ECOLOGICAL STUDIES ON BENTHIC AND PLANKTONIC ASSEMBLAGES IN LOWER DELAWARE BAY

Les Watling and Don Maurer, Editors

With contributions by
Dan Bottom, Peter Kinner, Rose Lambert,
Wayne Leathem, Ann Pembroke, Les Watling, and Chris Wethe

CMS-RANN-3-76

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RESEARCH ON THE EFFECTS OF CRUDE OIL TRANSFER AND UPSTREAM REFINERIES ON DELAWARE BAY

College of Marine Studies
University of Delaware
Newark, Delaware 19711

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College of Marine Studies
University of Delaware
Lewes, Delaware 19958
and
Newark, Delaware
19711

This research project was part of a program designed to delineate the effects on Delaware Bay of crude oil transfer and upstream refineries. Managed by the University of Delaware's College of Marine Studies, the 15-month program (1 March '74 - 31 May '75) was conducted under a $300,800 grant from the National Science Foundation's Research Applied to National Needs (RANN) Program, incorporating socio-economic assessments, engineering and oceanographic studies, as well as biological/ecological research. The research was conducted by the College of Marine Studies, the Departments of Civil Engineering, Biology and Geology, and the College of Business and Economics. Further information is available from the Program Manager, Dr. Robert Biggs, Assistant Dean, College of Marine Studies, University of Delaware, Newark, Delaware 19711, (302) 738-2842.

Already published under this program to date are: CMS-RANN-1-75: <u>Sea Surface Drift Currents</u>, by Jin Wu; CMS-RANN-2-75: <u>Sport Fishing in Western Delaware Bay: Assessment of Critical Areas</u>, by Ronal W. Smith; CMS-RANN-3-75: <u>Saturated Hydrocarbon Material in Sediments of the Delaware Estuary as Determined by Gas Chromatographic Analyses</u>, by John F. Wehmiller and Margaret Lethen; and CMS-RANN-1-76: <u>Computer Modeling of Oil Drift and Spreading in Delaware Bay</u>, by Hsiang Wang, John R. Campbell, and John D. Ditmars. Additional reports are in press.

PREFACE

The impact of human activities in the Delaware Bay region has increased dramatically over the past 20 years. These activities are often incompatible and compete for available resources. They range from oil lightering, power plant siting, and sanitation disposal on one hand to fishing and recreation on the other hand.

Confronted by these large scale and complex problems, the College of Marine Studies planned a baseline study in 1970 and in 1971 certain subprojects of the study were submitted to the National Science Foundation Research Applied to National Needs (NSF/RANN) program. During the summers of 1972 and 1973 a study of the benthic invertebrate assemblages of Delaware Bay was funded by NSF/RANN. After this survey it was decided that the oil lightering area in lower Delaware Bay should receive special attention and an intensive biological survey of this area in 1974 and 1975 was conducted with Don Maurer as the principal investigator. The present report contains the results of these two studies.

ABSTRACT

This study was undertaken to obtain baseline ecological data in Delaware Bay. During the summers of 1972 and 1973 the first bay-wide quantitative survey of benthic organisms was conducted. The survey consisted of 207 samples distributed over 26 transects from the bay mouth to Woodland Beach, Delaware. Based on the results of the bay-wide survey reported herein, it was decided to conduct an intensive study in the oil lightering area in lower Delaware Bay (1974-1975). The intensive study included quantitative monthly investigations of phytoplankton and zooplankton together with quarterly investigations of the benthos. Two 12-hour plankton studies were also conducted. In addition to the quantitative benthic studies, there were extensive samples with dredge hauls. Data from dredge hauls and grabs were compared to determine whether a useful method of community analysis could be developed based on dredge data alone. It was concluded that such a method was feasible but that it required additional refinement. Some of the survey data were never reported for Delaware Bay prior to this study.

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612		2007 = Hydractinia echinata
		8018 = Electra monostachys
614		Nassarius trivittatus for Nassarius obsoletus
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618		Ibid
		Scoloplos for Haploscoloplos
620		Nemertea sp. not underlined
622		Scoloplos for Haploscoloplos
624		Ibid
		Nemertea sp. not underlined
626		8023 = Schizoporella errata
		8002 = Alcyonidium polyoum
		7037 = Ampelisca verrilli
		8012 = Membranipora tenuis
627		8015 = Conopeum truitti
		1003 = Microciona prolifera
		8014 = Conopeum tenuissimum
		8008 = Bowerbankia gracilis
		8009 = Triticella elongata
		8018 = Electra monostachys
		1004 = Halichondria bowerbanki
628		Scoloplos for Haploscoloplos

ERRATA

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xi	5	mid-June for mid-July
xii	20	Pyramimonas sp. A for Pyramimonas sp.
xv	23	722/m^2 for 200/m^2
xvi	2	1972 and 1973
6	8	March for April
7	5	27.5 µg-at/ℓ for Station 3 value
13	1	temperature (°C) for temperature
14	1	salinity (o/oo) for salinity
63	16	than for that
66	15	December for Decmeber
66	19	Delete and April
73		Add Fager, E.W., 1972. Diversity: A Sampling Study. Amer. Nat. 106: 239-310. McCarthy, J.J., W.R. Taylor, and M.E. Loftus, 1974. Significance of nanoplankton in the Chesapeake Bay estuary and problems associated with the measurement of nanoplankton productivity. Mar. Biol. 24: 7-16. Delete Marshall, 1967
74		Pomeroy, L., H.H. Haskin and R.A. Ragotzkie, 1956 for Pomeroy, 1956. Delete Patten, et al., 1963 and Pratt, 1959
106	4 & 5	Delete listed in Table II-1
108		Add months to dates on Figure II-2 per Figure II-1
109		March 19 for March 18; station legends same as Figure II-2
123	9	Wilson (1932) for Wilson (1922)
126	29	February 20, 1975 and April 14 for February 20, 1974 and April 17
127	2	April 14 for April 17
127	21	Figure III-6 for Tables III-5 and III-6
127	23	April 14 for April 17
129	18	Deevey, 1956; for Deevey, 1948;
130	19-20	Deevey, 1956; for Deevey, 1948;
132	6	Jacobs, for Jacob
133	21	Sage and Herman, for Herman and Sage,
135		Conover, R.J., 1956, not 1958
136		Add Heinle, D.R., 1966. Production of a calanoid copepod, Acartia tonsa in the Patuxent River Estuary. Ches. Sci. 7: 59-74.
137		Delete Odum, 1971
137		Add Wilson, C.B., 1932. Copepods of the Woods Hole Region, Massachusetts. U.S. Nat. Mus. Bull. 158: 1-635.
148		Figure III-10, Add (Station 2). Figure III-11, Add (Station 2).
166	4	through for and

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173	28	1959 for 1958
	29	Ferguson-Wood for Wood and Ferguson
177	7	would be for would not be
179		Delete Conover, 1956
180	7	Should be Cupp, E.E.
183		Delete Riley and Bumpus, 1946
	8	1973 for 1970
236	25	72.2 for 20 and 722 for 200
	26	14 for ten
240		Scoloplos for Haploscoloplos
		Assemblage G (3 stations) for Assemblage F (3 stations)
243	17	Stephenson, et al., 1972
	21	Ibid
247		Add Stephenson, W., W.T. Williams, and S.D. Cook, 1972. Computer Analyses of Petersen's Original Data on Bottom Communities. Eco. Mon. 42: 387-415.
250		Add (Verrill, 1892) to Micrura leidyi
251		Add (Verrill, 1873) to Cirriformia sp. cf. C. grandis
		? Chaetozone sp. for ? Chaetozone
		Scoloplos for Haploscoloplos
253		Doridella for Dorodella
255		Add Rathbun, 1926 to Callianassa sp. cf. C. atlantica

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258	A-2	Insert	23-4 for none	1040	4
	C-1	Insert	4-7	1160	7
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	C-3	Add	11-6	1100	4
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259	last line	722 for 200
260		Scoloplos for Haploscoloplos
297	7	August 1975 for August 1974
298	6	95.46% for 96.65%
299	18	August 1974 for August 1975
310		Insert Phylum Platyhelminthes immediately before Flatworm A
311		Scoloplos for Haploscoloplos
313		Doridella for Dorodella
314		Insert Order Thoracia immediately before Balanus
315		Add Rathbun, 1926 to Callianassa sp. cf. C. atlantica
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319		Ibid
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337		Last 4 entries and totals for Station 10, February 1975 and May 1975 repeated.

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340		Xanthid sp. not underlined
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345		Dendrogram showing relationship of May sediment samples. Delete from quarterly stations.
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362	24	Stephenson, et al., 1974
364	4	(McCloskey, 1970) for (1971)
368	8	5, 18, 19, 13, and 17 for 5, 18, 13, and 17
371	27	2, 9, and 4 for 2, 3, and 4
381	29	McCloskey's (1970) for (1971)
385	17	Watling, et al., 1974 for 1973
386		Add Folk, R.L., 1968. Petrology of Sedimentary Rocks. Hemphill's, Austin, Texas, 170 pp.
387		Add Maurer, D., R. Biggs, W. Leathem, P. Kinner, W. Treasure, M. Otley, L. Watling, and V. Klemas, 1974. Effect of Spoil Disposal on Benthic Communities near the Mouth of Delaware Bay. Report to Delaware River and Bay Authority, University of Delaware, 200 pp.
388		Stephenson, W., W.T. Williams, and S.D. Cook, 1974. The benthic fauna of soft bottoms: Southern Moreton Bay. Mem. Qd. Mus. 17: 73-123.
		Add Watling, L., W. Leathem, P. Kinner, C. Wethe, and D. Maurer, 1974. Evaluation of sludge dumping off Delaware Bay. Mar. Poll. Bull. 5:39-42.
390 & 391		Pages out of Sequence
394		Callianassa atlantica Rathbun, 1926 for Callianassa atlantica (Smith, 1874)
419	3	S403 for S408
437		Xanthidae not underlined
438		Ibid
467		(Allen, 1965) cited on page 244 of report
471		(Folk, 1968) cited on page 244 of report
540	20	Ensis for Solen
	22	Arthropods for anthropods
552		Doridella for Dorodella
		Scoloplos for Haploscoloplos
554		Ibid
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		Xanthid sp. not underlined
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562		Scoloplos for Haploscoloplos
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577		Xanthid sp. not underlined
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INTRODUCTION

This research was undertaken to obtain biological baseline data at the oil lightering site in lower Delaware Bay off Big Stone Beach, Delaware. Specific objectives included: 1) monthly determination of phytoplankton populations, 2) monthly determination of zooplankton populations, 3) seasonal determination of benthic populations. A subproject of the benthic studies was concerned with developing a pollution ecology tool to assess benthic community composition based on qualitative dredge data. Other aspects of the biota were not included because they have been adequately identified (finfish), they were relatively unimportant (attached algae), and they were beyond the resources of this study (microbiology).

Research on finfish in the lower bay has been primarily conducted by State agencies and Dr. Frank Daiber of the University of Delaware and his students over a period of almost 20 years. A comprehensive account of monthly and seasonal distribution of finfish in the lower bay including the lightering site was available prior to the start of the present research.

In general, attached algae are not abundant or widely distributed in Delaware Bay. This is not the case in smaller bays in New Jersey and Delaware. Regardless, the most complete coverage of algae for the area was described by Dr. Jacques Zaneveld, Old Dominion University. Research on the taxonomy and ecology of edaphic diatoms in surrounding marshes has been conducted by several workers. Exclusive of some preliminary taxonomic work in the late twenties and unpublished lists of species, there has been little research on phytoplankton in Delaware Bay and nothing on primary production.

Data on zooplankton are slightly more abundant than data on phytoplankton. Exclusive of the upper estuary, there has only been one bay-wide zooplankton study and a detailed oyster larvae study off Cape May shore conducted by Dr. H. Haskin, Rutgers

University and his students. Several other studies primarily performed in the ocean off Delaware, did extend into Delaware Bay.

Benthic organisms have been the subject of considerable local interest for many years. Rutgers University Oyster Laboratory has conducted research on shellfish and associated benthos since the turn of the century and the University of Delaware since 1950. Although there have been many ecological studies dealing with various taxa, few studies are available on faunal assemblages. Recent work by Rutgers and Delaware has changed this direction.

Report Format

The report begins with a section containing a summary and conclusion for each chapter. This section is followed by seven chapters: I) Hydrography, II) Phytoplankton, III) Zooplankton, IV) Water Column Synthesis, V) Delaware Bay Benthic Invertebrate Assemblages, VI) Seasonal Changes of Benthic Invertebrate Assemblages in the Lightering Area, VII) Methodological Benthic Invertebrate Studies. Each chapter is complete in that it includes the purpose of the particular investigation, literature review, results with figures and tables, discussion and synthesis, and references cited. Chapter V deserves additional explanation. This chapter deals with benthic invertebrate assemblages throughout Delaware Bay. The bay-wide survey provides a valuable background to compare with the intensive survey conducted at the lightering area.

In turn, the seven chapters are followed by Appendix I which contains the documentation of a computer program for cluster analysis. Cluster analysis was used extensively throughout the study. Although our use of cluster analysis is not unique, the program was included to make it easy for others to use it as an analytical tool. Finally Appendix II with tables and figures was presented. Although each chapter can be read independently of

Appendix II, it contains all the data obtained in the study. We consider this important because it permits other workers to check our results and provides a permanent record of data which normally cannot be accommodated in journals. Since many of these studies were conducted for the first time here, the raw data are valuable for comparison with other areas and in years to come, regardless of our analysis and interpretation.

ACKNOWLEDGMENTS

A study of this magnitude must, of necessity, utilize the services and aid of many persons. We are especially grateful to the following for their particular contributions: Mr. Jeff Tinsman, field sampling; Capt. Tom White, ship operations; Ms. Debby Burbage and Ms. Susan Wilkens, sample processing and data synthesis; Ms. Sheryl Bottom, Ms. Peggy Brittingham, Ms. Barbara Barrentine, and Ms. Marie Bunker, chemical analysis; Ms. Margaret Huntzinger, Ms. Sandra Irving, and Ms. Marlene Justice, sediment analyses; Ms. Liz Gontarz, Mr. Henry Lind, and Mr. John Gorton, computer programming and data processing; Dr. Kent Mountford; Benedict Estuarine Laboratory, phytoplankton studies; Ms. Jan Sick, Ms. Lorraine Turner, and Ms. Lois Butler, illustrations; Ms. April Morris, manuscript typing and retyping. We would also like to extend our appreciation to the many persons who spent long hours picking organisms from the sediment in our samples.

This report has benefited from the constructive criticism of the following individuals, each of whom read one or more chapters: Dr. Kent Mountford, Benedict Estuarine Laboratory of the Philadelphia Academy of Natural Sciences; Dr. David Flemer, U.S. Fish and Wildlife Service, Washington, D.C.; Dr. Shirley Van Valkenburg, University of Maryland; Dr. Jack Pearce, National Marine Fisheries Service, Sandy Hook Laboratory; Dr. Donald Boesch, Virginia Institute of Marine Science. The authors and editors of this report, however, take full responsibility for its contents.

We also extend our appreciation to Dr. Richard Kolf, the initial NSF/RANN Program Monitor, for his aid in setting up this project, and to Dr. Robert Biggs who supported our efforts and facilitated our work at every level.

SUMMARY AND CONCLUSIONS

Chapter I: Hydrography

1. Seasonal changes in physical data were typical for an estuary from this region.

2. Surface temperature ranged from 3.5°C in February to 26.0°C in early August. Bottom temperatures were slightly lower (-1.0 to 2.0°C) than surface except for December and July.

3. Based on bottom water samples Delaware Bay can be divided into three salinity zones: a) upper polyhaline zone (25-30 o/oo), located in the deeper portions of the lower central bay, b) lower polyhaline zone (18-25 o/oo), extending up the lower part of the bay to a line connecting Egg Island Point to Leipsic River, c) mesohaline zone (5-18 o/oo), extending along the shallow areas in the Maurice River Cove and in the upper reaches of the bay. Salinity values at the lightering area were always in the polyhaline zone (18-30 o/oo).

4. Dissolved oxygen values were lower in the summer (3.9 ml/l) than in the winter (8.4 ml/l) and the water was only fully saturated from late winter to early spring.

5. Silicate concentrations ranged from near zero after the spring diatom bloom to a September peak of 32 μg-at/l. At the deepest station, surface waters contained higher silicate concentrations than the bottom waters, whereas silicate concentrations in surface and bottom waters of shallow stations were generally the same.

6. Ortho-phosphate concentration generally followed the same pattern as silicate as it ranged from near zero to 1.6 μg-at/l in September.

7. Ammonia concentration ranged from near zero to highs of 9.8 μg-at/l in July, 5.5 μg-at/l in September, and 7.4 μg-at/l in February.

8. Nitrate and nitrite concentration ranged from near zero to peaks of 17.5 μg-at/l in mid-July, 14.1 μg-at/l in September, and 27.5 μg-at/l in January. The deepest station showed some vertical stratification with lower concentrations in the bottom water.

9. Concentration of chlorophyll a, b, and c were high in August, October, and March. Chlorophyll a peak values were between 25 and 30 mg/m^3.

10. During the February 12-hour cruise, temperature and salinity increased with the incoming tide while dissolved oxygen concentration, concentrations of silicate, nitrate and nitrite, ammonia and ortho-phosphate decreased. The association between pigment values and tide varied depending on the type of chlorophyll.

11. During the April 12 cruise there was very little change in temperature, salinity, and dissolved oxygen with tidal effects. In contrast, concentrations of silicate, nitrate and nitrite, and ortho-phosphate declined as the tide ebbed. Changes in ammonia and pigment were not tide-related.

12. Based on nitrate and phosphate concentrations, lower Delaware Bay was not considered polluted when compared to nearby estuaries.

Chapter II: Phytoplankton

1. A total of 126 phytoplankton species were obtained in both net and whole water samples.

2. The following results applied to the whole water samples:

   a. The flora was composed primarily of small flagellates during the summer and early fall.

   b. Diatoms dominated from October through May.

   c. Highest species richness occurred in June (0.71), late August (0.56), and December (0.66).

   d. Evenness values decreased from the summer through November, increased sharply in December, remained moderately high even through the spring, and increased to high values in May.

   e. A shift in dominant species was observed. June dominants were gradually replaced through October, after which there was an entirely new suite of dominants. Another replacement occurred again in early spring.

   f. Cycles of abundance for the most dominant species showed; 1) Calycomonas ovalis, late summer months; 2) Pyramimonas sp., spring-early summer; 3) Cryptomonas acuta, warm months; 4) Chrysochromulina sp., summer; 5) Skeletonema costatum, late winter and early spring; 6) Katodinium rotundatum, mid-summer.

   g. Recurrent species groups based on cluster analysis reflected the seasonal change in species composition.

3. The following results applied to the net phytoplankton samples:

a. The diatom, Nitzschia seriata, dominated the winter samples whereas another diatom, Guinardia flaccida, dominated the spring samples.

b. In general, tidal stage had little influence on the composition of the dominant species.

Chapter III: Zooplankton

1. Seventy-one species, including 18 copepods and 15 decapod larvae were identified from the zooplankton samples.

2. Maximum zooplankton abundances occurred in the spring and summer at most stations. In general, higher numbers were found in bottom samples.

3. Copepods were the largest component of the population throughout most of the year and the meroplankton comprised a significant percent of the population during the summer.

4. Based on cluster analysis five time-related assemblages emerged: 1) June--Podon sp., A. tonsa, P. coronatus, C. hamatus; 2) July-August--A. tonsa, P. coronatus, N. texana (zoea), P. sayana (zoea), copepodites; 3) September-November--Oikopleura sp., Paracalanus spp., veliger larvae, polychaete larvae; 4) December--A. tonsa, veliger, Acartia copepodite; 5) January-May--C. hamatus, Centropages copepodites, T. longicornis, P. minutus.

5. During the 12-hour cruises there were higher numbers in the bottom waters in the day with vertical migration towards the surface at 1500. Zooplankton began their descent at about 1900.

6. The general pattern of zooplankton numbers and species occurrences did not differ appreciably from patterns found by earlier investigators.

7. The seasonal species replacement sequence in Delaware Bay was different from that of estuaries to the north.

Chapter IV: Water Column Synthesis

1. The highest net production occurred at the end of May (167.8 mgm C/m^3/6 hr). Surface assimilation numbers also peaked in late May (6.5 mg C/hr/mg Chl a). Delaware Bay was similar in production levels to parts of Chesapeake Bay.

2. The winter-spring Skeletonema bloom was associated with the lowest silicate concentrations. There was a negative association between diatoms and silicates.

3. Diatoms were negatively associated with ammonia.

4. Micro-flagellates were negatively associated with nitrate and nitrite.

5. Total whole water phytoplankton numbers were negatively associated with ortho-phosphate.

6. Herbivores were the dominant feeding group among zooplankton.

7. Based on cross-correlation time series analysis, herbivore numbers had a positive correlation with abundance of whole water phytoplankton after a lag of four to six weeks.

8. Based on feeding rates, carbon requirements, and cell carbon content, it was determined that the phytoplankton populations in Delaware Bay were more than sufficient to support the local zooplankton populations.

9. Since no one species of phytoplankton or zooplankton maintained dominance for a long period of time except in the spring (Skeletonema-Thalassiosira), the planktonic food web in Delaware Bay may be more complex than in estuaries to the north.

Chapter V: Delaware Bay Benthic Invertebrate Assemblages

1. A total of 207 samples were collected during the summers of 1972 and 1973.

2. Based on mean particle size and sorting coefficient sediments were classified into twelve major groups.

3. Coarse sand deposits were mainly found at the mouth of the bay with fine silt and clay in the upper bay, at river mouths and in protected areas near Delaware and Jersey shores.

4. A total of 109 and 125 species were collected in 1972 and 1973 respectively.

5. With the exception of the serpulid reef, few stations had more than 15 species.

6. One-third of the samples consisted of more than 75% deposit-feeding individuals. These samples were primarily located on the Delaware side of the bay.

7. The most widespread species were: Tellina agilis, Heteromastus filiformis, Glycera dibranchiata, Nephtys picta, Mulinia lateralis, Protohaustorius wigleyi, Gemma gemma, and Nucula proxima.

8. The average density ($200/m^2$) of benthic invertebrates in Delaware Bay was several orders of magnitude lower than other estuaries along the Atlantic Coast of the United States.

9. Based on cluster analysis, five and four assemblages emerged from the 1972 and 1972 samples respectively. The assemblages were not similar over the two years.

Chapter VI:
Seasonal Changes of
Benthic Invertebrate Assemblages in the Lightering Area

1. A total of 180 species of benthic invertebrates was collected.

2. Deposit-feeding organisms dominated all stations except 8 and 9 which were characterized by two suspension feeders (Mytilus edulis and Hydroides dianthus).

3. Suspension feeders comprised a greater percent of the fauna than did the carnivores or omnivores.

4. Dominant species were: Tellina agilis, Nucula proxima, Parahaustorius longimerus, Spio setosa, Mediomastus ambiseta, Mytilus edulis, and Hydroides dianthus.

5. Species dominance was evaluated using McNaughton's dominance index. Stations were dominated by haustoriid amphipods, various combinations of T. agilis, N. proxima, S. setosa, M. lateralis, and M. edulis, and H. dianthus.

6. Evenness diversity values were highest among the deposit-feeders and carnivores, and lower among the suspension feeders and omnivores.

7. At most stations there was a seasonal (usually a cold months--warm months) replacement of the dominant species.

8. Based on cluster analysis, the following stations had similar faunal assemblages: 1 and 6; 2 and 3; 5, 7, and 10; 8 and 9; and 4.

9. Specific animal-sediment associations were observed, but these were somewhat masked by other variables. Mytilus edulis, H. dianthus, N. proxima, and T. agilis were associated with hard substrata (pebbles, shell, calcareous tubes), silt-clay (20-75%), fine sand with silt-clay (10-30%), respectively.

10. Petersen type communities were not recognized in the lightering area.

11. Seasonal fluctuations observed in these stations indicated that long-term monitoring of the structure of selected assemblages would provide more useful data in assessing the stress of man-related activities than one-time surveys.

Chapter VII: Methodological Benthic Studies

1. A total of 146 and 158 species were collected from four stations (sand, muddy sand, polymodal sand, calcareous serpulid reef) with a Petersen grab and dredge haul, respectively.

2. At all stations the dredge sampled a larger number of species than did the grab.

3. Dominant grab species in the sand were T. agilis, G. capitata, S. fragilis, and A. verrilli, and dominant dredge species were T. agilis, N. americana, A. oculatus, and E. directus.

4. Dominant grab species in the muddy sand were N. proxima, T. agilis, and E. directus, and dominant dredge species included the above three together with C. septemspinosa and N. americana.

5. Dominant grab species in the polymodal sand were *M. edulis*, *M. ambiseta*, and *L. alba*, and dominant dredge species were *A. polyoum*, *S. errata*, *E. monostachys*, *M. tenuis*, *C. tenuissimum*, *N. americana*, and *C. septemspinosa*.

6. Dominant grab species in the serpulid reef intermixed with muddy sand were *A. oculatus*, *M. ambiseta*, *N. proxima*, *H. filiformis*, *S. benedicti*, and *U. serrata*, and dominant dredge species were *H. dianthus*, *U. serrata*, and *C. simile*.

7. The number of dominant species in the dredge samples was at least equal, but usually exceeded that of the grabs.

8. Station 9 was the only site where there was a significant difference in the order of importance of species between grab and dredge samples. Thus at this station the dredge presented a view of the community structure considerably different from that obtained from the grab.

9. To obtain 90% of the species in a particular substratum between 13 and 16 grab or dredge samples were needed.

10. All dominant species occurred in the first two grab or dredge samples.

11. The accuracy of the community structure estimate given by the dredge samples was related to the substratum composition.

12. Based on cluster analysis of grab and dredge samples, the fauna of the sand and muddy sand substrata showed less patchiness than the fauna of the polymodal sand and serpulid reef substrata.

13. Based on the rating scale devised for this study, the dredge data offered a reasonable estimate of differing community structure from different substrata. Improvements in the rating scale are expected to refine the accuracy of these estimates.

I. HYDROGRAPHY

Les Watling

INTRODUCTION

The general physical oceanographic features of Delaware Bay were described by Polis and Kupferman (1973) and Maurer and Wang (1973). Their reports considered wind and tide induced currents, and past salinity and temperature measurements. In contrast, chemical oceanographic data for Delaware Bay were virtually non-existent (Kester and Courant, 1973); however, some nutrient data were given in Szekielda (1973). The following account is summarized from these reports.

Climate

Precipitation averages 45 inches/year (1.14 m/yr) and is maximum in summer. Winds are predominantly from the west-northwest during the winter months (November-March). In April the wind gradually shifts to westerly onshore and south-southeasterly offshore, progressing to south-southwesterly in summer. Wind patterns are unstable in the fall. On an annual basis, wind speeds are less than 15 mph (6.7 m/s) 65% of the time and exceed 32 mph (14.3 m/s) only 1% of the time. In general summer winds are calmer and more variable whereas winter winds are stronger and steadier.

Tides and Circulation

The mean annual tidal range at the mouth of Delaware Bay varies from 4.1 feet (1.2 m) at Cape Henlopen to 4.7 feet (1.4 m) at Cape May Point. The waters of Delaware Bay circulate as a large rotary current, generally flowing southward along the Delaware shore and northward along the New Jersey shore. The northerly flow component is reinforced by the flood tide while the southerly current is reinforced by the ebb tide. As a consequence, a greater proportion of Delaware River water flows out of Delaware Bay along the Delaware shore. Tidal currents at the Delaware Bay mouth average a maximum of 1.8 knots (0.9 m/s) during both flood and ebb tide conditions. The values decrease slightly in the open central portion of the bay and increase to an average maximum of 2.5 knots (1.3 m/s) where the bay narrows near Woodland Beach. Within the bay tidal currents generally run parallel to its long axis. There is a net transport of water out of the bay on the Cape Henlopen side and a net transport into the bay in the deep channels and, at the surface, to the Cape May side. Salter (in Polis and Kupferman, 1973) suggests that this is explained by Coriolis forces.

Salinity

Delaware Bay is generally polyhaline (18-30 o/oo) from its mouth up to the vicinity of the Leipsic River and mesohaline from the Leipsic River to around Woodland Beach and also in the Maurice River Cove. Cronin, et al. (1962) demonstrated that the bay was strongly stratified only in the winter and spring as the river flow increased. In fact, Polis and Kupferman (1973) noted that yearly changes in river flow can drastically alter the salinity structure of the lower bay.

Temperature

In the fall and winter the bay shows little or no vertical temperature stratification whereas in the spring and summer bottom waters are generally cooler than surface waters, especially in the deeper regions. Temperatures generally range from 1°C in winter to 25-30°C in summer.

Dissolved Oxygen

The mesohaline and polyhaline zones of Delaware Bay are generally fully saturated with dissolved oxygen. Absolute values of dissolved oxygen vary as would be expected with temperature and salinity.

Nutrients and Pigments

There is, at the present time, no general picture of nutrient distributions in Delaware Bay. With regard to pigments, Szekielda (1973) presented a map of bay-wide chlorophyll distribution. High concentrations of chlorophyll were transported with the outflowing river water along the Delaware side of the bay.

METHODS

In the present study hydrographic data were obtained from two sources: monthly or bi-monthly plankton cruises in the vicinity of the anchorage area, and samples collected during the benthic cruises. Three plankton stations (Fig. I-1) were occupied 17 times from May 1, 1974 to May 28, 1975 always at high slack tide. In addition, two 12-hour cruises were conducted at plankton Station 2 on February 20, 1975 and April 14, 1975. Hydrographic data were also obtained from ten benthic stations in the anchorage region on a quarterly basis (May, August, and November 1974 and February and May 1975) and from 105 bay-wide stations in 1972 and an additional 102 stations in 1973.

Both surface and bottom water samples were taken at all of the above stations with the exception of the bay-wide series where only bottom water was sampled.

Temperatures were measured with standard reversing thermometers. Salinities were measured in the laboratory with a Beckman Model 6320N laboratory salinometer. Samples for nutrient analysis were stored frozen in plastic containers to await analysis. All samples for pigment analysis were filtered immediately on the ship using Whatman GF/C glass fiber filters. The filters were then frozen and stored in a dessicator until analyzed. Concentrations of dissolved oxygen, silicate, nitrate and nitrite, ortho-phosphate, ammonia, chlorophylls a, b, and c, phaeopigments, and carotenoids were analyzed following procedures described in Strickland and Parsons (1968). Pigment analyses followed the acetone extraction technique and extinction coefficients were measured on a D.U. spectrophotometer. Concentrations were estimated using the SCOR/UNESCO formulae.

RESULTS AND DISCUSSION

Values of temperature, salinity, silicate, ortho-PO_4, NH_3, $NO_3 + NO_2$, dissolved oxygen, and chlorophylls a, b, and c obtained at plankton Stations 1, 2, and 3 are given in Tables I-1 to I-10. Tables I-11 and I-12 contain similar data for the 12-hour cruises conducted at plankton Station 2 on February 20 and April 14, 1975. In addition, temperature, salinity, and dissolved oxygen values from the benthic cruises in the anchorage area are given in Appendix Tables AI-1 to AI-3. Cyclic and/or distributional changes in each of these hydrographic measures are detailed below.

