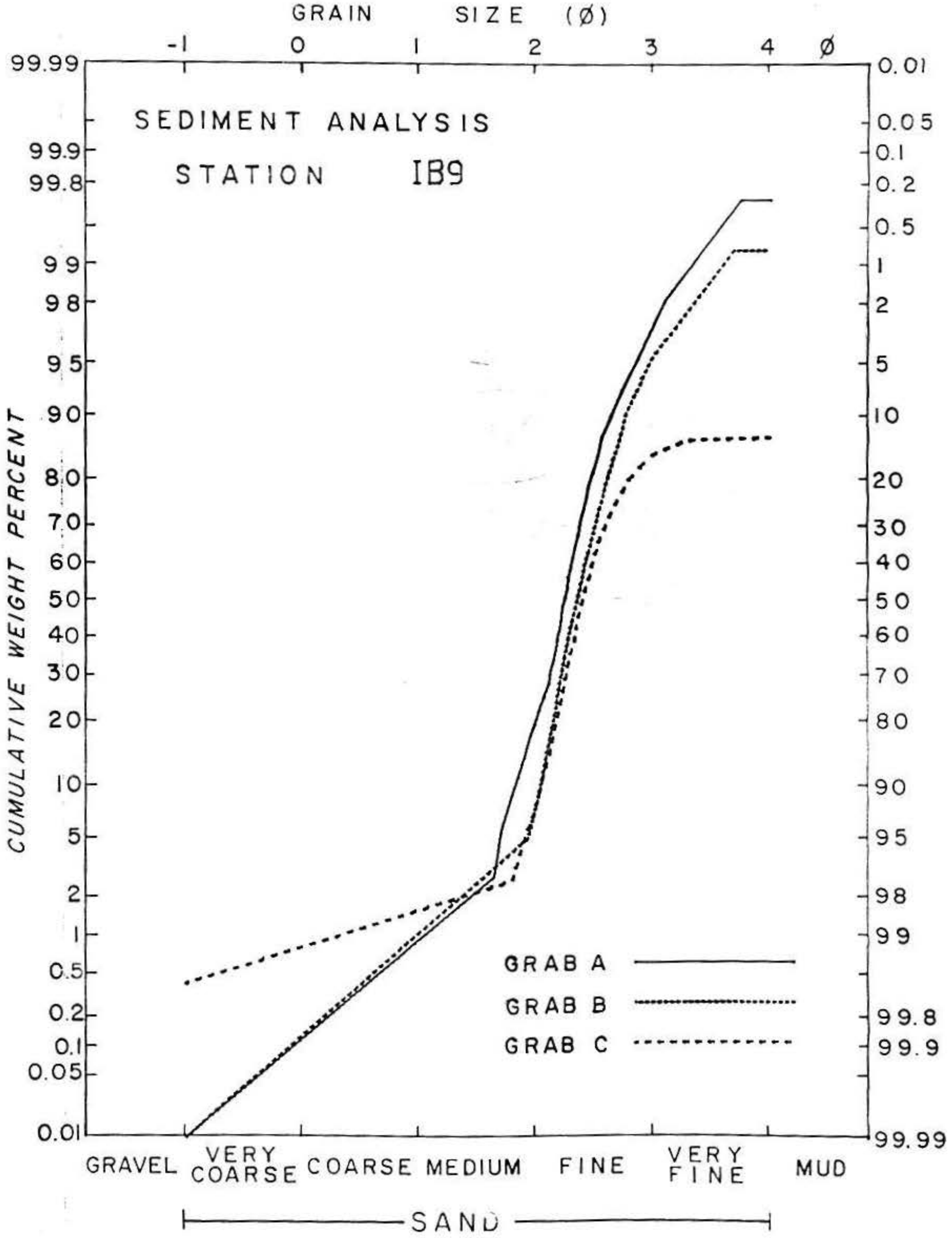
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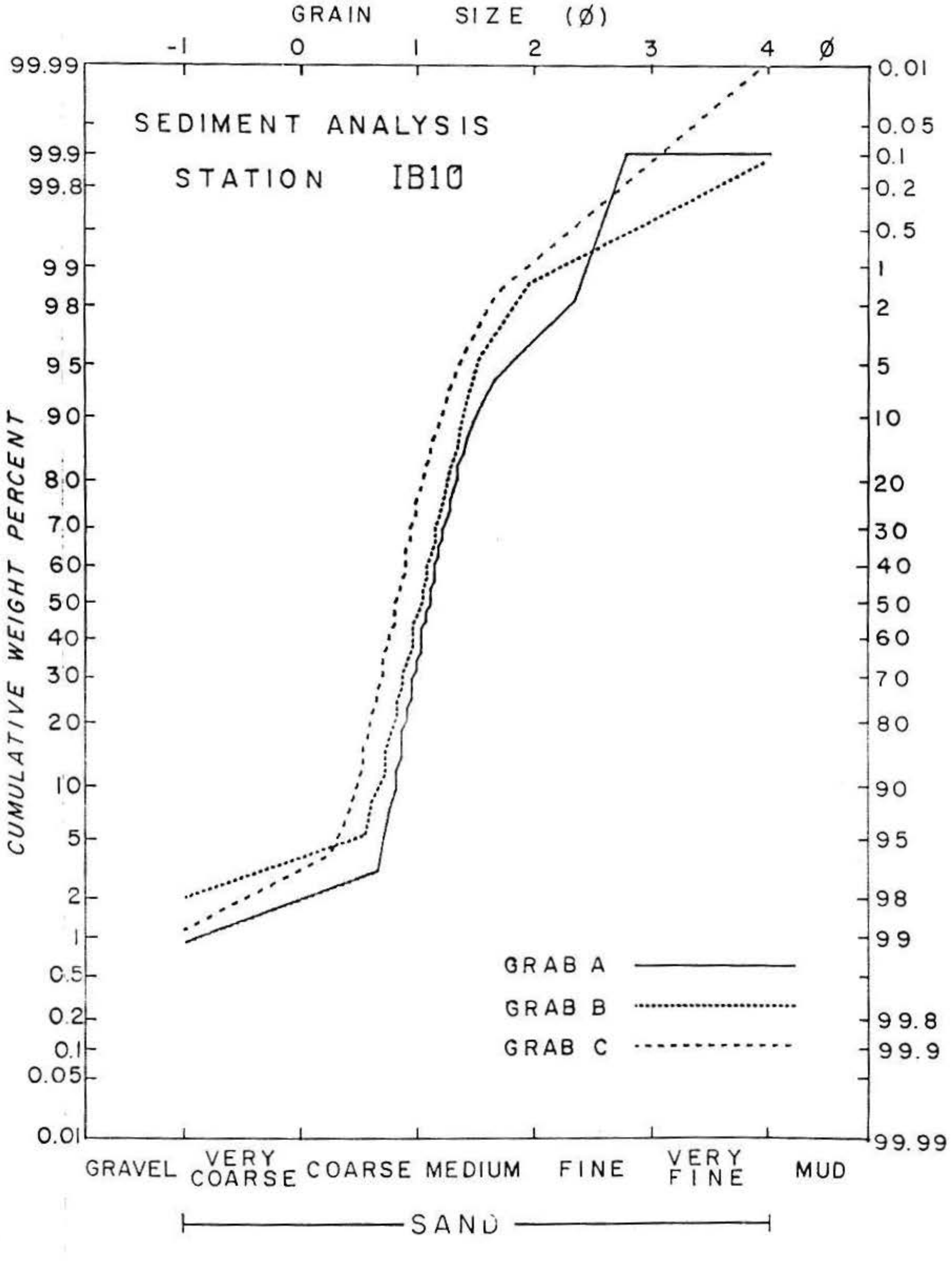
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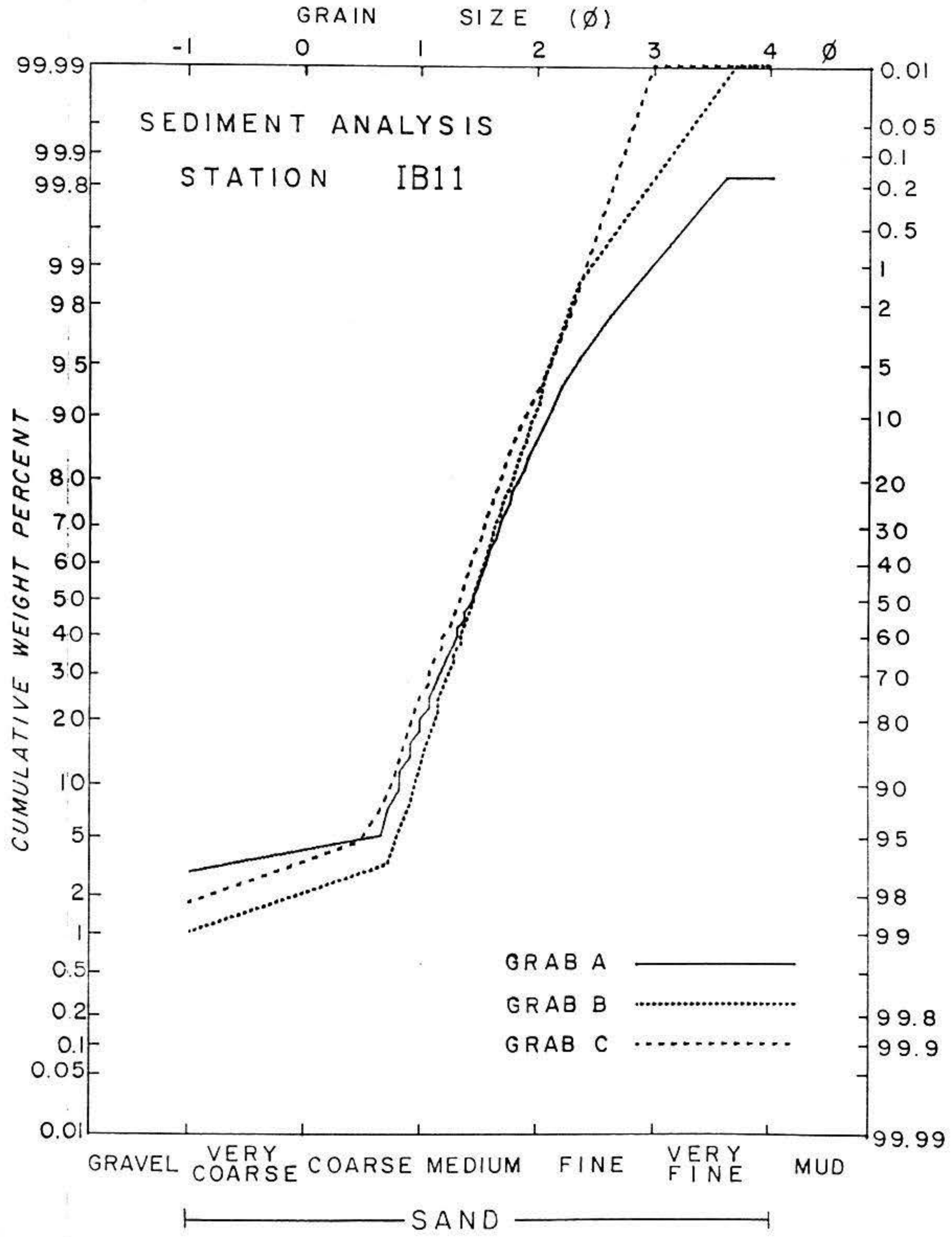
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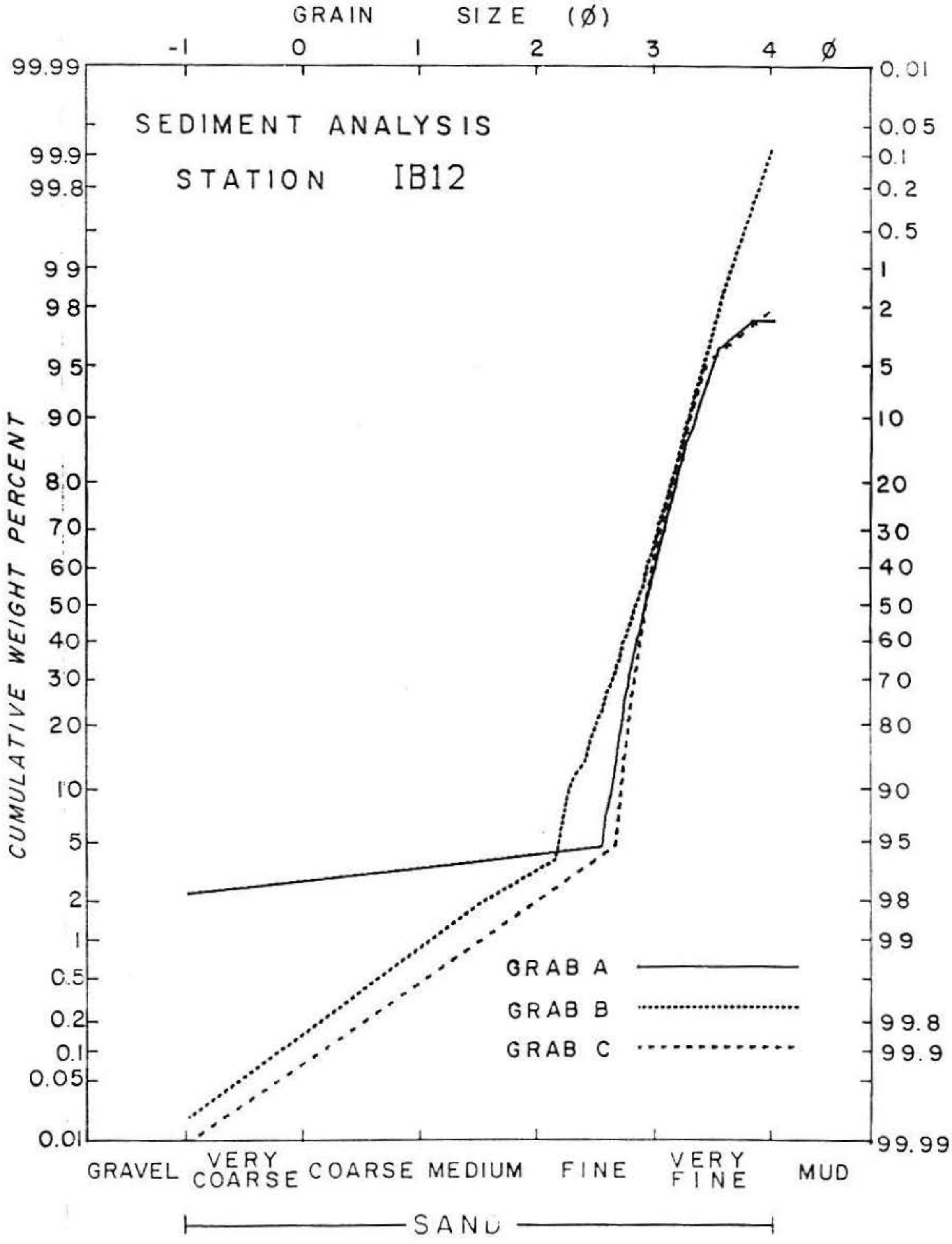
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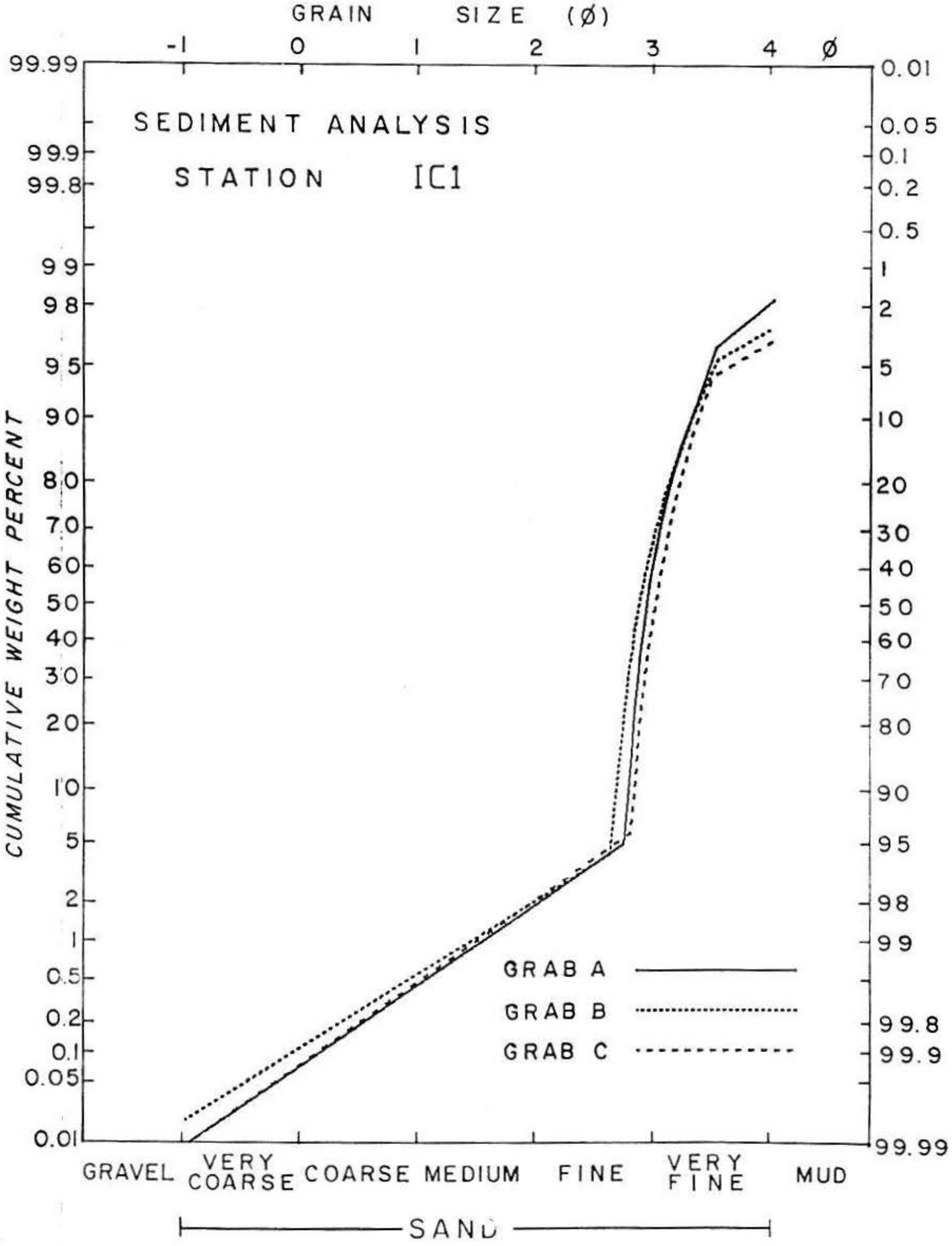
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99.8
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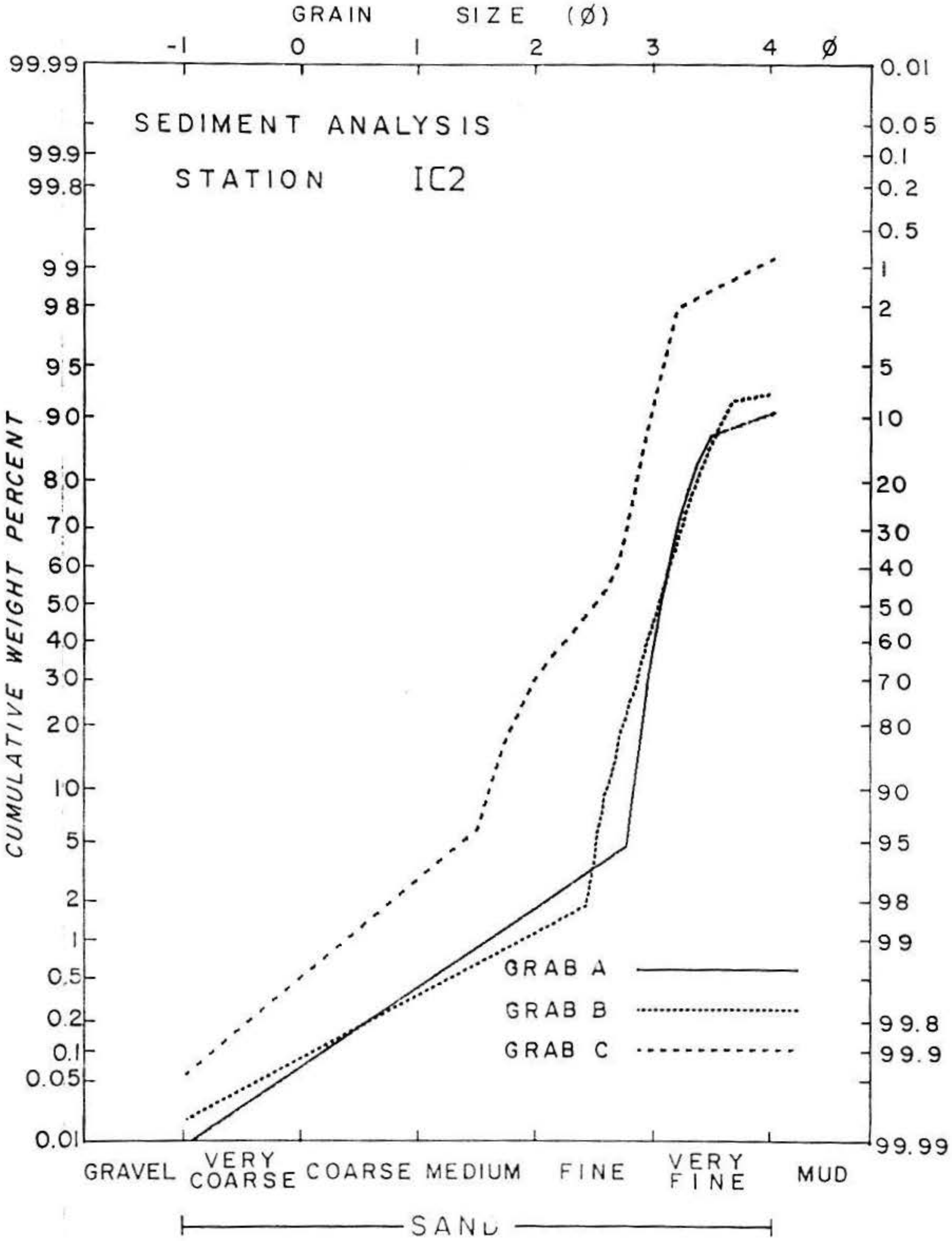
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99.8
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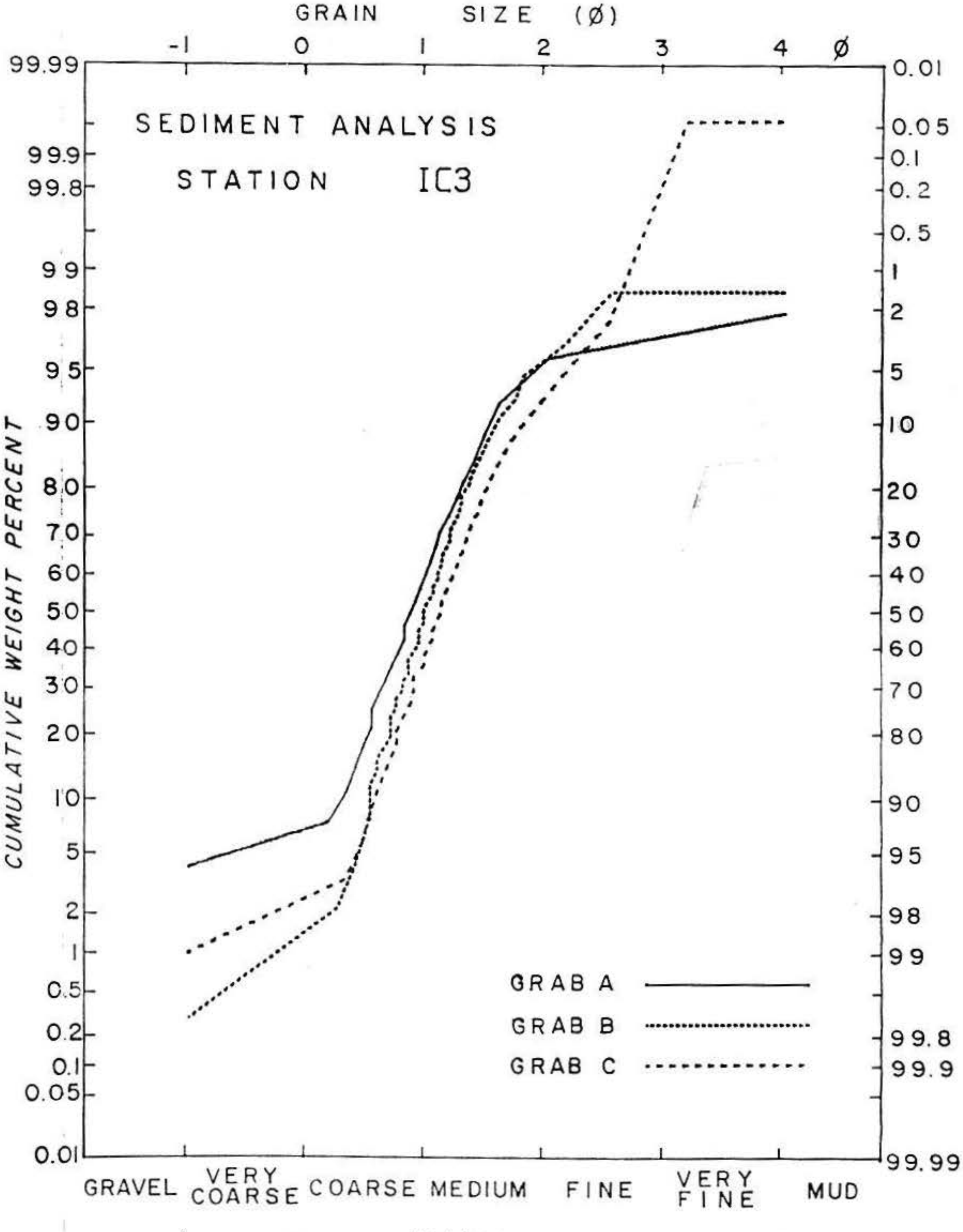
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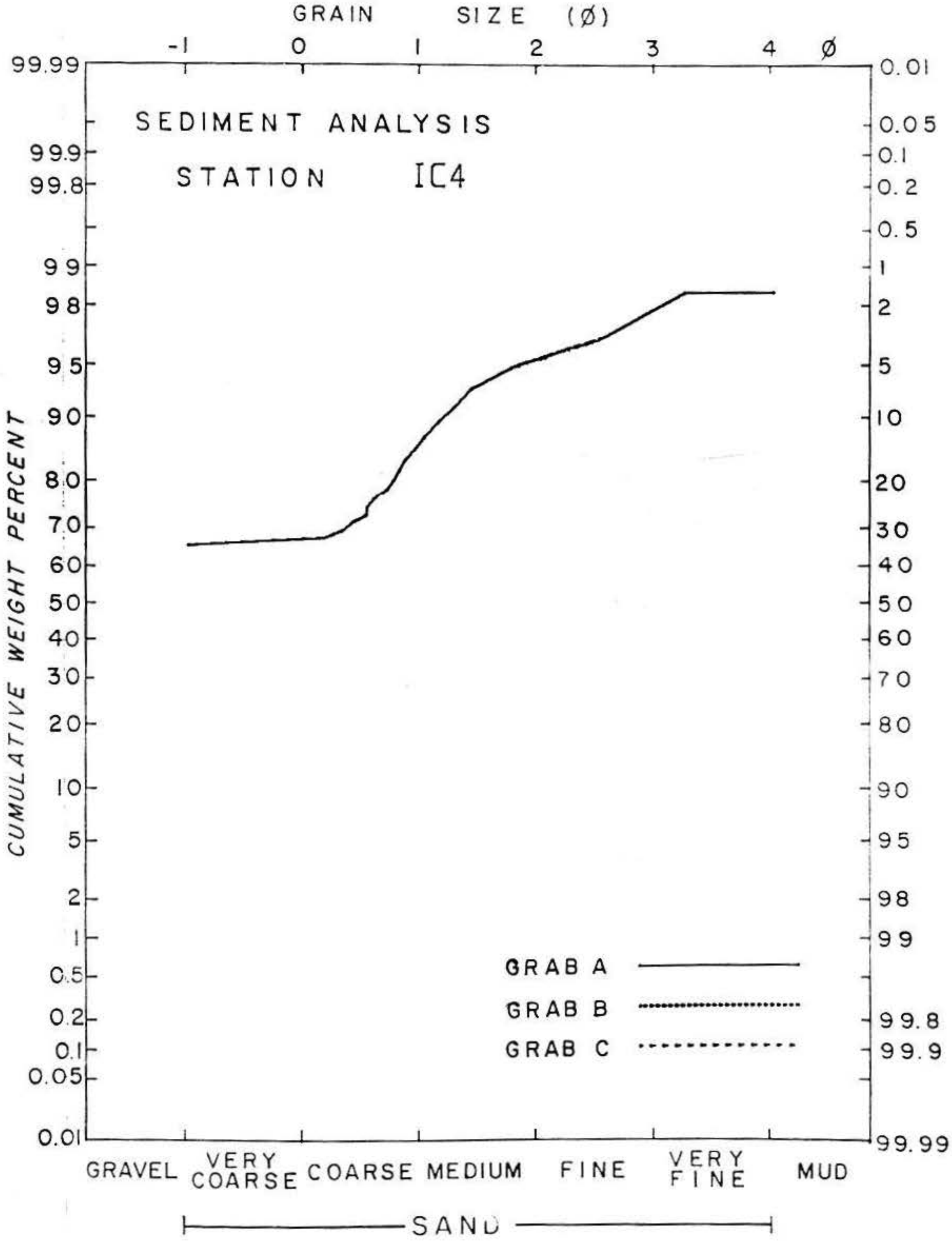
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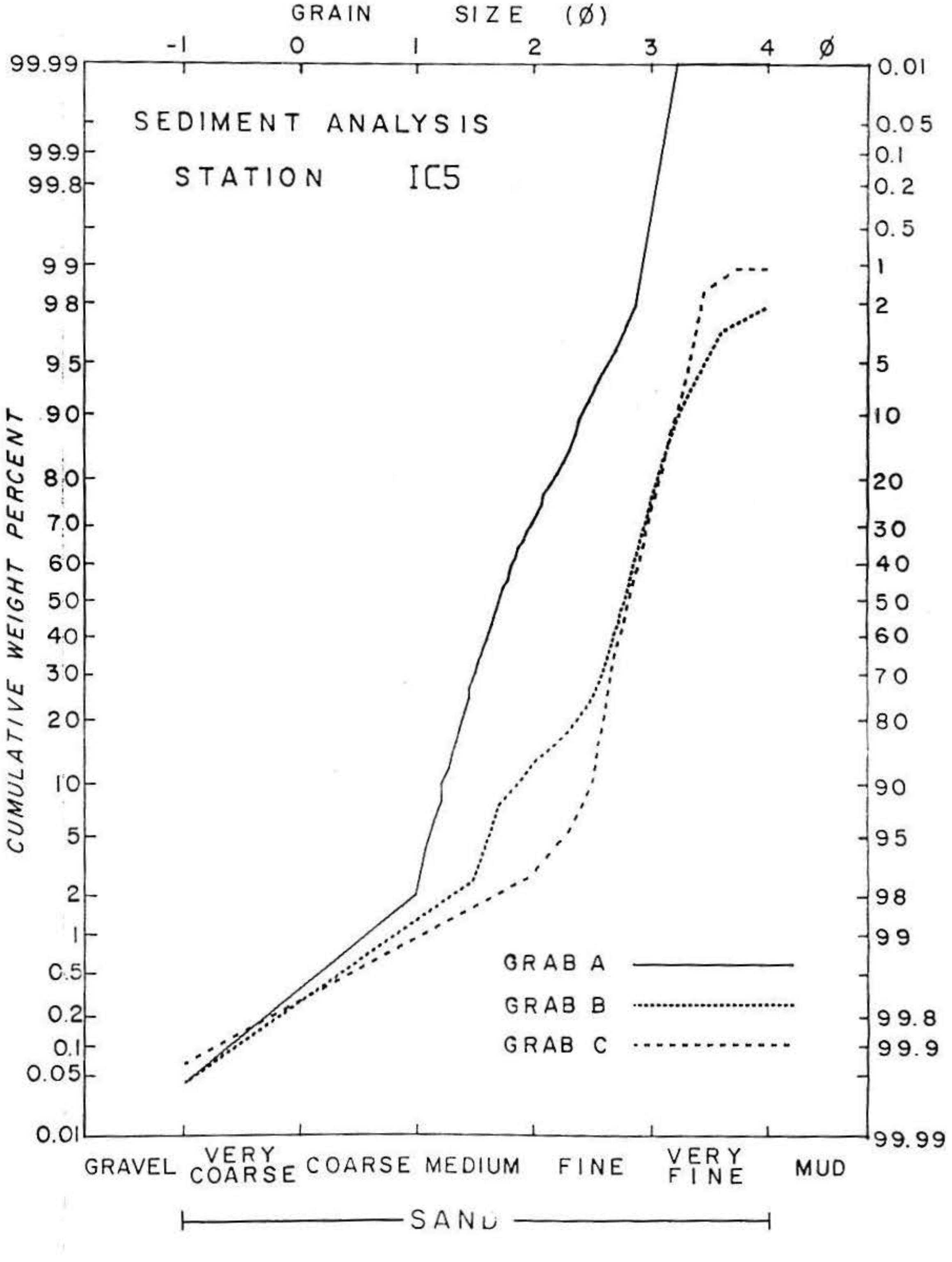
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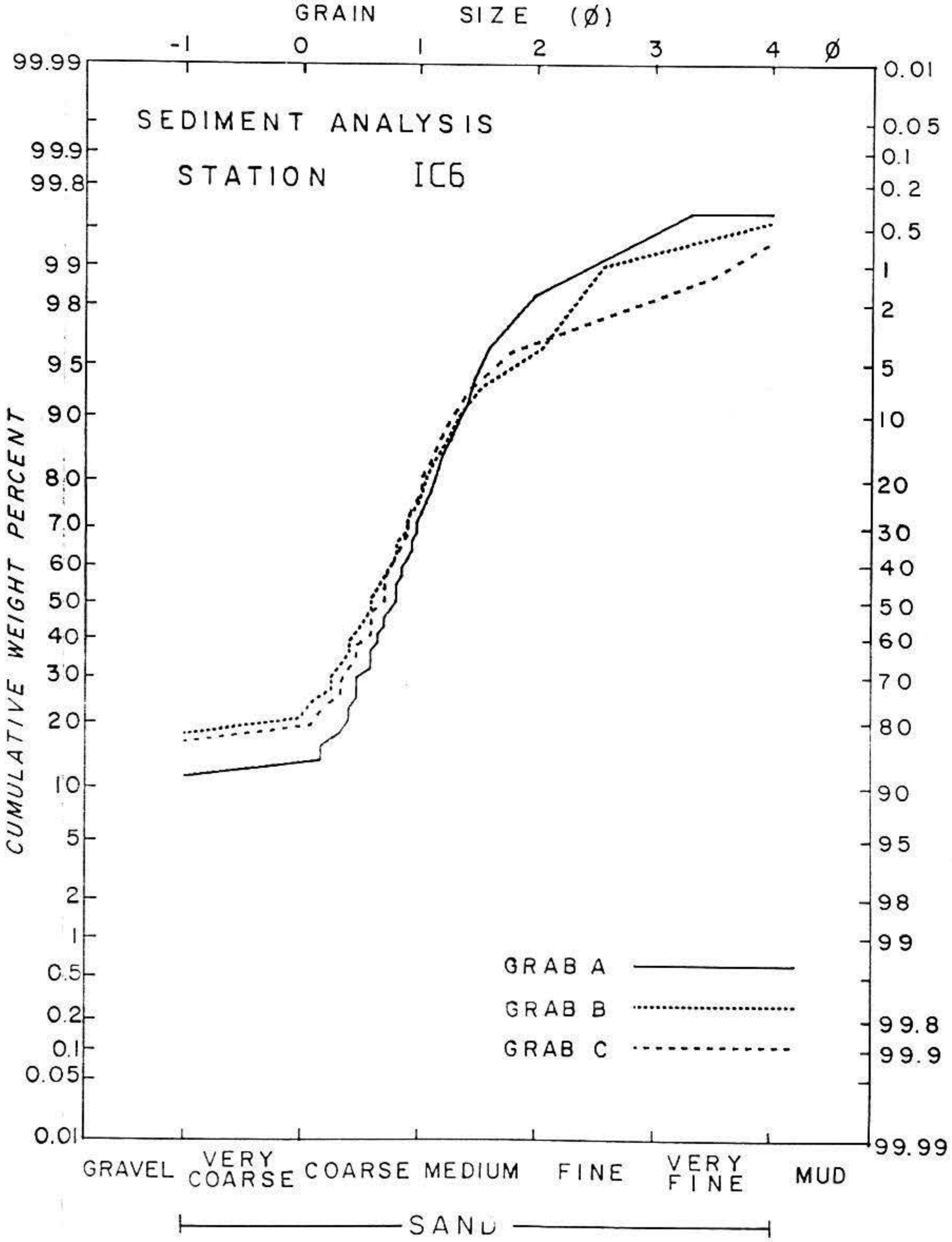
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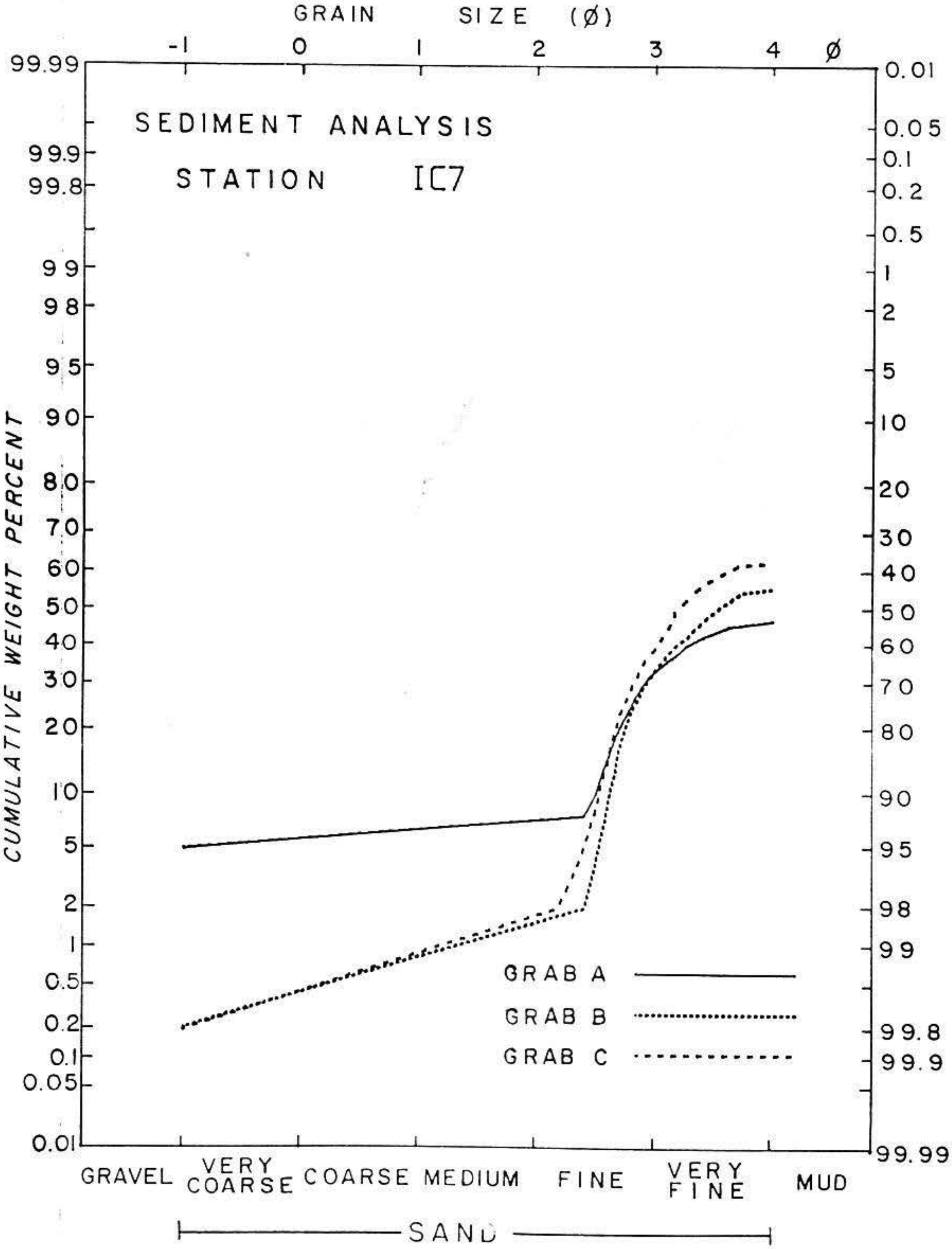
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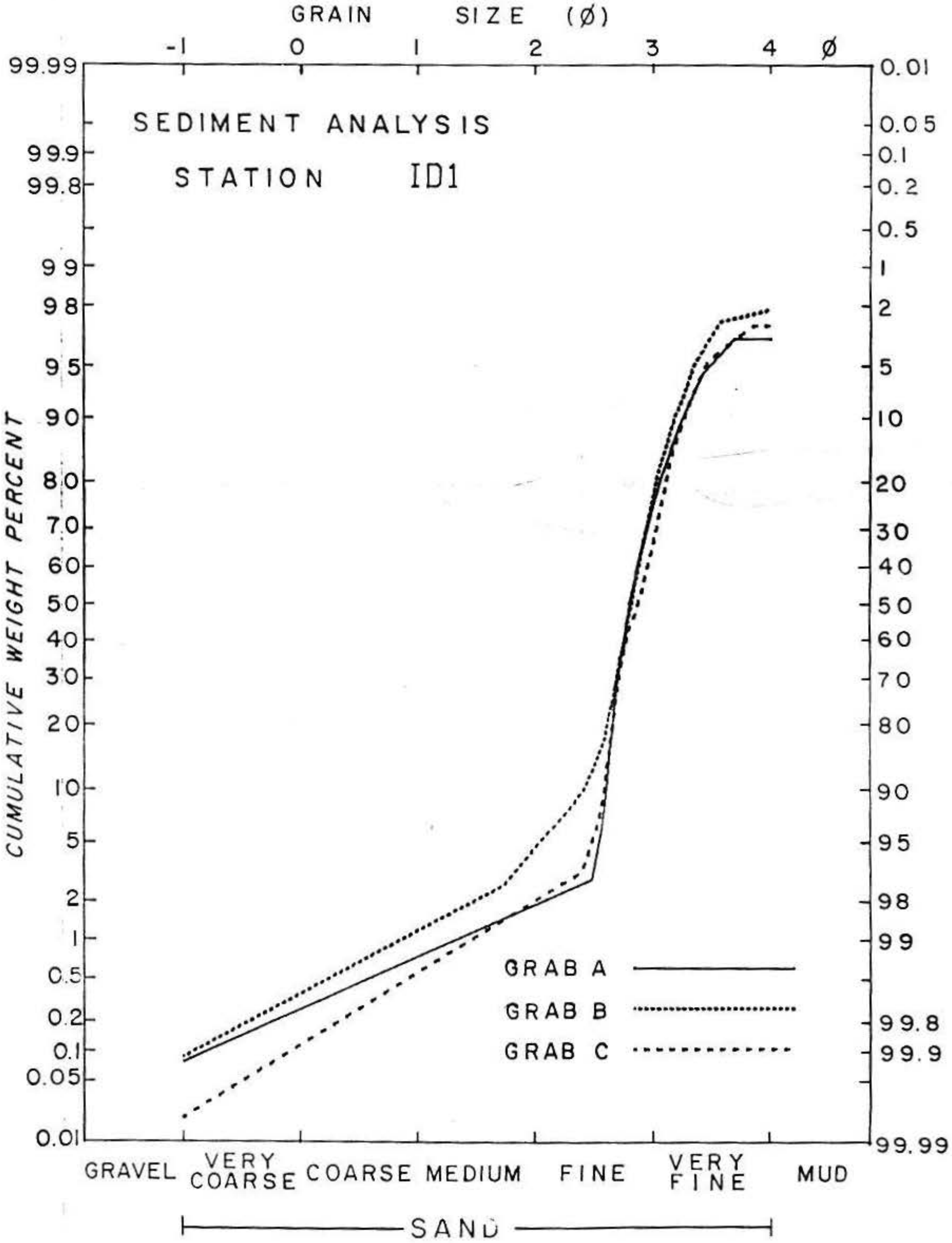
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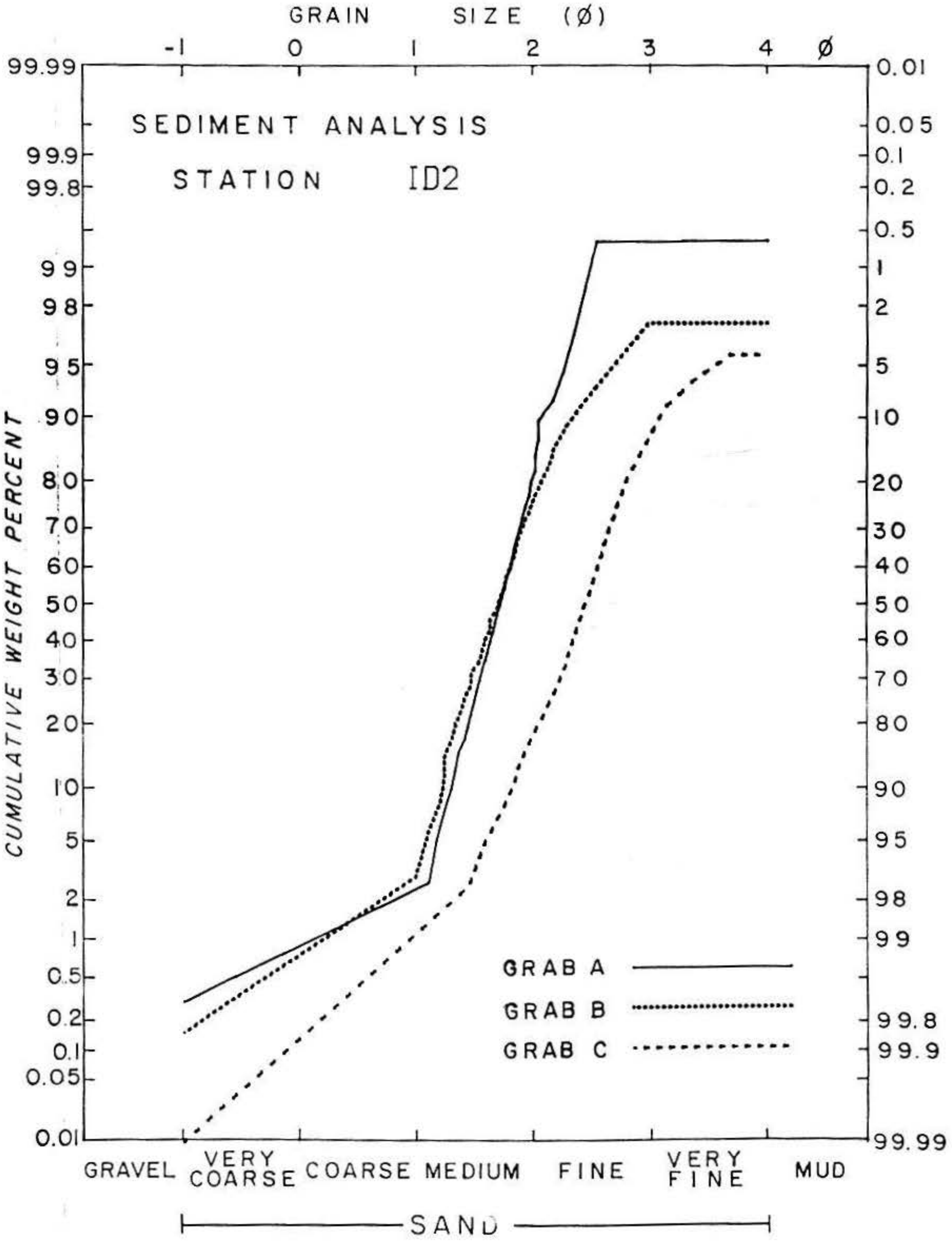
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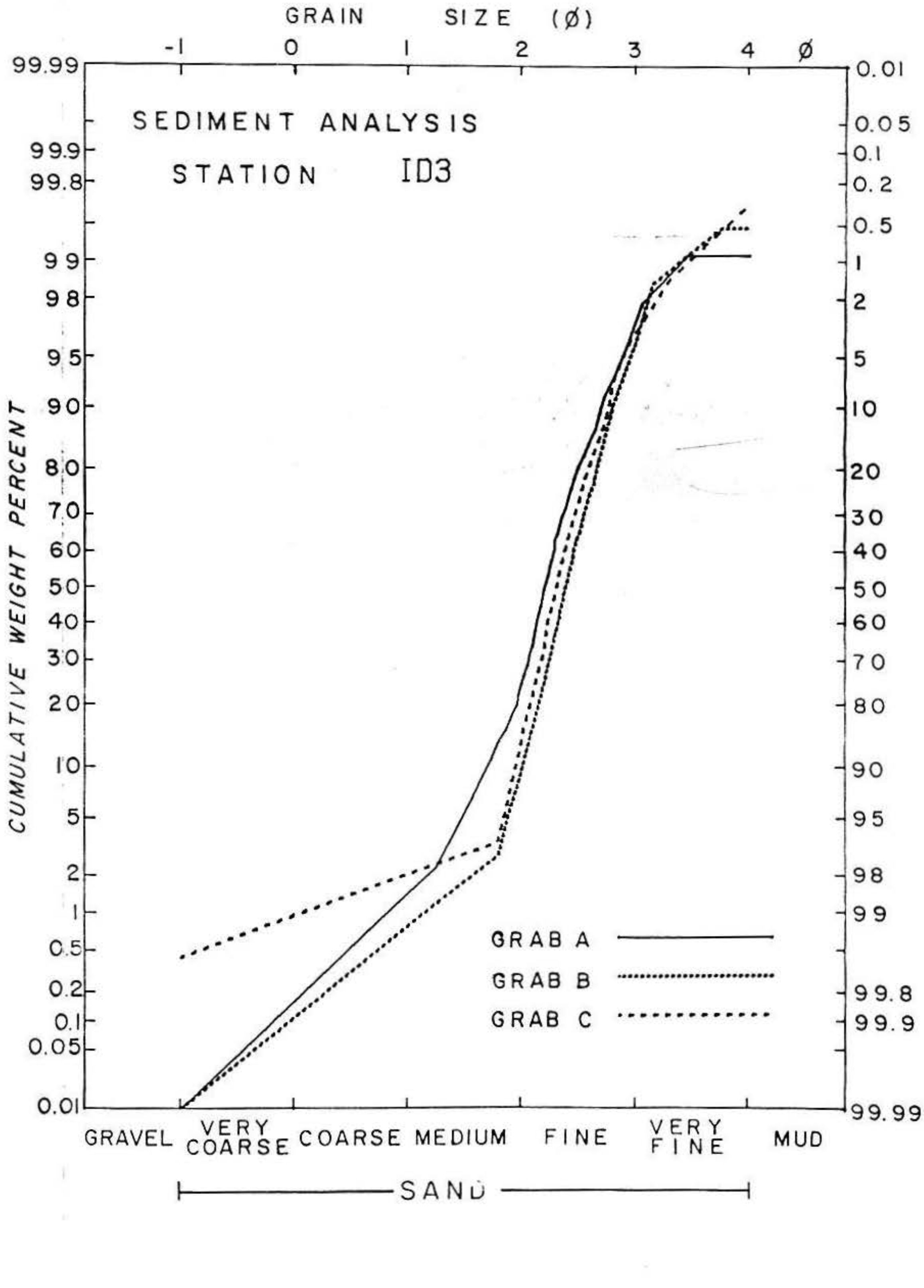
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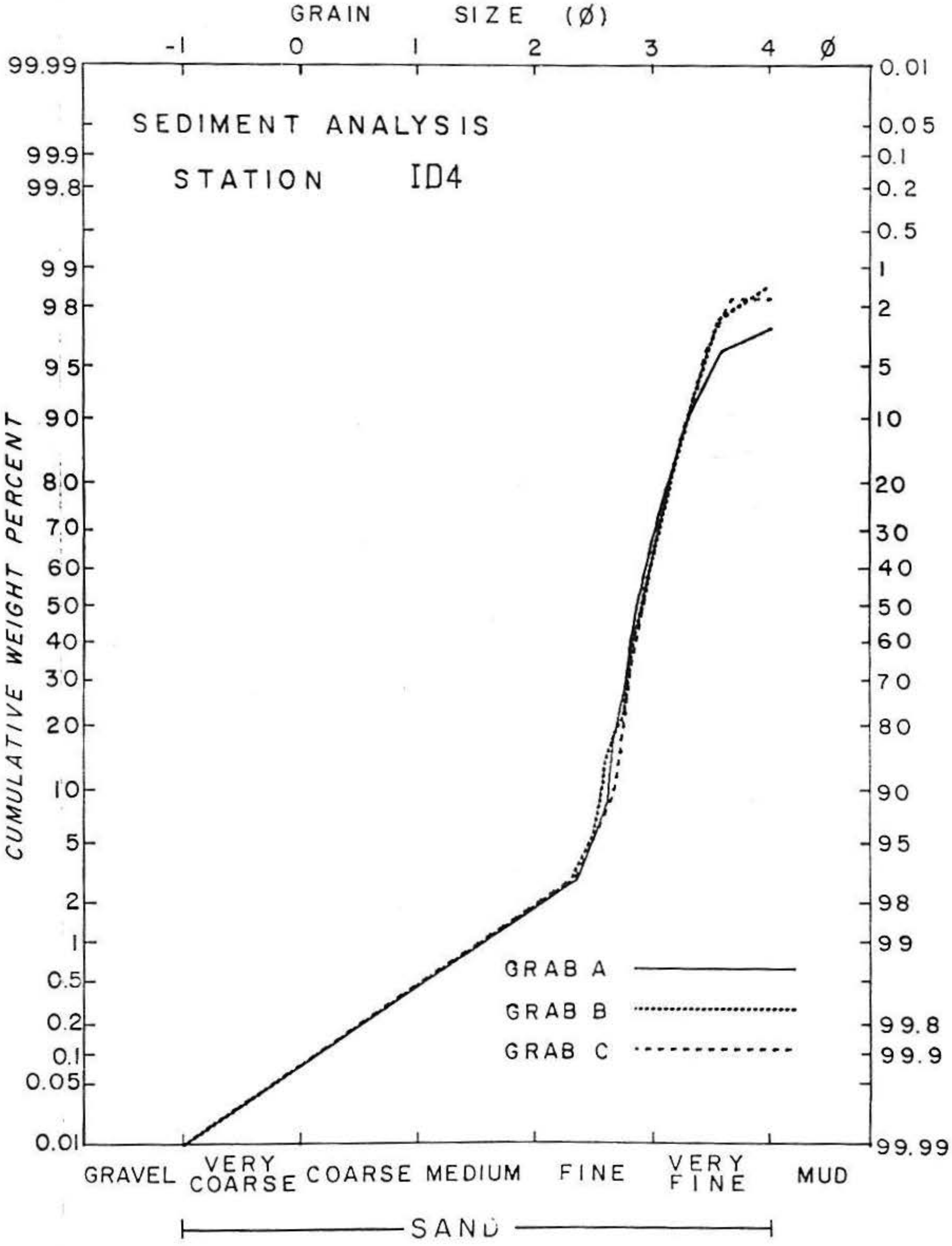
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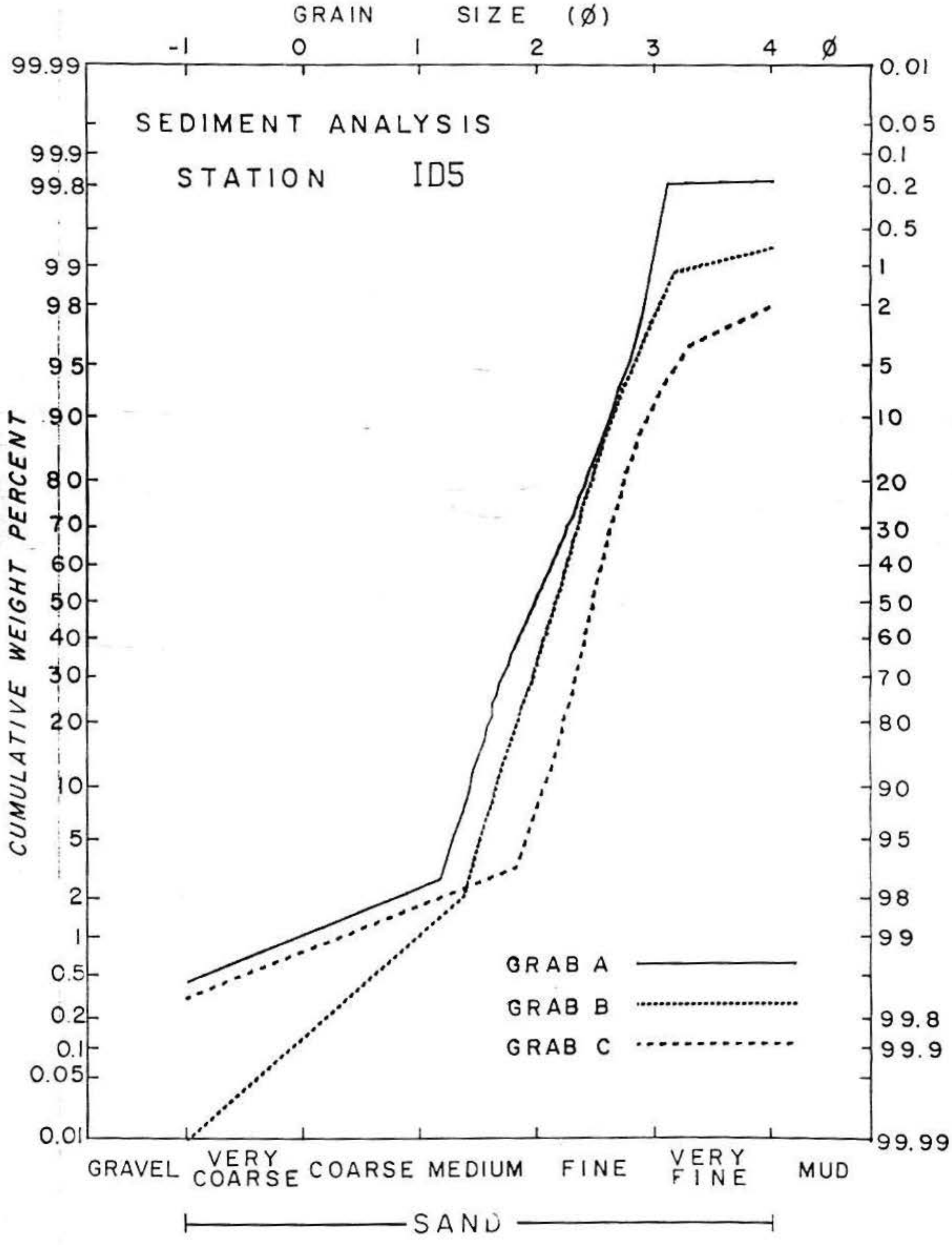
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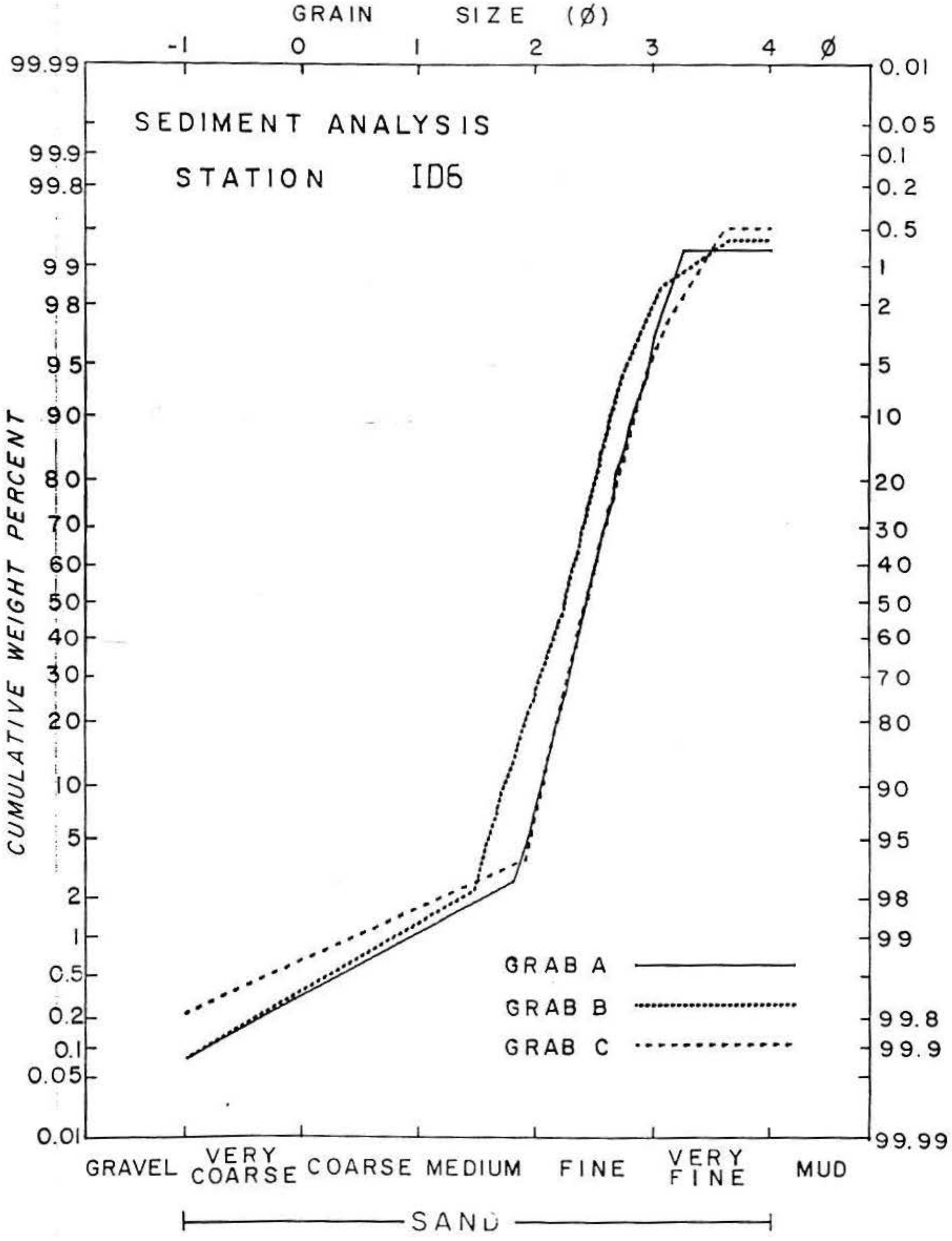
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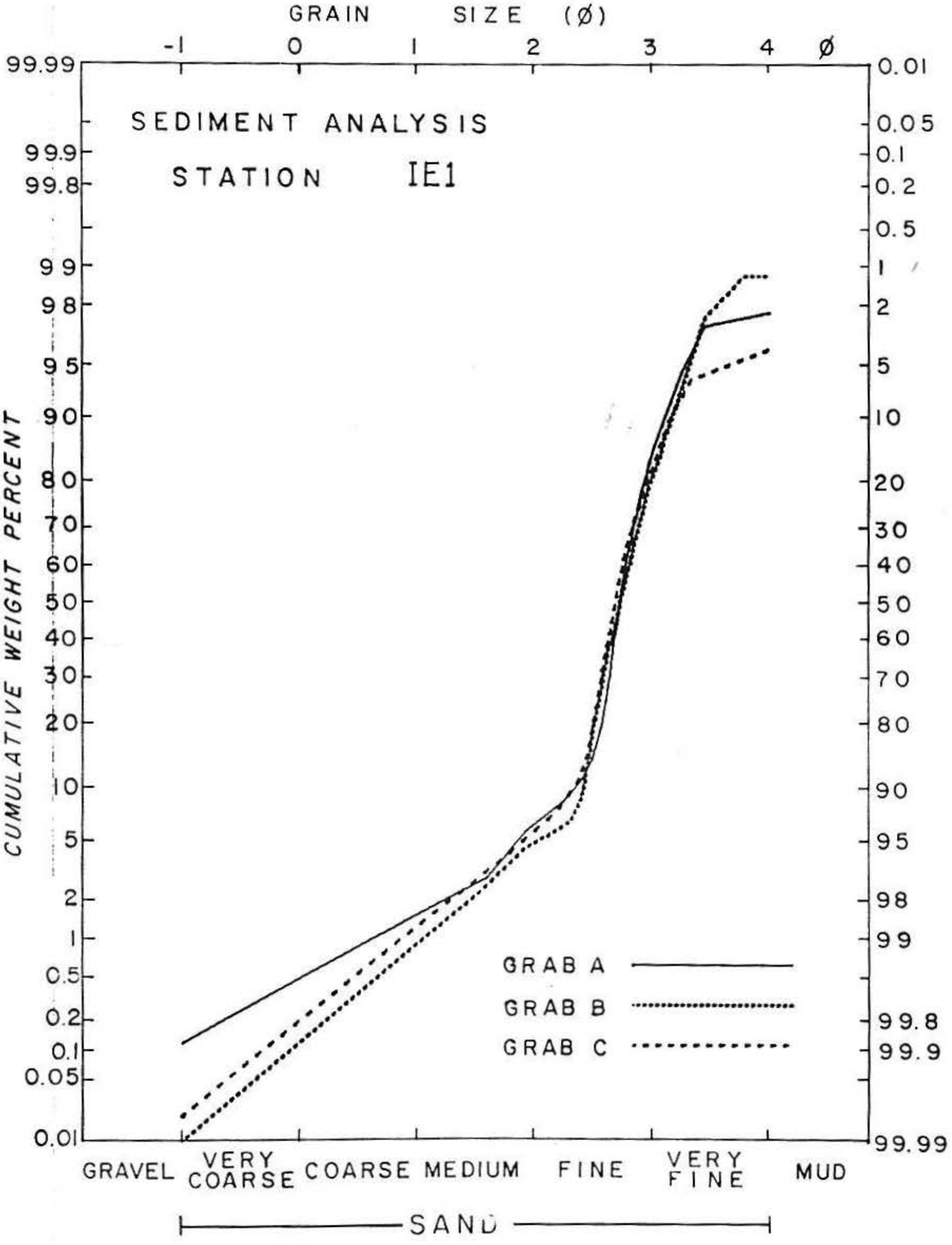
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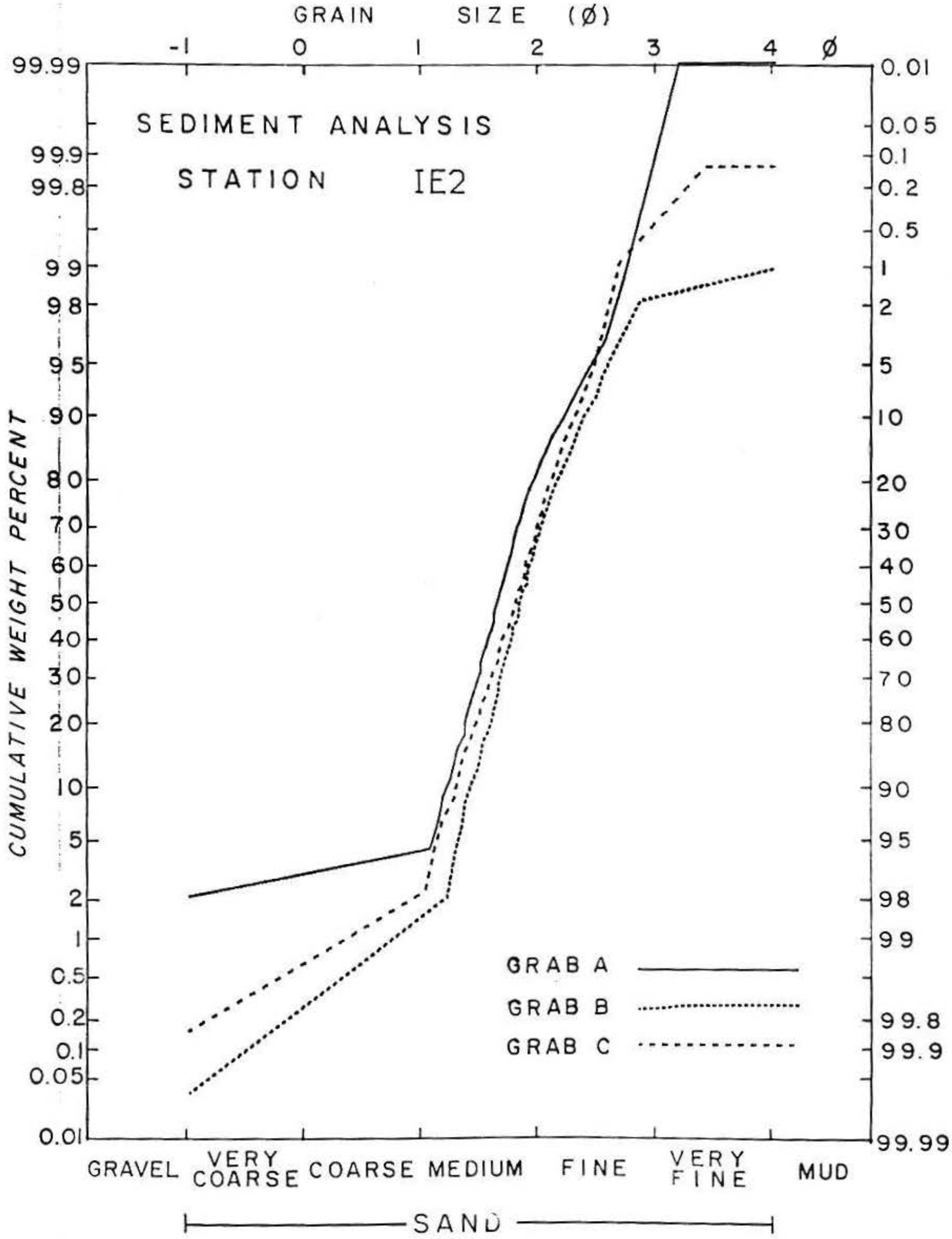
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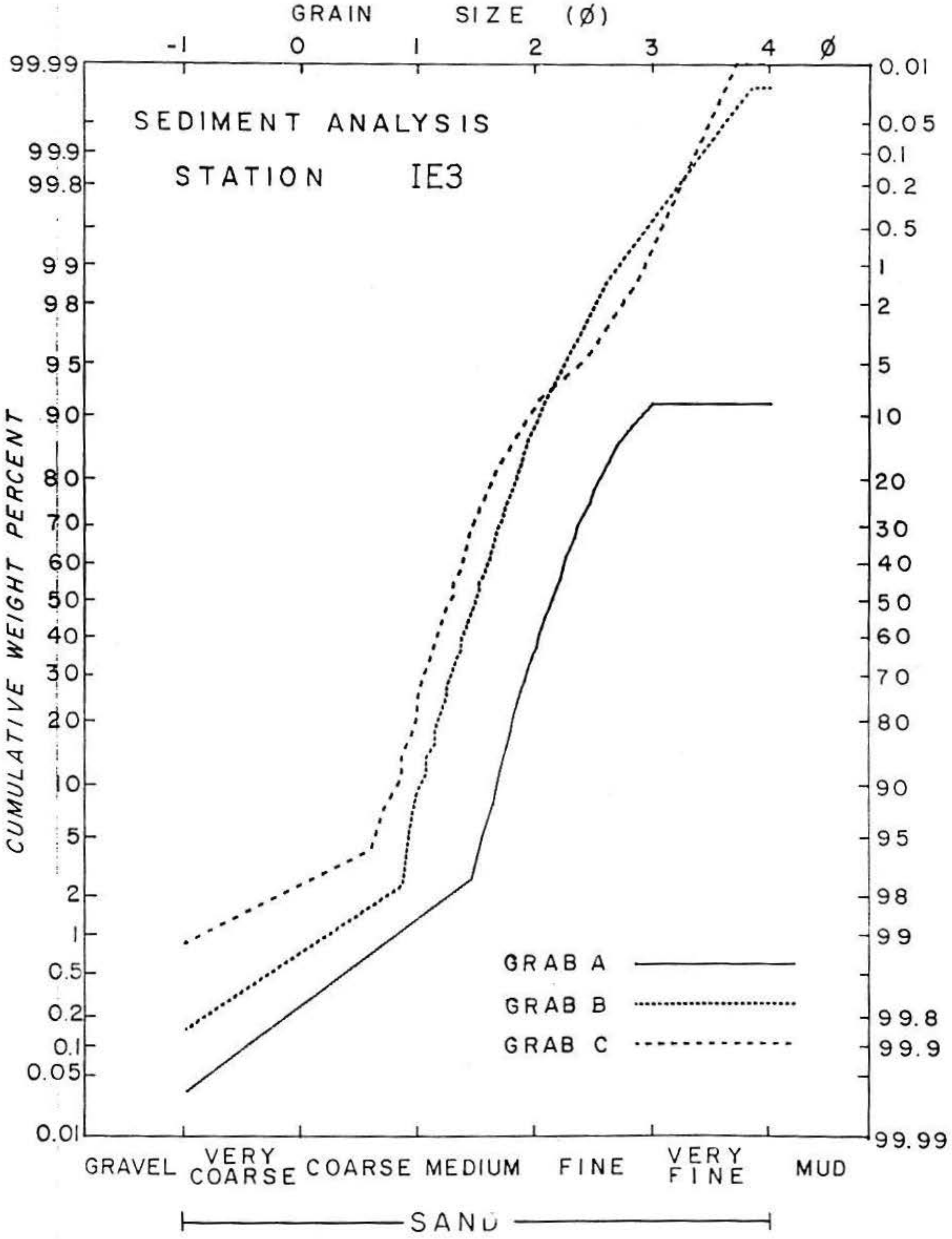
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GRAB A
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GRAB C
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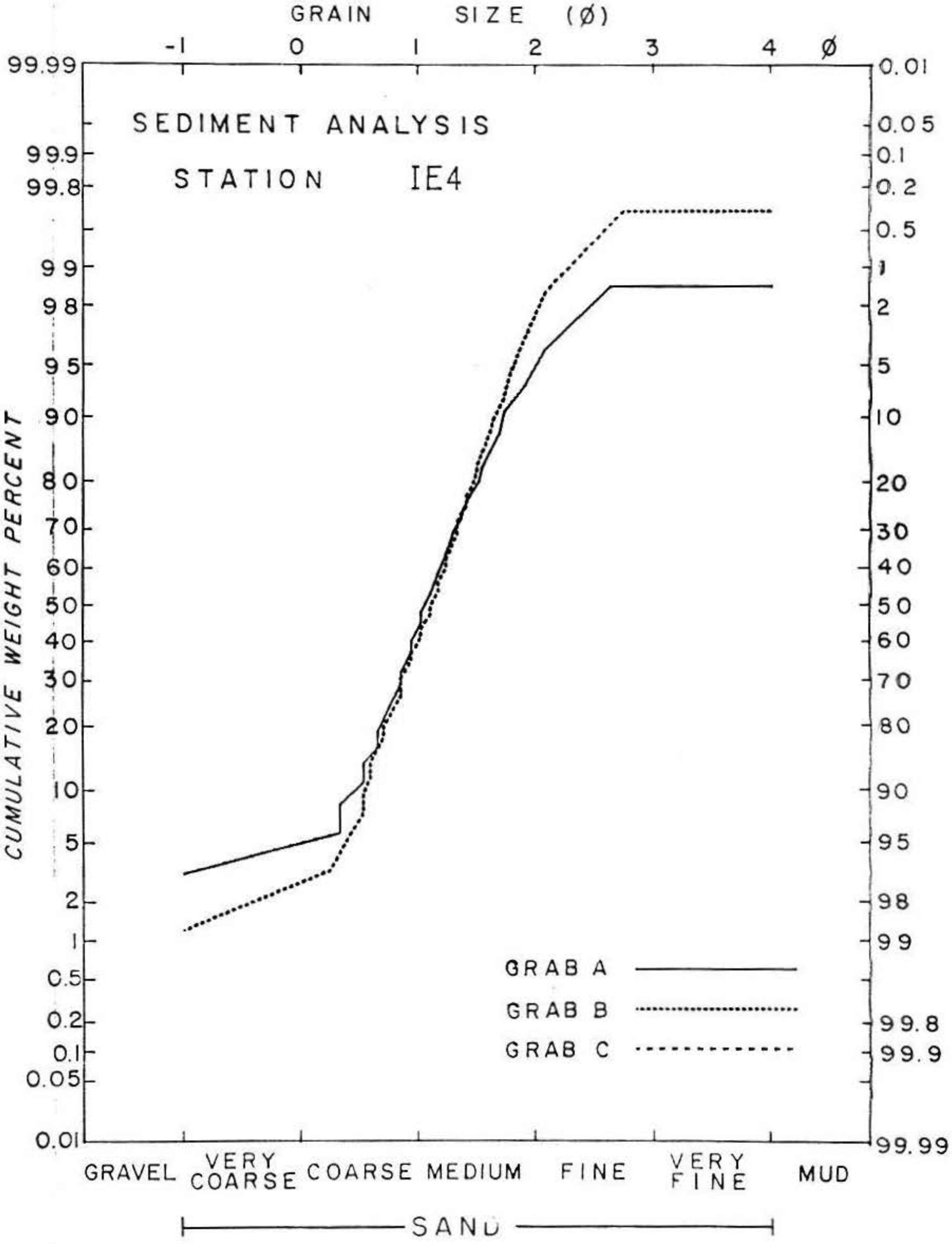
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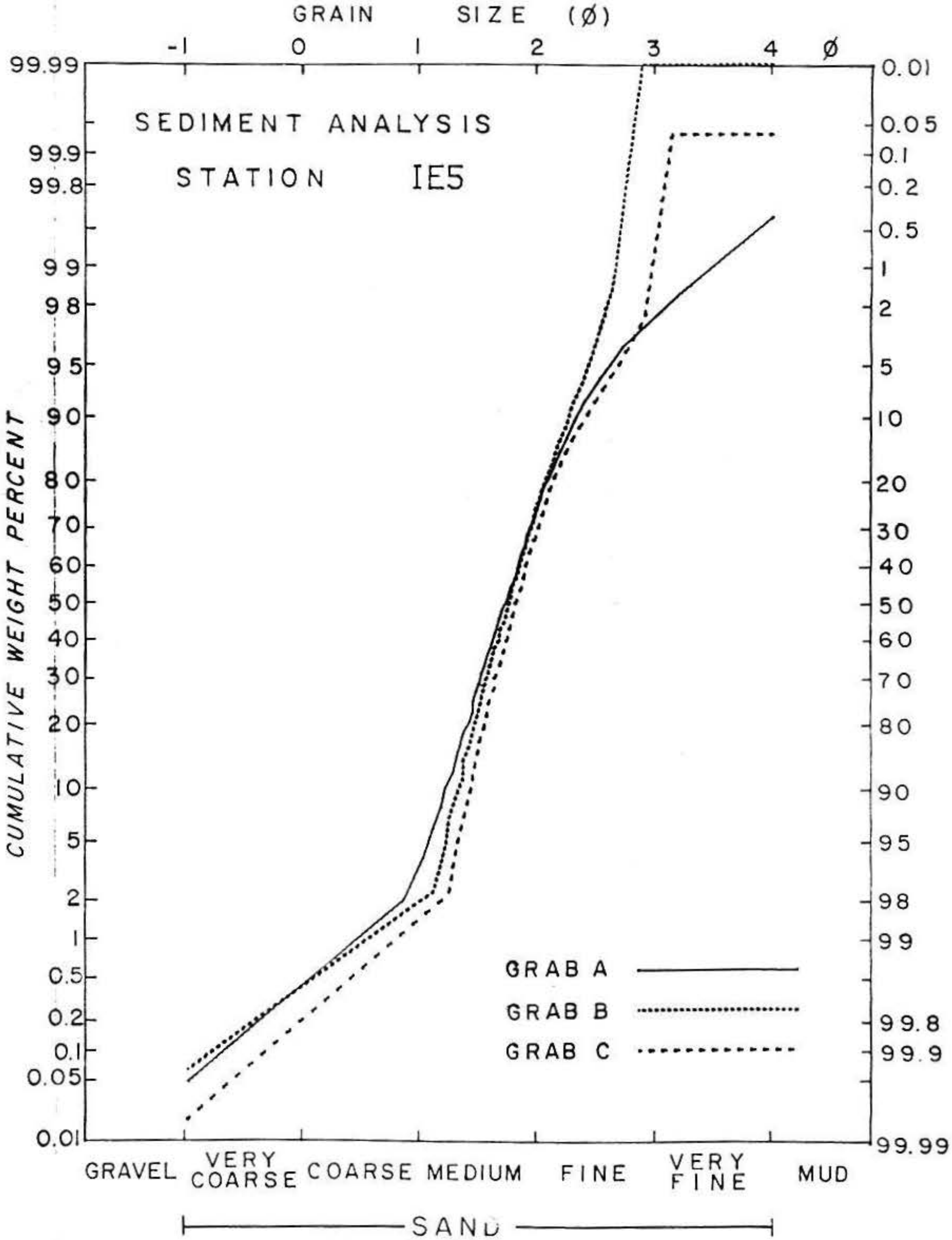
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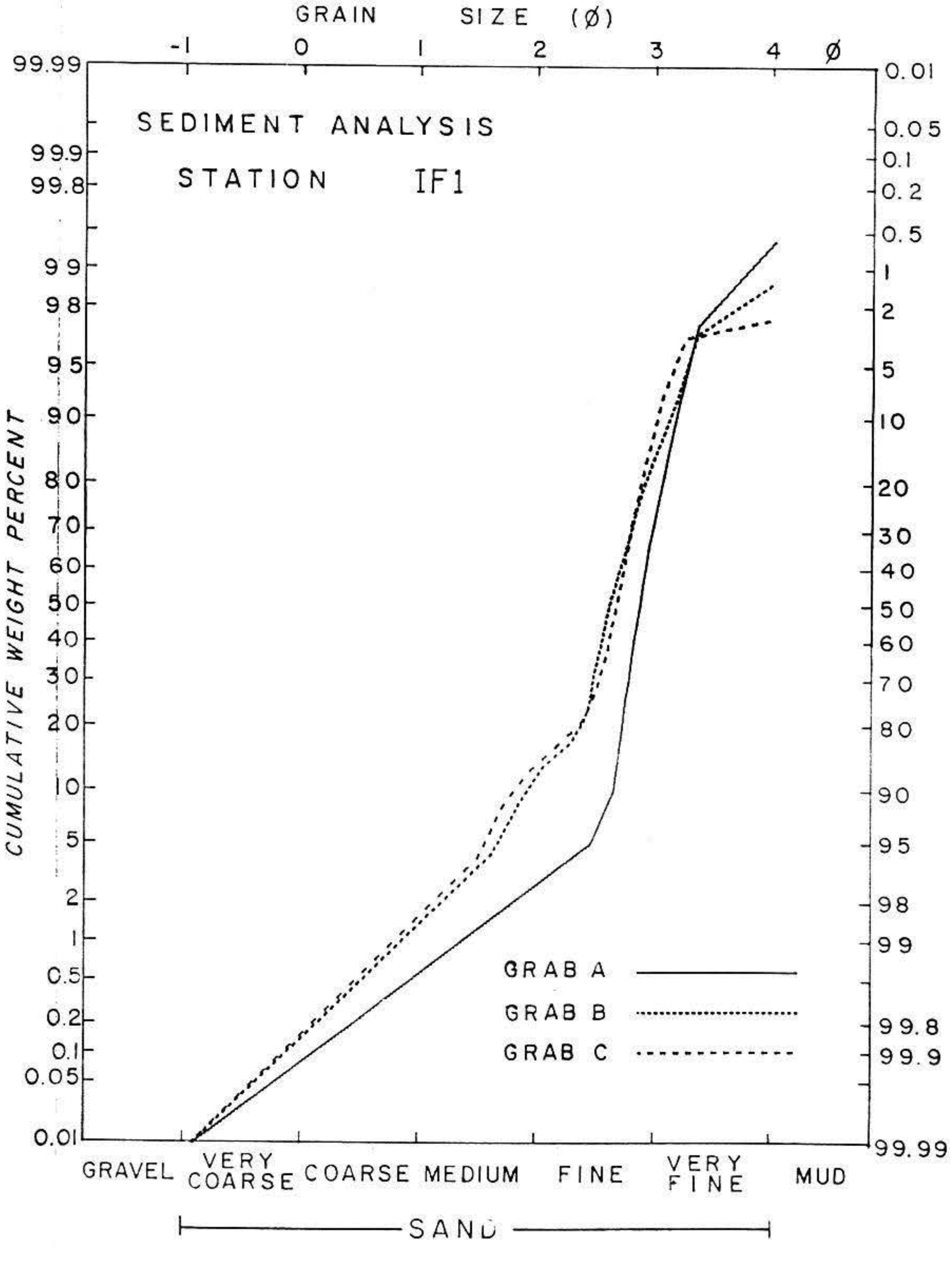
