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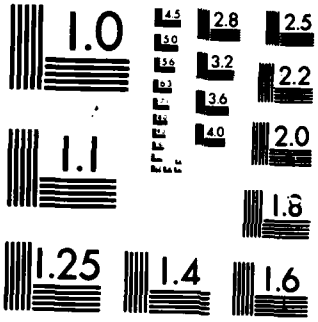

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DEPARTMENT OF GEOPHYSICAL SCIENCES
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NORFOLK, VIRGINIA

Technical Report GSTR-82-15

ENVIRONMENTAL STUDIES FOR THE PROPOSED NORFOLK HARBOR DEEPENING AND DISPOSAL PROJECT WITHIN THE NORFOLK DISTRICT

By

Randall S. Spencer, Principal Investigator

Final Report
For the period ending September 30, 1982

Prepared for the
Army Corps of Engineers
Norfolk District
Fort Norfolk
Norfolk, Virginia

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Under
Research Grant DACW65-81-C-0051
James Melchor, Technical Monitor

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Report presents preliminary data describing the Foraminiferal and Ostracodal meiofauna associated with the proposed Norfolk Harbor deepening.

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Under
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James Melchor, Technical Monitor

Submitted by the
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ENVIRONMENTAL STUDIES FOR THE PROPOSED NORFOLK HARBOR DEEPENING AND DISPOSAL PROJECT WITHIN THE NORFOLK DISTRICT

By

Randall S. Spencer*

Purpose

This report presents preliminary data describing the Foraminiferal and Ostracodal meiofauna associated with the Proposed Norfolk Harbor Deepening. Data in the present report represent samples collected during the month of August, 1982. Additional sampling over a year at least is recommended.

Method of Study

Seven stations along a traverse extending westward from offshore at latitude 36°55.50N, longitude 75°54.50W to near Mulberry Island, James River at latitude 37°2.42'N, longitude 76°33.0'N were sampled during August, 1982 (Figure 1). At each station three separate grab samples were obtained for analysis of the contained foraminifers and ostracodes. From each grab sample, 200 ml were extracted from the top few centimeters and immediately preserved in a solution of buffered formalin and Rose Bengal (Walton, 1952). Upon reaching the laboratory, each sample was carefully washed in water through a 62μ sieve in order to remove all clay and silt size particles while retaining the foraminifers, ostracodes, and all sand-size and coarser particles. Upon completion of the wash, the fraction of sediment remaining on the 62μ sieve was placed in sample bottles containing 95% ethanol. This procedure was necessary in order, first, to eliminate the possibility of the buffered formalin turning acidic, thereby dissolving the calcium carbonate shell material and secondly, in order to preserve the "living" meiofauna until further analyses could be performed on each sample. In order to extract the foraminifers and ostracodes from the preserved

*Chairman, Department of Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

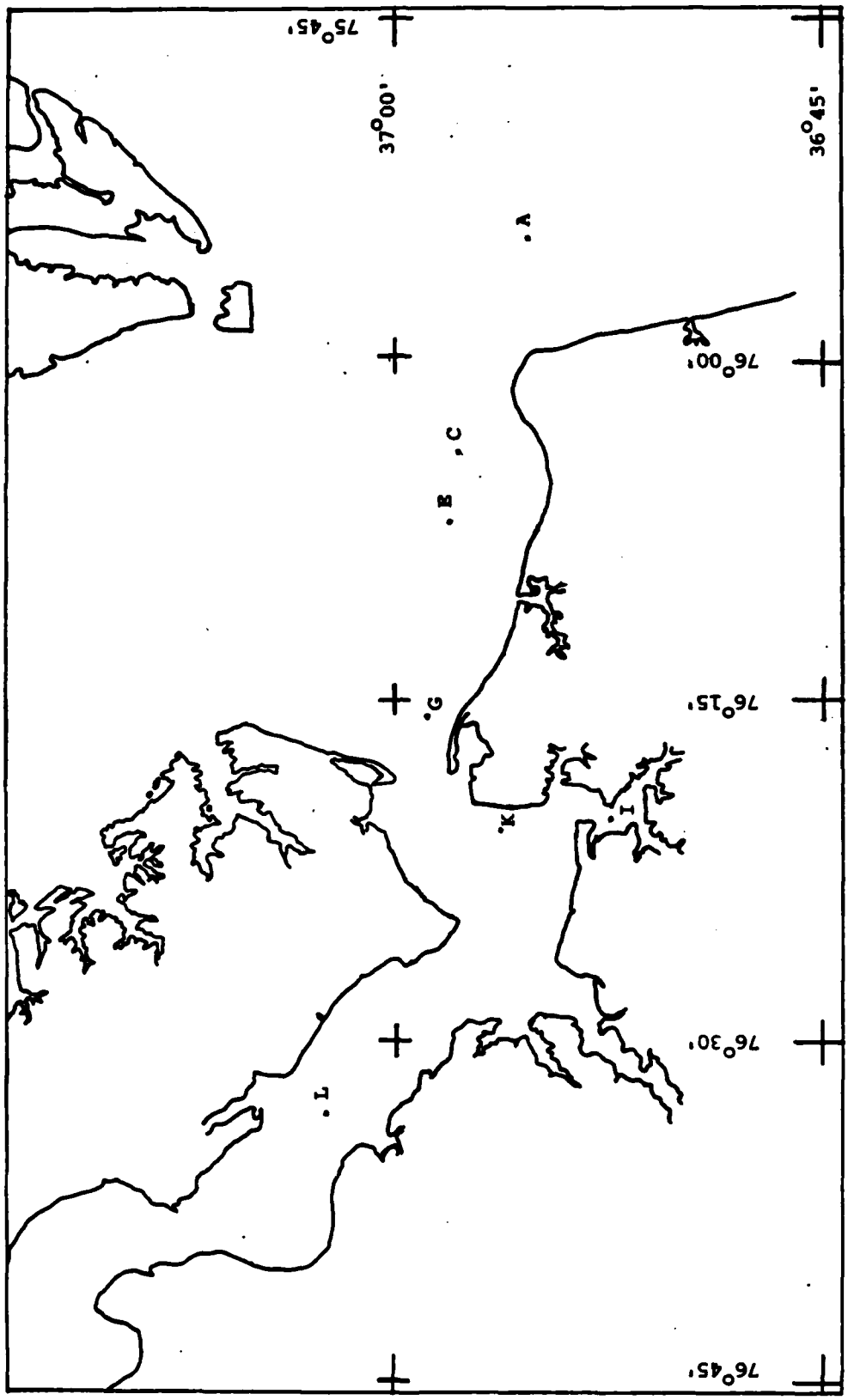

Figure 1 - Location of Stations

sediment fraction, a heavy liquid concentration technique was utilized. The samples were again washed in water through a 62μ sieve to remove the alcohol and then washed with acetone to remove the water and facilitate rapid drying. Once dry, each sample was slowly poured into a 10:4 mixture of tetrabromoethane and acetone (specific gravity 2.25) causing the foraminifers and ostracodes to float and be easily extracted from the sediment. The sample was subjected to a second flotation treatment, washed with acetone to remove all tetrabromoethane, and dried.

A careful examination of the sample after the tetrabromoethane treatments indicates that nearly all of the foraminifers and ostracodes were extracted. Once extracted, the float was evenly divided using a Carpco micro-splitter. A split of the float was then distributed over a gridded picking tray. Using a table of random numbers to select grids, all foraminifers were picked from each selected grid until a total of 300 individuals were collected. Any ostracodes encountered in this selection process were also picked and mounted on a separate slide. Once picked, the randomly selected foraminifers and ostracodes were sorted for living (stained red) and dead, identified, and tabulated.

Meiofaunal Community

The Foraminifera and Ostracoda found in samples at stations A (36°55.50'N, 75°54.50'W), C (36°57.95'N, 76°03.95'W), E (36°58.23'N, 76°07.11'W), G (36°59.10'N, 76°15.72'W), I (36°52.50'N, 76°20.28'W), K (36°56.38'N, 76°20.55'W), I (37°2.42'N, 76°33.0'W) are listed in Tables 1 and 2. A total of 52 species of foraminifers and 29 species of ostracodes were identified. The percent abundance for each foraminiferal species, both live and dead, of each sample is based upon the total population of that sample and is shown in Table 1. This and other analyses of the foraminifers

Table 1

Distribution of the Foraminifera by count and by percent of the total population for living (L) and dead (D) populations. Frequencies of less than 1 percent are tabulated to the nearest tenth of a percent. Percentages in parentheses.