A. *Yearly Summary*

Temperature

The annual pattern of surface temperature (Fig. I-2) was typical of a northeastern American estuary. Lowest and highest temperatures were recorded in February (3.5°C) and early August (26.0°C), respectively. Except during the months of December and January, temperatures on the bottom were slightly lower than at the surface (Table I-1).

Salinity

Since the plankton cruises were conducted at high slack tide, salinity values were always in the polyhaline range, and rarely was there any strong vertical stratification at any of the three stations (Table I-2). Bottom salinities throughout the bay provided a broader picture of the estuarine zonation as established by the Venice system (reviewed in Carriker, 1967). Figures I-3 and I-4 show the distribution of the mesohaline, lower polyhaline, upper polyhaline, and oceanic zones sampled during the 1972 and 1973 benthic transect studies. Of special interest was the distribution of mesohaline water along the shallow New Jersey side of Delaware Bay and the extension of upper polyhaline water along the deep channels and into the upper reaches of the Delaware portion of the bay. This suggested that bottom morphology may be as important as the Coriolis force in determining the water mass distributions in Delaware Bay. An account of the temperature and salinity distribution along the Cape May shore has been provided by Hidu and Haskin (1971).

Dissolved Oxygen

In general, all three stations showed the same yearly pattern of dissolved oxygen values being lower in the summer than in the winter. Only during the late winter to early spring period was the water consistently fully saturated (Table I-3); otherwise full saturation occurred only after the strong diatom bloom of mid-October.

Silicate

Silicate values showed several peaks, the highest (31.6 μg-at/l) occurring in September (Fig. I-5). Decreases in silicate were observed during and after blooms of diatoms in August, October, and April. At Station 1, silicate concentrations were higher in surface water than bottom water over most of the year (Table I-4). Concentrations of silicate were generally the same in the surface and bottom waters of the shallower Stations 2 and 3.

Ortho-phosphate

As for silicate, ortho-phosphate values showed several peaks, the highest (1.64 μg-at/l) occurring in September (Fig. I-6). Ortho-phosphate concentrations declined during phytoplankton blooms but increased immediately following the termination of the bloom. All of the detectable ortho-phosphate was removed from the water during the spring *Skeletonema* - *Thalassiosira* bloom. There were few differences between surface and bottom water or among stations (Table I-5).

Ammonia

Highest concentrations of ammonia were observed in July (9.8 μg-at/l), September (5.5 μg-at/l), and February (7.4 μg-at/l) with quite low concentrations present during the remaining sampling periods (Fig. I-7). Ammonia values changed rapidly during the summer and fall months but varied more gradually during the winter and after the spring bloom. Values were slightly higher in bottom water than in surface water, especially at Station 1, whose values were also slightly higher than those at Stations 2 and 3 (Table I-6).

Nitrate and Nitrite

Highest concentrations of nitrate and nitrite were observed in May at Stations 1 and 2 (22.0 and 19.1 μg-at/l) and January at Stations 1 (27.0 μg-at/l) and 3 (27.0 μg-at/l) whose values greatly exceeded those for any other time of the year (Fig. I-8, Table I-7). There was a sharp decrease in nitrate and nitrite concentrations in the June 20 sample which was not observed in the concentrations of any of the other nutrients. Station 1 exhibited some vertical stratification with the lower concentrations occurring in the bottom waters.

Chlorophylls

Surface concentrations of total chlorophyll a, chlorophyll b, and chlorophyll c at the three plankton stations are illustrated in Figures I-9, I-10, and I-11. In addition, both surface and bottom values of these pigment concentrations are given in Tables I-8, I-9, and I-10. Peak concentrations of chlorophyll a were measured on August 21 (24.1 mg/m^3), October 30 (28.1 mg/m^3), and March 18 (32.3 mg/m^3). Values at Station 1 were generally lower than at Stations 2 and 3. A generally similar pattern was seen for chlorophylls b and c.

B. *Twelve-hour Cruises of February 20, 1975 at Plankton Station 2*

The amount of change in the values of temperature, salinity, dissolved oxygen, nitrate and nitrite, ammonia, ortho-phosphate, chlorophylls a, b, and c, carotenoids, and phaeopigments, during a 12-hour period on February 20, 1975 are presented in Table I-11 and Figures I-12 to I-22. Temperature (Fig. I-12) and salinity (Fig. I-13) values increased with the incoming tide while the dissolved oxygen concentration (Fig. I-14) decreased. Concentrations of silicate (Fig. I-15), nitrate and nitrite (Fig. I-16), ammonia (Fig. I-17), and ortho-phosphate (Fig. I-18) also tended to decrease with increasing salinity. No consistent tide-associated vertical stratification was observed for any of these nutrients. Total chlorophyll a concentration (determined by the phaeo-pigment method) showed distinct peaks at 1100 (4.04 mg/m^3) and 1800 (5.19 mg/m^3) hours near the periods of slack tides (Fig. I-19 and I-20). Chlorophyll b (Fig. I-21) showed little tide-related change while concentrations of chlorophyll c increased strongly with the incoming tide (Table I-11).

C. Twelve-hour Cruise of April 14, 1975 at Plankton Station 2

Measures and concentrations of the physical, chemical, nutrient, and pigment factors discussed under the 12-hour cruise of February 20 are given for this cruise in Table I-12 and Figures I-22 to I-32. In comparison to the cruise of February 20, very little change in temperature (Figure I-22), salinity (Fig. I-23), and dissolved oxygen (Fig. I-24) values were observed during this 12-hour period. In contrast, concentrations of the nutrients, silicate (Fig. I-25), nitrate and nitrite (Fig. I-26), and ortho-phosphate (Fig. I-28) declined as the tide ebbed. The changes in ammonia (Fig. I-27) and pigment concentrations (Figs. I-29 to I-32) do not appear to be tide-related.

D. Comparisons with Regional Estuaries

Nutrient values obtained for Delaware Bay were compared with those of three nearby estuarine systems: Long Island Sound (Riley and Conover, 1956; Kester and Courant, 1973), Raritan Bay (Jeffries, 1962), and Chesapeake Bay (Kester and Courant, 1973). Of the three systems, only Long Island Sound was similar to the region of Delaware Bay examined here in having dissolved oxygen levels undersaturated during the summer months. Inorganic phosphate levels in Long Island Sound were approximately 2.5 μg-at/l from October to March and then decreased to very low values in May and June. In Raritan Bay, which Jeffries (1962) suggested was a strongly polluted estuary, inorganic phosphate values were near 6 μg-at/l in October and then decreased to levels between 2 and 3 μg-at/l from April through the summer. A similar cycle for Chesapeake Bay was not well defined but the values were always below 1.0 μg-at/l. Values for lower Delaware Bay were closest to those of Chesapeake Bay.

Nitrate levels in Long Island Sound ranged from <1 to 5 μg-at/l during the period March through August, but then increased to 12 to 20 μg-at/l from September to February. Again values in Raritan Bay were somewhat higher, ranging from 15 to 37 μg-at/l in the winter and spring, and 1 to 15 μg-at/l in the summer. Concentrations near 20 μg-at/l were recorded in Chesapeake Bay during the spring but decreased to less than 5 μg-at/l in the summer and fall. Highest concentrations of nitrate plus nitrite in lower Delaware Bay occurred during the winter months with occasional high values in the spring.

Much has been written about the relationship of nitrogen and phosphorus in coastal systems and the use of nitrogen-phosphorus (atoms) ratios as indicators of eutrophic conditions (Jeffries, 1962; Ryther and Dunstan, 1971; Banse, 1974). This ratio was approximately 8:1 throughout the year in Long Island Sound, varied from 35:1 to 1.3:1 in Raritan Bay (highest in March and April, lowest in July and August), and ranged between 90:1 (spring) to 2.5:1 (fall) in Cheapeake Bay. In lower Delaware Bay this ratio averaged 200:1 in May and June and approximately 20:1 throughout the summer and winter months. Of the four estuarine systems considered, only Long Island Sound did not have a strong input of river water nor is it surrounded by large salt marshes. Long Island Sound was also the only system where the nitrate and phosphate cycles were in near perfect correspondence. In the other estuaries, including Delaware Bay, the nitrate values varied randomly in relation to phosphate thus suggesting that the major river and/or the marshes and tidal creeks (Aurand and Daiber, 1973) may be responsible for the wide range of nitrate-phosphate ratios in these systems.

Ketchum (1967) noted earlier experiments had demonstrated that available nitrogen was probably the nutrient limiting algal growth and that high concentrations of inorganic phosphorus in the water reflected the excess of that element above the requirements of the phytoplankton. Thus the phosphorus concentration could be used as a pollution index. On this basis, Long Island Sound, Chesapeake Bay, and lower Delaware Bay did not show excess nutrient pollution as did Raritan Bay.

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Table I-1

Environmental Feature: <u>Temperature</u>

Cruise No.	Date	Station I T*	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	13.8	12.4	11.5	14.3	13.9	14.4	14.4
2	May 9, 1974	13.0	12.8	12.6	13.4	13.4	13.4	13.1
3	May 22, 1974	16.1	14.9	14.8	16.4	15.8	19.0	16.0
4	June 13, 1974	21.0	19.3	18.5	21.4	21.4	21.5	-
5	June 20, 1974	21.4	20.7	20.7	22.0	21.6	22.1	21.6
6	July 19, 1974	22.9	22.6	22.6	23.4	23.1	23.9	23.4
7	Aug. 1, 1974	24.8	24.2	23.6	25.4	25.2	26.0	25.6
8	Aug. 21, 1974	23.9	23.7	23.7	24.0	23.9	24.0	23.9
9	Sept. 17, 1974	22.3	22.4	22.3	22.5	22.4	22.6	22.4
10	Oct. 15, 1974	17.1	17.1	17.1	17.1	17.2	17.2	17.2
11	Oct. 30, 1974	14.1	14.1	14.1	14.2	14.1	13.9	13.9
12	Nov. 14, 1974	13.5	13.5	13.5	13.1	13.1	13.1	13.1
13	Dec. 13, 1974	6.4	6.4	6.4	5.9	6.0	5.9	5.9
14	Jan. 16, 1975	4.6	4.6	5.2	4.6	4.7	4.4	4.5
* 15	Feb. 20, 1975 (1800)	-	-	-	3.6	3.6	-	-
16	March 18, 1975	5.2	5.1	4.9	5.5	5.4	5.8	-
* 17	April 14, 1975 (0900)	-	-	-	6.3	6.2	-	-
18	May 9, 1975	13.0	-	11.0	13.4	11.3	13.3	13.4
19	May 28, 1975	18.4	17.7	17.6	18.5	18.6	17.6	17.2

* 12 hrs. at Station II only

For this and following tables, T = surface, M = middle depth, and B = bottom.

Table I-2

Environmental Feature: Salinity

Cruise No.	Date	Station I T	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	23.4	25.7	27.7	23.7	23.9	25.4	25.4
2	May 9, 1974	28.8	27.4	28.5	27.0	26.9	27.4	26.4
3	May 22, 1974	25.2	28.3	28.3	26.3	26.3	26.0	26.6
4	June 13, 1974	21.8	27.1	28.7	22.3	22.4	24.8	25.0
5	June 20, 1974	26.9	28.3	28.7	27.1	27.4	27.2	27.2
6	July 19, 1974	28.4	29.4	29.6	28.5	28.7	28.2	28.5
7	Aug. 1, 1974	28.5	29.8	30.2	28.3	29.0	28.0	29.0
8	Aug. 21, 1974	28.5	29.0	29.0	29.3	29.3	29.4	29.4
9	Sept. 17, 1974	28.2	29.0	29.1	28.6	28.6	28.7	28.6
10	Oct. 15, 1974	27.7	28 9	28.9	28.4	28.4	28.4	28.4
11	Oct. 30, 1974	28.1	28.9	29.4	27.9	27.9	26.7	27.7
12	Nov. 14, 1974	29.7	29.8	30.0	29.7	29.7	29.7	29.7
13	Dec. 13, 1974	28.6	28.8	28.9	28.9	28.9	28.7	28.7
14	Jan. 16, 1975	-	-	-	-	-	-	-
* 15	Feb. 20, 1975 (1800)	-	-	-	23.3	27.3	-	-
16	March 18, 1975	25.9	27.1	29.2	25.8	25.7	24.7	25.4
* 17	April 14, 1975 (0900)	-	-	-	26.7	27.0	-	-
18	May 9, 1975	24.3	29.1	29.2	24.7	28.9	25.3	25.5
19	May 28, 1975	24.3	27.4	29.3	24.0	26.2	26.3	26.9

* 12 hrs. at Station II only

Table I-3

Environmental Feature: Dissolved Oxygen (ml/l)

		Station I						Station II				Station III			
Cruise No.	Date	T	%	M	%	B	%	T	%	B	%	T	%	B	%
1	May 1, 1974	6.46	103	6.29	97	6.17	88	6.78	108	6.79	108	7.26	117	7.27	117
2	May 9, 1974	6.68	108	6.28	99	6.28	99	6.97	110	6.94	110	7.20	114	6.45	102
3	May 22, 1974	6.07	102	5.78	97	5.75	97	6.06	103	5.98	101	6.62	121	8.22	152
4	June 13, 1974	4.16	75	2.93	53	2.57	46	4.17	77	3.88	71	6.03	112	5.66	-
5	June 20, 1974	5.29	99	4.84	91	4.80	91	5.52	105	5.19	98	5.44	104	5.43	103
6	July 19, 1974	4.67	92	4.35	85	4.76	93	4.75	94	4.40	87	4.67	93	4.75	95
7	Aug. 1, 1974	4.64	95	-	-	3.97	80	4.63	95	4.43	90	4.96	103	5.07	104
8	Aug. 21, 1974	4.84	97	4.74	95	4.80	96	4.96	100	4.90	99	4.64	94	4.75	96
9	Sept. 17, 1974	4.59	89	4.55	88	4.55	88	4.49	87	4.47	87	4.52	88	4.49	88
10	Oct. 15, 1974	6.21	107	5.88	103	5.88	103	5.99	105	5.99	105	5.92	103	5.82	102
11	Oct. 30, 1974	4.53	74	5.88	97	4.70	78	5.57	91	6.50	107	6.72	109	8.82	143
12	Nov. 14, 1974	5.71	94	5.72	94	5.66	93	5.77	95	5.77	95	5.71	94	5.75	94
13	Dec. 13, 1974	6.99	98	6.94	97	6.91	97	7.06	97	7.13	98	7.13	98	7.15	99
14	Jan. 16, 1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* 15	Feb. 20, 1975 (1800)	-	-	-	-	-	-	8.48	105	7.85	100	-	-	-	-
16	March 18, 1975	8.18	108	7.91	105	7.57	102	8.40	112	9.05	120	9.03	121	8.20	-
* 17	April 14, 1975 (0900)	-	-	-	-	-	-	8.40	114	8.30	113	-	-	-	-
18	May 9, 1975	6.19	96	6.44	102	6.44	100	7.08	111	6.62	103	7.35	117	7.20	114
19	May 28, 1975	5.76	100	5.52	97	5.68	101	5.68	100	5.31	94	5.71	101	5.38	96

* 12 hrs. at Station II only

% refers to percent of full saturation

Table I-4

Environmental Feature: Silicate (ug-at/ l)

Cruise No.	Date	Station I T	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	-	-	-	-	-	-	-
2	May 9, 1974	1.74	1.79	2.20	1.79	1.79	1.26	1.21
3	May 22, 1974	3.54	10.8	4.46	3.58	3.00	2.75	3.92
4	June 13, 1974	6.50	6.77	6.67	3.00	2.92	3.15	2.95
5	June 20, 1974	5.44	4.78	3.13	3.13	4.10	3.31	4.13
6	July 19, 1974	10.2	9.8	7.75	12.2	12.3	16.3	14.6
7	Aug. 1, 1974	16.6	13.0	11.1	16.8	18.0	20.2	22.0
8	Aug. 21, 1974	13.2	11.5	10.9	9.8	9.6	10.7	10.4
9	Sept. 17, 1974	29.2	27.7	27.7	30.0	29.3	31.6	28.3
10	Oct. 15, 1974	4.8	4.3	4.8	6.3	6.5	7.1	6.5
11	Oct. 30, 1974	4.5	4.5	5.9	3.6	3.7	3.6	3.3
12	Nov. 14, 1974	11.2	11.0	8.85	9.7	8.9	10.0	10.7
13	Dec. 13, 1974	7.5	7.4	7.0	9.4	9.1	10.4	10.2
14	Jan. 16, 1975	11.0	12.0	10.5	10.2	8.7	16.6	12.5
* 15	Feb. 20, 1975 (1800)	-	-	-	13.7	9.0	-	-
16	March 18, 1975	2.6	0.8	1.4	0.7	1.4	0.3	0.2
* 17	April 14, 1975 (0900)	-	-	-	1.40	1.05	-	-
18	May 9, 1975	1.1	1.1	0.4	0.9	1.0	0.6	0.7
19	May 28, 1975	1.45	1.30	1.2	2.2	2.8	2.0	2.5

* 12 hrs. at Station II only

Table I-5

Environmental Feature: ortho-PO_4(ug-at/ l)

Cruise No.	Date	Station I T	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	0.08	0.10	0.10	0.06	0.05	0.05	0.05
2	May 9, 1974	0.10	0.08	0.05	0.02	0.04	0.05	0.04
3	May 22, 1974	0.08	0.13	0.21	0.11	0.09	0.08	0.17
4	June 13, 1974	0.07	0.14	0.42	0.06	0.08	0.04	0.07
5	June 20, 1974	0.16	0.38	0.26	0.20	0.21	0.18	0.22
6	July 19, 1974	0.72	0.70	0.69	0.78	0.81	0.81	0.82
7	Aug. 1, 1974	1.10	1.09	1.00	1.00	1.20	1.18	1.33
8	Aug. 21, 1974	1.11	1.03	1.04	0.66	0.70	0.87	0.86
9	Sept. 17, 1974	1.64	1.54	1.45	1.52	1.52	1.60	1.61
10	Oct. 15, 1974	0.49	0.52	0.50	0.49	0.54	0.47	0.48
11	Oct. 30, 1974	0.23	0.40	0.48	0.26	0.27	0.29	0.26
12	Nov. 14, 1974	0.98	1.00	0.97	0.92	0.93	0.93	0.91
13	Dec. 13, 1974	0.70	0.69	0.69	0.63	0.63	0.58	0.58
14	Jan. 16, 1975	0.56	0.56	0.45	0.58	0.48	0.58	0.53
* 15	Feb. 20, 1975 (1800)	-	-	-	0.36	0.46	-	-
16	March 18, 1975	0.01	0.01	0.01	≈ 0	≈ 0	≈ 0	≈ 0
* 17	April 14, 1975 (0900)	-	-	-	0.06	0.05	-	-
18	May 9, 1975	0.04	0.10	0.07	0.02	0.06	0.03	0.03
19	May 28, 1975	0.14	0.18	0.22	0.18	0.17	0.20	0.16

* 12 hrs. at Station II only

Table I-6

Environmental Feature: NH_3-N(ug-at/ l)

Cruise No.	Date	Station I T	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	1.5	2.0	1.9	1.4	1.4	1.1	1.0
2	May 9, 1974	0.8	1.0	1.5	0.5	0.5	0.6	0.7
3	May 22, 1974	1.5	1.7	1.9	1.2	1.0	1.0	1.6
4	June 13, 1974	1.5	3.0	3.8	1.5	1.6	1.4	2.4
5	June 20, 1974	1.8	2.6	4.0	1.4	3.9	1.7	1.5
6	July 19, 1974	6.7	7.7	6.8	6.1	9.8	7.6	8.5
7	Aug. 1, 1974	2.8	3.5	3.1	1.7	2.9	2.5	3.4
8	Aug. 21, 1974	1.6	1.9	1.9	0.7	0.8	1.6	1.6
9	Sept. 17, 1974	4.9	5.0	5.1	5.5	5.2	5.0	5.2
10	Oct. 15, 1974	1.0	1.1	1.1	1.5	0.9	0.6	1.8
11	Oct. 30, 1974	1.4	1.8	3.2	1.1	0.9	1.2	0.8
12	Nov. 14, 1974	2.3	2.2	2.1	2.1	2.2	2.2	2.5
13	Dec. 13, 1974	2.8	2.6	2.6	2.8	2.6	2.7	2.7
14	Jan. 16, 1975	3.8	3.2	2.0	3.1	2.6	4.0	3.1
* 15	Feb. 20, 1975 (1800)	-	-	-	7.4	4.5	-	-
16	March 18, 1975	≃ 0	≃ 0	≃ 0	≃ 0	≃ 0	≃ 0	≃ 0
* 17	April 14, 1975 (0900)	-	-	-	0.7	0.6	-	-
18	May 9, 1975	≃ 0	≃ 0	≃ 0	≃ 0	≃ 0	≃ 0	≃ 0
19	May 28, 1975	1.9	1.8	0.8	2.7	1.1	1.3	1.9

* 12 hrs. at Station II only

Table I-7

Environmental Feature: $NO_3 + NO_2$ (ug-at/ l)

Cruise No.	Date	Station I			Station II		Station III	
		T	M	B	T	B	T	B
1	May 1, 1974	22.0	14.7	10.2	19.1	18.8	8.0	8.9
2	May 9, 1974	4.5	5.1	3.1	0.5	0.4	0.4	2.8
3	May 22, 1974	11.6	2.5	2.6	4.0	4.5	0.6	5.3
4	June 13, 1974	17.5	4.0	1.2	12.7	12.6	3.8	4.4
5	June 20, 1974	1.2	0.5	0.7	0.2	0.2	0.2	0.2
6	July 19, 1974	4.0	2.1	1.7	2.8	2.4	2.5	2.6
7	Aug. 1, 1974	5.0	4.5	3.4	9.2	5.5	5.0	5.4
8	Aug. 21, 1974	12.7	10.5	10.1	8.2	8.0	8.1	9.1
9	Sept. 17, 1974	14.1	10.4	9.9	12.1	11.6	11.2	11.0
10	Oct. 15, 1974	9.2	6.0	5.6	8.4	7.6	11.7	11.8
11	Oct. 30, 1974	4.8	3.5	2.4	2.3	2.8	4.4	2.8
12	Nov. 14, 1974	4.9	5.9	3.8	0.1	0.1	4.1	7.3
13	Dec. 13, 1974	16.4	16.5	14.1	13.1	12.7	13.8	13.4
14	Jan. 16, 1975	27.0	19.1	24.2	18.3	25.2	27.5	17.9
* 15	Feb. 20, 1975 (1800)	-	-	-	18.2	13.4	-	-
16	March 18, 1975	11.5	7.7	4.4	9.4	7.8	9.7	9.7
* 17	April 14, 1975 (0900)	-	-	-	10.8	9.1	-	-
18	May 9, 1975	3.6	0.4	0.1	1.9	0.4	1.6	0.8
19	May 28, 1975	7.3	1.7	0.3	8.6	1.6	2.9	2.5

* 12 hrs. at Station II only

Table I-8

Environmental Feature: <u>Chlorophyll a</u> <u>(mg/m^3)</u>

Cruise No.	Date	Station I T	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	-	-	-	-	-	-	-
2	May 9, 1974	-	-	-	-	-	-	-
3	May 22, 1974	5.2	4.0	3.3	11.9	12.0	14.8	10.1
4	June 13, 1974	4.8	5.3	2.8	7.1	6.2	7.6	7.1
5	June 20, 1974	7.8	3.6	3.6	9.8	12.4	8.9	12.0
6	July 19, 1974	10.7	6.8	6.7	15.4	11.7	15.5	12.3
7	Aug. 1, 1974	3.5	3.4	2.7	10.7	6.8	11.8	9.8
8	Aug. 21, 1974	9.5	8.6	8.4	24.1	22.9	18.0	19.3
9	Sept. 17, 1974	2.9	3.8	4.2	5.0	7.1	3.8	4.1
10	Oct. 15, 1974	9.8	10.5	10.7	13.2	12.6	12.8	12.5
11	Oct. 30, 1974	6.0	1.9	1.7	13.0	12.7	28.1	15.5
12	Nov. 14, 1974	1.2	1.2	1.2	2.5	2.5	2.1	2.4
13	Dec. 13, 1974	3.4	4.1	6.4	6.5	6.3	6.7	5.9
14	Jan. 16, 1975	-	-	-	-	-	-	-
* 15	Feb. 20, 1975 (1800)	-	-	-	5.5	6.9	-	-
16	March 18, 1975	10.5	11.4	12.6	16.7	22.2	18.8	32.3
* 17	April 14, 1975 (0900)	-	-	-	8.4	6.7	-	-
18	May 9, 1975	3.6	8.2	6.8	7.1	8.2	7.3	12.7
19	May 28, 1975	5.3	5.8	8.4	4.3	9.7	8.3	8.8

* 12 hrs. at Station II only

Table I-9

Environmental Feature: Chlorophyll b (mg/m^3)

Cruise No.	Date	Station I T	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	-	-	-	-	-	-	-
2	May 9, 1974	-	-	-	-	-	-	-
3	May 22, 1974	1.0	0.7	0.6	2.0	1.9	2.6	1.8
4	June 13, 1974	1.4	0.9	0.5	1.9	1.4	1.5	1.5
5	June 20, 1974	1.1	0.8	0.9	1.5	2.0	1.3	1.6
6	July 19, 1974	1.4	0.9	0.8	1.7	1.6	2.0	1.6
7	Aug. 1, 1974	0.4	0.7	0.6	1.7	1.4	2.3	1.4
8	Aug. 21, 1974	1.2	1.4	1.5	2.7	2.1	2.1	2.1
9	Sept. 17, 1974	0.3	0.6	0.7	0.7	1.1	0.6	0.5
10	Oct. 15, 1974	0.7	1.0	0.9	1.0	0.9	0.9	0.9
11	Oct. 30, 1974	0.5	0.1	0.4	0.8	0.9	2.4	1.1
12	Nov. 14, 1974	0.1	0.2	0.2	0.6	0.4	0.4	0.4
13	Dec. 13, 1974	0.4	0.4	0.9	0.8	0.9	0.8	0.7
14	Jan. 16, 1975	-	-	-	-	-	-	-
* 15	Feb. 20, 1975 (1800)	-	-	-	0.4	0.4	-	-
16	March 18, 1975	0.8	0.5	0.8	0.7	2.4	2.0	5.9
* 17	April 14, 1975 (0900)	-	-	-	0.5	2.1	-	-
18	May 9, 1975	0.2	0.4	0.6	0.6	0.6	0.5	0.9
19	May 28, 1975	0.7	0.5	0.5	0.6	0.7	0.9	0.5

* 12 hrs. at Station II only

Table I-10

Environmental Feature: Chlorophyll c (mg/m^3)

Cruise No.	Date	Station I T	Station I M	Station I B	Station II T	Station II B	Station III T	Station III B
1	May 1, 1974	-	-	-	-	-	-	-
2	May 9, 1974	-	-	-	-	-	-	-
3	May 22, 1974	1.8	0.9	0.7	4.5	4.5	6.4	3.5
4	June 13, 1974	1.6	0.9	0.6	2.1	0.8	1.6	1.4
5	June 20, 1974	1.8	0.8	0.7	3.8	3.6	2.4	2.9
6	July 19, 1974	4.7	4.1	4.2	6.3	4.4	6.0	4.9
7	Aug. 1, 1974	0.8	1.3	1.5	3.2	3.0	4.7	3.0
8	Aug. 21, 1974	3.7	4.2	4.0	10.0	8.3	7.5	9.4
9	Sept. 17, 1974	1.4	1.2	1.6	1.7	2.4	2.4	1.5
10	Oct. 15, 1974	4.4	4.3	4.9	5.4	5.6	5.3	5.1
11	Oct. 30, 1974	2.0	0.6	1.2	6.0	4.6	12.1	6.5
12	Nov. 14, 1974	0.1	0.2	0.6	0.9	0.6	0.6	0.7
13	Dec. 13, 1974	0.5	0.7	1.6	1.6	1.2	1.4	0.9
14	Jan. 16, 1975	-	-	-	-	-	-	-
* 15	Feb. 20, 1975 (1800)	-	-	-	1.9	1.1	-	-
16	March 18, 1975	4.3	2.7	3.1	2.1	5.2	3.7	10.1
* 17	April 14, 1975 (0900)	-	-	-	1.8	4.0	-	-
18	May 9, 1975	-	1.3	1.5	1.4	1.0	1.2	1.8
19	May 28, 1975	1.1	1.2	1.8	0.4	2.5	2.1	1.6

* 12 hrs. at Station II only

Table I-11.

Summarization of hydrographic data obtained during 12-hour cruise of February 20, 1975

Time	Temperature		Salinity		Dissolved Oxygen (ml/l)		Silicate		NO_3 and NO_2		NH_3		ortho-PO_4	
	0m*	4m*	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m
0700	-	-	22.1	24.2	8.20	8.18	15.1	12.7	16.8	15.7	10.0	7.59	0.55	0.46
0800	3.0	3.4	21.5	23.1	8.32	8.18	11.9	14.2	12.8	16.4	7.70	8.57	0.46	0.46
0900	-	-	21.2	22.1	8.40	8.30	17.8	15.8	19.1	17.8	11.1	9.79	0.54	0.52
1000	3.2	3.2	21.7	22.0	8.29	8.55	17.0	15.5	18.8	16.2	10.7	8.60	0.60	0.53
1100	3.1	3.3	21.8	22.2	8.30	8.30	15.9	16.2	18.1	18.1	9.73	10.66	0.53	0.50
1200	3.3	3.2	21.9	22.1	8.88	8.34	18.5	17.4	21.0	20.5	10.4	10.3	0.57	0.54
1300	3.4	3.3	21.9	22.2	8.37	8.40	15.0	15.9	16.3	17.7	8.60	9.20	0.46	0.53
1400	3.6	3.3	22.2	23.8	8.40	8.42	14.7	13.2	16.3	14.7	8.72	6.23	0.58	0.37
1500	3.7	3.6	21.9	24.1	8.40	8.47	16.4	8.5	17.5	10.8	8.89	4.08	0.66	0.42
1600	3.7	3.6	23.0	24.3	8.47	8.37	11.8	10.6	14.1	13.7	6.79	4.92	0.36	0.36
1700	3.7	3.6	23.4	24.3	8.54	8.38	9.37	12.9	11.7	17.6	5.57	6.49	0.37	0.38
→1800	3.6	3.6	23.3	27.3	8.48	7.85	13.7	8.96	18.2	13.4	7.38	4.45	0.36	0.46
1900	3.6	3.6	22.4	26.9	8.44	7.88	13.3	9.05	15.4	12.8	8.09	4.57	0.44	0.42

*0m = surface depth
4m = bottom depth

Table I-11 (cont.)