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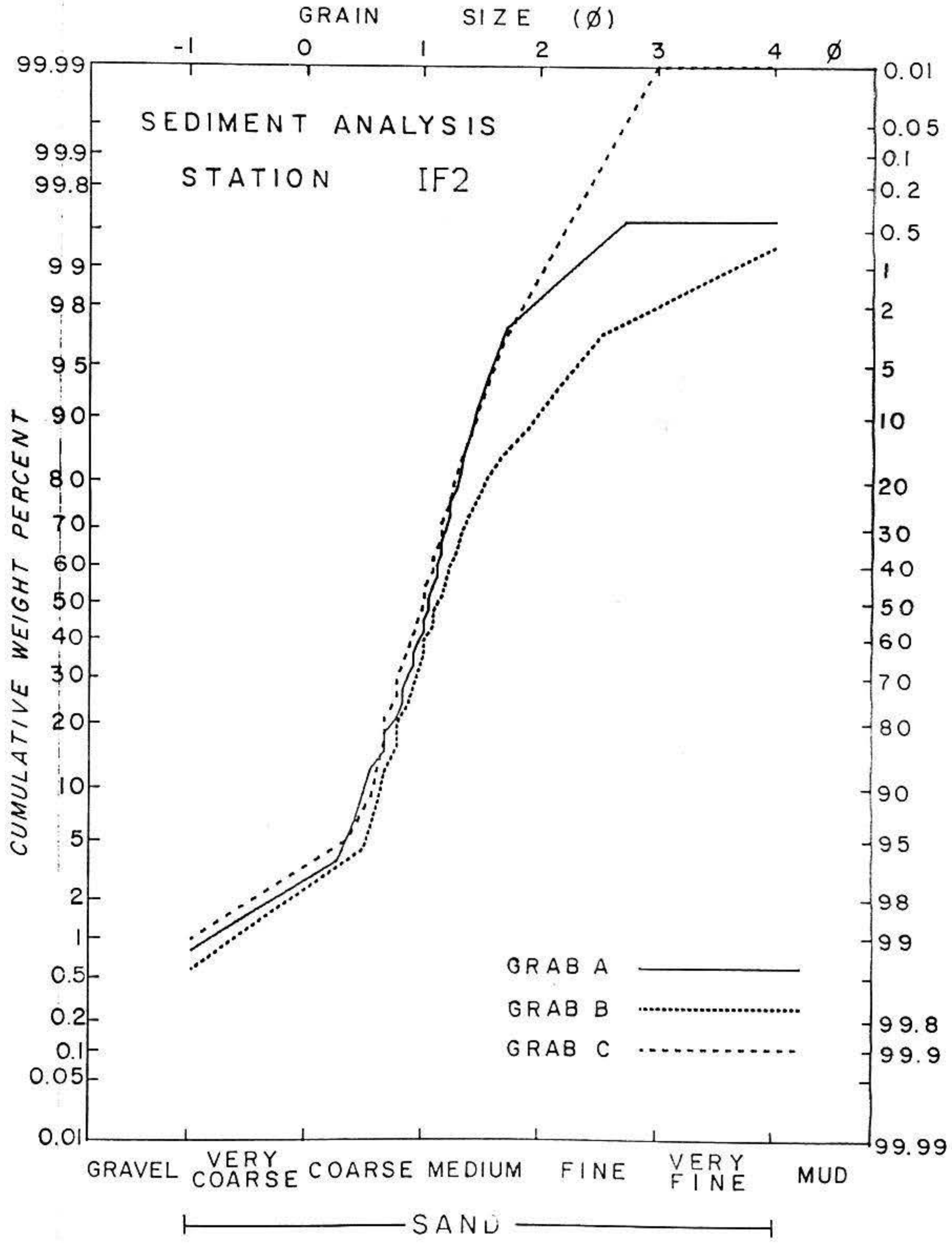
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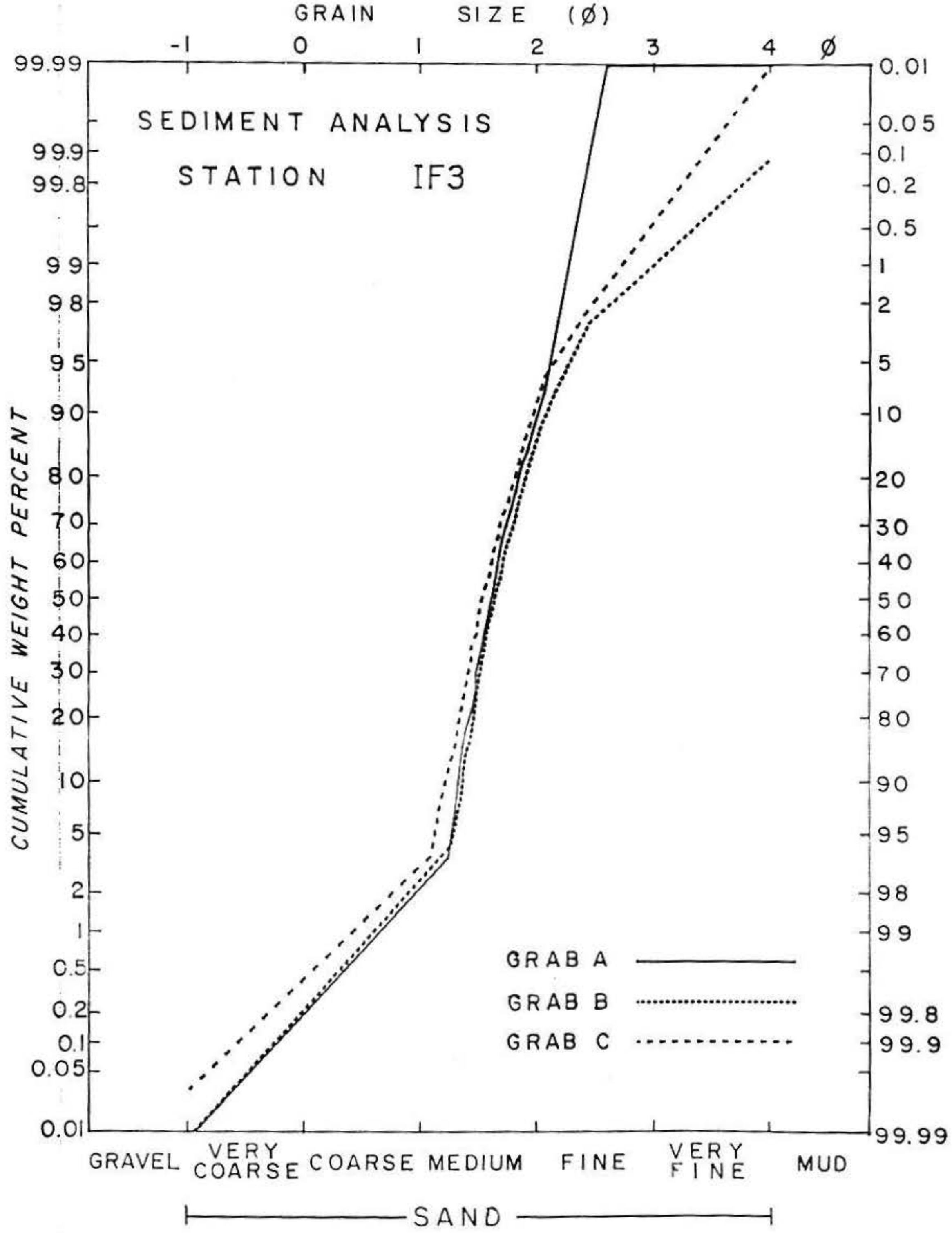
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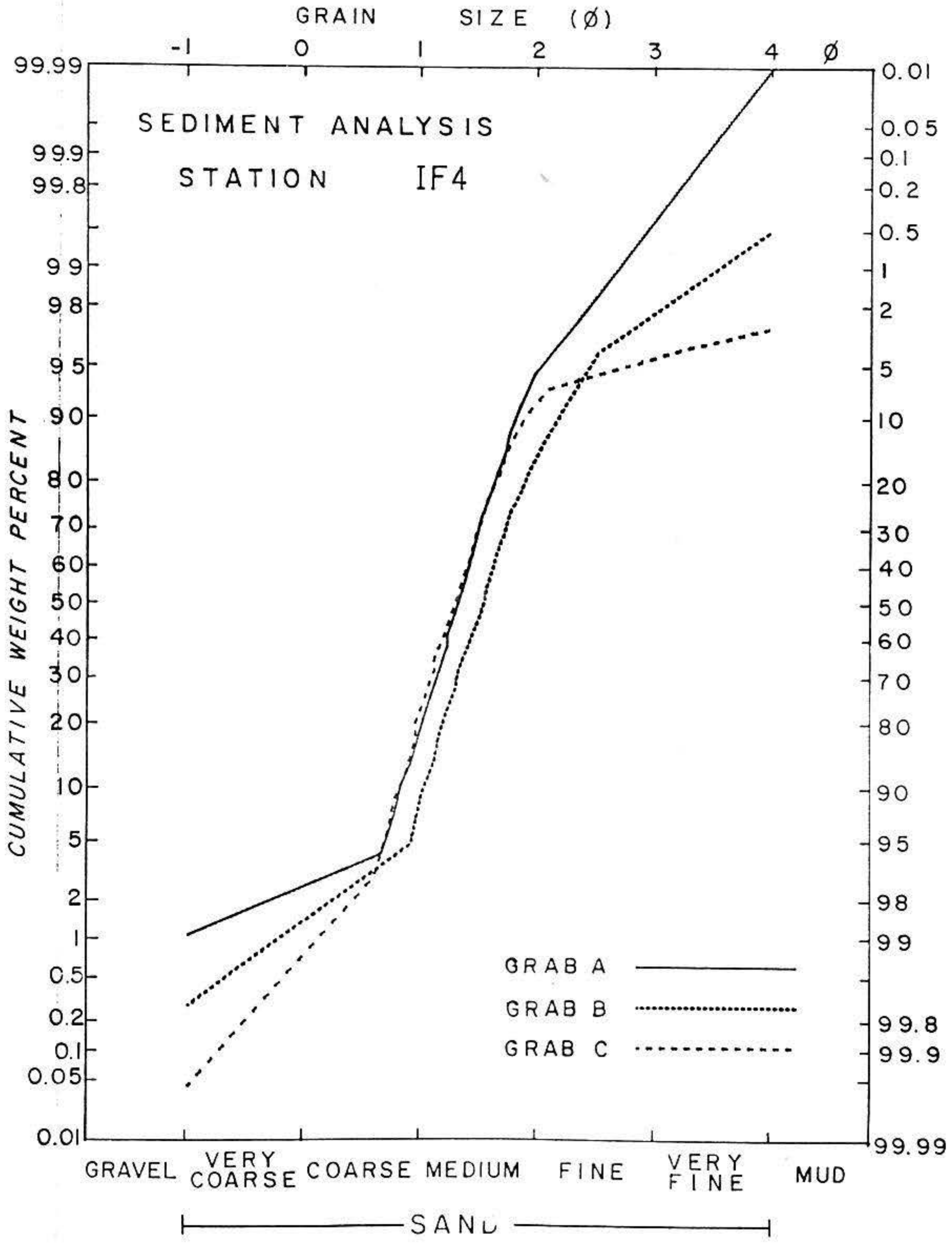
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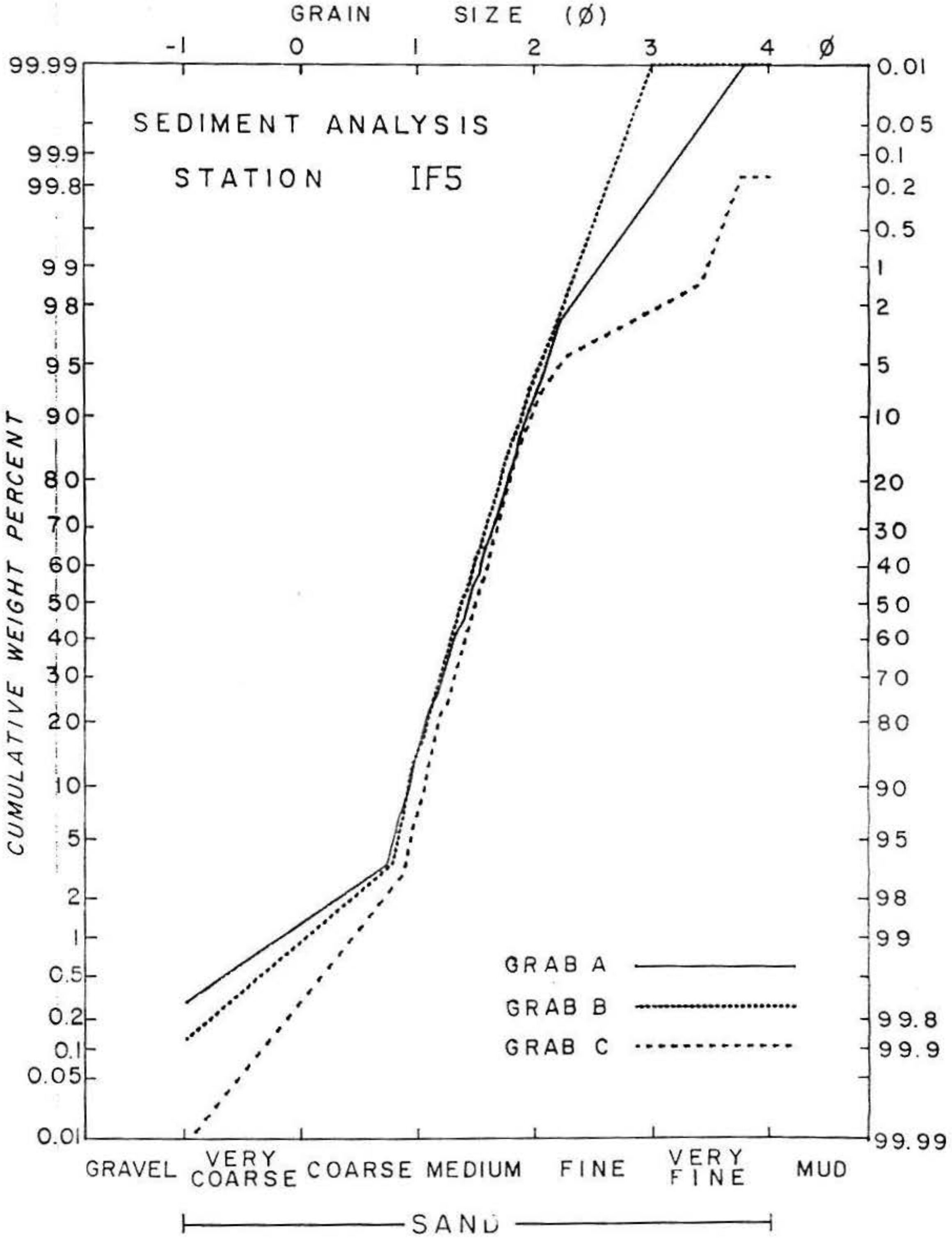
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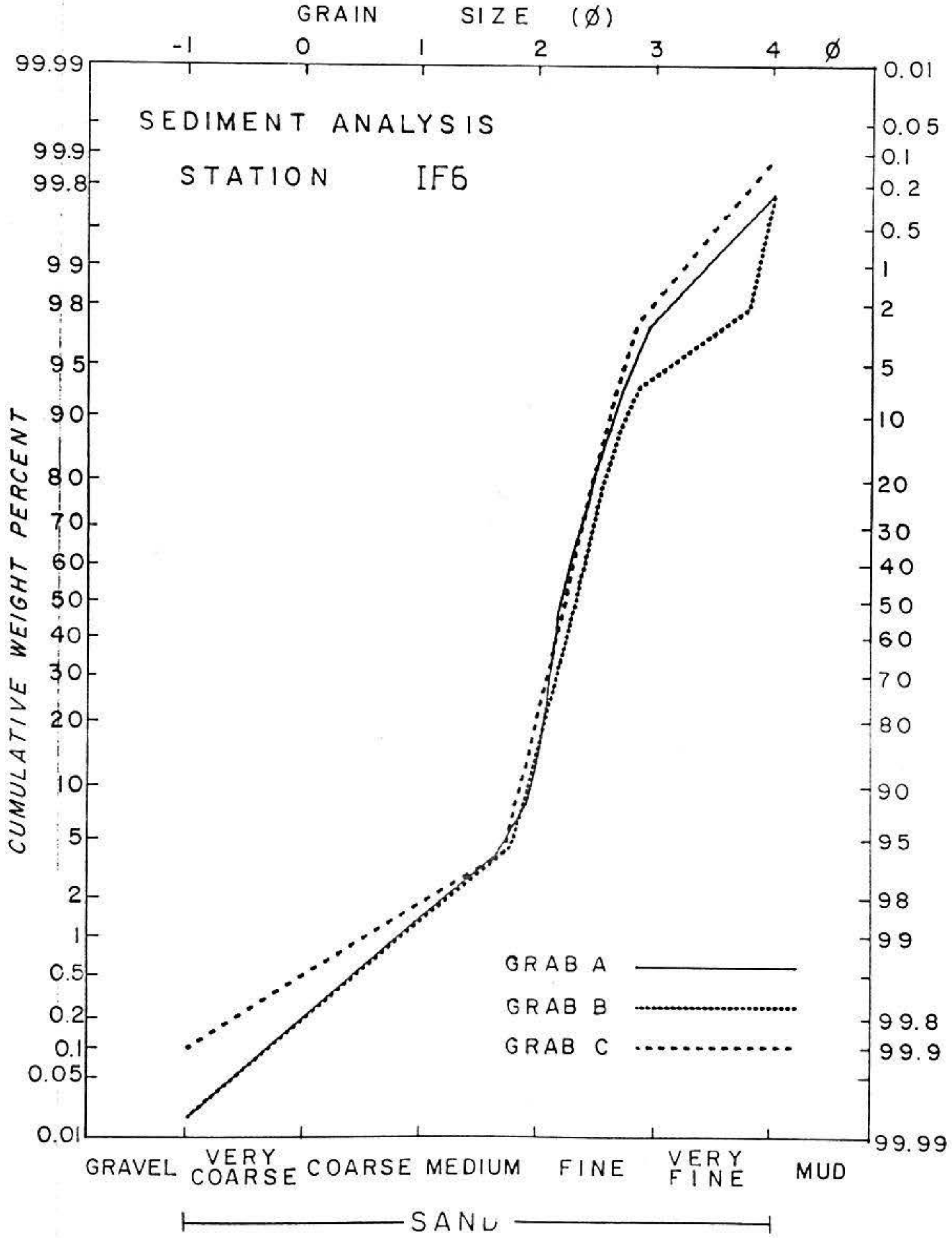
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99.9
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MEDIUM
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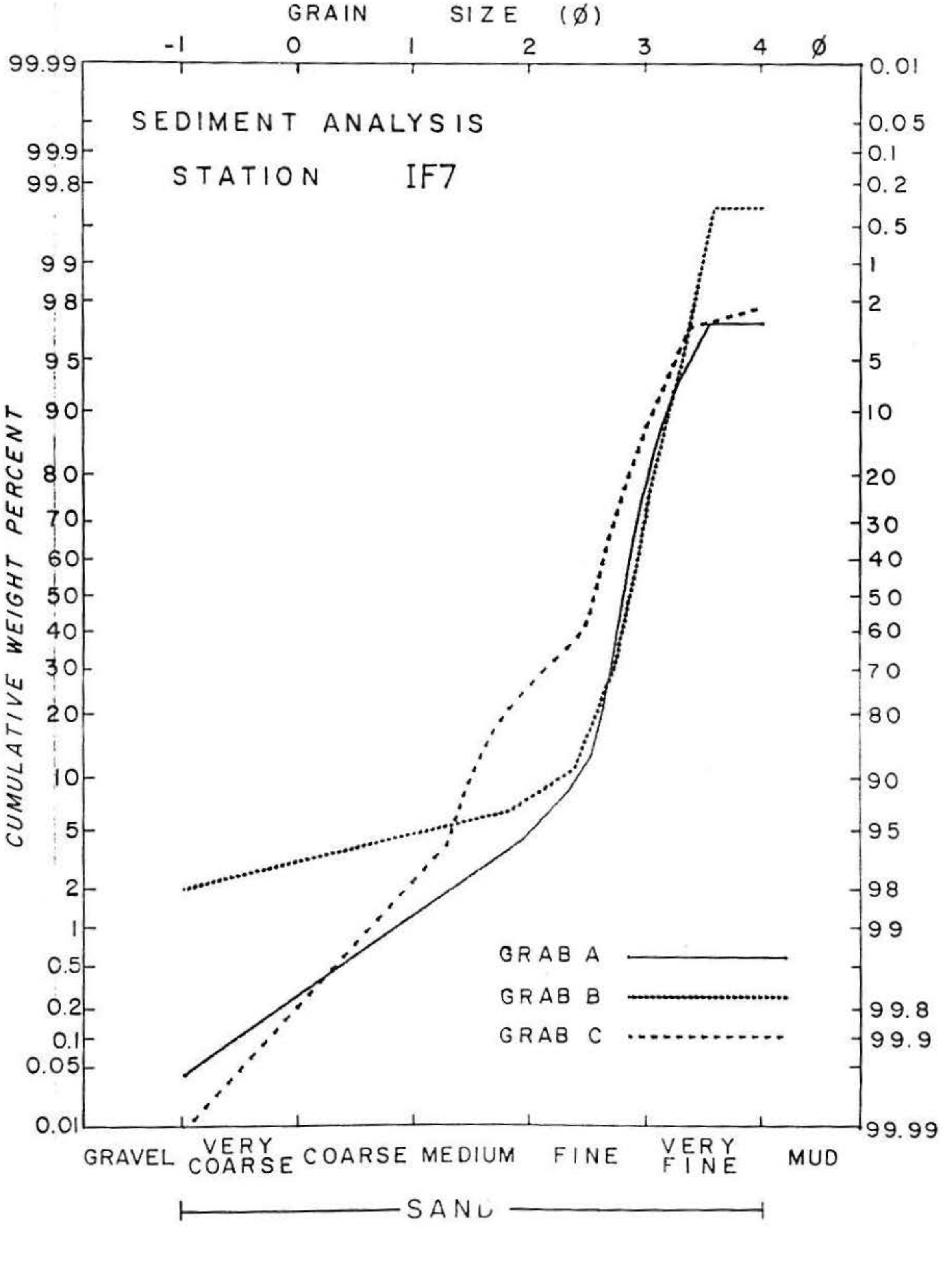
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STATION IF7
CUMULATIVE WEIGHT PERCENT
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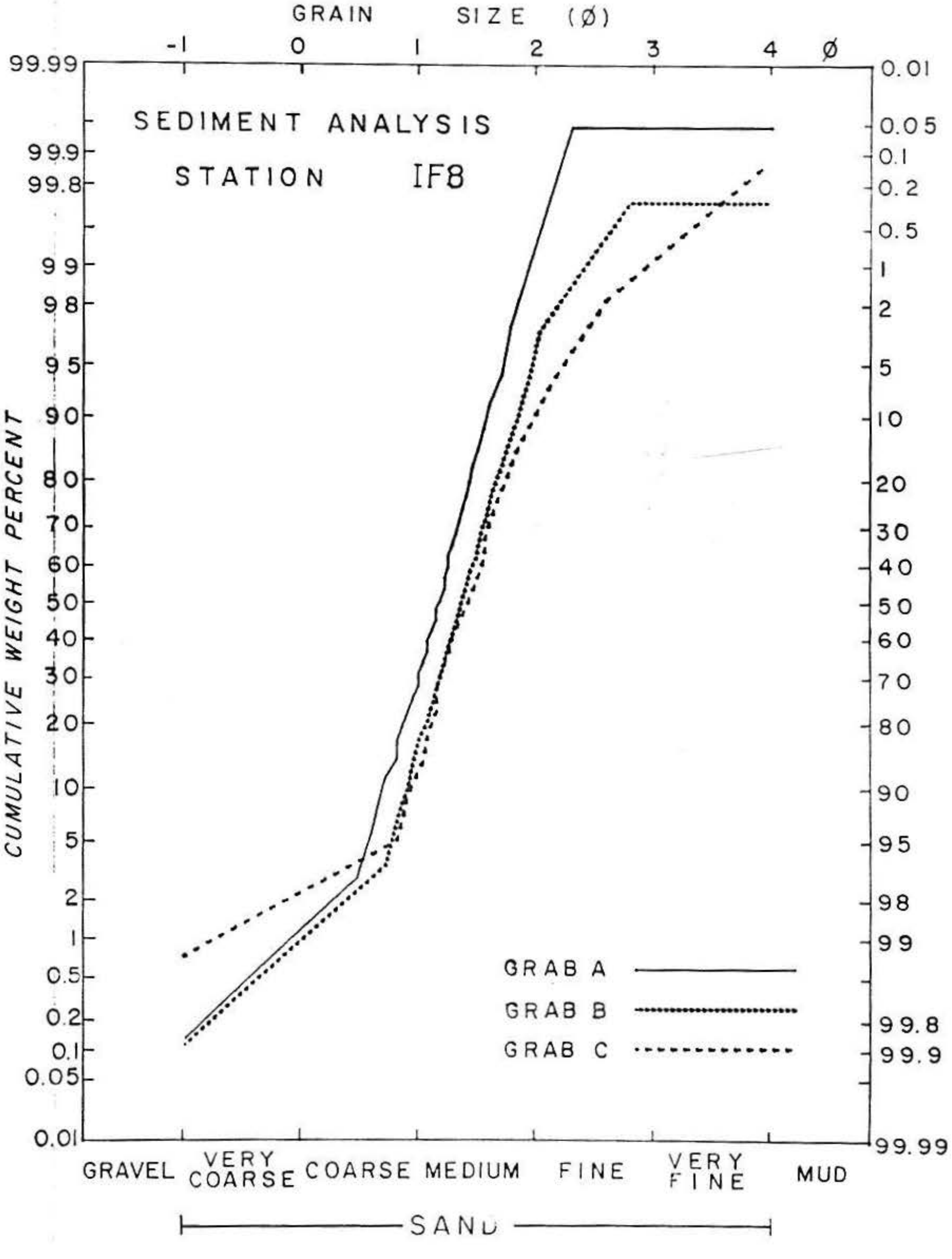
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STATION IF8
CUMULATIVE WEIGHT PERCENT
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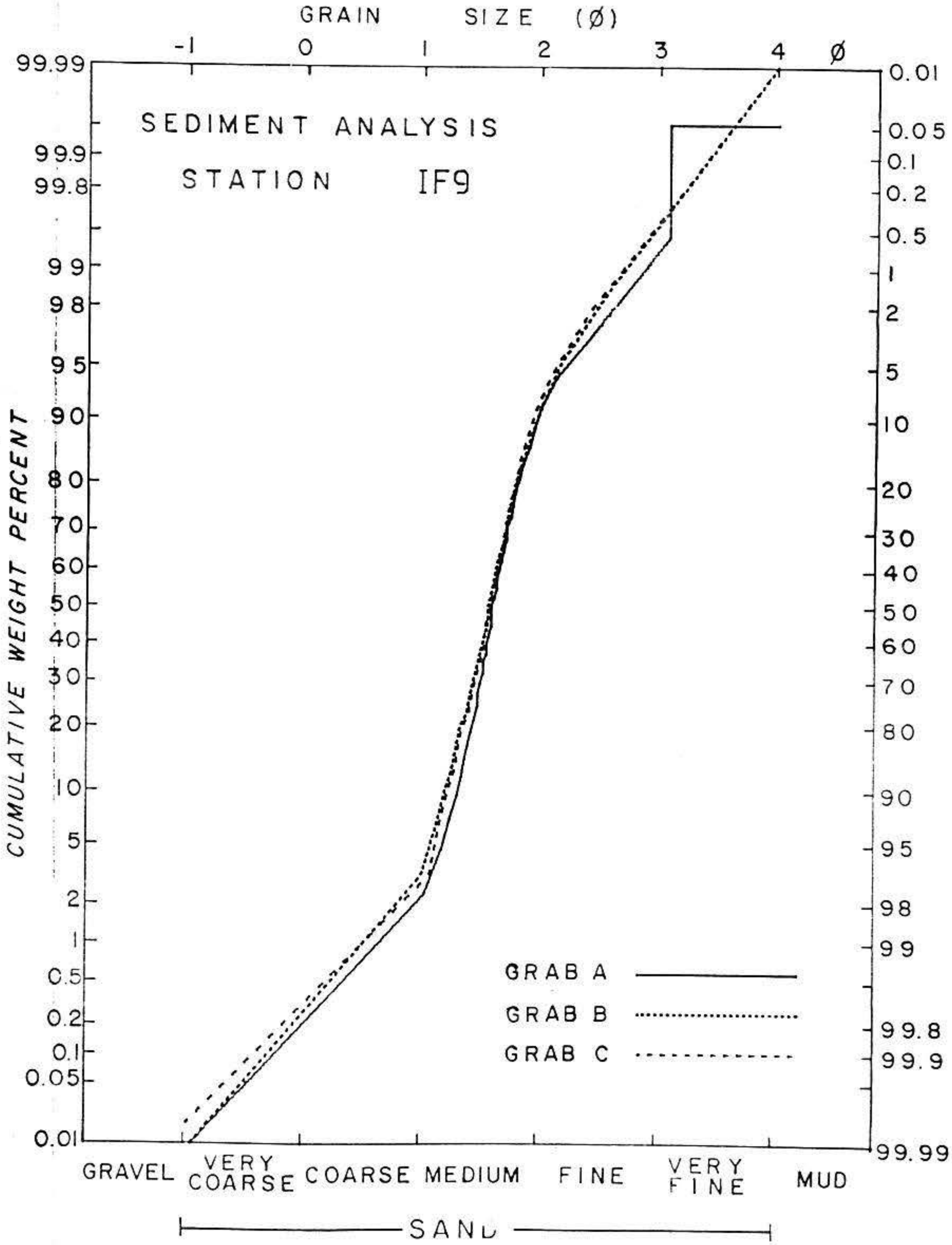
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STATION IF9
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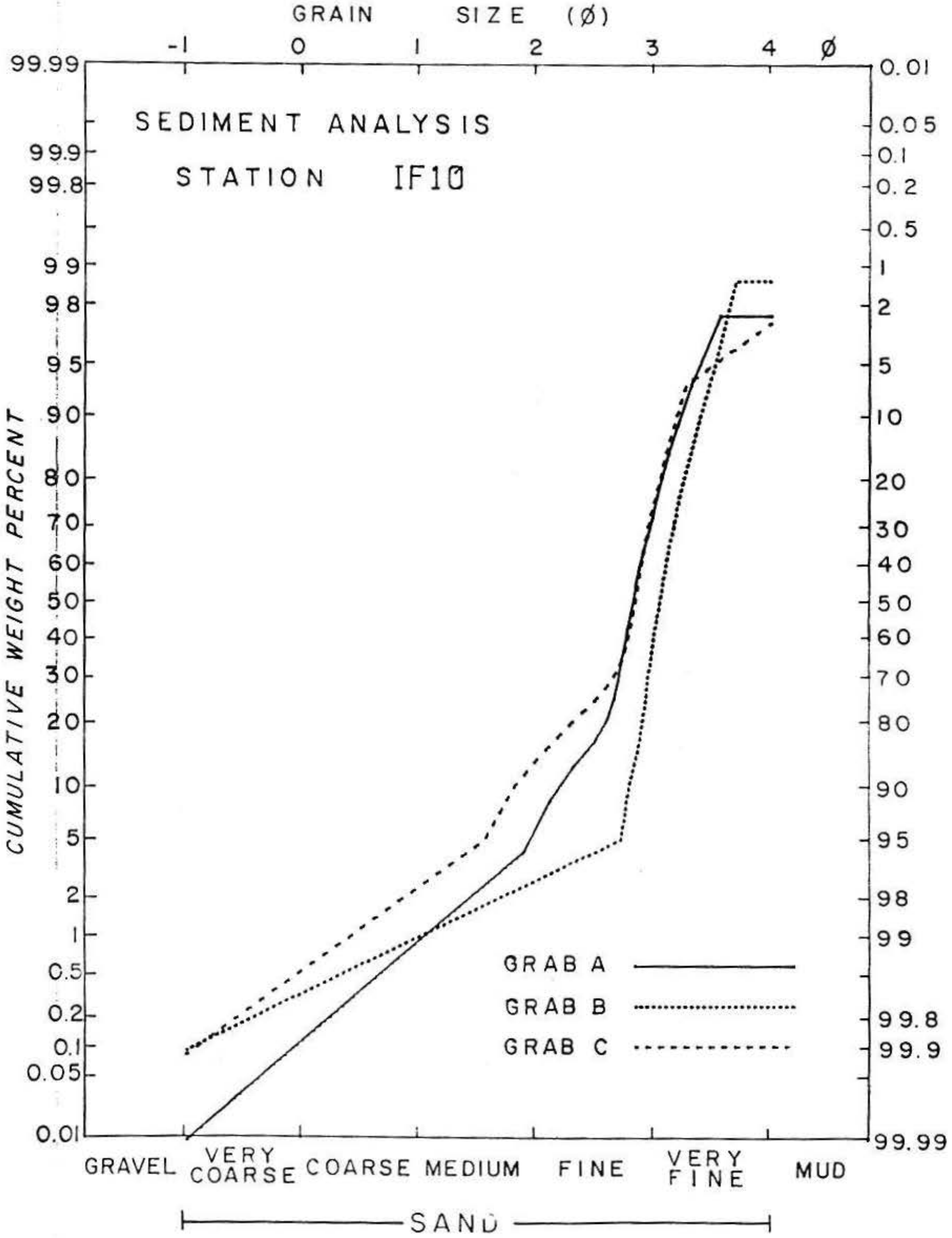
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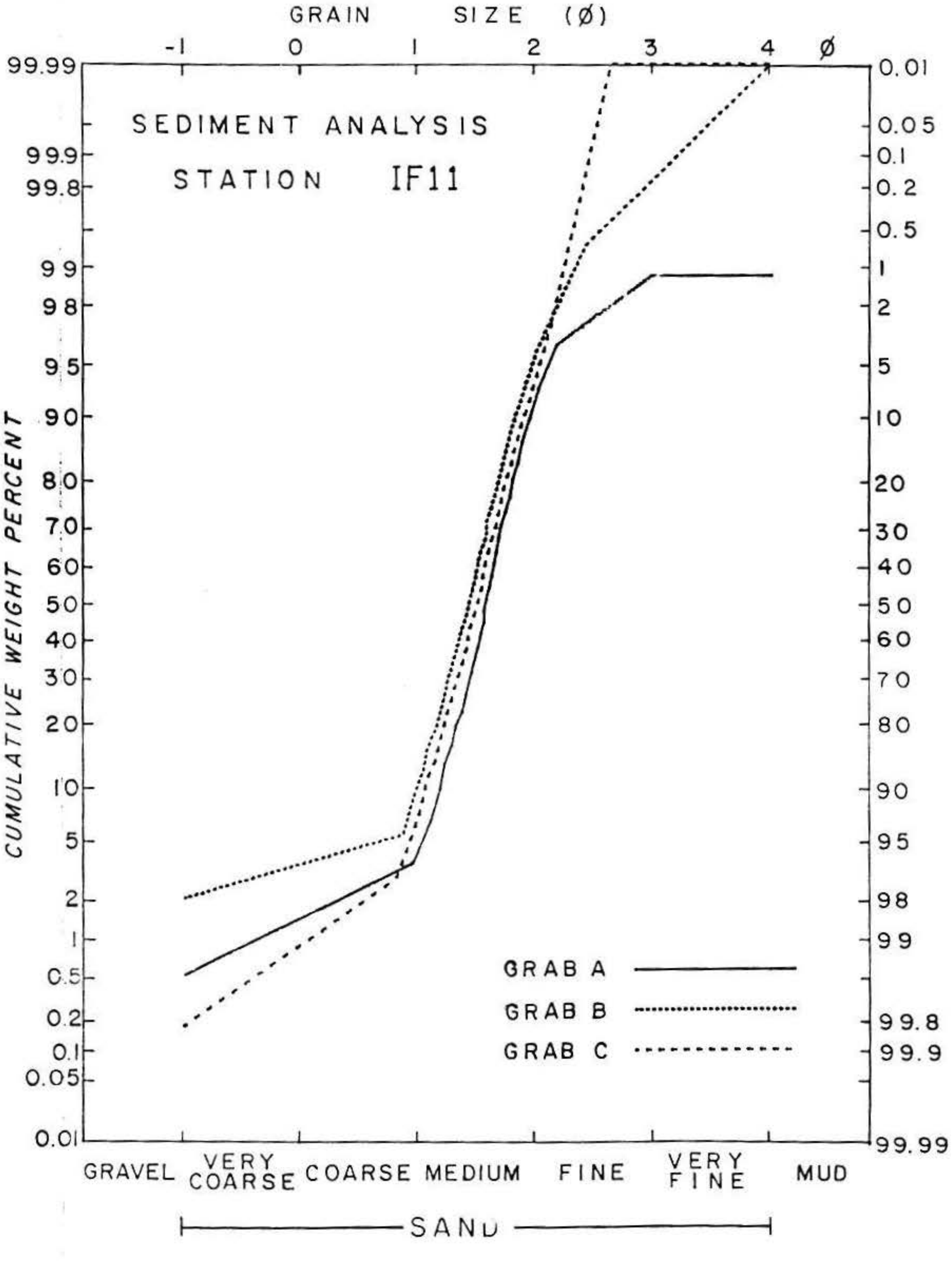
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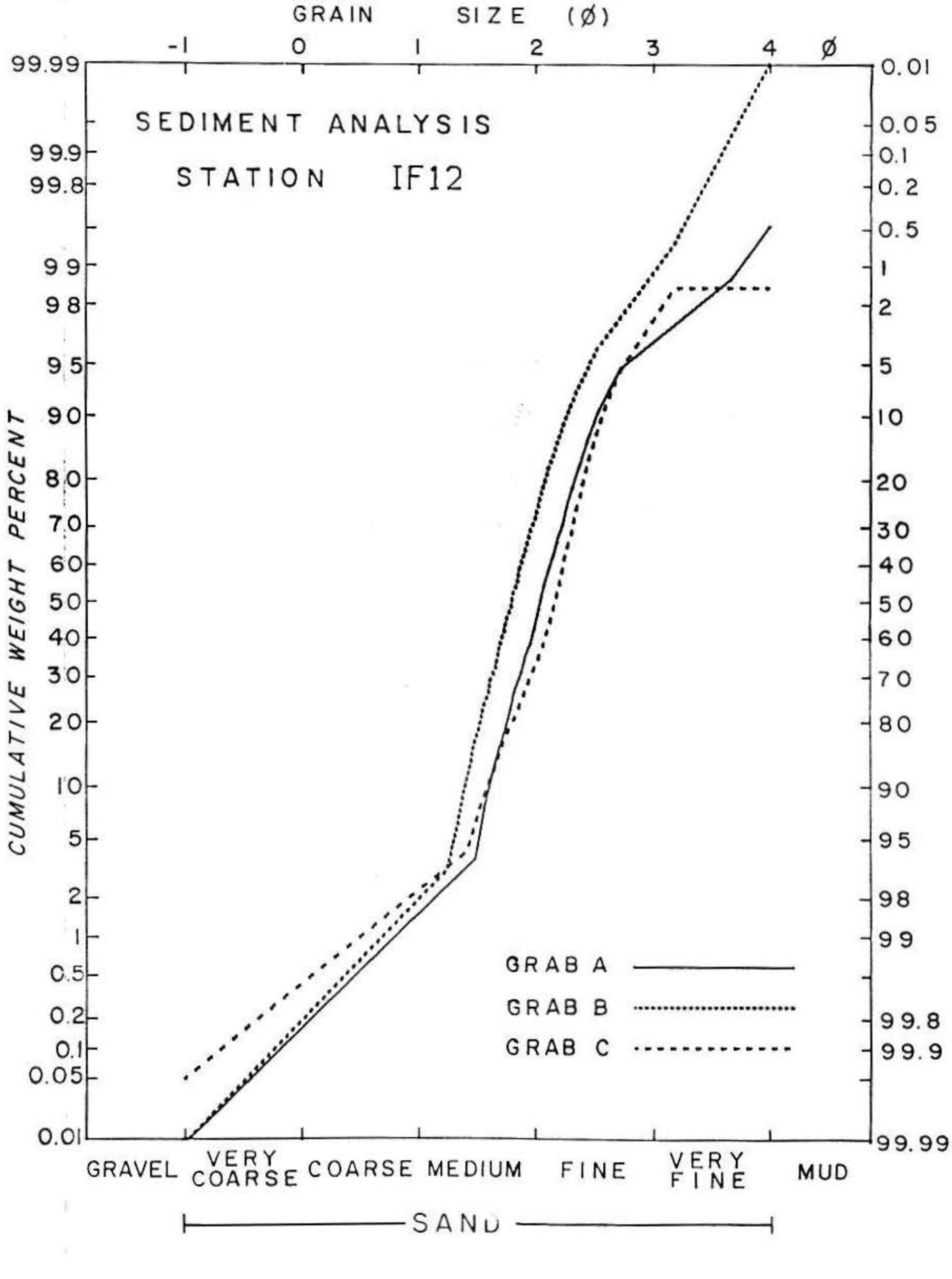
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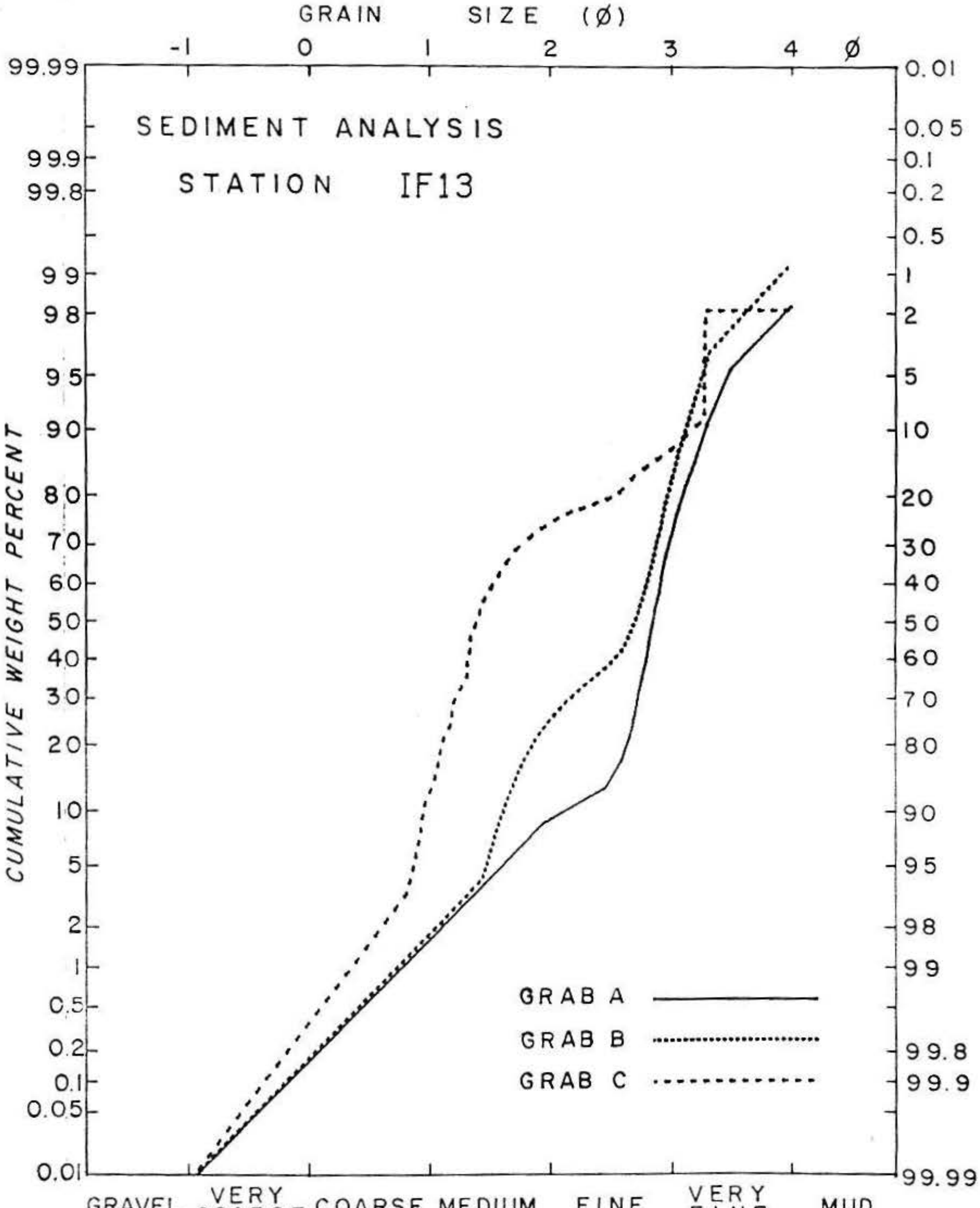
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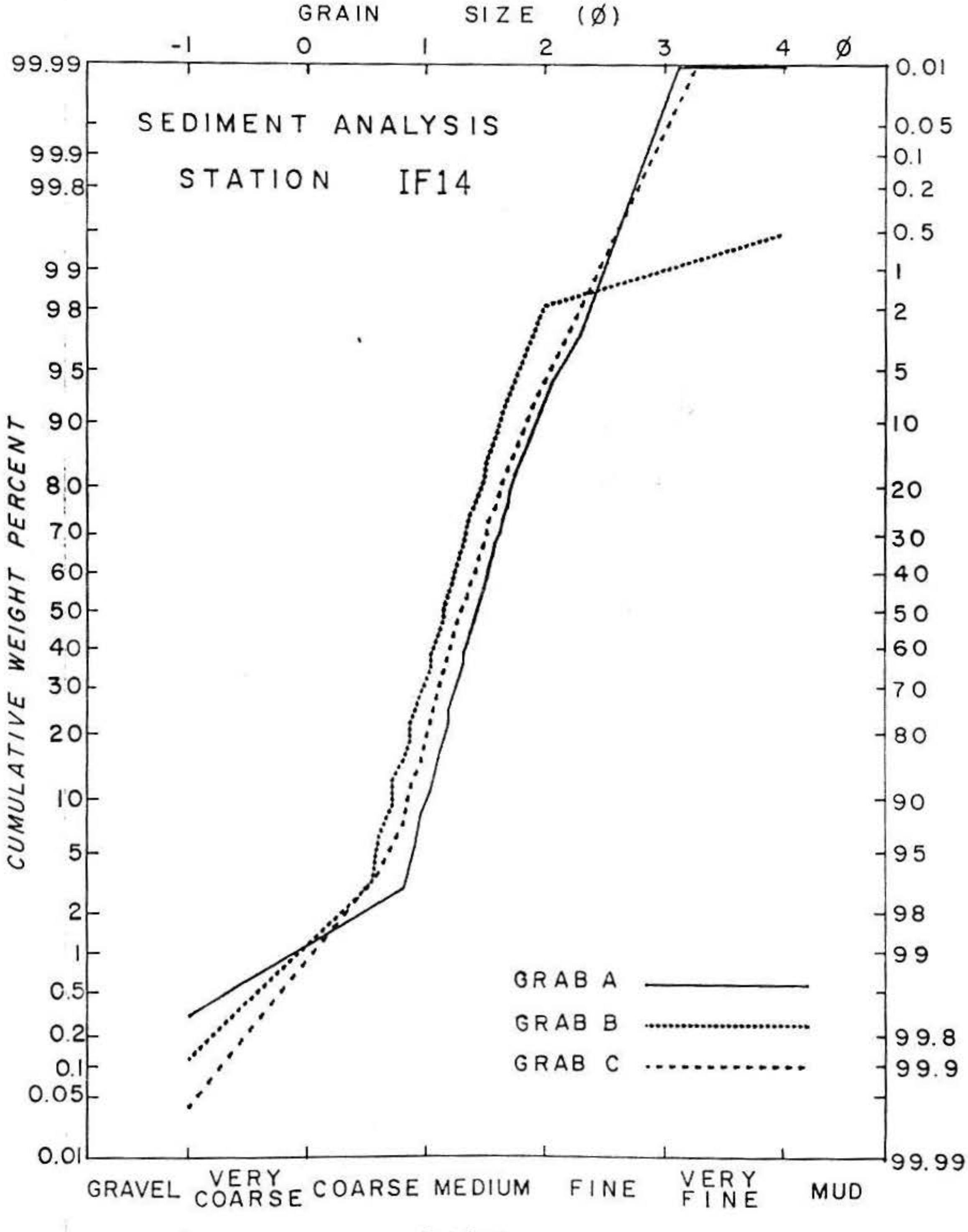
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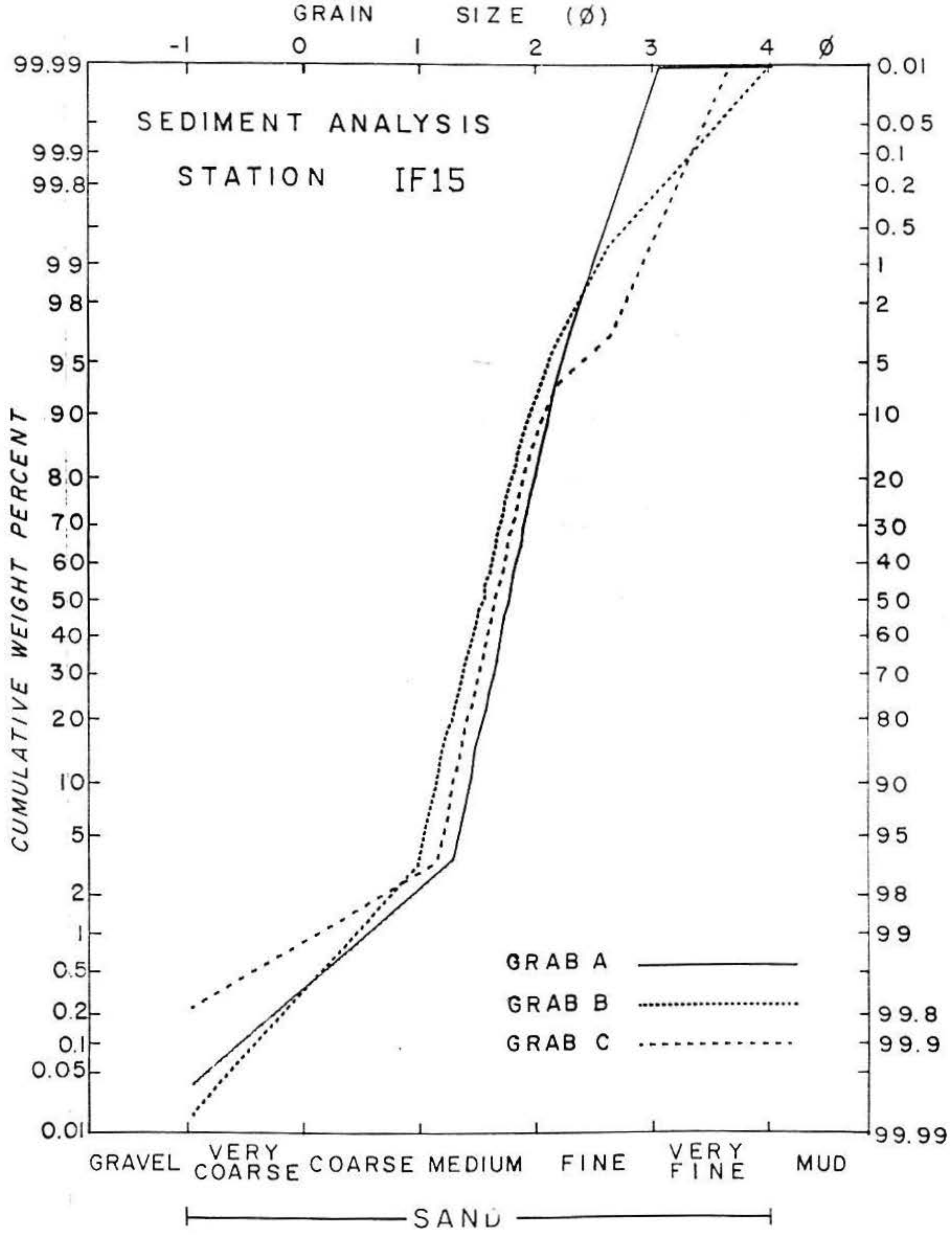
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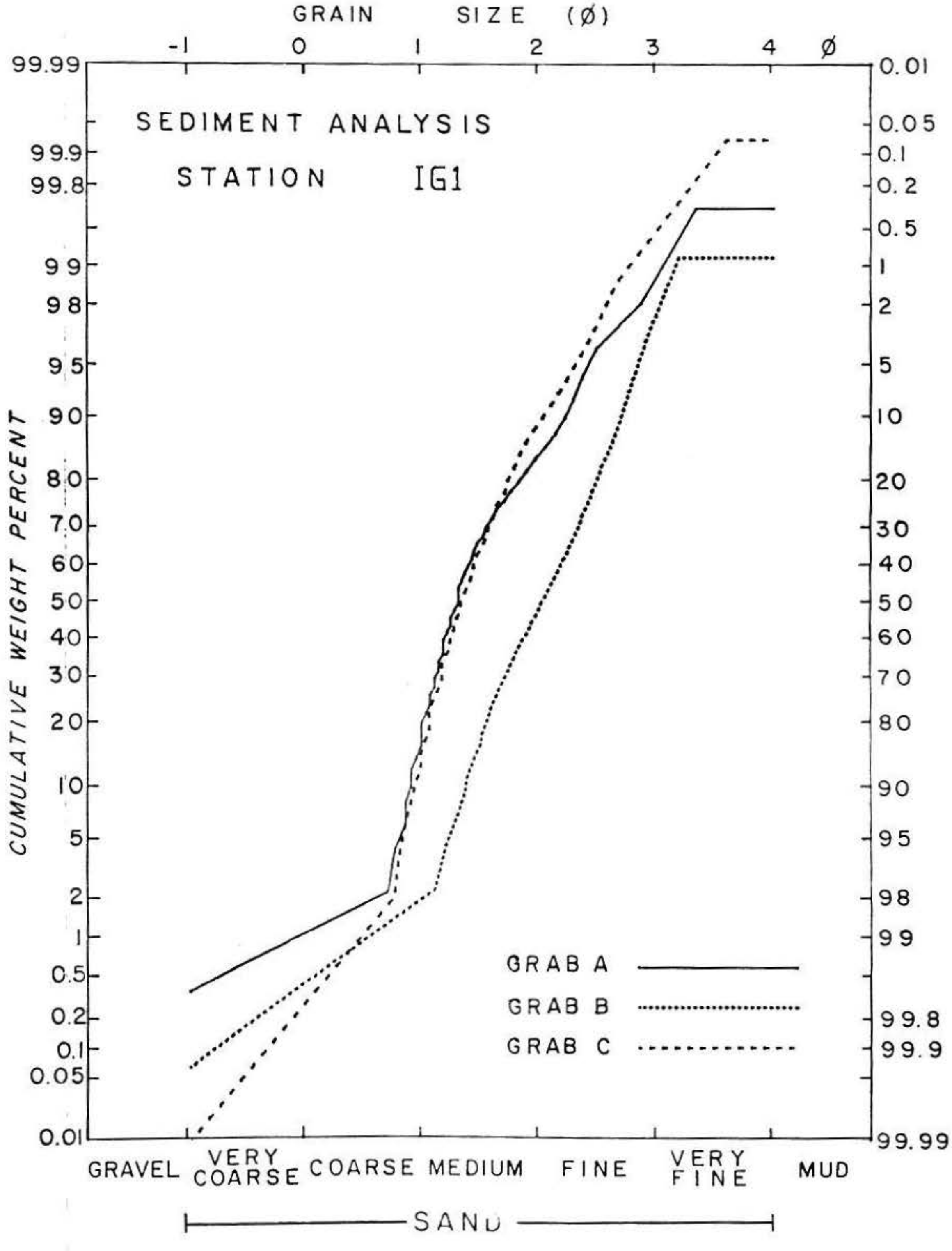
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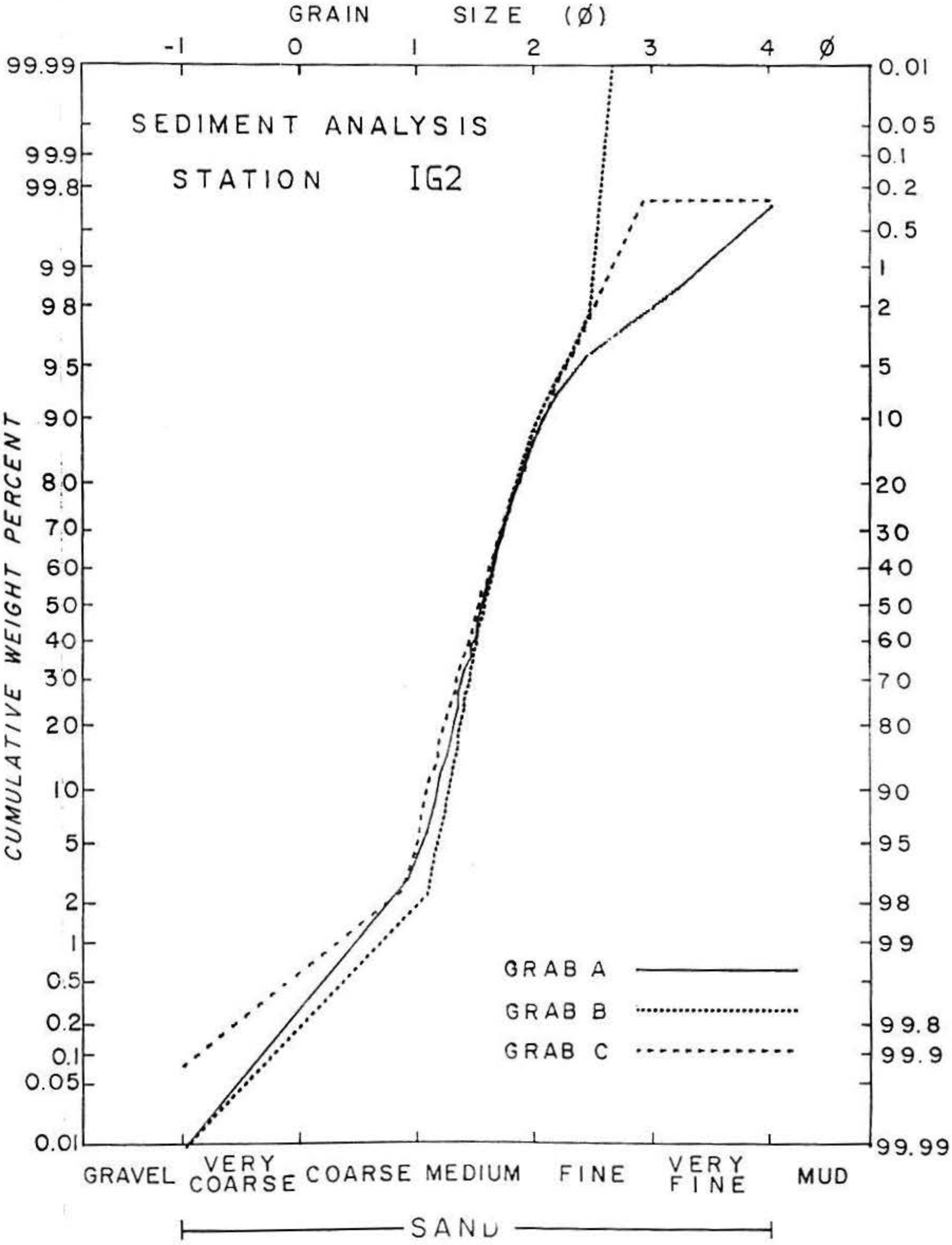
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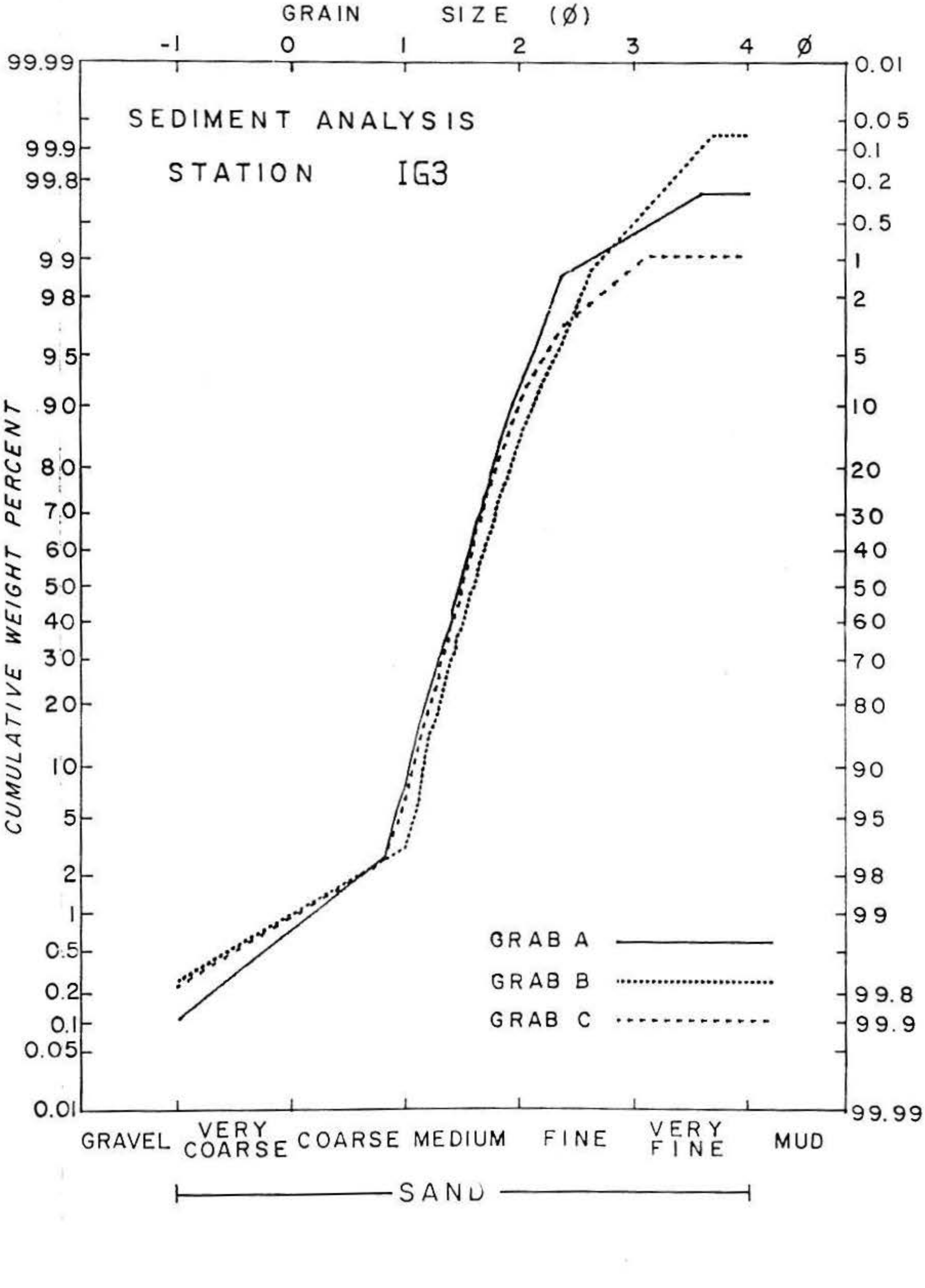
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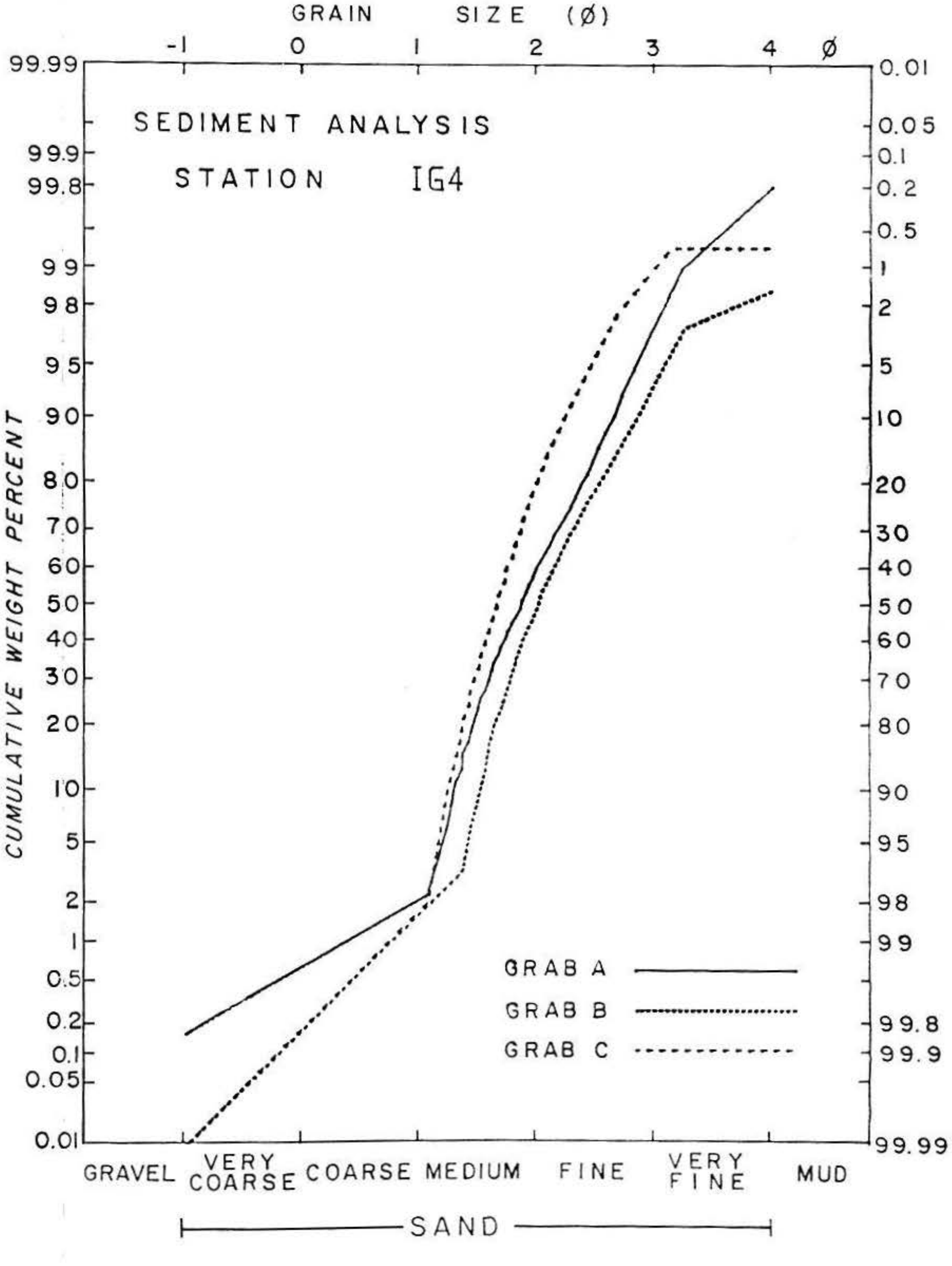
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COARSE
MEDIUM
FINE
VERY FINE
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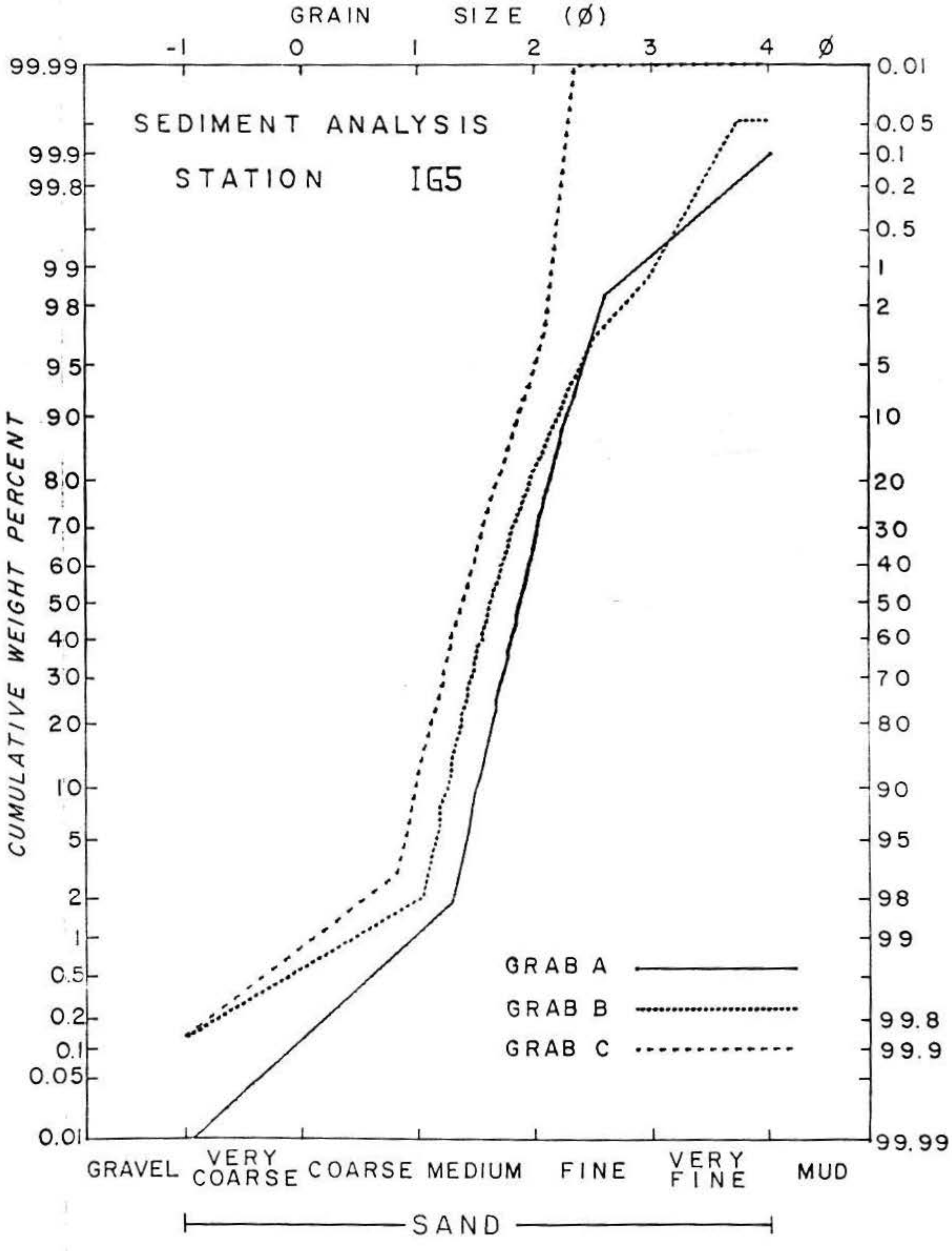
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GRAB B
GRAB C