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Species	Station: A-8 L	A-8 D	A-9 L	A-9 D	A-10 L	A-10 D
Ammobaculites crassus	-	-	-	-	-	-
" dilatatus	-	-	-	-	-	-
" exiguus	-	-	-	-	-	-
Ammonia beccarii	-	2 (0.7)	-	1 (0.3)	-	3 (1.0)
Ammotium cassis	-	-	-	-	-	-
" fragile	-	-	-	-	-	-
Buccella frigida	-	2 (0.7)	-	1 (0.3)	-	-
" sp. A.	-	-	-	-	-	-
Bulimina sp.	-	-	-	-	-	-
Cancris sagra	-	-	-	-	-	-
Candeina nitida	-	-	-	-	-	-
Cibicides cf. bradyi	-	-	-	-	-	-
" lobatulus	-	-	-	2 (0.7)	-	1 (0.3)
" pseudoungerianus	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	-
" sp. B.	-	-	-	-	-	-
Cyclogyra selseyensis	-	-	-	-	-	-
Dentalina sp.	-	-	-	-	-	-
Elphidium bartletii	-	-	-	1 (0.3)	-	6 (2.0)
" discoidale	-	-	-	-	-	2 (0.7)
" excavatum	9 (3.0)	283 (93.7)	8 (2.7)	266 (88.4)	5 (1.6)	274 (89.3)

Station:	A-8		A-9		A-10	
Species	L	D	L	D	L	D
Elphidium frigidum	-	-	-	-	-	-
" galvestonense	-	-	-	2 (0.7)	1 (0.3)	3 (1.0)
" incertum	-	-	-	-	-	-
" mexicanum	-	-	-	-	-	-
" poeyanum	-	-	-	-	-	-
" cf. rugulosum	-	-	-	-	-	-
" sp.	-	-	-	-	-	-
Eponides repandus	-	-	-	-	-	-
Globergerina bulloides	-	-	-	-	-	-
Globorotalia truncatulinoides	-	-	-	1 (0.3)	-	-
Guttulina lactea	-	1 (0.3)	-	1 (0.3)	-	-
Hanzawaia concentrica	-	-	-	-	-	-
Haynesina germanica	-	-	-	-	-	-
Lagena sp.	-	-	-	-	-	-
Lenticulina occidentalis	-	-	-	-	-	-
Massilina sp.	-	-	-	-	-	-
Miliammina fusca	-	-	-	-	-	-
Pseudoclavulina gracilis	-	-	-	-	-	-
Pseudononion atlanticum	-	2 (0.7)	-	8 (2.7)	-	2 (0.7)
Quinqueloculina seminula	-	-	1 (0.3)	9 (3.0)	-	10 (3.3)

Species	Station: A-8 L	A-8 D	A-9 L	A-9 D	A-10 L	A-10 D
Reophax nana	-	-	-	-	-	-
" scorpiurus	-	-	-	-	-	-
Rhabdamina sp.	-	-	-	-	-	-
Rosalina floridana	-	1 (0.3)	-	-	-	-
" sp. A.	-	2 (0.7)	-	-	-	-
Spiroplectamina typica	-	-	-	-	-	-
Textularia candeiana	-	-	-	-	-	-
" conica	-	-	-	-	-	-
" cf. earlandi	-	-	-	-	-	-
Trochammina inflata	-	-	-	-	-	-
" macresens	-	-	-	-	-	-
Virgulina loeblichi	-	-	-	-	-	-
Subtotal	9 (2.9)	293 (97.1)	9	292	6	301
Total	302		301		307	

Species	Station: C-8 L	C-8 D	C-9 L	C-9 D	C-10 L	C-10 D
Ammobaculites crassus	-	-	-	-	-	-
" dilatatus	-	-	-	-	-	-
" exiguus	-	-	-	-	-	-
Ammonia beccarii	1 (0.3)	2 (0.7)	3 (1.0)	2 (0.7)	-	-
Ammotium cassis	-	-	-	-	-	-
" fragile	-	-	-	-	-	-
Buccella frigida	-	2 (0.7)	-	3 (1.0)	-	-
" sp. A.	-	-	-	-	-	-
Bulimina sp.	-	-	-	-	-	-
Cancris sagra	-	-	-	-	-	-
Candeina nitida	-	-	-	-	-	-
Cibicides cf. bradyi	-	-	-	-	-	-
" lobatulus	-	-	-	1 (0.3)	-	-
" pseudoungerianus	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	-
" sp. B.	-	-	-	-	-	1 (0.3)
Cyclogyra selseyensis	-	-	-	-	-	-
Dentalina sp.	-	-	-	-	-	-
Elphidium bartletii	-	-	-	-	-	-
" discoidale	-	2 (0.7)	-	-	-	-
" excavatum	13 (4.2)	282 (92.2)	41 (13.7)	245 (81.7)	30 (10.0)	266 (88.4)

Species	Station: C-8 L	C-8 D	C-9 L	C-9 D	C-10 L	C-10 D
Elphidium frigidum	-	-	-	-	-	-
" galvestonense	-	-	-	-	-	-
" incertum	-	-	-	-	-	-
" mexicanum	-	-	-	-	-	-
" poeyanum	-	-	-	-	-	-
" cf. rugulosum	-	-	-	-	-	-
" sp.	-	-	-	-	-	-
Eponides repandus	-	-	-	-	-	-
Globergerina bulloides	-	-	-	-	-	-
Globorotalia truncatulinoides	-	-	-	-	-	-
Guttulina lactea	-	-	-	-	-	-
Hanzawaia concentrica	-	1 (0.3)	-	1 (0.3)	-	-
Haynesina germanica	-	-	-	-	-	-
Lagena sp.	-	-	-	-	-	-
Lenticulina occidentalis	-	-	-	-	-	-
Massilina sp.	-	-	-	-	-	-
Miliammina fusca	-	-	-	-	-	-
Pseudoclavulina gracilis	-	-	-	-	-	-
Pseudononion atlanticum	-	1 (0.3)	-	-	-	-
Quinqueloculina seminula	-	2 (0.7)	-	2 (0.7)	-	-

Station:	C-8		C-9		C-10	
Species	L	D	L	D	L	D
Reophax nana	-	-	-	-	-	-
" scorpiurus	-	-	-	-	-	-
Rhabdamina sp.	-	-	-	-	-	-
Rosalina floridana	-	-	-	2 (0.7)	-	-
" sp. A.	-	-	-	-	-	-
Spiroplectamina typica	-	-	-	-	-	-
Textularia candeiana	-	-	-	-	-	4 (1.3)
" conica	-	-	-	-	-	-
" cf. earlandi	-	-	-	-	-	-
Trochammina inflata	-	-	-	-	-	-
" macresens	-	-	-	-	-	-
Virgulina loeblichi	-	-	-	-	-	-
Subtotal	14	292	44	256	30	271
Total	306		300		301	

Species	Station: E-8 L	E-8 D	E-9 L	E-9 D	E-10 L	E-10 D
Ammobaculites crassus	-	-	-	-	-	-
" dilatatus	-	-	-	-	-	-
" exiguus	-	-	-	-	-	-
Ammonia beccarii	-	1 (0.3)	-	1 (0.3)	-	2 (0.7)
Ammotium cassis	-	-	-	-	-	-
" fragile	-	-	-	-	-	-
Buccella frigida	-	1 (0.3)	-	4 (1.3)	-	1 (0.5)
" sp. A.	-	-	-	1 (0.3)	-	-
Bulimina sp.	-	-	-	-	-	-
Cancris sagra	-	-	-	-	-	-
Candeina nitida	-	-	-	-	-	-
Cibicides cf. bradyi	-	-	-	-	-	-
" lobatulus	-	-	-	-	-	-
" pseudoungerianus	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	-
" sp. B.	-	-	-	-	-	-
Cyclogyra selseyensis	-	-	-	-	-	-
Dentalina sp.	-	-	-	-	-	-
Elphidium bartletii	-	3 (1.0)	1 (0.3)	3 (1.0)	-	1 (0.7)
" discoidale	-	9 (3.0)	-	2 (0.7)	-	3 (1.1)
" excavatum	8 (2.7)	261 (87.0)	7 (2.3)	273 (91.0)	5 (1.8)	262 (91.9)