Time	Chlorophyll a		Chlorophyll b		Chlorophyll c		Carot.		Chl. a/Carot.		Chl. a/Phaeo.		Phaeo.	
	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m
0700	3.606	5.192	0.173	0.389	0.158	0.544	1.166	1.399	3.092	3.708	3.204	0.320	1.121	7.817
0800	3.444	2.144	0.162	0.035	0.533	-0.009	0.861	0.509	3.999	4.212	1.089	0.256	3.678	2.960
0900	1.791	2.249	0.066	0.126	0.103	-1.269	0.308	0.573	5.808	3.921	0.064	0.512	2.768	2.576
1000	2.656	3.115	0.299	0.502	-0.595	0.017	0.631	0.571	4.204	5.451	0.384	0.833	3.703	3.812
1100	4.685	-	0.369	-	0.193	-	1.632	-	2.869	-	4.037	-	1.480	-
1200	2.578	2.532	0.268	0.212	-0.389	-0.682	0.494	0.586	5.218	4.317	0.256	-1.794	3.723	6.927
1300	2.832	4.682	0.390	0.349	-0.179	1.198	0.632	1.680	4.475	2.786	0.448	3.844	3.844	1.614
1400	3.105	4.955	0.077	0.340	0.233	0.509	0.689	1.181	4.506	4.194	0.448	0.512	4.120	6.895
1500	2.361	5.596	0.240	0.380	0.532	0.498	0.531	1.118	4.444	5.001	0.576	-0.320	2.755	9.451
1600	3.466	5.776	0.203	0.465	0.485	0.299	1.340	1.000	2.585	5.771	1.217	0.833	2.992	7.933
1700	4.079	5.248	0.243	0.370	0.617	0.517	0.893	1.433	4.568	3.661	0.897	1.089	4.889	6.728
→1800	5.537	6.933	0.353	0.397	1.921	1.100	1.907	2.306	2.903	3.006	5.190	2.242	1.147	6.952
1900	2.263	7.711	0.206	0.959	-0.478	0.084	0.446	2.118	5.072	3.640	0.576	2.947	2.704	7.721

Table I-12

Summarization of hydrographic data obtained during 12-hour cruise of April 14, 1975

Time	Temperature		Salinity		Dissolved Oxygen (ml/l)		Silicate		NO_3 and NO_2		NH_3		ortho-PO_4	
	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m
0800	6.2	6.4	26.3	26.7	7.99	7.76	8.80	1.49	10.8	10.6	0.32	0.80	0.04	0.04
0900	6.3	6.2	26.7	27.0	7.76	7.71	1.40	1.05	10.8	9.05	0.74	0.64	0.06	0.05
1000	6.6	6.5	26.5	26.7	8.23	8.18	0.482	0.789	10.5	10.5	0.11	0.11	0.04	0.02
1100	6.8	6.6	26.6	26.7	8.18	8.11	0.702	1.32	8.93	9.05	0.32	0.21	0.04	0.04
1200	6.6	6.6	26.6	26.7	8.40	8.20	0.526	0.526	7.96	8.70	0.11	0.58	0.02	0.24
1300	7.6	6.6	26.4	26.7	8.39	8.13	0.526	0.526	8.60	8.54	0.00	0.64	0.01	0.02
1400	6.5	-	26.7	26.8	8.31	8.14	0.096	0.385	7.00	8.06	0.23	0.23	0.02	0.02
1500	7.3	6.7	25.9	26.3	8.60	8.41	0.289	0.385	6.78	0.91	0.63	0.80	0.006	0.012
1600	6.9	6.7	26.5	26.6	8.30	8.21	0.481	0.577	6.41	6.97	0.23	0.23	0.012	0.012
1700	7.0	6.7	26.1	26.3	8.60	8.21	0.192	0.289	6.13	5.00	0.23	0.34	0.000	0.006
1800	6.9	6.7	26.2	26.2	8.35	8.26	0.770	0.289	1.59	0.76	0.23	0.34	0.012	0.012
1900	6.9	6.9	26.0	26.1	8.77	8.51	0.192	0.192	7.05	6.73	-	0.11	0.036	0.006

Table I-12 (cont.)

Time	Chlorophyll a		Chlorophyll b		Chlorophyll c		Carot.		Chl. a/Carot.		Chl. a/Phaeo.		Phaeo.	
	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m	0m	4m
0800	14.578	19.347	1.386	2.111	3.186	5.879	3.410	5.314	4.274	3.640	4.741	10.765	15.859	16.109
0900	8.419	6.739	0.532	2.070	1.870	4.008	2.766	1.906	3.043	3.534	3.460	-4.357	8.291	11.444
1000	14.345	18.231	1.198	1.767	5.234	5.493	5.868	7.412	2.444	2.459	12.751	13.905	4.402	8.971
1100	13.695	20.005	1.080	1.599	3.709	8.508	4.679	7.937	2.926	2.520	8.650	16.660	9.035	6.798
1200	8.654	14.534	0.812	1.056	2.588	2.860	2.911	4.954	2.972	2.933	4.165	3.204	7.542	18.147
1300	6.329	14.996	2.868	1.440	9.488	4.192	0.035	5.655	176.151	2.651	1.666	4.293	8.464	17.852
1400	21.479	21.390	2.013	1.922	5.859	4.268	7.109	6.262	3.021	3.415	13.713	7.048	14.257	23.869
1500	11.751	22.725	0.750	1.706	2.196	4.931	3.166	6.370	3.710	3.567	4.421	13.520	12.328	14.937
1600	15.651	20.156	1.195	1.863	2.171	5.104	4.648	6.079	3.366	3.315	3.716	11.598	18.839	14.392
1700	16.246	18.559	1.662	1.462	7.044	5.489	5.898	5.851	2.754	3.171	14.289	11.534	5.062	12.213
1800	14.518	13.029	1.599	1.248	5.163	4.193	4.558	3.610	3.184	3.608	8.586	6.023	9.663	11.656
1900	7.933	10.629	0.820	0.787	1.634	0.282	2.363	3.474	3.355	3.059	3.139	0.512	8.074	16.128

FIGURE CAPTIONS FOR CHAPTER I

Figure I- 1: Map of Delaware Bay showing location of hydrographic and plankton stations.

Figure I- 2: Seasonal surface temperature values at hydrographic stations.

Figure I- 3: Distribution of bottom salinity values at transect 1-13 stations sampled in the summer of 1972.

Figure I- 4: Distribution of bottom salinity values at transect 14-26 sampled in the summer of 1973.

Figure I- 5: Seasonal cycle of silicate concentrations in surface samples at hydrographic stations.

Figure I- 6: Seasonal cycle of ortho-phosphate concentrations in surface samples at hydrographic stations.

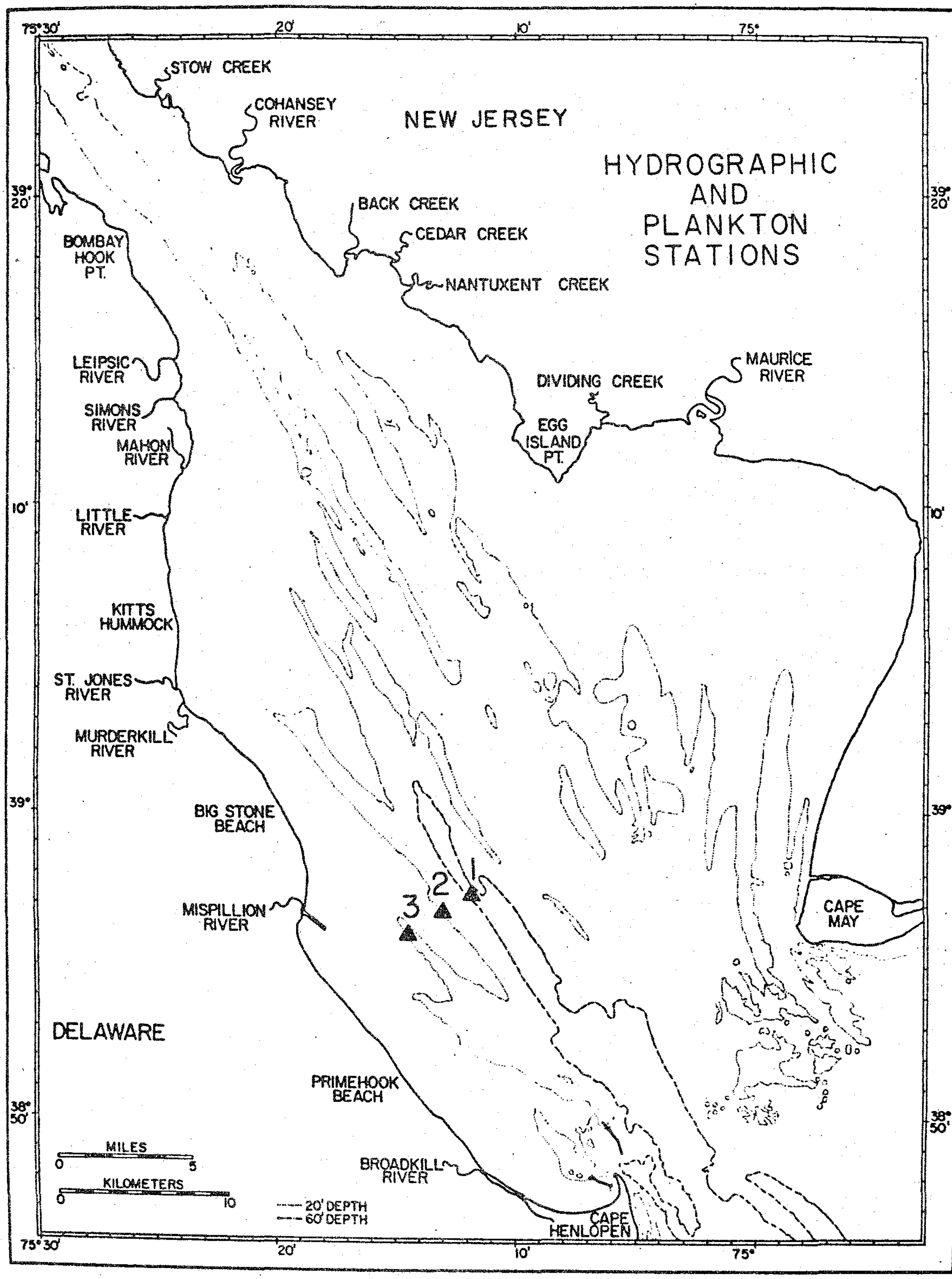
Figure I- 7: Seasonal cycle of ammonia concentrations in surface samples at hydrographic stations.

Figure I- 8: Seasonal cycle of nitrate plus nitrite concentrations in surface samples at hydrographic stations.

Figure I- 9: Seasonal cycle of total chlorophyll a concentrations in surface samples at hydrographic stations.

Figure I-10: Seasonal cycle of chlorophyll b concentrations in surface samples at hydrographic stations.

Figure I-11: Seasonal cycle of chlorophyll c concentrations in surface samples at hydrographic stations.



75°30'
20'
10'
75°
STOW CREEK
COHANSEY RIVER
NEW JERSEY
HYDROGRAPHIC AND PLANKTON STATIONS
39° 20'
BACK CREEK
CEDAR CREEK
BOMBAY HOOK PT.
NANTUXENT CREEK
LEIPSIC RIVER
DIVIDING CREEK
MAURICE RIVER
SIMONS RIVER
EGG ISLAND PT.
MAHON RIVER
10'
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
39°
BIG STONE BEACH
1
2
3
MISPILLION RIVER
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
38° 50'
MILES
0
5
KILOMETERS
0
10
BROADKILL RIVER
20' DEPTH
60' DEPTH
CAPE HENLOPEN

Figure I-1

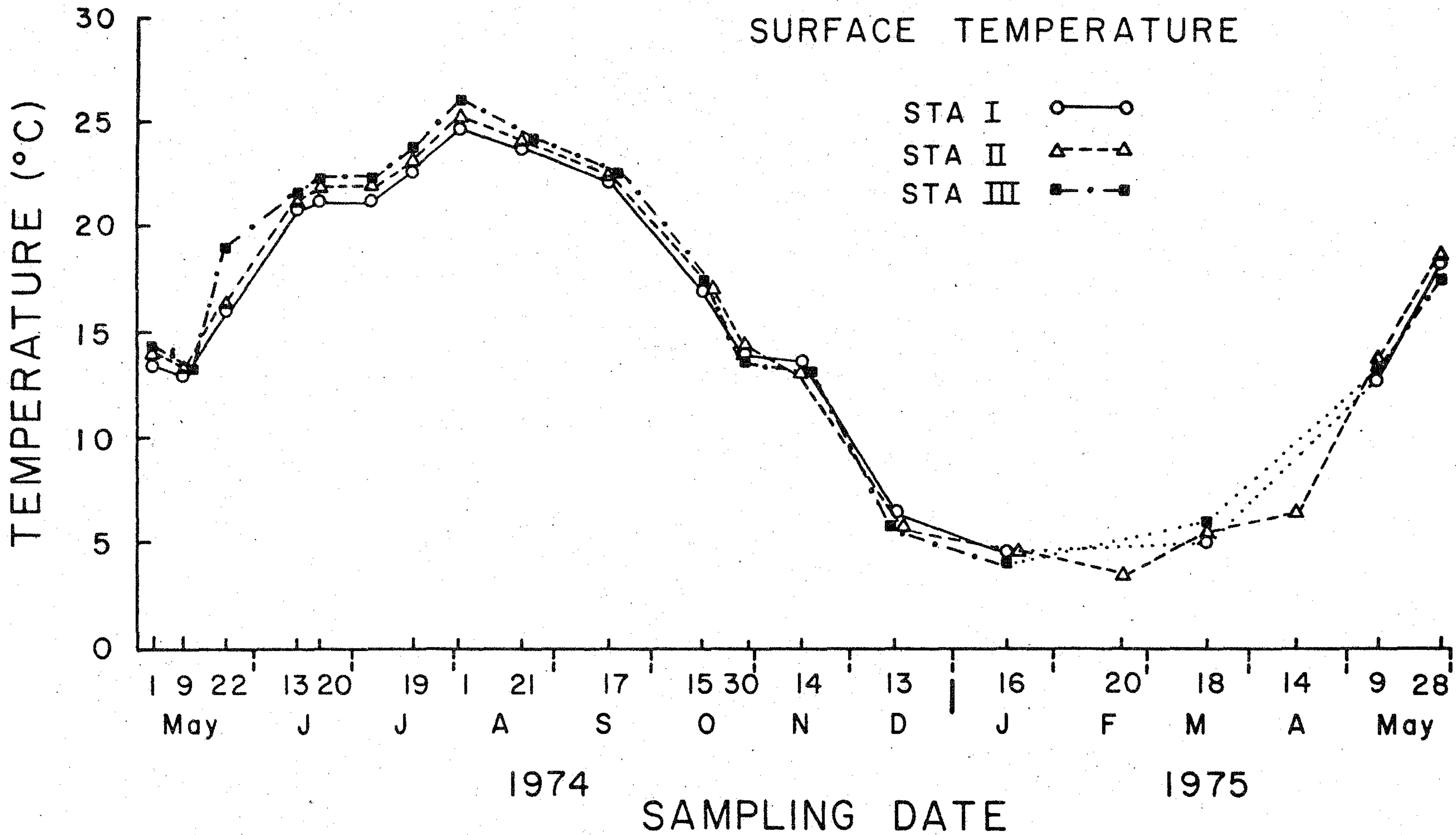

SURFACE TEMPERATURE
STA I
STA II
STA III
TEMPERATURE (°C)
30
25
20
15
10
5
0
1 9 22
May
13 20
J
19
J
1
21
A
17
S
15 30
O
14
N
13
D
16
J
20
F
18
M
14
A
9 28
May
1974
1975
SAMPLING DATE

Figure I-2

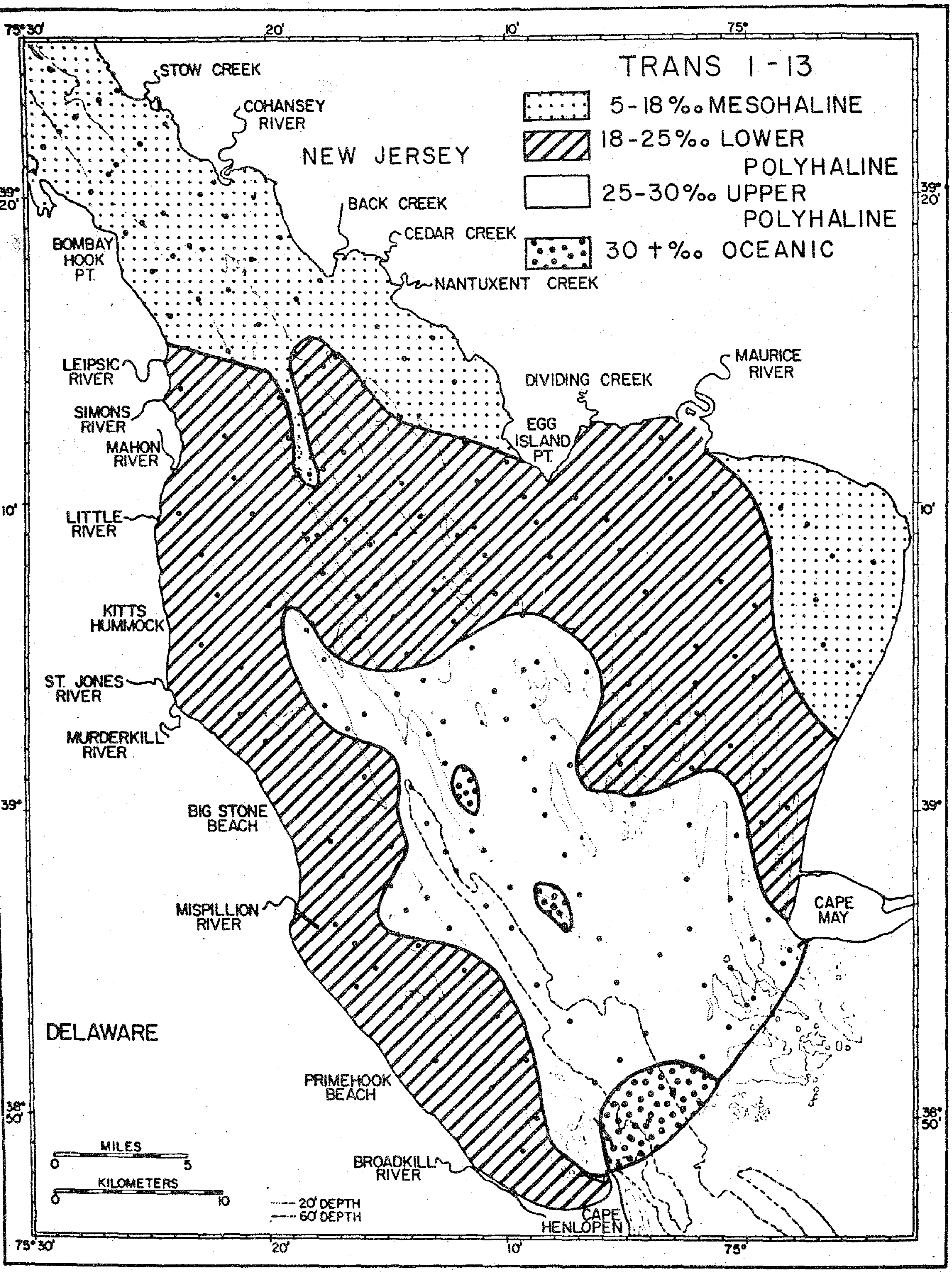
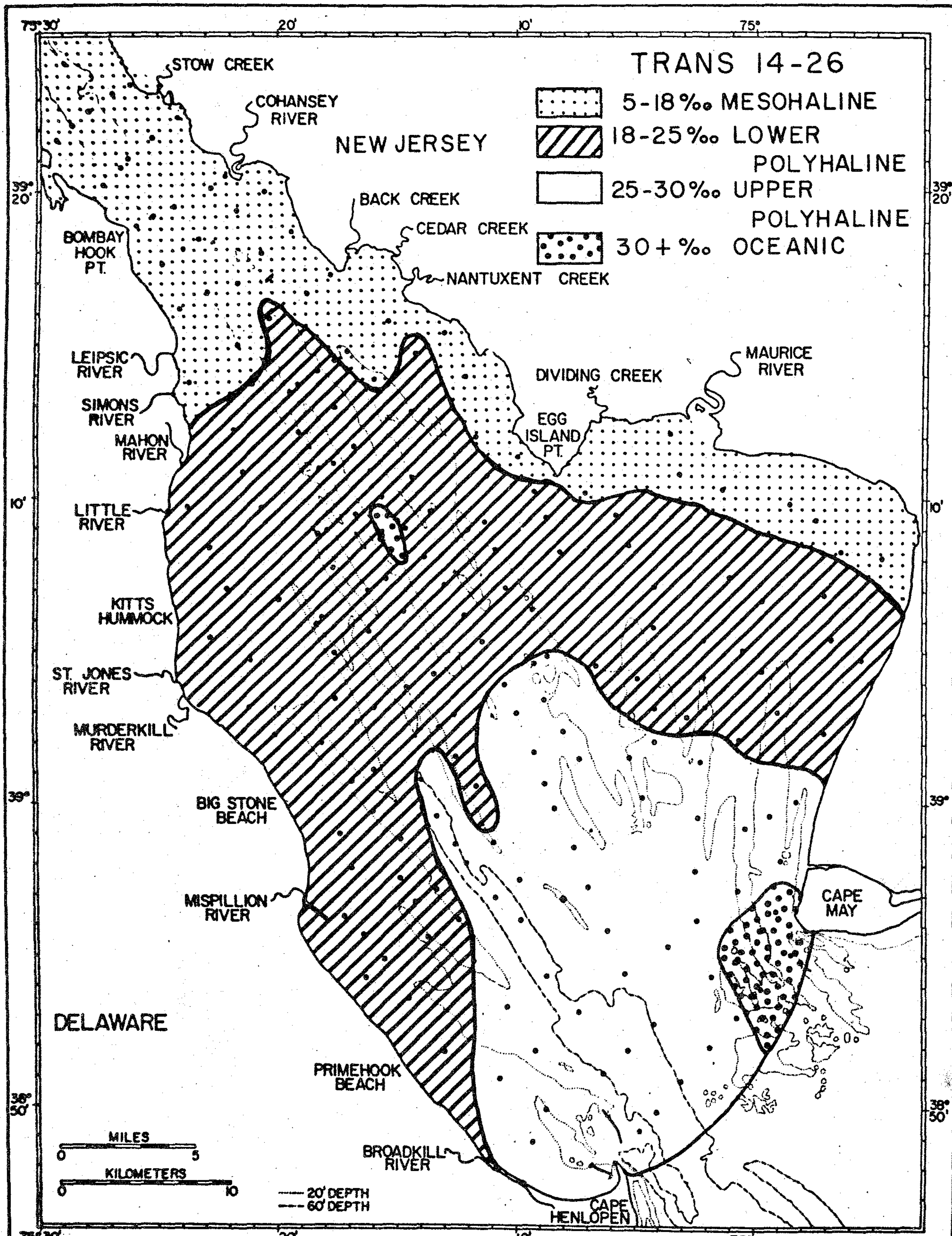

TRANS I - 13
5-18‰ MESOHALINE
18-25‰ LOWER POLYHALINE
25-30‰ UPPER POLYHALINE
30 +‰ OCEANIC
NEW JERSEY
DELAWARE
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
DIVIDING CREEK
EGG ISLAND PT.
MAURICE RIVER
CAPE MAY
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'

Figure I-3



TRANS 14-26
5-18‰ MESOHALINE
18-25‰ LOWER POLYHALINE
25-30‰ UPPER POLYHALINE
30+‰ OCEANIC
NEW JERSEY
DELAWARE
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
CAPE MAY
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'

Figure I-4

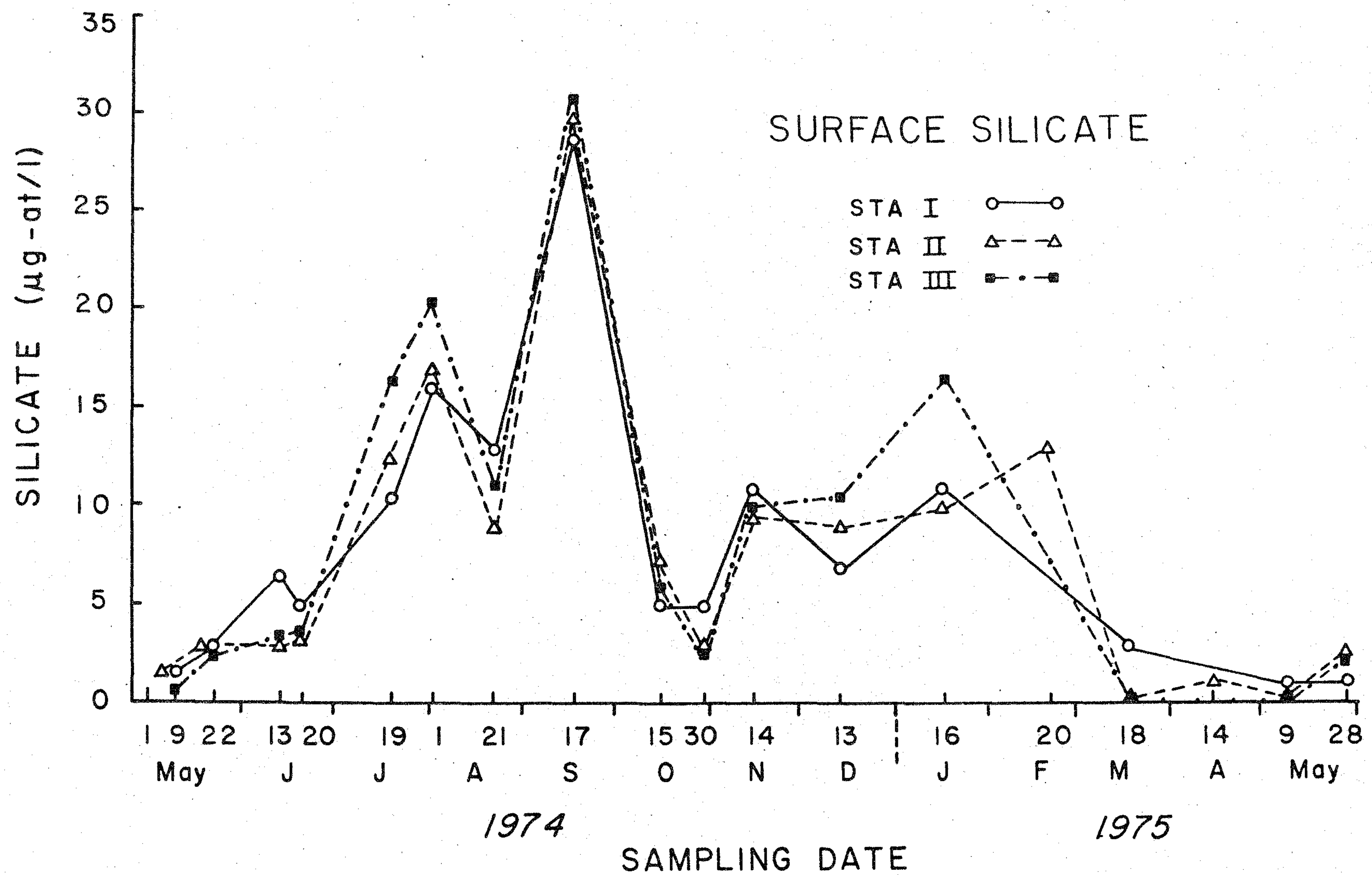

SURFACE SILICATE
STA I
STA II
STA III
SILICATE (µg-at/l)
35
30
25
20
15
10
5
0
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure I-5

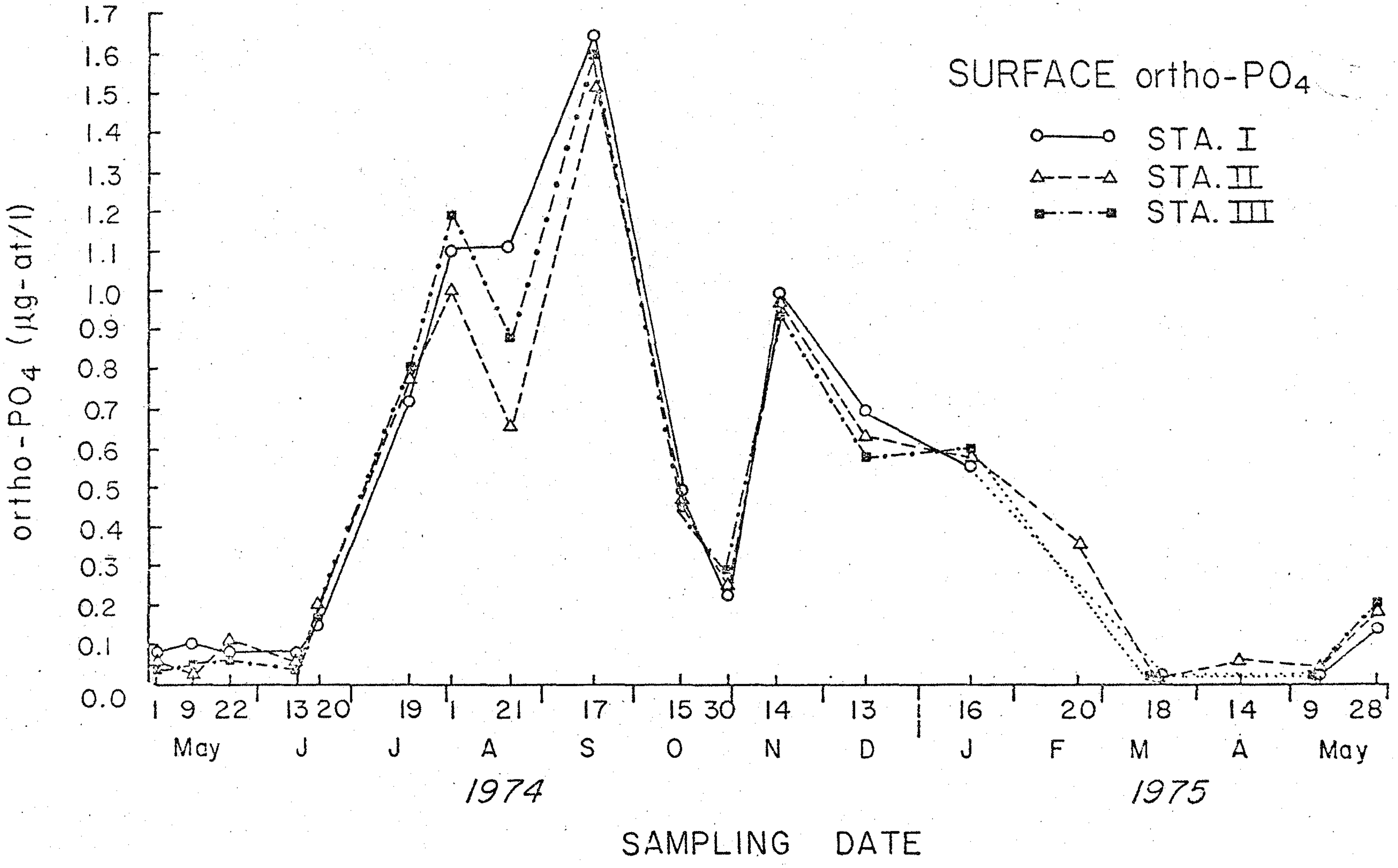

SURFACE ortho-PO4
STA. I
STA. II
STA. III
ortho-PO4 (µg-at/l)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure I-6