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COARSE
MEDIUM
FINE
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MUD
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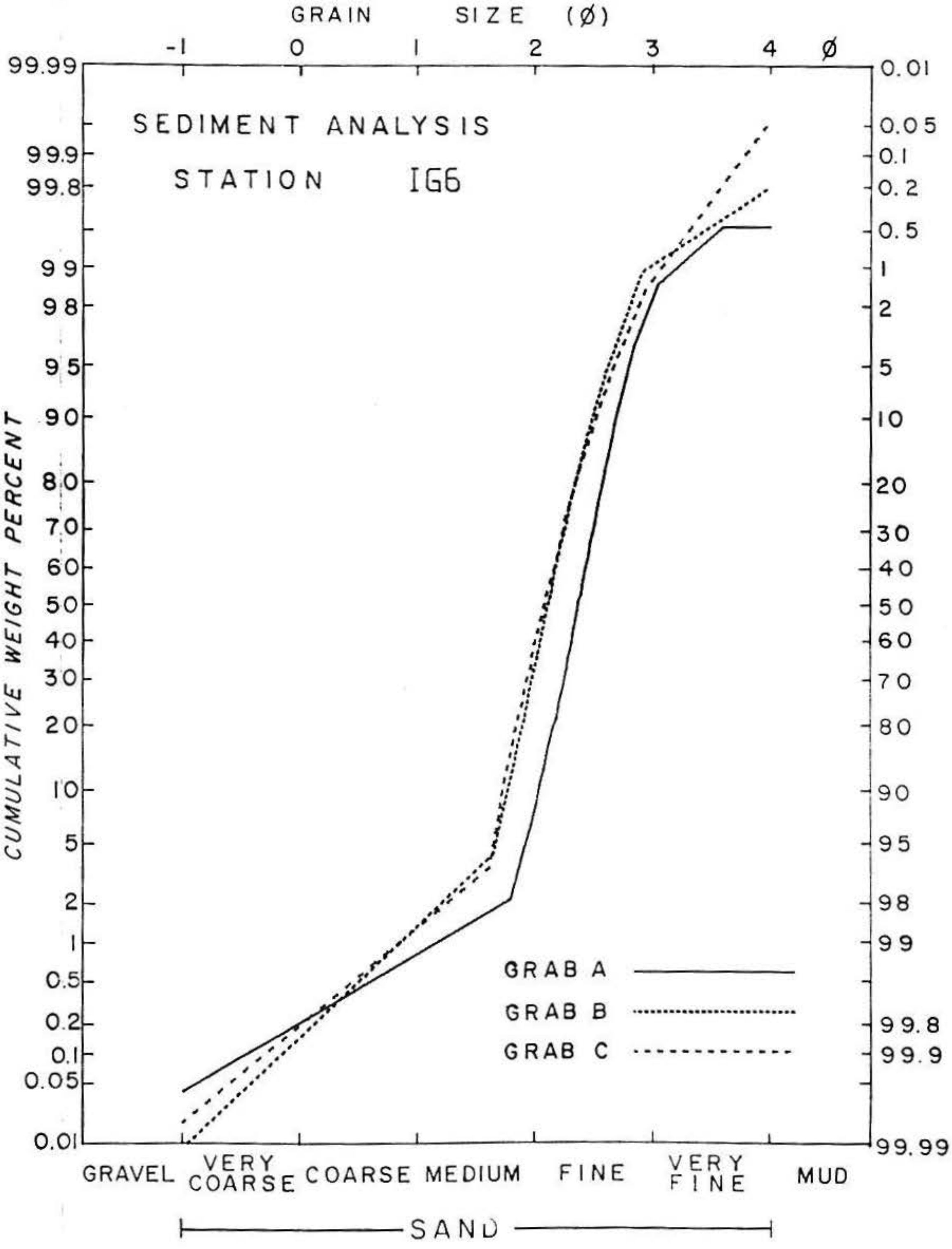
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CUMULATIVE WEIGHT PERCENT
SEDIMENT ANALYSIS
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GRAB C
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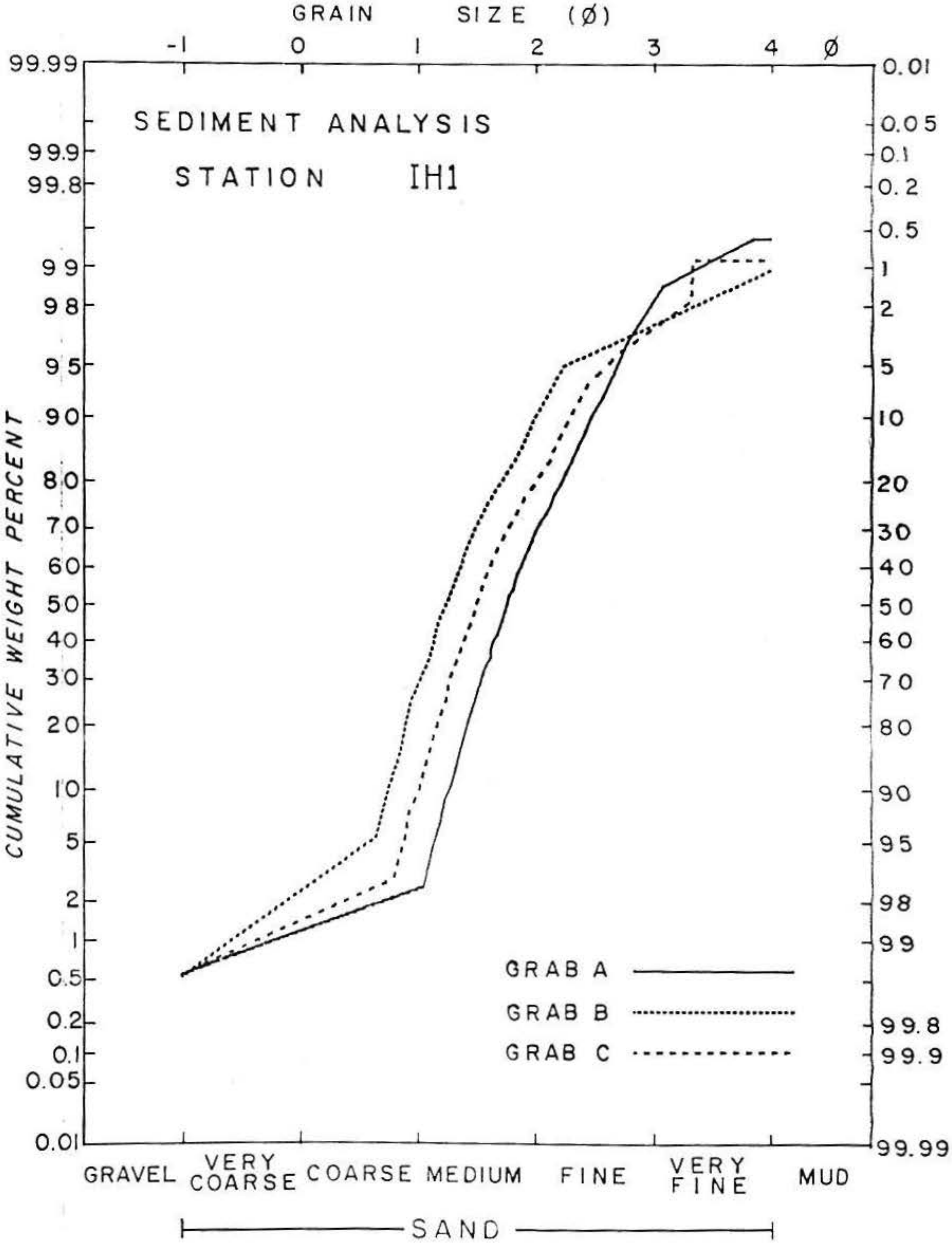
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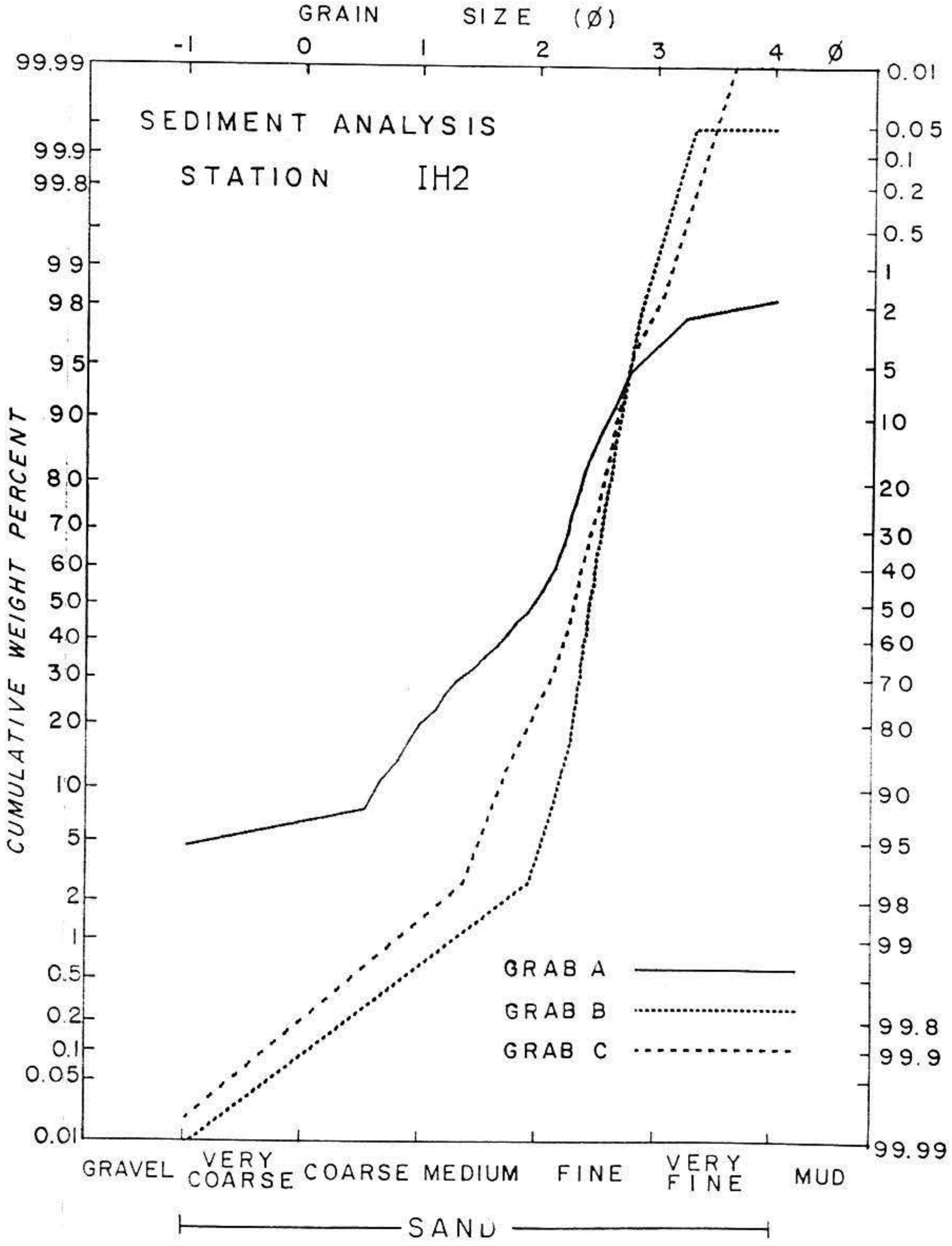
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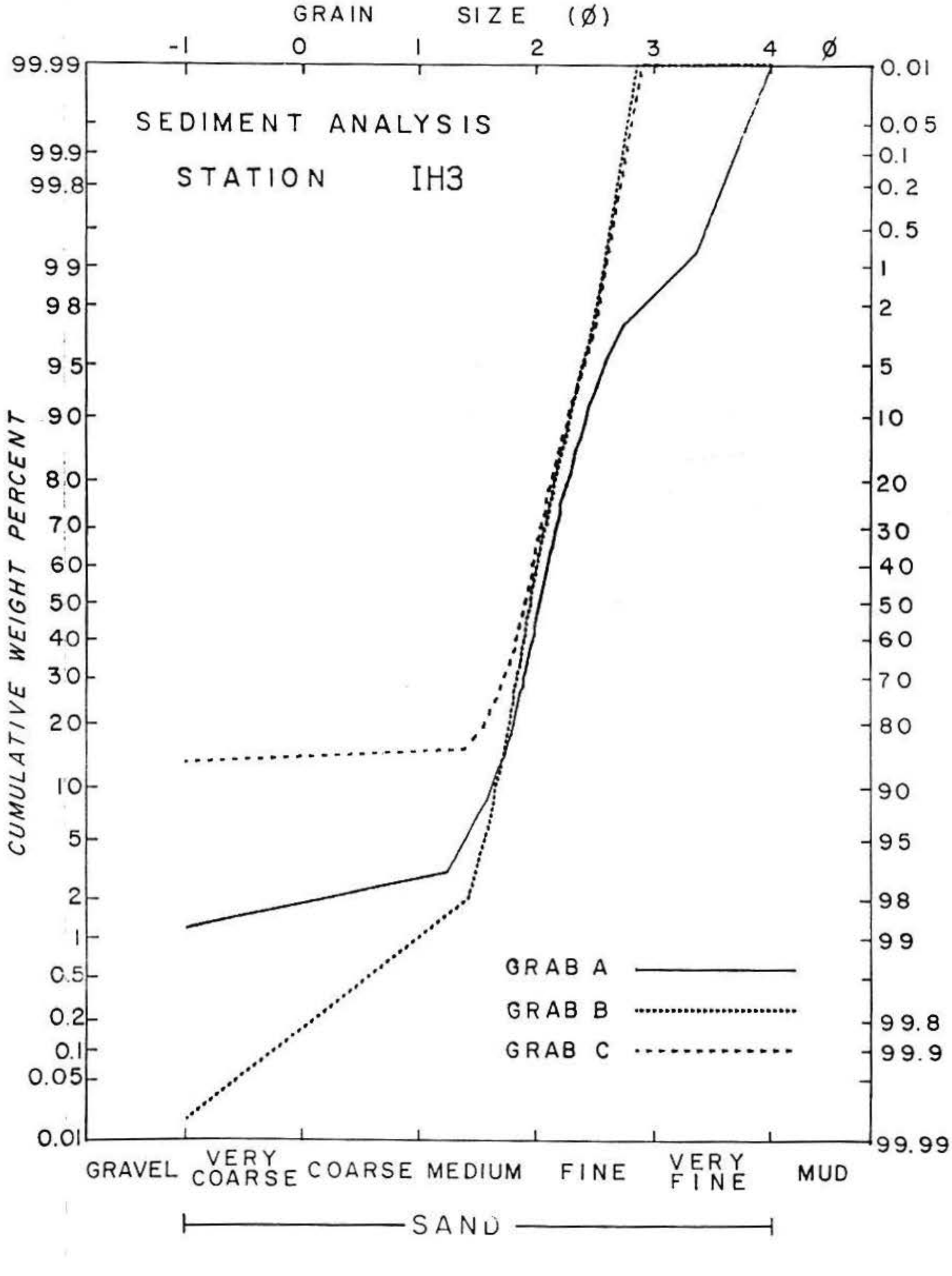
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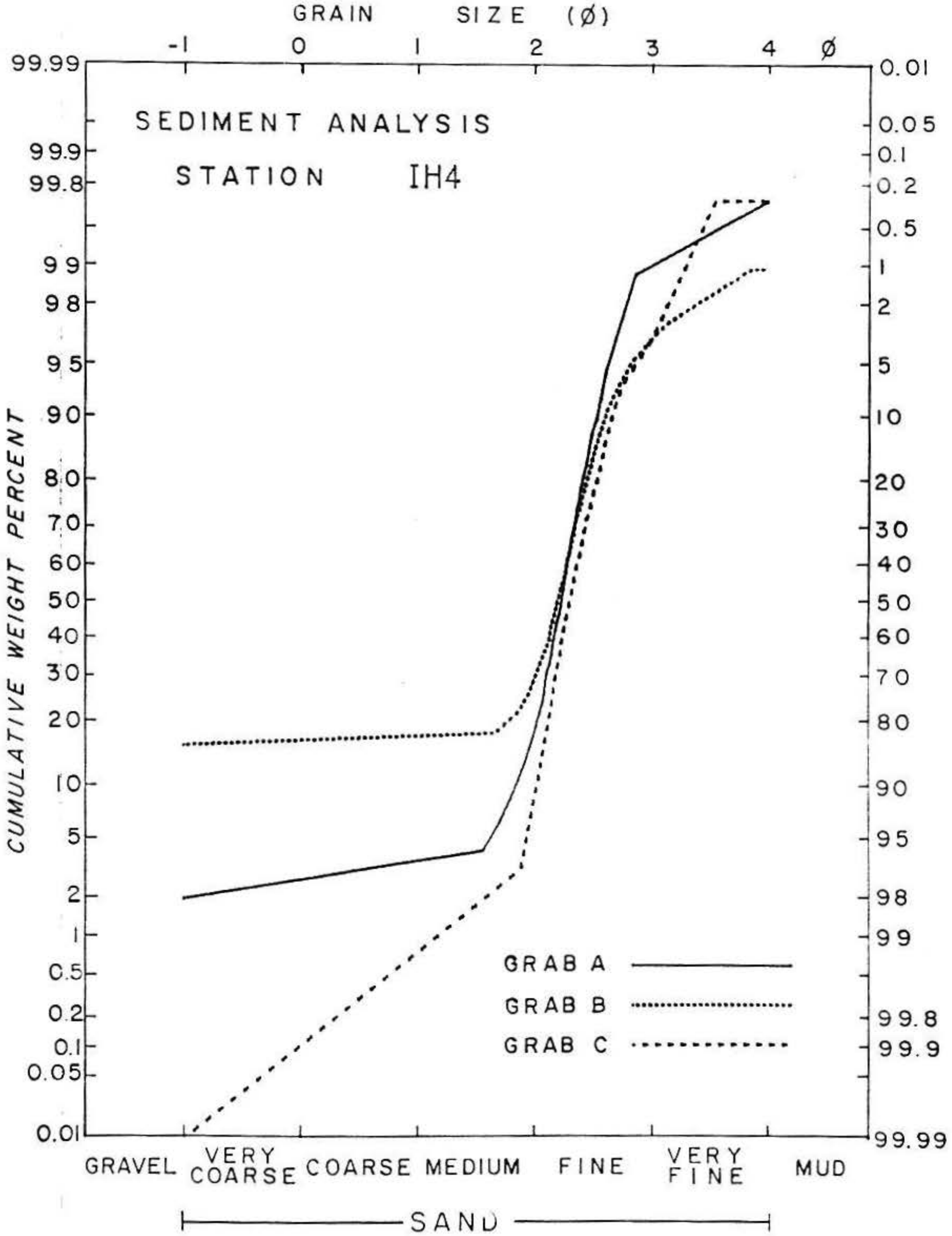
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99.8
99.9
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GRAB C
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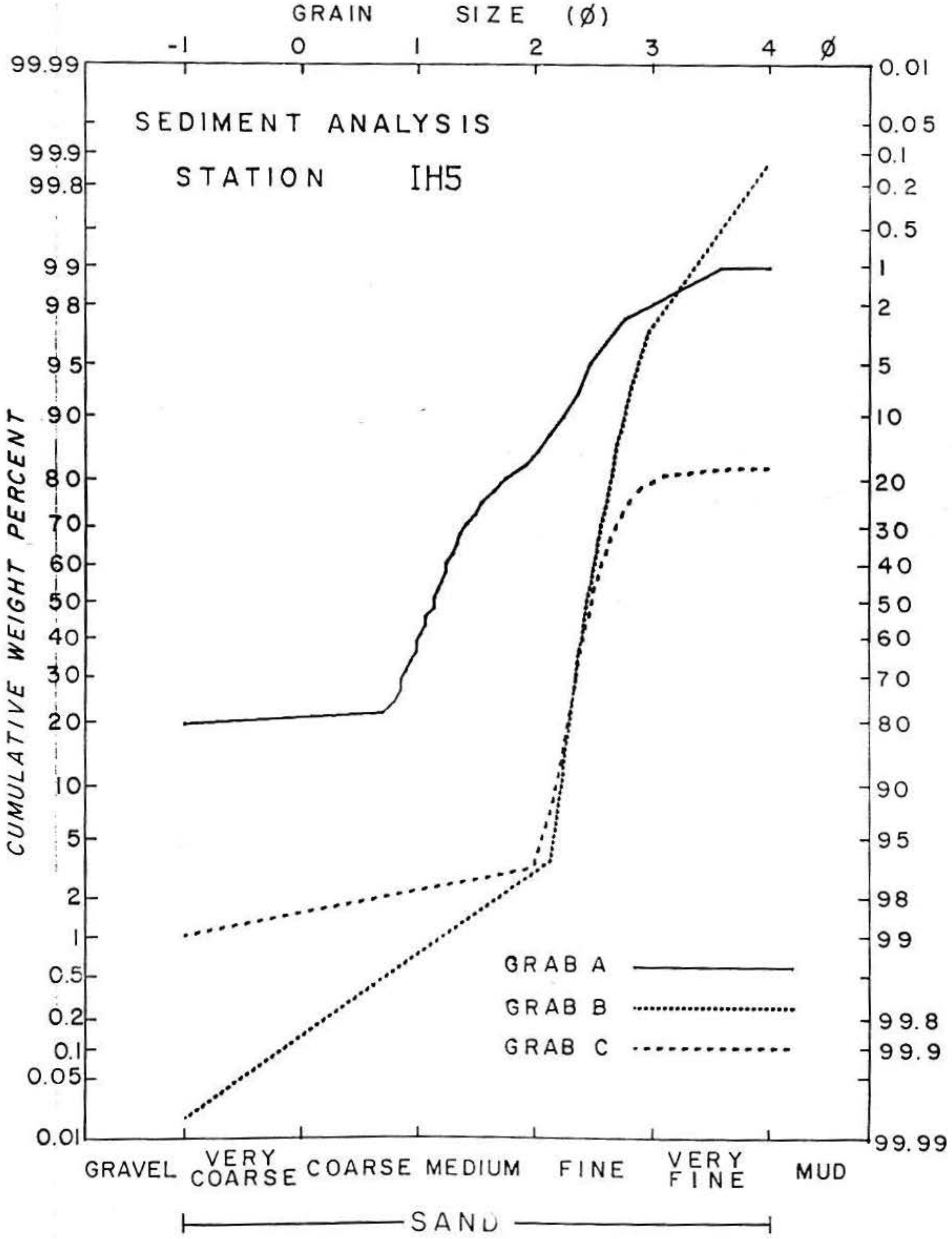
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GRAB C
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MEDIUM
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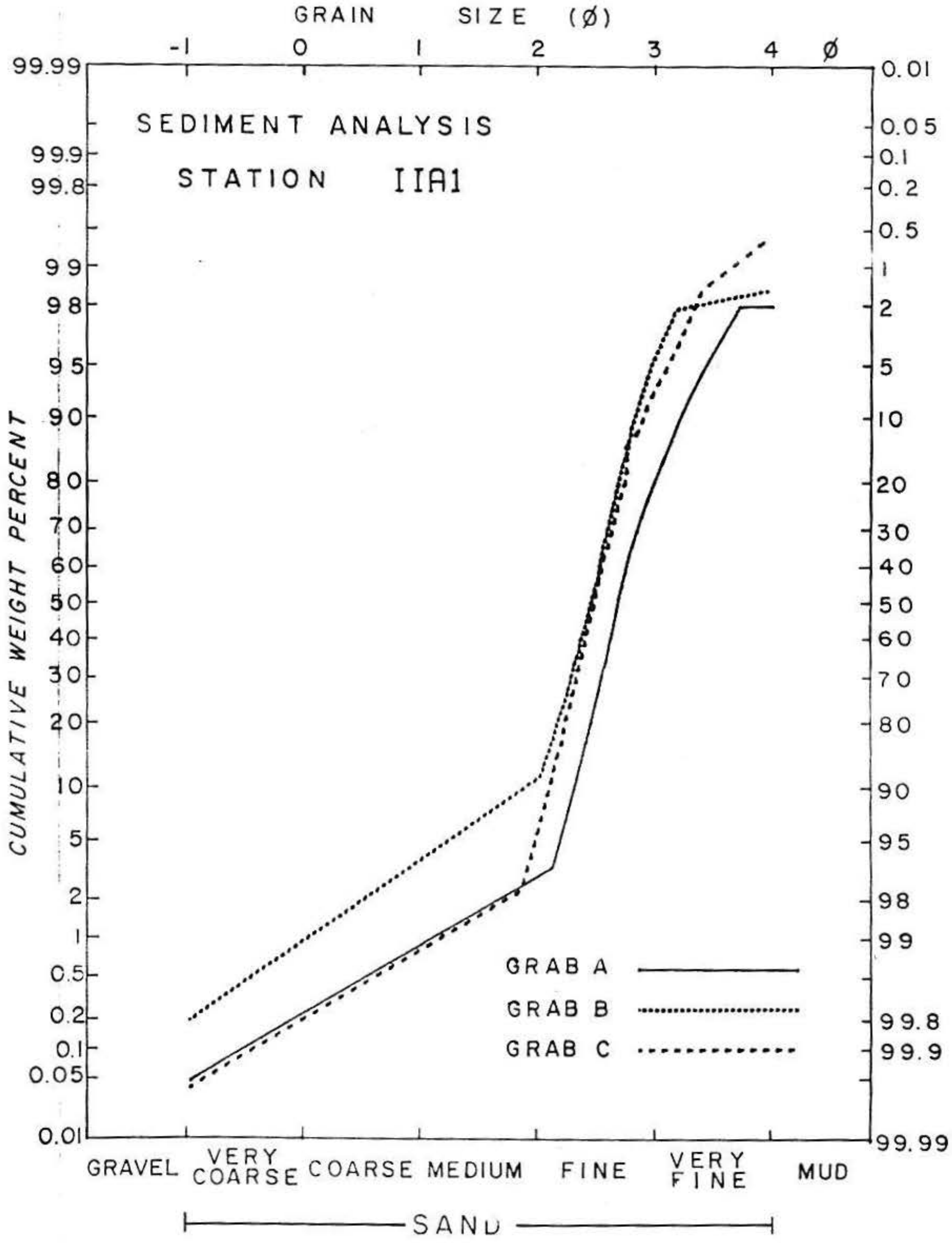
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STATION IIA1
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GRAB C
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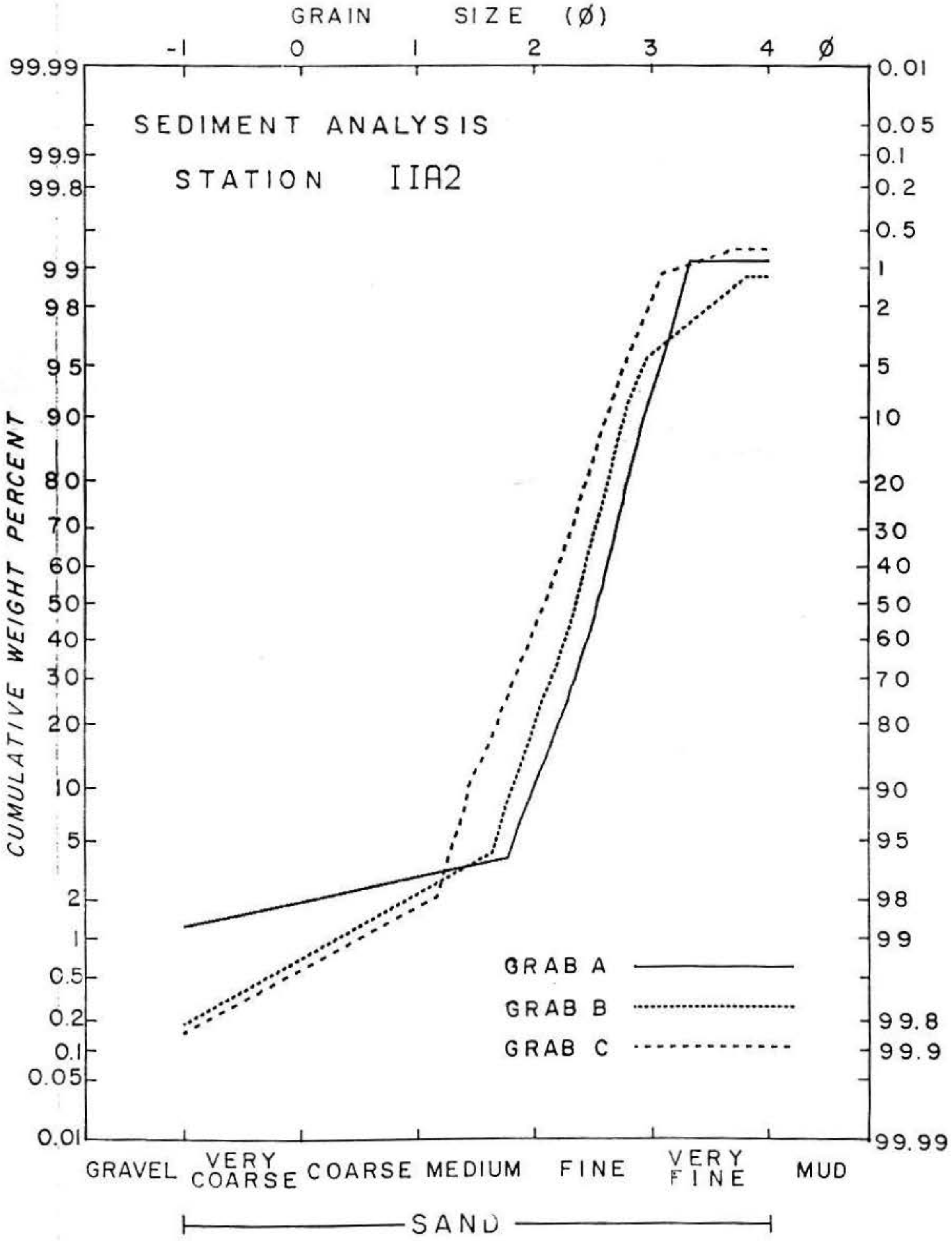
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GRAB C
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MEDIUM
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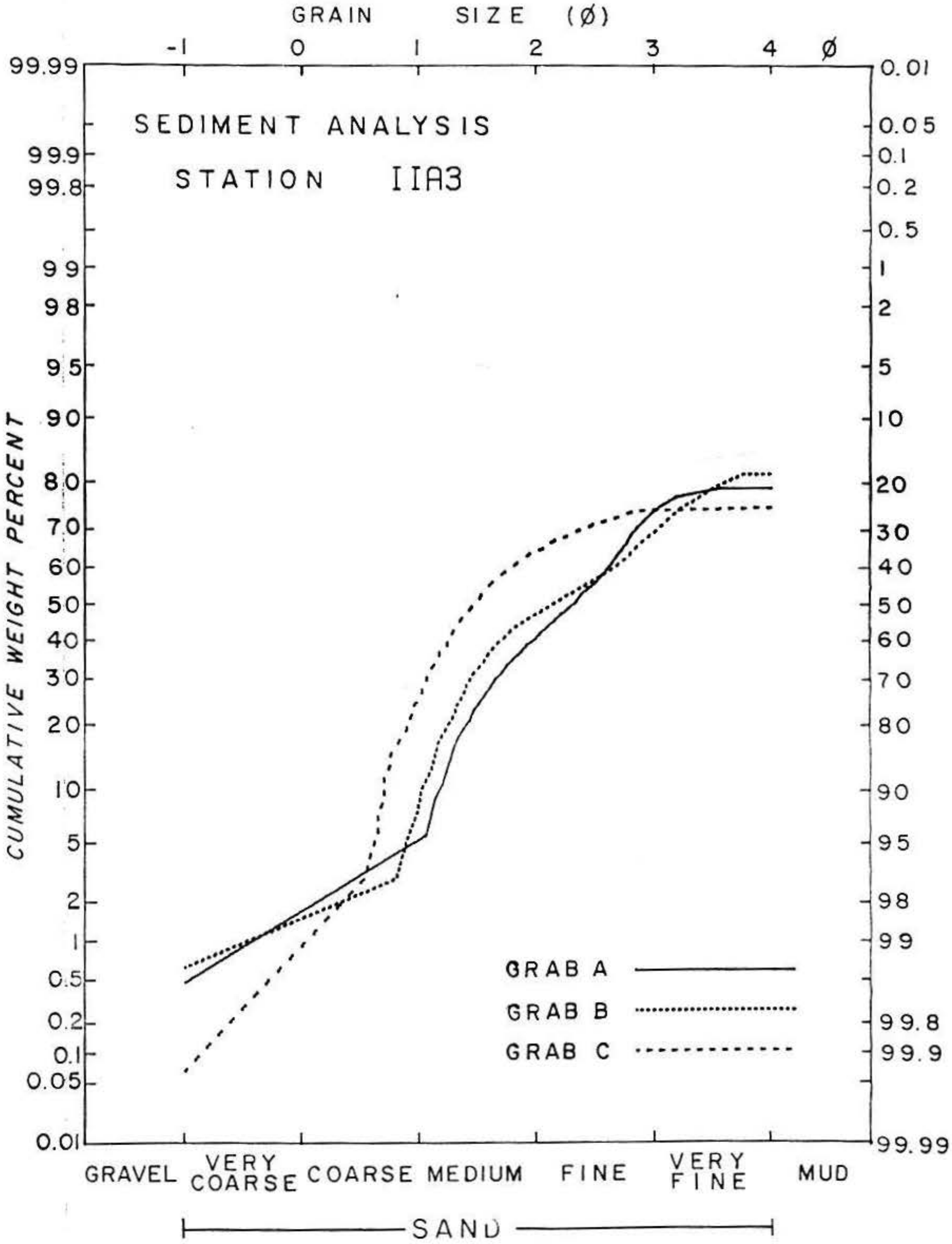
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STATION IIA3
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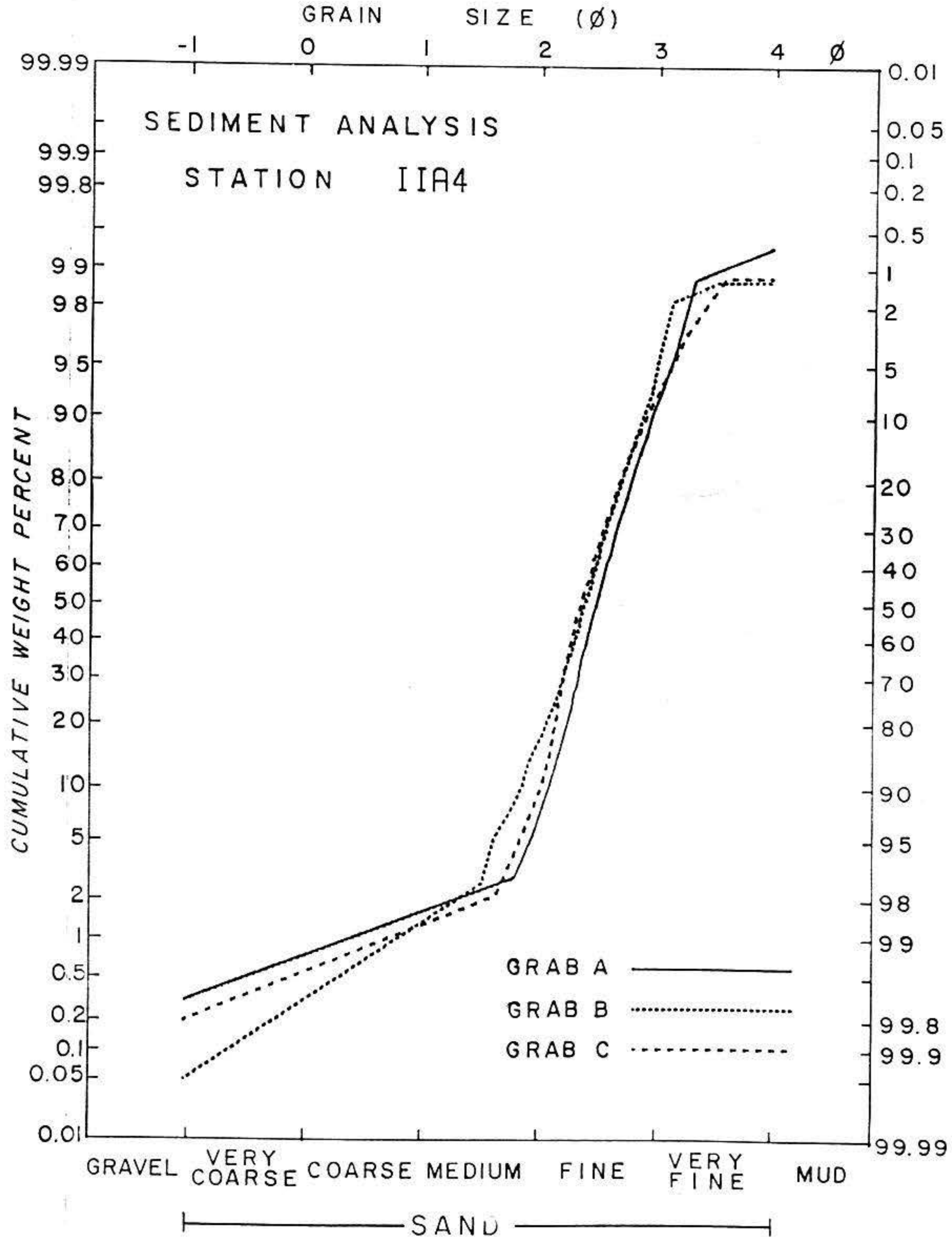
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GRAVEL
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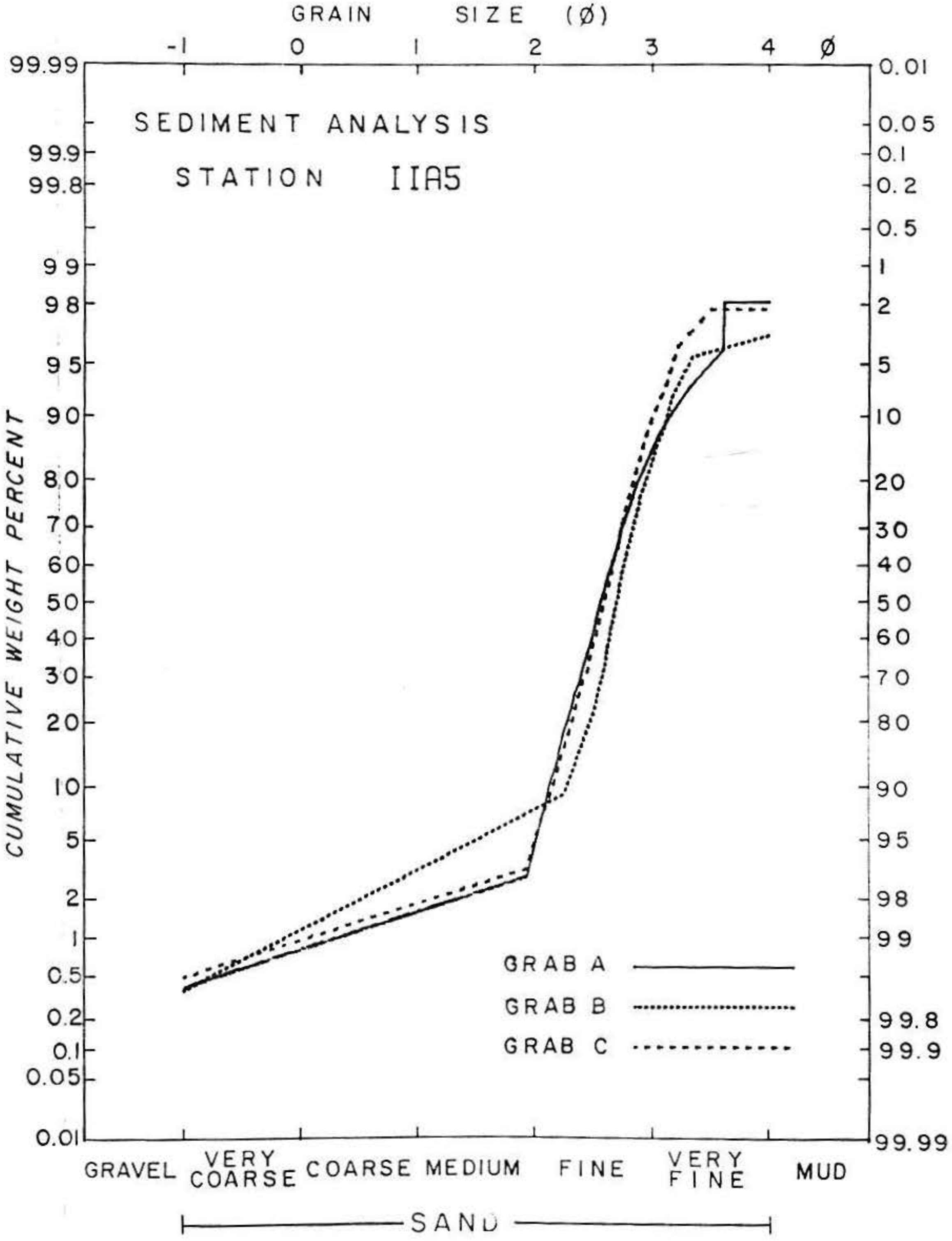
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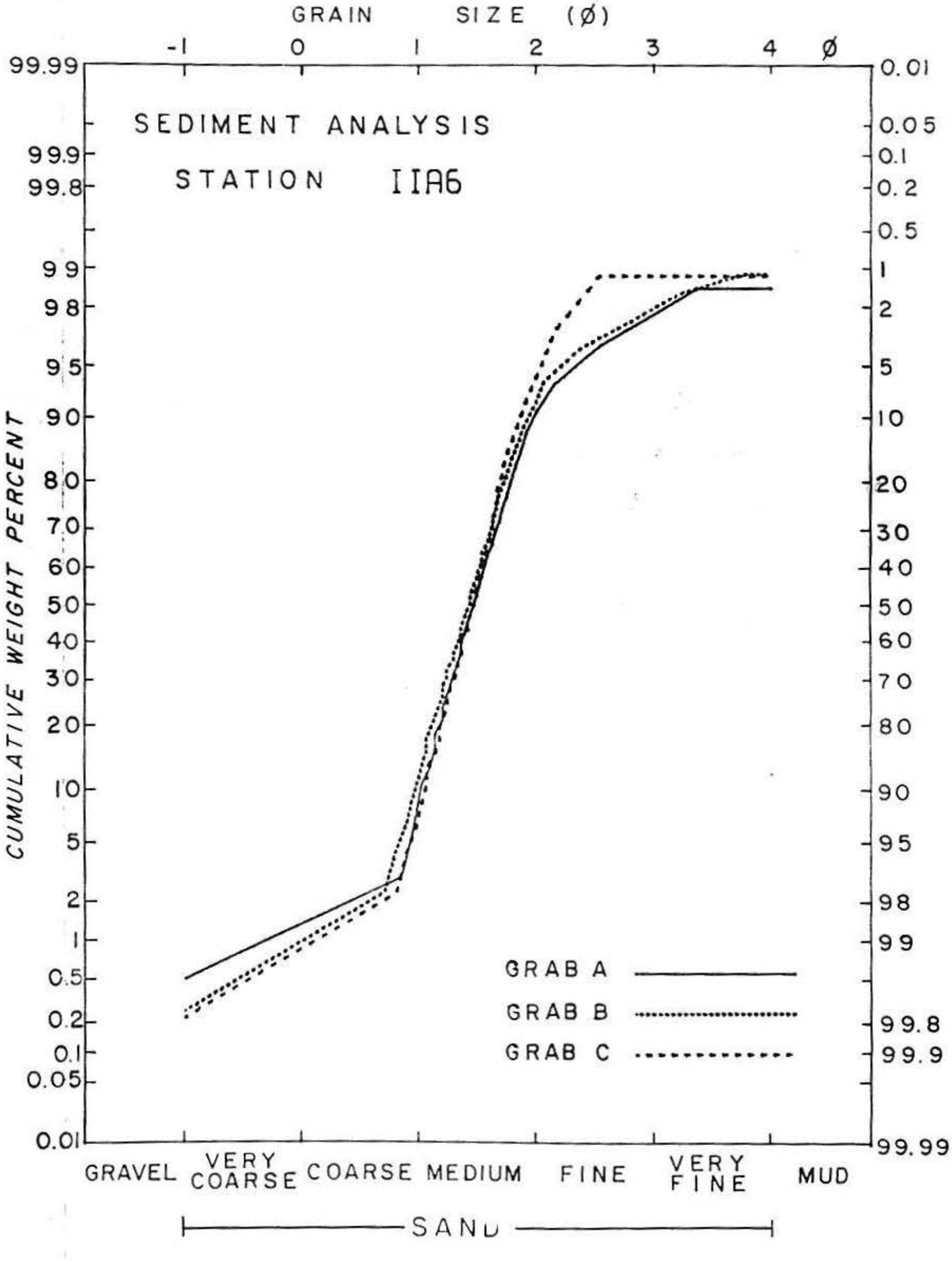
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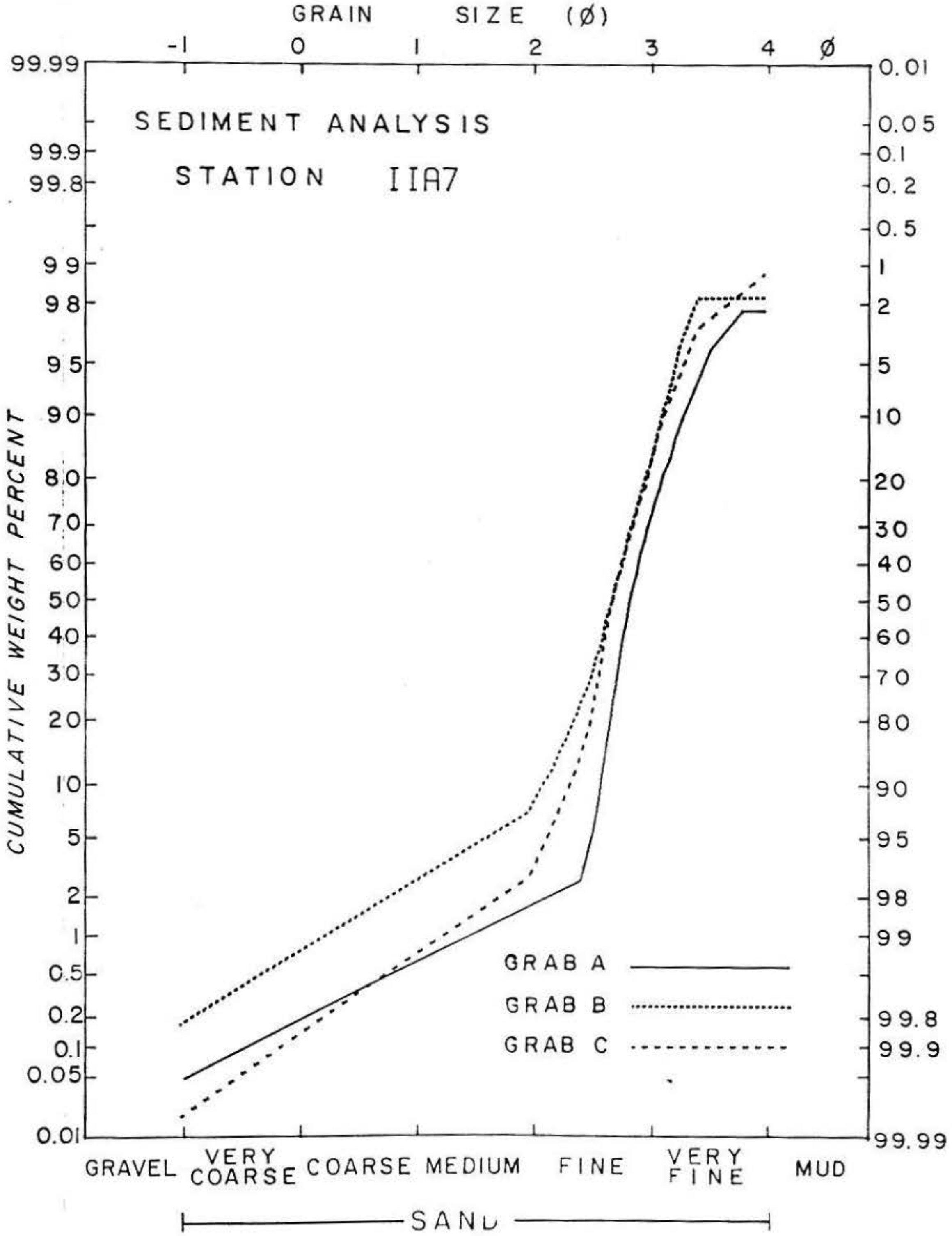
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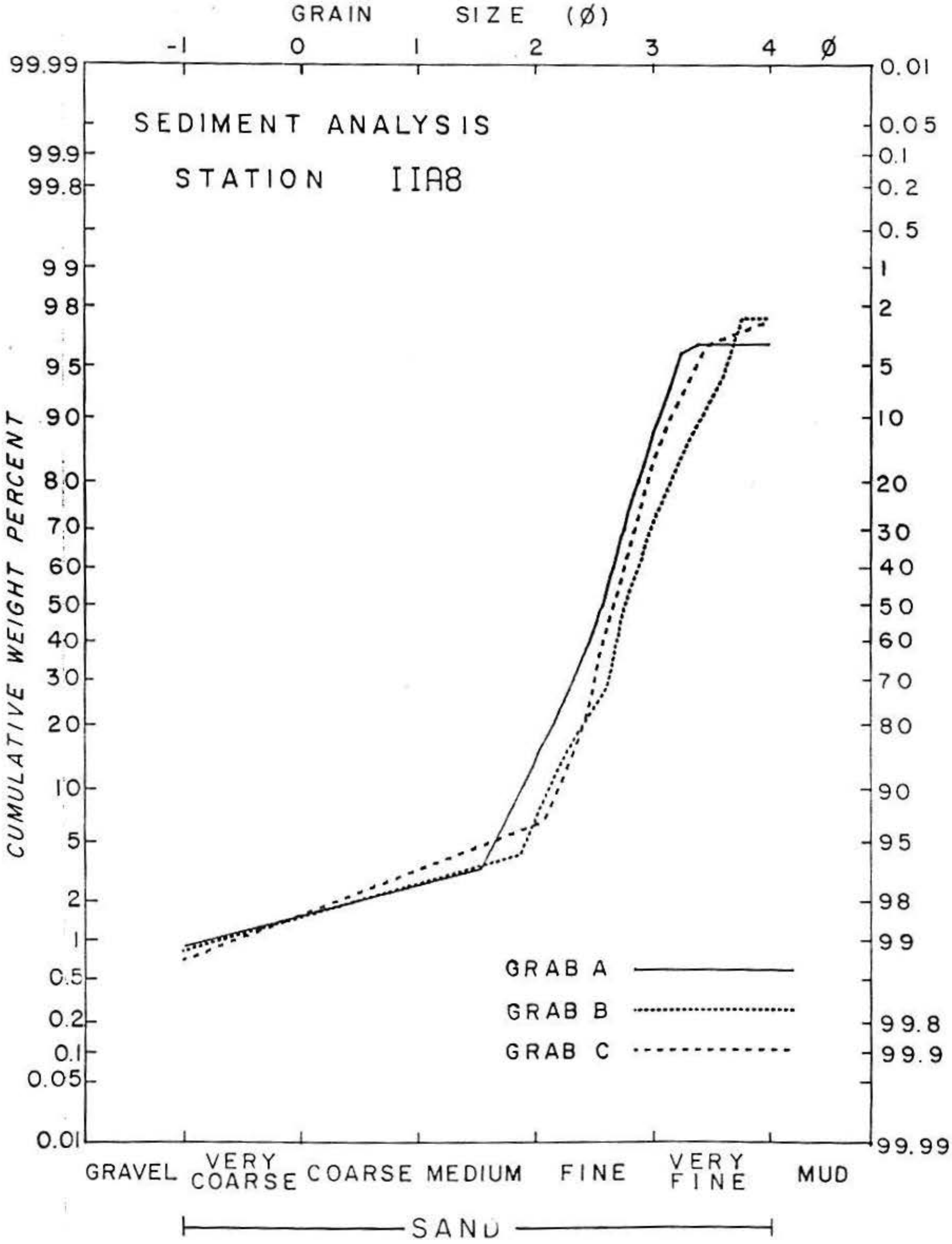
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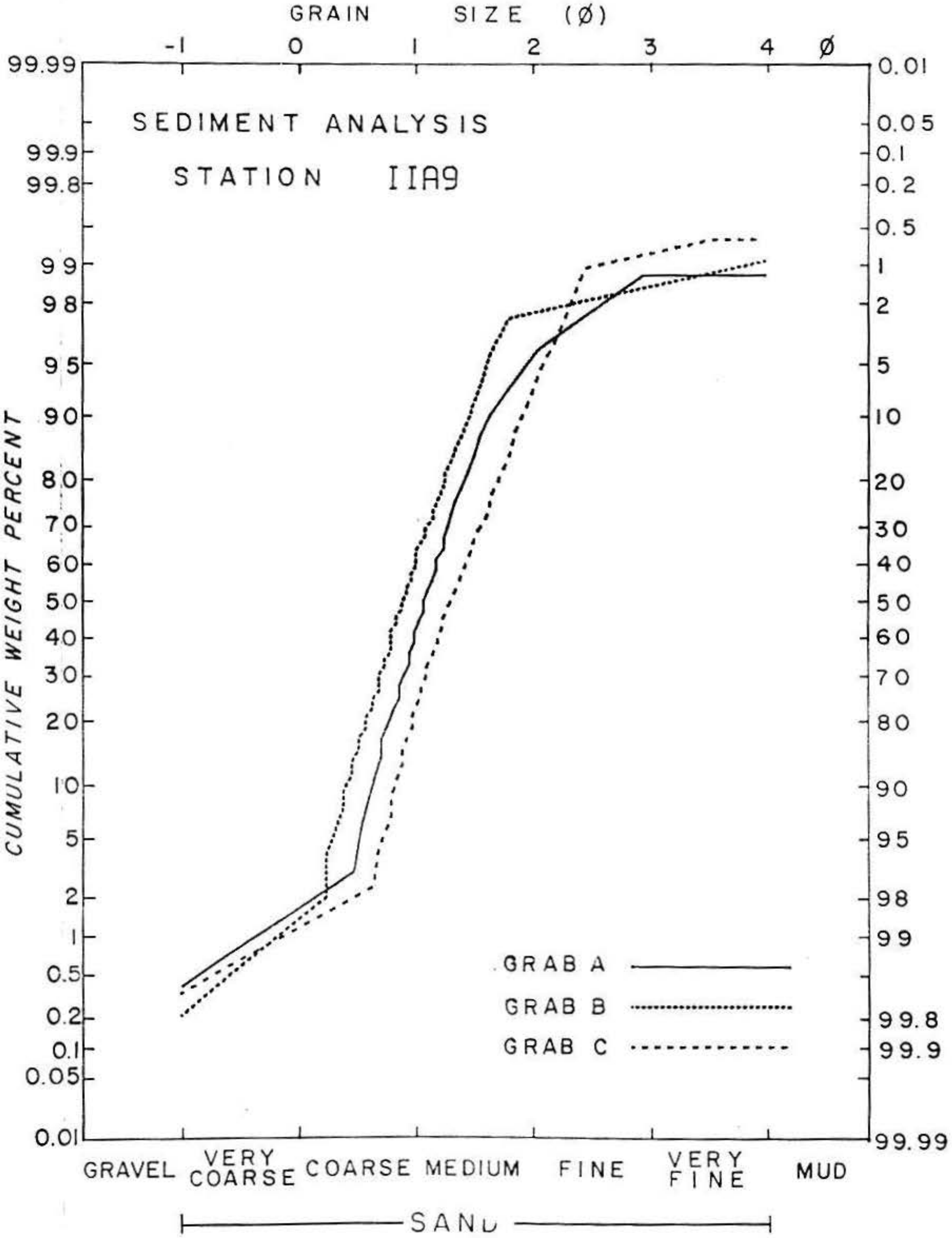