Species	Station: E-8 L	E-8 D	E-9 L	E-9 D	E-10 L	E-10 D
Elphidium frigidum	-	-	-	-	-	-
" galvestonense	-	2 (0.7)	-	-	-	4 (1.4)
" incertum	-	-	-	-	-	-
" mexicanum	-	-	-	-	-	4 (1.4)
" poeyanum	-	-	-	-	-	1 (0.3)
" cf. rugulosum	-	-	-	-	-	-
" sp.	-	-	-	-	-	-
Eponides repandus	-	-	-	-	-	-
Globergerina bulloides	-	-	-	-	-	1 (0.3)
Globorotalia truncatulinoides	-	-	-	-	-	-
Guttulina lactea		-	-	-	-	-
Hanzawaia concentrica	-	-	-	-	-	-
Haynesina germanica	-	1 (0.3)	-	-	-	1 (0.3)
Lagena sp.	-	-	-	-	-	-
Lenticulina occidentalis	-	-	-	-	-	-
Massilina sp.	-	-	-	-	-	-
Miliammina fusca	-	-	-	-	-	-
Pseudoclavulina gracilis	-	-	-	-	-	-
Pseudononion atlanticum	1 (0.3)	-	-	-	-	-
Quinqueloculina seminula	2 (0.7)	7 (2.3)	-	-	-	-

	E-8		E-9		E-10	
	L	D	L	D	L	D
Reophax nana	-	-	-	-	-	-
" scorpiurus	-	-	-	-	-	-
Rhabdamina sp.	-	-	-	-	-	-
Rosalina floridana	-	4 (1.3)	-	6 (2.0)	-	-
" sp. A.	-	-	-	-	-	-
Spiroplectamina typica	-	-	-	-	-	-
Textularia candeiana	-	-	-	-	-	-
" conica	-	-	-	-	-	-
" cf. earlandi	-	-	-	-	-	-
Trochammina inflata	-	-	-	-	-	-
" macresens	-	-	-	-	-	-
Virgulina loeblichi	-	-	-	2 (0.7)	-	-
Subtotal	71 (3.7)	289 (96.3)	8 (2.7)	292 (97.3)	5 (1.8)	280 (98.2)
Total	300		300		285	

Species	Station: G-8 L	G-8 D	G-9 L	G-9 D	G-10 L	G-10 D
Ammobaculites crassus	-	-	-	-	-	-
" dilatatus	-	-	-	-	-	-
" exiguus	-	-	-	-	-	-
Ammonia beccarii	2 (0.7)	29 (10.1)	1 (0.3)	29 (9.7)	-	30
Ammotium cassis	-	-	-	-	-	-
" fragile	-	-	-	-	-	-
Buccella frigida	-	-	-	1 (0.3)	-	2
" sp. A.	-	1 (0.3)	-	-	-	-
Bulimina sp.	-	1 (0.3)	-	-	-	-
Cancris sagra	-	-	-	-	-	-
Candeina nitida	-	-	-	-	-	-
Cibicides cf. bradyi	-	-	-	-	-	-
" lobatulus	-	-	-	2 (0.7)	-	-
" pseudoungerianus	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	1
" sp. B.	-	-	-	-	-	-
Cyclogyra selseyensis	-	-	-	-	-	-
Dentalina sp.	-	-	-	-	-	-
Elphidium bartletii	-	-	-	-	-	-
" discoidale	-	-	-	-	-	-
" excavatum	2 (0.7)	248 (86.4)	14 (4.7)	250 (83.9)	52	268

Station:	G-8		G-9		G-10	
Species	L	D	L	D	L	D
Elphidium frigidum	-	-	-	-	-	-
" galvestonense	-	-	-	-	-	-
" incertum	-	-	-	-	-	1
" mexicanum	-	-	-	-	-	-
" poeyanum	-	-	-	-	-	-
" cf. rugulosum	-	-	-	-	-	1
" sp.	-	1 (0.3)	-	-	-	-
Eponides repandus	-	-	-	-	-	-
Globergerina bulloides	-	-	-	-	-	-
Globorotalia truncatulinoides	-	1 (0.3)	-	-	-	-
Guttulina lactea	-	-	-	-	-	-
Hanzawaia concentrica	-	-	-	-	-	-
Haynesina germanica	-	1 (0.3)	-	-	-	-
Lagena sp.	-	1 (0.3)	-	-	-	-
Lenticulina occidentalis	-	-	-	-	-	-
Massilina sp.	-	-	-	-	-	-
Miliammina fusca	-	-	-	-	-	-
Pseudoclavulina gracilis	-	-	-	-	-	-
Pseudononion atlanticum	-	-	-	1 (0.3)	-	-
Quinqueloculina seminula	-	-	-	-	-	-

	G-8		G-9		G-10	
	L	D	L	D	L	D
Reophax nana	-	-	-	-	-	-
" scorpiurus	-	-	-	-	-	-
Rhabdamina sp.	-	-	-	-	-	-
Rosalina floridana	-	3 (1.0)	-	1 (0.3)	-	2 (0.6)
" sp. A.	-	-	-	-	-	-
Spiroplectamina typica	-	-	-	-	-	-
Textularia candeiana	-	-	-	-	-	-
" conica	-	-	-	-	-	1 (0.3)
" cf. earlandi	-	-	-	-	-	-
Trochammina inflata	-	-	-	-	-	-
" macresens	-	-	-	-	-	-
Virgulina loeblichi	-	-	-	-	-	-
Subtotal	4 (1.4)	283 (98.6)	15 (5.0)	283 (95.0)	52 (14.5)	306 (85.5)
Total	287		298		358	

Species	Station: I-8 L	I-8 D	I-9 L	I-9 D	I-10 L	I-10 D
Ammobaculites crassus	-	-	-	-	-	-
" dilatatus	-	-	-	-	-	-
" exiguus	-	-	-	-	-	-
Ammonia beccarii	5 (1.7)	242 (79.8)	7 (2.3)	271 (90.3)	7 (2.3)	9 (3.0)
Ammotium cassis	-	-	-	-	-	-
" fragile	-	-	-	-	-	-
Buccella frigida	-	1 (0.3)	-	-	-	-
" sp. A.	-	-	-	-	-	-
Bulimina sp.	-	-	-	-	-	-
Cancris sagra	-	-	-	-	-	-
Candeina nitida	-	-	-	-	-	-
Cibicides cf. bradyi	-	-	-	-	-	-
" lobatulus	-	-	-	-	-	-
" pseudoungerianus	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	-
" sp. B.	-	-	-	-	-	-
Cyclogyra selseyensis	-	-	-	-	-	-
Dentalina sp.	-	-	-	-	-	-
Elphidium bartletii	-	-	-	-	-	-
" discoidale	-	-	-	-	-	-
" excavatum	-	53 (17.5)	-	22 (7.3)	1 (0.3)	286 (94.4)

Station:	I-8		I-9		I-10	
Species	L	D	L	D	L	D
Elphidium frigidum	-	-	-	-	-	-
" galvestonense	-	-	-	-	-	-
" incertum	-	-	-	-	-	-
" mexicanum	-	-	-	-	-	-
" poeyanum	-	-	-	-	-	-
" cf. rugulosum	-	-	-	-	-	-
" sp.	-	-	-	-	-	-
Eponides repandus	-	-	-	-	-	-
Globergerina bulloides	-	-	-	-	-	-
Globorotalia truncatulinoides	-	-	-	-	-	-
Guttulina lactea	-	-	-	-	-	-
Hanzawaia concentrica	-	-	-	-	-	-
Haynesina germanica	-	-	-	-	-	-
Lagena sp.	-	-	-	-	-	-
Lenticulina occidentalis	-	-	-	-	-	-
Massilina sp.	-	-	-	-	-	-
Miliammina fusca	-	-	-	-	-	-
Pseudoclavulina gracilis	-	-	-	-	-	-
Pseudononion atlanticum	-	-	-	-	-	-
Quinqueloculina seminula	-	-	-	-	-	-