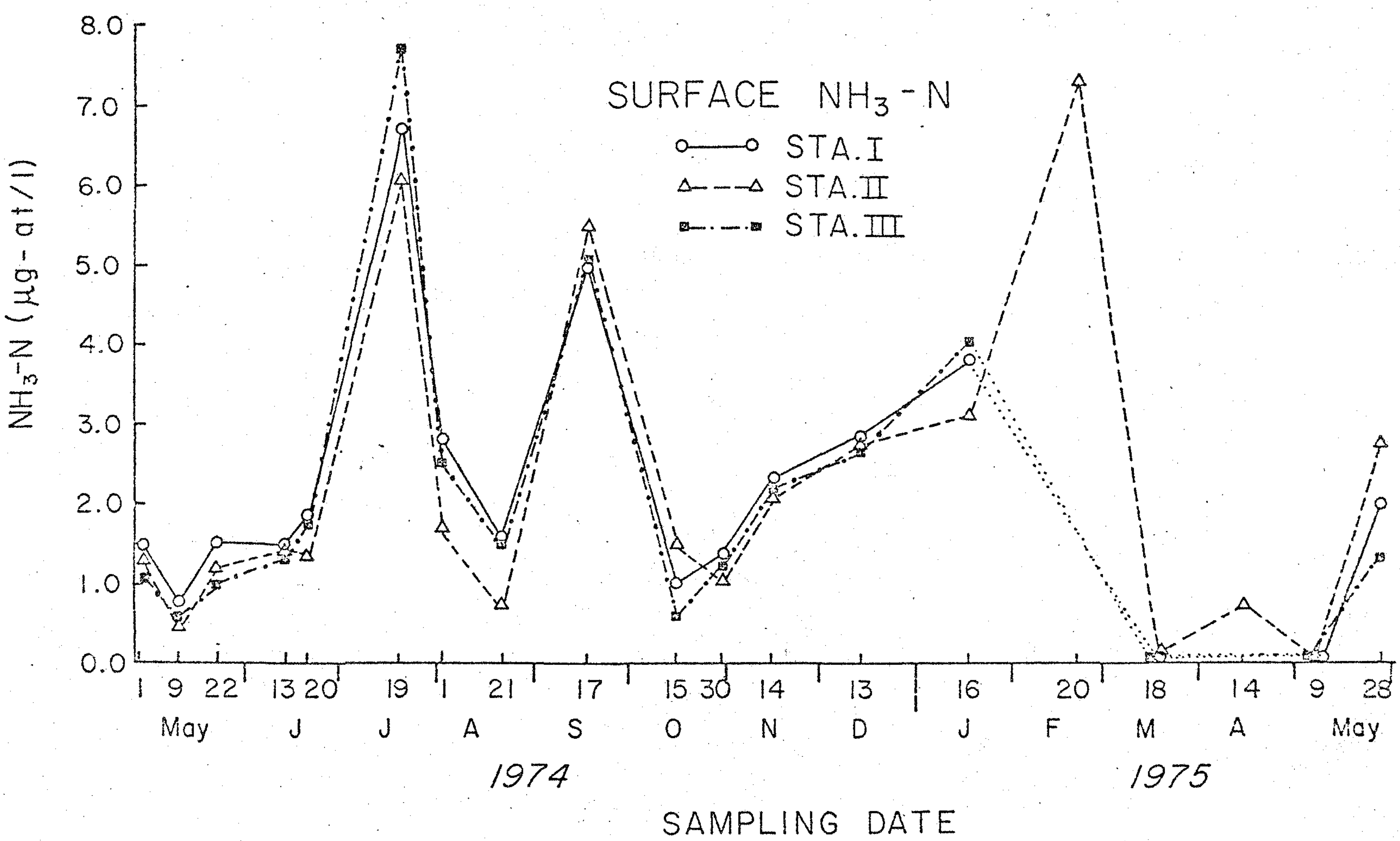

SURFACE NH_3-N
STA. I
STA. II
STA. III
NH_3-N (μg-at/l)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure I-7

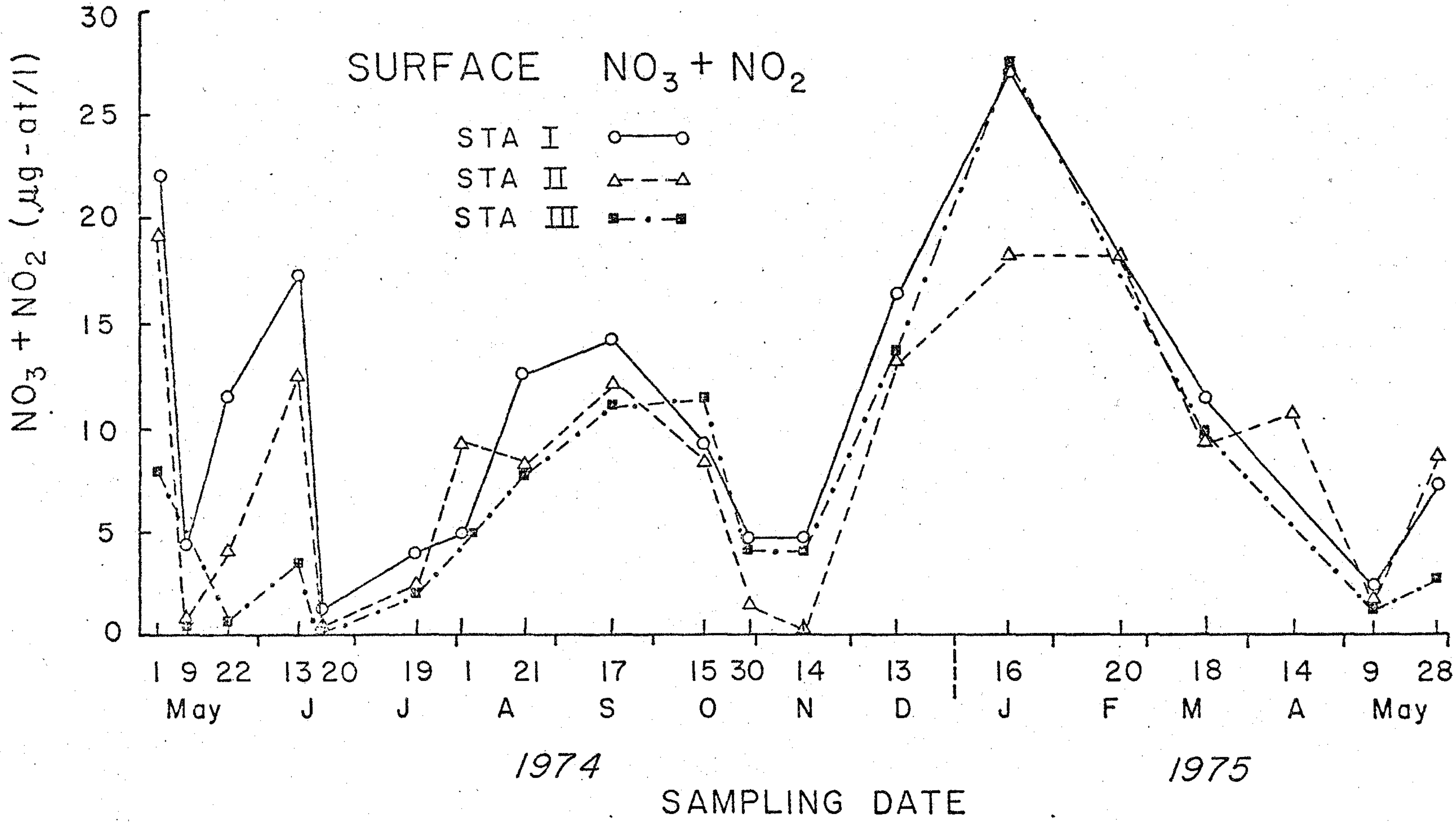

SURFACE $NO_3 + NO_2$
STA I
STA II
STA III
$NO_3 + NO_2$ (µg-at/l)
30
25
20
15
10
5
0
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure I-8

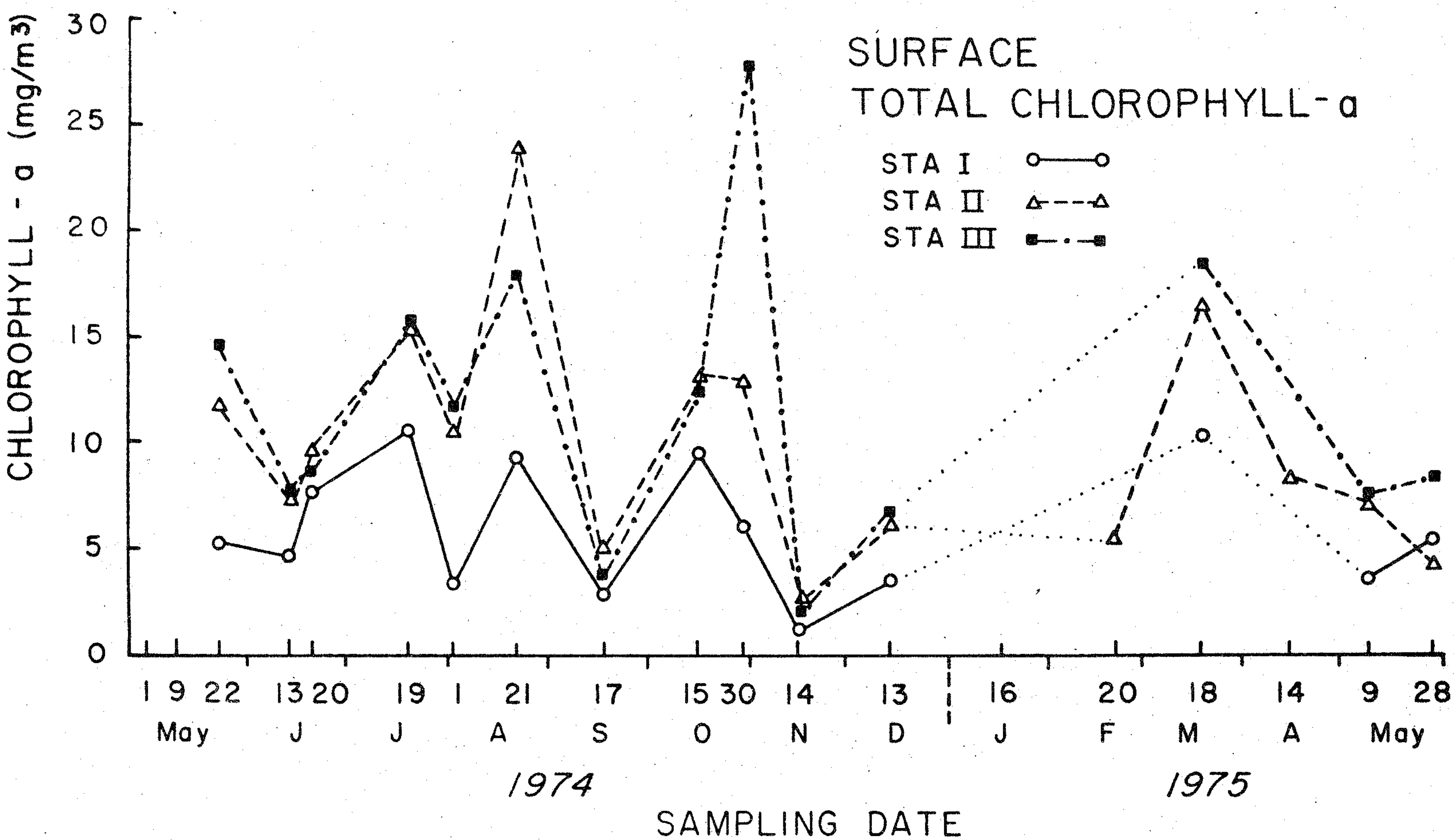

SURFACE
TOTAL CHLOROPHYLL-a
STA I
STA II
STA III
CHLOROPHYLL - a (mg/m3)
0
5
10
15
20
25
30
1 9 22
May
13 20
J
19
J
1 21
A
17
S
15 30
O
14
N
13
D
16
J
20
F
18
M
14
A
9 28
May
1974
1975
SAMPLING DATE

Figure I-9

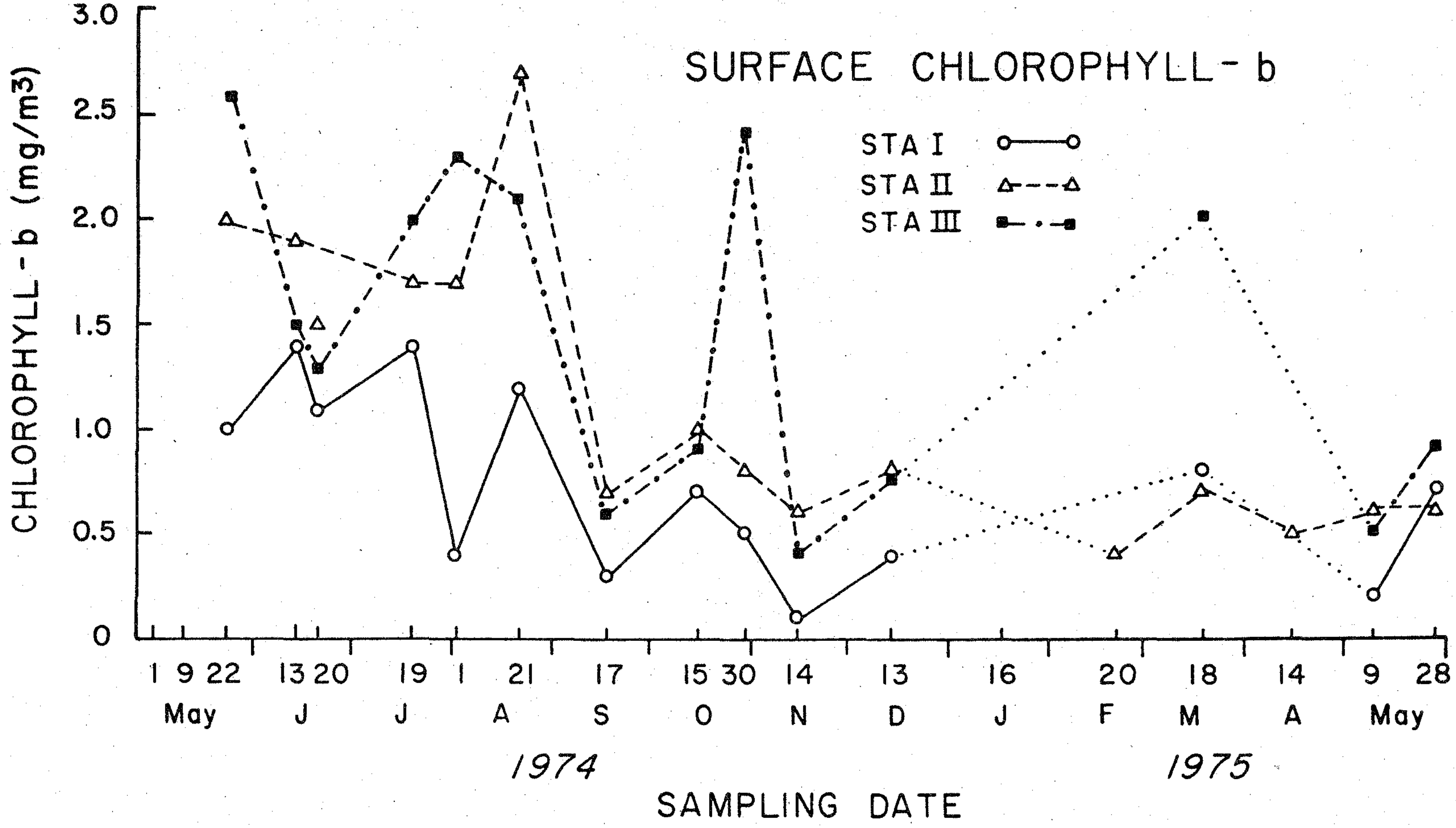

SURFACE CHLOROPHYLL- b
STA I
STA II
STA III
CHLOROPHYLL - b (mg/m³)
3.0
2.5
2.0
1.5
1.0
0.5
0
1 9 22
May
13 20
J
19
J
1 21
A
17
S
15 30
O
14
N
13
D
16
J
20
F
18
M
14
A
9 28
May
1974
1975
SAMPLING DATE

Figure I-10

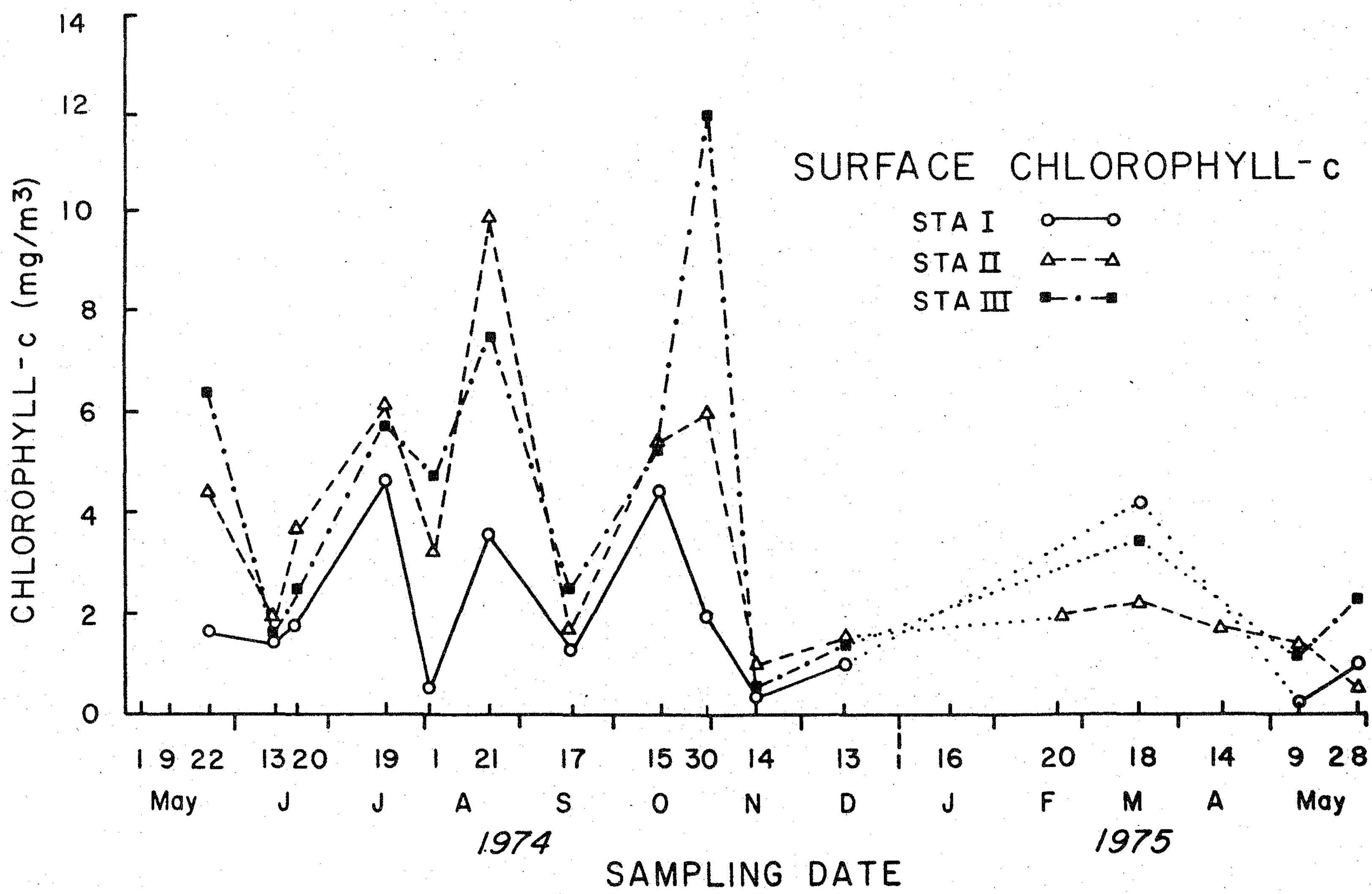

SURFACE CHLOROPHYLL-c
STA I
STA II
STA III
CHLOROPHYLL-c (mg/m³)
14
12
10
8
6
4
2
0
1 9 22
May
13 20
J
19
J
1
21
A
17
S
15 30
O
14
N
13
D
16
J
20
F
18
M
14
A
9 28
May
1974
1975
SAMPLING DATE

Figure I-11

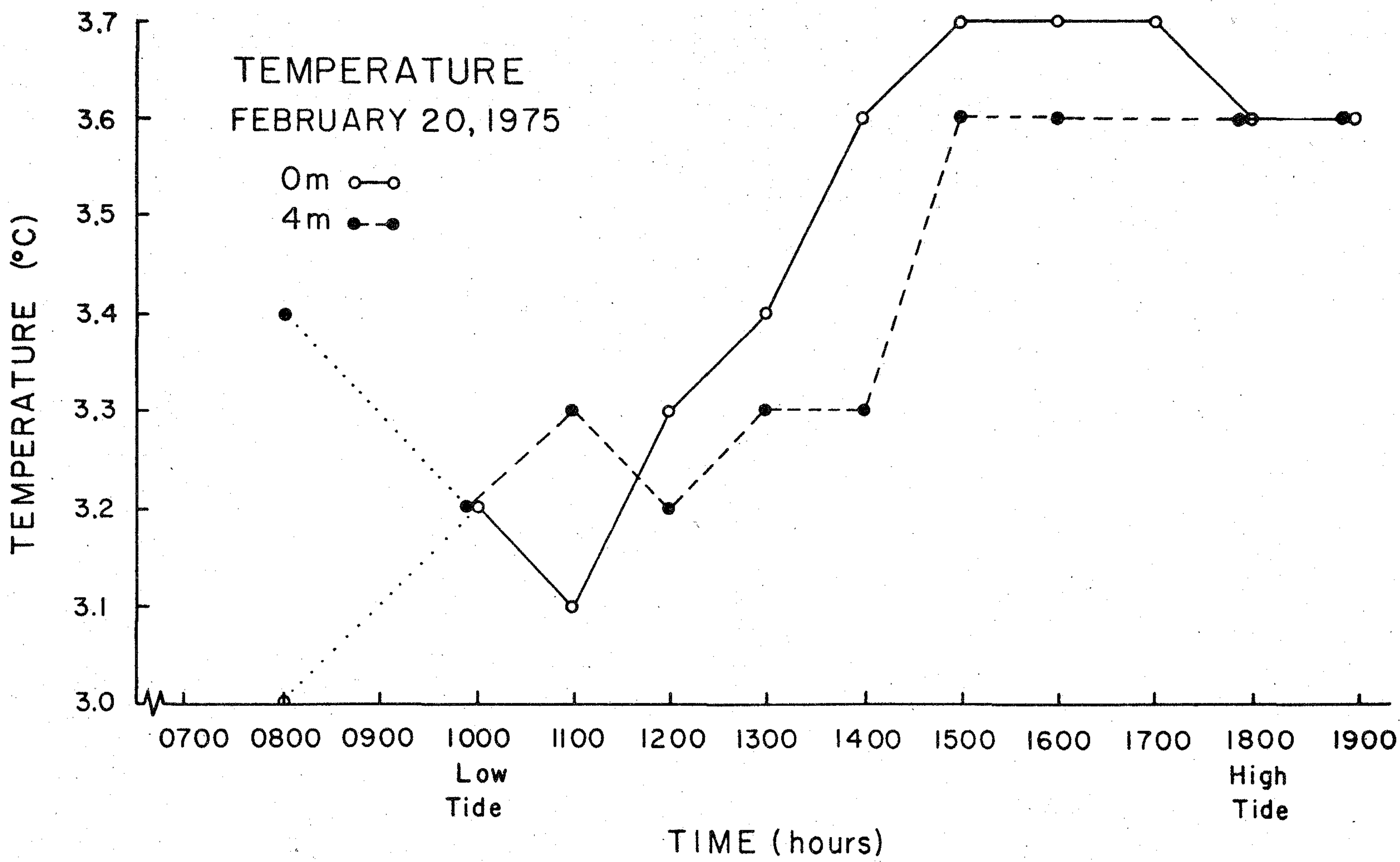

TEMPERATURE
FEBRUARY 20, 1975
0m
4m
TEMPERATURE (°C)
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
0700
0800
0900
1000
Low Tide
1100
1200
1300
1400
1500
1600
1700
1800
High Tide
1900
TIME (hours)

Figure I-12

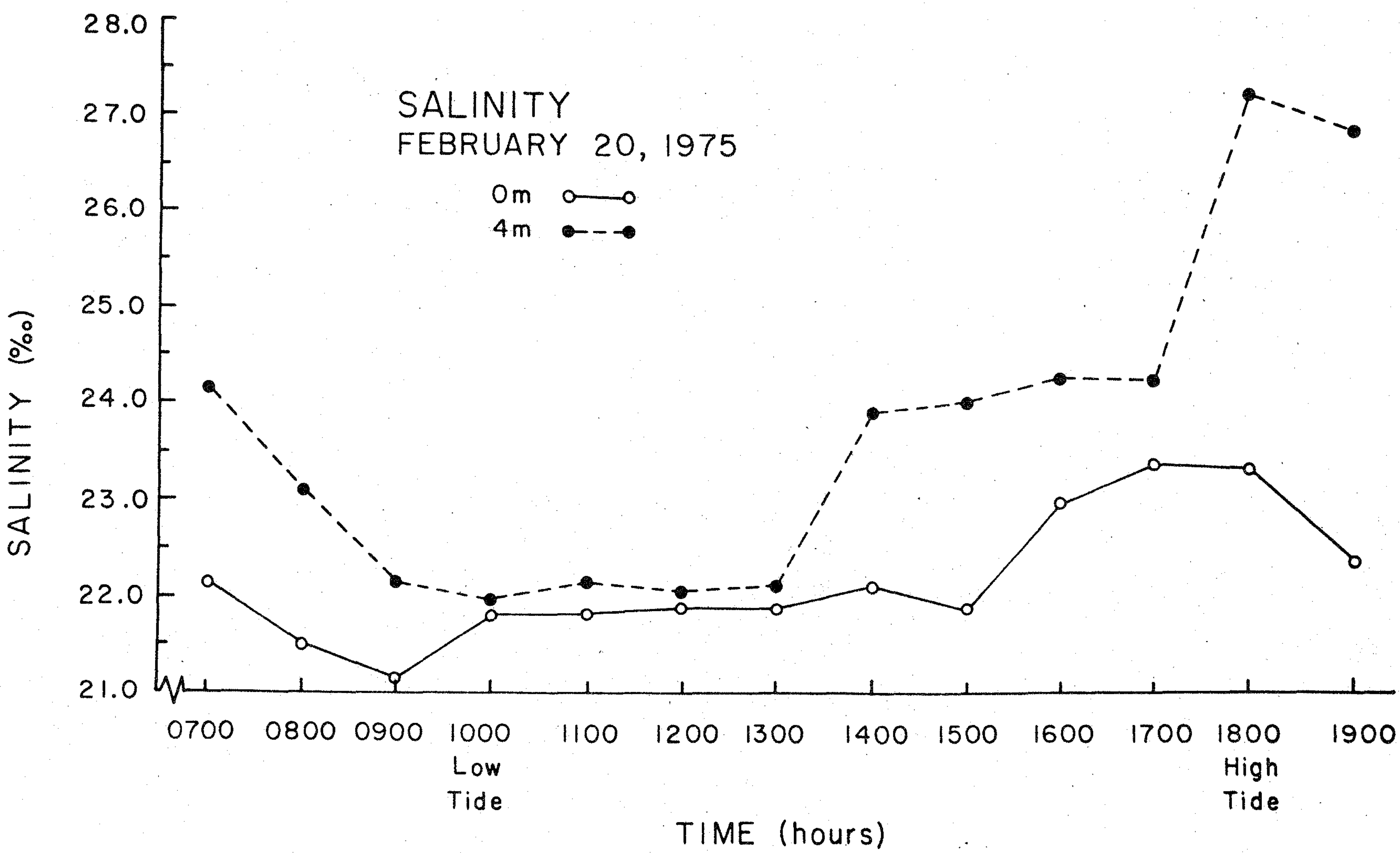

SALINITY
FEBRUARY 20, 1975
0m
4m
SALINITY (‰)
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
0700
0800
0900
1000
Low
Tide
1100
1200
1300
1400
1500
1600
1700
1800
High
Tide
1900
TIME (hours)

Figure I-13

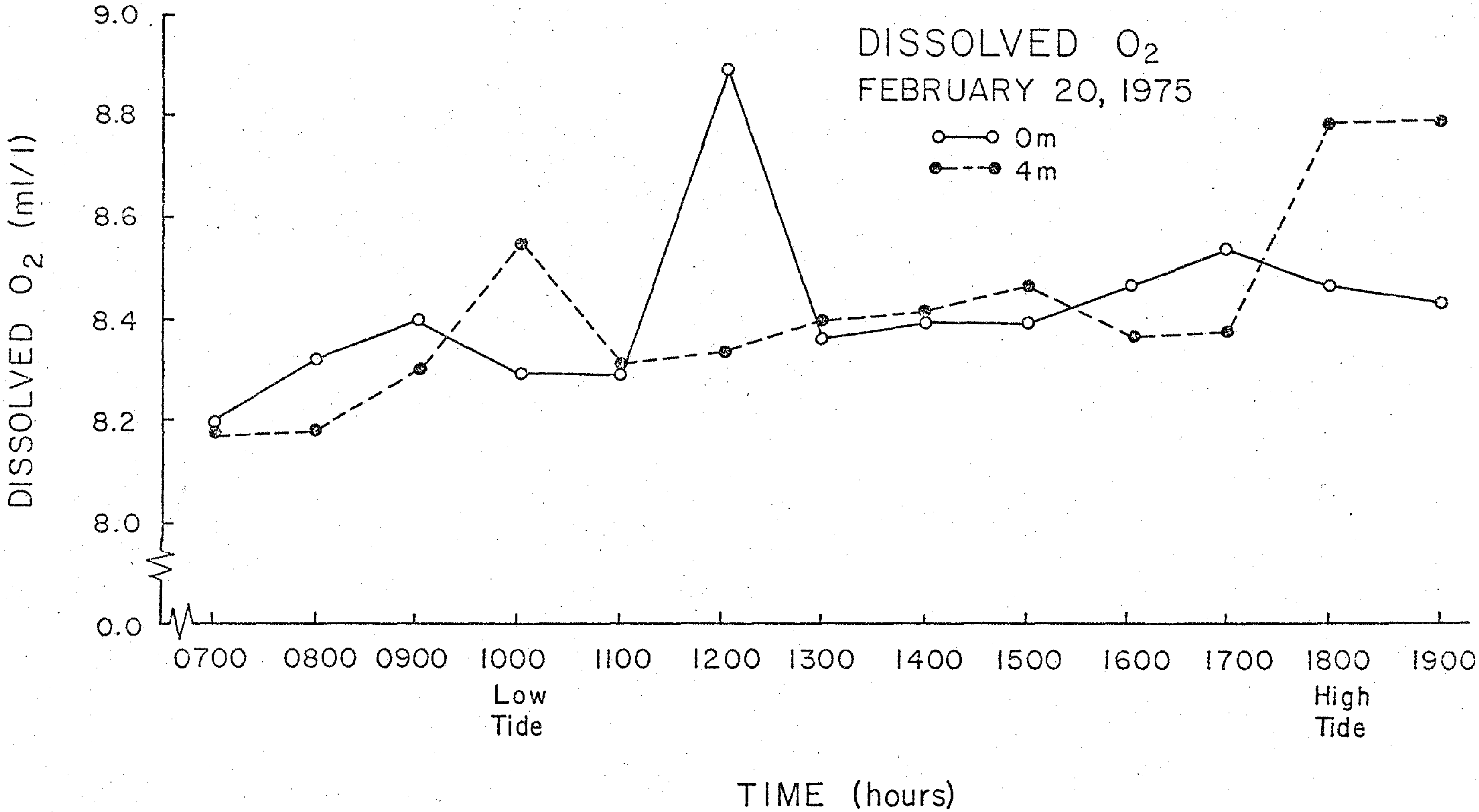

DISSOLVED O2
FEBRUARY 20, 1975
0m
4m
DISSOLVED O2 (ml/l)
9.0
8.8
8.6
8.4
8.2
8.0
0.0
0700
0800
0900
1000
Low Tide
1100
1200
1300
1400
1500
1600
1700
1800
High Tide
1900
TIME (hours)