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STATION IIA9
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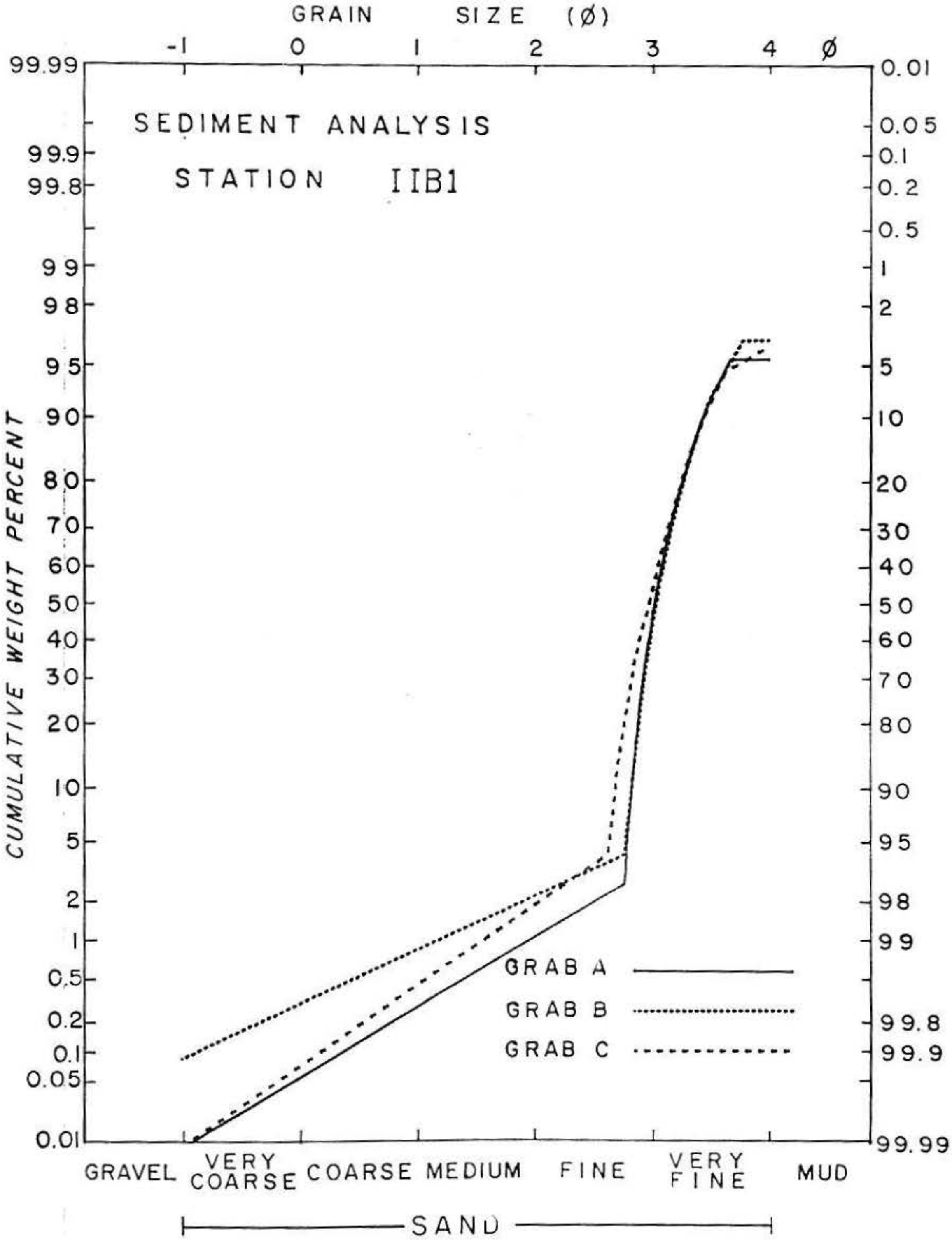
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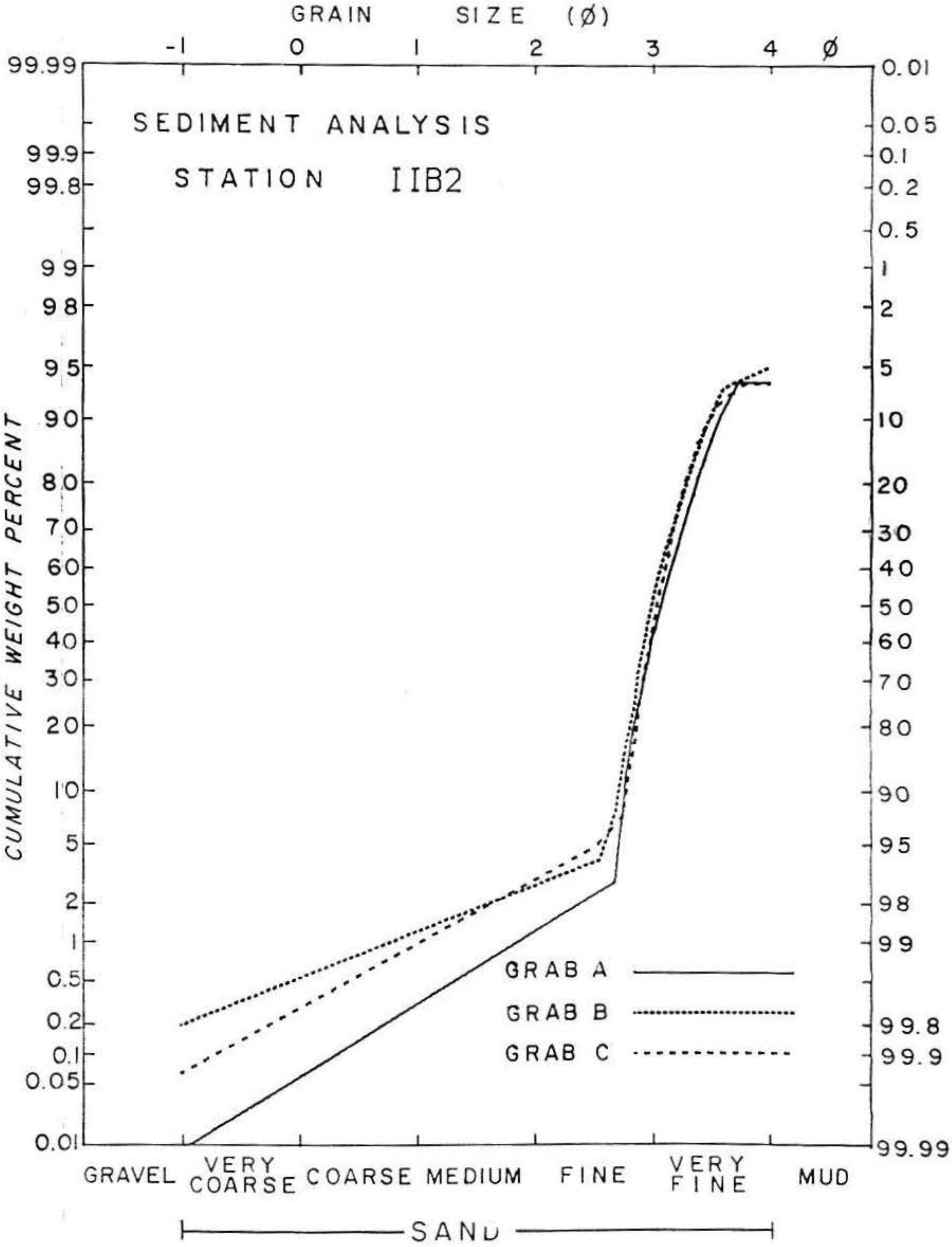
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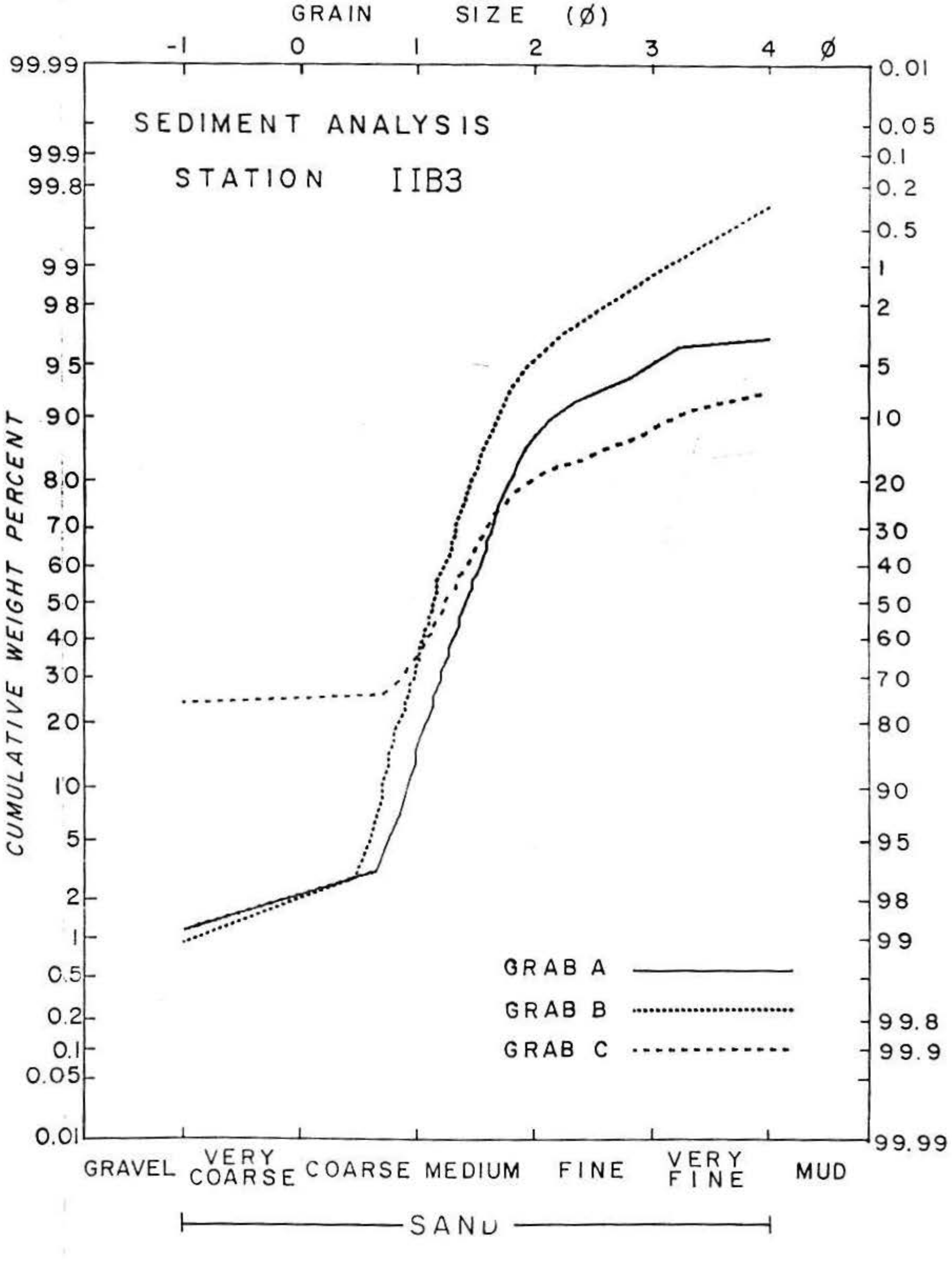
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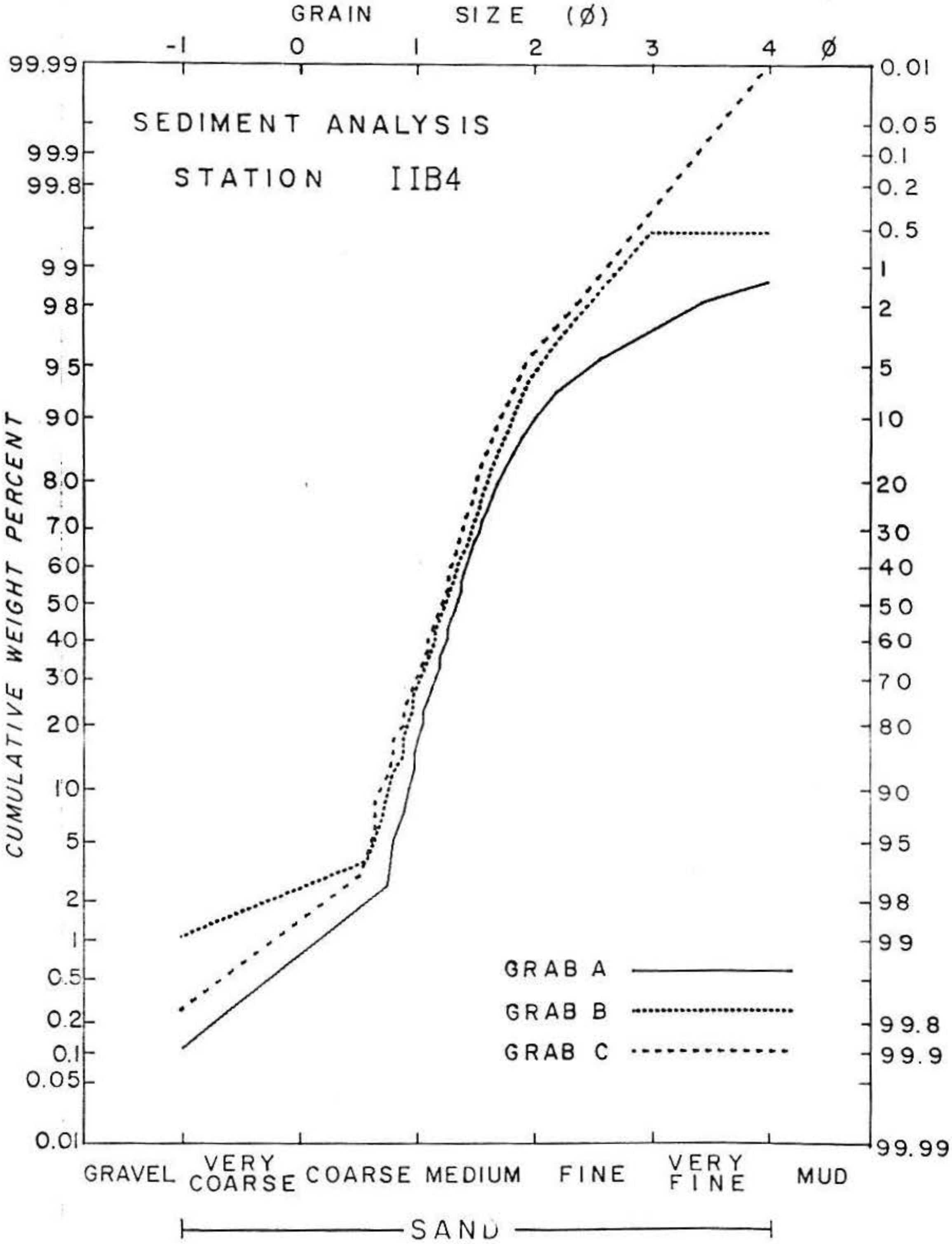
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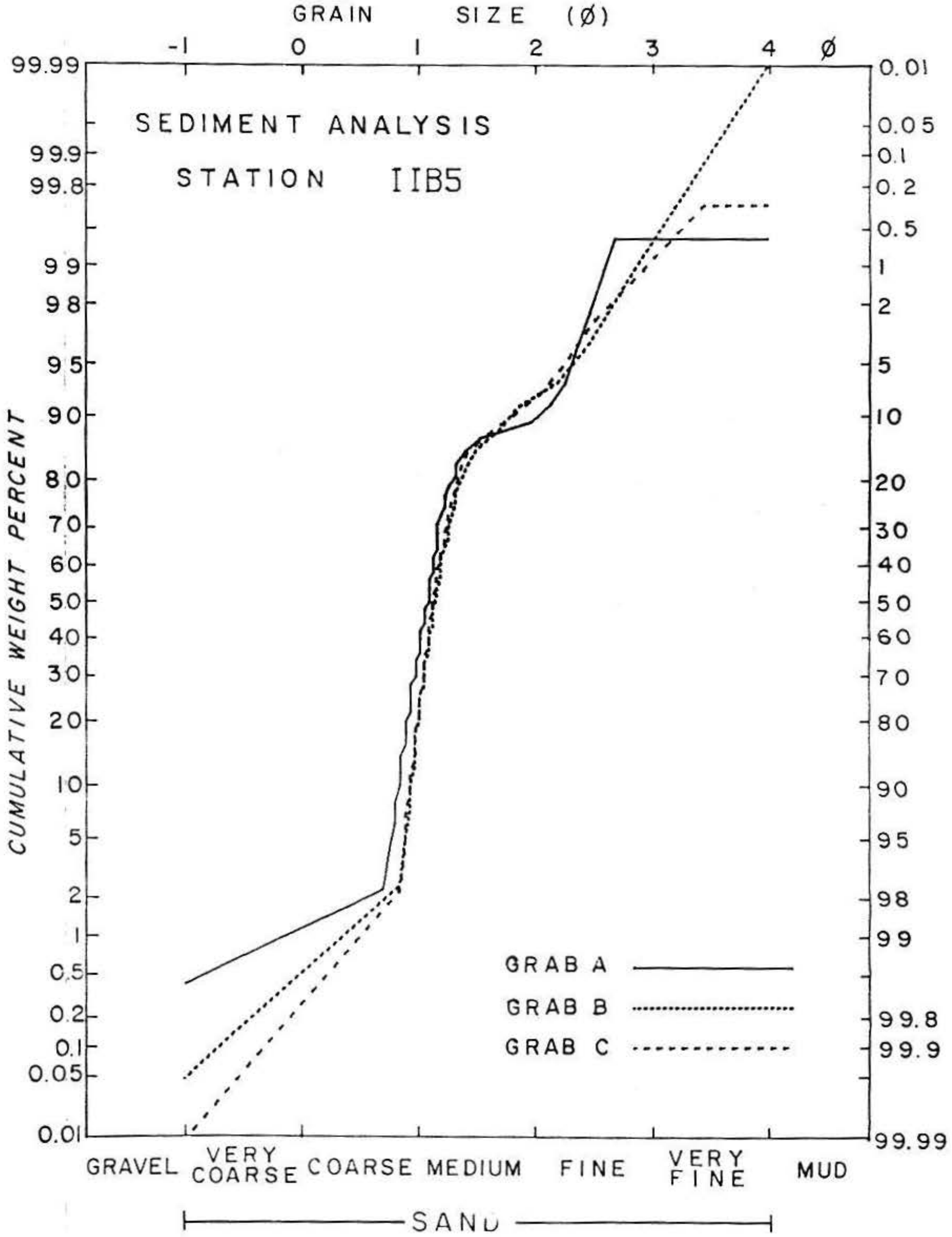
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GRAB B
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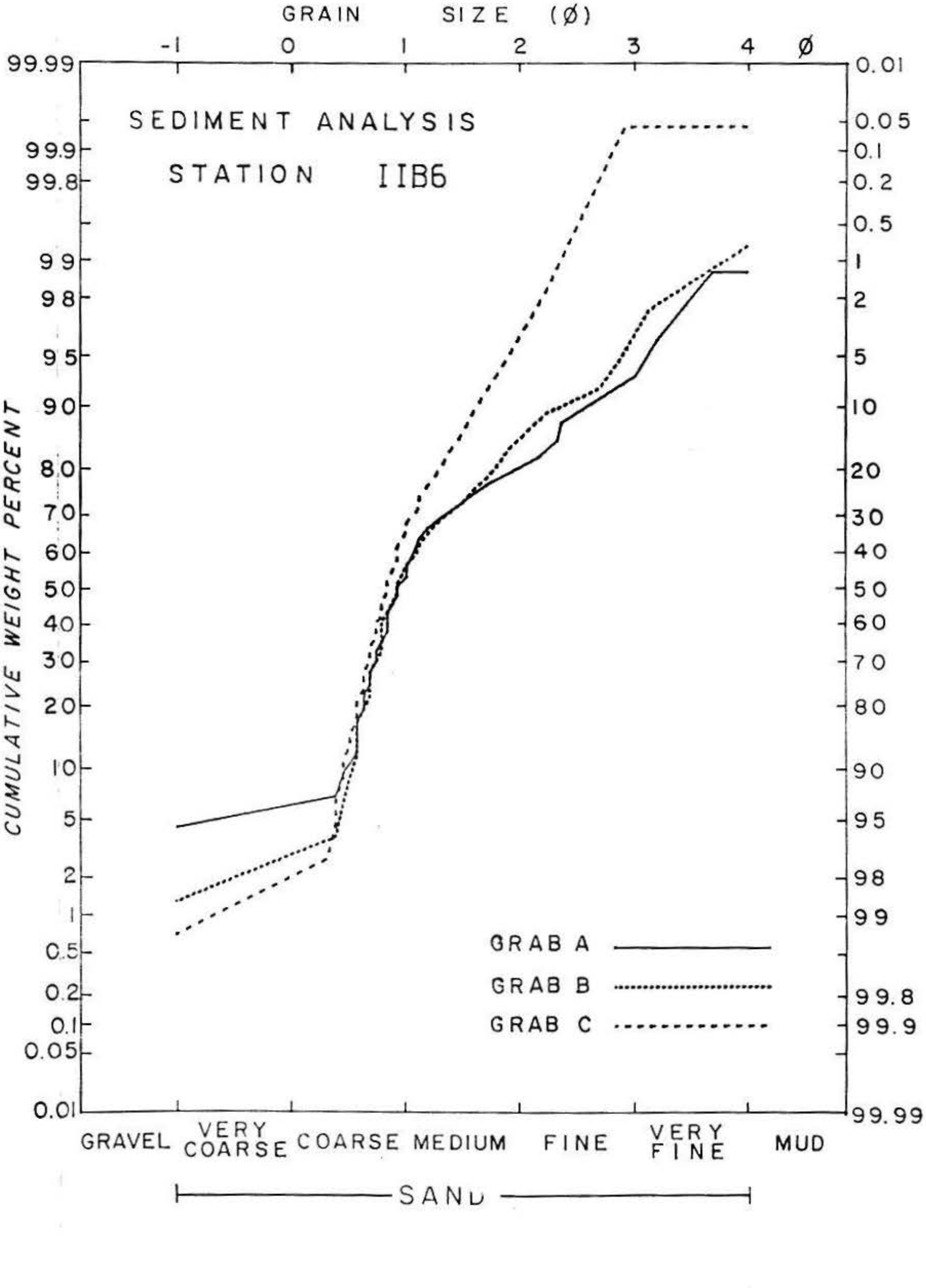
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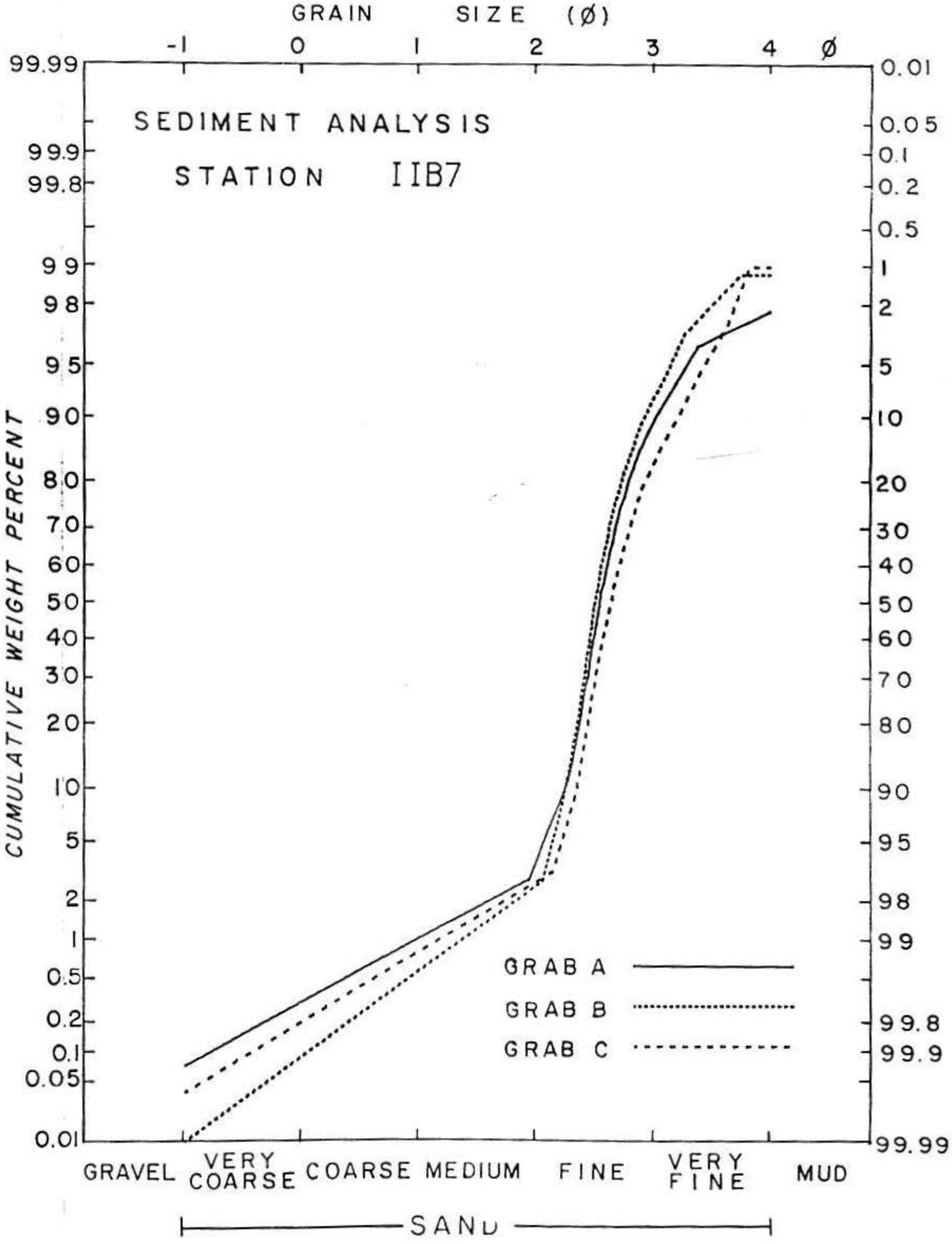
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99.8
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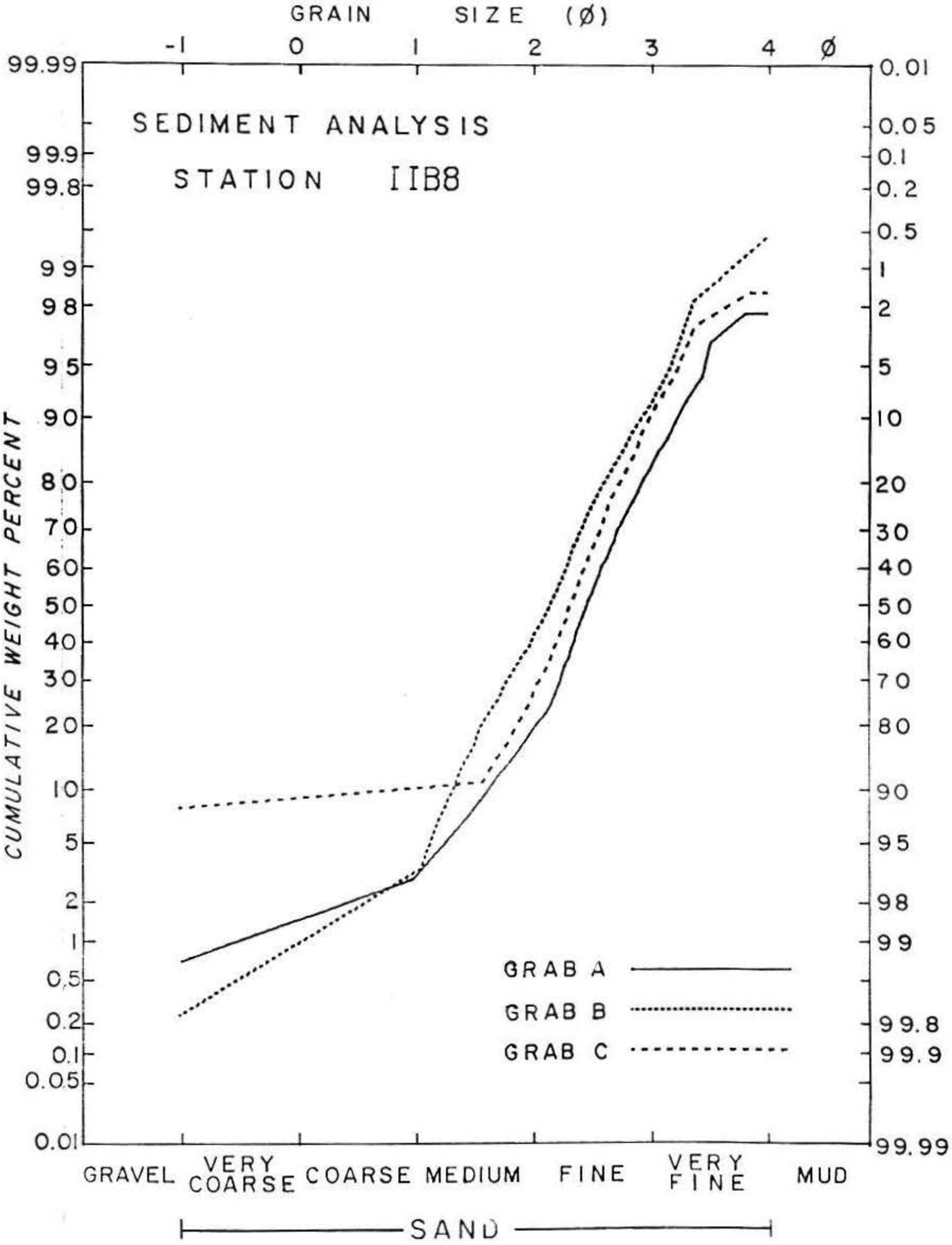
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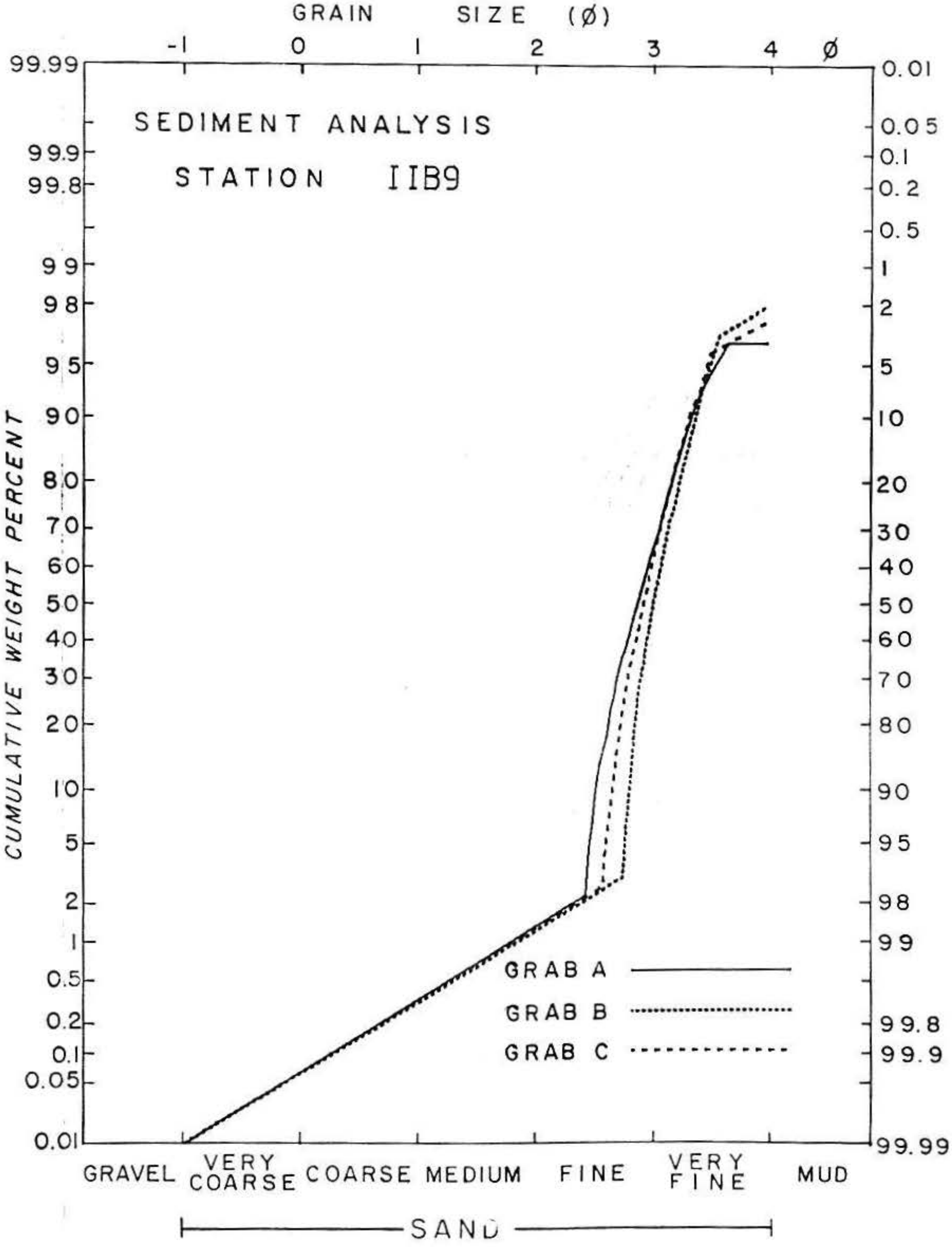
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0.1
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99.9
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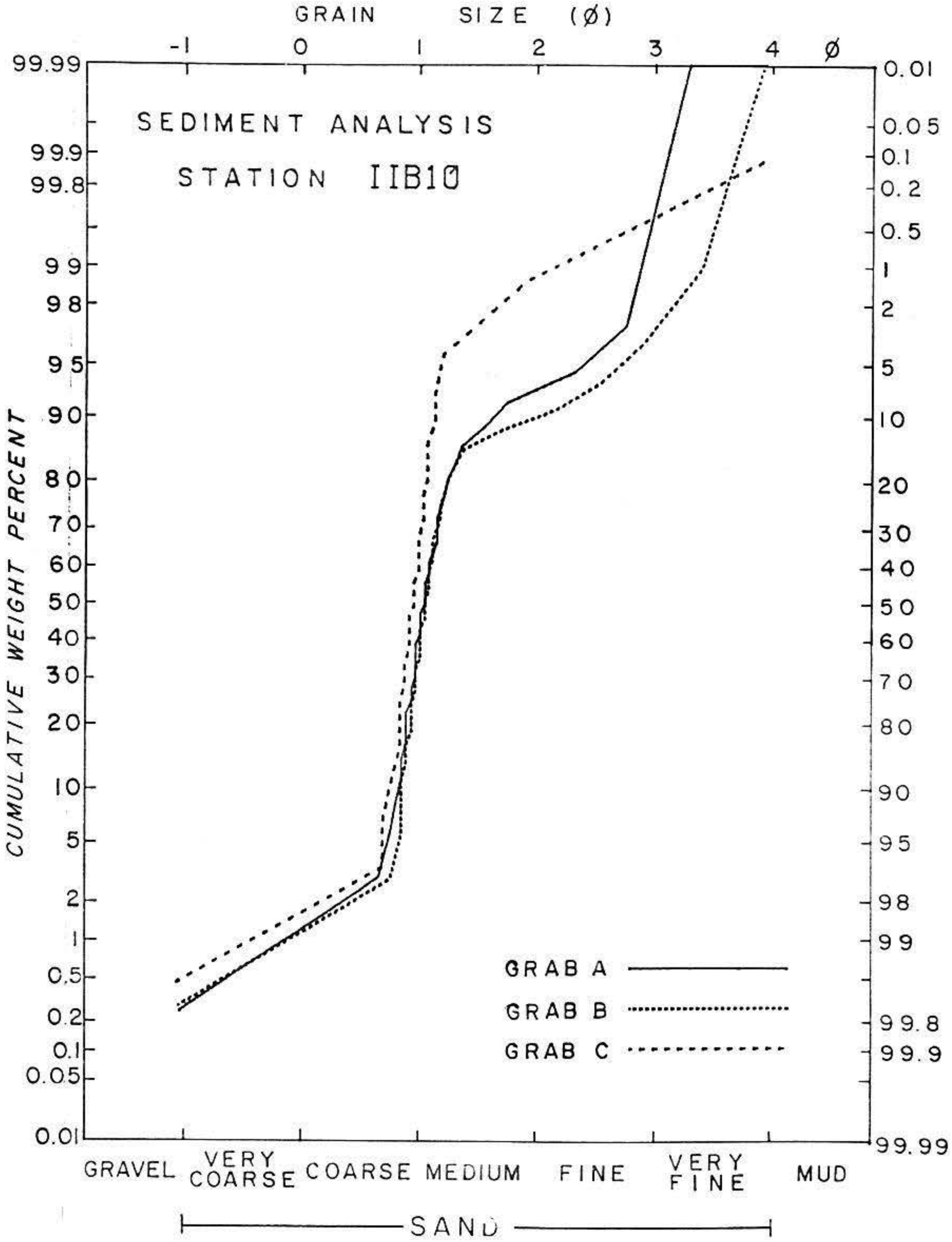
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99.8
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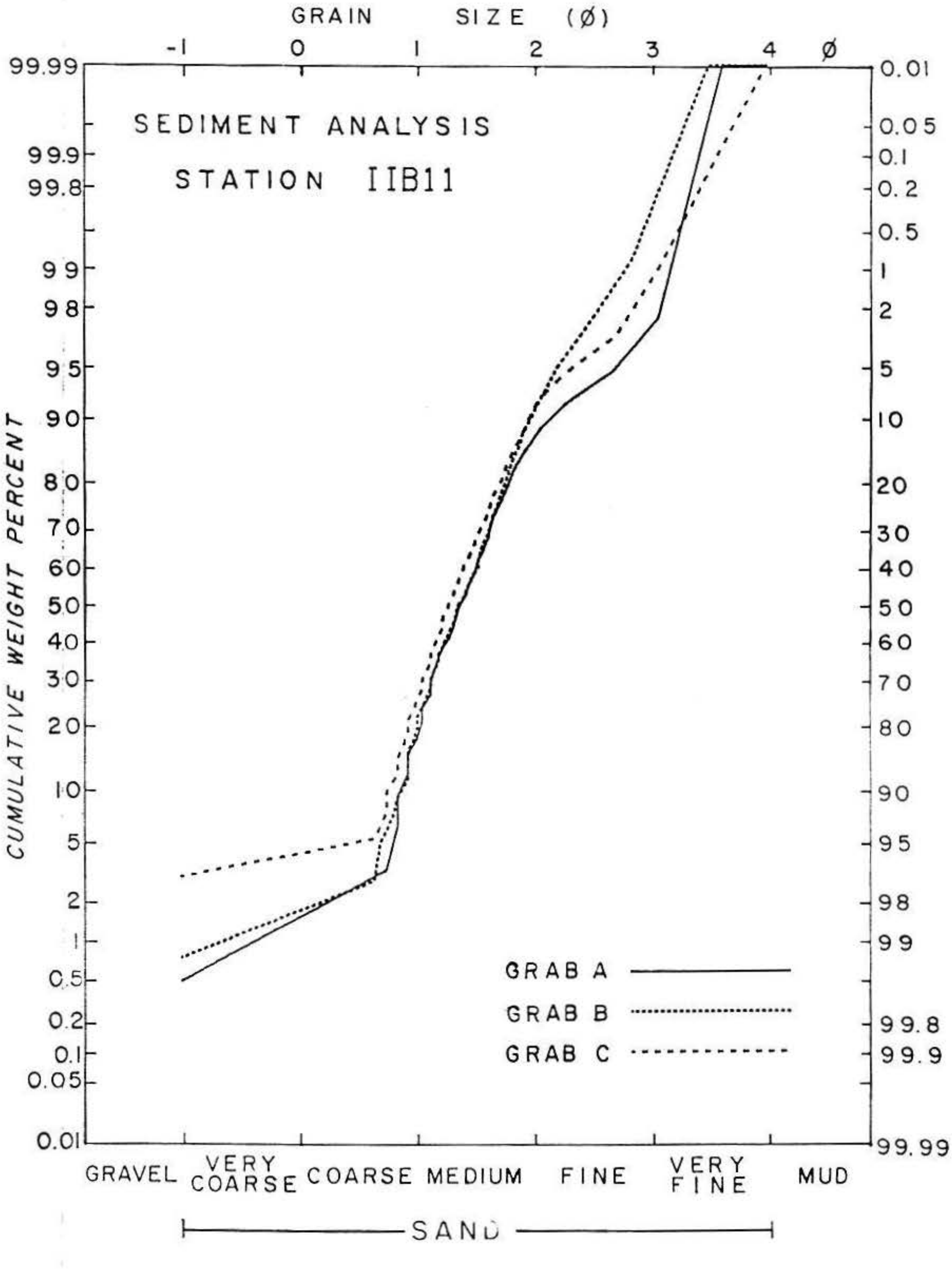
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0.01
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98
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99.8
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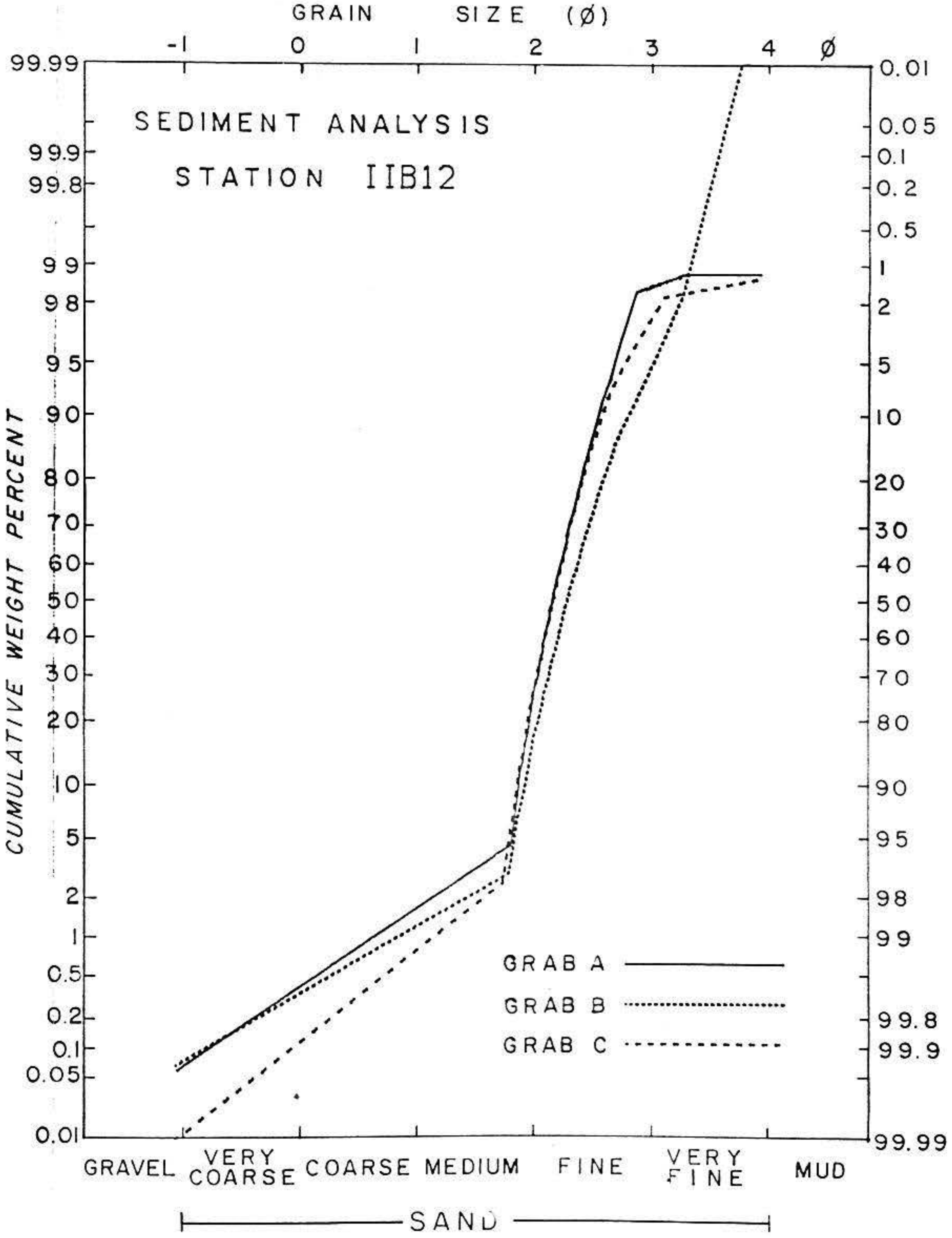
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99.8
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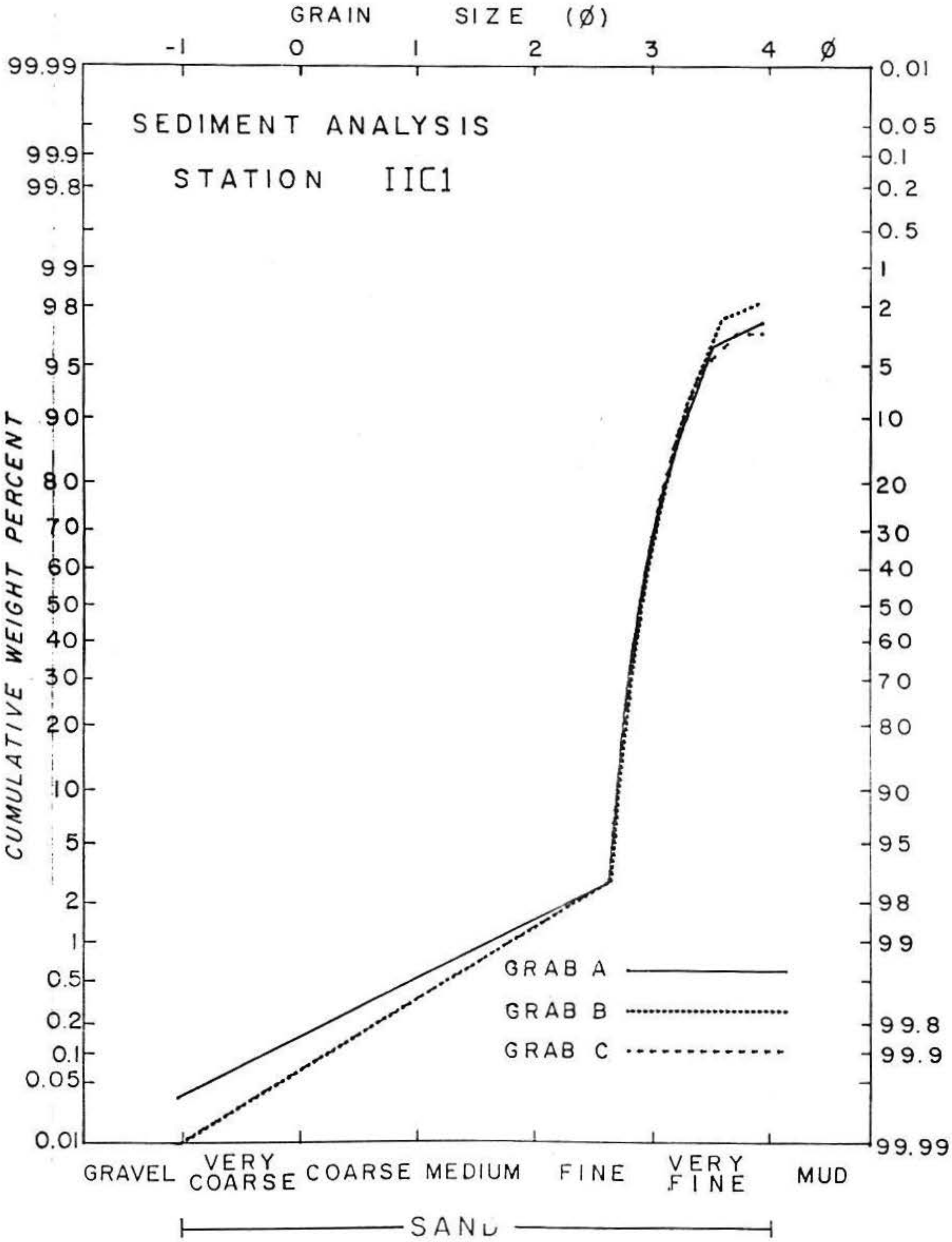
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CUMULATIVE WEIGHT PERCENT
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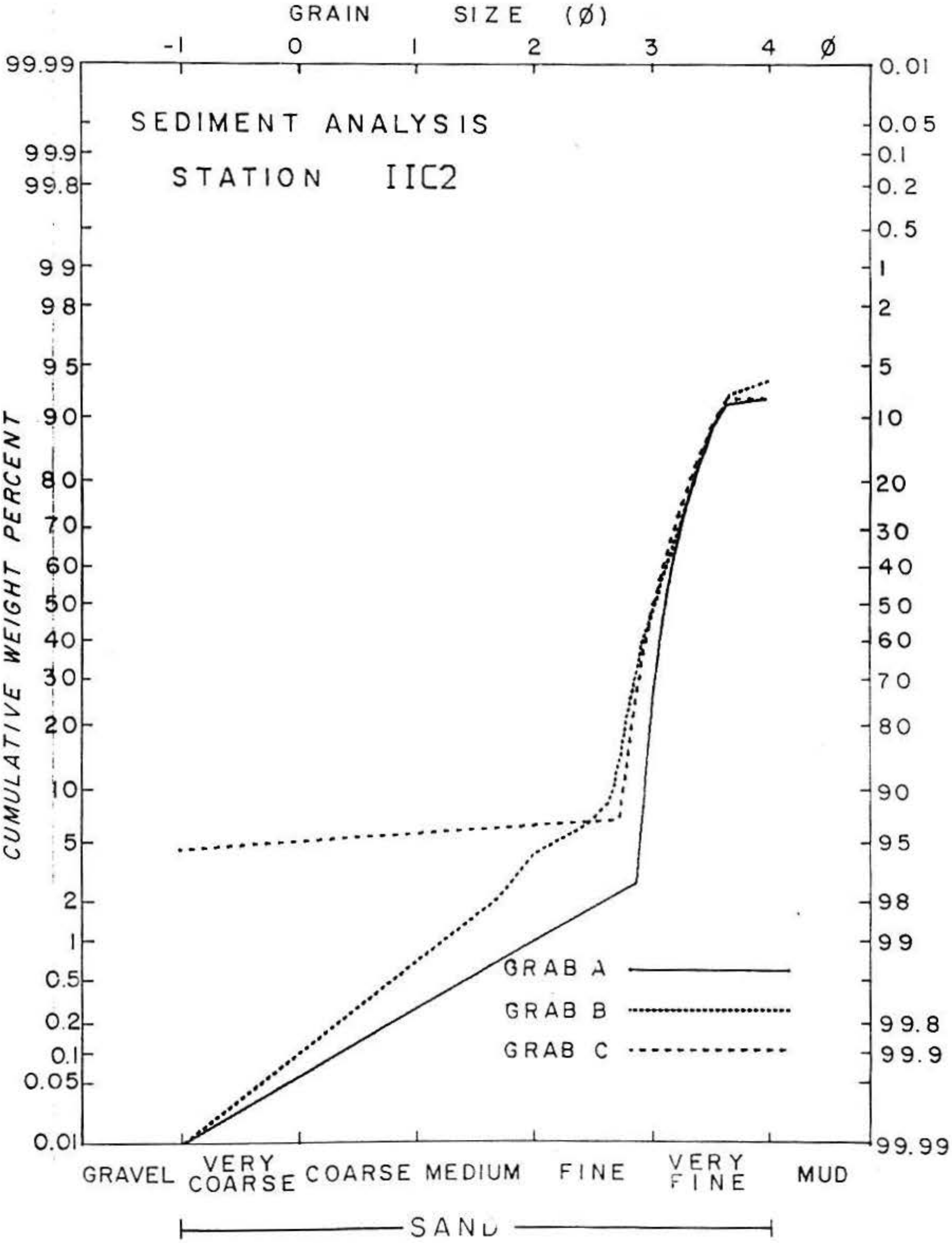
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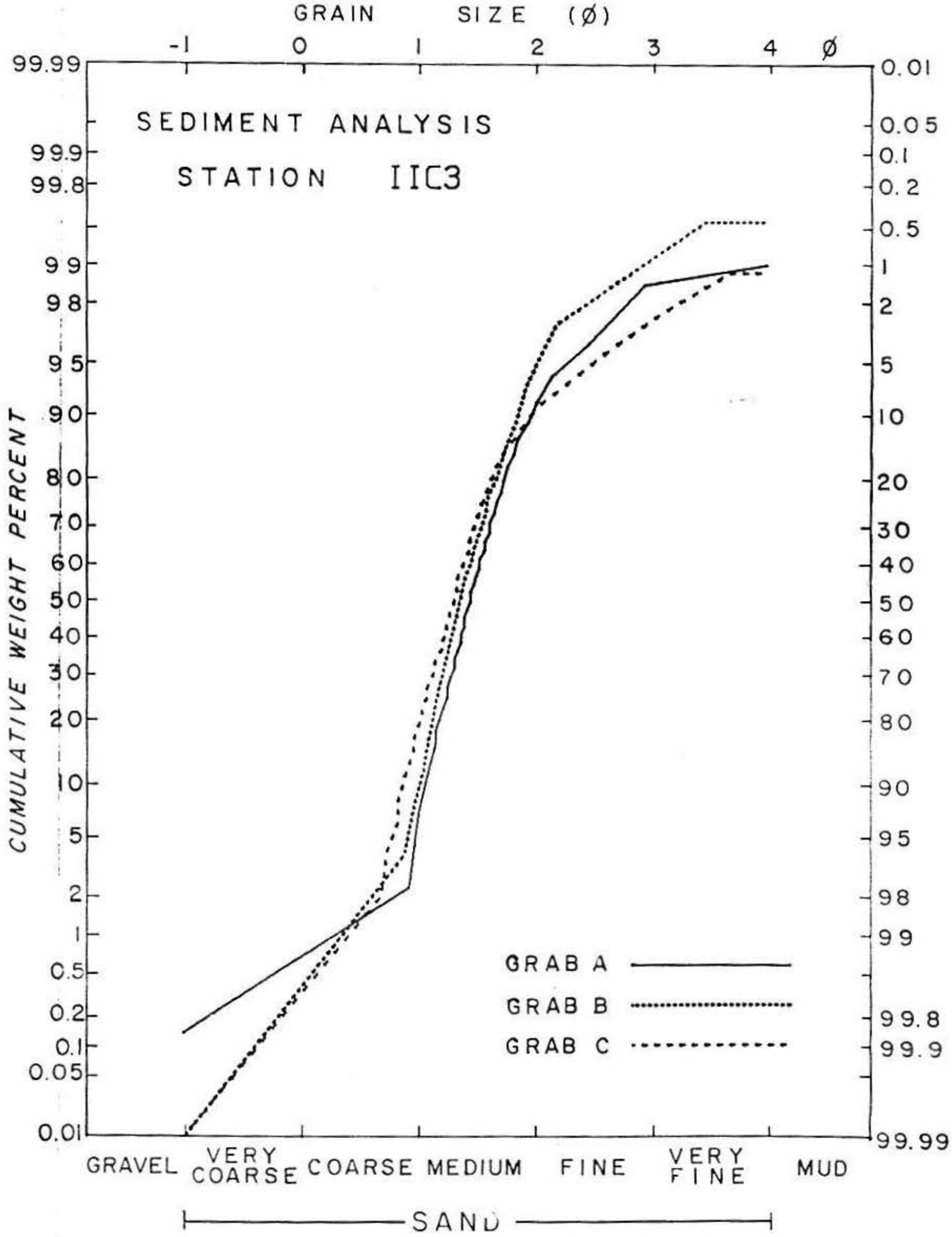
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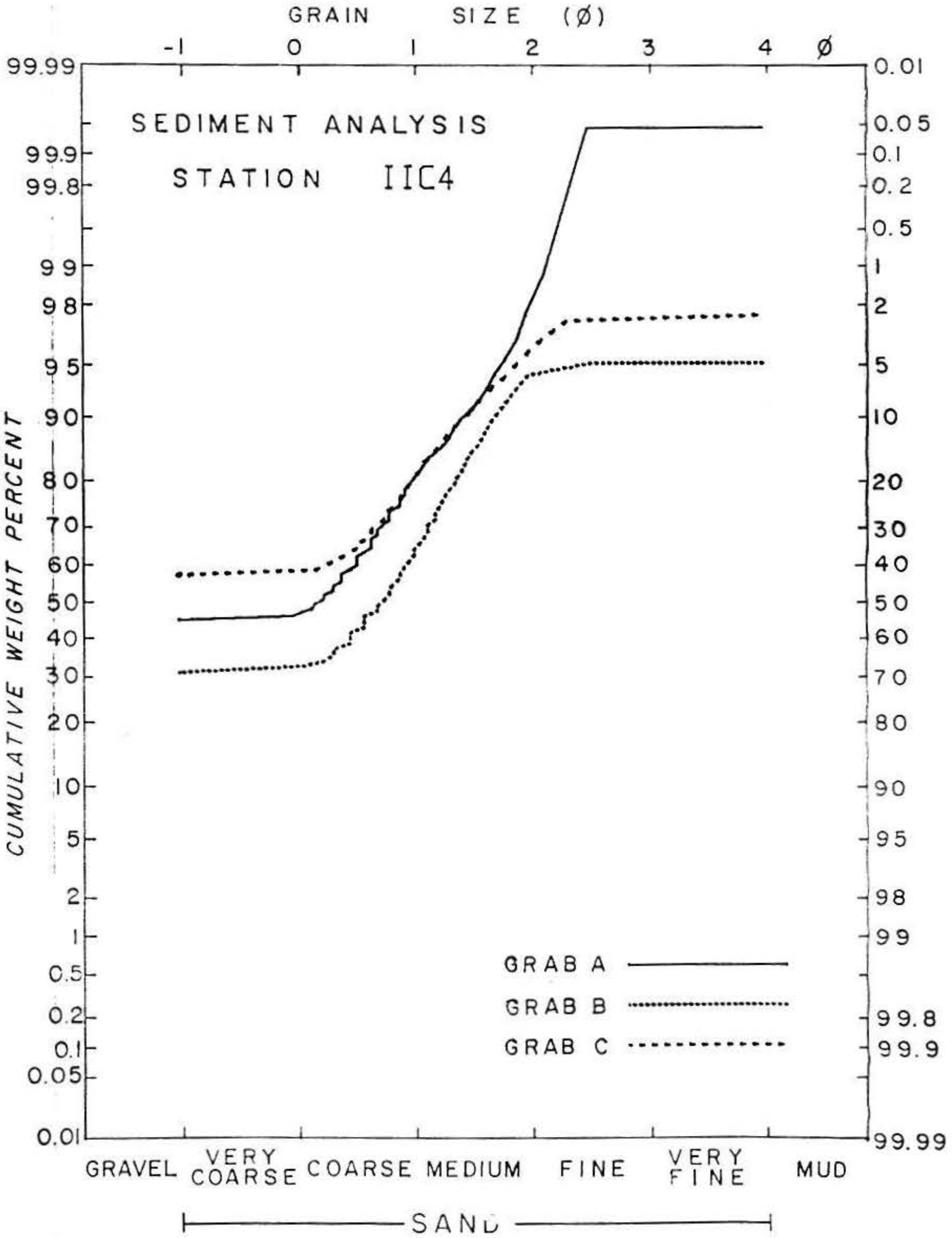
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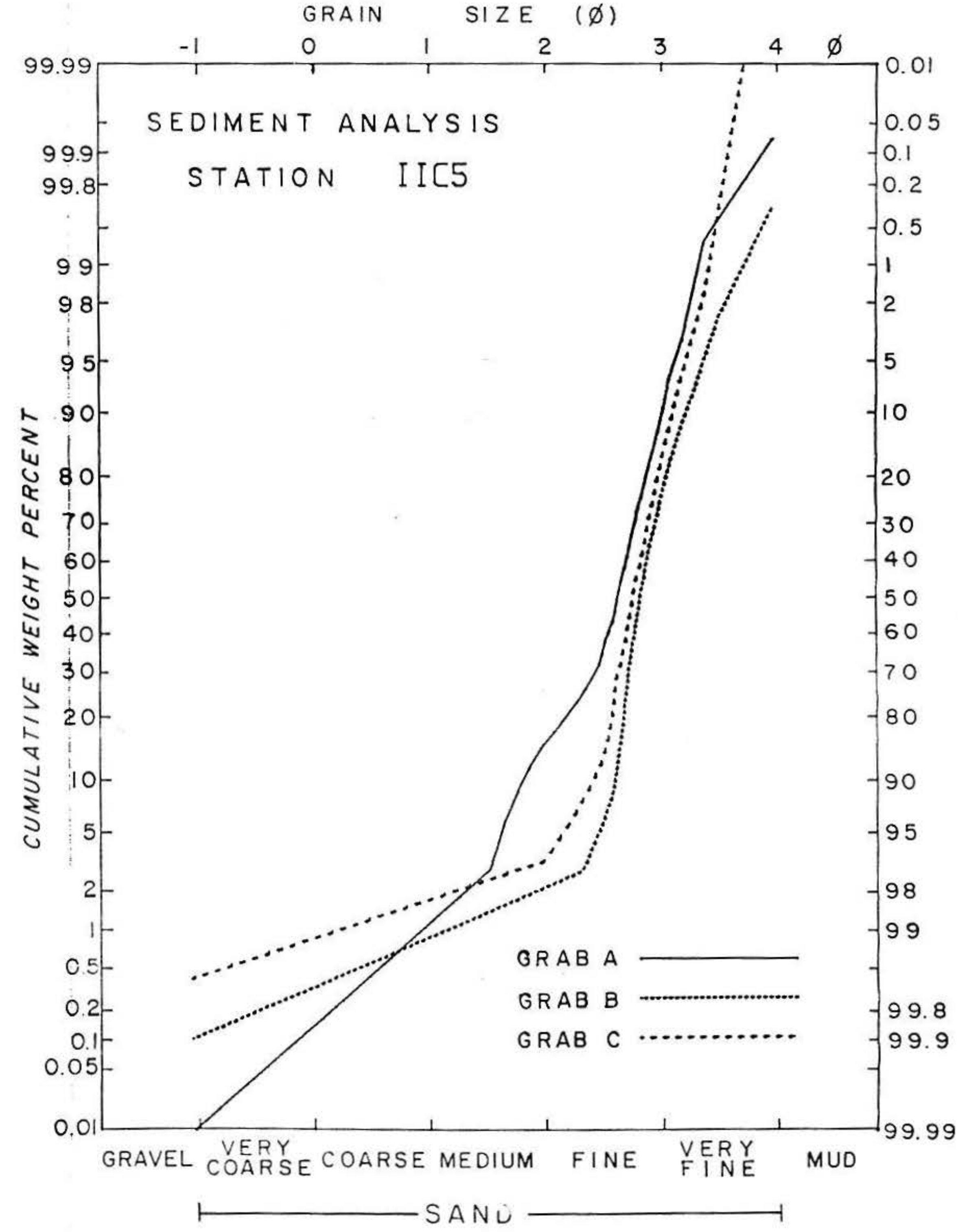
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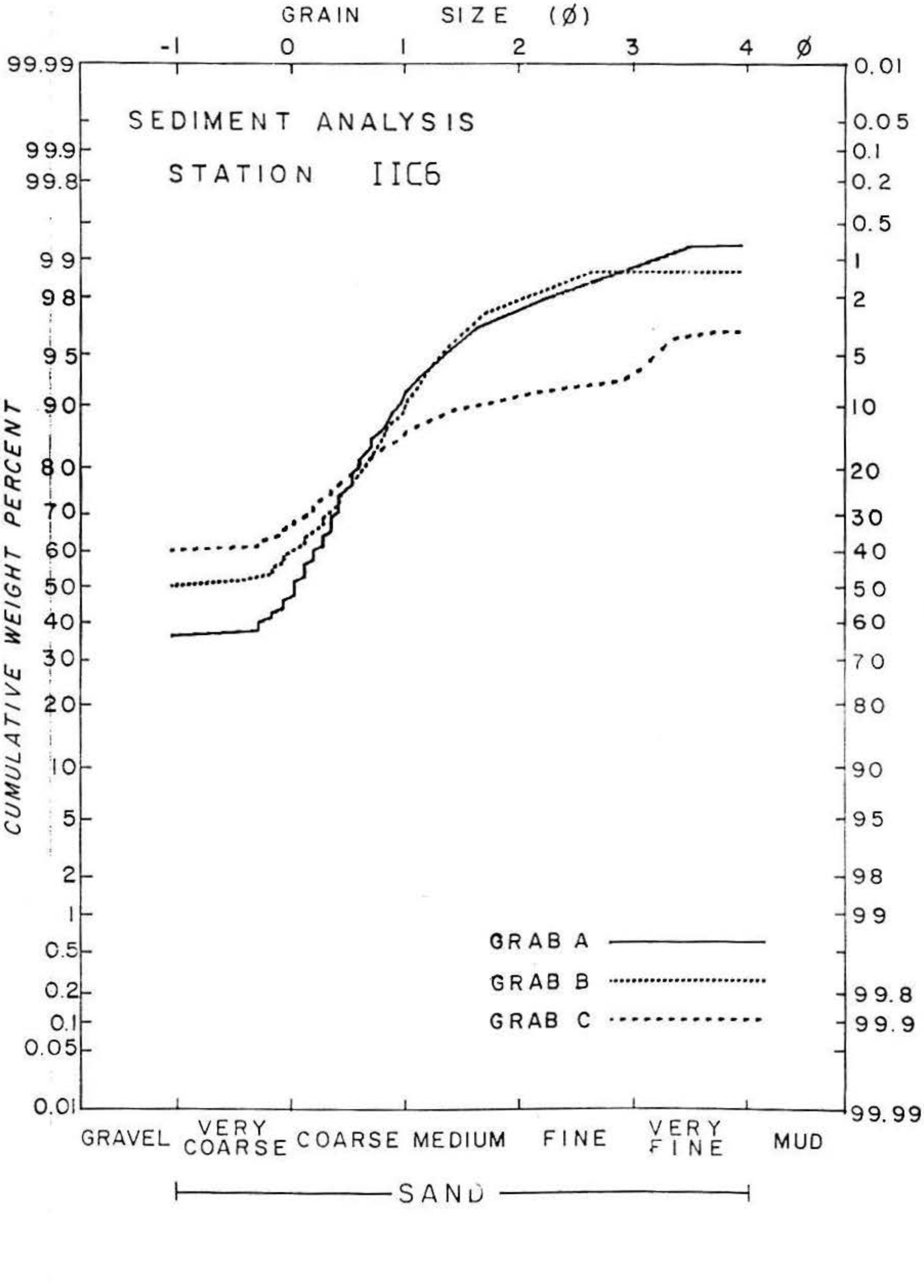