	I-8		I-9		I-10	
	L	D	L	D	L	D
Reophax nana	-	-	-	-	-	-
" scorpiurus	-	-	-	-	-	-
Rhabdamina sp.	-	-	-	-	-	-
Rosalina floridana	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	-
Spiroplectamina typica	-	-	-	-	-	-
Textularia candeiana	-	-	-	-	-	-
" conica	-	-	-	-	-	-
" cf. earlandi	-	-	-	-	-	-
Trochammina inflata	-	-	-	-	-	-
" macresens	-	-	-	-	-	-
Virgulina loeblichi	-	-	-	-	-	-
Subtotal	5 (1.7)	298 (98.3)	7 (2.3)	293 (97.7)	8 (2.7)	295 (97.3)
Total	303		300		303	

Species	Station: K-1 L	K-1 D	K-2 L	K-2 D	K-3 L	K-3 D
Ammobaculites crassus	-	-	-	1 (0.3)	-	-
" dilatatus	-	-	-	-	-	-
" exiguus	-	-	-	-	-	-
Ammonia beccarii	-	46 (15.3)	-	52 (17.3)	-	25 (6.8)
Ammotium cassis	-	-	-	-	-	-
" fragile	-	-	-	-	-	-
Buccella frigida	-	2 (0.7)	-	2 (0.7)	-	11 (3.0)
" sp. A.	-	-	-	-	-	-
Bulimina sp.	-	-	-	-	-	-
Cancris sagra	-	-	-	-	-	1 (0.3)
Candeina nitida	-	-	-	-	-	1 (0.3)
Cibicides cf. bradyi	-	-	-	1 (0.3)	-	-
" lobatulus	-	-	-	-	-	7 (1.9)
" pseudoungerianus	-	-	-	-	-	1 (0.3)
" sp. A.	-	-	-	-	-	-
" sp. B.	-	-	-	-	-	-
Cyclogyra selseyensis	-	-	-	-	-	1 (0.3)
Dentalina sp.	-	-	-	-	-	1 (0.3)
Elphidium bartletii	-	-	-	-	-	-
" discoidale	-	-	-	-	-	-
" excavatum	-	251 (83.7)	1 (0.3)	238 (79.3)	-	246 (66.8)

Species	Station: K-1 L	K-1 D	K-2 L	K-2 D	K-3 L	K-3 D
Elphidium frigidum	-	-	-	-	-	1 (0.3)
" galvestonense	-	-	-	-	-	1 (0.3)
" incertum	-	-	-	-	-	-
" mexicanum	-	-	-	1 (0.3)	-	1 (0.3)
" poeyanum	-	-	-	-	-	1 (0.3)
" cf. rugulosum	-	-	-	-	-	1 (0.3)
" sp.	-	-	-	-	-	-
Eponides repandus	-	-	-	-	-	1 (0.3)
Globergerina bulloides	-	-	-	-	-	1 (0.3)
Globorotalia truncatulinoides	-	-	-	-	-	-
Guttulina lactea	-	-	-	-	-	-
Hanzawaia concentrica	-	-	-	1 (0.3)	-	41 (11.1)
Haynesina germanica	-	-	-	-	-	-
Lagena sp.	-	-	-	-	-	-
Lenticulina occidentalis	-	-	-	-	-	1 (0.3)
Massilina sp.	-	-	-	-	-	1 (0.3)
Miliammina fusca	-	-	-	-	-	-
Pseudoclavulina gracilis	-	-	-	-	-	-
Pseudononion atlanticum	-	-	-	-	-	11 (2.9)
Quinqueloculina seminula	-	-	-	-	-	-

	K-1		K-2		K-3	
	L	D	L	D	L	D
Reophax nana	-	-	-	-	-	-
" scorpiurus	-	-	-	-	-	-
Rhabdamina sp.	-	-	-	-	-	-
Rosalina floridana	-	1 (0.3)	-	3 (1.0)	-	4 (1.1)
" sp. A.	-	-	-	-	-	-
Spiroplectamina typica	-	-	-	-	-	-
Textularia candeiana	-	-	-	-	-	1 (0.3)
" conica	-	-	-	-	-	8 (2.2)
" cf. earlandi	-	-	-	-	-	-
Trochammina inflata	-	-	-	-	-	-
" macresens	-	-	-	-	-	-
Virgulina loeblichi	-	-	-	-	-	-
Subtotal	0	300 (100)	1 (0.3)	299 (99.7)	0	368 (100)
Total	300		300		368	

Species	Station: L-9 L	L-9 D	L-10 L	L-10 D	L-11 L	L-11 D
Ammobaculites crassus	-	7 (7.4)	1 (0.4)	235 (82.5)	-	146 (55.1)
" dilatatus	-	-	-	-	-	3 (1.1)
" exiguus	-	1 (1.1)	-	-	-	-
Ammonia beccarii	2 (2.1)	15 (15.8)	-	-	5 (1.9)	7 (2.6)
Ammotium cassis	-	-	-	7 (2.5)	-	-
" fragile	-	-	-	10 (3.5)	-	20 (7.5)
Buccella frigida	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	-
Bulimina sp.	-	-	-	-	-	-
Cancris sagra	-	-	-	-	-	-
Candeina nitida	-	-	-	-	-	-
Cibicides cf. bradyi	-	-	-	-	-	-
" lobatulus	-	-	-	-	-	-
" pseudoungerianus	-	-	-	-	-	-
" sp. A.	-	-	-	-	-	-
" sp. B.	-	-	-	-	-	-
Cyclogyra selseyensis	-	-	-	-	-	-
Dentalina sp.	-	-	-	-	-	-
Elphidium bartletii	-	-	-	-	-	-
" discoidale	-	-	-	-	-	-
" excavatum	2 (2.1)	61 (64.2)	1 (0.4)	19 (6.7)	2 (0.8)	82 (30.9)

Species	Station: L-9 L	L-9 D	L-10 L	L-10 D	L-11 L	L-11 D
Elphidium frigidum	-	-	-	-	-	-
" galvestonense	-	-	-	-	-	-
" incertum	-	-	-	-	-	-
" mexicanum	-	-	-	-	-	-
" poeyanum	-	-	-	-	-	-
" cf. rugulosum	-	-	-	-	-	-
" sp.	-	-	-	-	-	-
Eponides repandus	-	-	-	-	-	-
Globergerina bulloides	-	-	-	-	-	-
Globorotalia truncatulinoides	-	-	-	-	-	-
Guttulina lactea	-	-	-	-	-	-
Hanzawaia concentrica	-	2 (2.1)	-	-	-	-
Haynesina germanica	-	-	-	1 (0.4)	-	-
Lagena sp.	-	-	-	-	-	-
Lenticulina occidentalis	-	-	-	-	-	-
Massilina sp.	-	-	-	-	-	-
Miliammina fusca	-	-	-	1 (0.4)	-	-
Pseudoclavulina gracilis	-	-	-	-	-	2 (0.8)
Pseudononion atlanticum	-	-	-	-	-	-
Quinqueloculina seminula	-	-	-	-	-	-

	L-9		L-10		L-11	
	L	D	L	D	L	D
Reophax nana	-	-	-	1 (0.4)	-	-
" scorpiurus	-	2 (2.1)	-	-	-	-
Rhabdamina sp.	-	-	-	1	-	-
Rosalina floridana	-	-	-	6	-	-
" sp. A.	-	-	-	-	-	-
Spiroplectamina typica	-	-	-	1	-	-
Textularia candeiana	-	-	-	-	-	-
" conica	-	-	-	-	-	-
" cf. earlandi	-	-	-	1	-	-
Trochammina inflata	-	3 (3.2)	-	-	-	4 (1.5)
" macresens	-	-	-	-	-	1 (0.4)
Virgulina loeblichi	-	-	-	-	-	-
Subtotal	4 (4.2)	91 (95.8)	2 (0.7)	283 (99.3)	7 (2.6)	265 (97.4)
Total	95		285		272	

	A-8	A-9	A-10	C-8	C-9	C-10	E-8	E-9	E-10	G-8	G-9	G-10	I-8	I-9	I-10	K-1	K-2	K-3	L-9	L-10	L-11
Aurilia conradi	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-
" floridana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bensonocythere whitei	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cushmanidea echolsae	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
" seminuda	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" sp. B.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cytheretta edwardsii	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cytheromorpha newportensis	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2
Cytherura forulata	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
" howei	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" reticulata	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" sp. B.	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eucythere declivis	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haplocytheridea setipunctata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hulingsina rugipustulosa	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" sp. A.	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" sp. B.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" sp. C.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocythere nikraveshae	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Loxoconcha matagordensis	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neolophocythere subquadrata	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1
Paradoxostoma sp. F.	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-
Propontocypris edwardsi	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proteoconcha gigantica	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Protocytheretta sp. A.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Puriana floridana	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Sahnia subulata	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" sp. A.	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triginglymus arenicola	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2

Distribution of the Ostracoda

were not done for the ostracodes because of the small numbers of the latter organisms encountered in the samples.