Figure I-14

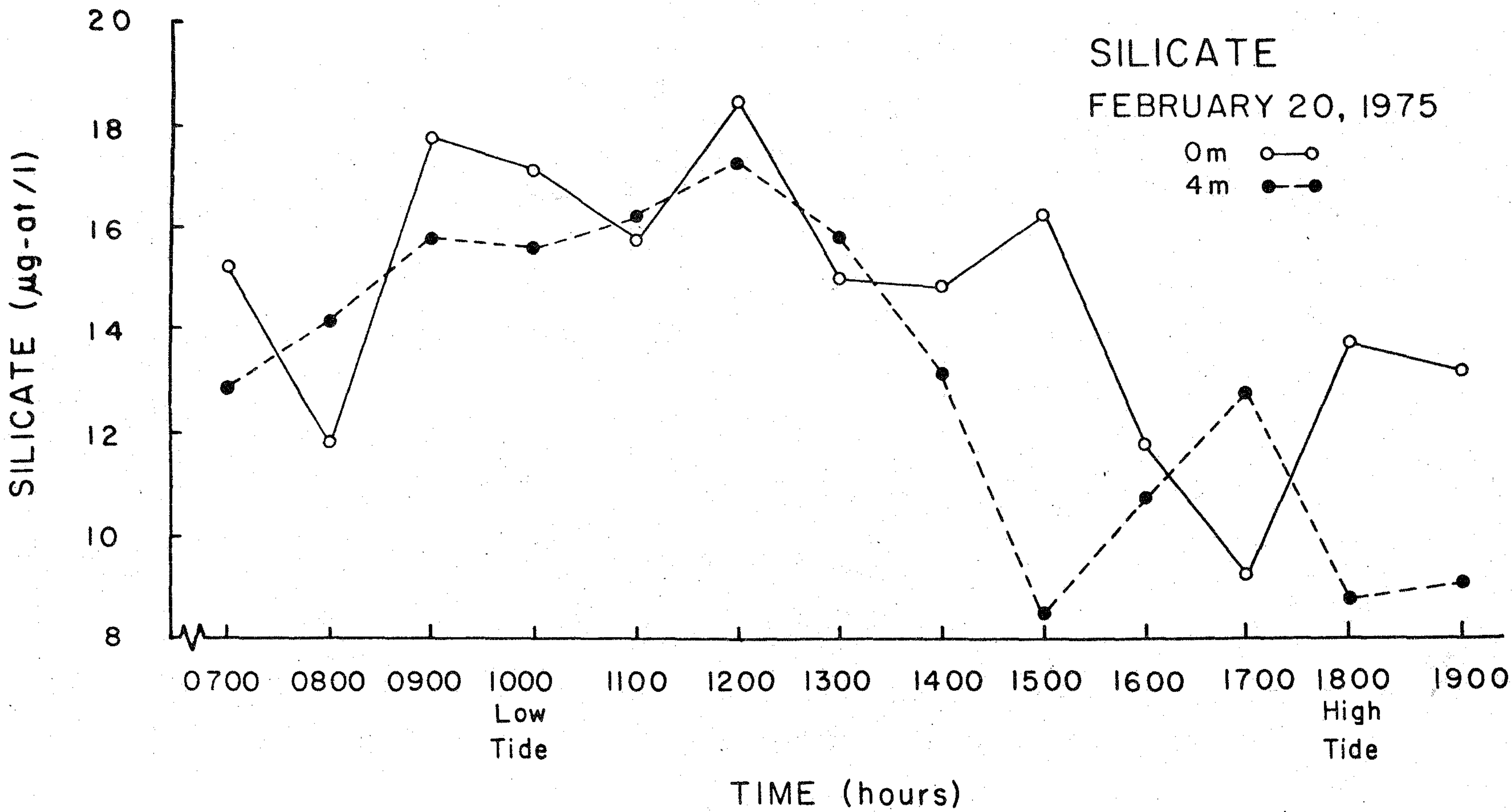

SILICATE
FEBRUARY 20, 1975
0m
4m
SILICATE (µg-at/l)
20
18
16
14
12
10
8
0700
0800
0900
1000
Low
Tide
1100
1200
1300
1400
1500
1600
1700
1800
High
Tide
1900
TIME (hours)

Figure I-15

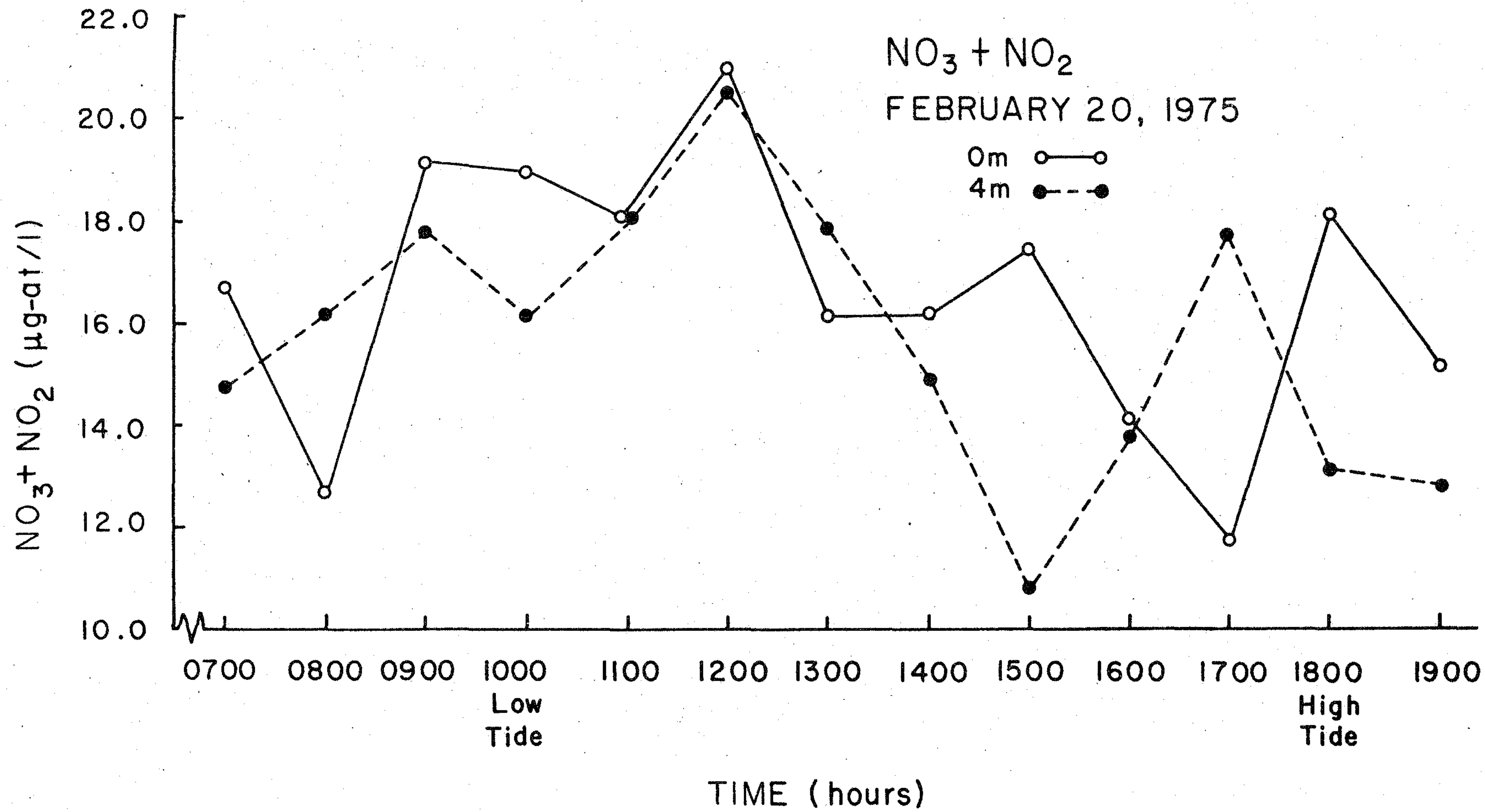

NO3 + NO2
FEBRUARY 20, 1975
0m
4m
22.0
20.0
18.0
16.0
14.0
12.0
10.0
NO3+NO2 (µg-at/l)
0700
0800
0900
1000
Low Tide
1100
1200
1300
1400
1500
1600
1700
1800
High Tide
1900
TIME (hours)

Figure I-16

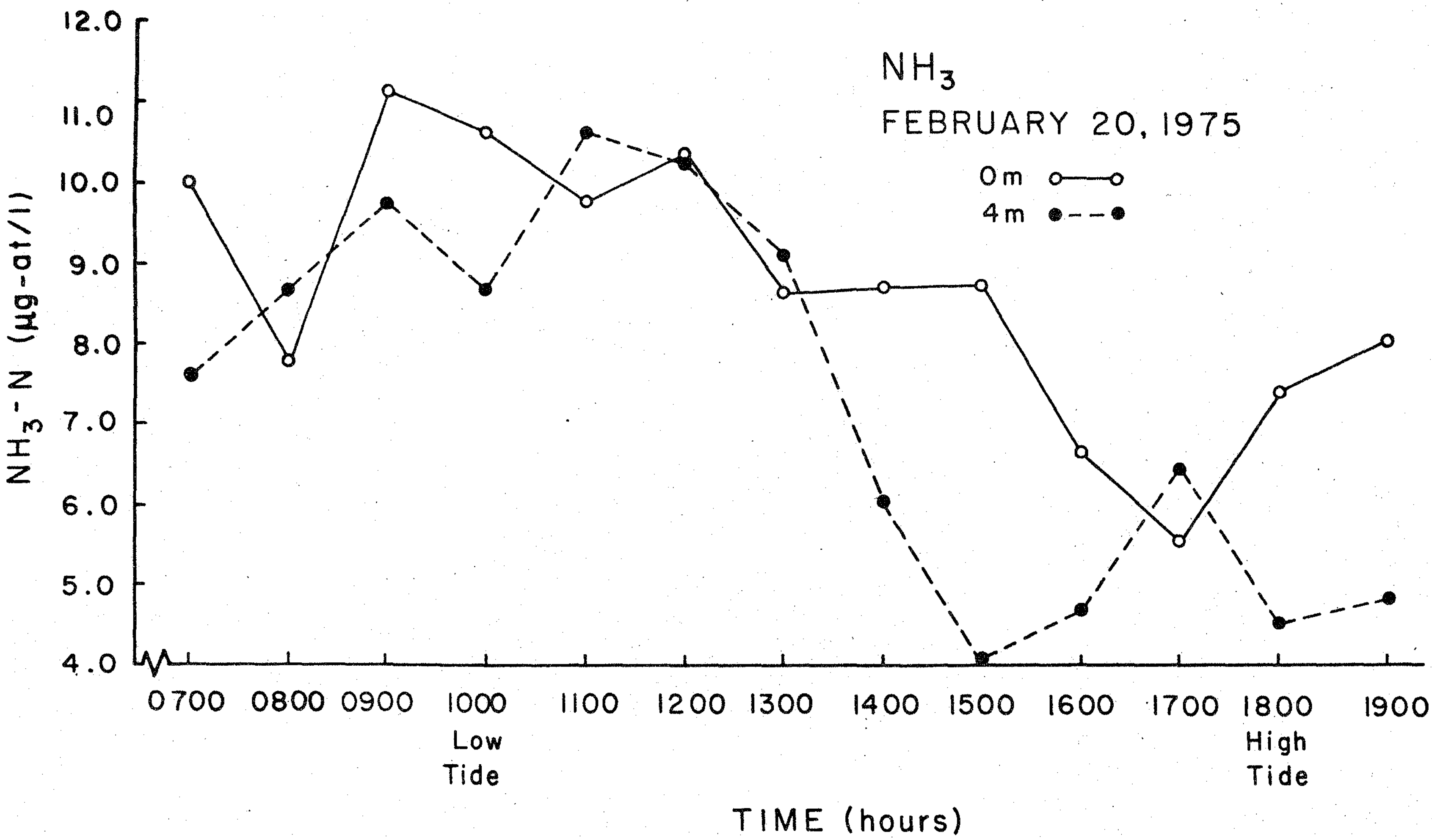

NH3
FEBRUARY 20, 1975
0m
4m
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
NH3-N (μg-at/l)
0700
0800
0900
1000
Low Tide
1100
1200
1300
1400
1500
1600
1700
1800
High Tide
1900
TIME (hours)

Figure I-17

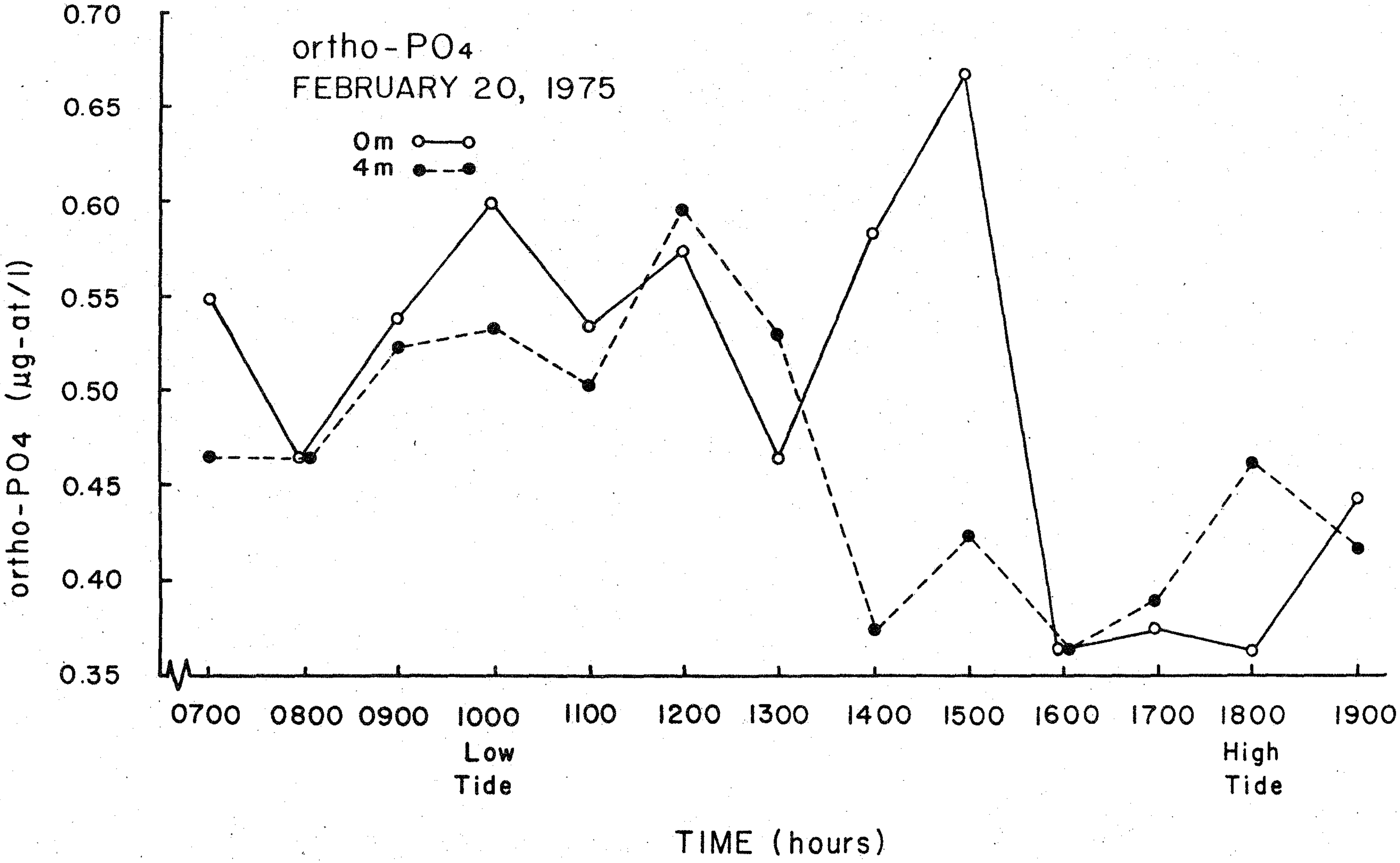

ortho-PO4
FEBRUARY 20, 1975
0m
4m
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
ortho-PO4 (µg-at/l)
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Low Tide
High Tide
TIME (hours)

Figure I-18

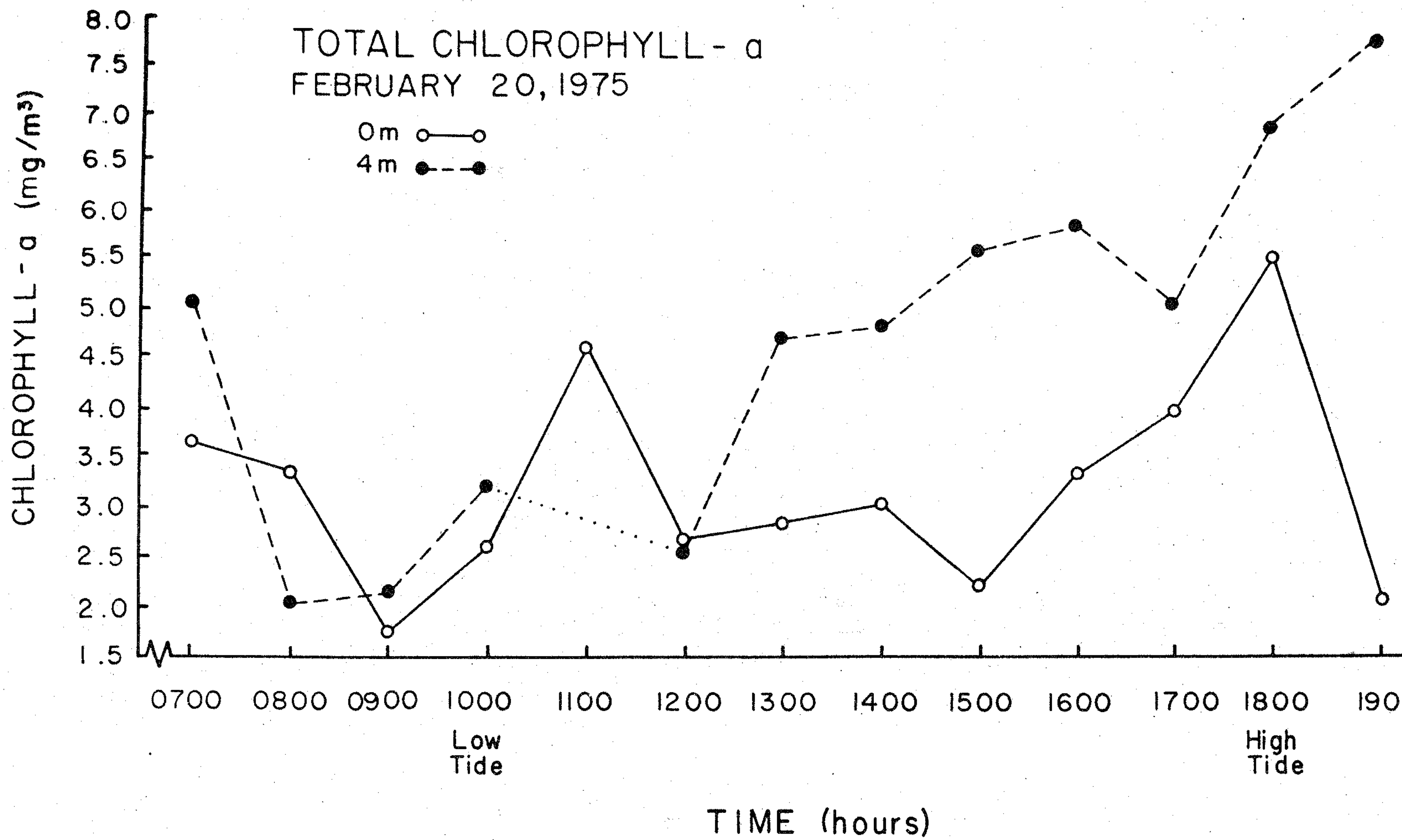

TOTAL CHLOROPHYLL - a
FEBRUARY 20, 1975
0m
4m
CHLOROPHYLL - a (mg/m³)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Low Tide
High Tide
TIME (hours)

Figure I-19

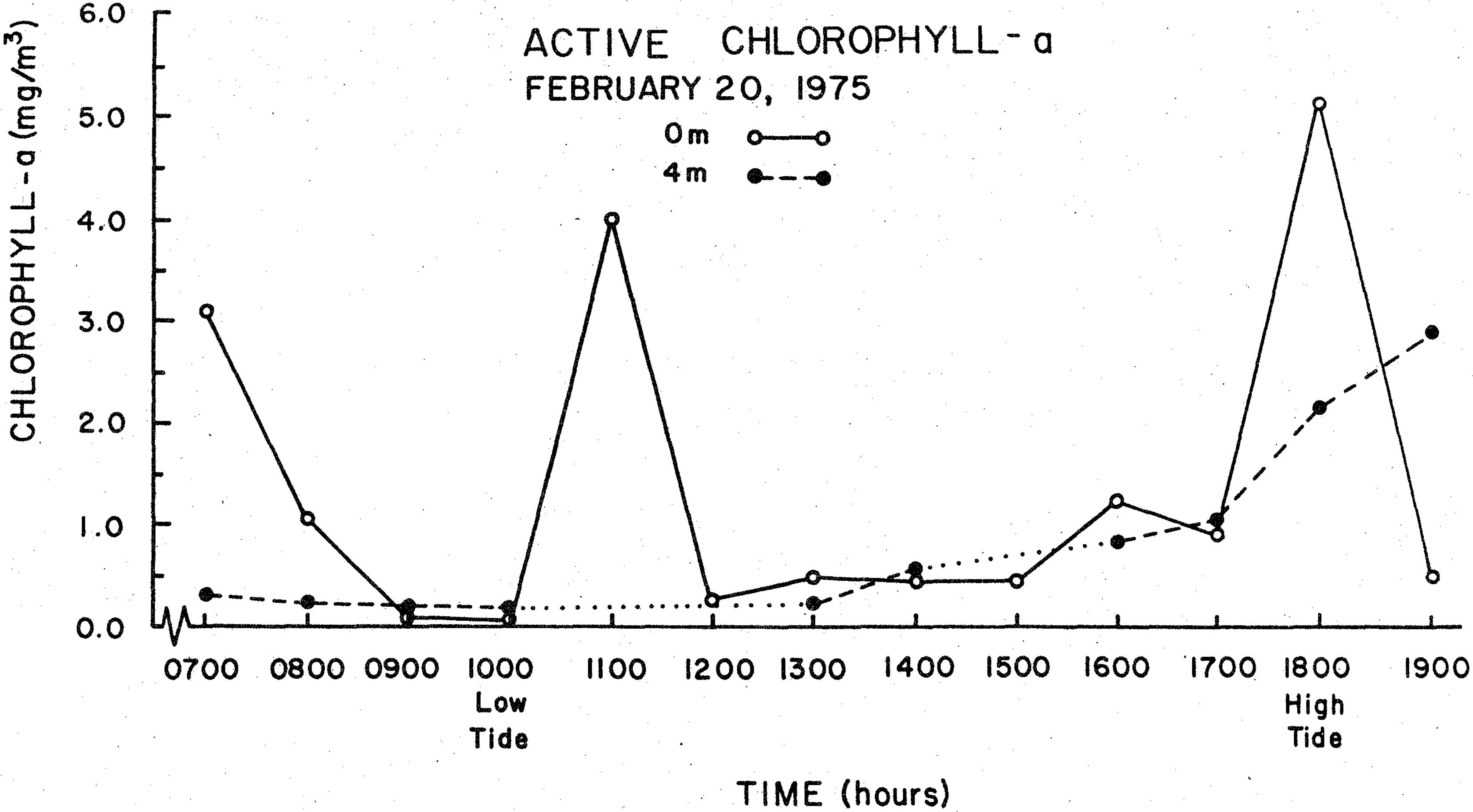

ACTIVE CHLOROPHYLL - a
FEBRUARY 20, 1975
0m
4m
CHLOROPHYLL - a (mg/m³)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0700
0800
0900
1000
Low Tide
1100
1200
1300
1400
1500
1600
1700
1800
High Tide
1900
TIME (hours)

Figure I-20

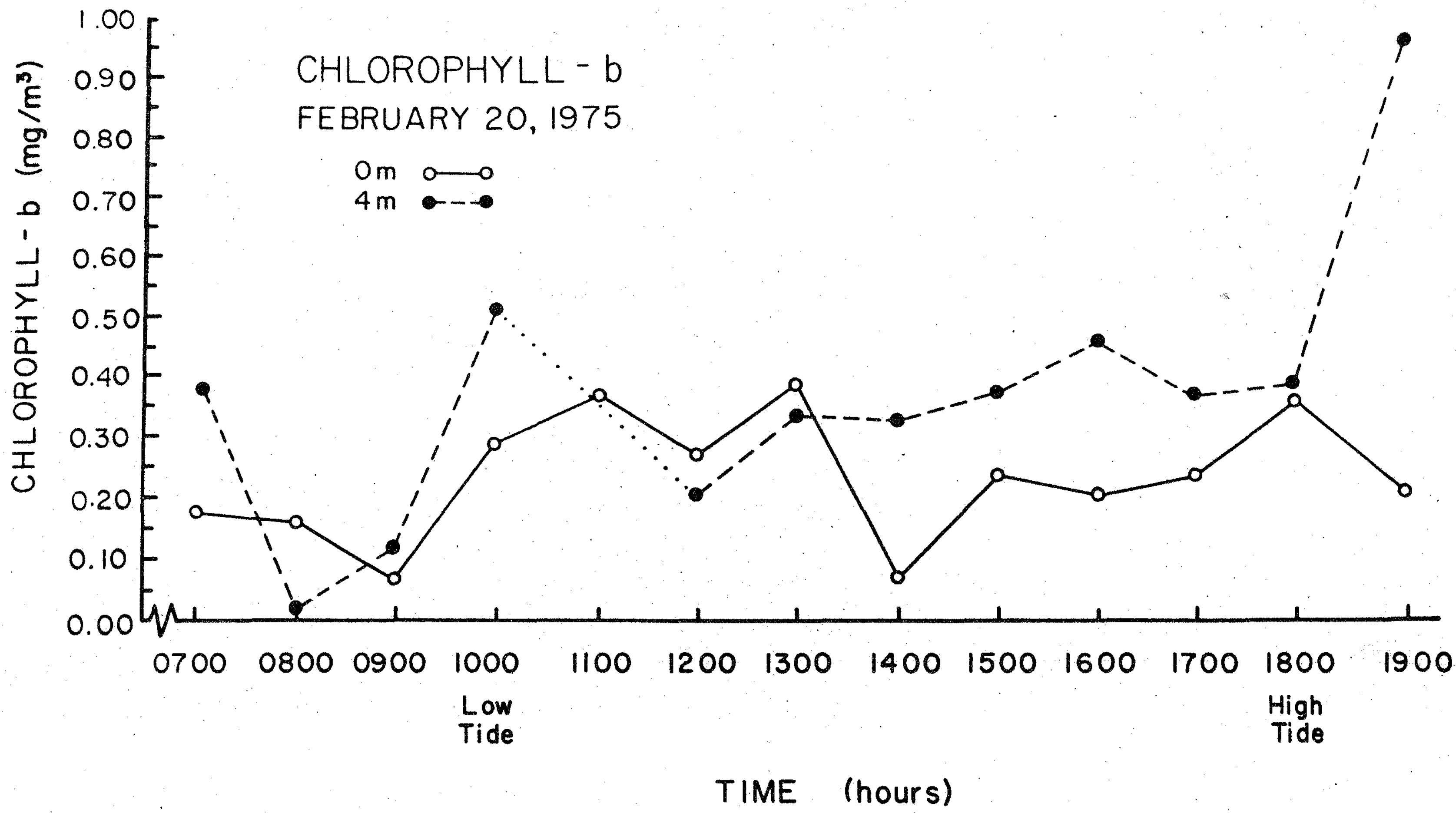

CHLOROPHYLL - b
FEBRUARY 20, 1975
0m
4m
CHLOROPHYLL - b (mg/m³)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Low Tide
High Tide
TIME (hours)