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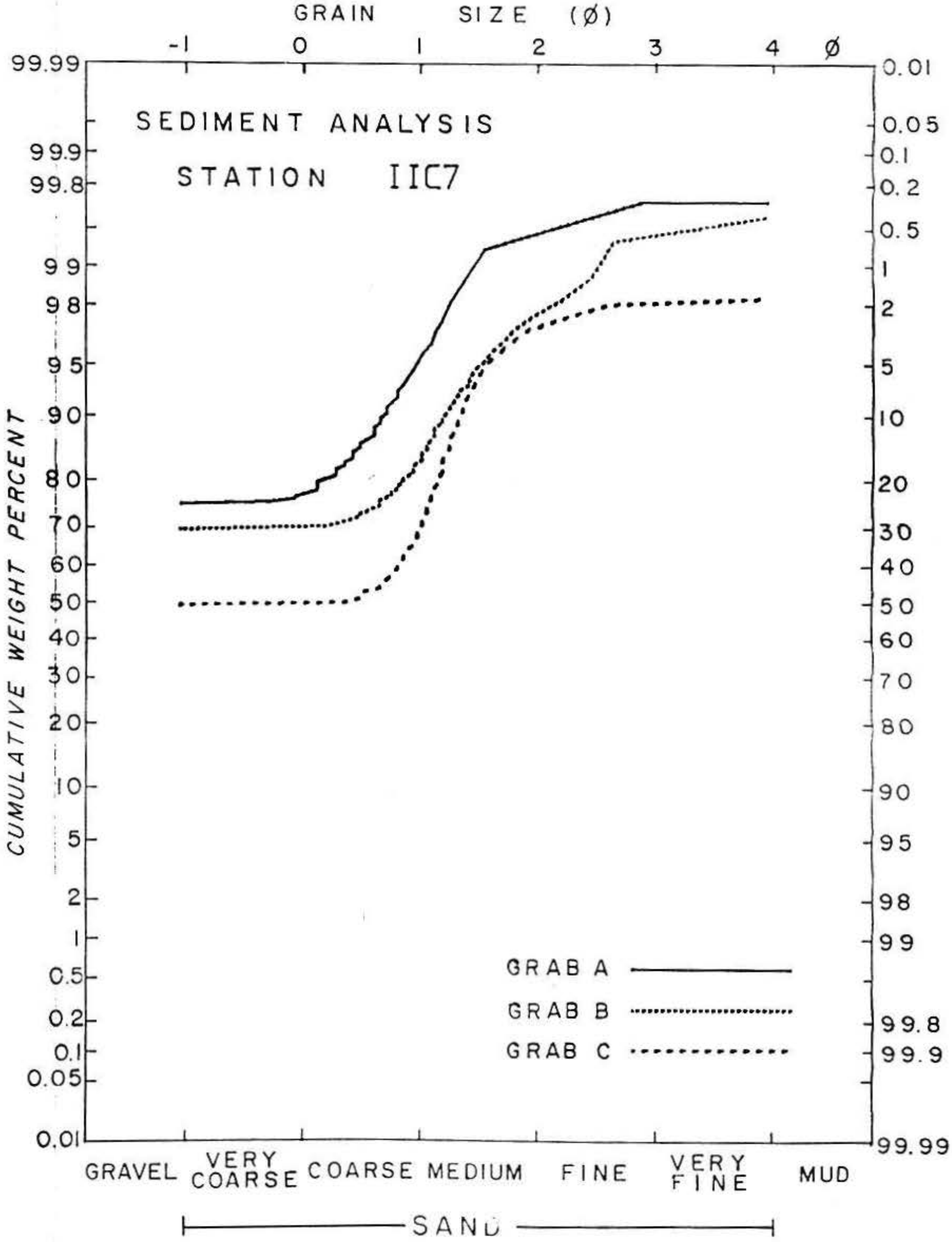
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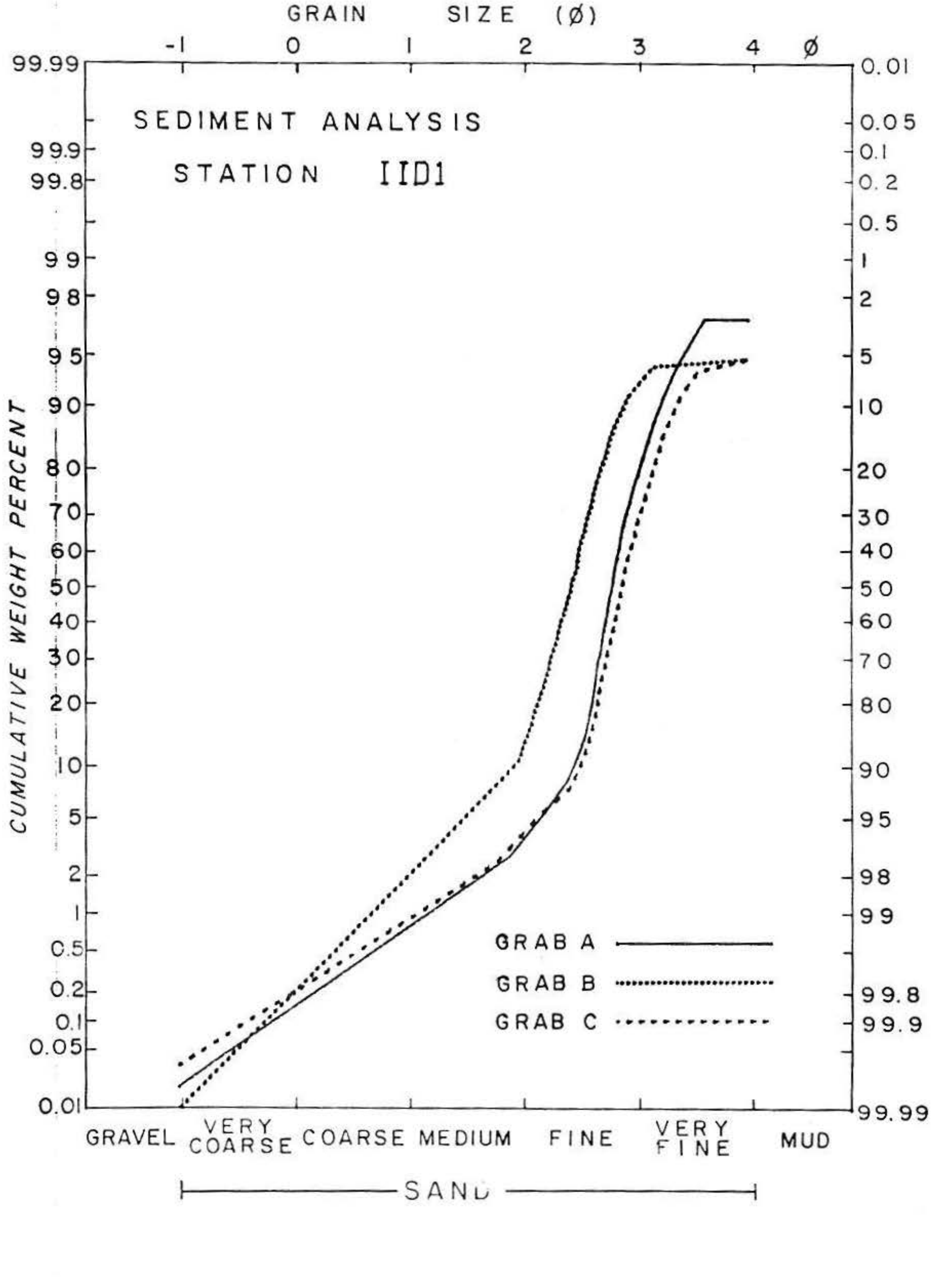
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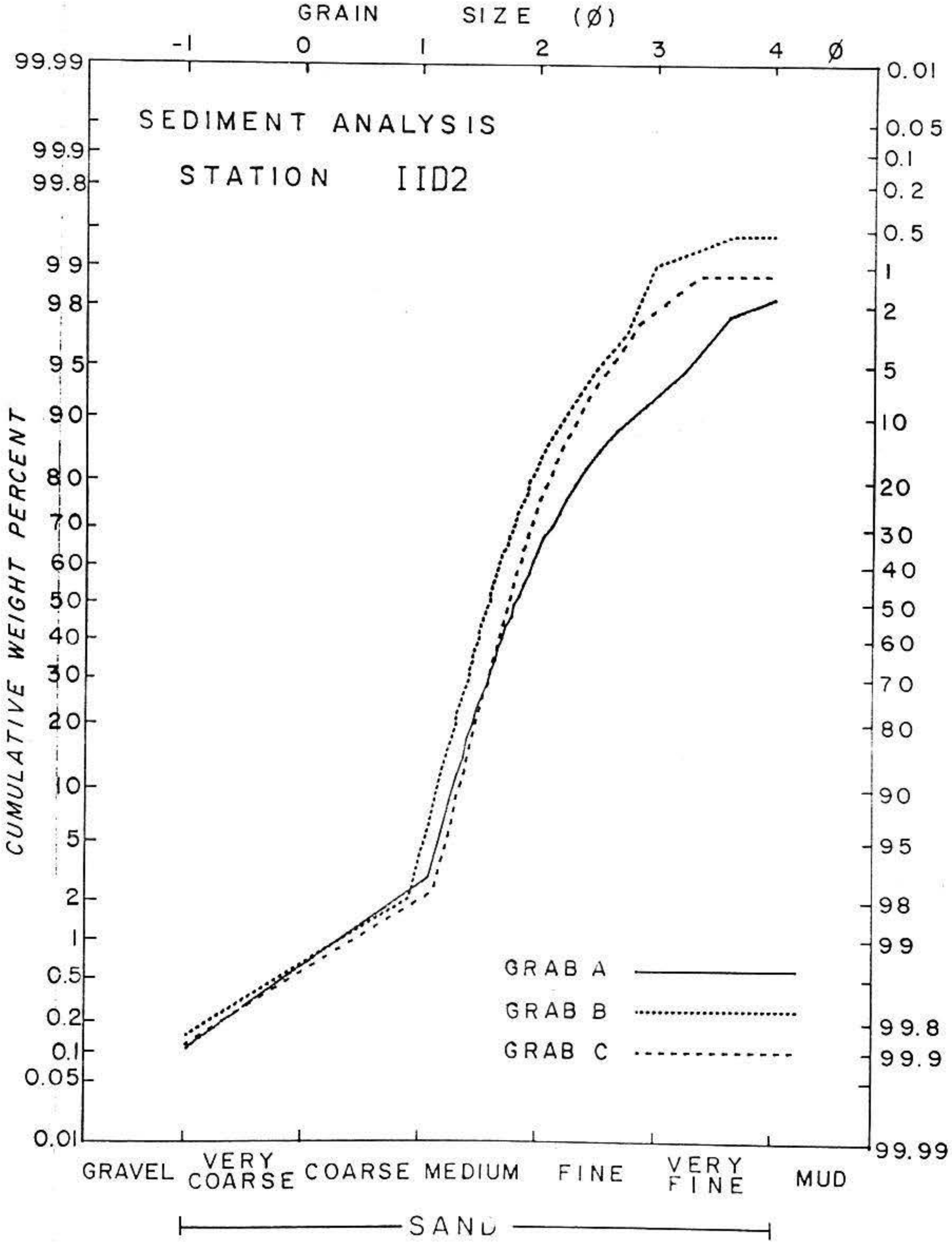
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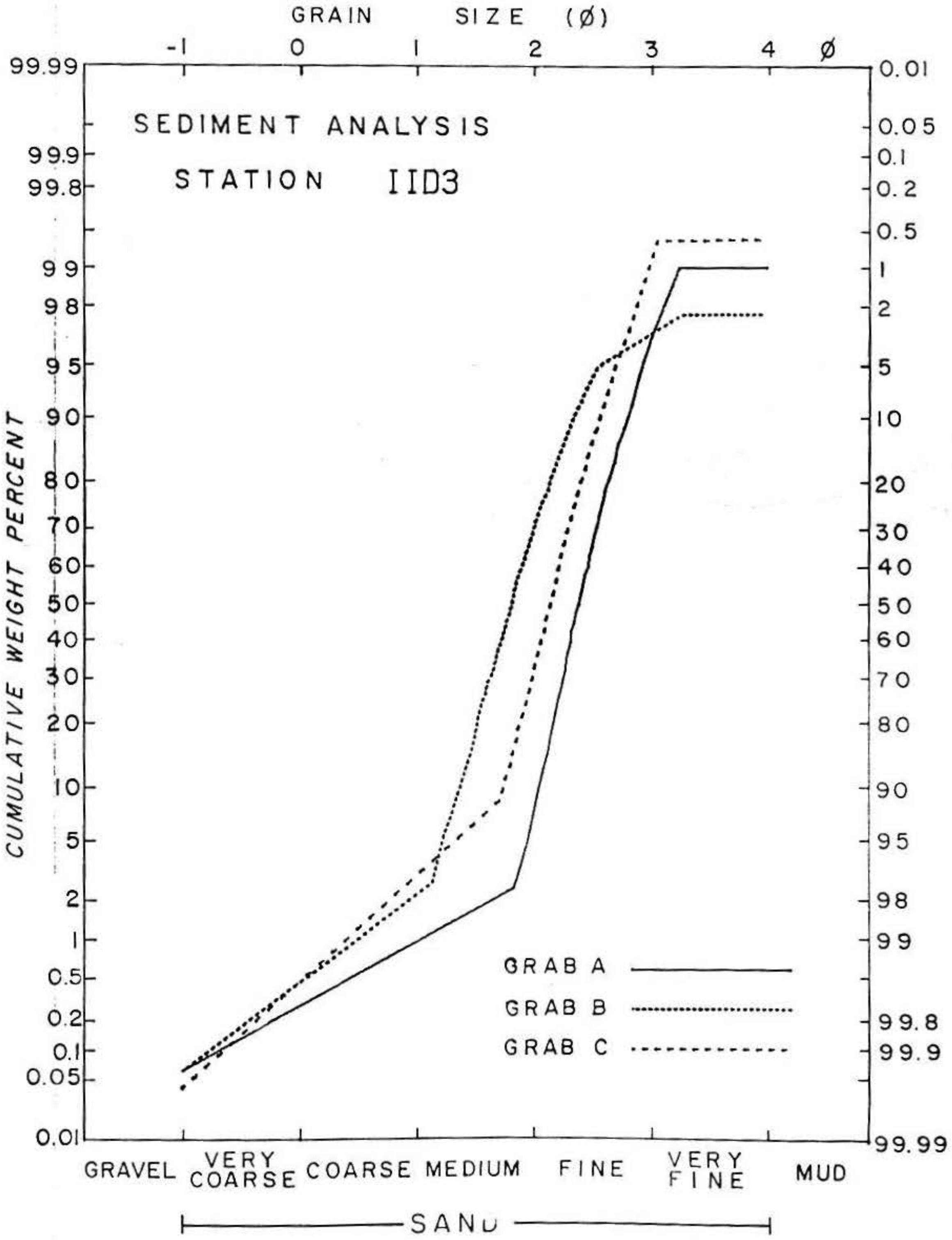
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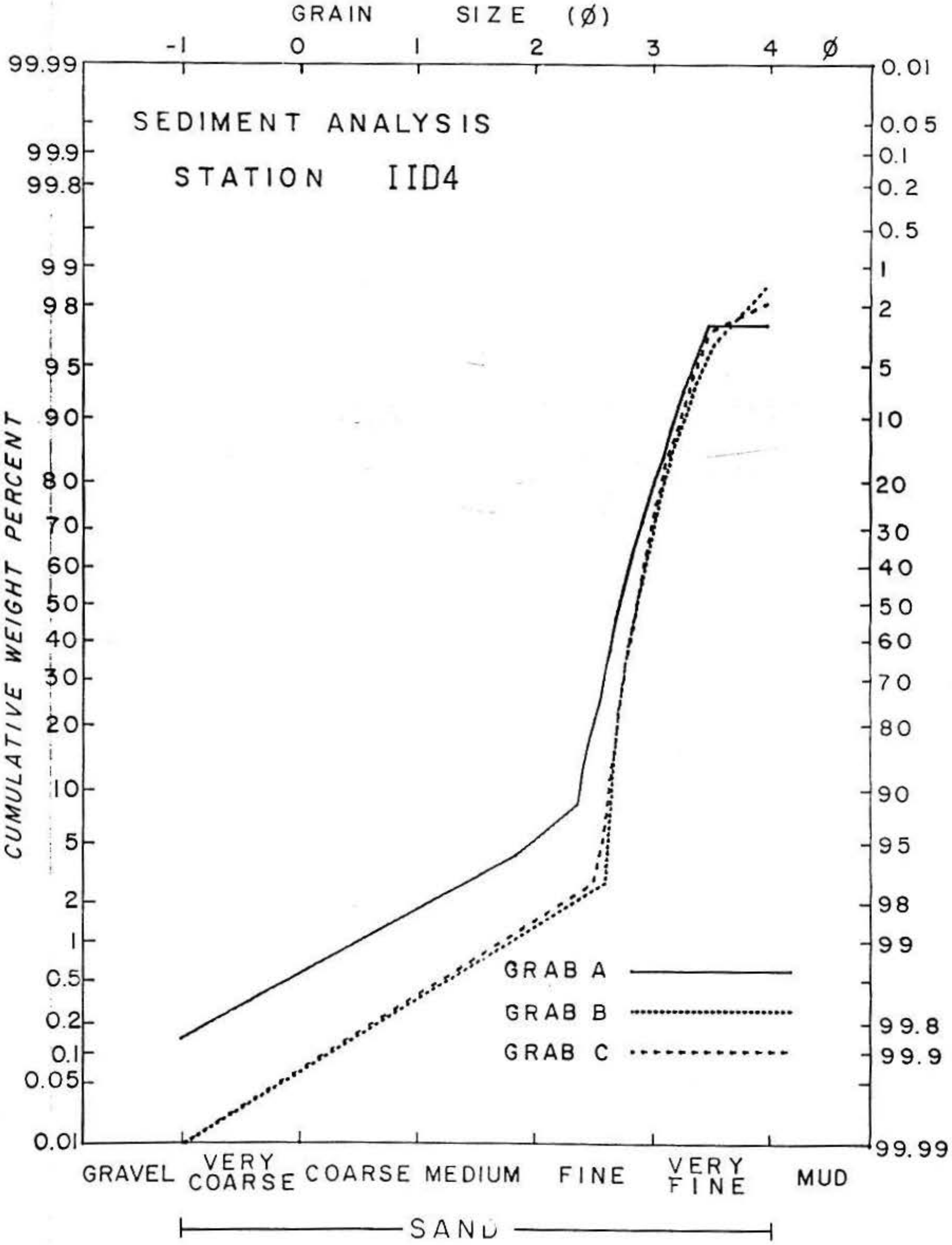
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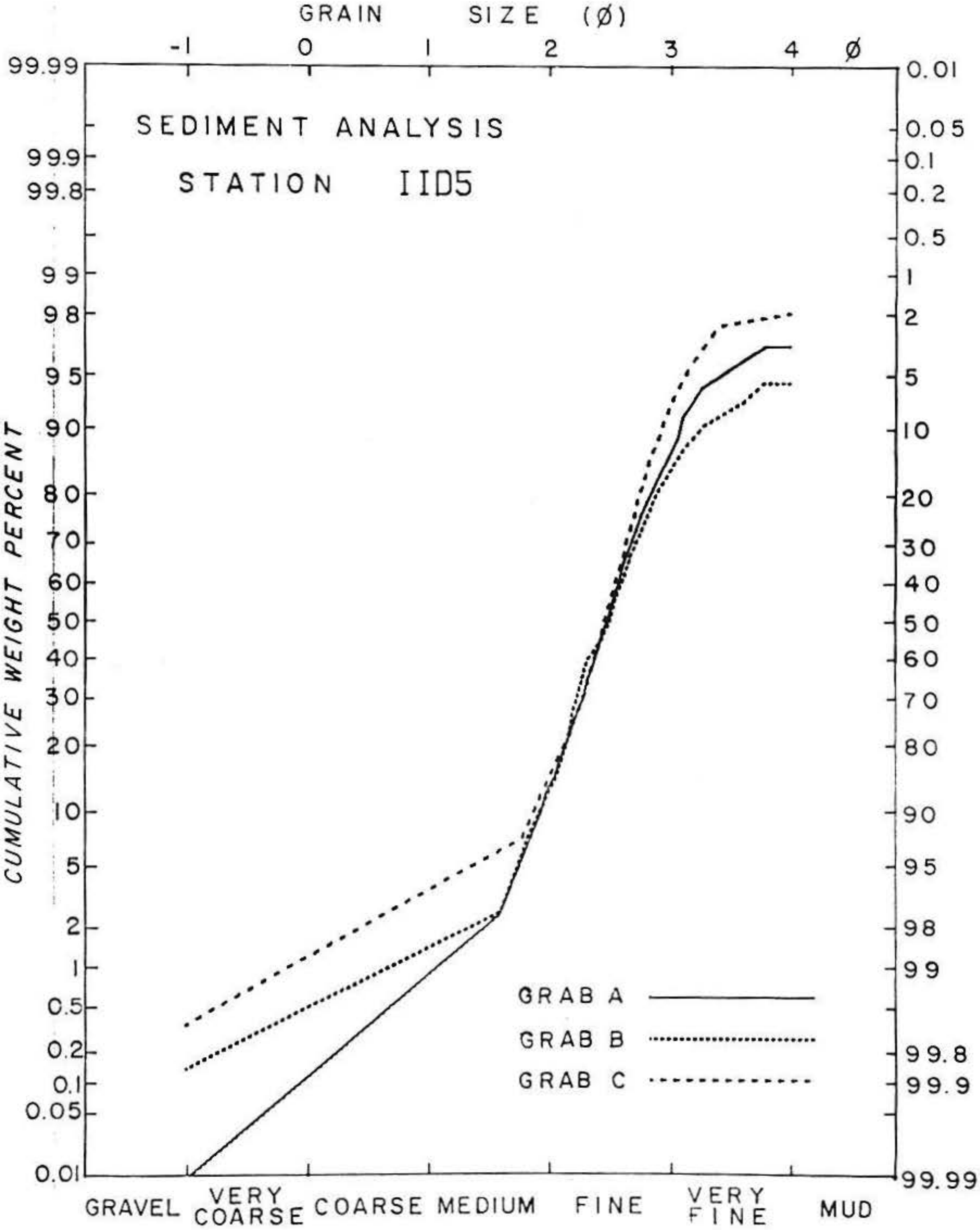
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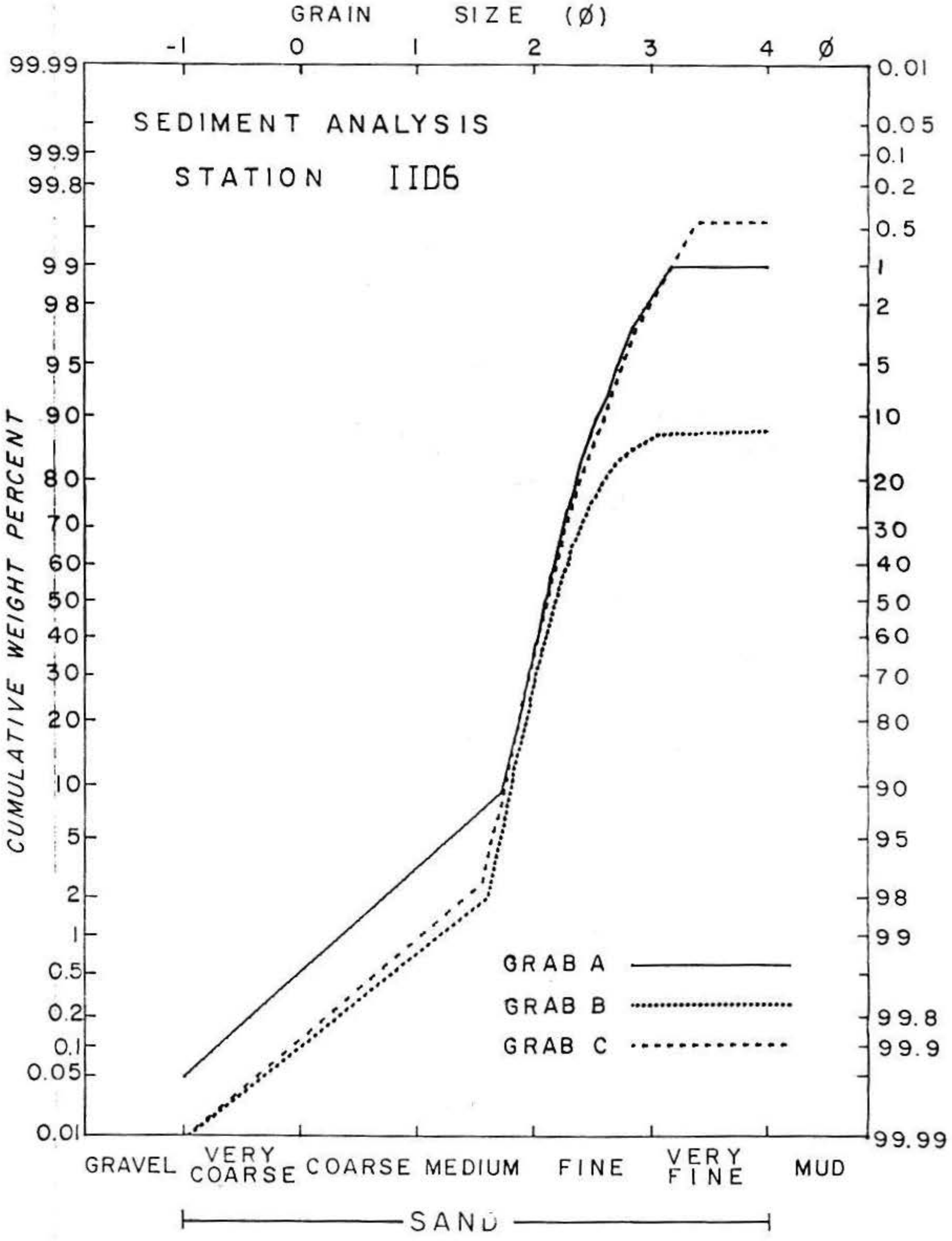
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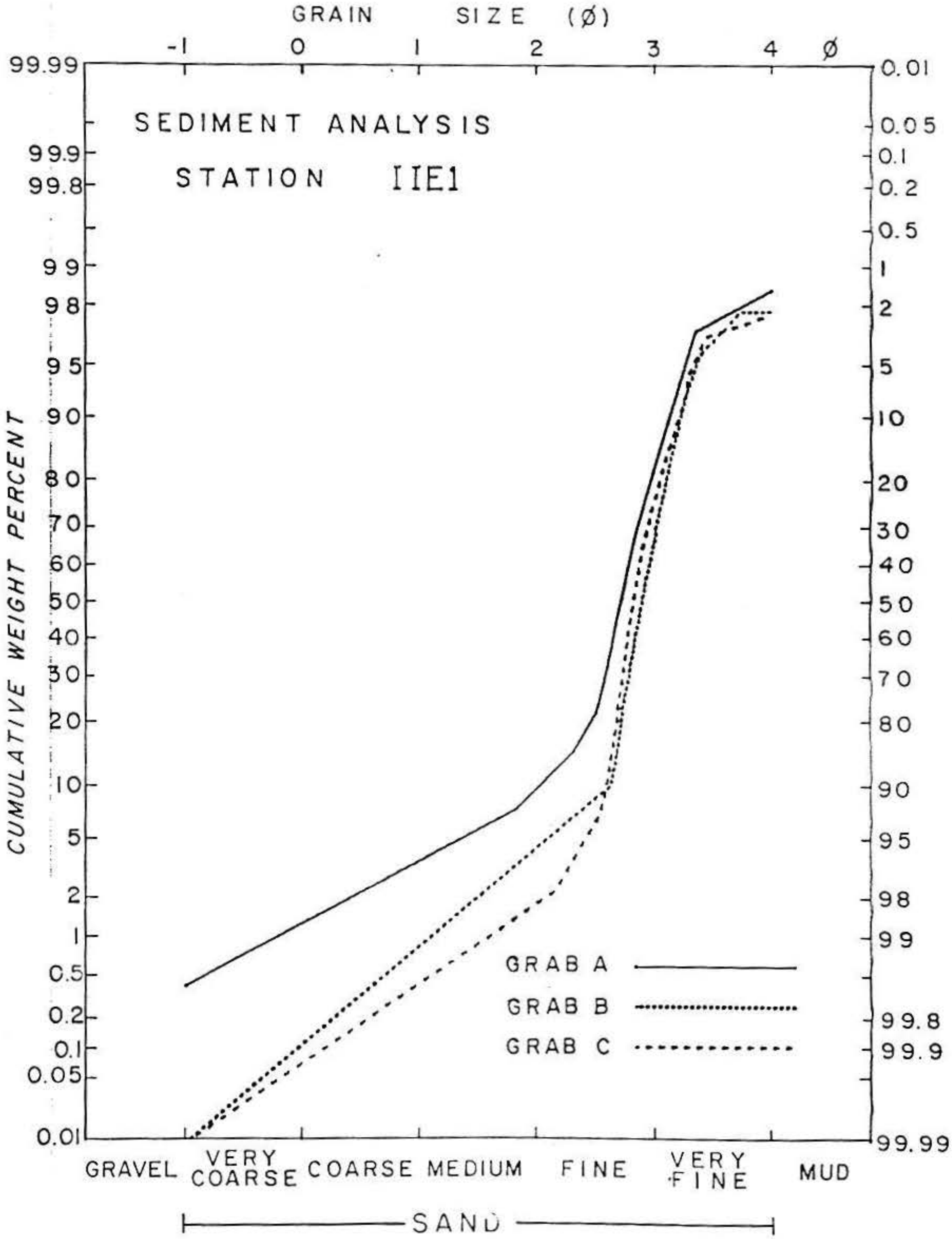
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STATION IIE1
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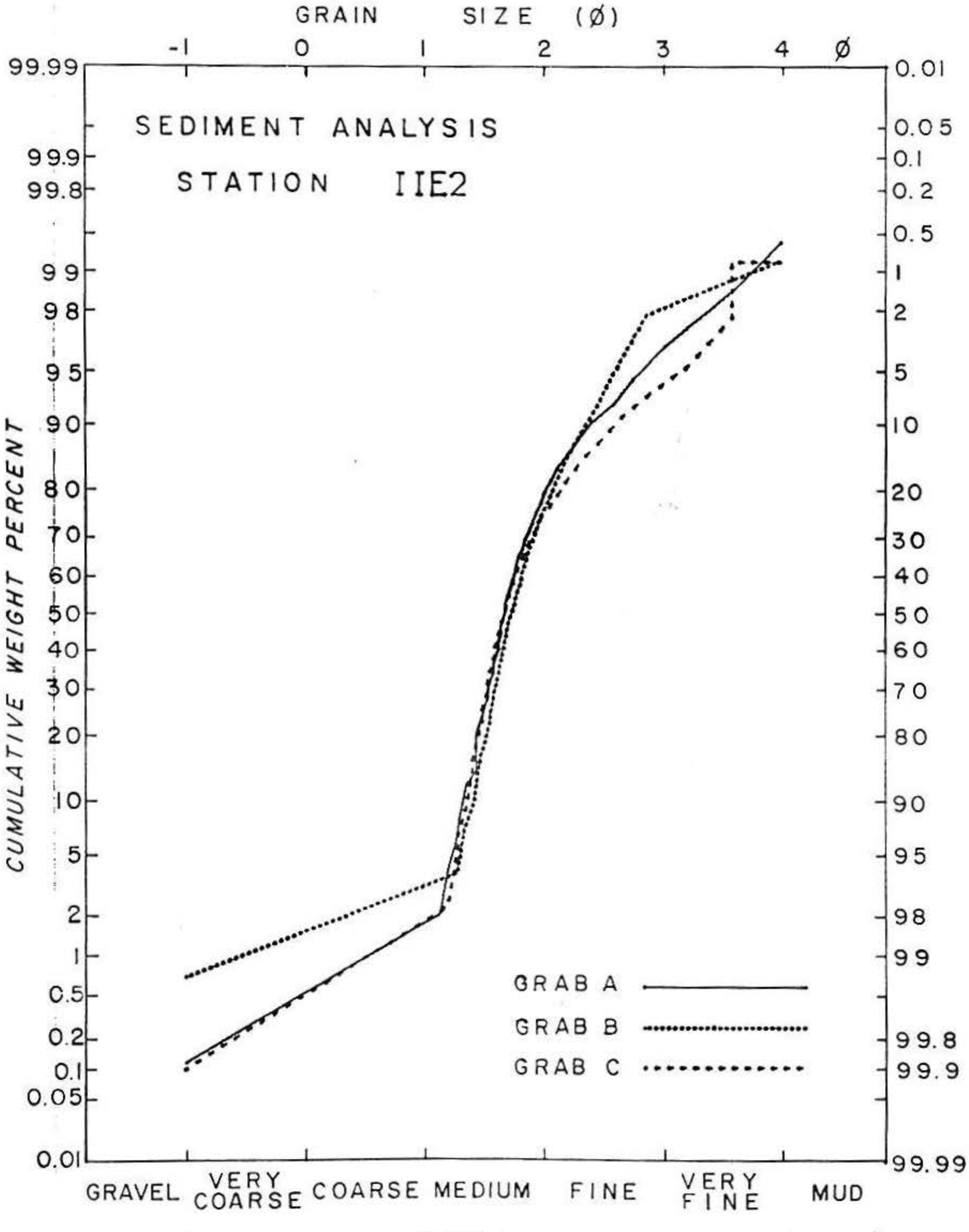
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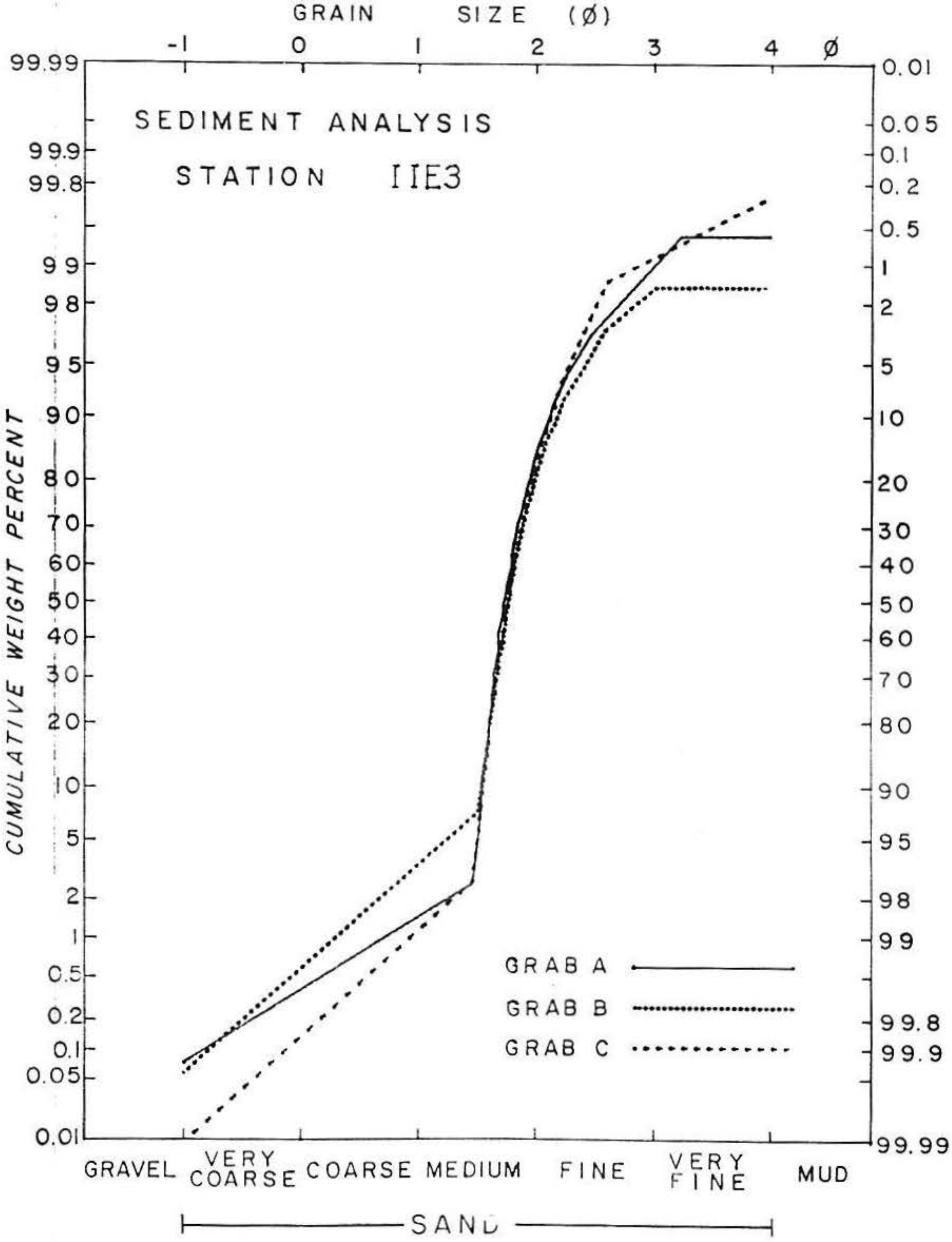
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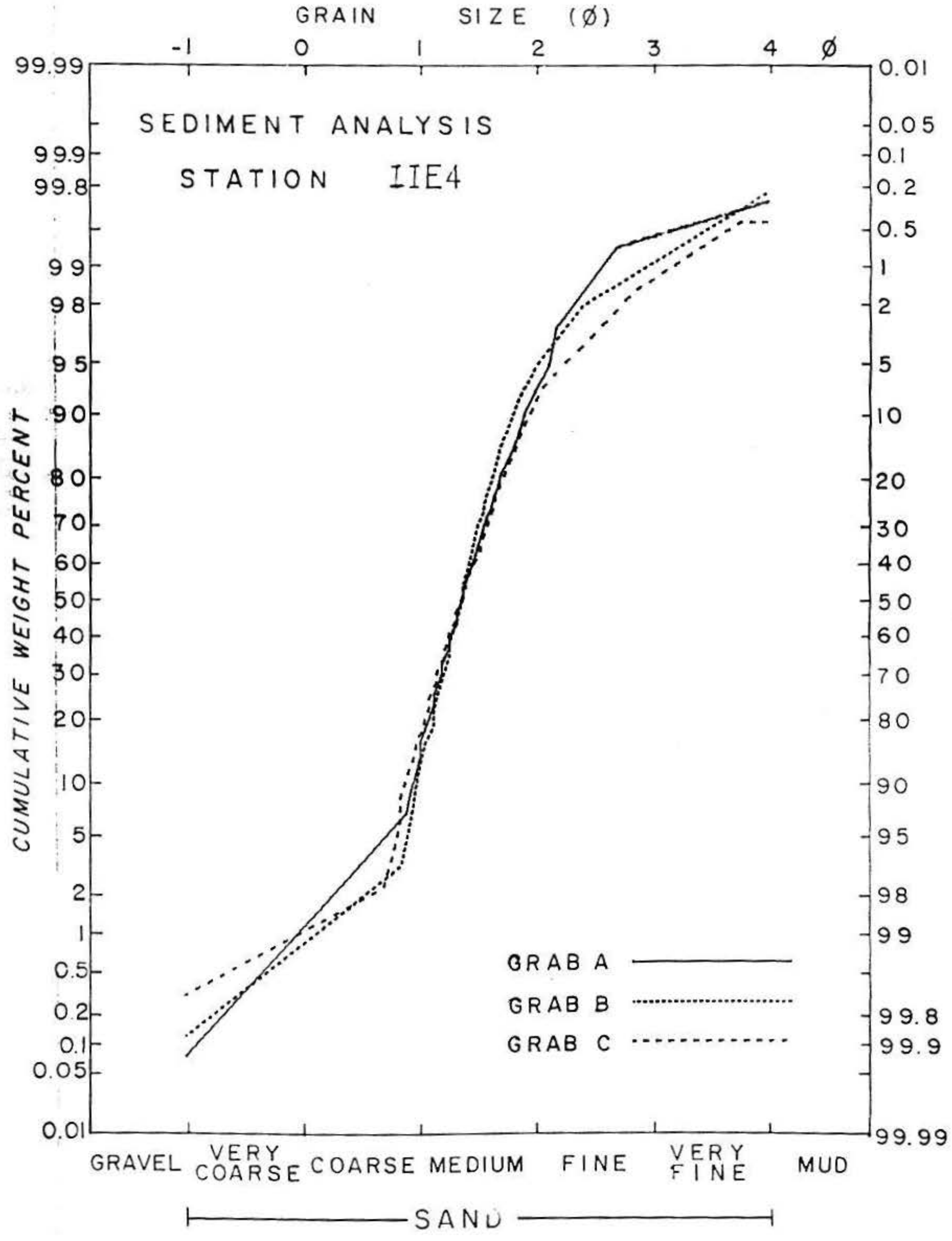
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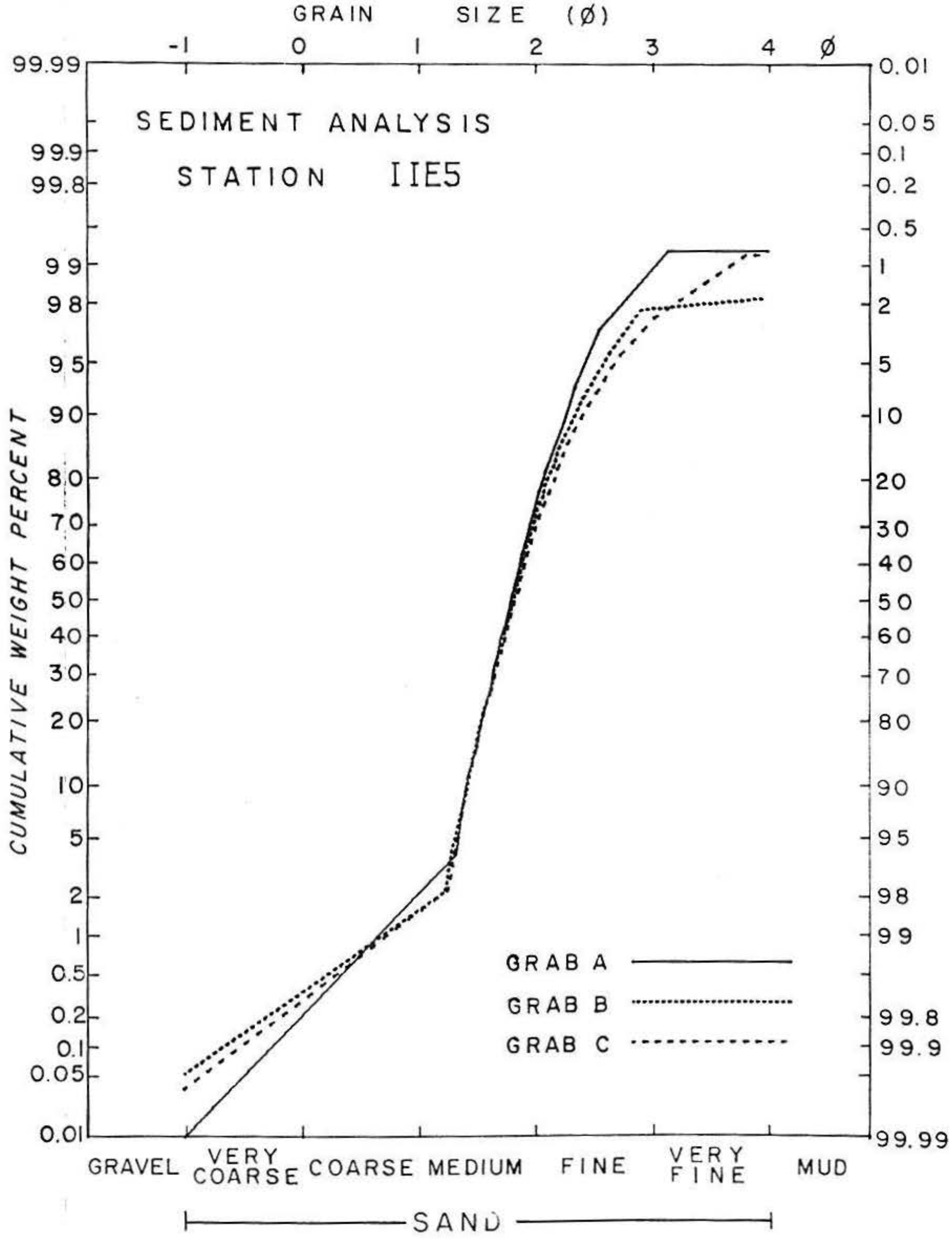
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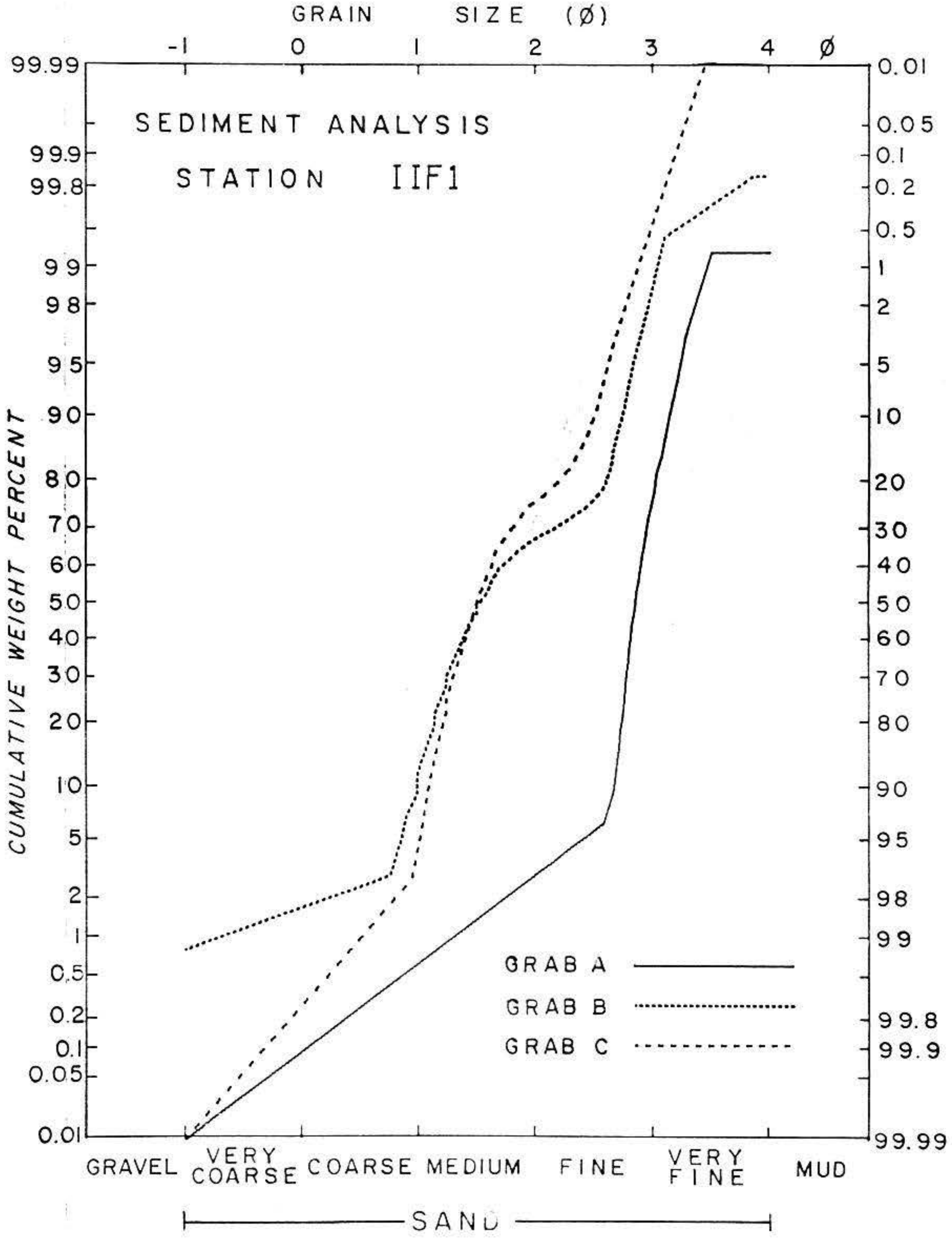
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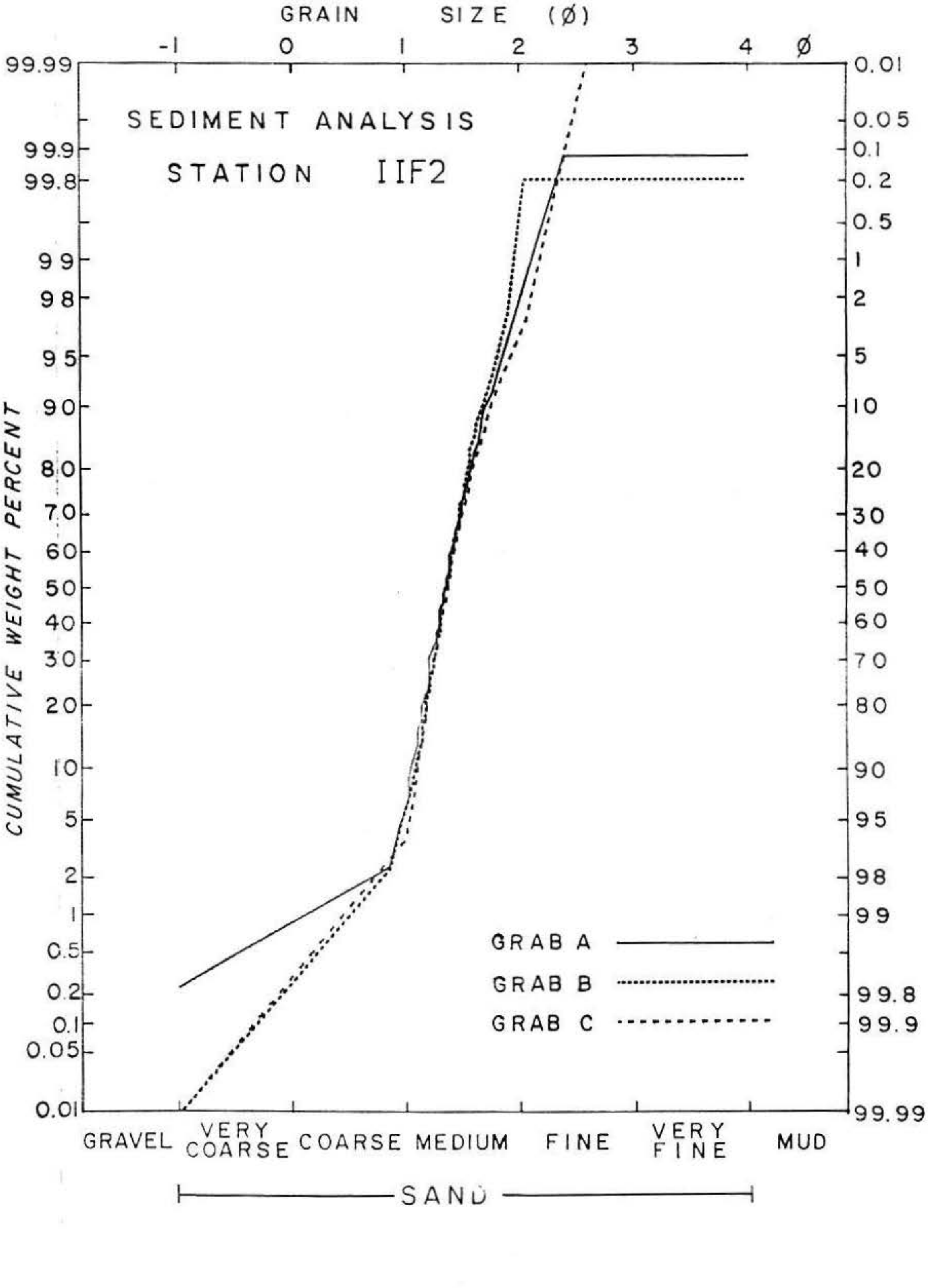
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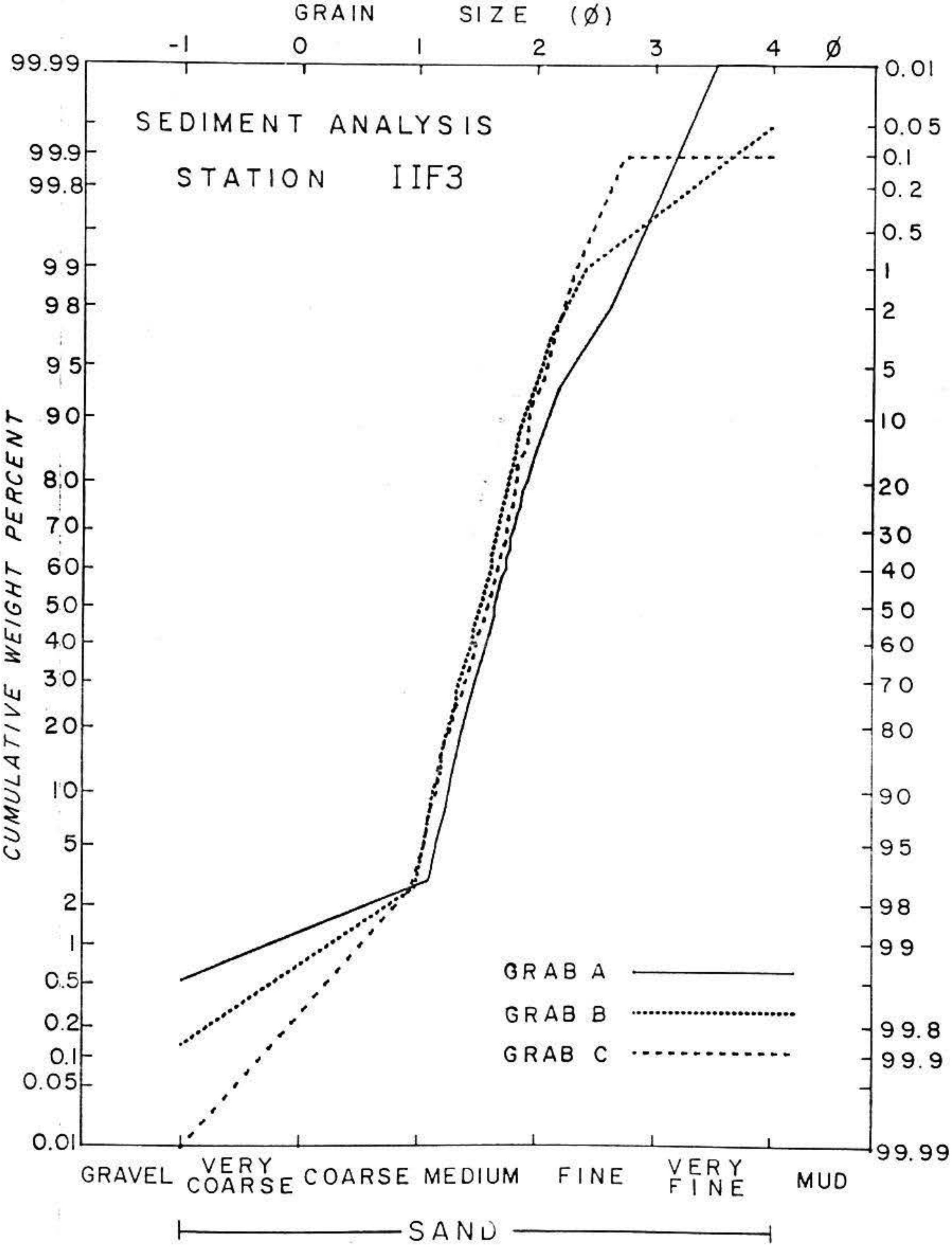
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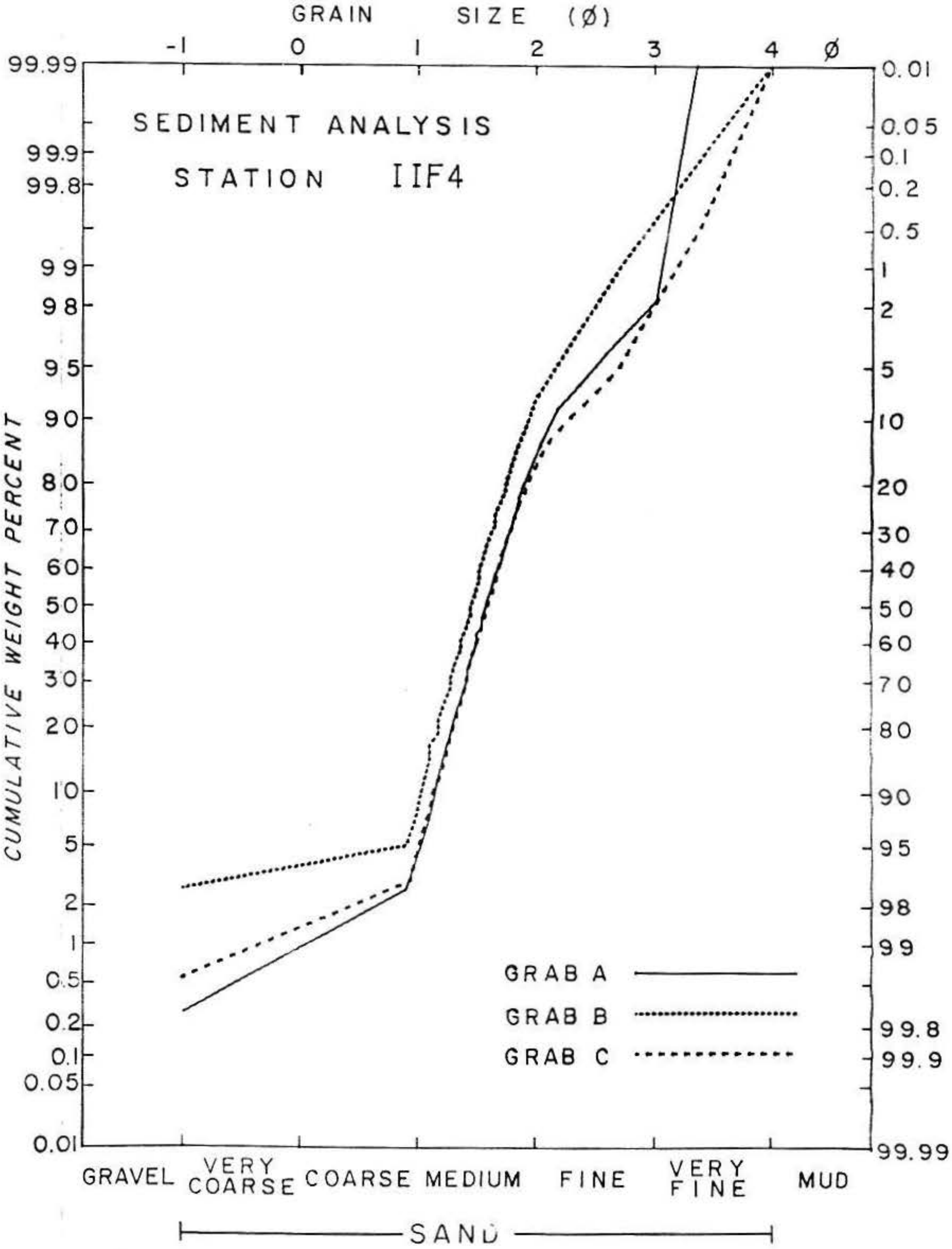
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CUMULATIVE WEIGHT PERCENT
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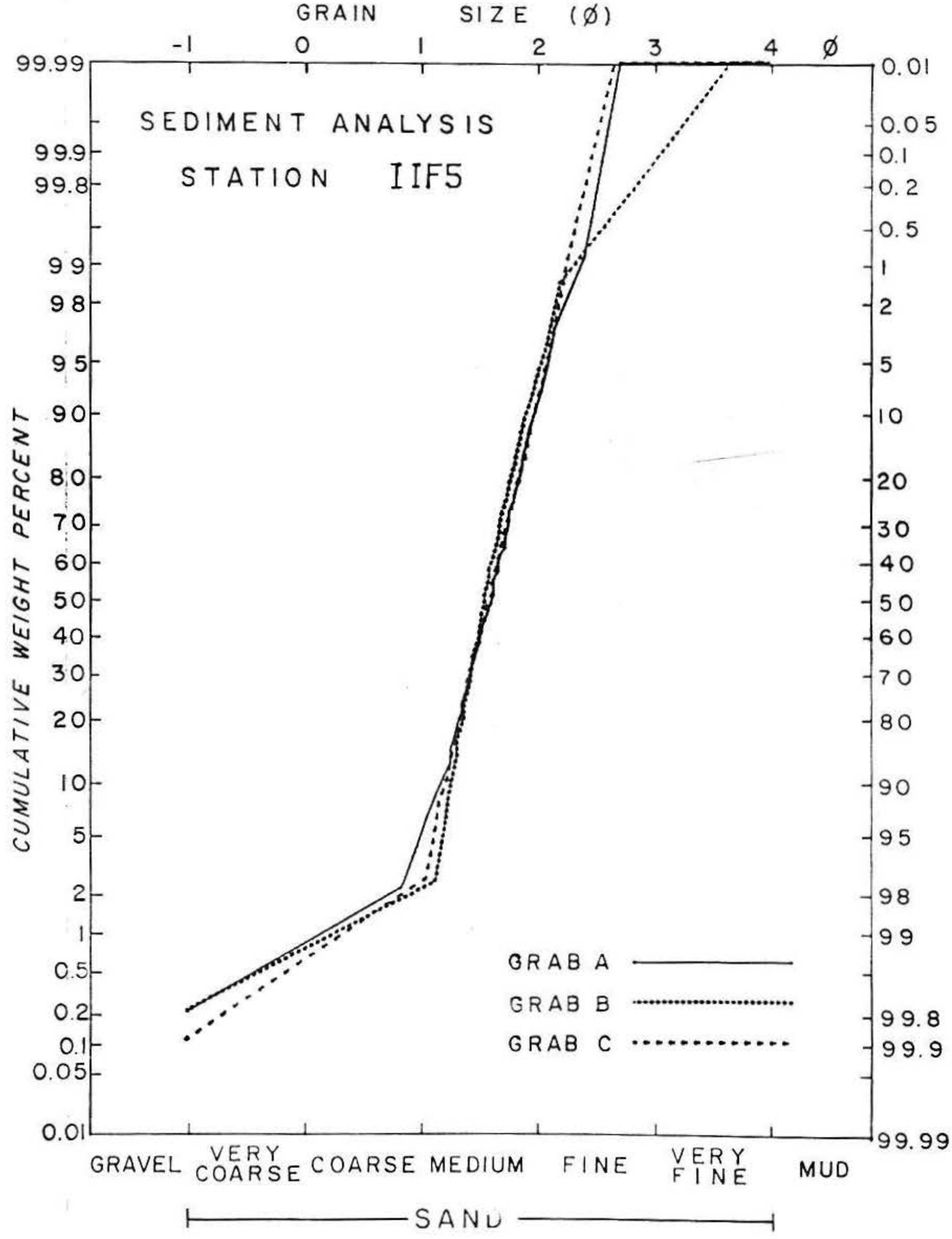
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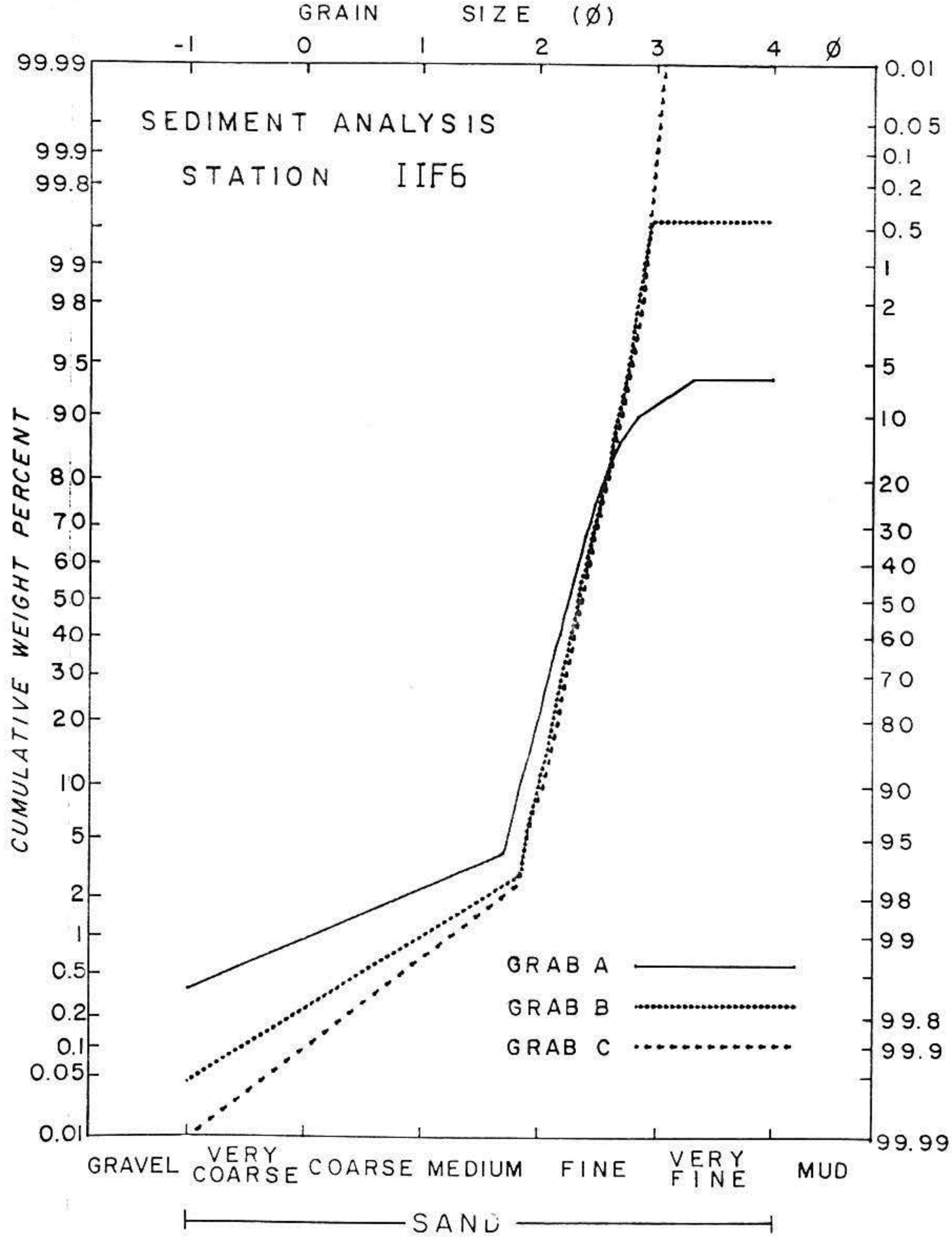
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STATION IIF6
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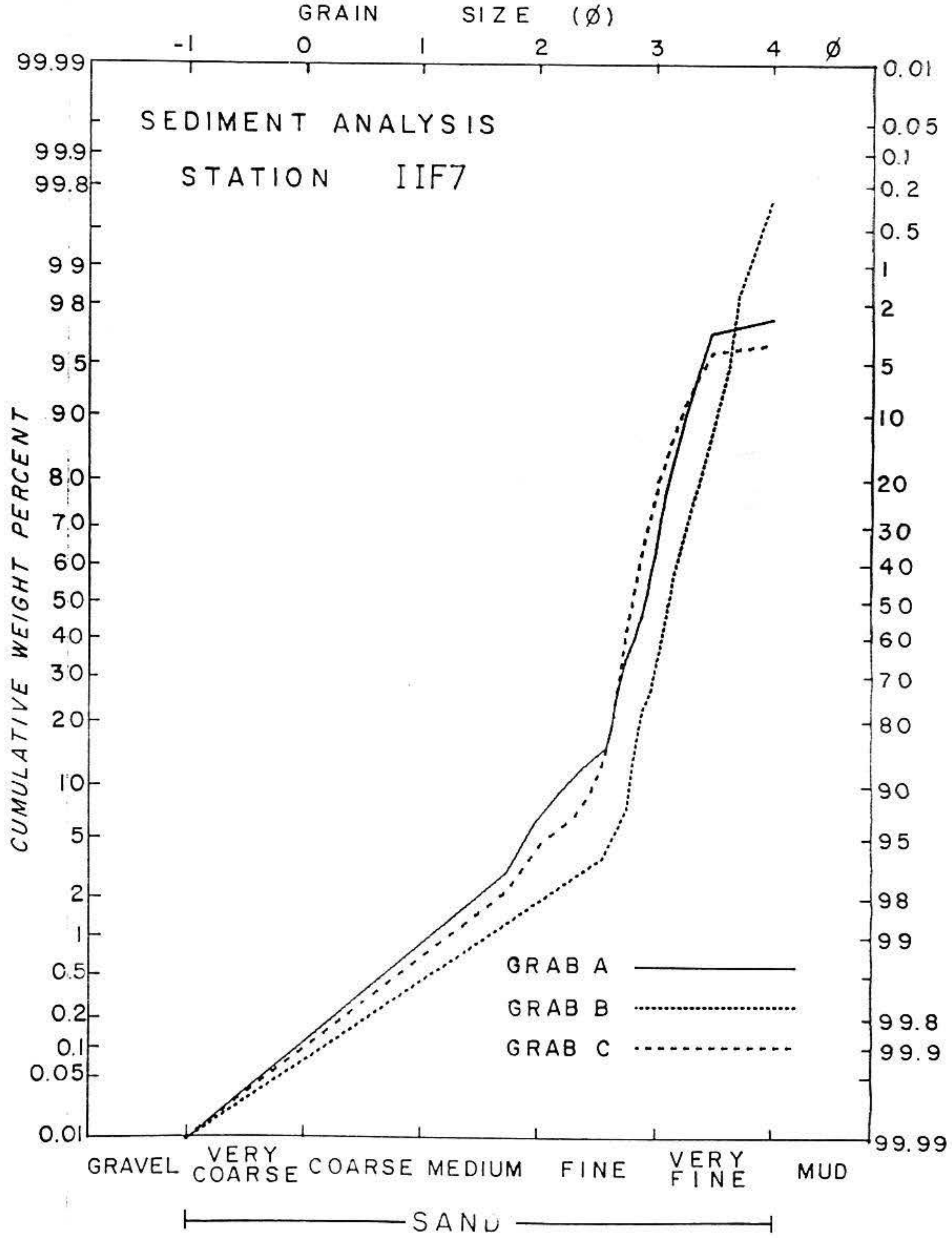
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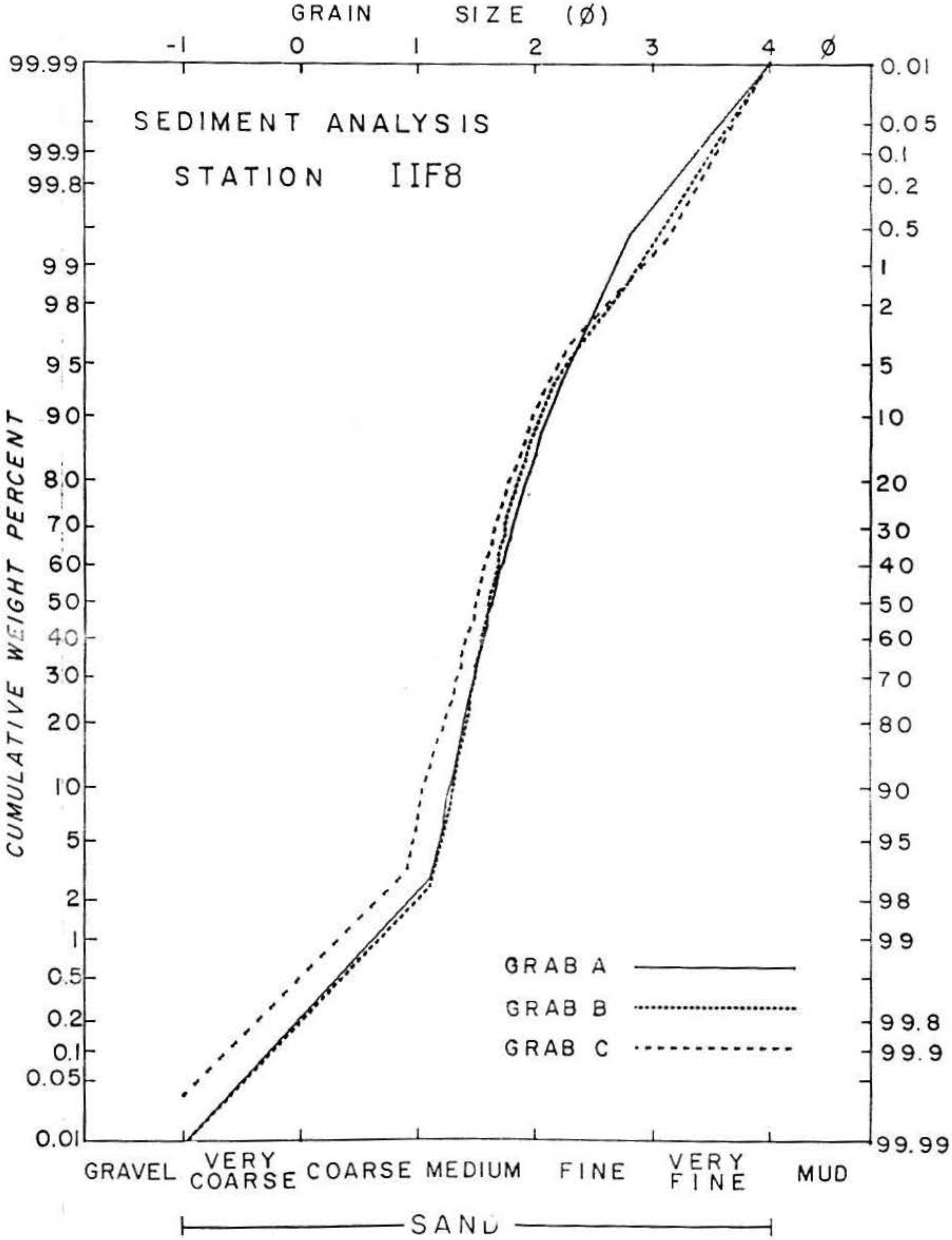
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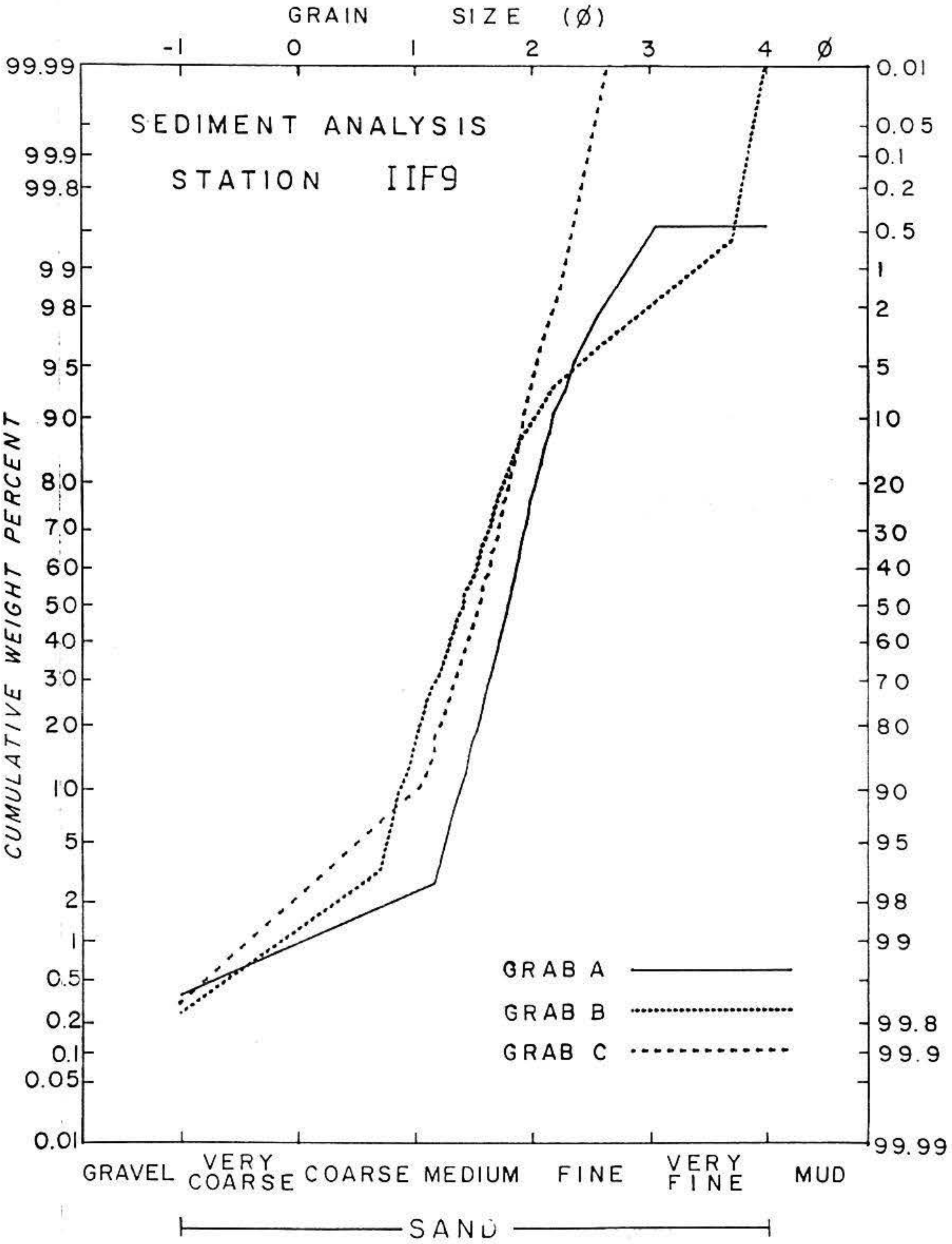
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CUMULATIVE WEIGHT PERCENT
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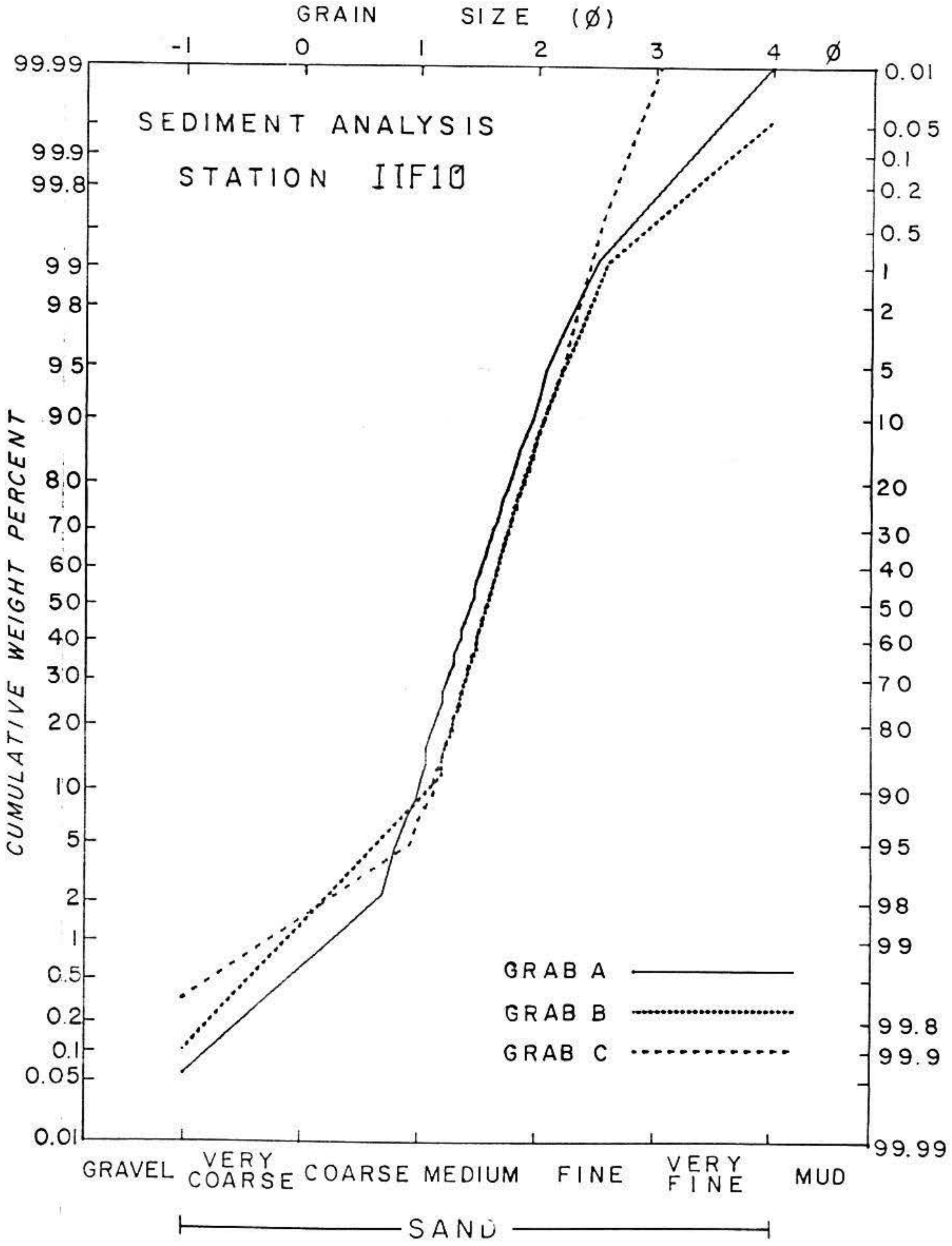