Because the analyses of the meiofauna are based only one traverse taken during August, 1982 from widely spaced stations, observations and conclusions should be viewed as tentative.

Species Dominance

Percent histograms of the more commonly occurring live and total foraminiferal species averaged for each station are shown in Figure 2. The species Elphidium excavatum, both live and total, dominates the foraminiferal populations at stations A, C, E, G, and K. The percentage of living specimens at these stations is not large, ranging from 0.1 to 9.2 percent of the total population. However, in terms of percent of living species encountered at each station E. excavatum ranges from 83 to 100 percent. At Station I Ammonia beccarii is the dominant species with the living population representing 2.1 percent and the live plus dead representing 58.9 percent of the total population, respectively. At this same station, E. excavatum has a living representation of 0.1 percent while live plus dead comprises 40.7 percent of the total population, respectively. The species Ammonia beccarii is found at all stations sampled, but not in so high a proportion of the total population as at station I. The total population at station L is dominated by Ammobaculites crassus. While this agglutinated species comprises 59.6 percent of the total population at this station, the living specimens make up only 0.4 percent of the total population. Another agllutinated species Ammotium fragile is found here and comprises about 4 percent of the total population. Of the calcareous foraminifers at station L, E. excavatum has a living representation of 0.7 percent and a live plus

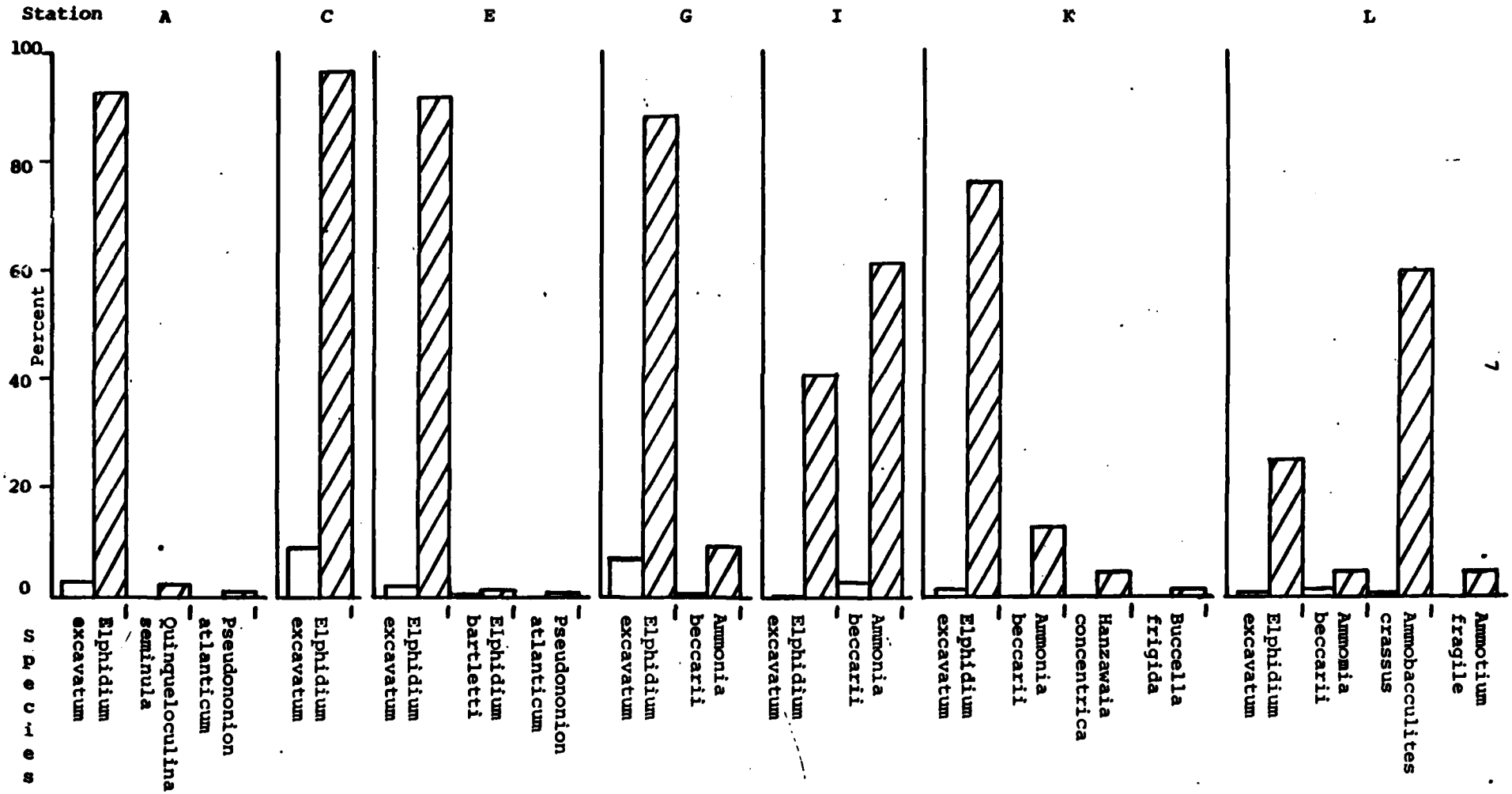

Figure 2 - Average species dominance by percent for live and total populations of each station sampled. Live population is denoted by an open bar. Total population is denoted by a hachure bar.

dead representation of 24.8 percent of the total population, respectively. A. beccarii has 1.0 percent living and 3.3 percent live plus dead of the total population.

Other stations have similarly small percentages of other foraminiferal species. Pseudononion atlanticum and Quinqueloculina seminula, both known to live and be common in waters of normal oceanic salinity, surprisingly did not have living representatives at station A and had empty tests comprising only 1.3 and 2.2 percent of the total population respectively.

As mentioned previously, any ostracodes encountered during the random selection of 300 foraminifer specimens were picked and identified. Although 29 different species of ostracodes were found, the entire population is very small ranging from no specimens at station I to 14 specimens comprising nine different species at station A. No species at any station appeared to dominate, but with such a small population obtained from the random samples, this may be misleading.

Species Diversity

Because sampling occurred only during the month of August for all stations, the Shannon-Weiner and the equitability functions were not used in this preliminary assessment of diversity. In general, species diversity should increase offshore. However, this trend was not very apparent in the present. Species diversity of the live population (Figure 3) is low with a maximum of three living species in sample E-8 and an average of about two species for most other samples. Species diversity of the total population by sample and station is shown in Figure 4 and by station in Figure 5. Of particular note is the relatively high species diversity for station K. An examination of Table 1 shows that much of this diversity is due to the