Figure I-21

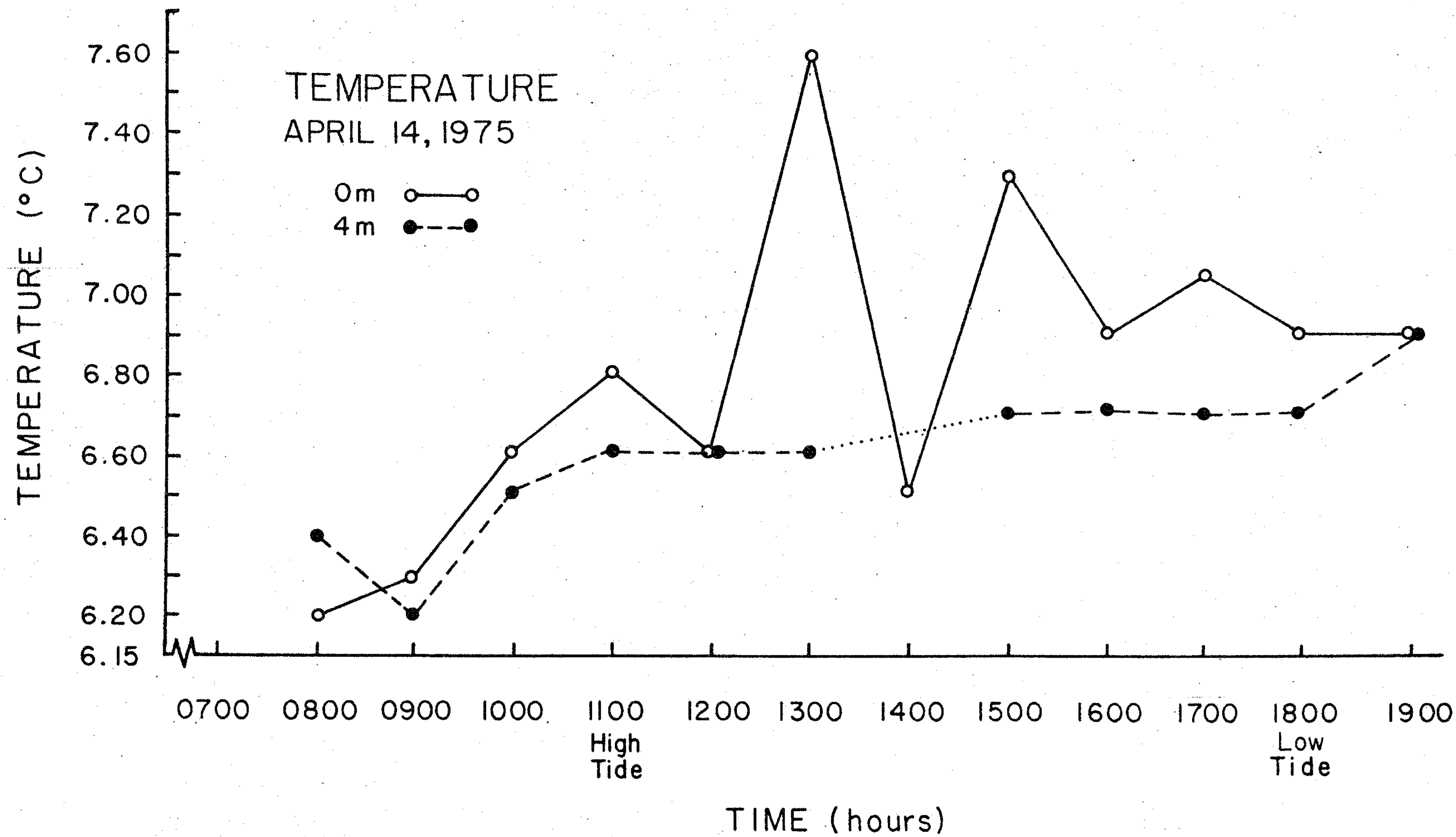

TEMPERATURE
APRIL 14, 1975
0m
4m
TEMPERATURE (°C)
7.60
7.40
7.20
7.00
6.80
6.60
6.40
6.20
6.15
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-22

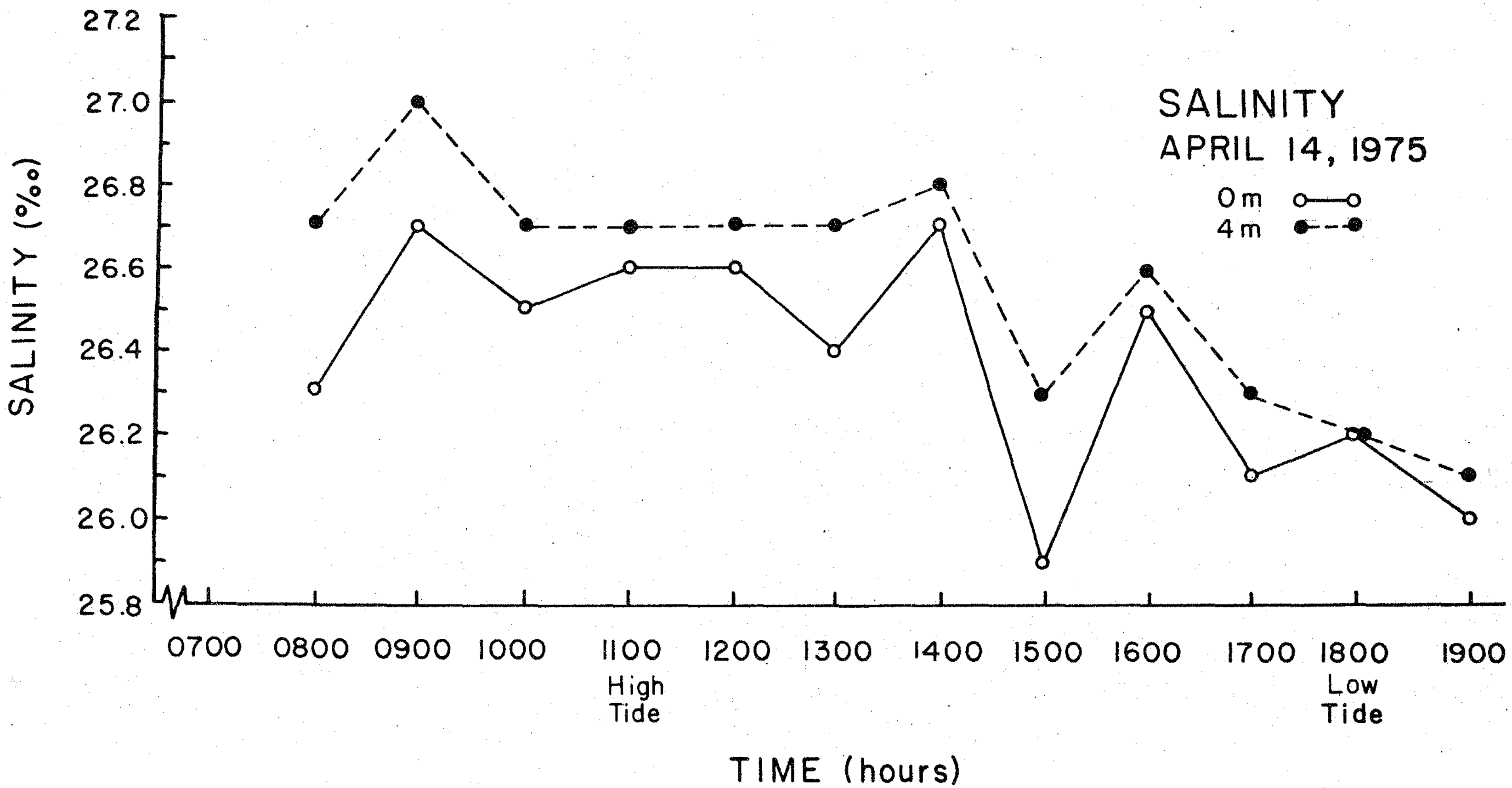

SALINITY
APRIL 14, 1975
0 m
4 m
SALINITY (‰)
27.2
27.0
26.8
26.6
26.4
26.2
26.0
25.8
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-23

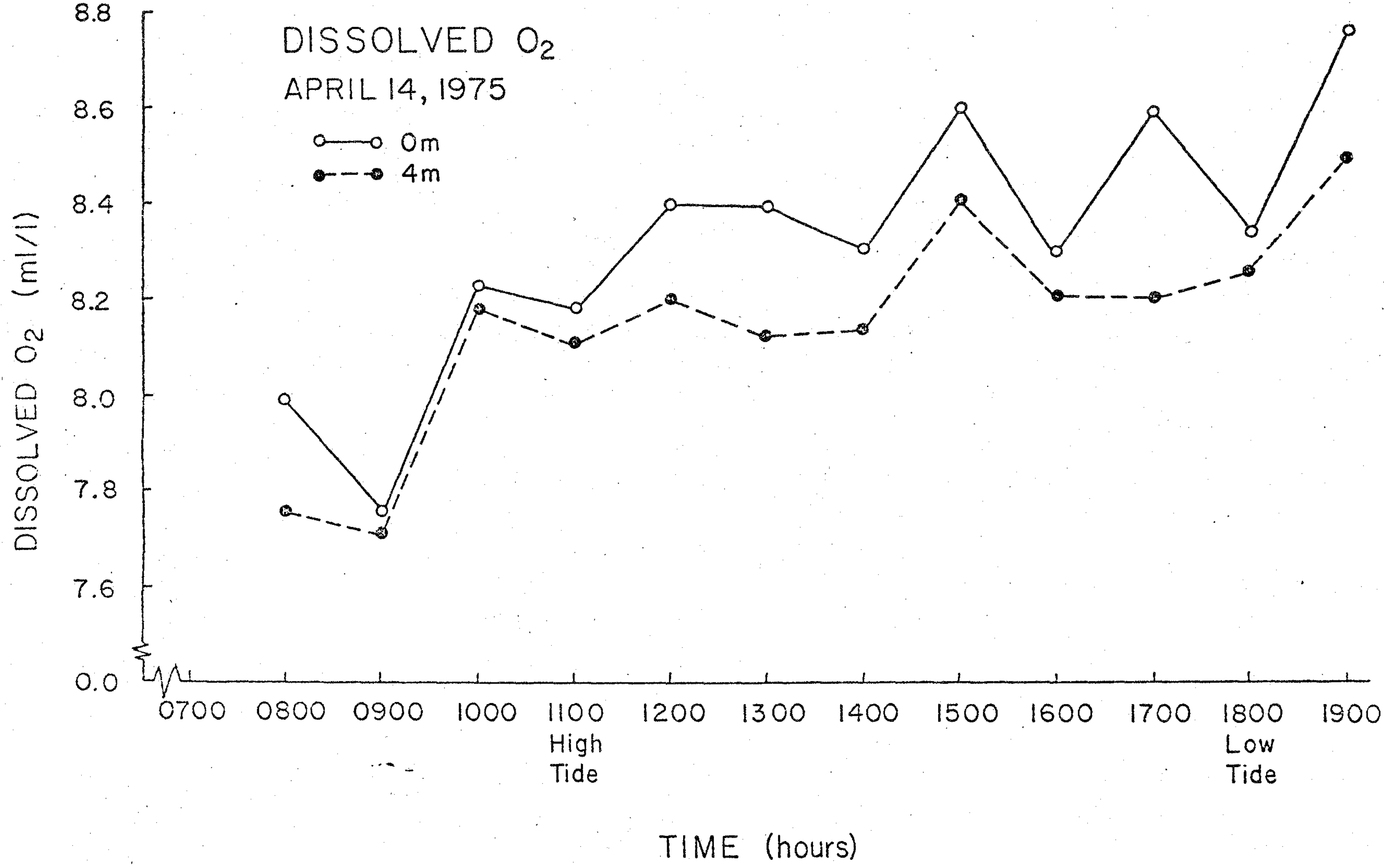

DISSOLVED O_2
APRIL 14, 1975
0m
4m
DISSOLVED O_2 (ml/l)
8.8
8.6
8.4
8.2
8.0
7.8
7.6
0.0
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-24

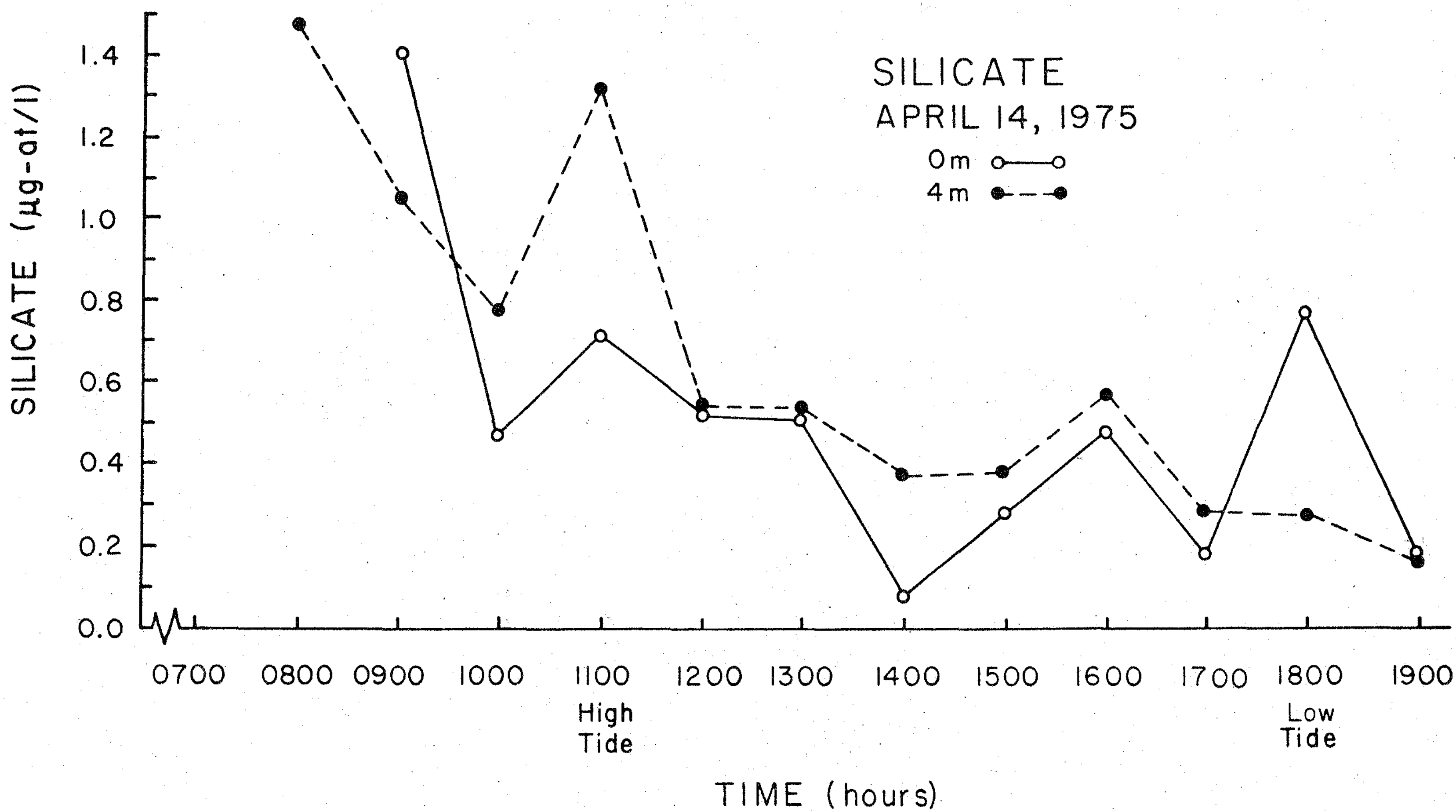
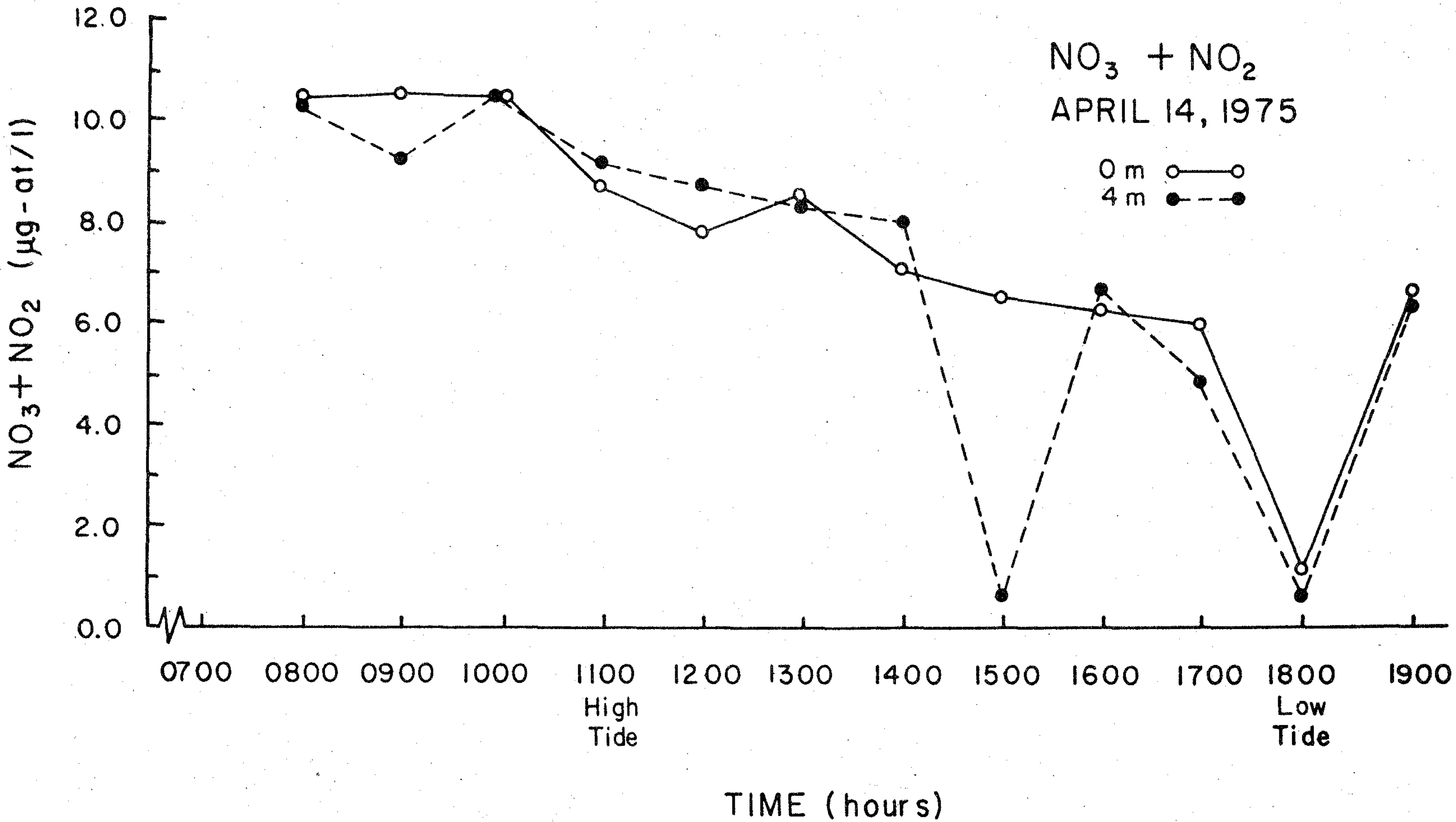

SILICATE
APRIL 14, 1975
0m
4m
SILICATE (µg-at/l)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-25



NO3 + NO2
APRIL 14, 1975
0 m
4 m
12.0
10.0
8.0
6.0
4.0
2.0
0.0
NO3 + NO2 (µg-at/l)
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-26

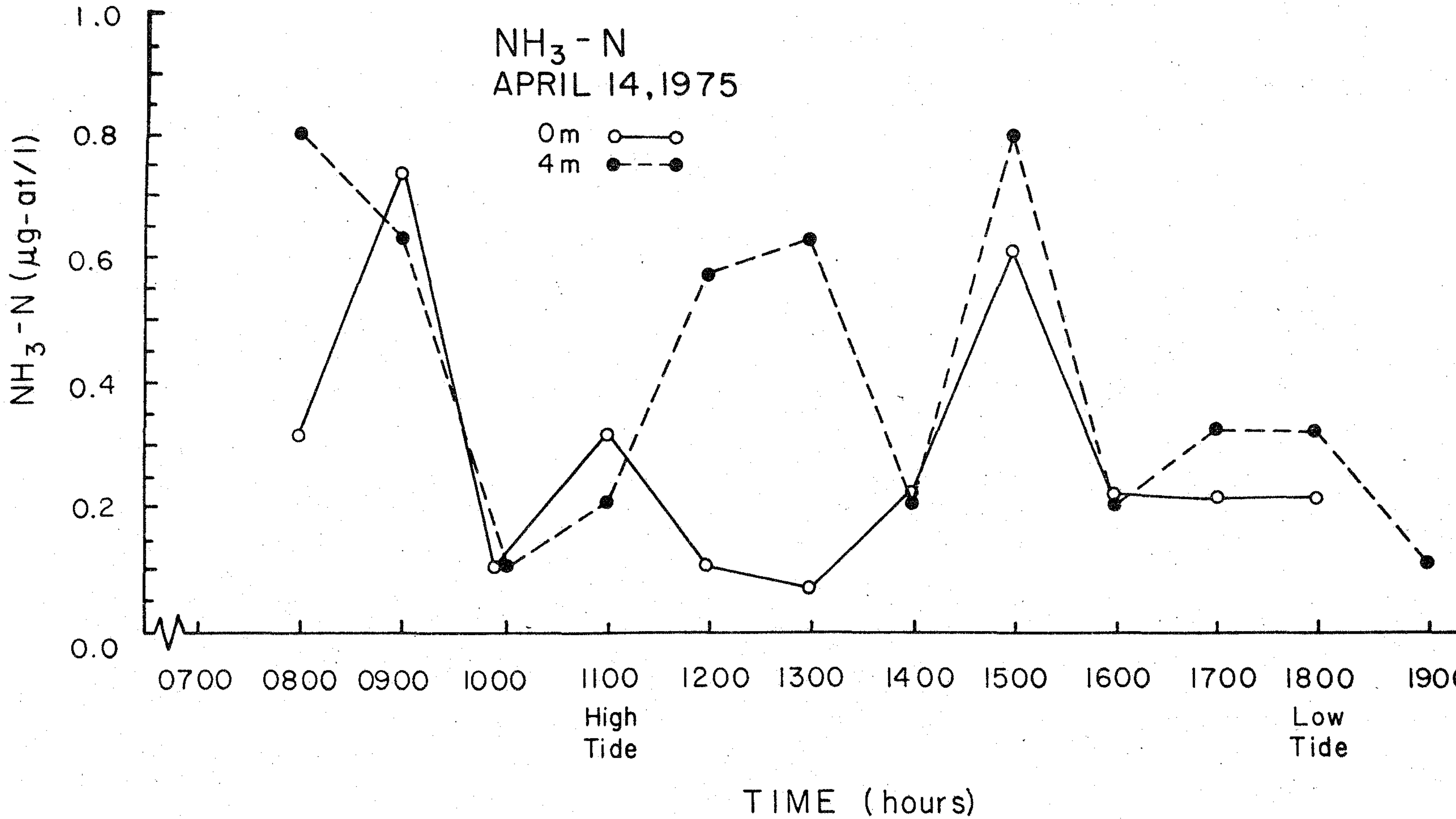

NH$_3$ - N
APRIL 14, 1975
0 m
4 m
NH$_3$-N (μg-at/l)
1.0
0.8
0.6
0.4
0.2
0.0
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
High Tide
Low Tide
TIME (hours)

Figure I-27

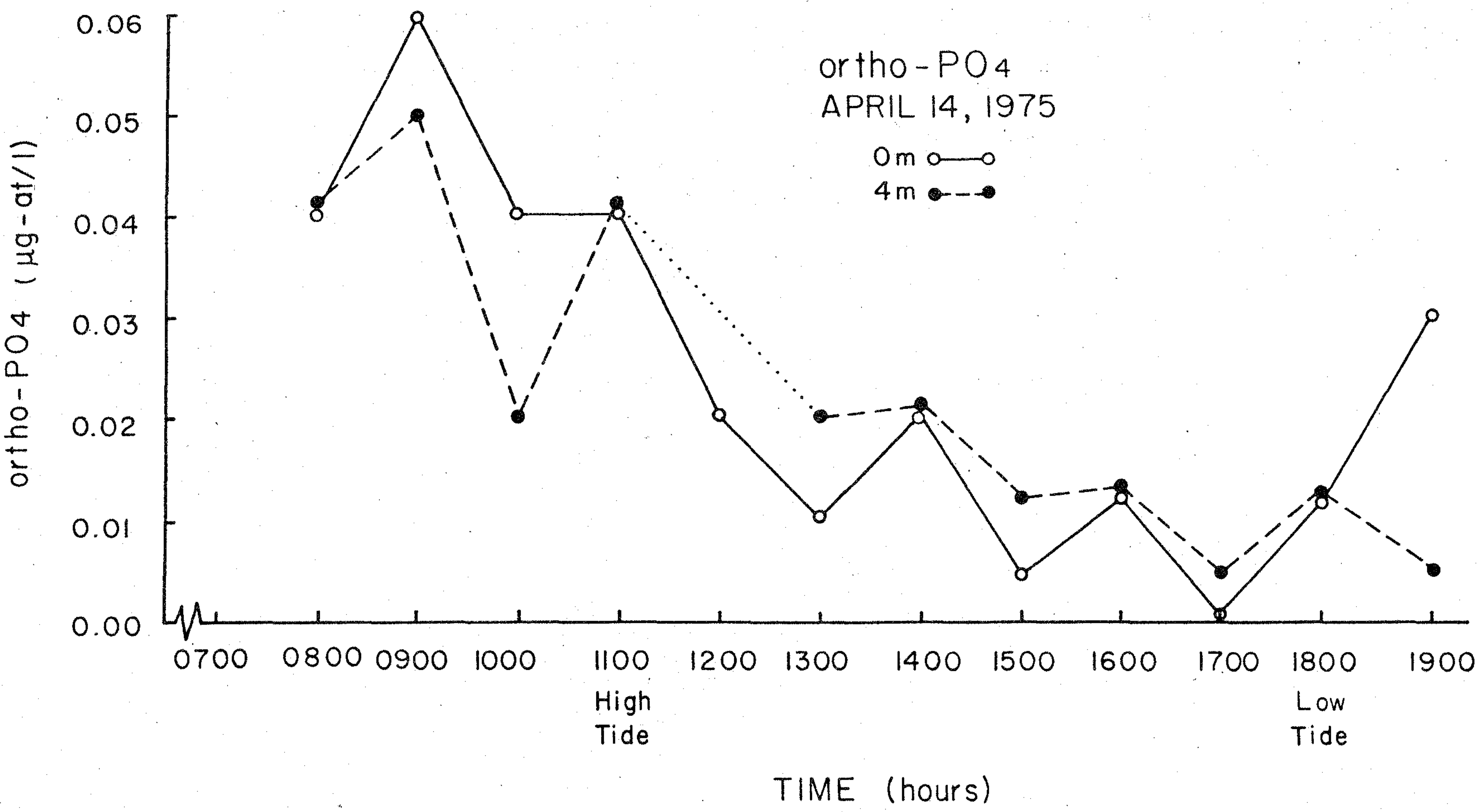
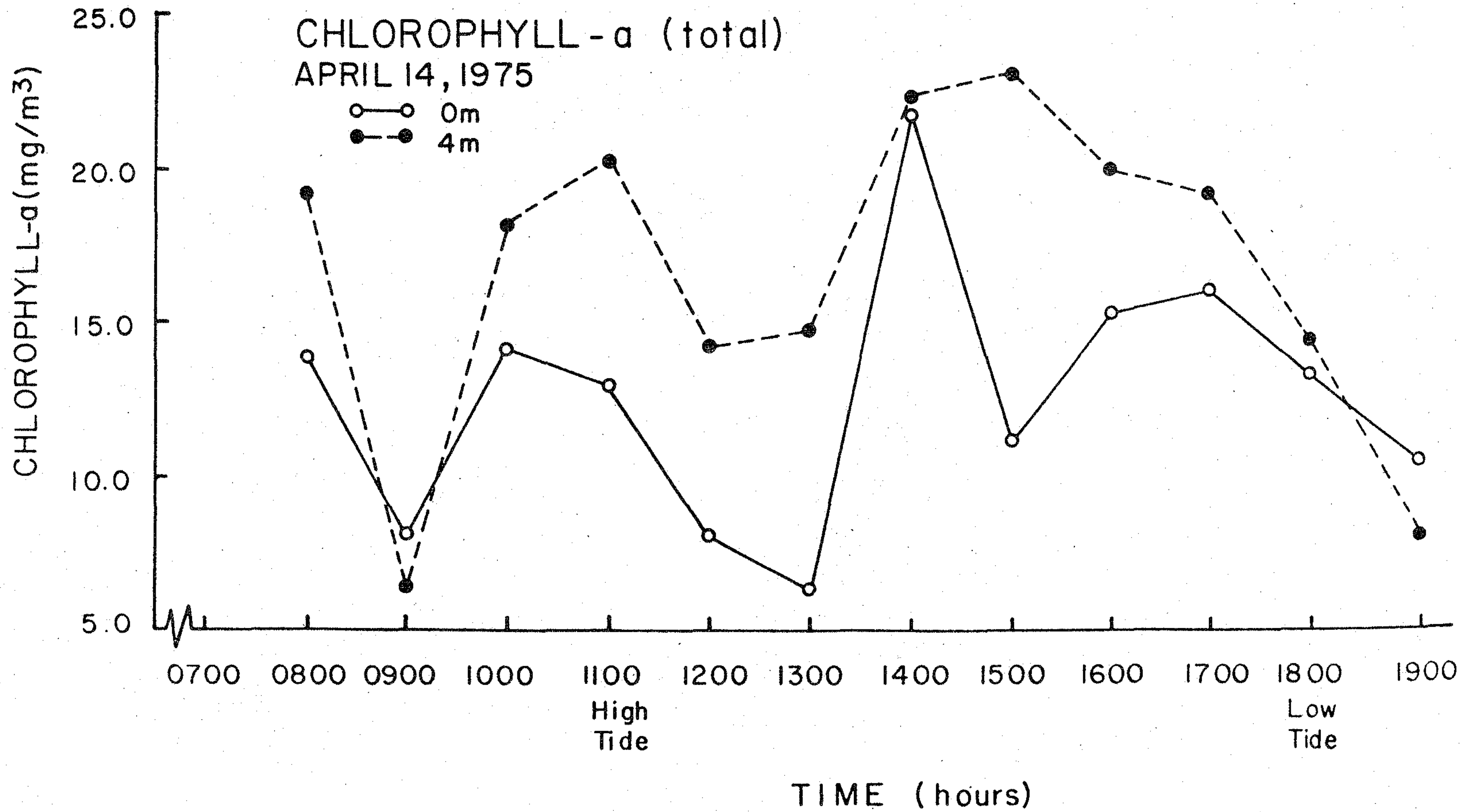

ortho-PO4
APRIL 14, 1975
0m
4m
0.06
0.05
0.04
0.03
0.02
0.01
0.00
ortho-PO4 (µg-at/l)
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-28



CHLOROPHYLL - a (total)
APRIL 14, 1975
0m
4m
25.0
20.0
15.0
10.0
5.0
CHLOROPHYLL-a (mg/m3)
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
High Tide
Low Tide
TIME (hours)