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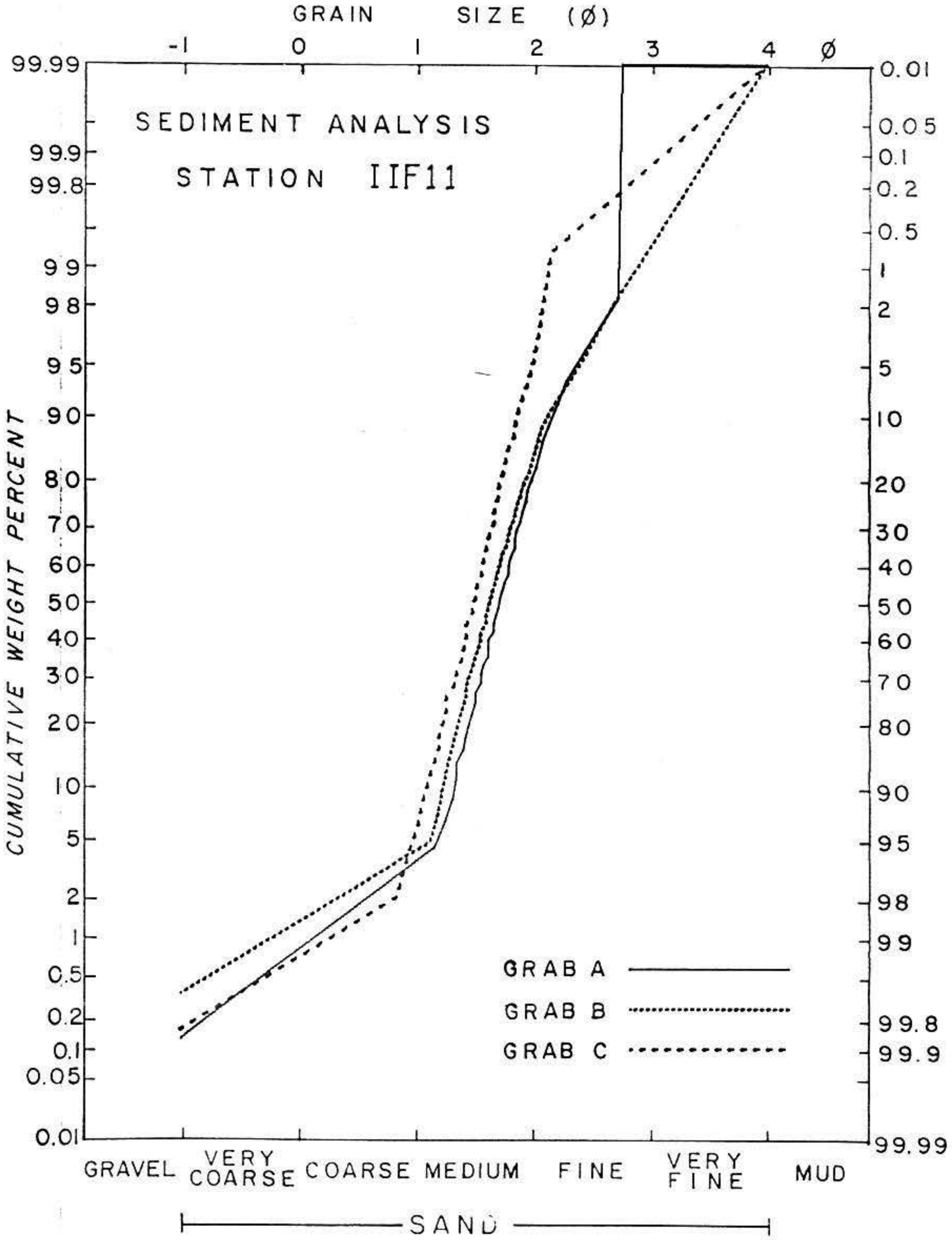
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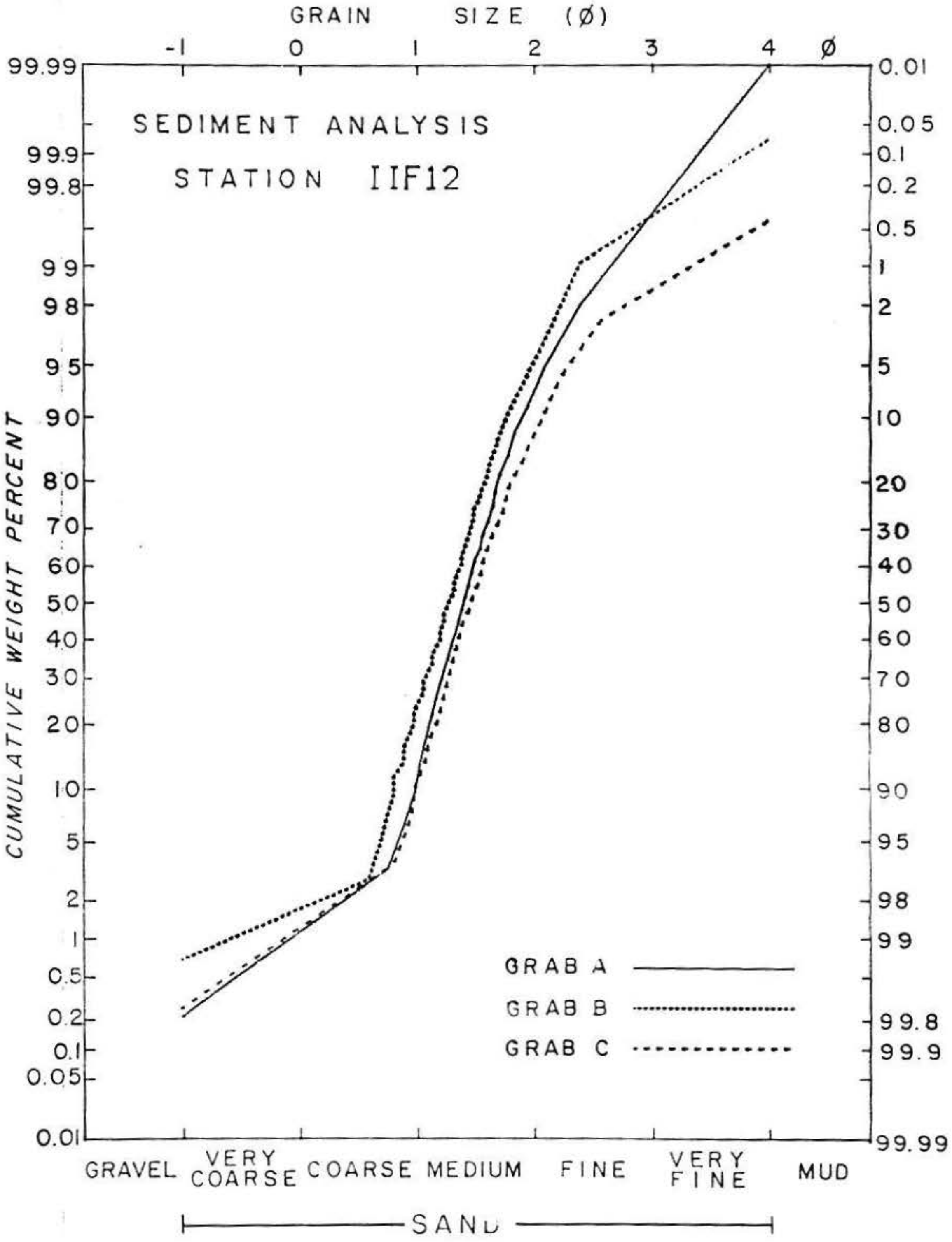
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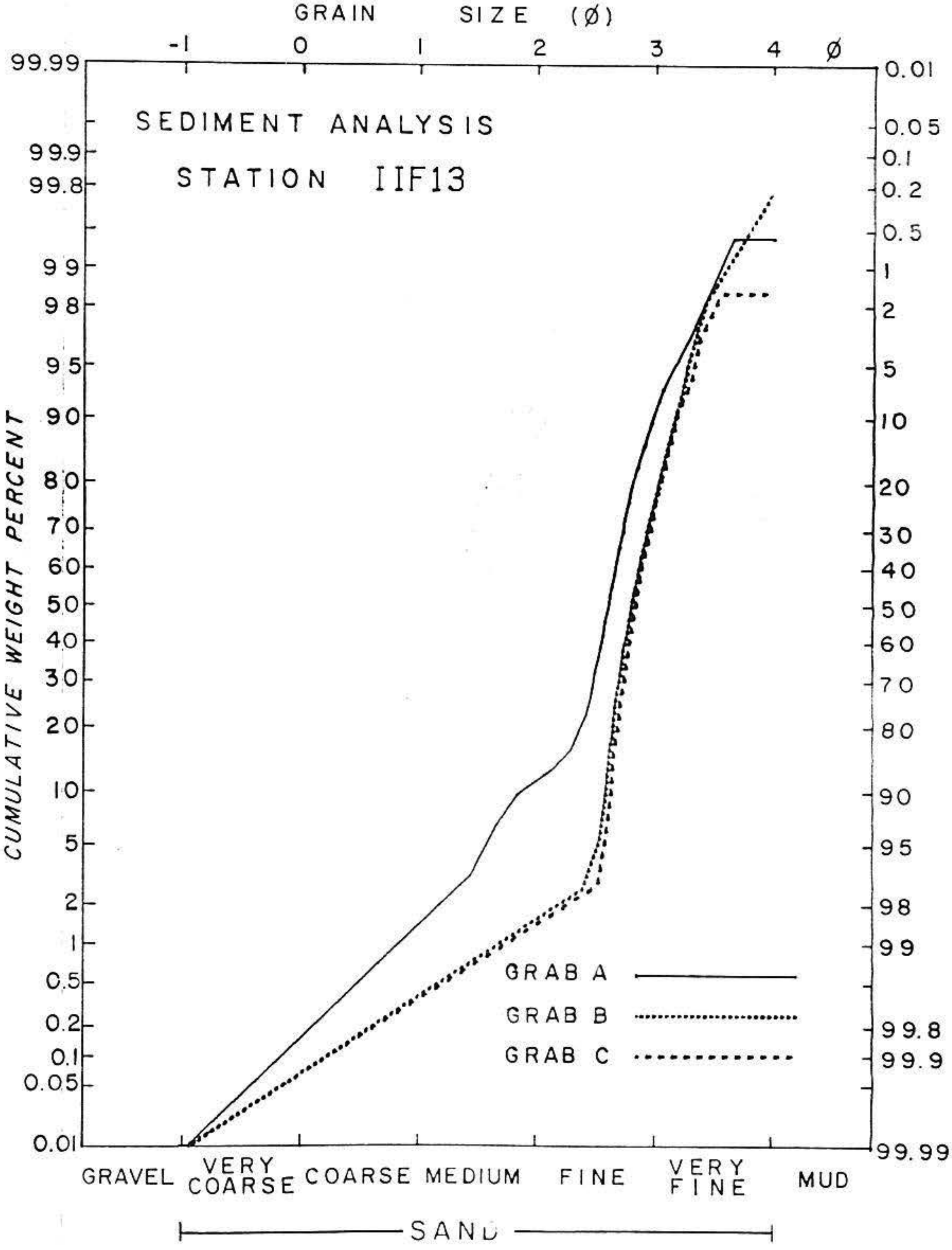
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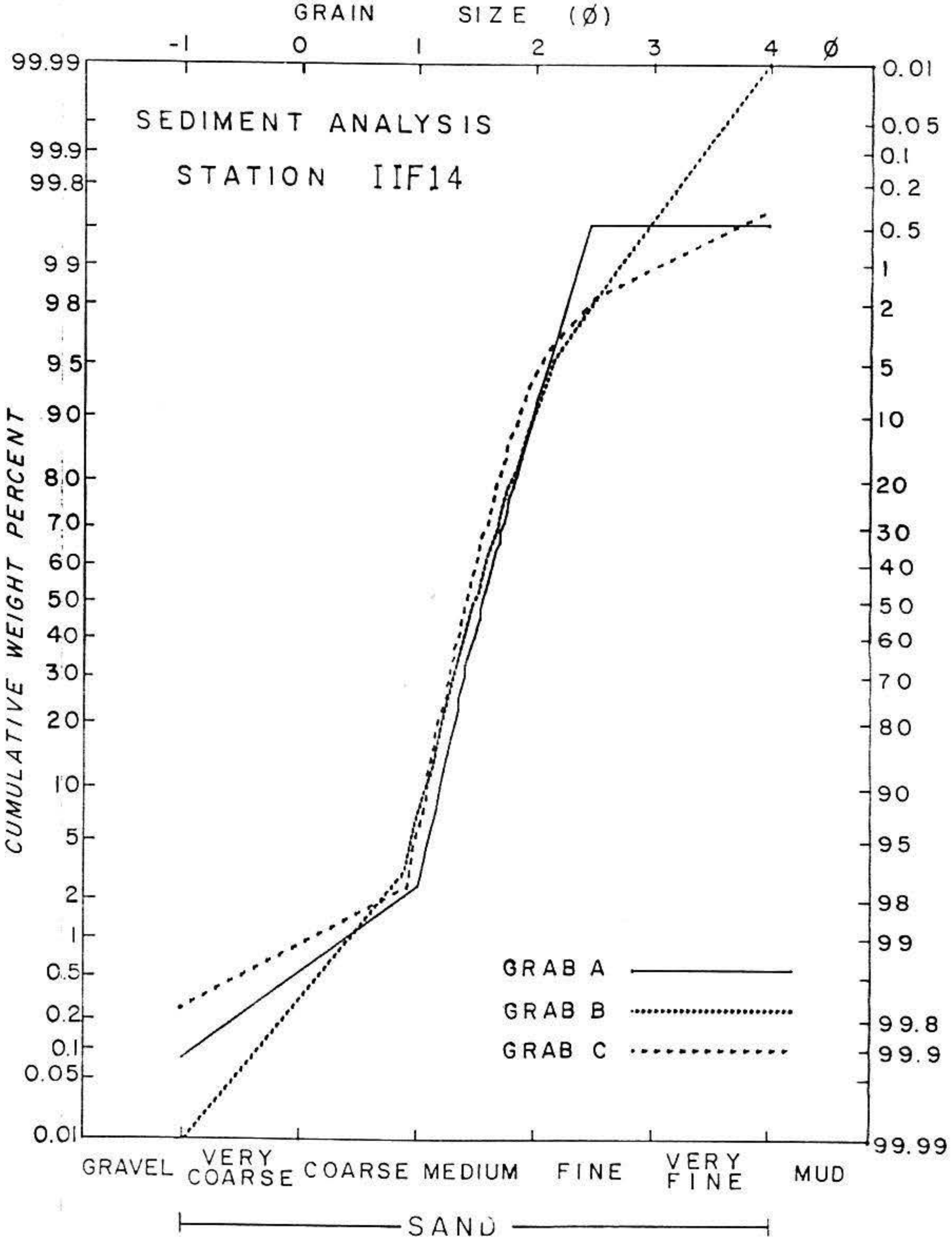
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STATION IIF14
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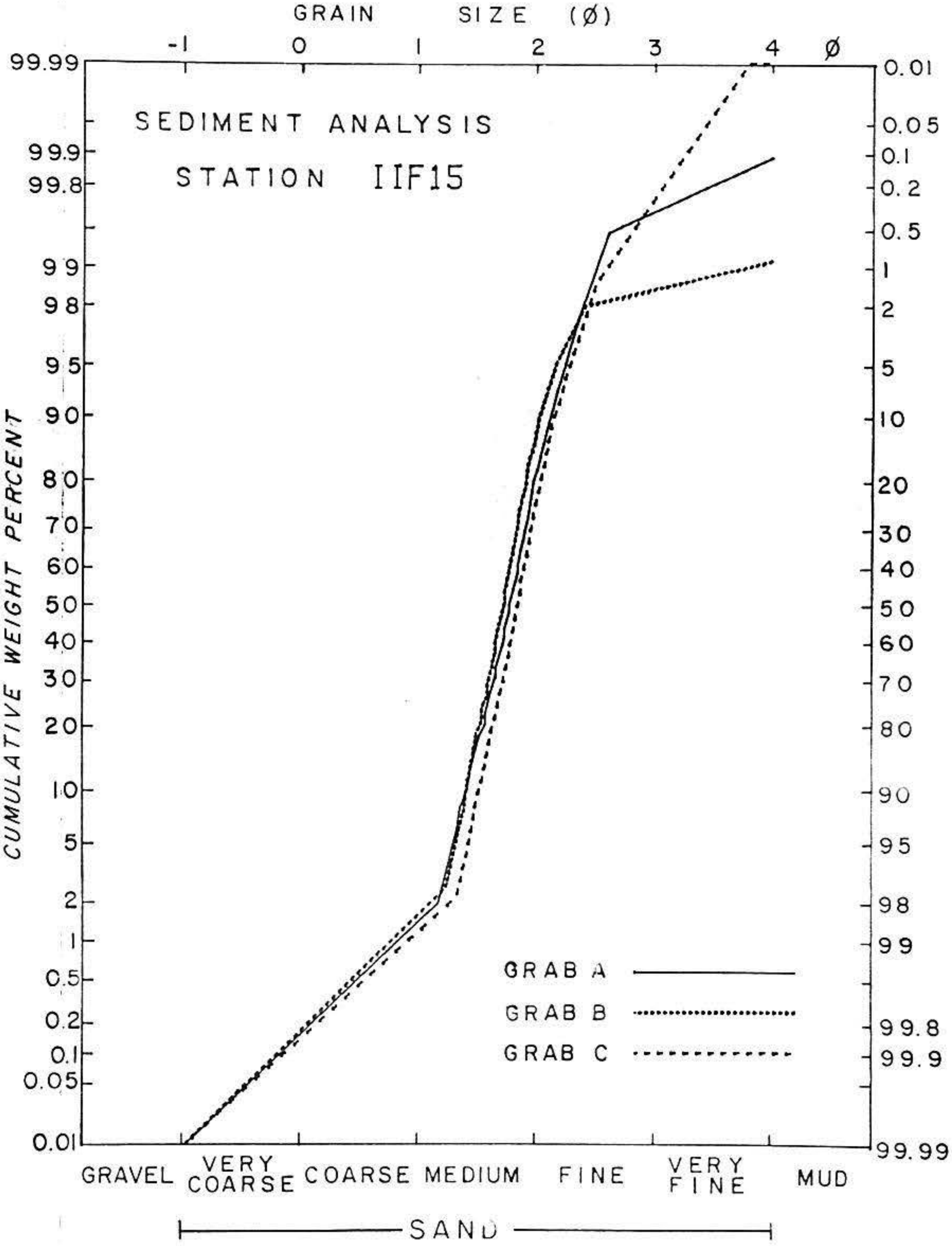
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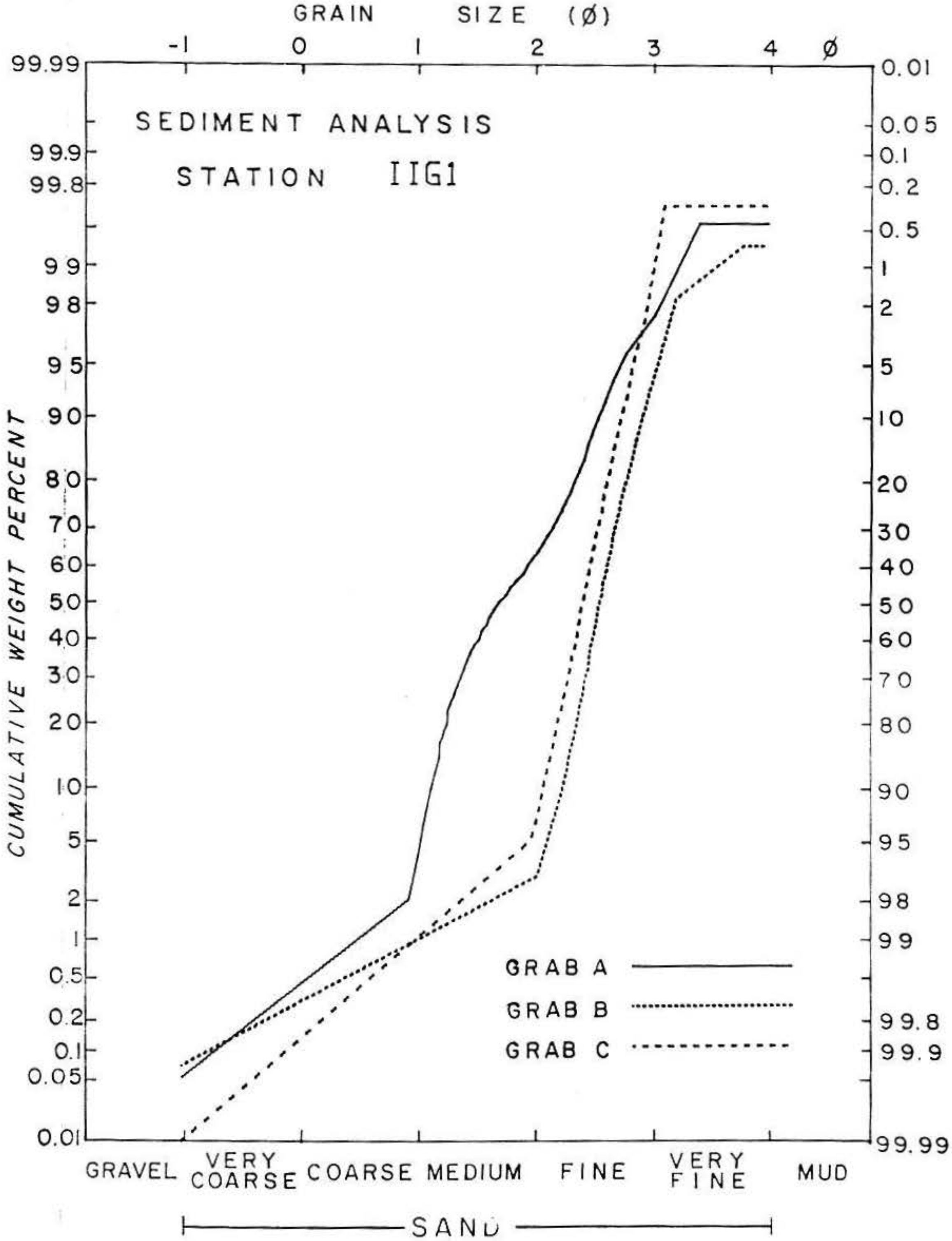
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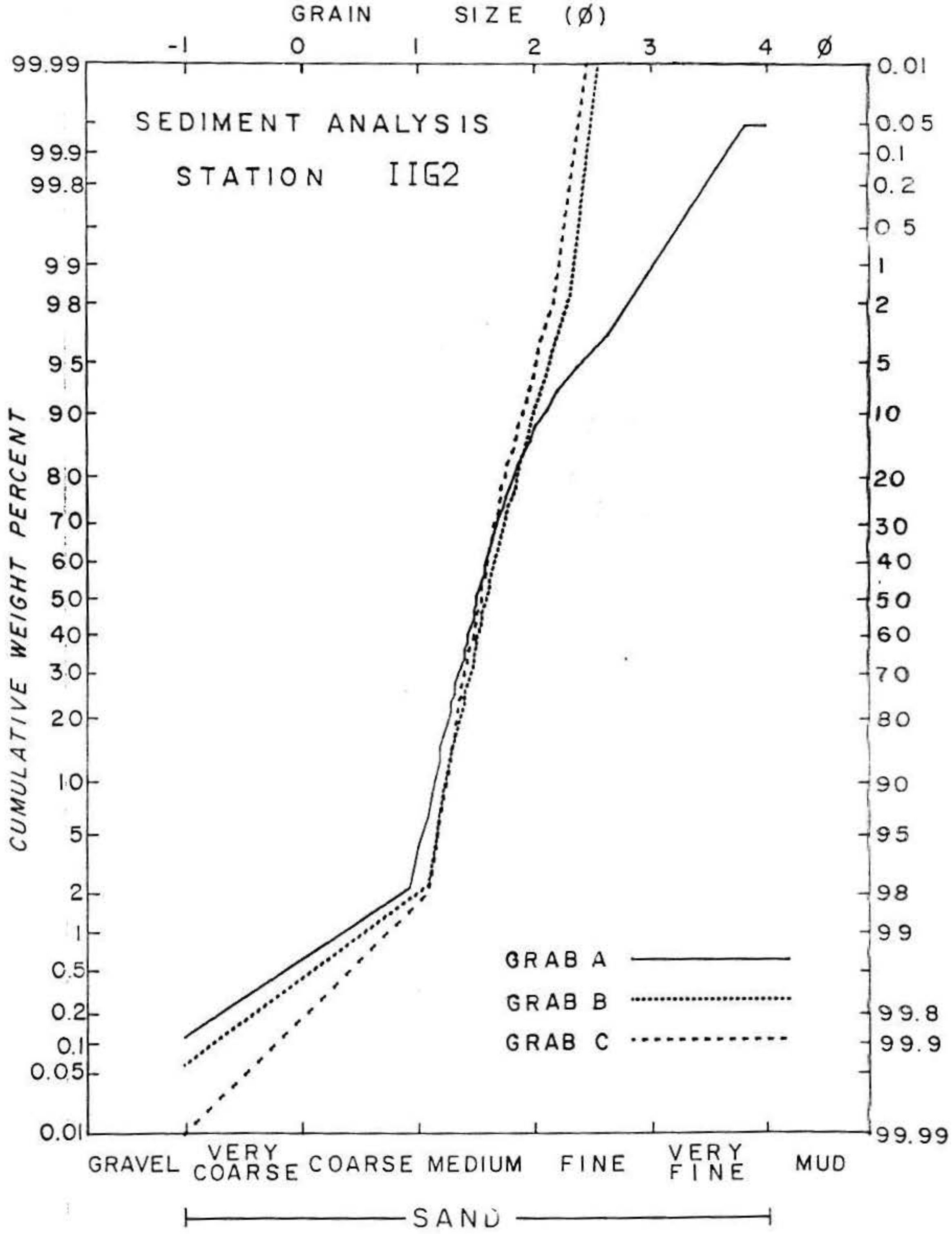
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GRAB C
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FINE
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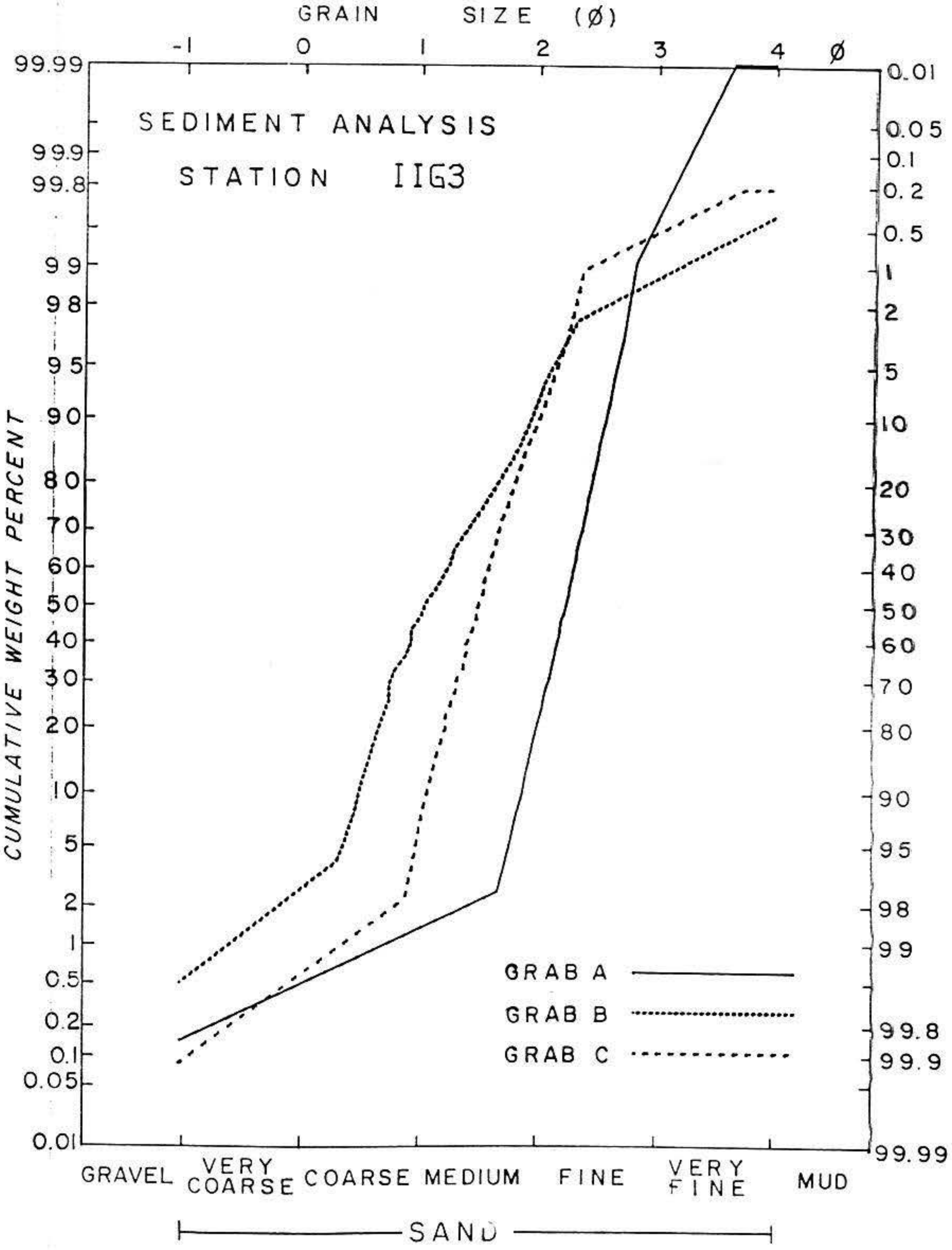
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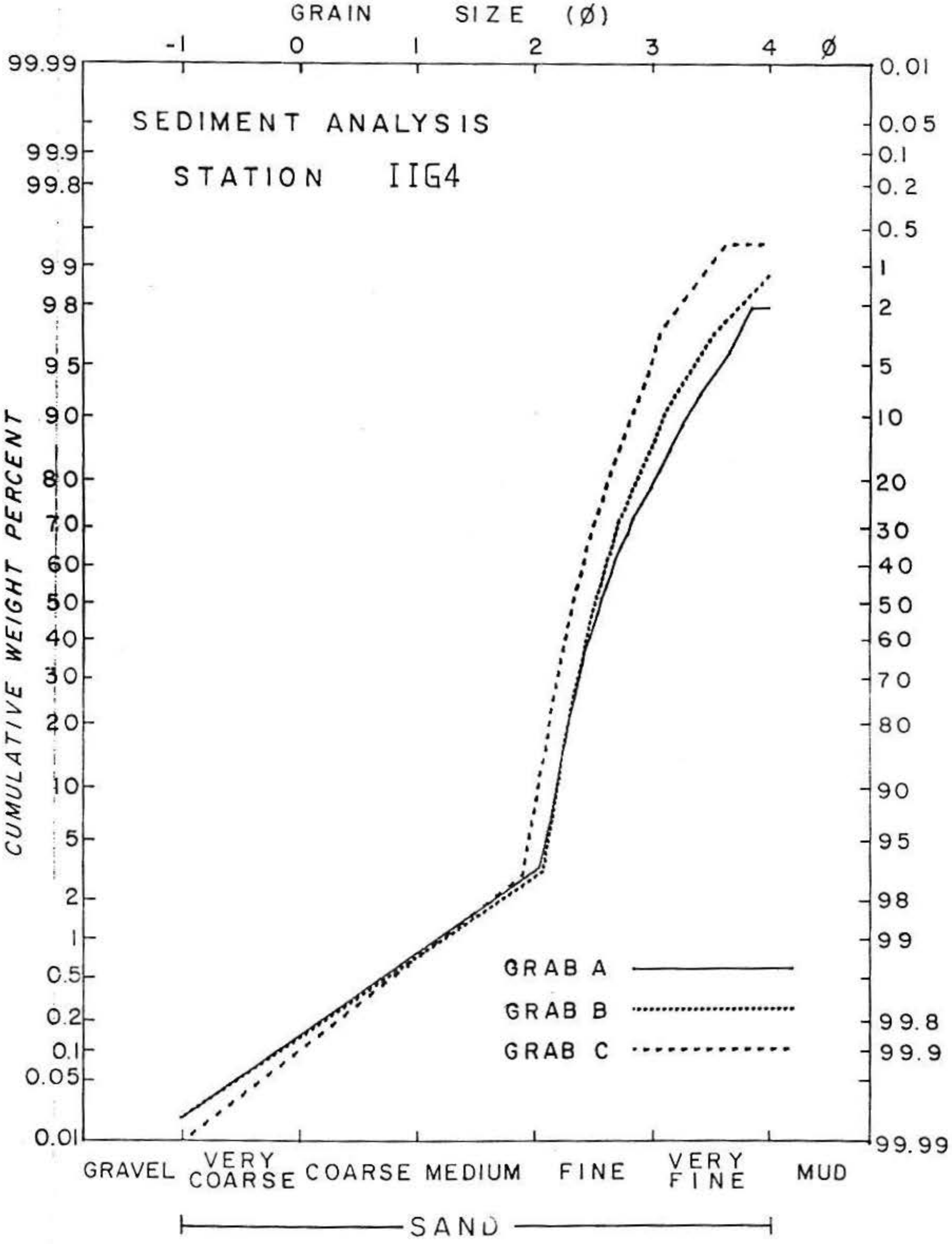
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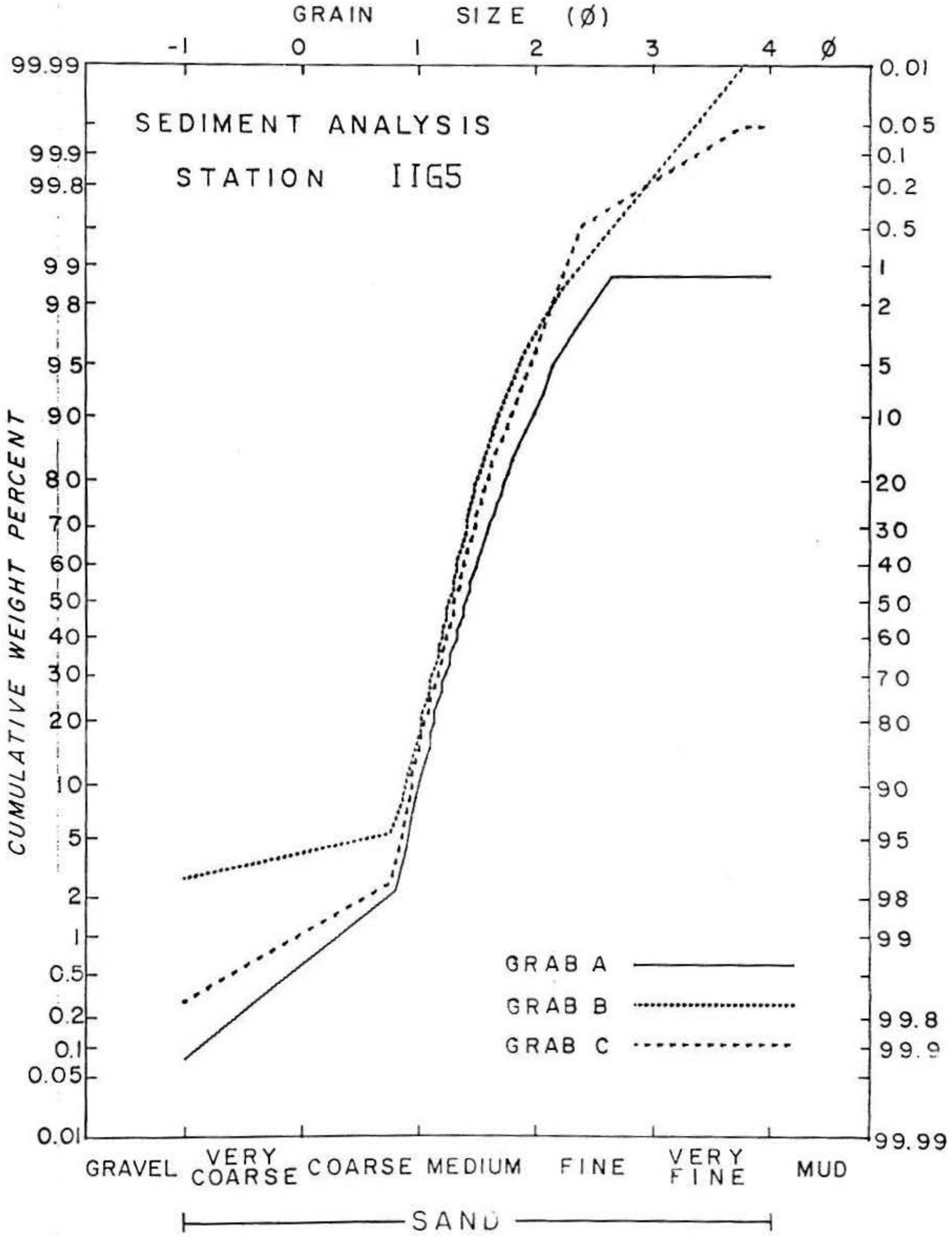
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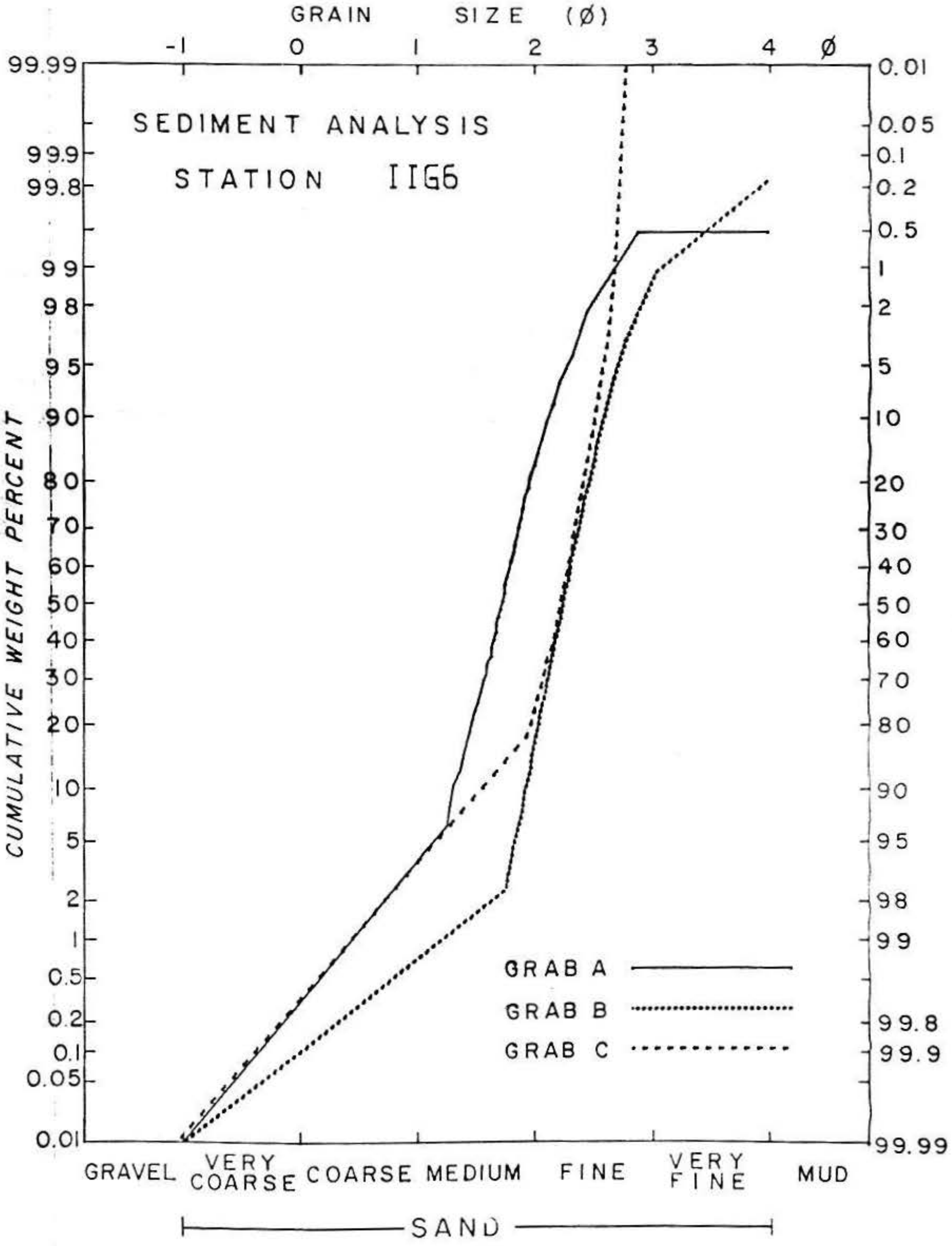
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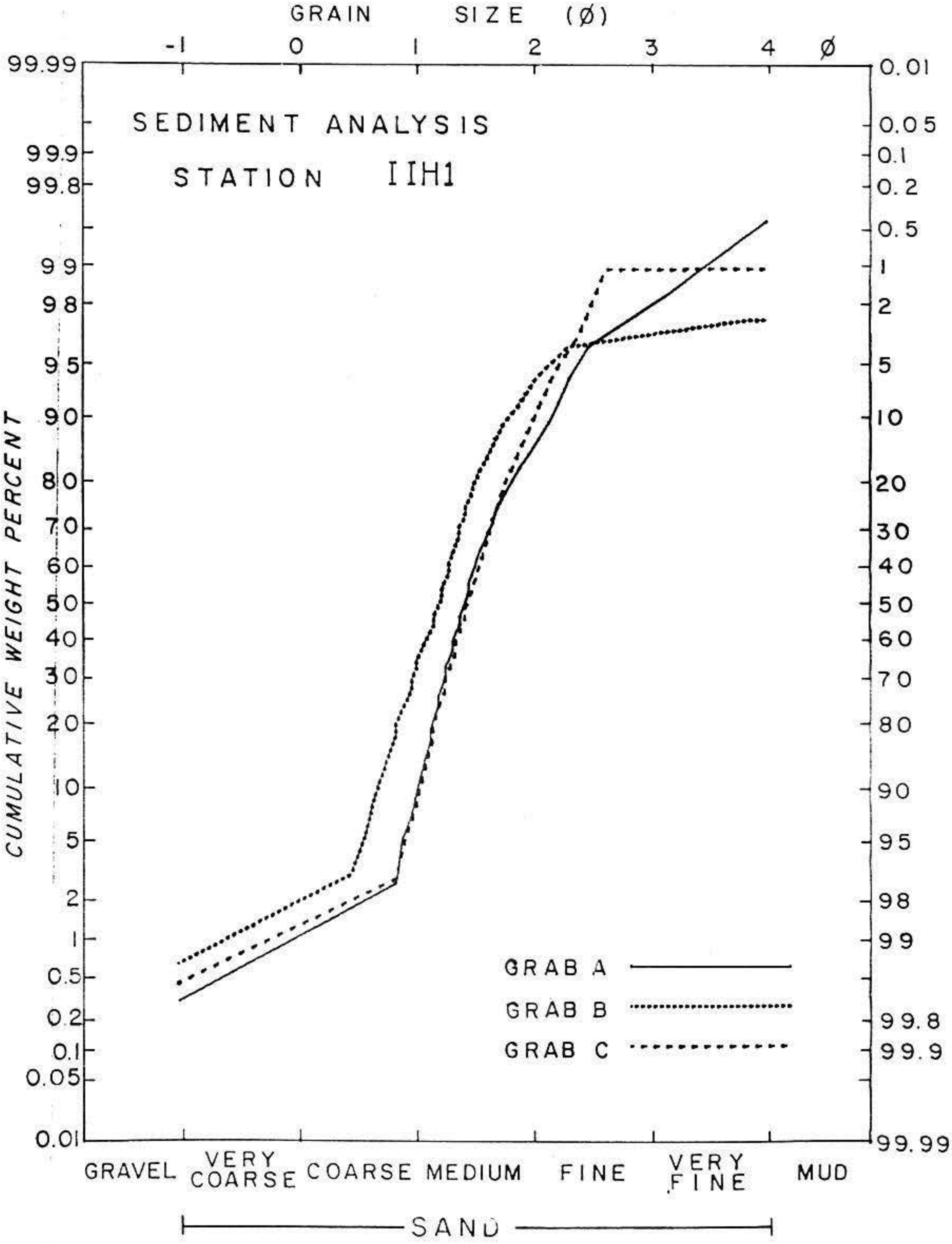
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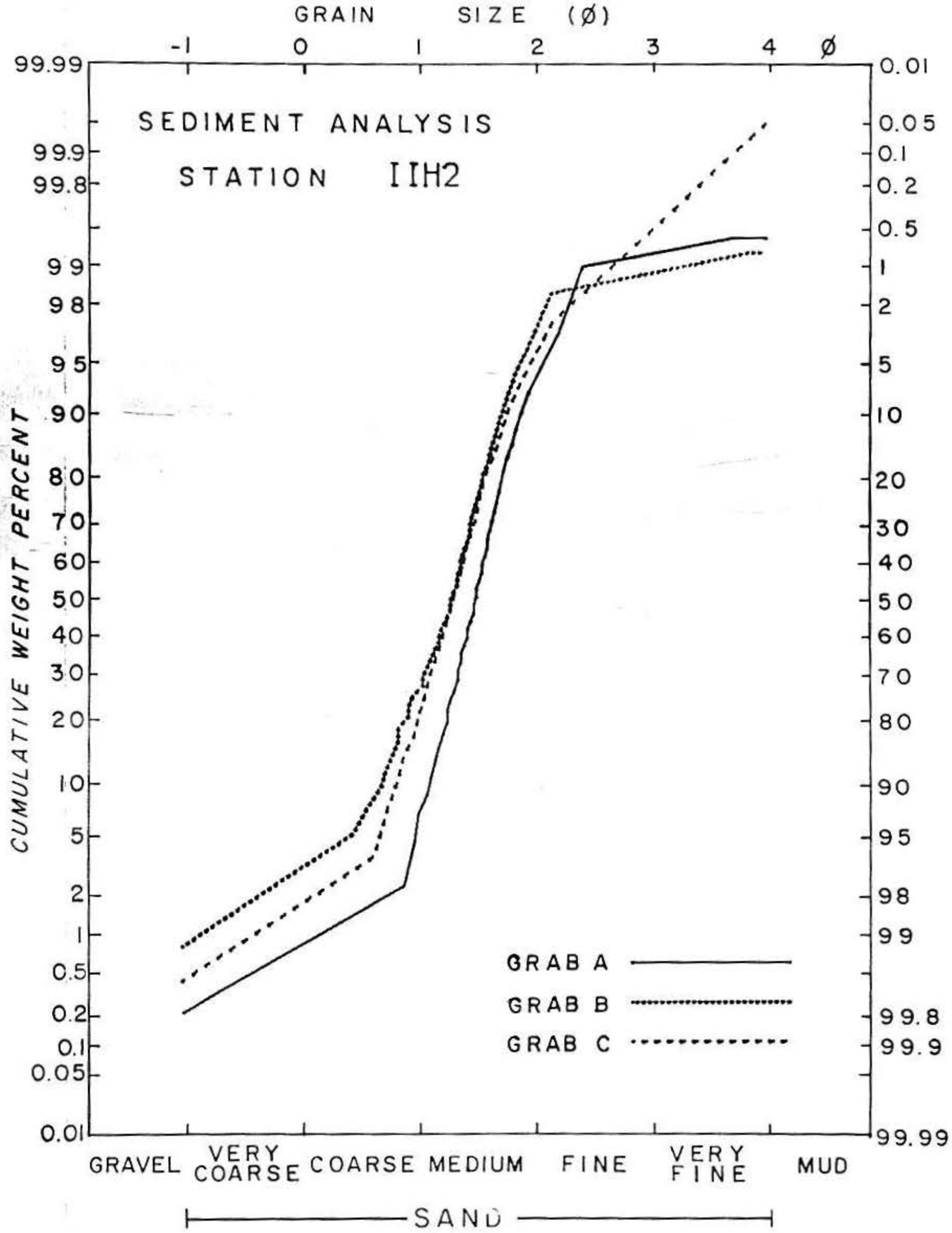
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GRAB C
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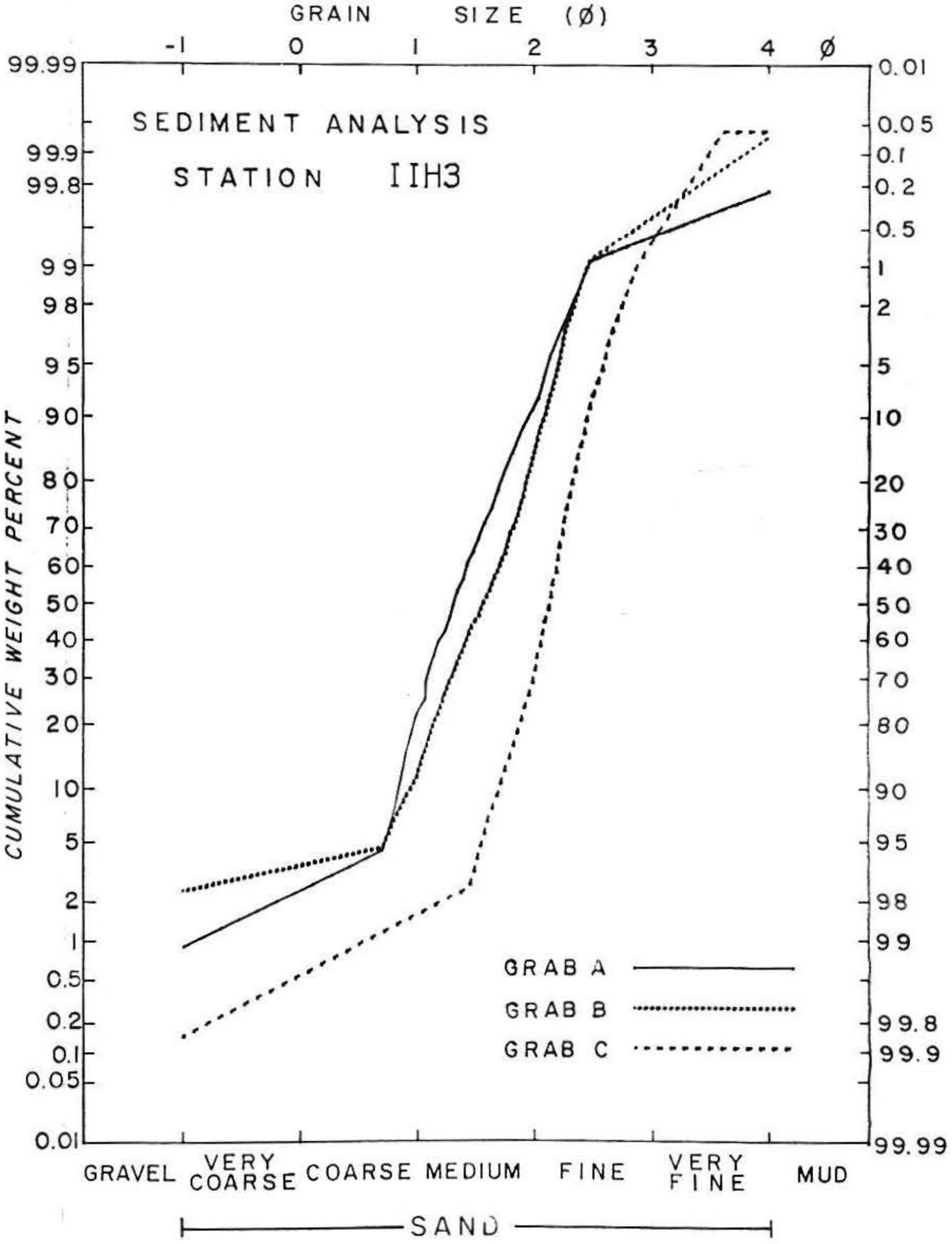
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SEDIMENT ANALYSIS
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CUMULATIVE WEIGHT PERCENT
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GRAB C
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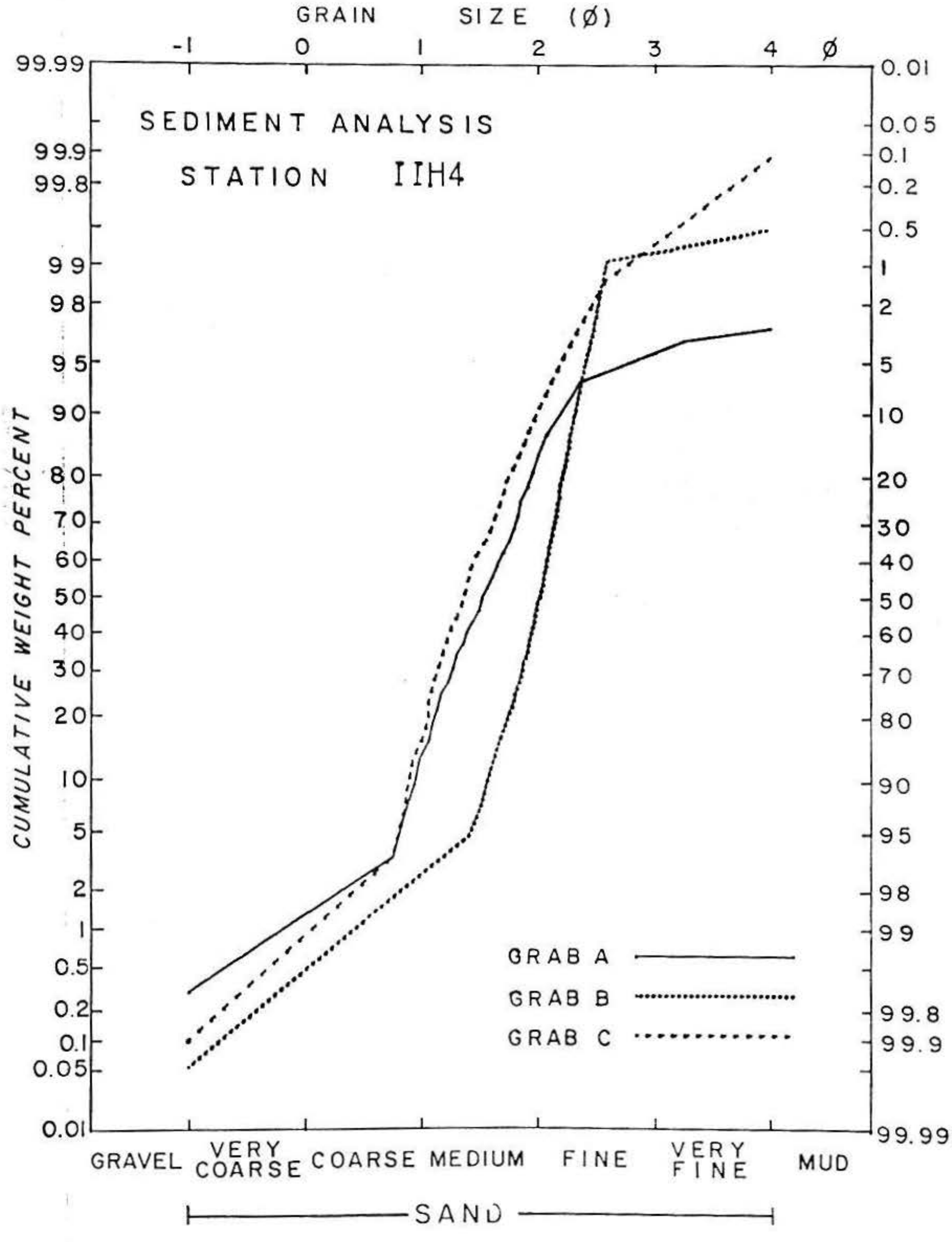
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STATION IIH4
CUMULATIVE WEIGHT PERCENT
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GRAB C
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MEDIUM
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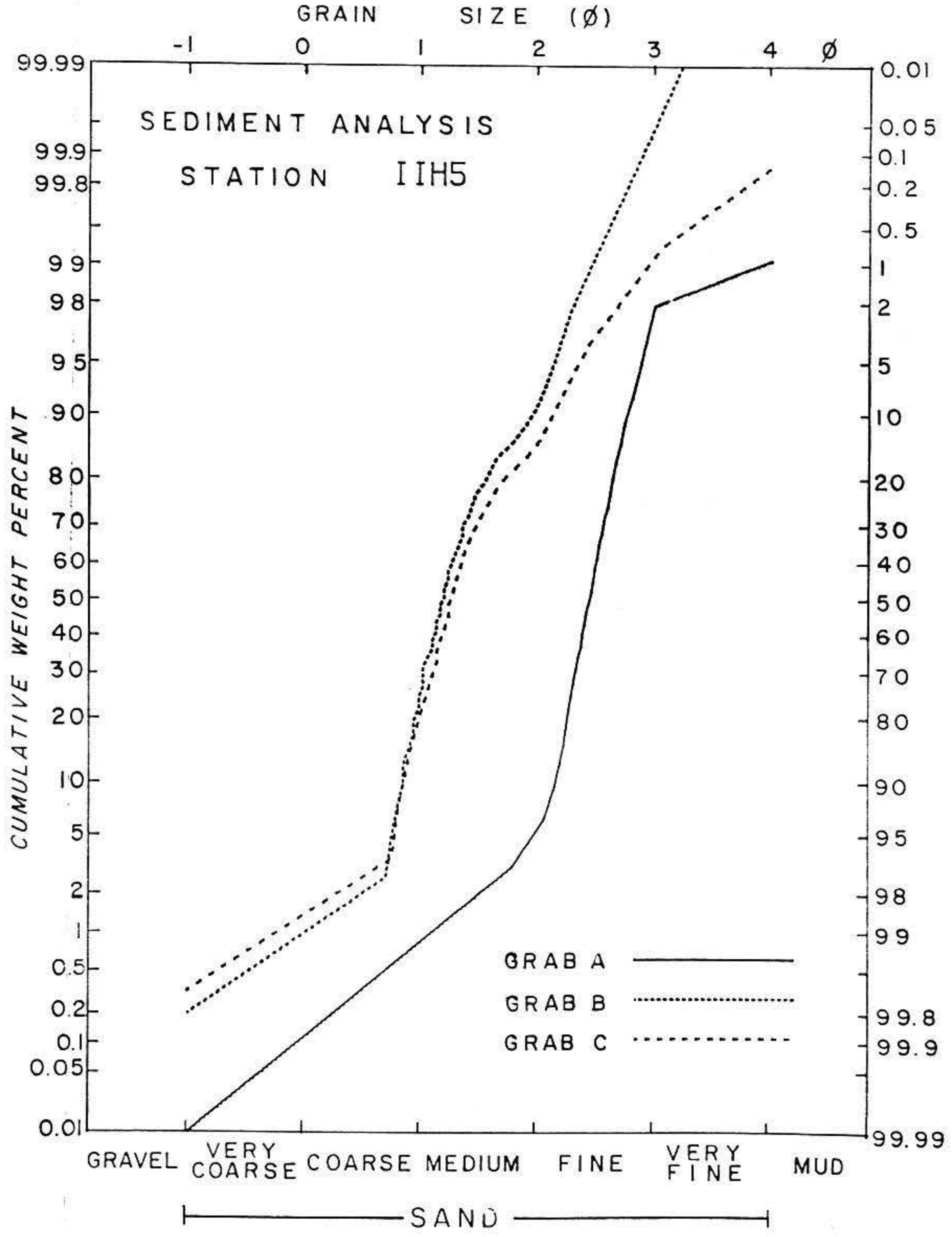
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SEDIMENT ANALYSIS
STATION IIH5
CUMULATIVE WEIGHT PERCENT