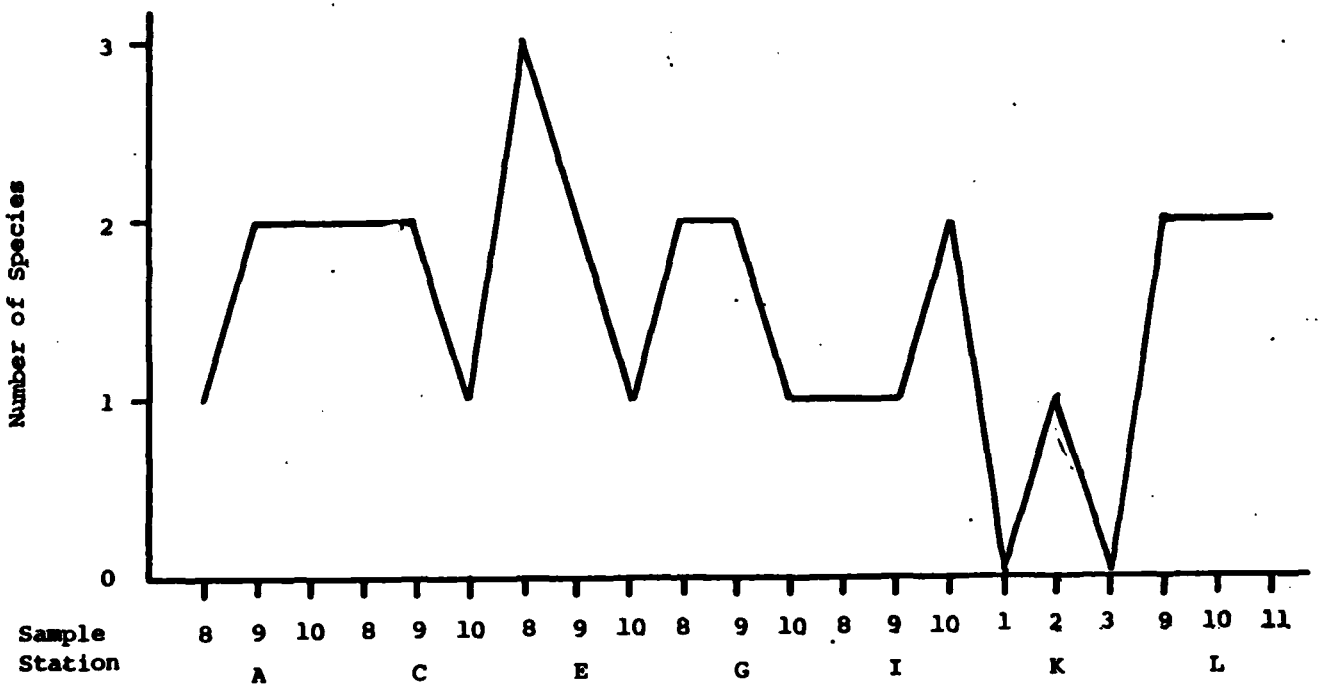

Figure 3 - Species diversity of the live population by sample and station.

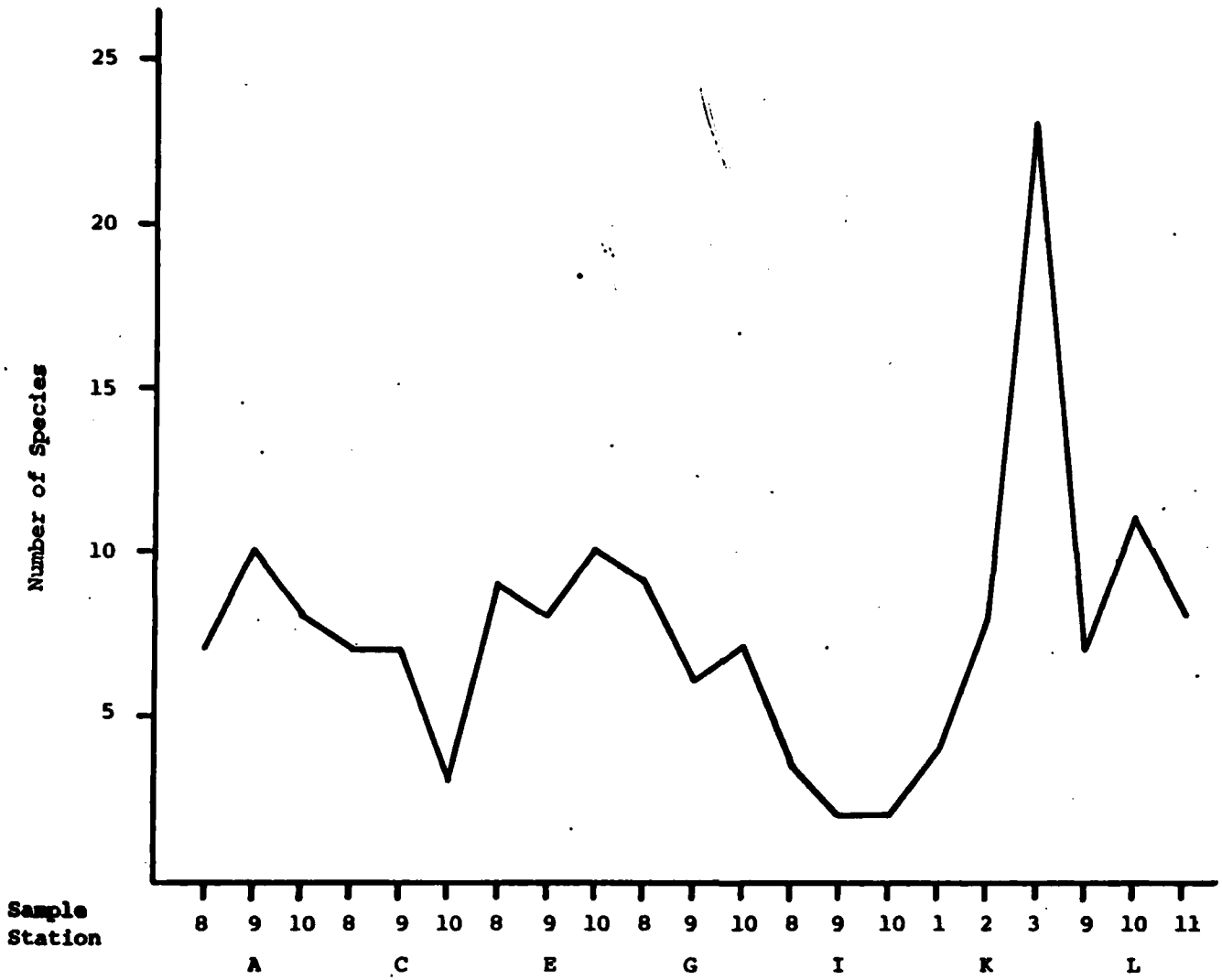

Figure 4 - Species diversity of total population by sample and station.