Figure I-29

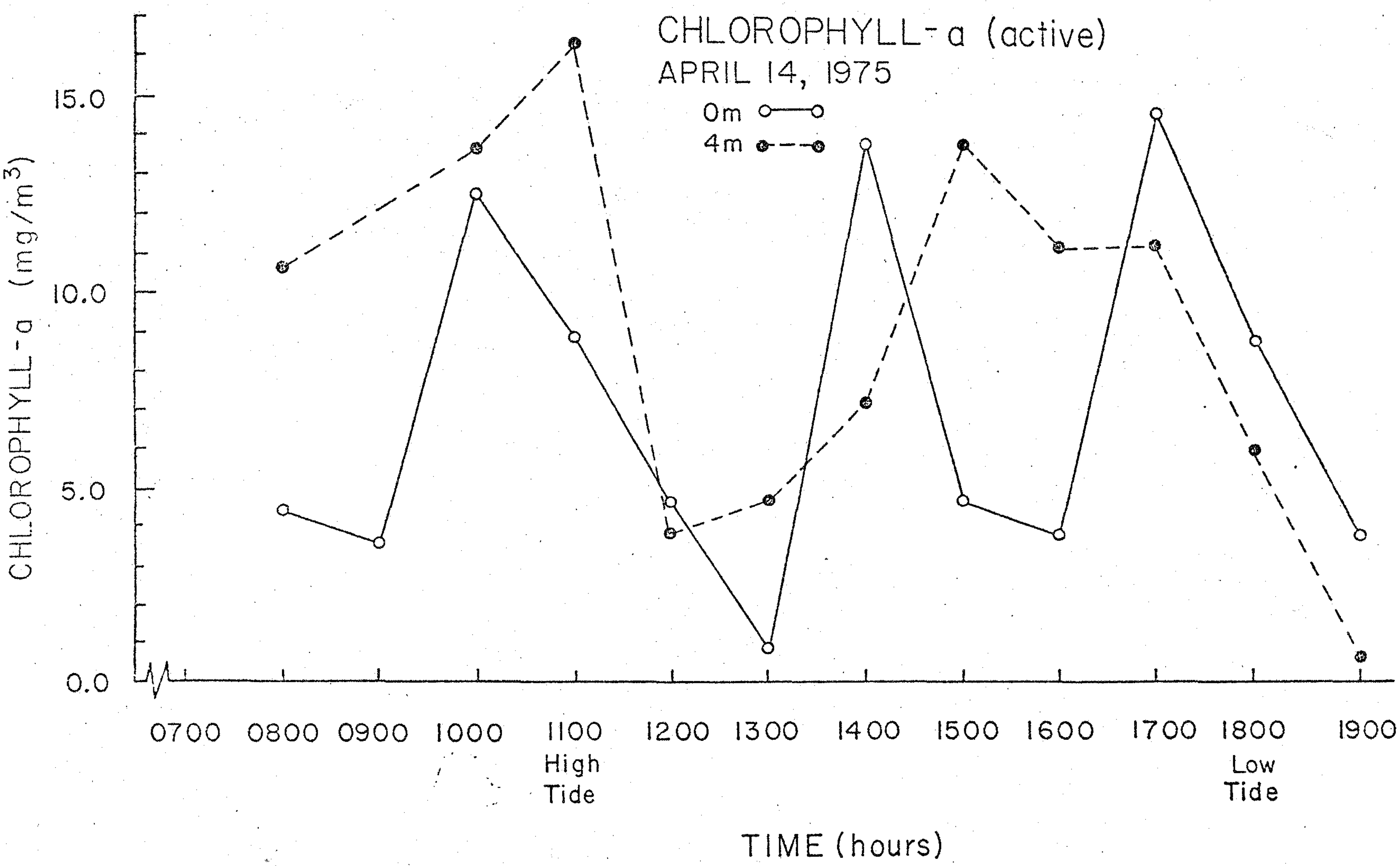

CHLOROPHYLL-a (active)
APRIL 14, 1975
0m
4m
CHLOROPHYLL-a (mg/m^3)
15.0
10.0
5.0
0.0
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-30

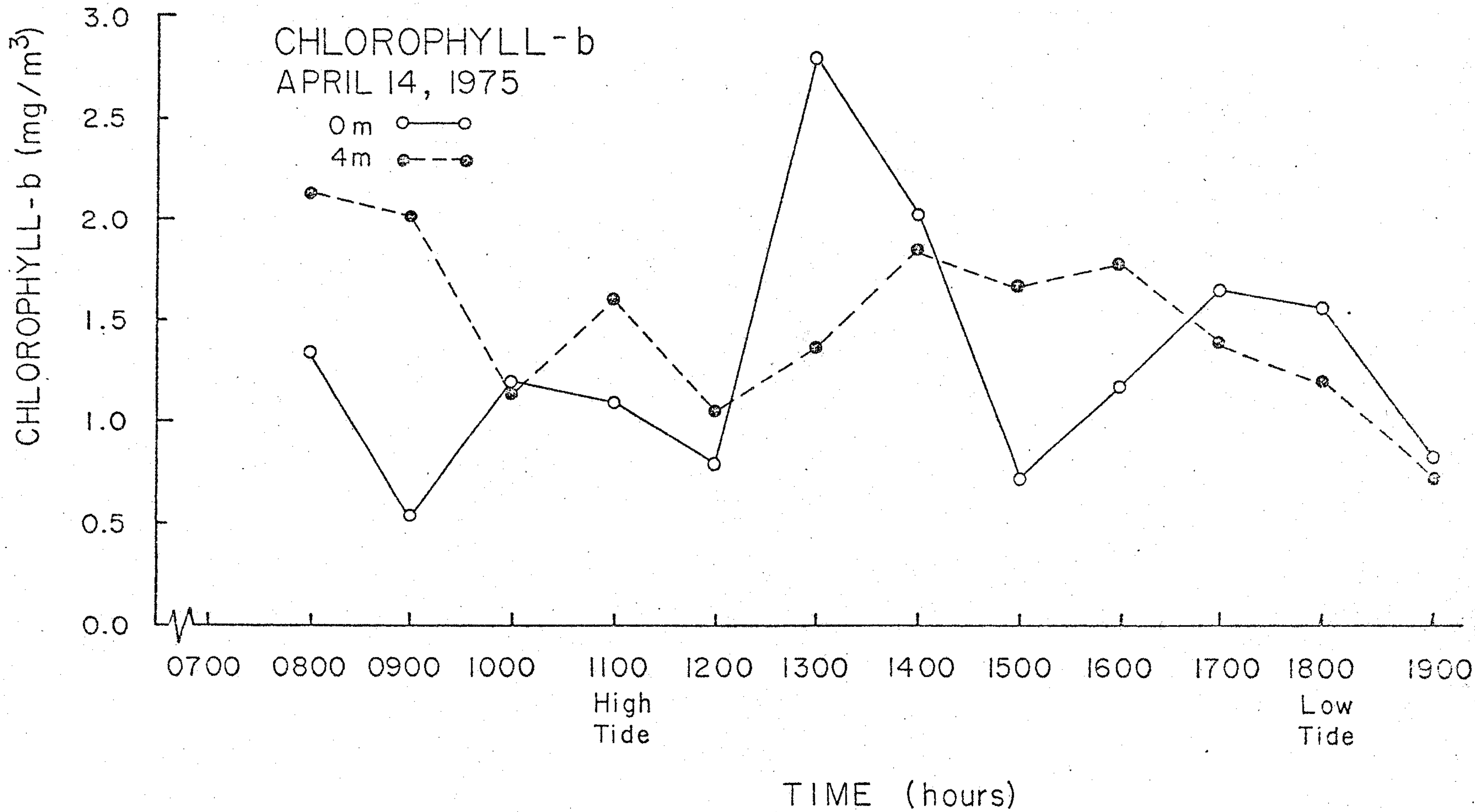

CHLOROPHYLL-b
APRIL 14, 1975
0 m
4 m
CHLOROPHYLL-b (mg/m³)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-31

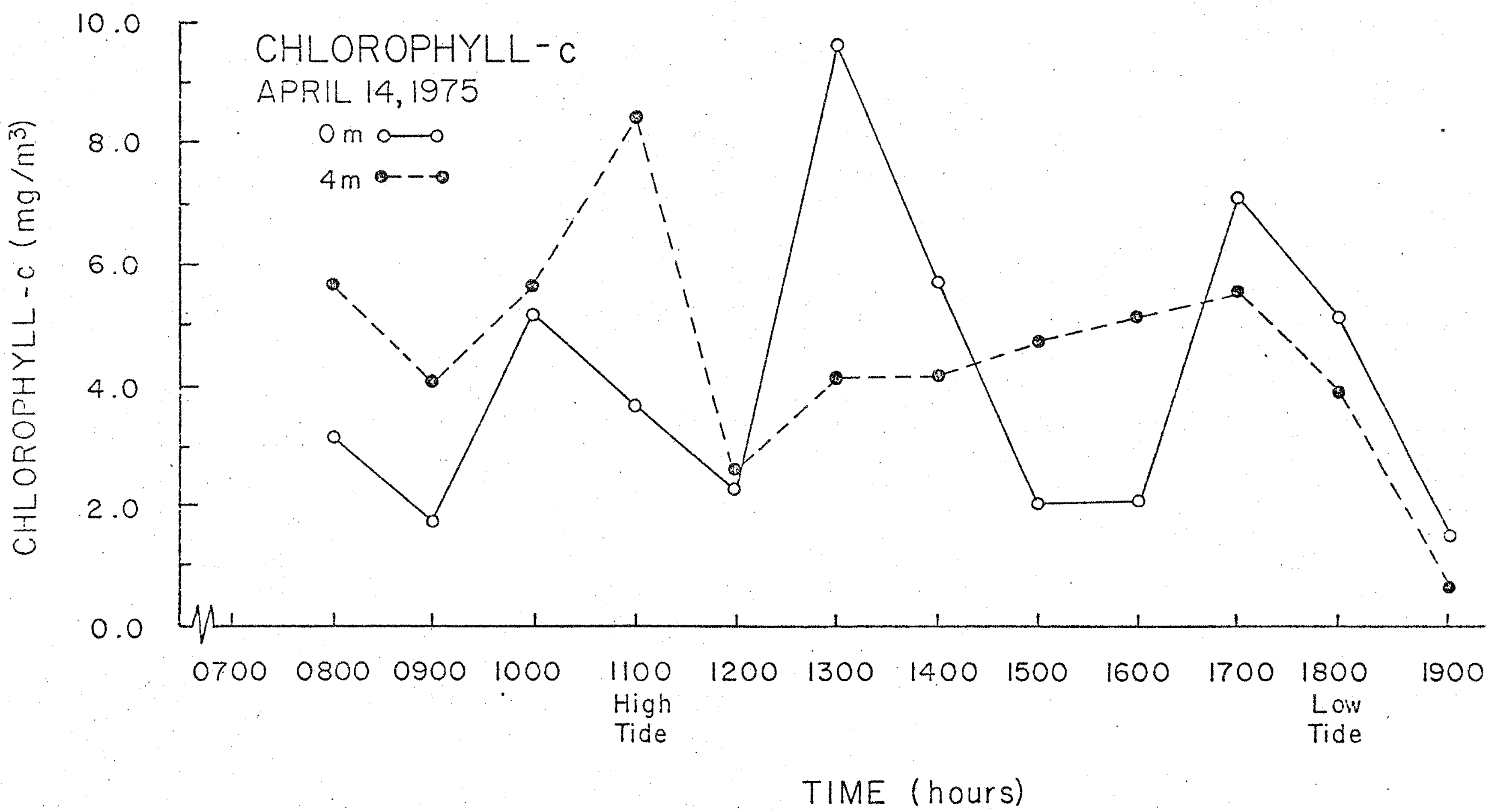

CHLOROPHYLL-c
APRIL 14, 1975
0 m
4 m
CHLOROPHYLL-c (mg/m³)
10.0
8.0
6.0
4.0
2.0
0.0
0700
0800
0900
1000
1100
High Tide
1200
1300
1400
1500
1600
1700
1800
Low Tide
1900
TIME (hours)

Figure I-32

II. PHYTOPLANKTON

Dan Bottom
Les Watling
Ann Pembroke

INTRODUCTION

The coastal region between Cape Cod and Cape Hatteras is composed of a large number of estuaries consisting of coastal salt ponds or large bays. Many of these estuaries are presently receiving the direct environmental effects of domestic and/or industrial pollutants. For many, there are varying amounts of information regarding the population dynamics and energetics of the primary producer components of the system. Unfortunately, no information of this type is available for Delaware Bay phytoplankton.

Studies on the taxonomy and ecology of phytoplankton in Delaware Bay began with the research on dinoflagellates by Martin (1928, 1929), who identified 41 species. He noted that in late summer Amphidinium fusiforme and Gymnodinium spp occasionally produced characteristic red tide blooms. Martin (1928) also felt that summer dinoflagellate populations produced more potential food for larger marine animals that did diatoms. More recent studies in Delaware Bay have largely been concerned with the diatoms and blue-green algae of the marshes (Obeng-Asamoa, 1968; Sullivan, 1971; Somers, 1973). Near the freshwater end of the bay Raytheon (1975) conducted a 12-month study of the net phytoplankton from the Chesapeake and Delaware Canal while two seasonal studies were conducted in coastal waters immediately south of Delaware Bay (Mulford and Norcross, 1971; DuPont, et al., 1972). In the latter region large populations of diatoms were found to dominate the early spring bloom while dinoflagellates dominated the late spring-summer period. Diatoms were again dominant during the winter. In coastal waters north of Delaware Bay Currie (1975) found diatoms to be most abundant in September (826,000 cells/l) with a secondary peak in February (248,000 cells/l) while peaks in dinoflagellate abundance occurred in June and late August (240,000 and 384,000 cells/l, respectively).

Most of the phytoplankton studies conducted in the Cape Cod to Cape Hatteras region have been concerned, until relatively recently, with what is termed the "net phytoplankton" (Smayda, 1973). These are algal cells, such as the diatoms and many dinoflagellates that are strained from the water with a fine mesh net. In the last few years, however, it has become evident that as much as 80% of the total primary production occurring in marine and estuarine waters is generated by those organisms not retained by a fine mesh net (McCarthy, et al., 1974). These are referred to as nannoplankton and are enumerated from small volumes of water collected with water bottle samplers. Net phytoplankton studies are considered to be qualitative while whole water counts are quantitative.

METHODS

Whole water phytoplankton samples were obtained from the three hydrographic and plankton stations (see Fig. I-1, previous chapter) on a once- or twice-monthly basis during the period June 13, 1974 to May 28, 1975. On ten of these cruises, qualitative phytoplankton samples were also taken by towing a #20 net for approximately five minutes. All samples were taken at the surface. Three whole water samples of 25 ml each were obtained from a Niskin water bottle sampler and preserved with Lugol's solution. The remainder of the water sample was then used for nutrient and pigment analysis.

The preserved whole water samples were stored upright in the dark until they could be counted. For counting, the upper 15-20 ml of the sample was carefully removed with a Pasteur pipette. The remaining 5-10 ml was thoroughly stirred by pumping it 10-20 times through a wide bore syringe. When the sample was sufficiently dispersed, it was transferred to a 10 ml counting chamber where it was allowed to settle at least 12 hours before being counted. All cell counts were obtained using a Wild inverted microscope at 600x magnification. At least 25 fields were utilized; beyond that, counting continued until 500 cells or 50 fields had been enumerated. Cells below 3 μm size were not identified. The fields examined were located by applying random numbers to the microscope stage graduations as coordinates.

Cell counts were converted to cells/ml through the use of the following relationships:

The chamber area = 451 mm^2; the field area = 0.052 mm^2 at 600x; and the sample volume = 25 ml; thus,

$$\text{cells/ml} = \left[\frac{451\ \text{mm}^2}{(0.052\ \text{mm}^2/\text{field})\ (\text{No. fields})\ (25\ \text{ml})}\right]\ (\text{cell count}).$$

RESULTS AND DISCUSSION

A total of 126 phytoplankton species were identified from both the net and whole water samples. These were distributed among the major plant groups as follows: Chlorophyta, 10 species; Chrysophyceae, 7; Xanthophyceae, 1; Diatomophyceae (= Bacillariophyceae), 62; Cryptophyceae, 4; Dinophyceae, 35; Euglenophyta, 2; Cyanophyceae, 1; and flagellates of unknown affinity, 4. A complete list of the species identified is given in Table II-1 and their cell counts in Appendix Table AII-1. The classification scheme used follows Bourrelly (1968, 1970, 1972) for the higher taxa, and Butcher (1964) and Parke and Dixon (1968) for the diatoms and dinoflagellates.

1. Whole Water Samples

The seasonal distribution of phytoplankton species from the whole water samples by major taxa is given in Figure II-1 and Table II-2. The flora was composed primarily of small flagellates during the summer and early fall. In October, the diatoms became dominant and, except during November, remained strongly dominant until May. Of the phytoflagellates, the Cryptophyceae were always present and dominanted the flora when the diatom numbers were reduced.

Seasonal changes in total cells/ml, number of species, and evenness diversity values are given in Table II-3 and Figures II-2 and II-3. The highest species richness occurred in June (38 and 28 species), late August (26), and Decmeber (23 and 24) at Stations 1 and 2, and in June (26), early August (23), and early October (23) at Station 3. Peak values of total cells/ml occurred in the samples taken at Station 3 (10,007) on October 30, 1974, and at Stations 2 (16,350) and 3 (20,681) in March and April of 1975 (Fig. II-2). Lowest numbers of cells/ml occurred in September (1,490) and November (728) 1974 and in May (2,980) 1975. In each case these low densities followed numbers representing bloom conditions.

Diversity was measured using the scaled standard deviation measure of Fager (1972). This is an evenness measure and is highest when the individuals are distributed most evenly over the species in the sample. In the whole water phytoplankton samples, evenness was high in June (0.716) and decreased steadily until November (Table II-3). In December (0.665), evenness was again high (Fig. II-3). During the spring diatom bloom, the evenness values declined slightly, then rose as the bloom abated. It is interesting to note here that, even though the species composition of the June 1974 and May 1975 samples was considerably different, the cycle of evenness values returned in May 1975 to what it was in June 1974.

The abundances (cells/ml) of the dominant species at Stations 1, 2, and 3 are given in Tables II-4 through II-6. The species included for each station were among the five most abundant species in at least one sample taken at that station during the year. Particularly evident was the shift in dominant species as the seasons' progressed. Those species which were dominant in June 1974 (i.e., C. acuta, Chrysochromulina sp., C. ovalis) were gradually replaced through October (L. danicus, Cryptomonad B, N. seriata), after which there was an entirely new suite of dominants present. This replacement occurred again, especially at Stations 2 and 3, during the early spring of 1975. Only one (C. acuta) of the five most abundant species of June 1974 was among the top five species in May 1975.

Cycles of abundance for the most dominant species over the year are given in Figures II-4 to II-9. These curves showed varying peaks of abundance suggesting again a series of dominance shifts. Calycomonas ovalis (Fig. II-4) was most abundant at Stations 1 and 3 during the late summer months. An abundance peak in spring-early summer with very low winter numbers was exhibited by Pyramimonas sp. A (Fig. II-5). Cryptomonas acuta (Fig. II-6) was nearly always present, but was most abundant during the warmer months. The remaining dominant phytoflagellate, Chrysochromulina sp., was also most abundant in the summer and rarely present during the winter (Fig. II-7). Skeletonema costatum (Fig. II-8) was occasionally present in small numbers during the summer months, but was present in exceedingly high numbers during the late winter-early spring. The one dinoflagellate which appeared in any substantial numbers was Katodinium rotundatum (Fig. II-9) which was most abundant in mid-summer.

To assess the extent to which the samples were similar, cluster analysis techniques were used. This analysis can be used to provide two types of groupings: a) samples can be grouped according to their species-abundance composition; and b) species can be grouped according to the stations at which they occurred. The first type is referred to as site-groups, the latter as species-groups. Since our plankton stations were occupied over successive time periods, our "site-groups" are also "time-groups." Computational techniques used in this analysis are documented in Appendix I.

The dendrogram of similarities for the whole water samples is given in Figure II-10. The clusters were formed using the Czekanowski coefficient and group-average sorting. Two patterns emerged. First, the three samples taken during any one cruise almost always clustered together, thus indicating that the species composition at all stations is changing continuously between sampling periods. Second, the large, widely separated clusters linked sampling cruises into three contiguous time groups: a) summer, consisting of samples taken from June through September; b) fall, October and November; c) winter-spring, December 1974 through May 1975. This latter group corroborated our earlier ideas on the lack of similarity between the June 1974 and May 1975 samples.

Recurrent species groups were also determined by cluster analysis. The resulting dendrogram is illustrated in Figure II-11 and the groups are listed in Table II-7. Eight species-groups were found using the Czekanowski coefficient and group-average clustering strategy. Groups I, III, V, and VI contained species that appeared in reasonably high numbers during a particular season. In contrast, species in groups II, IV, and VII occurred in low numbers over a short time span. Group VIII species were present at low levels in nearly all samples.

2. *Net Phytoplankton*

Thirty-nine species of phytoplankton were found in the net survey--seven species of dinoflagellates, 14 centric diatoms, seven pennate diatoms, and 11 unidentified species. Their occurrence is shown in Appendix Table AII-2; the values given are proportions of total cells counted. Those species which comprised ≥5% of any sample are listed in Table II-8. The dominant species included 14 diatoms and three dinoflagellates. Usually the dominants were similar between stations during any particular cruise.

Two diatoms, *Nitzschia seriata* and *Guinardia flaccida*, were the most frequently important members of the plankton. Figures II-12 and II-13 illustrate their occurrences. The fall-winter dominance of *Nitzschia seriata* shifted to a bloom of *Guinardia flaccida* in the spring (February 20 to March 18).

During the 12-hour cruise of February 20, there were nine species which were abundant. *Guinardia flaccida* was the only species whose population numbers correlated with the tidal cycle (Fig. II-14). Peaks in the population occurred 1-2 hours after both high and low tides suggesting that this species may occur in distinct patches. *Guinardia flaccida* was again dominant on April 14 during a second 12-hour cruise. During this period, however, population size was totally unrelated to the tidal cycle (Fig. II-14).

Jaccard coefficients and Canberra metric coefficients were calculated to determine the similarity of species composition and abundance, respectively, between sampling cruises and stations within cruises (Table II-9 to II-14). A value <0.600 was considered to indicate significant difference for either coefficient. On this basis, Stations II and III were similar with regard to species composition during five of the ten regular cruises while Stations I and II and I and III were similar only twice (Table II-10). There were only two periods of high similarity of species composition when stations were compared between cruises--i.e., October 15 and 30, 1974 at Station II and October 30 and November 14, 1974 at Station III (Table II-9).

Species composition showed little variation during the 12-hour cruise of February 20 with values ≥0.600 about 2/3 of the time

(Table II-11). This can be attributed to the fact that there were nine dominant species present at that time. On the other hand, the 12-hour cruise of April 14 exhibited relatively little similarity between samples since there was only one dominant and several rare species.

Jaccard coefficients can be misleading, since the relative abundances of the species are not considered. Relative abundances can be taken into account by applying the Canberra metric coefficient to the species proportions. In Table II-13 the stations were compared for each cruise. Every value was greater than the 0.600 level which indicated that the dominant species for each cruise were usually the same at all stations.

High Canberra metric coefficients were commonly obtained (except for a few cases) when different cruises were compared at each station (Table II-12). At Station I, the cruise of December 13 was dissimilar to the cruises of May 22, 1974, March 18, May 9, and May 28, 1975, which reflected the change of dominance from Nitzschia seriata to Guinardia flaccida. This pattern was not repeated at Stations II and III.

During the 12-hour cruises, Canberra metric coefficients were always high (Table II-14). Those of February 20 were lower than during April 14 due to the overwhelming dominance of one species during the latter cruise. The high values during each of the cruises indicated that tidal stage had little influence on the composition of the dominant species.

3. *Habitat Comparisons*

The whole water samples in the present study were dominated by dinoflagellates during the summer and early fall with diatoms generally dominant from October through May. The net phytoplankton showed a fall-winter dominance of N. seriata and an early spring bloom of G. flaccida with the addition of dinoflagellates (e.g., Ceratium tripos) in May. Whole water samples in the Chesapeake and Delaware Canal contained low total numbers in January (c. 6,000 cells/ml which increased gradually to a maximum of 60,000 cells/ml in July; Raytheon, 1975). In this latter study, Achnanthes lanceolata, Melosira granulata, and Fragilaria spp. were dominant in winter to early spring with Chlorella spp., Scenedesmus spp., Calycomonas ovalis and Cyclotella spp. dominant in the summer to early fall.

Net phytoplankton samples in coastal waters south of Delaware Bay indicated the presence of a spring-summer dinoflagellate regime and a winter diatom regime (DuPont, et al., 1972). Ceratium tripos was the primary dinoflagellate and N. seriata, G. flaccida, Thalassiosira sp. and R. alata were dominant among the diatoms. In another net phytoplankton study off Chesapeake Bay species of Ceratium and G. flaccida were important in spring and summer while Chaetoceros, Rhizosolenia, and Skeletonema were most abundant during fall (Mulford and Norcross, 1971). Although there were some similarities with seasonal distributions in the Chesapeake and Delaware Canal, patterns in lower Delaware Bay were more similar to those of the coastal waters. Moreover, even though S. costatum was collected in great numbers at one station during one sampling period (Fig. II-8), this species did not show the type of dominance so characteristic of northeastern United States estuarine and coastal waters (Smayda, 1973; Currie, 1975).

Comparison of the whole water phytoplankton assemblage composition with nutrient levels and zooplankton numbers are given in Chapter IV.

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Table II-1

List of phytoplankton species obtained in lower Delaware Bay

Division Chlorophyta
- Class Chlorophyceae
  - Order Volvocales
    - Family Pyramimonaceae
      - *Pyramimonas* sp. A
      - *Pyramimonas* sp. B
    - Family Tetraselmiaceae
      - *Tetraselmis* sp. A
    - Family Chlamydomonadaceae
      - *Chlamydomonas* sp. A
      - *Brachiomonas submarina* Bohlin 1897
  - Order Chlorococcales
    - Family Oocystaceae
      - *Ankistrodesmus* sp.
      - *Kirchneriella* sp.
    - Family Scenedesmaceae
      - *Scenedesmus* sp.
    - Family Unknown
      - Chlorococcales sp. A
- Class Prasinophyceae
  - Order Unknown
    - Prasinophyte sp. A

Division Chromophyta
- Class Chrysophyceae
  - Subclass Heterochrysophysidae
    - Order Chromulinales
      - Family Chrysococcaceae
        - *Calycomonas ovalis* Wulff 1919
      - Family Pedinellaceae
        - *Pseudopedinella pyriforme* Carter 1937
    - Order Ochromonadales
      - Family Ochromonadaceae
        - *Ochromonas* sp.
      - Family Synuraceae
        - *Catenochrysis* (=*Chrysodidymus*) *gracilis* (Prowse 1962)
        - *Ebria tripartita* (Schumann) Lemmermann 1899
  - Subclass Isochrysophycidaceae
    - Order Prymnesiales
      - Family Prymnesiaceae
        - *Chrysochromulina* sp.
      - Family Coccolithaceae
        - Coccolithaceae sp.

Table II-1 (cont.)

Class Xanthophyceae
    Order Heterochloridales
        Family Heterochloridaceae
            Olisthodiscus sp.
Class Diatomophyceae (= Bacillariophyceae)
    Subclass Centrophycidae
    Order Coscinodiscales
        Family Coscinodiscaceae
            Paralia sulcata Cleve 1873
            Coscinodiscus lineatus Ehrenberg 1838
            Coscinodiscus radiatus Ehrenberg 1839
            Coscinodiscus sp.
            Thalassiosira nordenskioldii Cleve 1873
            Thalassiosira ? _gravida_ Cleve 1896
            Thalassiosira sp. A
            Skeletonema costatum (Greville) Clark 1878
            Planktoniella sol (Wallich) Schutt 1893
            Cyclotella sp.
        Family Actinodiscaceae
            Actinoptychus undulatus (Bailey) Ralfs 1861
    Order Rhizosoleniales
        Family Rhizosoleniaceae
            Rhizosolenia alata Brightwell 1858
            Rhizosolenia delicatula Cleve 1900
            Rhizosolenia fragilissima Bergon 1903
            Rhizosolenia stolterfothii Peragallo 1888
            Rhizosolenia setigera Brightwell 1858
            Rhizosolenia styliformis Brightwell 1858
        Family Leptocylindraceae
            Leptocylindrus danicus Cleve 1889
            Leptocylindrus minimus
            Schroderella delicatula Pavillard 1913
            Guinardia flaccida (Castr.) H. Peragallo 1892
            Detonula confervacea (Cleve) Gran 1900
    Order Biddulphiales
        Family Biddulphiaceae
            Biddulphia granulata Roper 1859
            Biddulphia regia
            Biddulphia favus (Ehrenberg) V. Heurck 1883
            Biddulphia sp.
            Biddulphia rhombus (Ehrenberg) W. Smith 1856

Table II-1 (cont.)

Family Biddulphiaceae (cont.)
  Cerataulina bergonii Peragallo 1892
  Lithodesmium undulatum Ehrenberg 1840
  Streptotheca thamensis Shrubsole 1890
  Ditylum brightwelli (West) Grunow 1880-1885
Family Chaetoceraceae
  Chaetoceros decipiens Cleve 1873
  Chaetoceros simplex
  Chaetoceros sp. A
  Chaetoceros sp.
Order Fragilariales
Family Fragilariaceae
  Fragilaria oceanica Cleve 1873
  Raphoneis amphiceros Ehrenberg
  Asterionella japonica Cleve 1882
  Synedra sp.
  Thalassionema nitzschioides Grunow 1880-1885
  Grammatophora marina (Lyngbye) Kutzing 1819
  Plagiogramma vanheurckii Grunow 1880-1885
  Thalassiothrix frauenfeldii Grunow 1880
Order Achnanthales
Family Achnanthaceae
  Cocconeis sp.
Order Naviculales
Suborder Naviculineae
Family Naviculaceae
  Navicula sp. A
  Navicula sp. B
  Navicula sp. C
  Navicula sp. D
  Navicula sp. E
  Navicula membranacea Cleve 1897
  Navicula septentrionalis (Grunow) Cleve 1896
  Navicula sp.
  Diatom 1-E
  Diploneis sp.
  Gyrosigma spenceri (Quekett) Cleve 1894
  Pleurosigma sp.
Family Cymbellaceae
  ? Phaeodactylum tricornutum
  Amphora sp.

Table II-1 (cont.)

Family Bacillariaceae
    Cylindrotheca (= Nitzschia) closterium
        (Ehrenberg)
    Nitzschia seriata Cleve 1883
Suborder Surirellineae
    Family Surirellaceae
        Surirella sp.
Order Unknown
        Pennatae sp.

Division Pyrrhophyta
    Class Cryptophyceae
        Order Cryptomonadales
            Family Cryptomonadacea
                Cryptomonas acuta Butcher 1967
                Chroomonas sp.
            Family Unknown
                Cryptomonad B
                Cryptomonad C
    Class Dinophyceae
        Order Prorocentrales
                Prorocentrum minimum Schiller 1933
                Prorocentrum scutellum Schroeder 1901
                Prorocentrum micans Ehrenberg 1833
                Exuviaella compressa Ostenfeld 1899
                Exuviaella baltica Lohmann 1908
                Exuviaella apora Schiller 1918
                Exuviaella sp.
        Order Peridiniales
            Family Gymnodiniaceae
                Gymnodinium ? roseostigma Campbell 1973
                Gymnodinium ? aurantium Campbell 1973
                Gymnodinium ? simplex (Lohmann) Kofoid and Swezy 1921
                Gymnodinium ? arcticum Wulff 1916
                Gymnodinium ? punctatum Pouchet 1887
                Gymnodinium sp. A
                Gymnodinium sp. B
                Gymnodinium sp.
                Katodinium rotundatum (Lohmann) Conrad 1927
                Gyrodinium ? carteretensis Campbell 1973
                Gyrodinium spirale (Bergh) Kofoid and Swezy 1921
                Gyrodinium ? metum Hulburt 1957
                Gyrodinium ? grossestriatum Campbell 1973

Table II-1 (cont.)

Family Peridiniales (cont.)
- *Gyrodinium* sp. A
- *Gyrodinium* sp.