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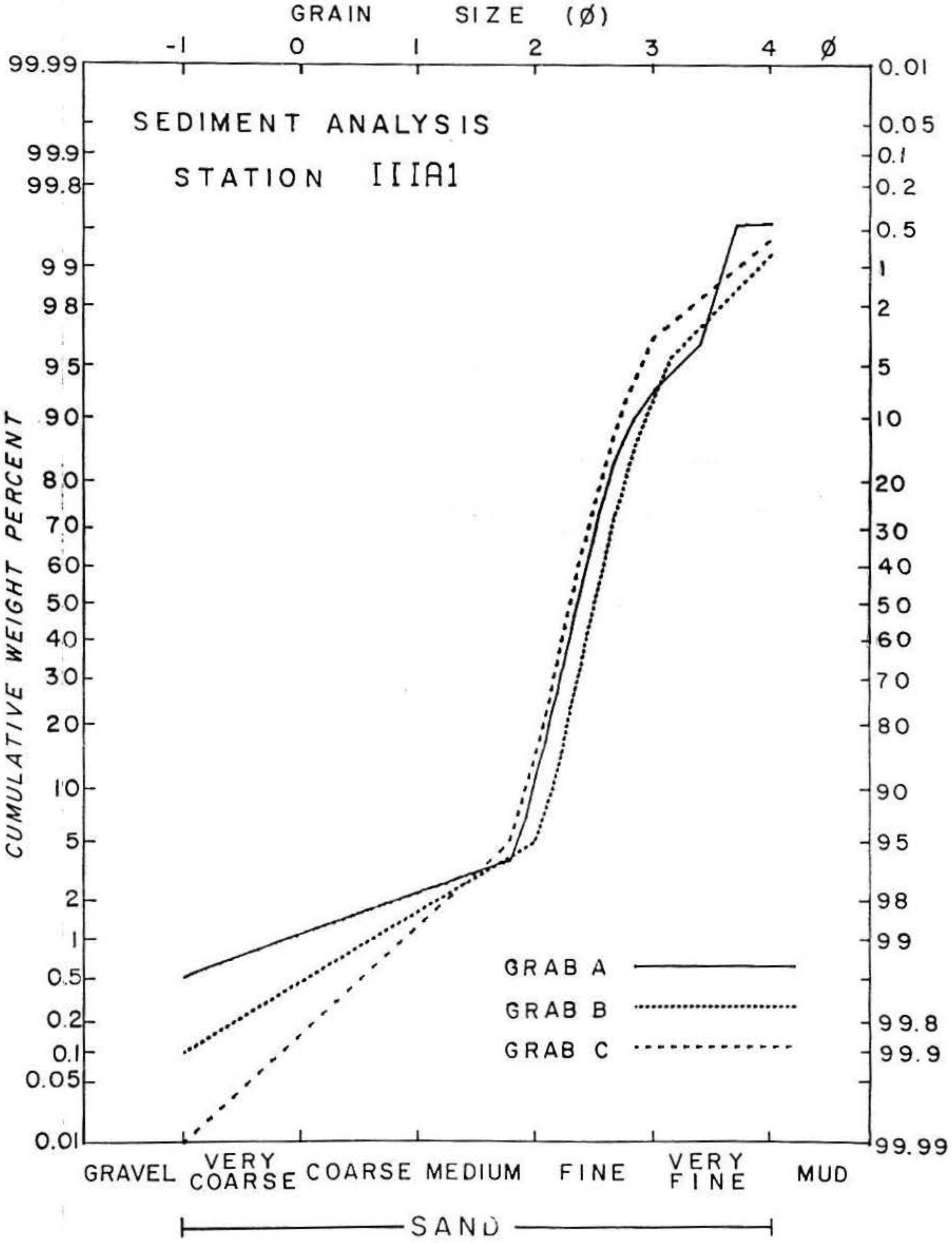
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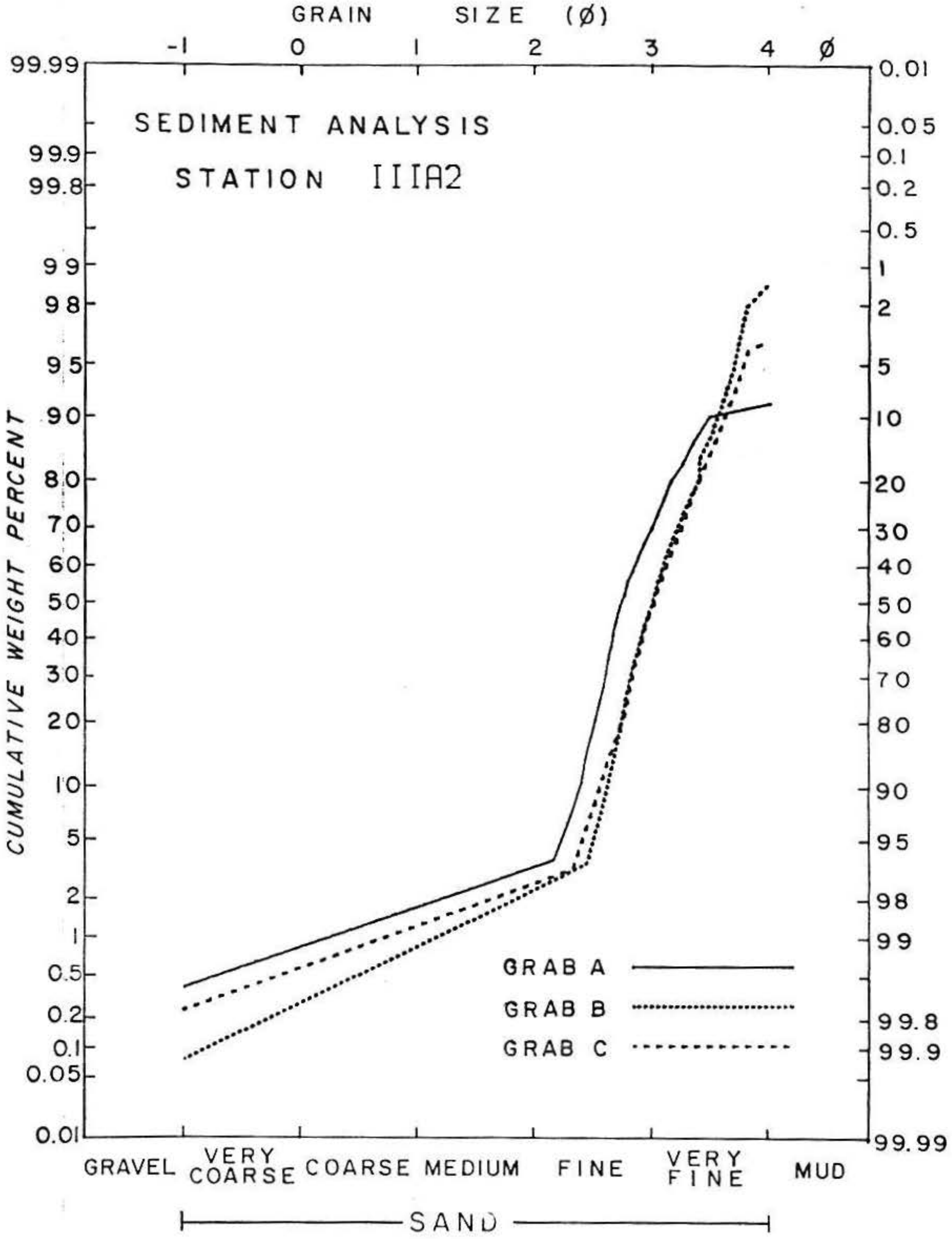
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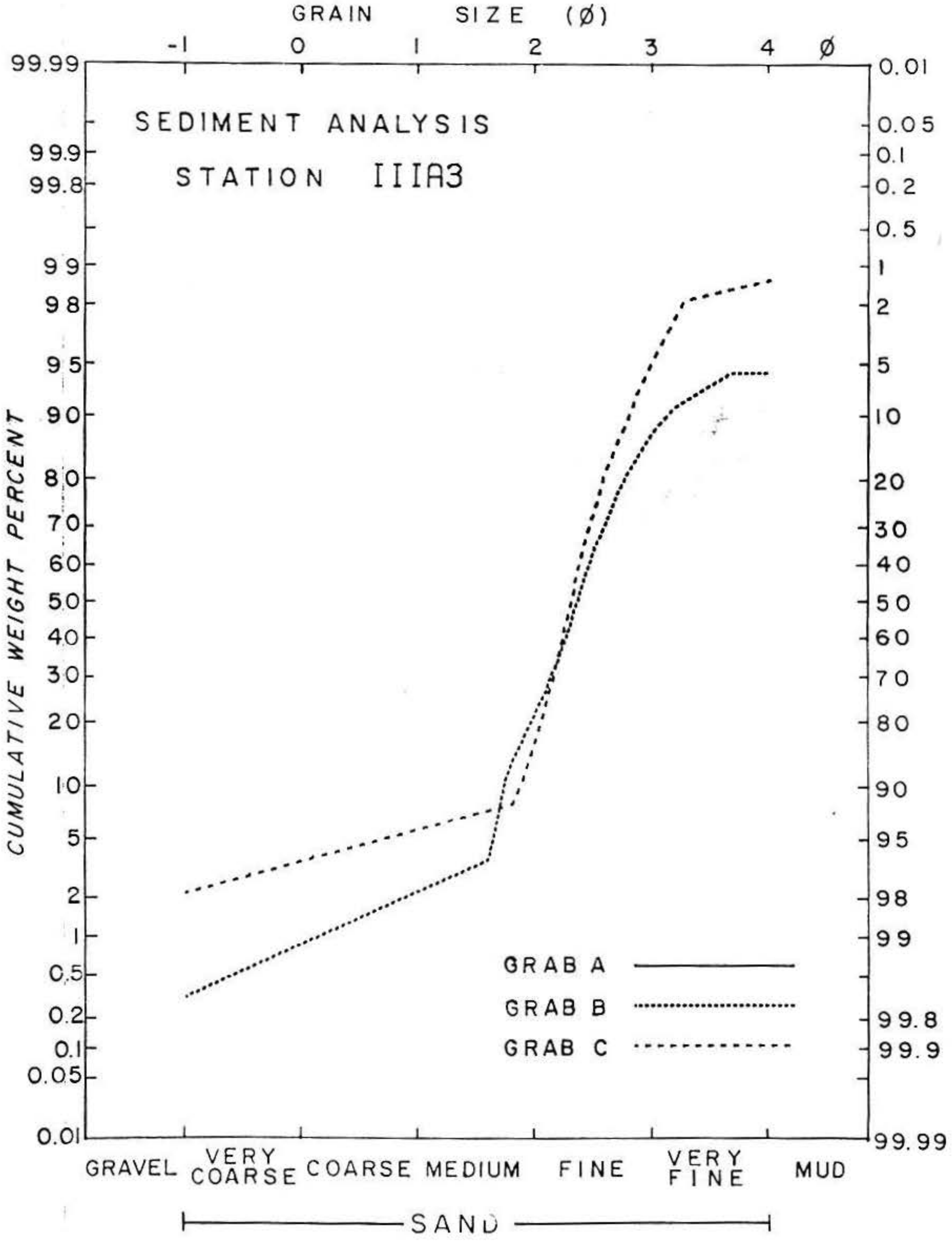
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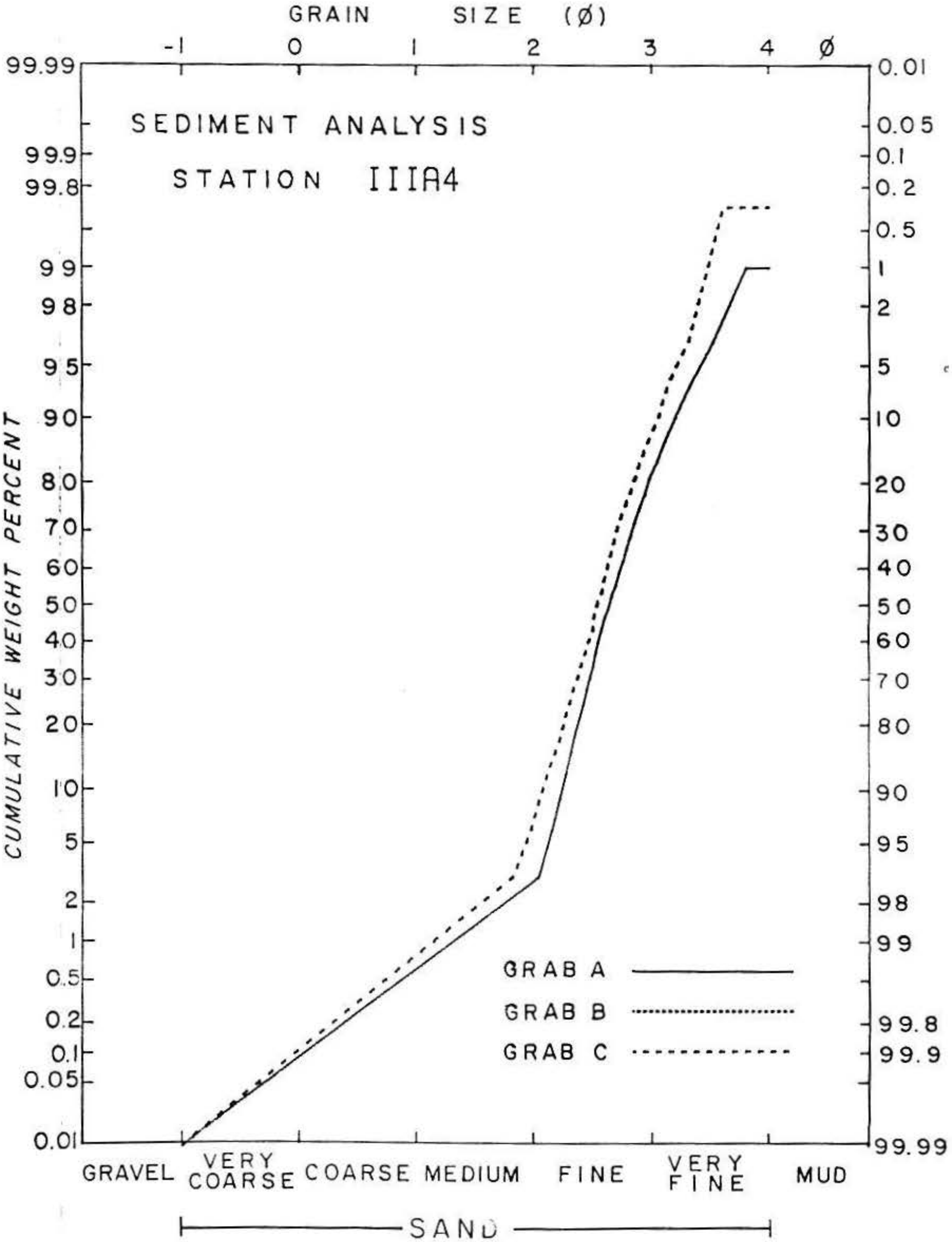
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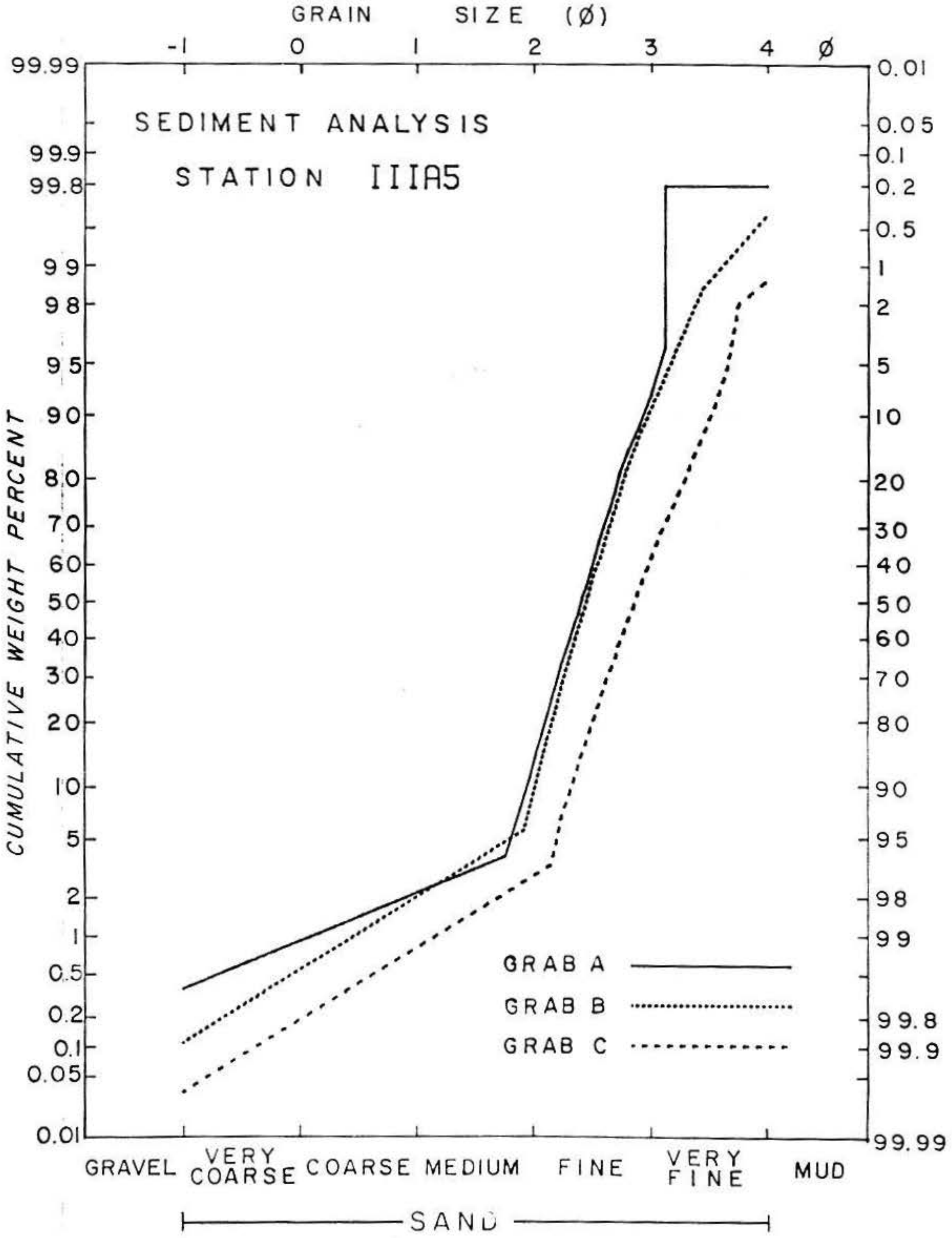
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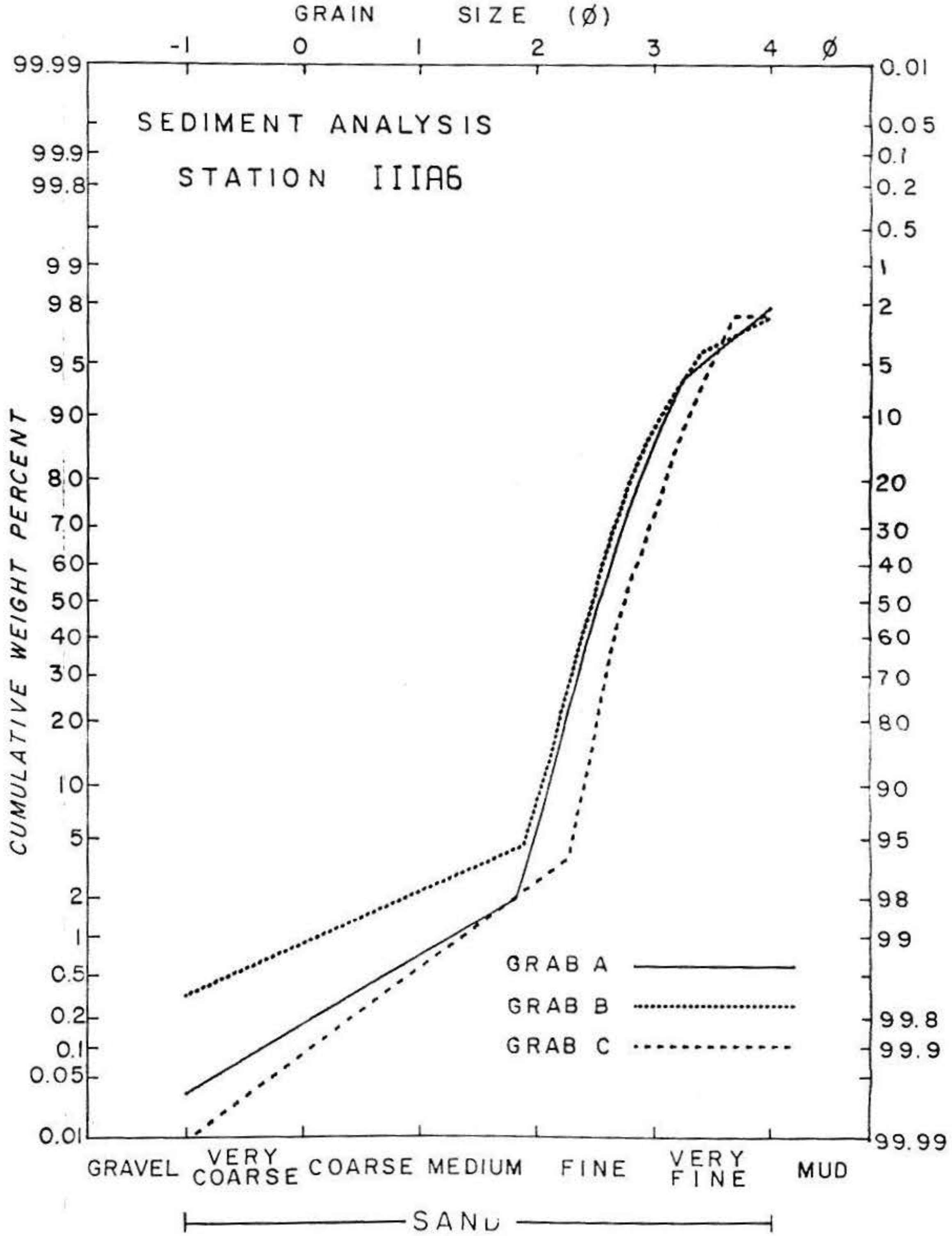
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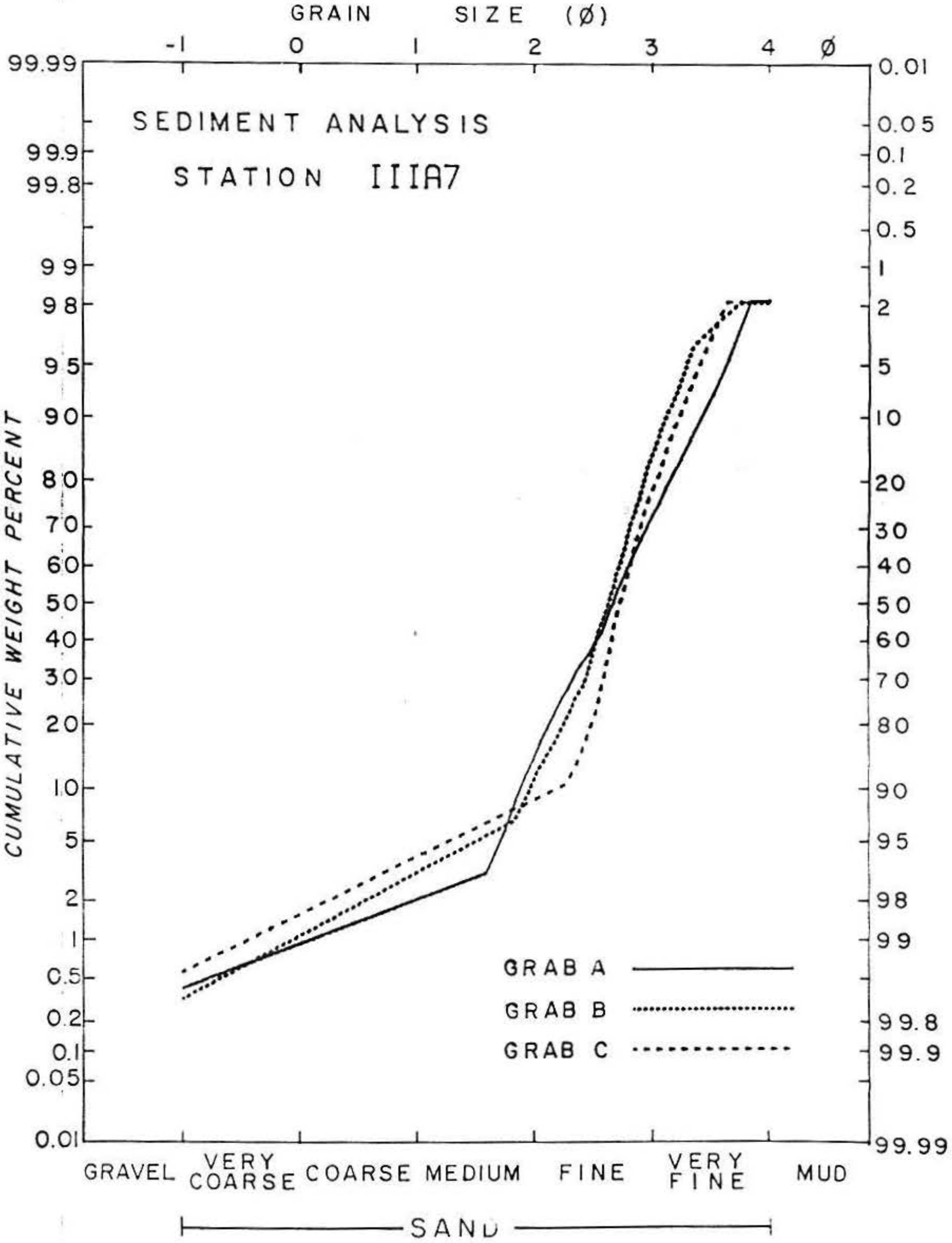
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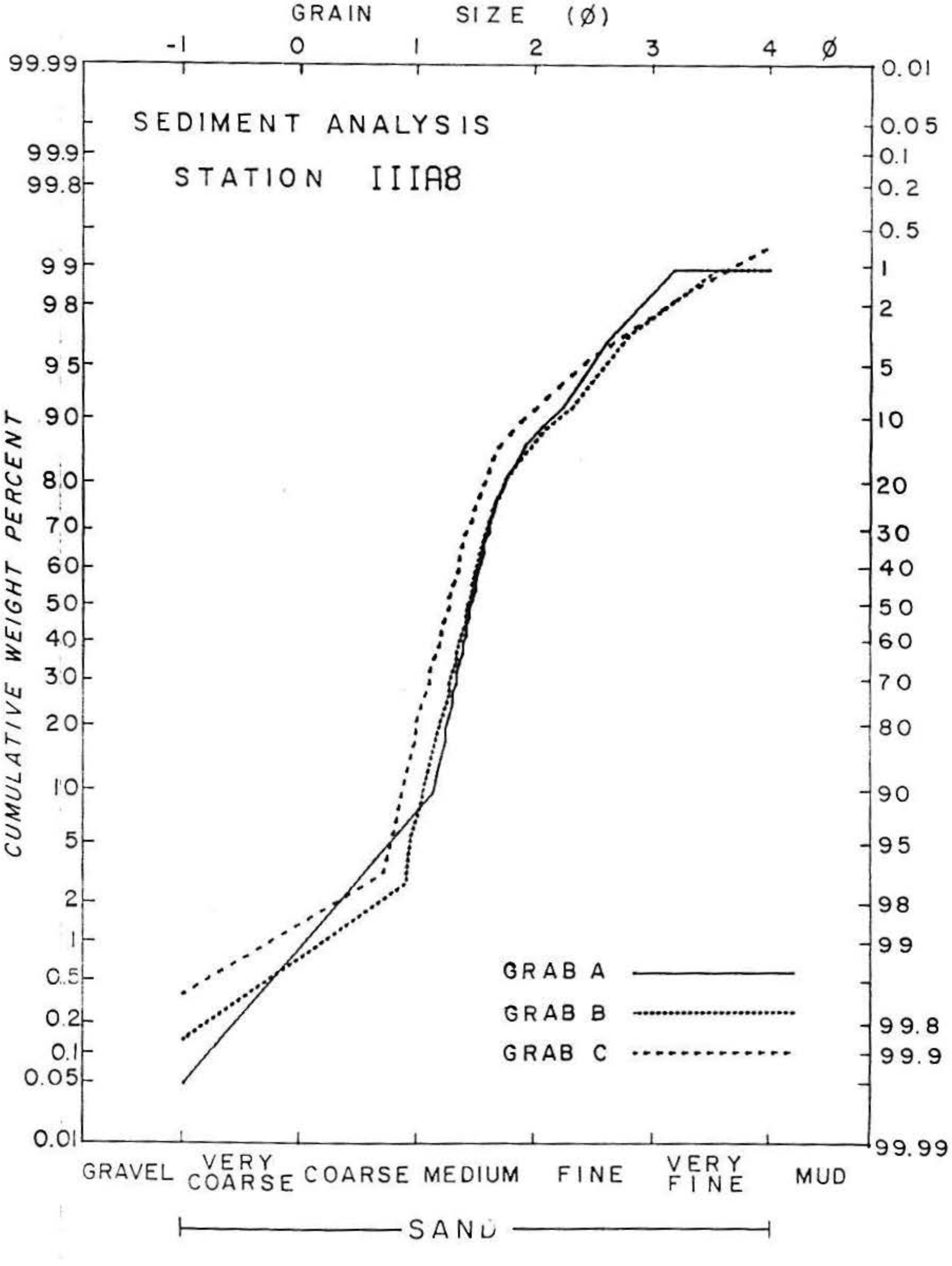
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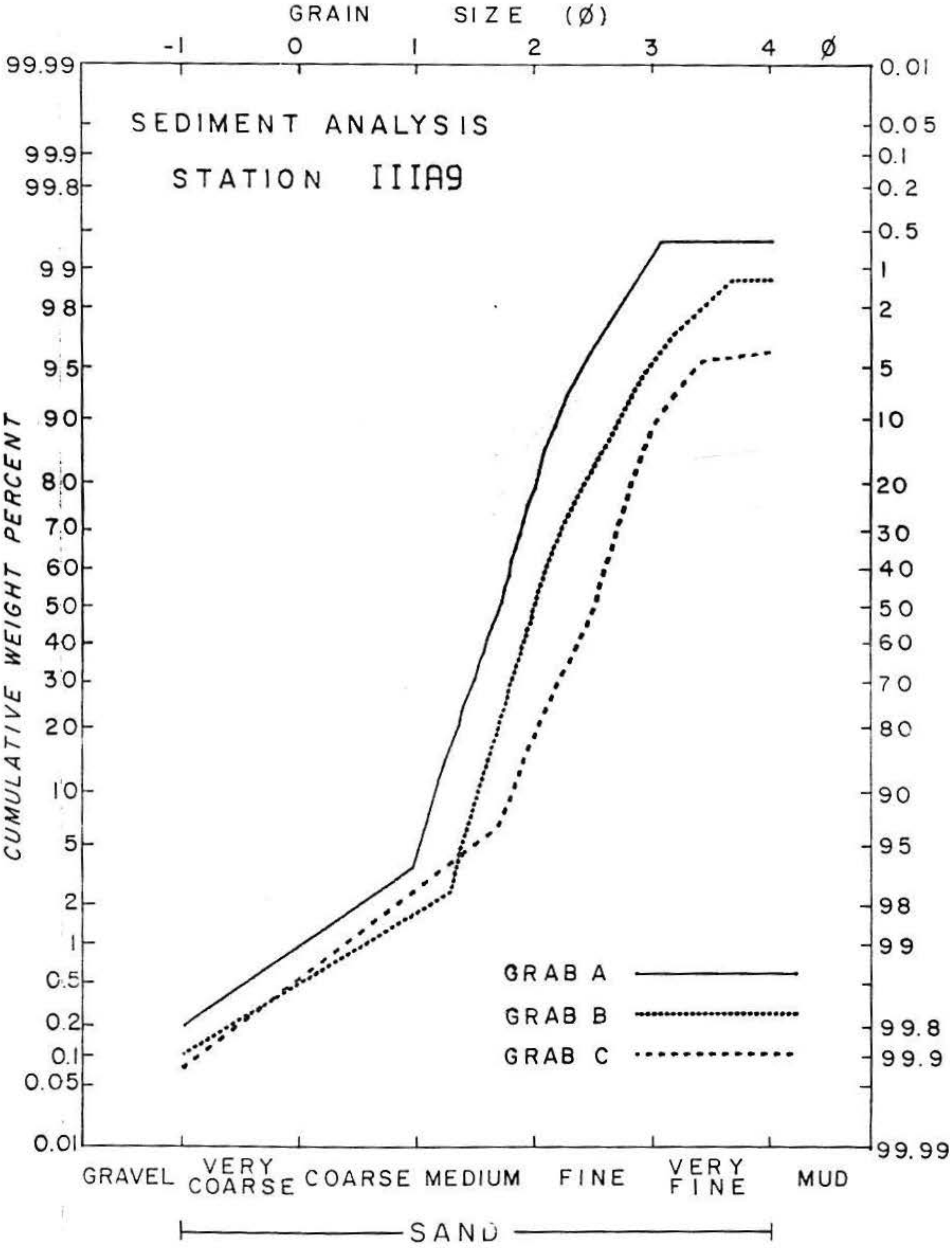
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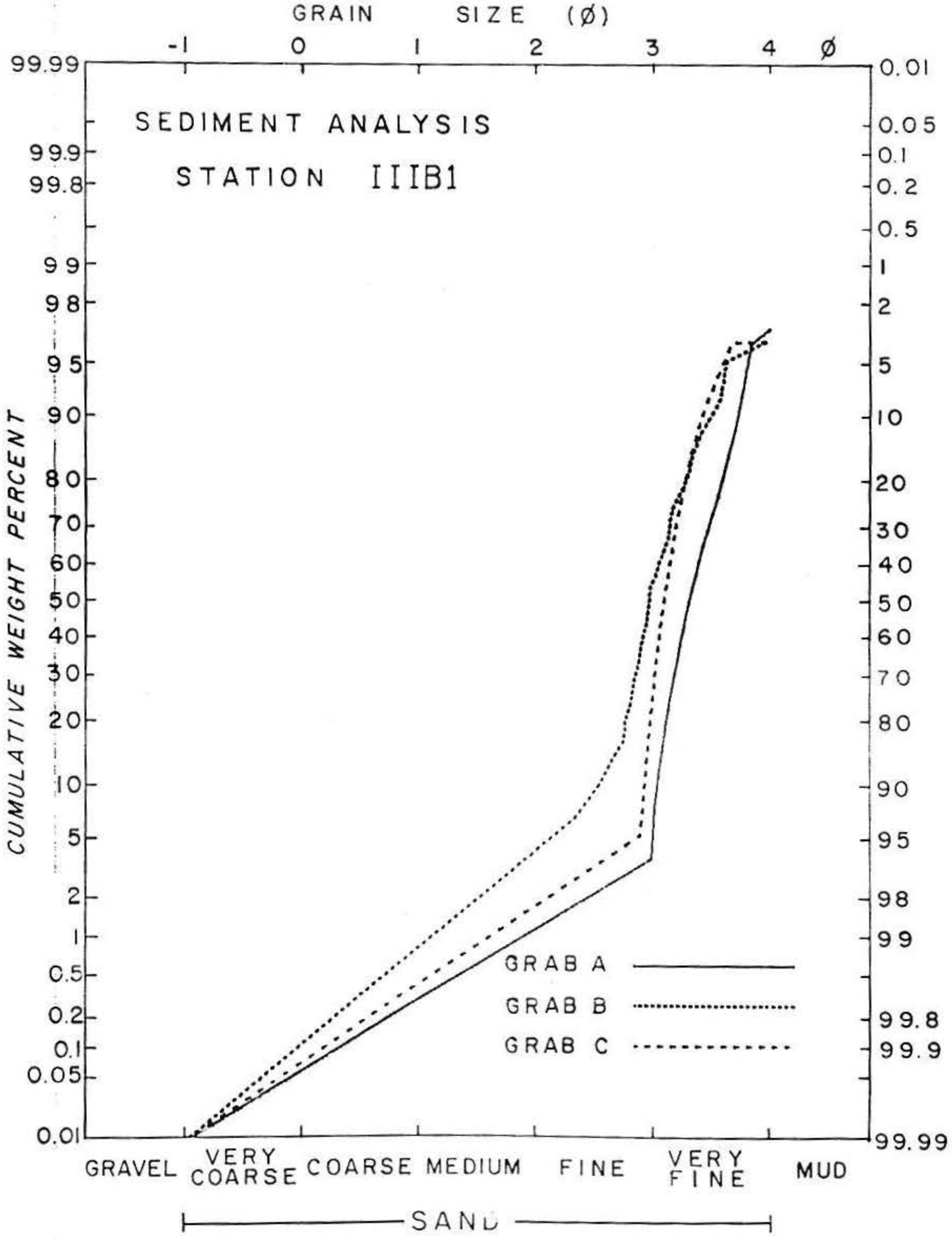
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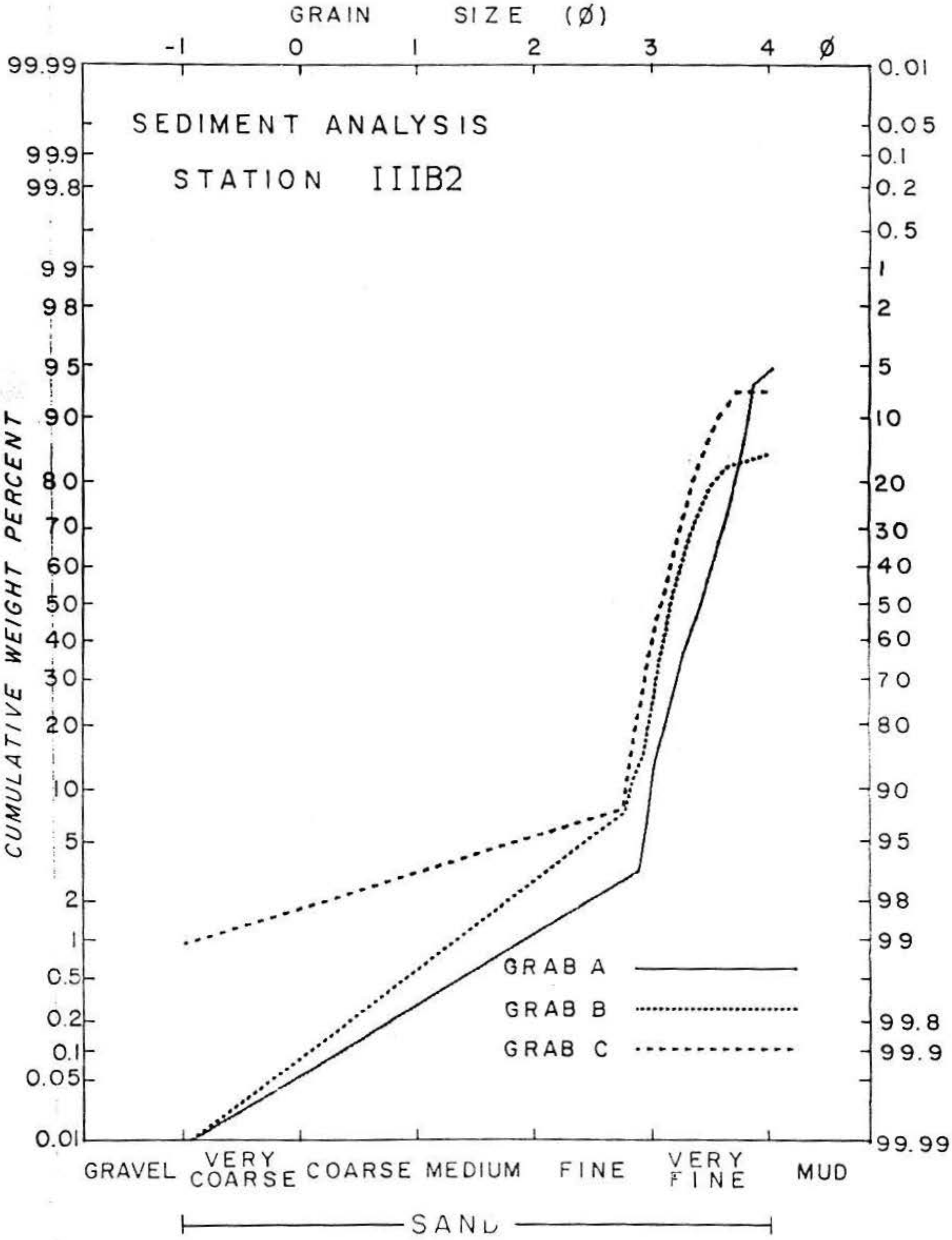
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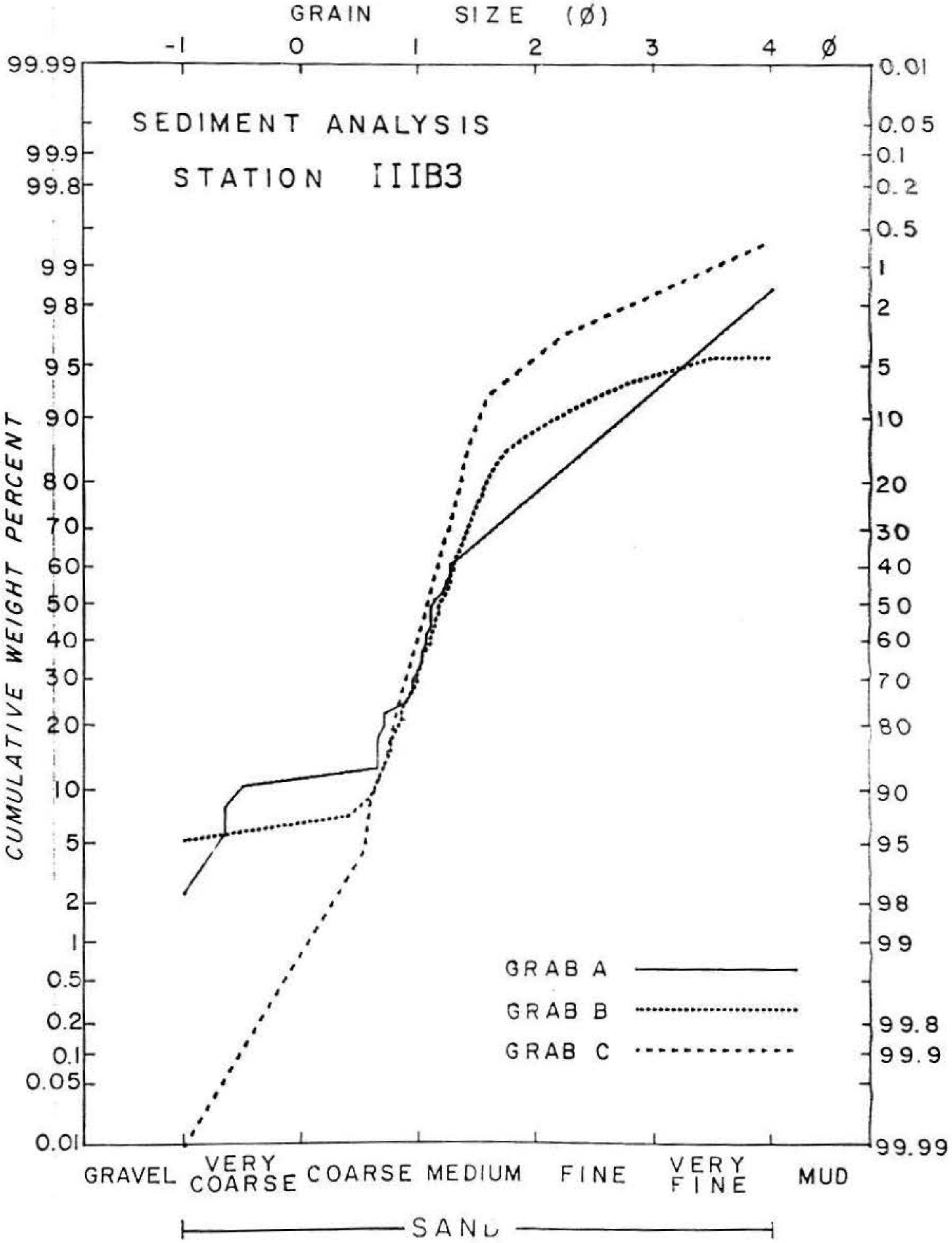
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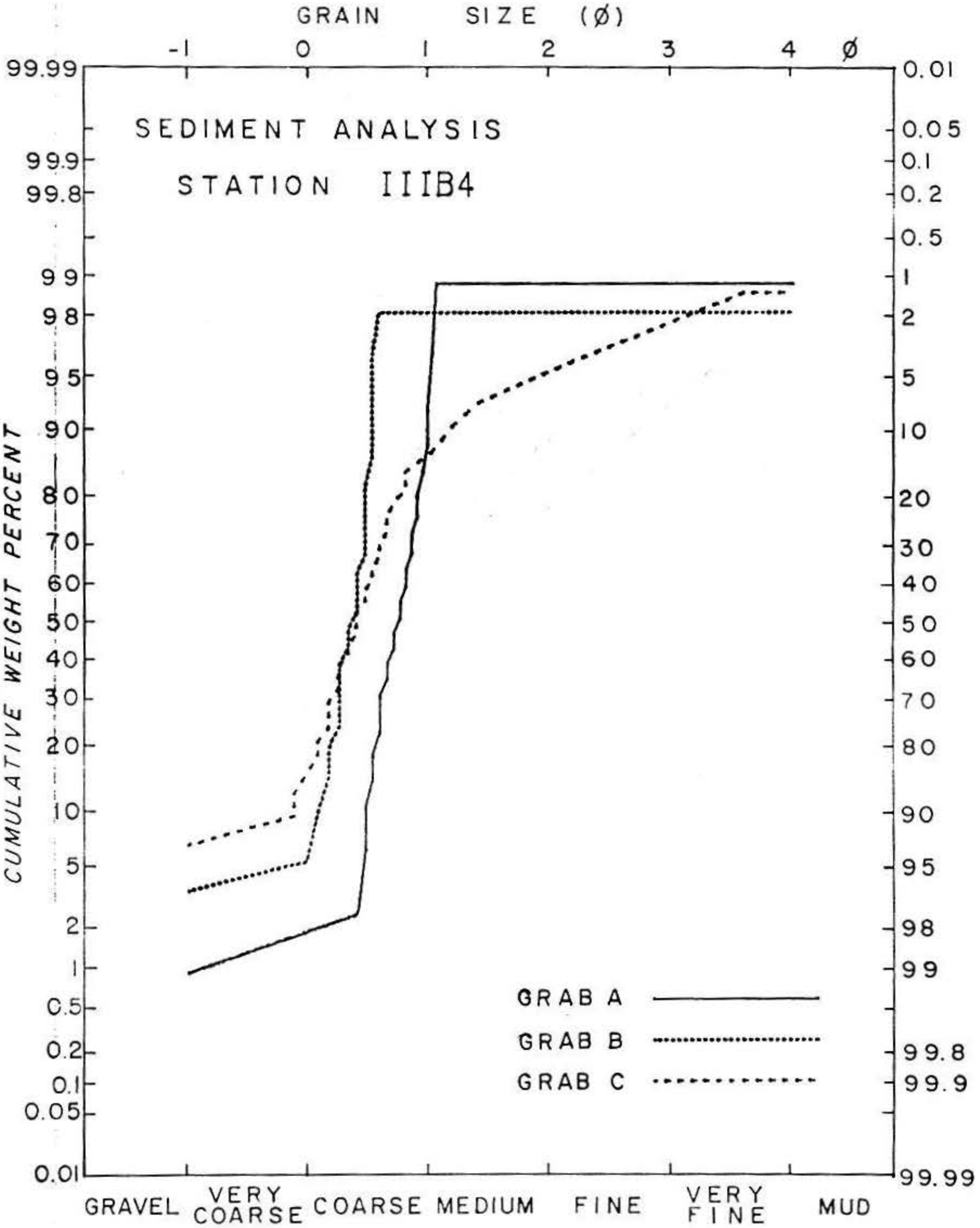
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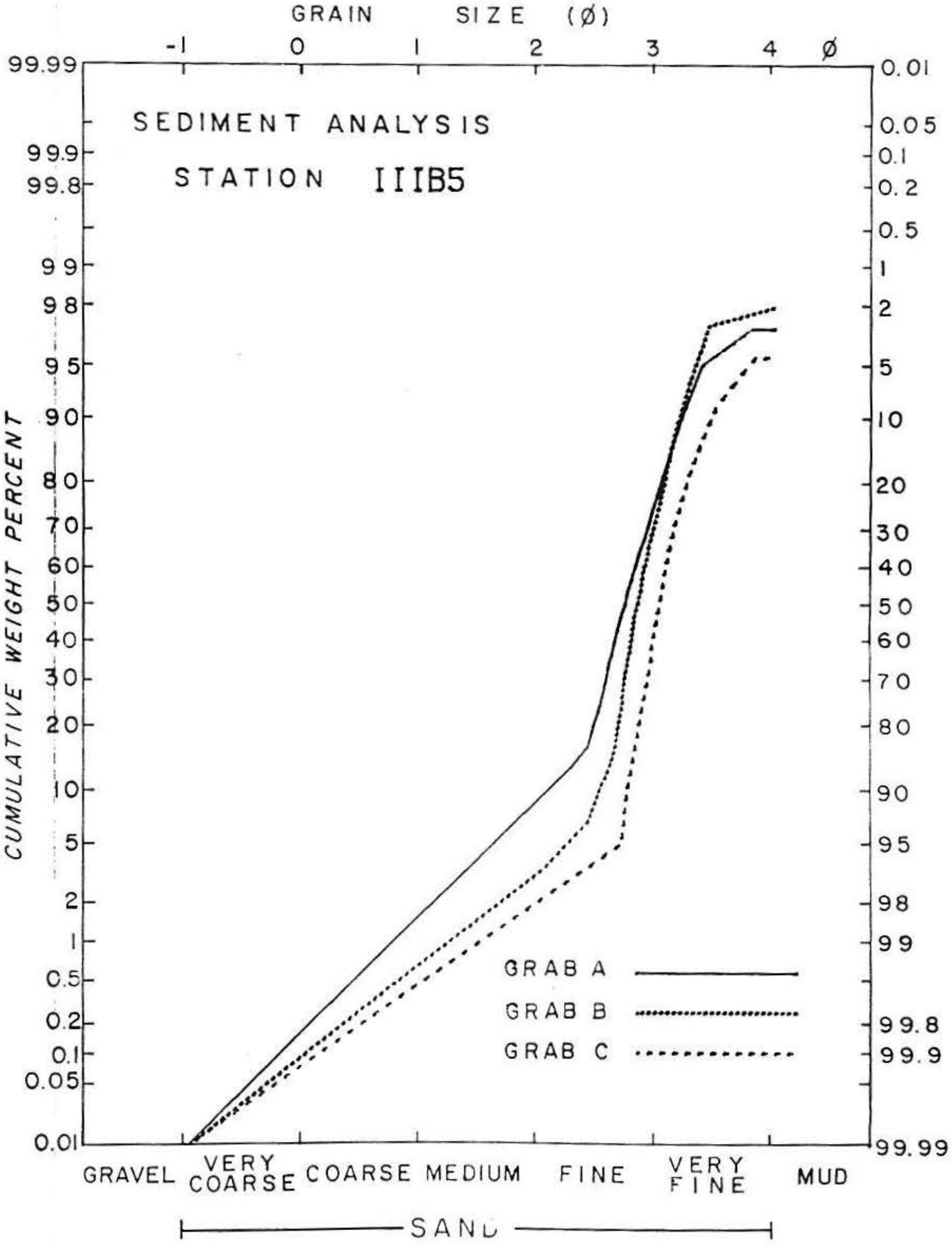
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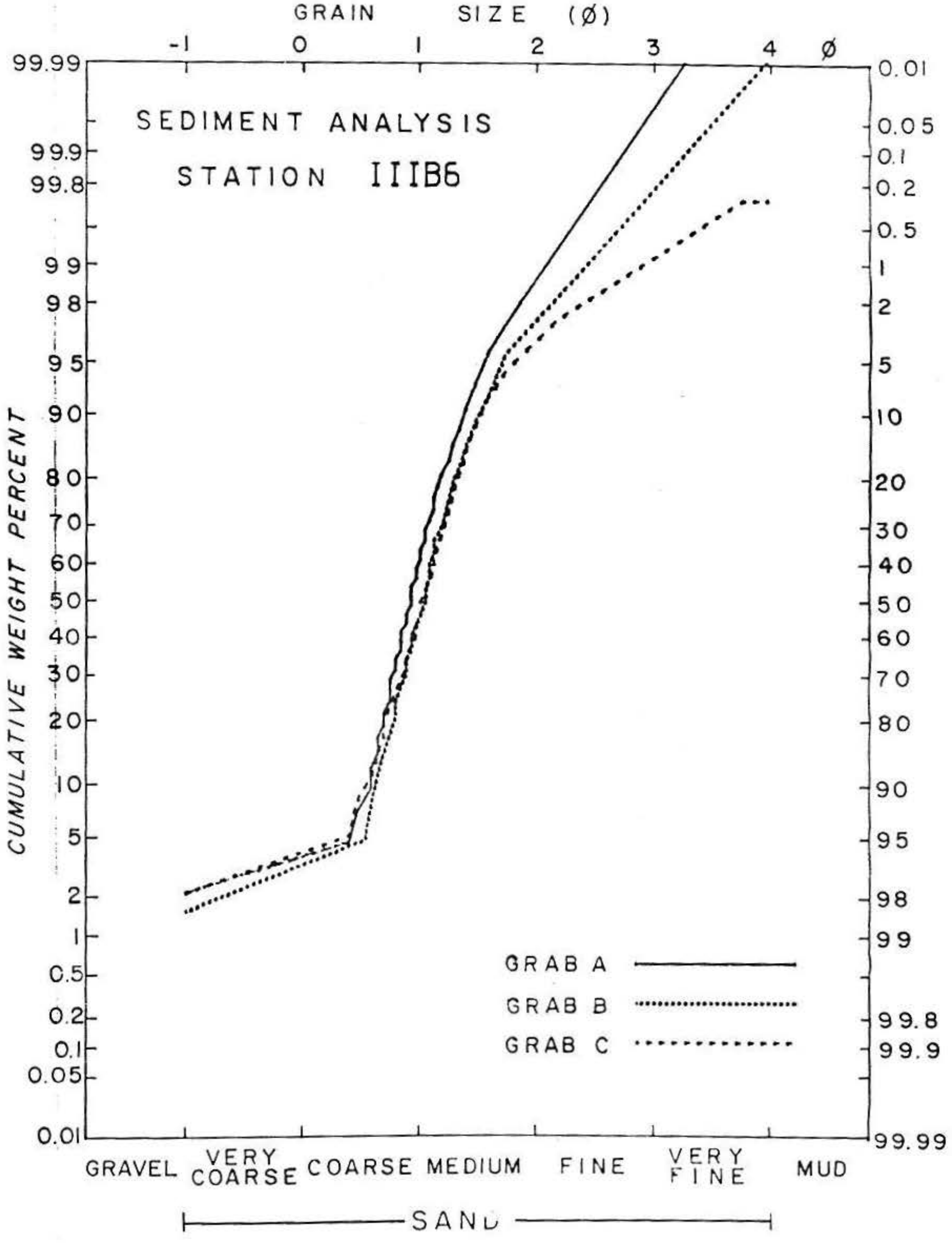
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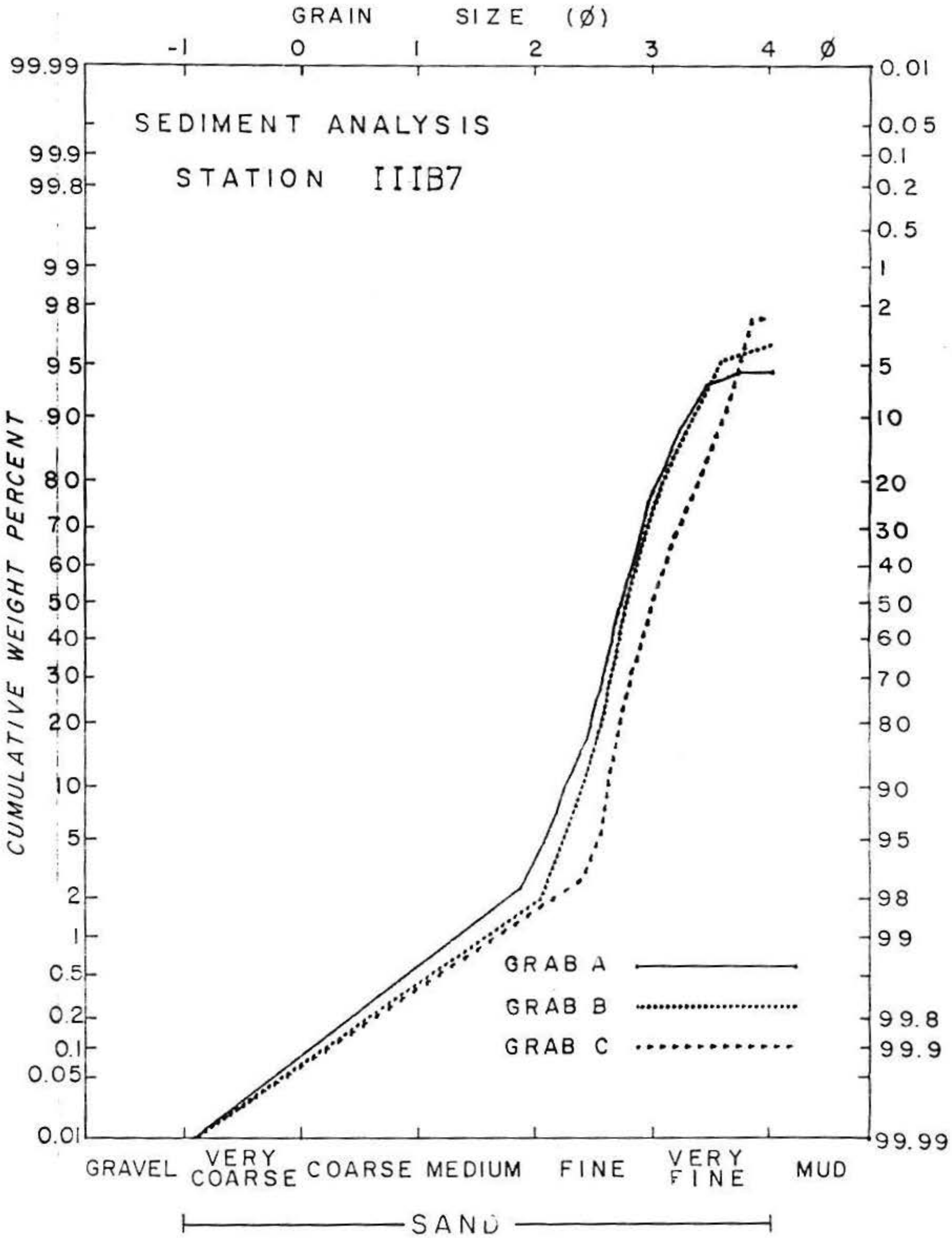
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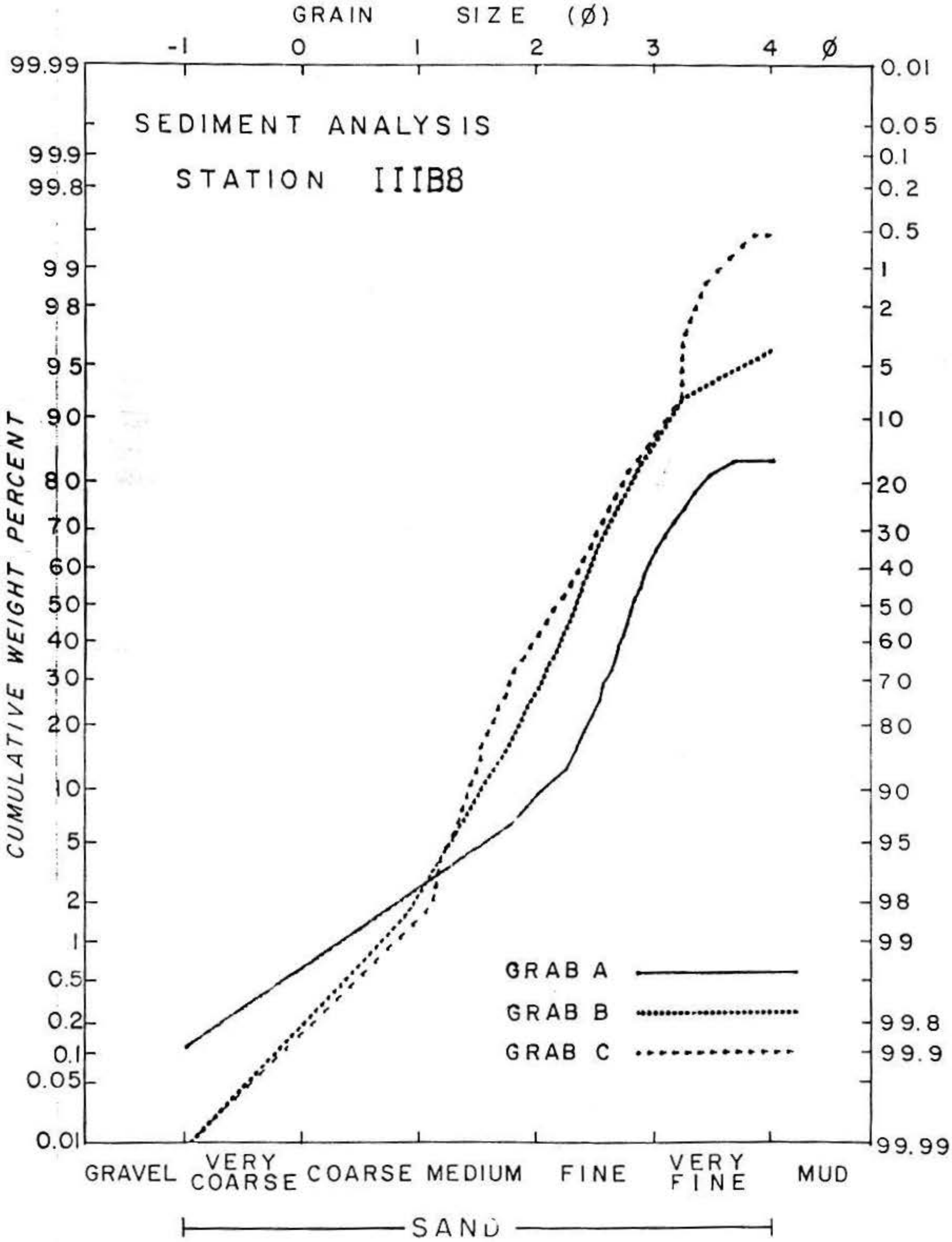
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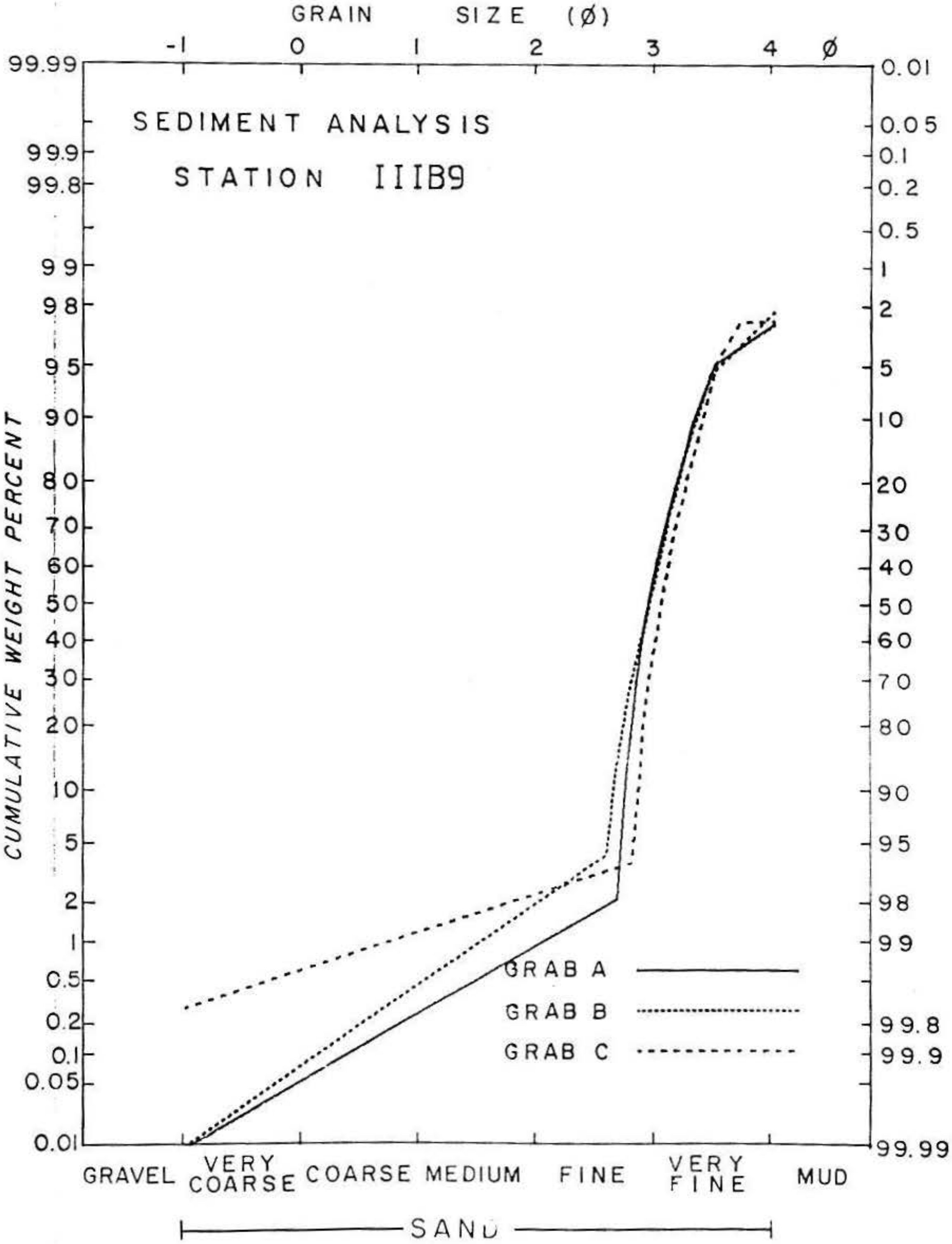
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99.8
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GRAB C
GRAVEL
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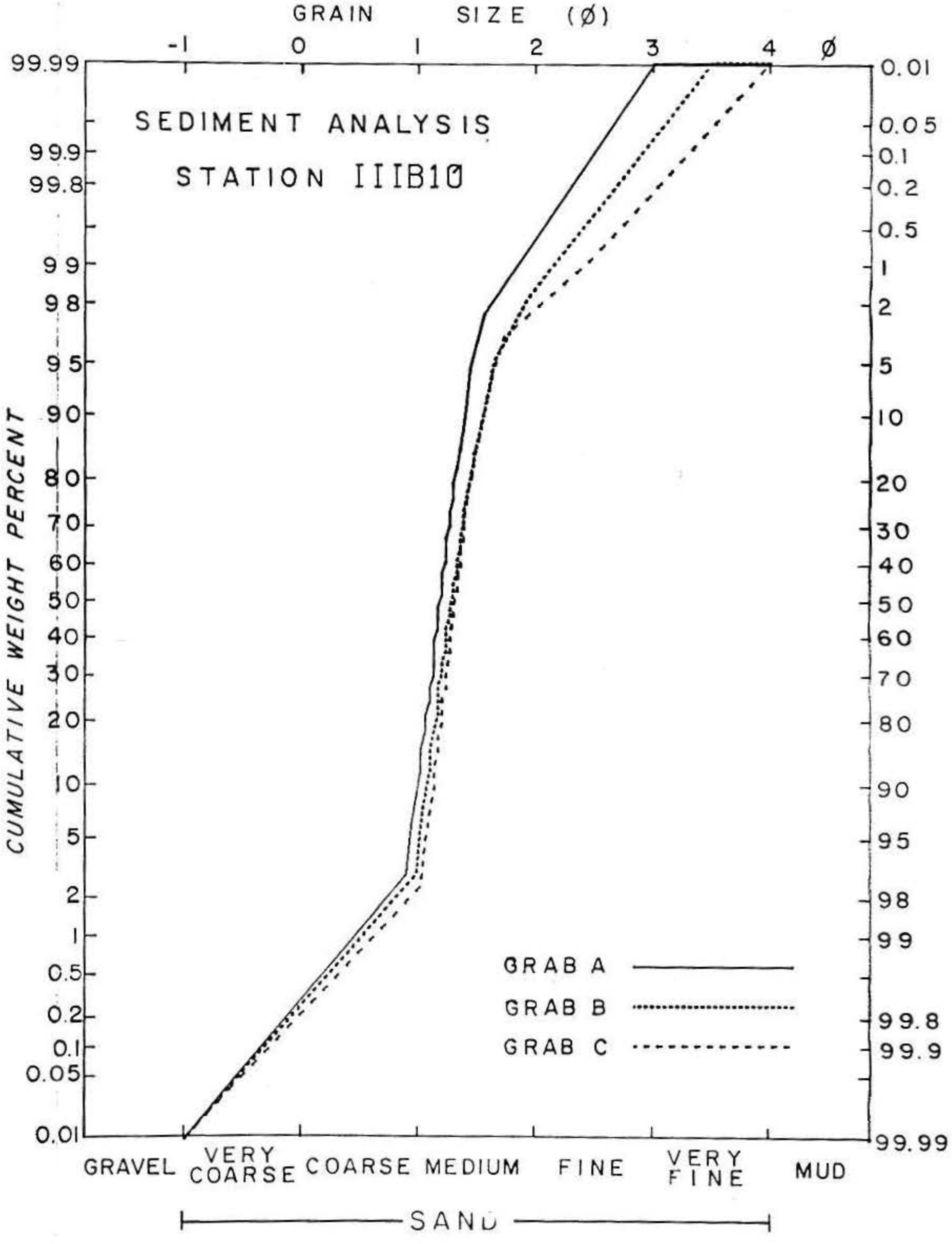
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99.8
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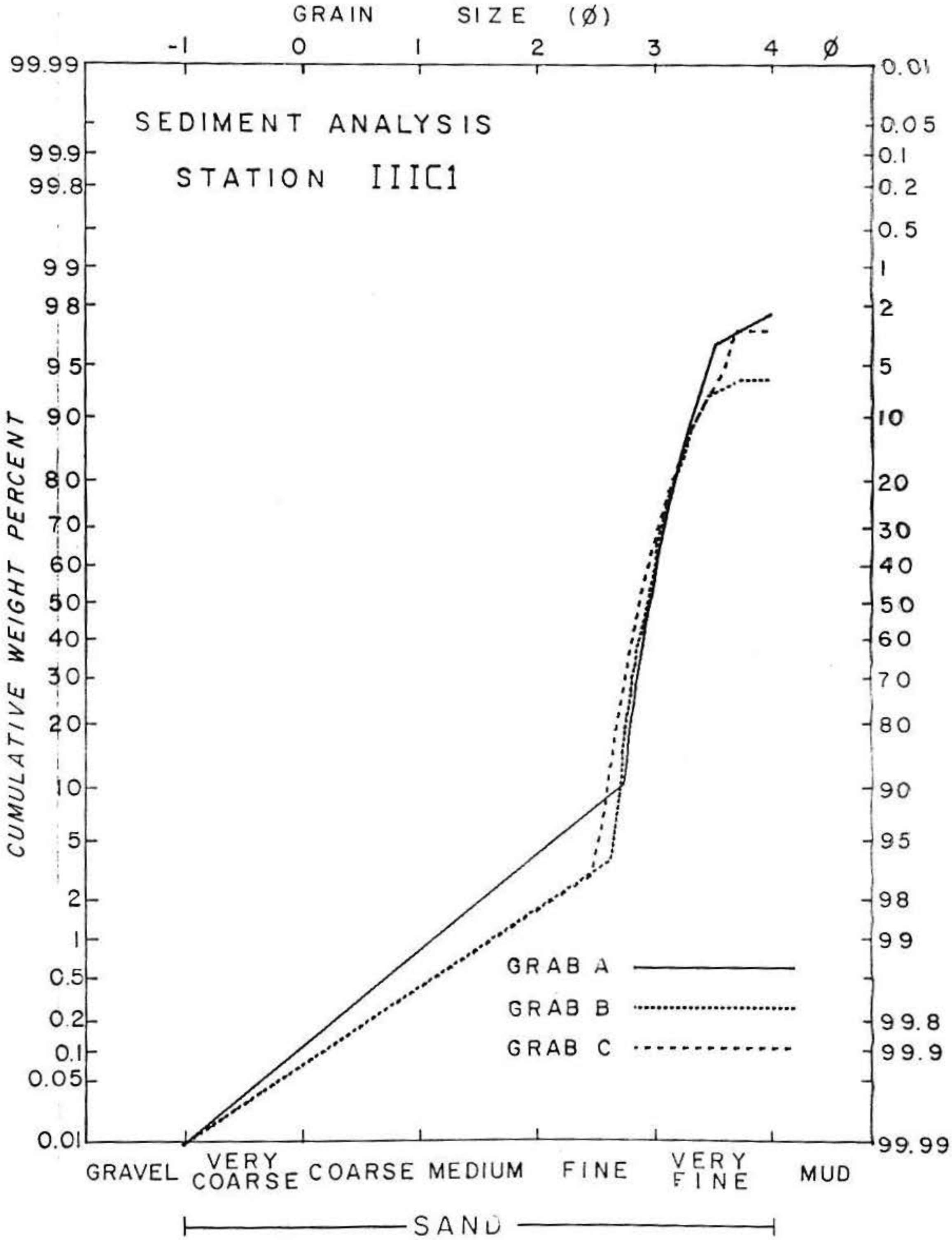
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CUMULATIVE WEIGHT PERCENT
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GRAB C
GRAVEL
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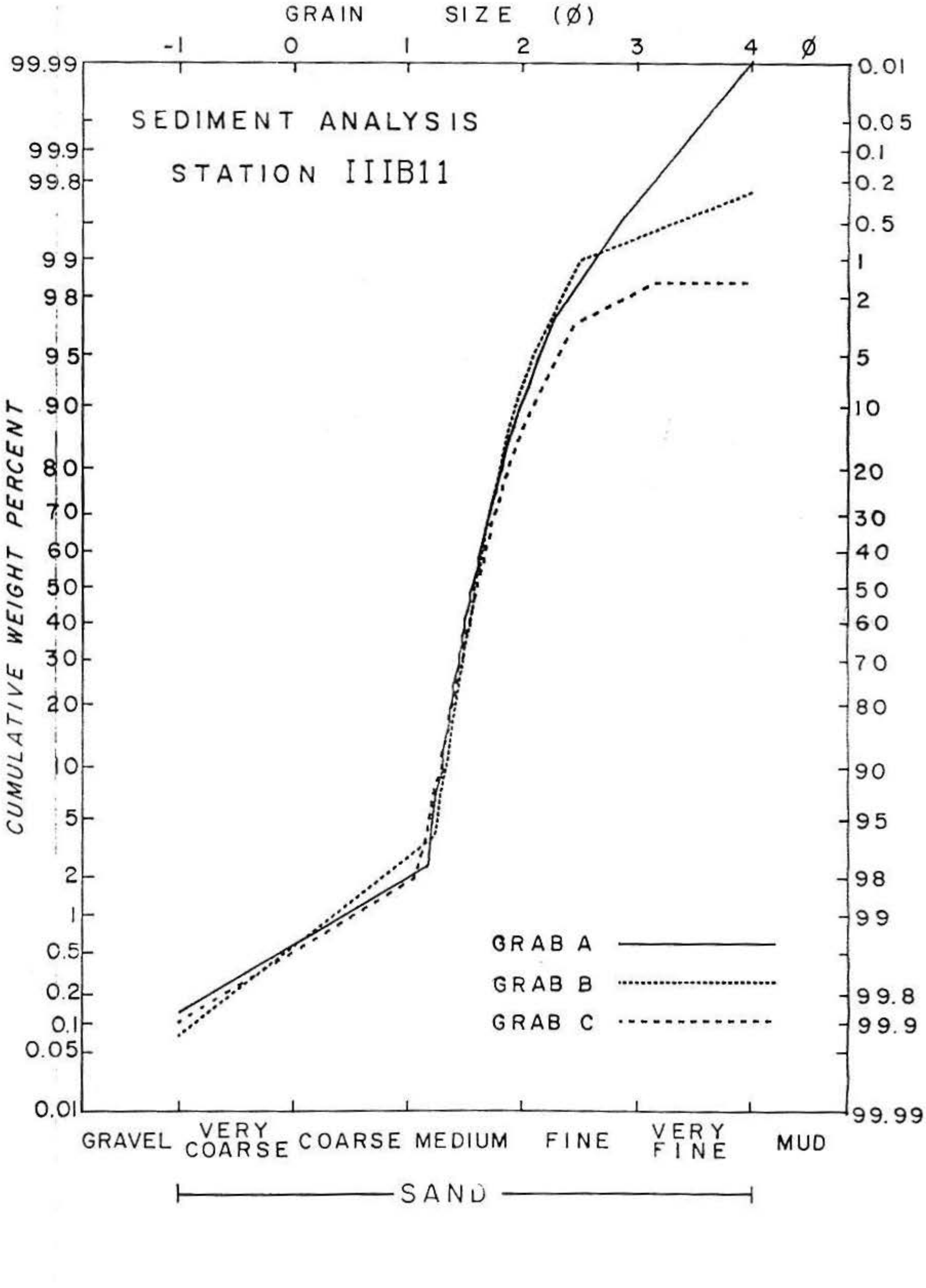
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STATION IIIB11