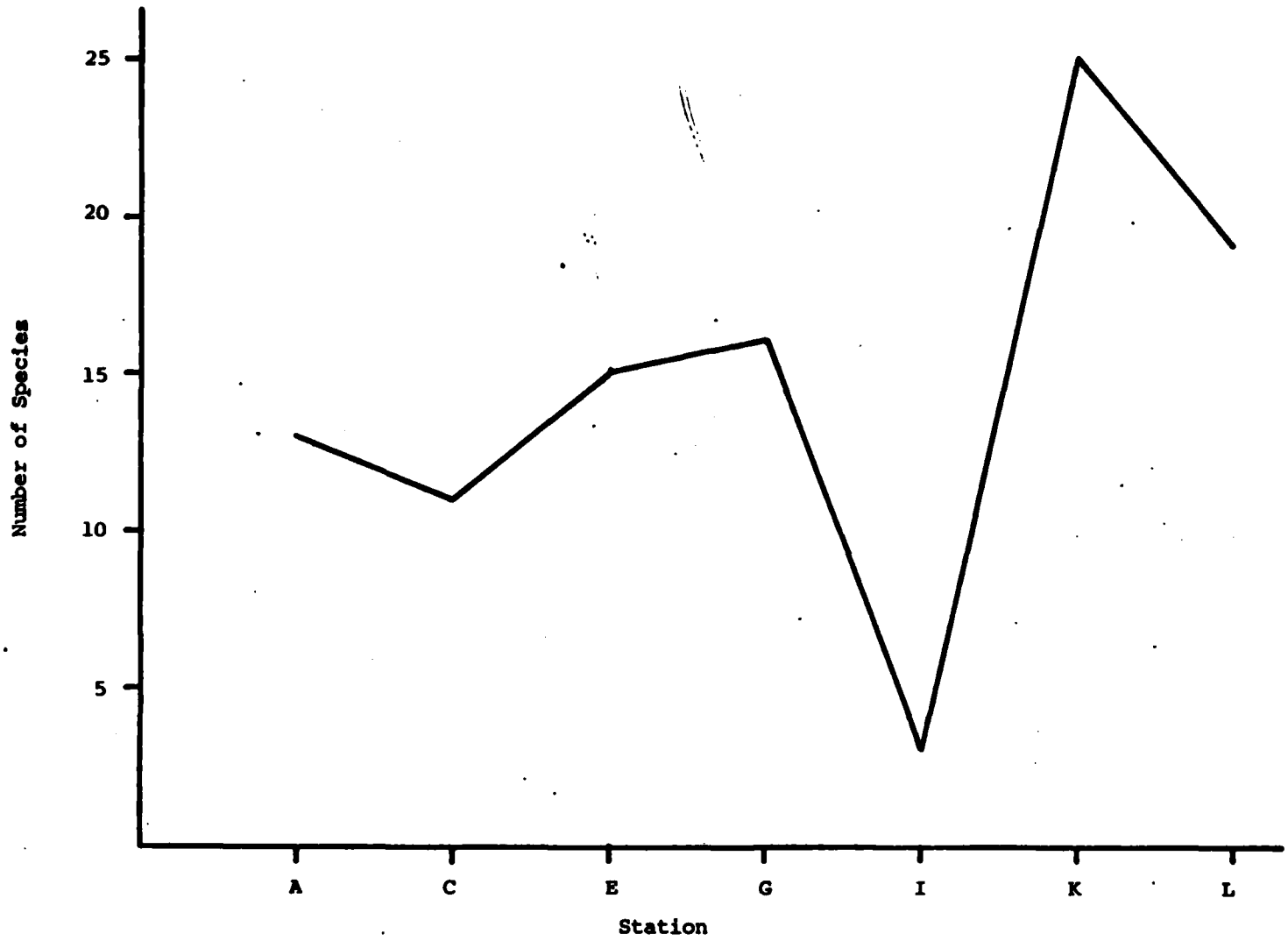

Figure 5 - Species diversity of total population by station.

presence in the total population of several species such as Eponides repondus, Hanzawaia concentrica, Lenticulina occidentalis, Massilina sp., Cancris sagra, and Candeina nitida which are very characteristic of continental shelf to slope environments. The reason for their occurrence in what should be an estuarine environment is not clear. Compounding this problem is the presence of a stained specimen of Hanzawaia concentrica found during a rapid re-examination of the samples from station K. Station L also has high species diversity in its total population which is due to an increase in low salinity agglutinated foraminifers mixed with more higher salinity calcareous species. In comparison, station I, which is not too distant from station K, has a very low species diversity consisting primarily of A. beccarii and E. excavatum. Inspection of Table 1 and Figure 2 shows that it is this station that has an anomalously high occurrence of A. beccarii with respect to the other stations.

Equally interesting is the relatively low diversity at stations A and C which should have relatively high diversity patterns because of their proximity to oceanic conditions.

Abundance Trends

Figure 6 is a Bandygram of the major groups of foraminifers encountered and their trend along the traverse. In general, the trend is similar to that found by Ellison and Nichols (1976) with Elphidium and other calcareous forms decreasing in number and variety as the James River is approached. There are some significant differences, however, with the trends found by Ellison and Nichols (1976) and that of this current survey. These are the lack of arenaceous species and the lack of a larger amount of calcareous species, other than Elphidium at the more seaward stations A and C; the

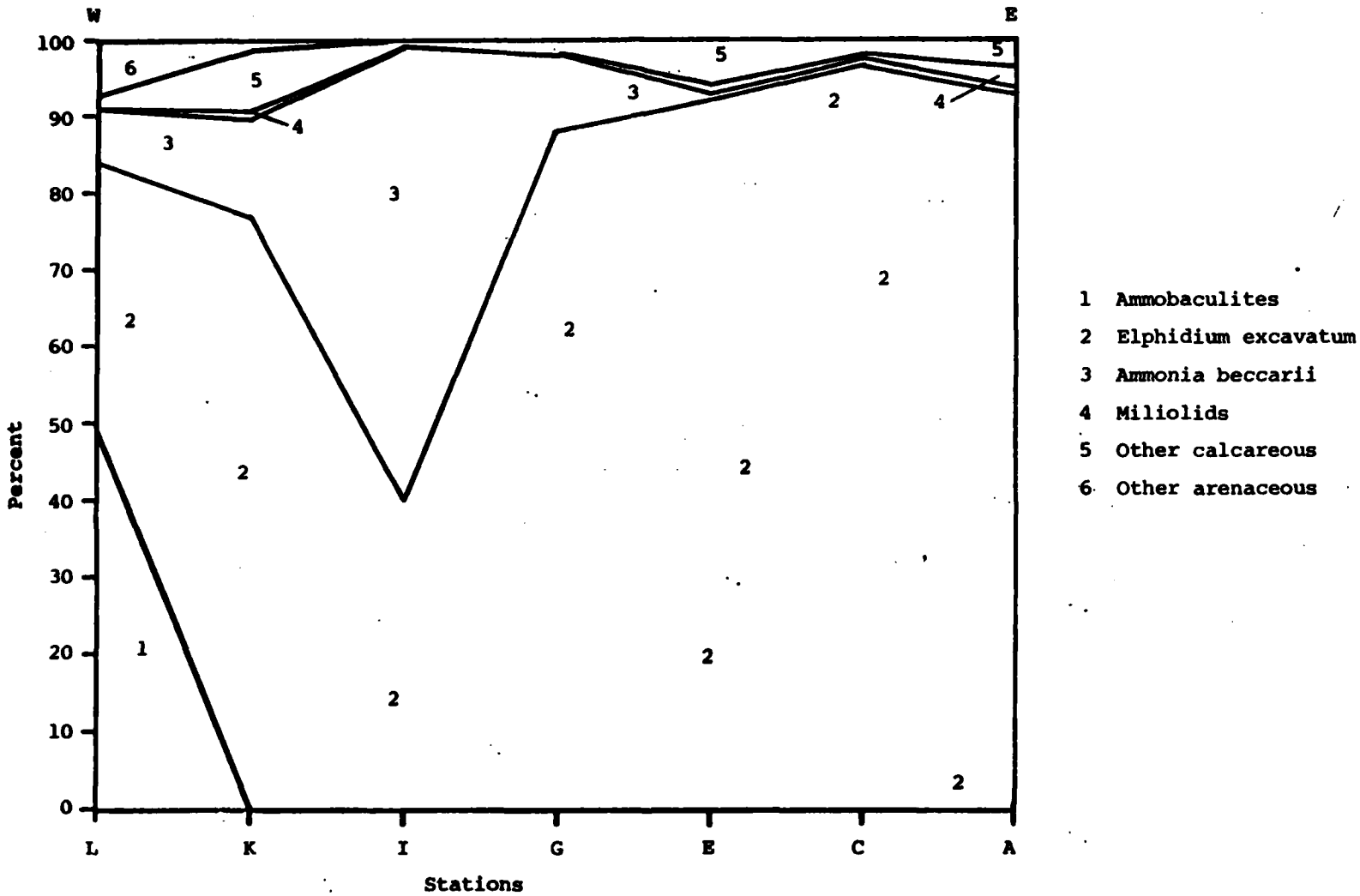

Figure 6 - Bandygram of sampled stations showing percent variation in species composition along the traverse.

presence of Ammonia beccarii as a dominant species, and the unusually high percentage of other calcareous species, both of which occur in an estuary at stations I and K, respectively.

Foraminiferal Density

Table 3 shows the estimated density and biomass of the foraminiferal population, both live and total, for each station as well as their live/dead ratios. Total population densities per 200 ml for stations I, K, and L are considerably below the average of 5,000 specimens per 20 ml reported by Ellison and Nichols (1970, 1976) for the middle portions of the James and Rappahannock estuaries. These authors also report total populations in the Chesapeake Bay ranging from zero to over 15,000 specimens per 20 ml with an average of 600 per ml. By comparison, the total populations at stations E, G, and C exceed 30,000 specimens per 200 ml. Because of the small size of individuals, biomass cannot be measured directly. Consequently, the approach of Murray (1968) was used. Once total volume is calculated, the protoplasmic density of 1g/ml (Beams and King, 1941) can be employed to obtain biomass.

Caution should be exercised in comparing density figures from Ellison and Nichols (1976) with that of this report because the above mentioned authors are using averaged densities for large areas such as the James and Rappahannock River estuaries and Chesapeake Bay where data points range from many hundreds for the estuaries to few for Chesapeake Bay.

Table 3

Estimated densities and biomass of the live and dead populations of foraminifers and their live/dead ratios for each station.

Station	Total Est. No. per 200 ml	Live Est. No. per 200 ml	Live/Dead Ratio	Est. Live Biomass	Est. Total Biomass
A	8,468	237	.03	.06 g/200 ml	2.17 g/200 ml
C	30,285	2,770	.40	.71	7.77
E	35,814	856	.03	.21	9.18
G	30,367	1,437	.07	.36	7.79
I	8,327	190	.02	.05	2.13
K	2,039	28	.001	.007	0.52
L	1,077	26	.02	.006	0.27

Comparison With Other Studies

Although this report represents analyses of samples taken during one cruise only, some very general comparisons to studies involving sampling over a much longer period of time can be made.

The Ammobaculites fauna found at station L inhabits the river-influenced, low-salinity reaches of tributary estuaries where the Ammobaculites fauna is found on the shoals and the Elphidium fauna is found in the higher salinity, deeper, medial channels (Ellison, 1972, 1978; Ellison and Nichols, 1970, 1975, 1976; Ellison, Nichols and Hughes, 1965; Nichols and Ellison, 1967; Nichols and Norton, 1969). Ellison and Nichols (1965) place the boundary between these two faunas where the number of Elphidium is equal to the number of Ammobaculites. Nichols and Norton (1968) report a total population density of over 100,000 specimens per 20 ml from a sample in the James estuary. Ellison and Nichols (1976) report an average of about 5,000 specimens from the middle stretches of tributary estuaries. Ellison and Nichols (1965) report a total population of Ammobaculites ranging from 36 to 2,235 specimens in 20 ml samples occurring about 17 miles upstream from the mouth of the Rappahannock River. Nichols and Norton (1969) in analyzing the foraminifera of the James River estuary found that 68 percent of the total population at their sample station 146 consisted of Ammobaculites. This compares favorably in this report to what was found at Station L which is located in the same general proximity. However, at this same station Nichols and Norton (1969) report only 8 percent of the total population to be composed of Elphidium, while the current study has this species comprising about 25 percent of the total population.

Station K of this report is near Nichols and Norton's (1969) locality 114, but they do not report the anomalous occurrence of many shelf and slope

foraminiferal species and list Elphidium as being 65 percent of the total population whereas this study has found Elphidium to comprise 76 percent of the total population. Except for their station 114, Nichols and Norton (1969) did not sample the Elizabeth River estuary. Consequently, the high and anomalous occurrence of Ammonia beccarii previously mentioned has not been reported.

Comparison to other studies in the Chesapeake Bay itself is not possible because of the total lack of any published reports on foraminiferal distribution, a fact that Culver and Buzas (1980) commented upon in their very comprehensive analyses of Recent distributions of Atlantic Coast benthic foraminifera.

Ellison and Nichols (1976) published a generalized Bandygram that extends 180 km from near the head of the James River estuary into the Atlantic Ocean shelf with the Chesapeake Bay representing about 12 percent of this diagram. They used averaged foraminiferal densities for large areas such as the James River, Chesapeake Bay, and Atlantic Ocean shelf. These densities represent averages of published data points ranging from many hundreds in the river estuaries to few for the Chesapeake Bay.

In very general terms the Bandygram of this report is comparable to that of Ellison and Nichols (1976) except for: 1) the lack of arenaceous foraminifers and the small percentage of calcareous foraminifers, excluding Elphidium at stations A and C; 2) the unusually high percentage of Ammonia beccarii at station I; 3) and the very anomalous occurrence and high percentage of other calcareous foraminifers at station K.

One of the most abundant constituents of the permanent meiofauna are foraminifera (Olsson and Eriksson, 1974). Several researchers (Lynts, 1971; Lankford and Phleger, 1973; Buzas et al. 1977) have shown that physio-chemical

variables often do not account for observed foraminiferal density patterns. Buzas et al. (1977) has suggested that predation is a means of regulating foraminiferal densities. Buzas (1977, 1978) conducted a two-year caging experiment on foraminifera in the Indian River estuary, Florida, and found that predation is important in regulating foraminiferal densities. He found that a variety of deposit feeders including species of crabs, shrimp, gastropods, pelecypods and a variety of polycheates as well as a small fish (Gobionellus boleosoma) commonly ingest foraminifera. Buzas (1978) found that, contrary to previous ideas (Mare, 1942; Thorson, 1966), foraminifera are very important contributors to the standing crop of the benthos. The difference in biomass over the two year period between inside and outside the cages ranged from 3 to 12 g/m^2 and indicate the importance of foraminifera as a food source (Buzas, 1978).

Biomass has not previously been determined for any part of the Chesapeake Bay system. Consequently, the estimated biomass shown in Table 3 of this study has no comparative information for this area. Depending upon rates of sedimentation at various stations, the estimated total population in 200 ml obtained from the top few centimeters of a dredge sample could represent significant contributions of biomass from a large foraminiferal standing crop to the food source of the area.

References

Beams, H.W. and R.L. King. 1941. Some physical properties of the protozoa. In Protozoa in Biologic Research, G.N. Balkins, and F.M. Summers, eds., Hofner, New York.

Buzas, M.A. 1977. Vertical distribution of foraminifera in the Indian River, Florida. J. Foram. Res., 7, 234-237.

_____. 1978. Foraminifera as prey for benthic deposit feeders: results of predator exclusion experiments. J. Mar. Res., 36, 617-625.

Culver, S.J. and M.A. Buzas. 1980. Distribution of Recent benthic Foraminifera off the North American Atlantic Coast. Smithsonian Contrib. Mar. Sci., (6), 1-512.

Ellison, R.L. 1972. Ammobaculites, foraminiferal proprietor of the Chesapeake Bay estuaries. In Environmental Framework of Coastal Plain Estuaries, B.W. Nelson, ed., Geol. Soc. Amer. Memoir, 133, 247-262.

_____. 1978. Benthic ecological studies: Foraminifera. Virginia Inst. Mar. Sci., Contract AA550-CT6-62, Bureau of Land Managements, 1-33.

_____ and M.M. Nichols. 1970. Estuarine Foraminifera from the Rappahannock River, Virginia. Contrib. Cushman Found. Foram. Res., 21(1), 1-17.

_____. 1975. Significance of foraminiferal communities in the Chesapeake region (abs.). Abstracts, Benthonics '75, Dalhousie Univ., Halifax, Nova Scotia, 13.

_____. 1976. Modern and Holocene Foraminifera in the Chesapeake Bay region. In 1st International Symposium on Benthonic Foraminifera of Continental Margins, C.T. Schafer and B. Pelletier, eds., Maritime Sediments, Special Publication 1, 131-151.

_____, _____ and J. Hughes. 1965. Distribution of Recent Foraminifera in the Rappahannock River estuary. Virginia Inst. Mar. Sci., Spec. Sci. Rept., 47, 1-35.

Lankford, R.R. and F.B. Phleger. 1973. Foraminifera from the near-shore turbulent zone, western North America. J. Foram. Res., 3, 101-132.

Lynts, G.W. 1971. Distribution and model studies on Foraminifera living in Buttonwood Sound, Florida Bay. In A Symposium on Recent South Florida Foraminifera. Memoir 1. J.I. Jones and W.D. Block, eds., Miami Geol. Soc., Miami, 245pp.

Mare, M.F. 1942. A study of a marine benthic community with special reference to the micro-organisms. J. Mar. Biol. Assoc. U.K., 25, 527-554.

Murray, J.W. 1968. Living Foraminifera of lagoons and estuaries. Micropaleont., 14, 435-455.

Olsson, I. and B. Eriksson. 1974. Horizontal distribution of meiofauna within a small area, with special reference to Foraminifera. Zoon, 2, 67-84.

Nichols, M.M. and R.L. Ellison. 1967. Sedimentary patterns of microfauna in a coastal plain estuary. In Estuaries. G.H. Lauff, ed., Amer. Assoc. Adv. Sci., publ. 83, 283-288.

_____ and W. Norton. 1969. Foraminiferal populations in a coastal plain estuary. Palaeogeography, Palaeoclimatology, Palaeoecology, 6,(3), 197-213.

Thorson, G. 1966. Some factors influencing the recruitment and establishment of marine benthic communities. Neth. J. Sea Res., 3, 267-293.

Walton, W.R. 1952. Techniques for recognition of living foraminifera. Contrib. Cushman Found. Foram. Res., 3, 56-60.

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