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GRAVEL
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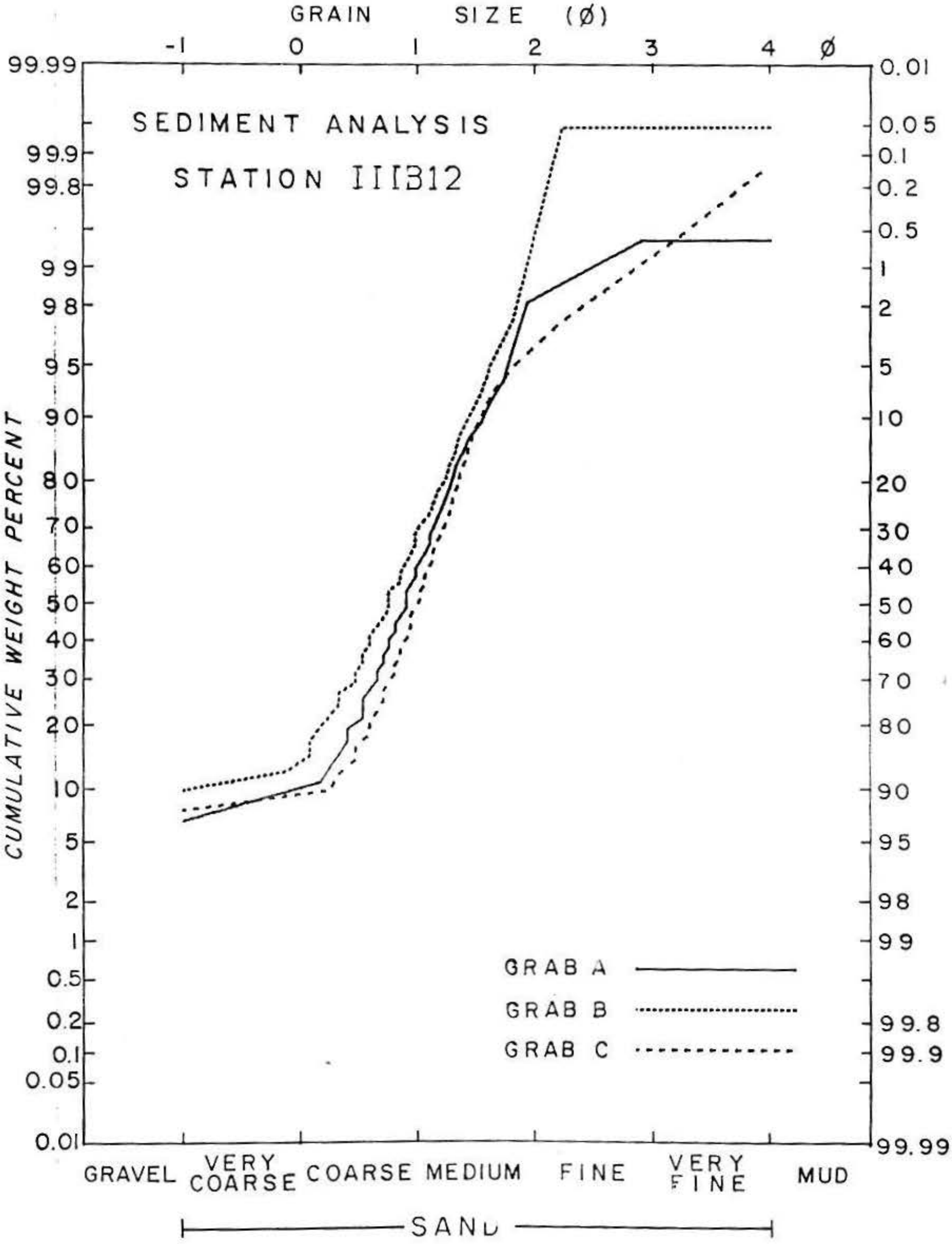
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GRAVEL
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MEDIUM
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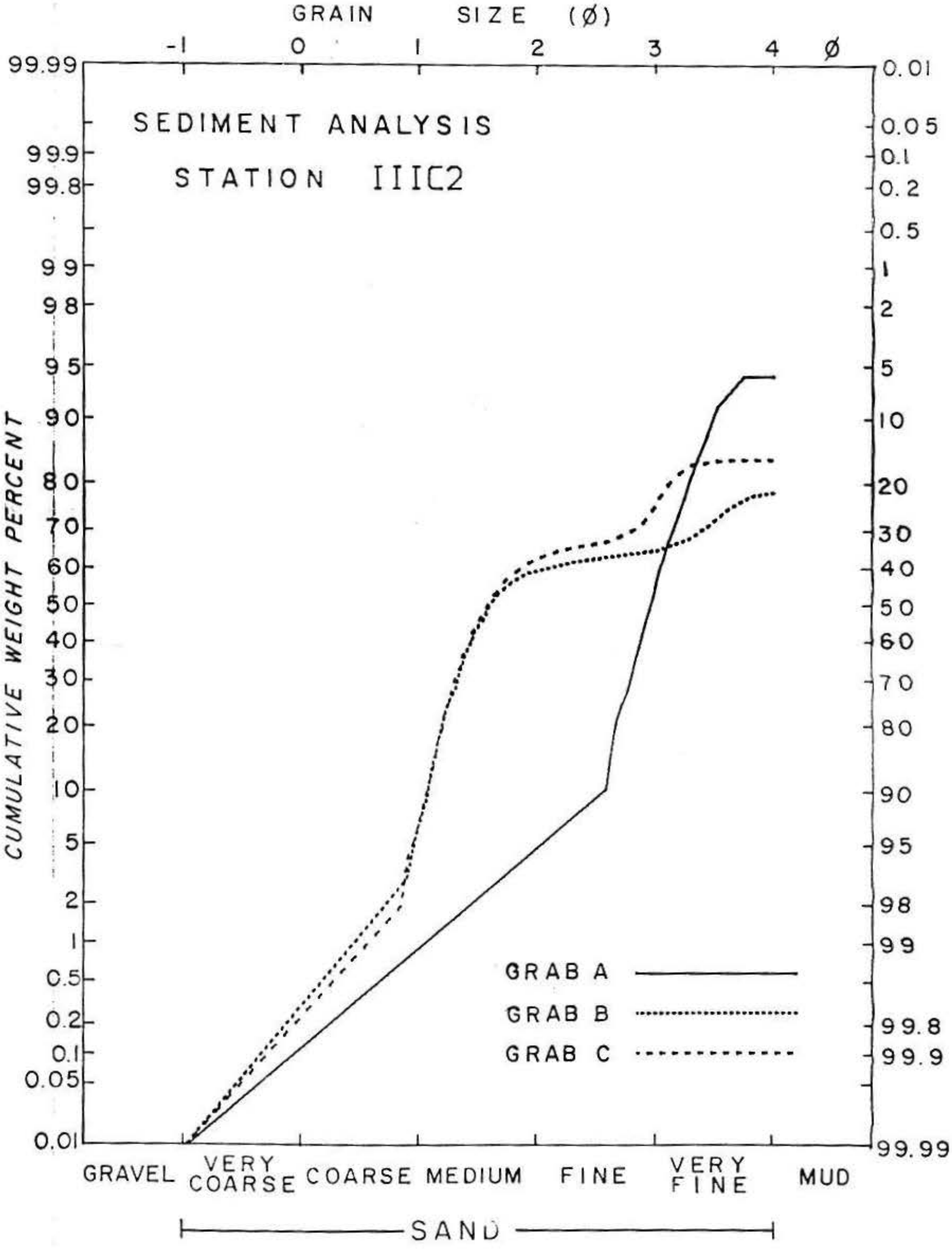
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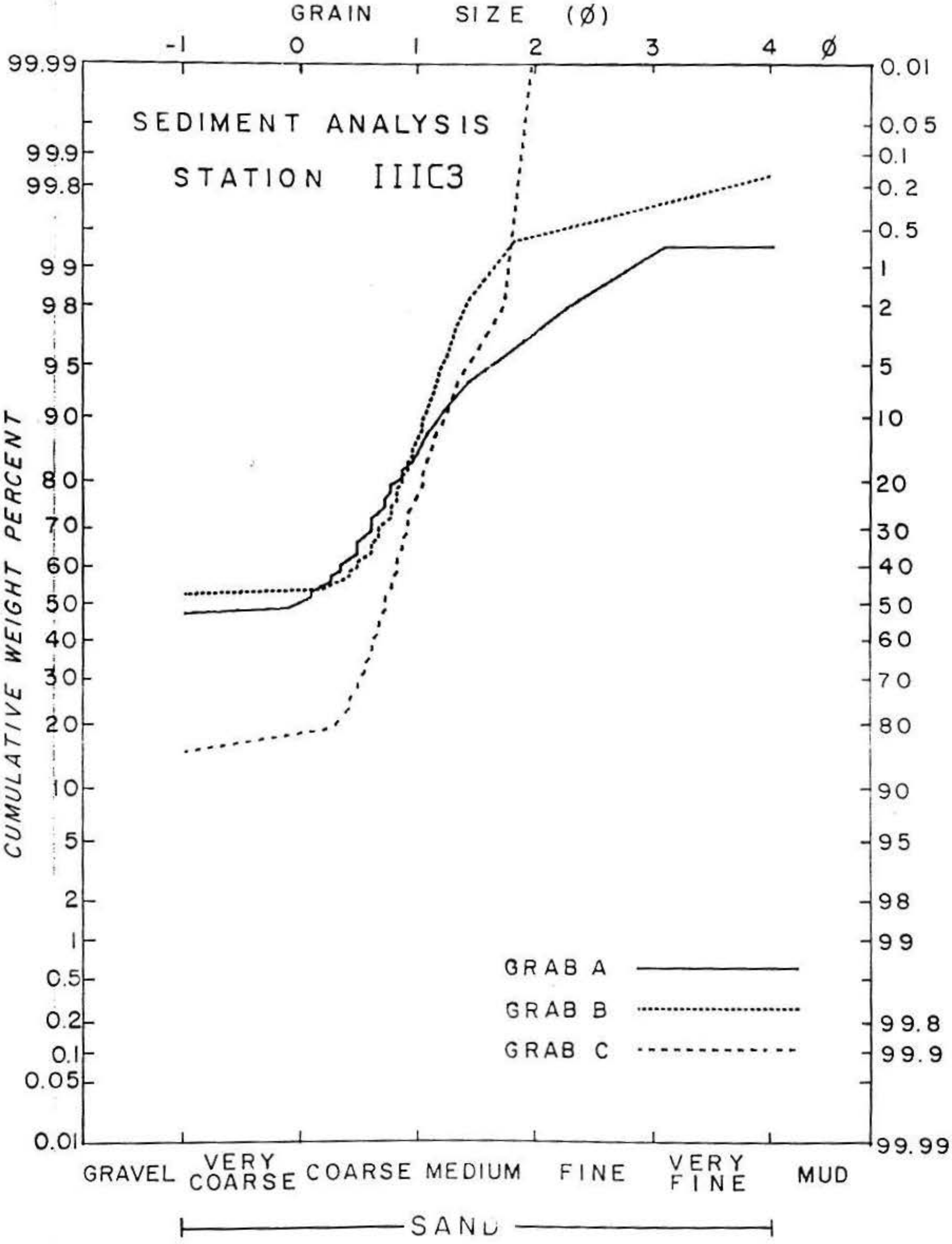
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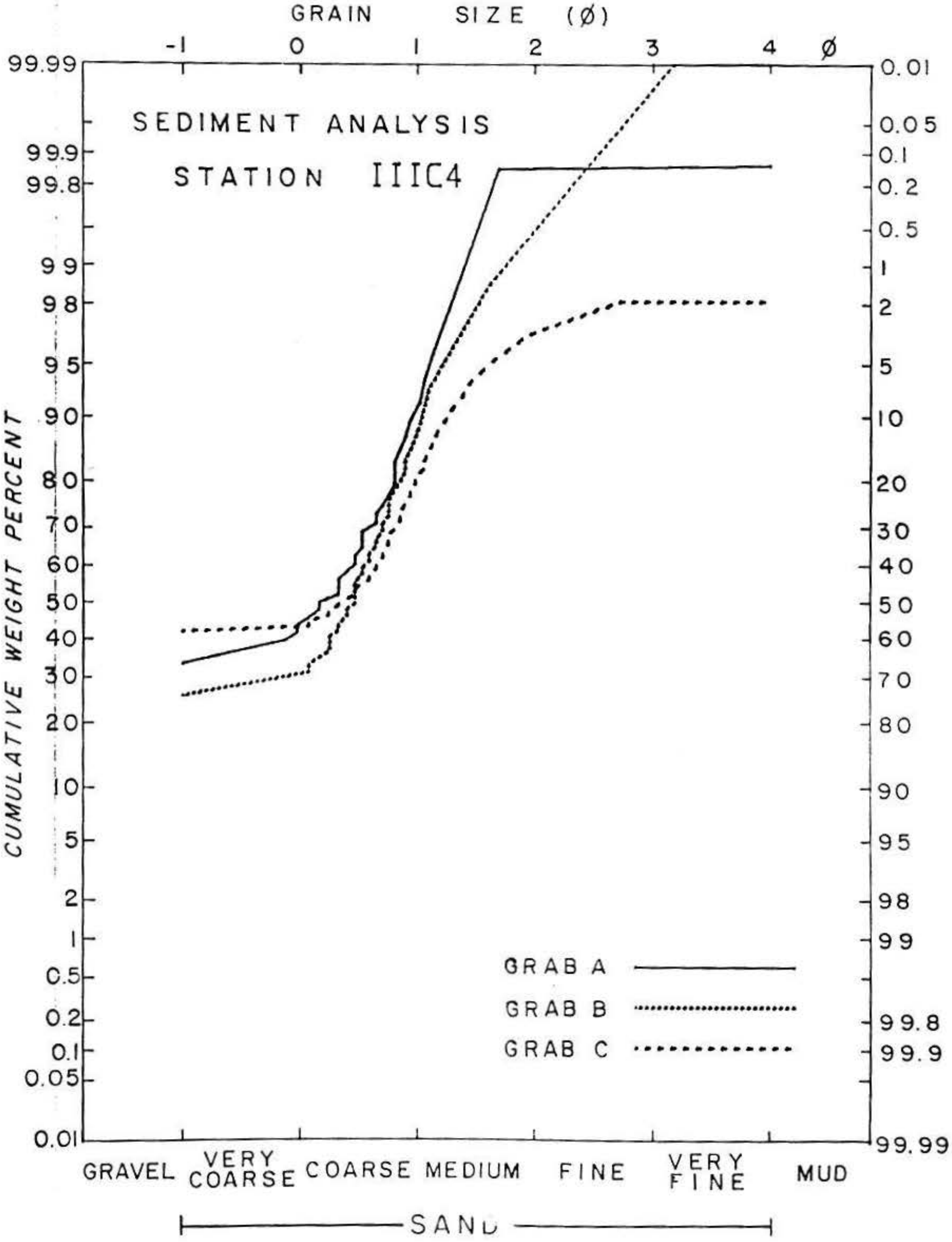
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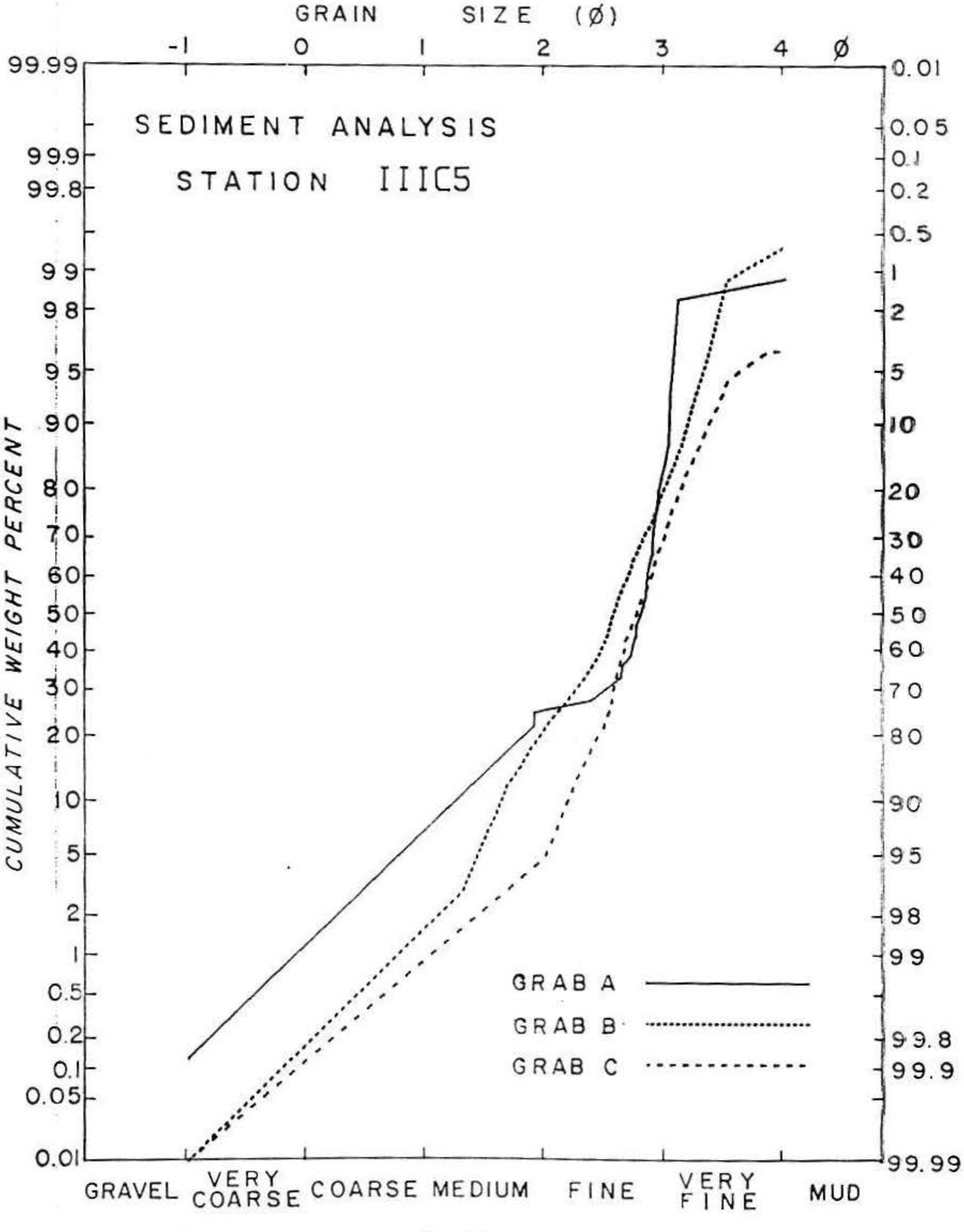
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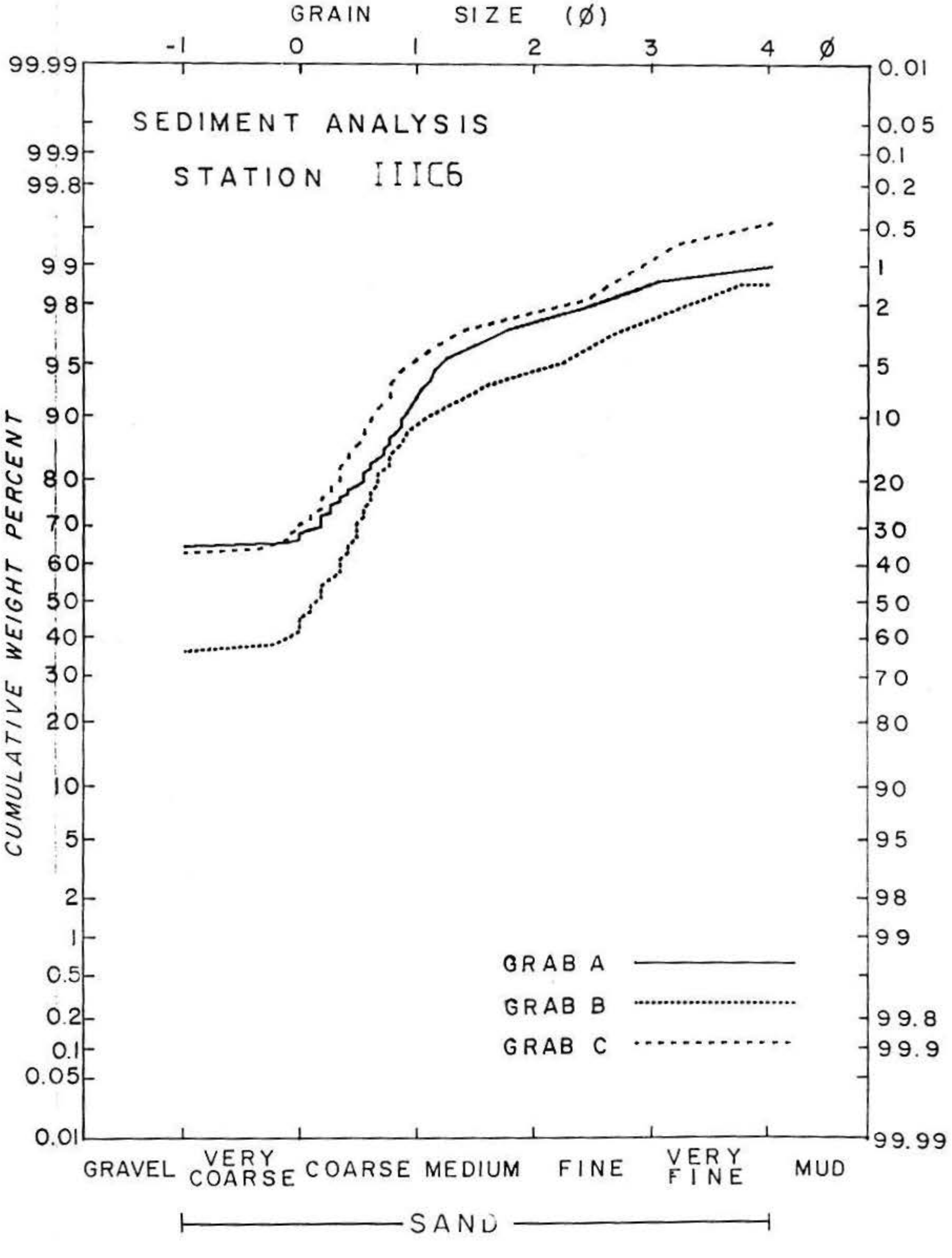
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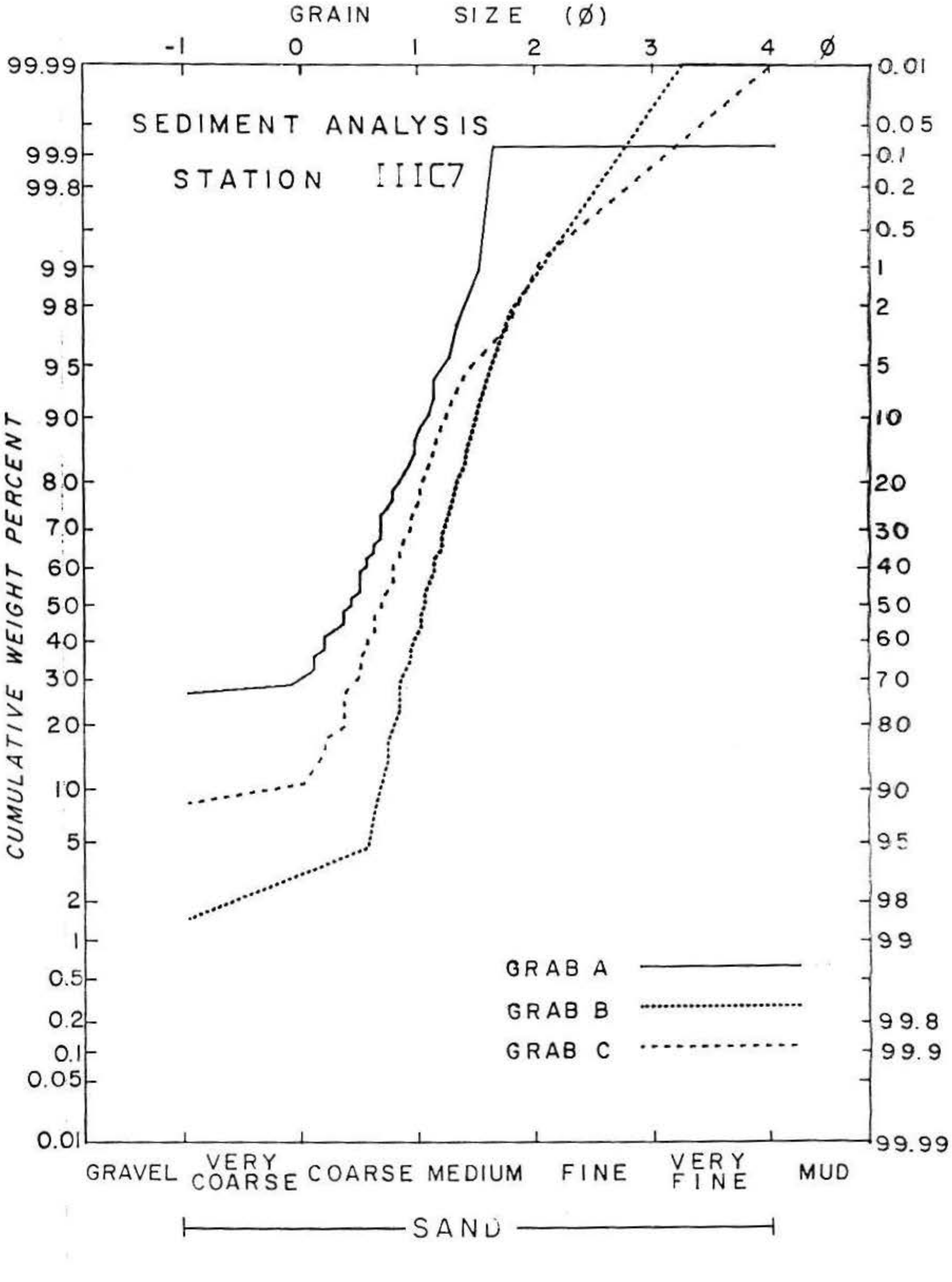
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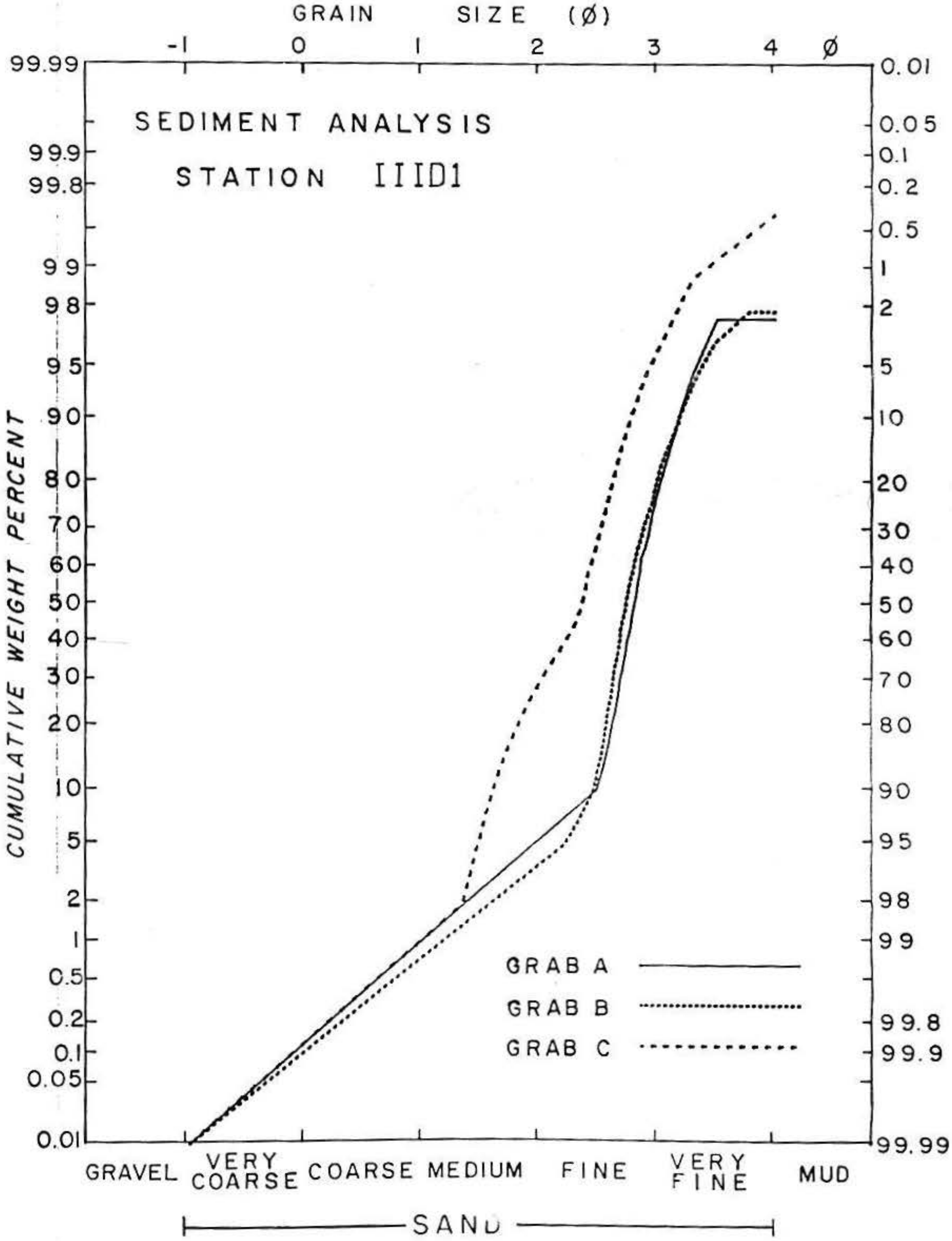
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STATION IIID1
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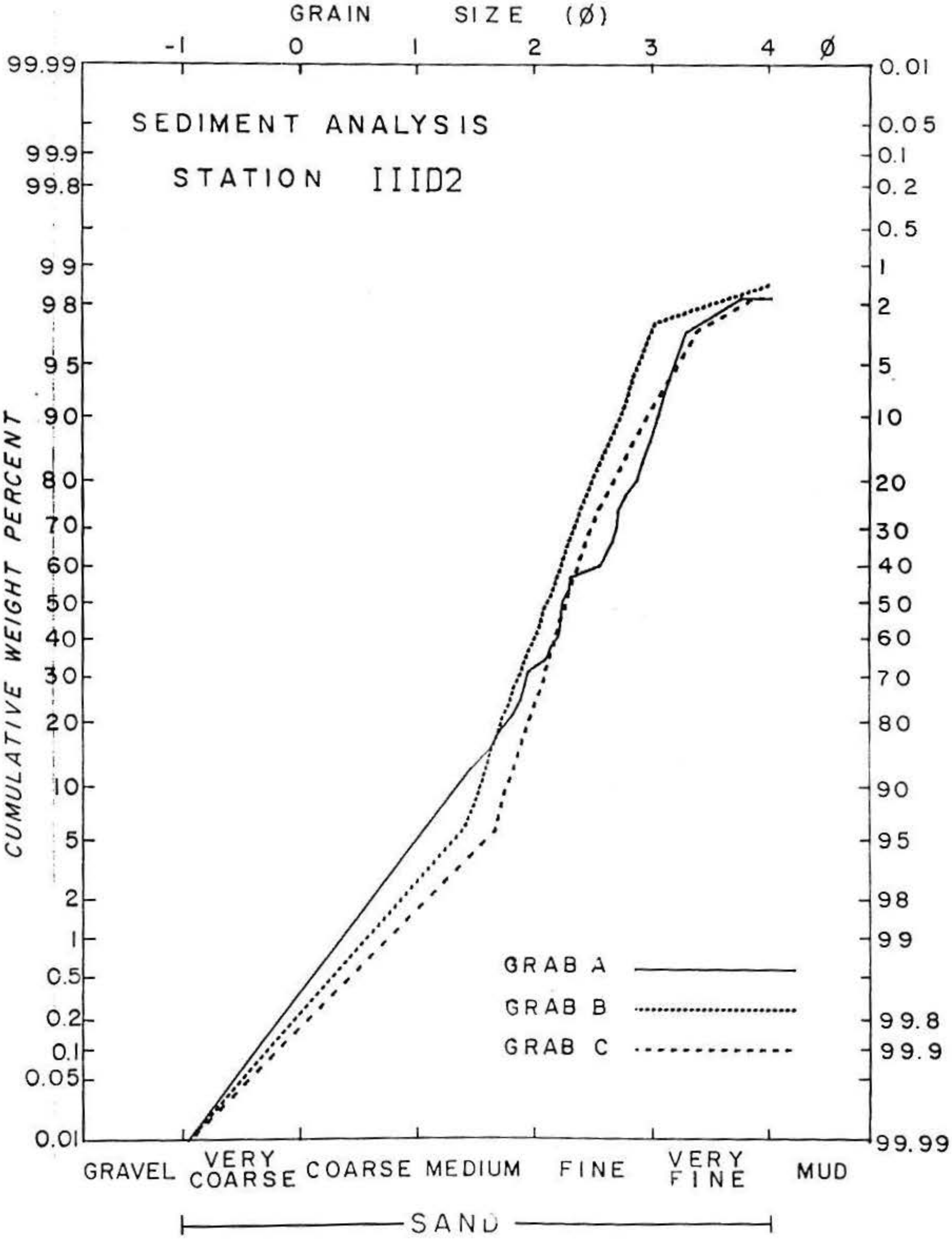
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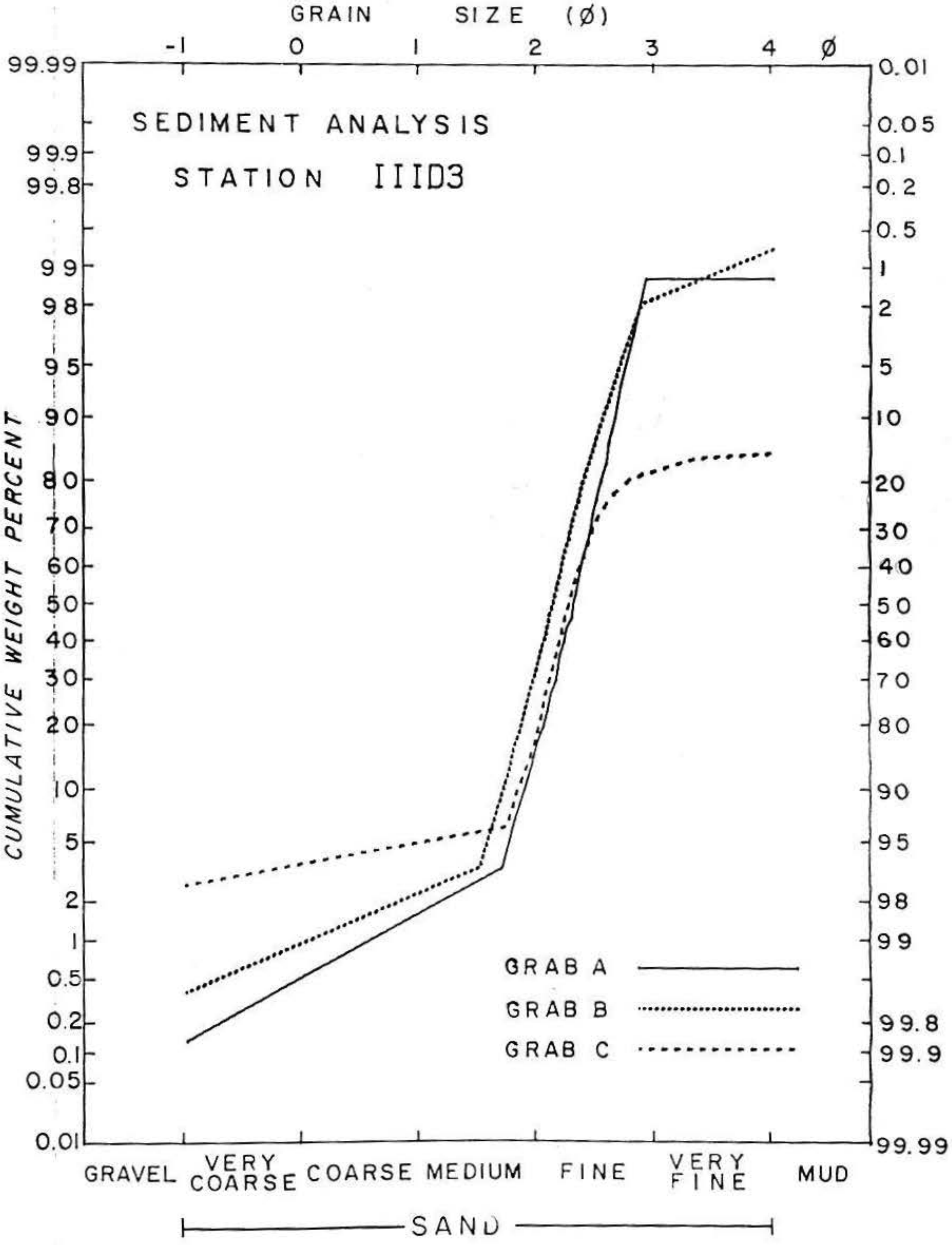
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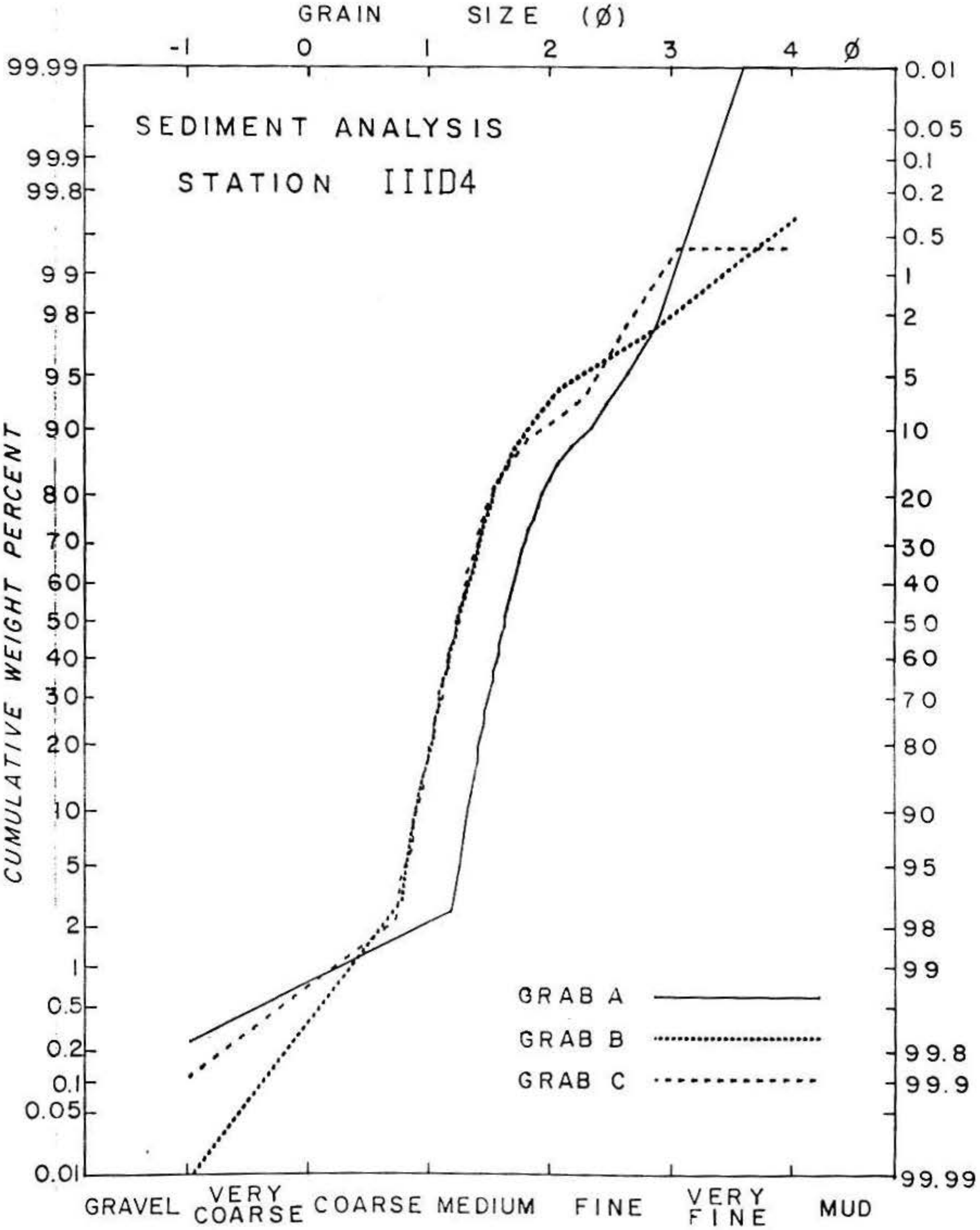
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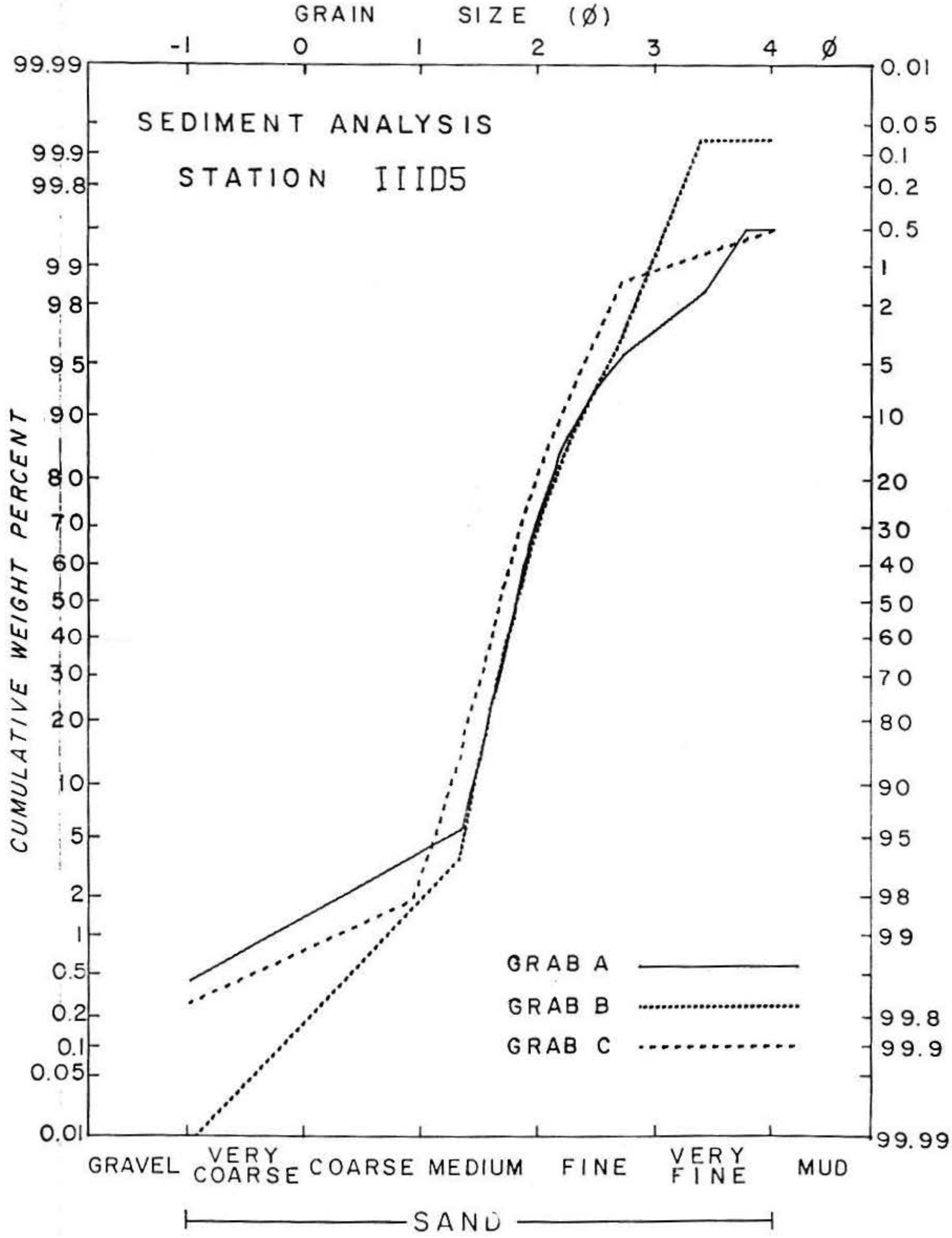
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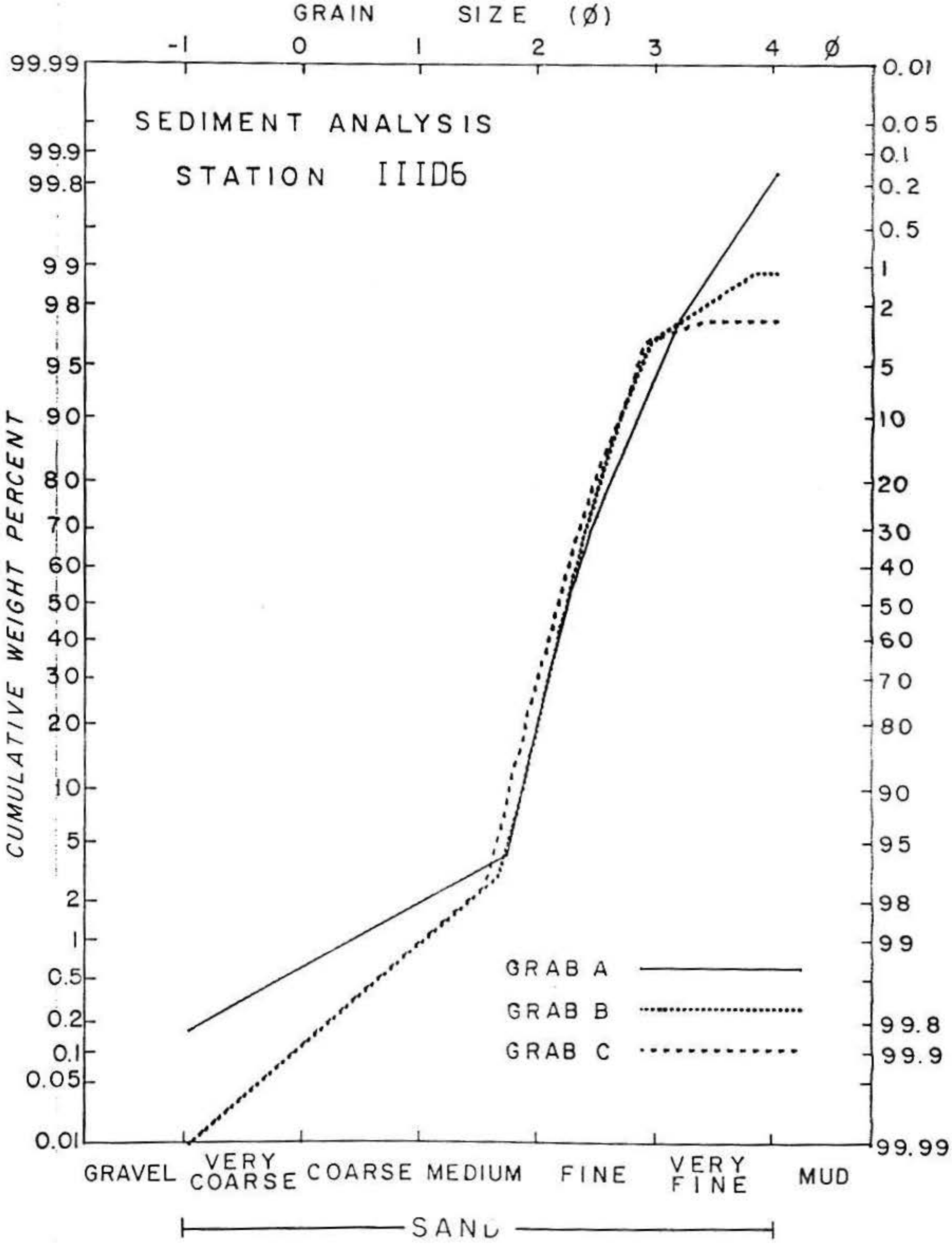
99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND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SEDIMENT ANALYSIS
STATION IIID6
CUMULATIVE WEIGHT PERCENT
99.99
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GRAB A
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GRAB C
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MEDIUM
FINE
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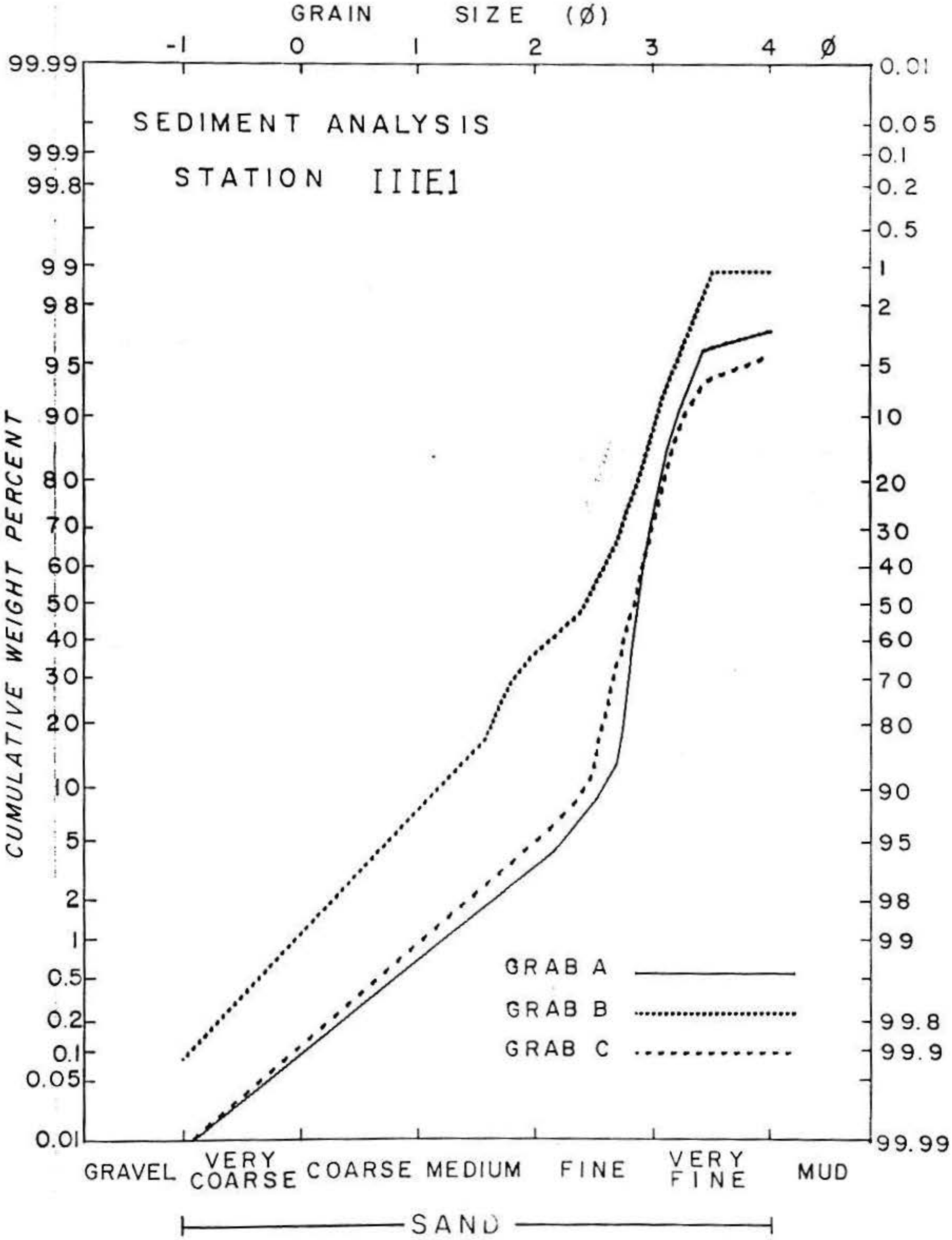
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SEDIMENT ANALYSIS
STATION IIIE1
CUMULATIVE WEIGHT PERCENT
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99.9
99.8
99
98
95
90
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99.8
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99.99
GRAB A
GRAB B
GRAB C
GRAVEL
VERY COARSE
COARSE
MEDIUM
FINE
VERY FINE
MUD
SAND