Family Noctilucaceae
- *Noctiluca scintillans* Macartney 1836

Family Glenodiniaceae
- *Glenodinium danicum* Paulsen 1907
- *Glenodinium rotundum* (Lebour) Schiller 1937

Family Peridiniaceae
- *Peridinium trochoideum* (Stein) Lemmerman 1910
- *Peridinium depressum* Bailey 1855

Family Gonyaulacaceae
- *Gonyaulax spinifera* (Claparede and Lachmann) Diesing 1865

Family Ceratiaceae
- *Ceratium tripos* (O.F. Muller) Nitzsch 1817
- *Ceratium furca* (Ehrenberg) Claparede and Lachmann 1858-1861
- *Ceratium fusus* (Ehrenberg) Dujardin 1841
- *Ceratium macroceros* (Ehrenberg) Cleve 1900

Family Warnowiaceae
- *Warnowia* (= *Pouchetia*) sp.

Order Dinophysiales

Family Dinophysiaceae
- *Dinophysis* (= *Phalacroma*) sp.

Order Unknown
- Dinoflagellate A

Division Euglenophyta

Class Euglenophyceae

Order Euglenales

Family Eutreptiaceae
- *Eutreptia* sp.

Family Euglenaceae
- *Euglena* sp. A

Division Procaryota

Class Cyanophyceae
- *Cyanophyceae* sp. A

Table II-1 (cont.)

Incertae sedis	
	unidentified flagellate <5μ
	PZ-10 flagellate
	silicoflagellate
	Flagellate D

Table II-2

Composition of flora by class, all samples combined for each sampling date

	Sample Dates								
	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74	11/14/74
Diatomophyceae									
(# Species)	22	20	12	11	22	15	20	8	15
(# Ind.)	5235	5668	554	1354	6832	1224	8255	15,927	279
(Prop.)	.262	.428	.034	.149	.552	.228	.870	.807	.114
	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75		
	18	17	12	19	11	15	13		
	2307	5477	4203	39,436	7247	2054	3825		
	.651	.800	.867	.932	.834	.215	.218		
	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74	11/14/74
Dinophyceae									
(# Species)	12	8	4	7	4	7	4	7	4
(# Ind.)	892	470	5887	397	220	98	37	103	56
(Prop.)	.045	.035	.366	.044	.018	.018	.004	.005	.023
	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75		
	5	1	2	3	3	6	4		
	195	42	60	192	56	397	748		
	.055	.006	.012	.004	.006	.041	.043		
	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74	11/14/74
Cryptophyceae									
(# Species)	2	2	2	2	1	2	1	2	2
(# Ind.)	4557	3054	6073	3764	2023	2157	465	3048	1851
(Prop.)	.228	.230	.378	.414	.164	.403	.048	.154	.785

Table II- 2 (cont.)

	Sample Dates								
	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75		
Cryptophyceae	2	3	1	1	4	3	3		
(cont.)	701	500	426	856	487	4913	8381		
	.198	.073	.088	.020	.056	.513	.478		
	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74	11/14/74
Chlorophyta									
(# Species)	6	3	3	3	4	2	1	-	1
(# Ind.)	4912	1911	1595	780	182	312	7	-	14
(Prop.)	.246	.144	.099	.086	.015	.058	.001	-	.006
	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75		
	2	1	1	2	1	3	6		
	97	7	30	25	14	977	1262		
	.027	.001	.006	.002	.002	.102	.072		
	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74	11/14/74
Chrysophyceae									
(# Species)	5	4	3	3	3	2	2	1	4
(# Ind.)	4227	2139	1889	2628	2834	1477	146	103	63
(Prop.)	.212	.159	.117	.289	.229	.276	.015	.005	.026
	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75		
	5	2	2	1	-	2	3		
	119	42	99	14	-	21	130		
	.034	.006	.020	.001	-	.002	.007		

Table II- 2 (cont.)

Sample Dates

	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/75	10/30/74	11/14/74
Euglenophytae									
(# Species)	-	1	1	1	1	1	-	-	-
(# Ind.)	-	8	56	179	266	90	-	-	-
(Prop.)	-	.001	.003	.020	.021	.017	-	-	-

	12/13/74	1/16/75	2/30/75	3/18/75	4/14/75	5/ 9/75	5/28/75
	1	1	-	-	-	-	2
	14	7	-	-	-	-	60
	.004	.001	-	-	-	-	.003

	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/75	10/30/74	11/14/74
Xanthophyceae									
(# Species)	-	-	1	-	-	-	-	-	-
(# Ind.)	-	-	28	-	-	-	-	-	-
(Prop.)	-	-	.002	-	-	-	-	-	-

	12/13/74	1/16/75	2/30/75	3/18/75	4/14/75	5/ 9/75	5/28/75
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-

	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/75	10/30/74	11/14/74
Cyanophyceae									
(# Species)	-	-	-	-	-	-	-	-	-
(# Ind.)	-	-	-	-	-	-	-	-	-
(Prop.)	-	-	-	-	-	-	-	-	-

Table II-2 (cont.)

	Sample Dates						
	12/13/74	1/16/75	2/30/75	3/18/75	4/14/75	5/ 9/75	5/28/75
Cyanophyceae (cont.)	-	1	-	1	1	1	1
	-	748	-	1662	486	1213	1514
	-	.109	-	.039	.056	.127	.086

	6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74	11/14/74
Unknown flagellates									
(# Species)	1	-	-	-	-	-	1	1	1
(# Ind.)	162	-	-	-	-	-	582	563	180
(Prop.)	.008	-	-	-	-	-	.061	.029	.074

	12/13/74	1/16/75	2/30/75	3/18/75	4/14/75	5/ 9/75	5/28/75
	1	1	1	1	1	-	1
	111	21	30	116	403	-	1627
	.031	.003	.006	.003	.046	-	.093

Table II-3

Number of species, total cells/ml, and evenness of nannoplankton at each station by sampling period

Cruise No.	Date	Station I No. Species	Station I Total cells/ml	Station I SDN	Station II No. Species	Station II Total cells/ml	Station II SDN	Station III No. Species	Station III Total cells/ml	Station III SDN
4	June 13	38	8570	.644	28	7468	.716	32	3945	.665
5	June 20	26	3551	.663	26	5426	.572	26	4476	.492
6	July 19	15	7731	.520	15	5142	.618	19	3209	.583
7	Aug. 1	19	4249	.437	-	-	-	23	4789	.543
8	Aug. 21	26	3830	.534	26	3631	.561	21	4897	.565
9	Sept. 17	14	1915	.661	19	1490	.477	19	1947	.516
10	Oct. 15	17	3112	.255	19	2744	.372	23	3631	.361
11	Oct. 30	10	4414	.325	12	5326	.168	13	10007	.189
12	Nov. 14	13	852	.098	13	859	.201	12	728	.299
13	Dec. 13	23	991	.649	24	1317	.627	22	1227	.665
14	Jan. 16	12	1310	.463	22	2980	.375	14	2564	.482
15	Feb. 20	-	-	-	19	4847	.433	-	-	-
16	March 18	19	5267	.480	15	16350	.187	19	20681	.182
17	April 14	-	-	-	21	8689	.439	-	-	-
18	May 9	15	3119	.545	24	2980	.564	19	3472	.500
19	May 28	21	5560	.652	22	5945	.593	26	6040	.635

Table II-4

Abundance (cells/ml) of the dominant species at Station I
(each species was among the top five in at least one sample)

Species	Sample Dates 6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74
Cryptomonas acuta	2306[1]	722[1]	1929[2]	2300[1]	722[3]	472[1]	139[2]	929[2]
Prasinophyte A	1713[2]	440[4]	180	270[3]	-	-	-	-
Calycomonas ovalis	1037[3]	695[2]	208	826[2]	1274[1]	305[4]	21	83[4]
Phaeodactylum tricornutum	792[4]	46	-	-	-	319[3]	-	-
Pyramimonas sp. A	454[5]	74	500[4]	143[4]	28	180[5]	-	-
Rhizosolenia fragilissima	56	681[3]	-	26	-	-	97[5]	-
Unidentified flagellate	162	199[5]	-	-	-	-	111[3]	-
Katodinium rotundatum	-	-	3345[1]	133	85	-	-	14
Chroomonas sp.	-	65	944[3]	56	-	361[2]	-	-
Chrysochromulina sp.	398	176	305[5]	143[5]	21	56	-	-
Skeletonema costatum	-	28	-	-	1083[2]	-	69	-
Asterionella japonica	190	-	-	5	142[4]	-	21	-
Leptocylindrus danicus	-	5	-	-	85[5]	-	2280[1]	2959[1]
Cyclotella sp.	431	120	42	-	-	14	104[4]	-
Flagellate PZ-10	-	-	-	-	-	-	-	263[3]
Cryptomonad B	-	-	-	-	-	-	-	76[5]
Thalassiosira sp. A	-	-	-	-	-	-	-	-
Nitzschia seriata	-	9	-	-	78	-	49	55
Cyanophyceae sp. A	-	-	-	-	-	-	-	-
Leptocylindrus minimus	-	-	-	-	-	-	-	-
Flagellate D	-	-	-	-	-	-	-	-

Table II-4 (cont.)

Species	11/14/74	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75
	Sample Dates							
Cryptomonas acuta	700^{1}	215^{2}	111^{4}		147^{4}		166^{5}	740^{2}
Prasinophyte A	-	-	-		-		-	-
Calycomonas ovalis	7	-	7		-		-	23
Phaeodactylum tricornutum	-	-	-		-		-	12
Pyramimonas sp. A	7	7	-		-		256^{3}	474
Rhizosolenia fragilissima	-	7	-		-		-	-
Unidentified flagellate	-	-	-		-		-	-
Katodinium rotundatum	-	28	21		11		139	46
Chroomonas sp.	-	-	-		-		1344^{1}	1653^{1}
Chrysochromulina sp.	7	14	-		-		-	23
Skeletonema costatum	-	236^{1}	665^{1}		2268^{1}		-	69
Asterionella japonica	-	21	21		84^{5}		21	-
Leptocylindrus danicus	7	-	-		11		-	-
Cyclotella sp.	7	-	-		-		-	243
Flagellate PZ-10	42^{2}	55^{5}	-		74		-	-
Cryptomonad B	35^{3}	-	-		-		-	-
Thalassiosira sp. A	-	104^{3}	215^{2}		1229^{2}		42	670^{3}
Nitzschia seriata	-	76^{4}	7		-		-	-
Cyanophyceae sp. A	-	-	208^{3}		1176^{3}		624^{2}	509^{5}
Leptocylindrus minimus	-	-	-		-		249^{4}	-
Flagellate D	-	-	21		-		-	670^{4}

* = rank of species within sample

Table II-5

Abundance (cells/ml) of the dominant species at Station II

Species	Sample Dates 6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74
Cryptomonas acuta	1491[1*]	735[3]	673[4]		568[3]	638[1]	132[3]	530[2]
Prasinophyte A	1236[2]	818[2]	-		14	-	-	-
Chrysochromulina sp.	894[3]	291[5]	286		14	42	7	-
Calycomonas ovalis	806[4]	707[4]	734[3]		180[4]	416[2]	55	20
Phaeodactylum tricornutum	611[5]	21	-		-	125[3]	-	-
Rhizosolenia fragilissima	116	2024[1]	-		14	-	76[5]	-
Katodinium rotundatum	-	90	1693[1]		21	7	-	-
Chroomonas sp.	125	-	1051[2]		-	-	-	-
Pyramimonas sp. A	352	236	367[5]		35	14	-	-
Skeletonema costatum	51	-	-		1095[1]	-	118[4]	-
Asterionella japonica	-	7	-		1060[2]	-	49	-
Euglena sp. A	-	-	-		166[5]	14	-	-
Thalassionema nitzschioides	-	-	31		97	55[4]	-	-
Leptocylindrus danicus	-	-	-		14	49[5]	1691[1]	4386[1]
Unidentified flagellate	-	-	-		-	-	187[2]	-
Cryptomonad B	-	-	-		-	-	-	153[3]
Flagellate PZ-10	-	-	-		-	-	-	133[4]
Nitzschia seriata	14	21	-		21	-	76	40[5]
Fragilaria oceanica	-	-	-		-	-	-	-
Thalassiosira sp. A	-	-	-		-	-	-	-
Cyanophyceae sp. A	-	-	-		-	-	-	-
Flagellate D	-	-	-		-	-	-	-
Leptocylindrus minimus	-	-	-		-	-	-	-
Guinardia flaccida	-	-	-		-	-	-	-

Table II-5 (cont.)

Species	11/14/74	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75
	Sample Dates							
Cryptomonas acuta	631^{1}	180^{3}	139^{4}	426^{3}	278^{4}	167	118	598^{3}
Prasinophyte A	-	-	-	-	-	-	-	-
Chrysochromulina sp.	7	-	-	-	-	-	14	48
Calycomonas ovalis	21	7	14	30	14	-	-	-
Phaeodactylum tricornutum	-	-	-	-	-	-	-	36
Rhizosolenia fragilissima	-	7	-	-	-	-	-	-
Katodinium rotundatum	-	42	7	50	97	14	49	120
Chroomonas sp.	-	-	-	-	-	264^{5}	1213^{1}	1926^{1}
Pyramimonas sp. A	7	62^{5}	7	30	-	14	353^{2}	167
Skeletonema costatum	-	388^{1}	1733^{1}	2250^{1}	13269^{1}	3984^{1}	21	132
Asterionella japonica	-	7	35	99^{5}	194	14	7	12
Euglena sp. A	-	7	7	-	-	-	-	-
Thalassionema nitzschioides	-	14	-	-	-	-	-	-
Leptocylindrus danicus	-	-	7	-	-	-	-	-
Unidentified flagellate	-	-	-	-	-	-	-	-
Cryptomonad B	-	-	14	-	-	-	-	-
Flagellate PZ-10	55^{3}	35	-	30	28	-	-	-
Nitzschia seriata	-	125^{4}	55^{5}	-	-	-	-	-
Fragilaria oceanica	83^{2}	35	14	109^{4}	430^{3}	-	-	24
Thalassiosira sp. A	-	201^{2}	554^{2}	1615^{2}	1513^{2}	2901^{2}	83	586^{4}
Cyanophyceae sp. A	-	-	270^{3}	-	250^{5}	486^{3}	215^{4}	742^{2}
Flagellate D	-	-	-	-	-	403^{4}	-	574^{5}
Leptocylindrus minimus	-	-	-	-	-	-	270^{3}	-
Guinardia flaccida	-	55	-	10	97	139	173^{5}	36

* = rank of species within sample

Table II-6

Abundance (cells/ml) of the dominant species at Station III

Species	Sample Dates 6/13/74	6/20/74	7/19/74	8/ 1/74	8/21/74	9/17/74	10/15/74	10/30/74
Asterionella japonica	977[1*]	-	-	-	614[4]	-	42	-
Cryptomonas acuta	616[2]	178[5]	416[4]	1398[2]	733[3]	686[1]	194[4]	888[2]
Calycomonas ovalis	532[3]	76	104[5]	1591[1]	1318[2]	644[2]	49	-
Chrysochromulina sp.	431[4]	161	104[5]	48	20	7	14	-
Phaeodactylum tricornutum	366[5]	25	21	-	-	166[3]	-	-
Rhizosolenia fragilissima	69	1802[1]	7	174[4]	10	-	55	-
Chroomonas sp.	-	1354[2]	1060[1]	10	-	-	-	-
Pyramimonas sp. A	93	330[3]	513[3]	96	40	21	7	-
Katodinium rotundatum	-	195[4]	728[2]	154[5]	30	-	-	-
Cerataulina bergonii	9	34	-	790[3]	-	-	62	-
Skeletonema costatum	79	17	-	-	1566[1]	-	215[3]	-
Paralia sulcata	-	17	21	-	99[5]	49	28	-
Cyclotella sp.	273	-	-	10	-	104[4]	83	-
Prasinophyte A	199	-	-	106	30	97[5]	-	-
Leptocylindrus danicus	-	-	-	-	-	21	2259[1]	8078[1]
Unidentified flagellate	-	-	-	-	-	-	284[2]	-
Nitzschia seriata	9	-	-	-	30	-	111[5]	180[4]
Cryptomonad B	-	-	-	-	-	-	-	472[3]
Flagellate PZ-10	-	-	-	-	-	-	-	167[5]
Cryptomonad C	-	-	-	-	-	-	-	-
Thalassiosira sp. A	-	-	-	-	-	-	-	-
Cyanophyceae sp. A	-	-	-	-	-	-	-	-
Fragilaria oceanica	-	-	-	-	-	-	-	-
Guinardia flaccida	-	-	-	-	-	-	-	-
Flagellate D	-	-	-	-	-	-	-	-

Table II-6 (cont.)

Species	Sample Dates 11/14/74	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/ 9/75	5/28/75
Asterionella japonica	-	7	69	-	139	-	14	-
Cryptomonas acuta	171^{1}	243^{1}	180^{4}	-	431^{4}	-	180^{5}	598^{3}
Calycomonas ovalis	-	7	-	-	-	-	-	-
Chrysochromulina sp.	-	-	-	-	-	-	-	24
Phaeodactylum tricornutum	14	-	-	-	-	-	-	24
Rhizosolenia fragilissima	-	14	-	-	-	-	14	-
Chroomonas sp.	-	-	-	-	-	-	1719^{1}	1926^{1}
Pyramimonas sp. A	-	14	14	-	14	-	222^{3}	490
Katodinium rotundatum	21	90^{5}	14	-	56	-	97	60
Cerataulina bergonii	-	-	-	-	14	-	139	72
Skeletonema costatum	-	215^{3}	1234^{1}	-	16795^{1}	-	-	167
Paralia sulcata	7	35	-	-	56	-	-	96
Cyclotella sp.	-	-	7	-	-	-	-	-
Prasionophyte A	-	-	-	-	-	-	-	-
Leptocylindrus danicus	-	7	-	-	14	-	-	-
Unidentified flagellate	-	-	-	-	-	-	-	-
Nitzschia seriata	-	229^{2}	21	-	-	-	-	-
Cryptomonad B	-	-	-	-	-	-	-	-
Flagellate PZ-10	83^{2}	21	-	-	14	-	-	-
Cryptomonad C	49^{3}	14	35	-	-	-	69	275
Thalassiosira sp. A	14	146^{4}	603^{2}	-	2040^{2}	-	49	586^{4}
Cyanophyceae sp. A	-	-	270^{3}	-	236^{5}	-	374^{2}	742^{2}
Fragilaria oceanica	-	-	76^{5}	-	527^{3}	-	-	-
Guinardia flaccida	-	42	-	-	125	-	208^{4}	48
Flagellate D	-	-	-	-	-	-	-	574^{5}

* = rank of species within sample

Table II-7

Primary producers recurrent species groups

I. Summer Dominants:

Cryptomonas acuta	*Cerataulina bergonii*
Calycomonas ovalis	*Prasinophyte* A
Chrysochromulina sp.	*Rhizosolenia fragilissima*
Pyramimonas sp. A	*Phaeodactylum tricornutum*
Katodinium rotundatum	*Cyclotella* sp.
Chroomonas sp.	

II. Summer Subdominants:

Pseudopedinella pyriforme	*Gymnodinium* sp. A
Tetraselmis sp. A	*Navicula* sp. C
Prorocentrum minimum	

III. Fall Dominants:

Navicula sp. D	*Cryptomonad* B
Gyrodinium spirale	*Nitzschia seriata*
Navicula septentrionalis	*Leptocylindrus danicus*

IV. Fall Subdominants:

Ochromonas sp.	Flagellate PZ-10
Fragilaria oceanica	

V. Winter-Early Spring Dominants:

Thalassiosira sp. A	Cryptomonad C
Cyanophyceae sp. A	*Asterionella japonica*
Guinardia flaccida	*Skeletonema costatum*

VI. Spring Dominants:

Gyrodinium sp. A	*Leptocylindrus minimus*
Flagellate D	

VII. Spring Subdominants:

Rhizosolenia setigera	*Ankistrodesmus* sp.
Rhizosolenia delicatula	*Prorocentrum scutellum*
Chaetoceros sp.	coccolith sp.
Ceratium tripos	

VIII. Year-Round Subdominants:

Coscinodiscus sp.	*Euglena* sp. A
Synedra sp.	*Navicula* sp. B
Paralia sulcata	*Navicula* sp.

Table II-8

Net phytoplankton species whose abundance was greater than 5% of a sample

	Proportion
5/9/74	
Station 1:	
Ceratium tripos	.327
Thalassiosira spp.	.316
Asterionella japonica	.167
Rhizosolenia setigera	.094
Chaetoceros sp. D	.063
Station 2:	
Asterionella japonica	.341
Rhizosolenia setigera	.249
Ceratium tripos	.211
Thalassiosira spp.	.111
Biddulphia granulata	.051
Station 3:	
Asterionella japonica	.482
Rhizosolenia setigera	.207
Thalassiosira spp.	.126
Ceratium tripos	.104
sp. H	.057
5/22/74	
Station 1:	
Ceratium tripos	.937
Station 2:	
Asterionella japonica	.595
Ceratium tripos	.311
Station 3:	
Asterionella japonica	.563
Ceratium tripos	.259
Nitzschia seriata	.096
Biddulphia granulata	.071

	Proportion
10/15/74	
Station 1:	
Rhizosolenia delicatula	.491
Nitzschia seriata	.383
Chaetoceros sp. B	.099
Station 2:	
Nitzschia seriata	.726
Chaetoceros sp. B	.104
Coscinodiscus spp.	.069
Station 3:	
Nitzschia seriata	.420
Rhizosolenia delicatula	.356
Chaetoceros sp. B	.154
10/30/74	
Station 1:	
Nitzschia seriata	.540
Noctiluca sp.	.430
Station 2:	
Noctiluca sp.	.497
Nitzschia seriata	.482
Station 3:	
Rhizosolenia delicatula	.761
Nitzschia seriata	.223
11/14/74	
Station 2:	
Noctiluca sp.	.843
Guinardia flaccida	.073
Station 3:	
Noctiluca sp.	.912

Table II-8 (cont.)

12/13/74 Station 1:	Proportion
Nitzschia seriata	.858
Guinardia flaccida	.123
Station 2:	
Nitzschia seriata	.740
Guinardia flaccida	.212
Station 3:	
Nitzschia seriata	.822
Guinardia flaccida	.146
1/16/75 Station 1:	
Nitzschia seriata	.591
Thalassiothrix frauenfeldii	.124
Asterionella japonica	.116
Thalassionema nitzschioides	.108
Station 2:	
Skeletonema costatum	.496
Thalassiothrix frauenfeldii	.229
Thalassionema nitzschioides	.093
Nitzschia seriata	.088
Station 3:	
Nitzschia seriata	.483
Thalassiothrix frauenfeldii	.204
Thalassionema nitzschioides	.137
Biddulphia granulata	.069

2/20/75 Station 2 --0700:	Proportion
Asterionella japonica	.378
Guinardia flaccida	.268
Nitzschia seriata	.110
sp. E	.069
Thalassionema nitzschioides	.059
0800:	
Nitzschia seriata	.339
Asterionella japonica	.281
Thalassiothrix frauenfeldii	.085
Thalassionema nitzschioides	.071
Ceratium fusus	.063
0900:	
Nitzschia seriata	.443
Asterionella japonica	.177
Thalassionema nitzschioides	.079
Thalassiothrix frauenfeldii	.059
1000:	
Asterionella japonica	.394
Rhizosolenia delicatula	.186
Nitzschia seriata	.176
1100:	
Nitzschia seriata	.372
Asterionella japonica	.202
Thalassiosira spp.	.095
Ceratium fusus	.059
1200:	
Asterionella japonica	.300
Guinardia flaccida	.263
Nitzschia seriata	.154
Thalassiosira spp.	.072
Rhizosolenia delicatula	.061

Table II-8 (cont.)

2/20/75 (cont.)
Station 2--1300:

	Proportion
Guinardia flaccida	.305
Asterionella japonica	.261
Nitzschia seriata	.147
Thalassiosira spp.	.101
Rhizosolenia delicatula	.055

1400:

Nitzschia seriata	.325
Asterionella japonica	.244
Thalassiothrix frauenfeldii	.108
Thalassiosira spp.	.101
Thalassionema nitzschioides	.098
sp. H	.088

1500:

Nitzschia seriata	.243
Asterionella japonica	.222
Thalassionema nitzschioides	.134
Thalassiothrix frauenfeldii	.086
Thalassiosira spp.	.061

1600:

Thalassiothrix frauenfeldii	.521
Nitzschia seriata	.144
Biddulphia granulata	.113
sp. D	.082

1700:

Asterionella japonica	.337
Thalassiothrix frauenfeldii	.128
Nitzschia seriata	.124
Guinardia flaccida	.112
Thalassiosira spp.	.095

1800:

	Proportion
Asterionella japonica	.283
Nitzschia seriata	.227
Biddulphia granulata	.131
Thalassiosira spp.	.067
Thalassionema nitzschioides	.067
Ceratium fusus	.051
Thalassiothrix frauenfeldii	.051

1900:

Asterionella japonica	.323
Thalassiothrix frauenfeldii	.155
Nitzschia seriata	.141
Guinardia flaccida	.115
Thalassionema nitzschioides	.068
Biddulphia granulata	.054
Thalassiosira spp.	.052

3/18/75
Station 1:

Guinardia flaccida	.433
Thalassiosira spp.	.221
Nitzschia seriata	.120
Asterionella japonica	.114

Station 2:

Guinardia flaccida	.383
Skeletonema costatum	.347
Thalassiosira spp.	.160
Nitzschia seriata	.051

Station 3:

Skeletonema costatum	.557
Guinardia flaccida	.192
Thalassiosira spp.	.184

Table II-8 (cont.)

4/14/75 Station 2--0800:	Proportion
Guinardia flaccida	.839
Skeletonema costatum	.125
0900:	
Guinardia flaccida	.876
1000:	
Guinardia flaccida	.932
1100:	
Guinardia flaccida	.881
1200:	
Guinardia flaccida	.883
sp. E	.065
1300:	
Guinardia flaccida	.957
1400:	
Guinardia flaccida	.881
Thalassiosira spp.	.081
1500:	
Guinardia flaccida	.931
1600:	
Guinardia flaccida	.954
1700:	
Guinardia flaccida	.977
1800:	
Guinardia flaccida	.942
1900:	
Guinardia flaccida	.957

5/9/75 Station 1:	Proportion
Guinardia flaccida	.984
Station 2:	
Guinardia flaccida	.915
Station 3:	
Guinardia flaccida	.945
5/28/75 Station 1:	
Ceratium tripos	.559
sp. M	.263
Ceratium fusus	.060
Guinardia flaccida	.055
Station 2:	
Ceratium tripos	.299
Ceratium fusus	.134
Rhizosolenia alata	.116
sp. M	.113
Guinardia flaccida	.110
Biddulphia granulata	.079
Station 3:	
Ceratium tripos	.263
Biddulphia granulata	.161
Ceratium fusus	.135
Rhizosolenia setigera	.087
sp. M	.069
Rhizosolenia alata	.067
Guinardia flaccida	.056

Table II-9

Similarity of species composition between cruises--Jaccard Coefficient

Station 1

	5/9/74	5/22/74	10/15/74	10/30/74	12/13/74	1/16/75	3/18/75	5/9/75	5/28/75
5/22/74	.400								
10/15/74	0.00	.154							
10/30/74	.083	.300	.167						
12/13/74	.083	.300	.273	.500					
1/16/75	.158	.222	.278	.167	.235				
3/18/75	.357	.267	.176	.200	.385	.227			
5/ 9/75	.333	.091	0.00	.100	.222	.111	.417		
5/28/75	.333	.538	.105	.267	.267	.333	.389	.200	

Station 2

	5/9/74	5/22/74	10/15/74	10/30/74	11/14/74	12/13/74	1/16/75	2/20/75	3/18/75	4/14/75	5/9/75
5/22/74	.385										
10/15/74	.222	.222									
10/30/74	.250	.154	.357								
11/14/74	.267	.118	.353	.600							
12/13/74	.385	.200	.467	.364	.462						
1/16/75	.357	.357	.353	.231	.250	.462					
2/20/75	.444	.300	.500	.211	.286	.529	.500				
3/18/75	.267	.118	.278	.231	.250	.462	.333	.421			
4/14/75	.308	.063	.015	.167	.286	.417	.286	.250	.500		
5/ 9/75	.313	.313	.316	.200	.375	.500	.375	.450	.294	.429	
5/28/75	.438	.533	.286	.333	.333	.438	.333	.476	.556	.375	.400

Table II-9 (cont.)

Station 3

	5/9/74	5/22/74	10/15/74	10/30/74	11/14/74	12/13/74	1/16/75	3/18/75	5/9/75
5/22/74	.385								
10/15/74	.059	.231							
10/30/74	0.00	.083	.182						
11/14/74	.133	.154	.154	.333					
12/13/74	.200	.231	.333	.300	.667				
1/16/75	.294	.538	.333	.133	.267	.429			
3/18/75	.143	.077	.167	.100	.182	.273	.200		
5/ 9/75	.545	.364	.071	.091	.400	.364	.267	.182	
5/28/75	.412	.375	.158	.188	.400	.467	.368	.538	.400

Table II-10

Similarity of species composition between stations

Jaccard Coefficient

Date	Stations 1 & 2	2 & 3	1 & 3
5/ 9/74	.545	.667	.462
5/22/74	.417	.700	.600
10/15/74	.313	.399	.455
10/30/74	.714	.100	.375
11/14/74	-	.545	-
12/13/74	.667	.700	.750
1/16/75	.471	.692	.499
3/18/75	.467	.455	.286
5/ 9/75	.308	.429	.300
5/28/75	.421	.750	.588

Table II-11

Similarity of species composition over twelve hour cruises--Jaccard Coefficient

February 20, 1975

	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
0800	.588											
0900	.667	.706										
1000	.499	.524	.591									
1100	.571	.600	.842	.652								
1200	.476	.579	.650	.636	.800							
1300	.591	.545	.681	.739	.739	.727						
1400	.522	.545	.762	.667	.818	.727	.826					
1500	.571	.524	.750	.652	.810	.714	.739	.818				
1600	.500	.438	.444	.381	.381	.350	.409	.348	.318			
1700	.545	.571	.714	.625	.773	.609	.640	.783	.696	.364		
1800	.632	.667	.737	.800	.714	.700	.727	.727	.636	.421	.682	
1900	.550	.667	.737	.714	.714	.700	.652	.652	.636	.350	.682	.889

April 14, 1975

	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
0900	.454										
1000	.416	.700									
1100	.285	.500	.727								
1200	.307	.307	.454	.357							
1300	.250	.250	.454	.545	.333						
1400	.363	.500	.454	.416	.333	.556					
1500	.416	.333	.285	.357	.285	.454	.600				
1600	.363	.667	.600	.545	.333	.400	.750	.454			
1700	.181	.444	.400	.500	.167	.333	.500	.400	.714		
1800	.250	.363	.454	.416	.454	.556	.556	.600	.400	.333	
1900	.231	.333	.416	.385	.307	.500	.500	.545	.363	.300	.667

Table II-12

Species abundance
Similarity between cruises

Canberra Metric Coefficient

Station 1

	5/9/74	5/22/74	10/15/74	10/30/74	12/13/74	1/16/75	3/18/75	5/9/75
5/22/74	.775							
10/15/74	.620	.706						
10/30/74	.715	.789	.756					
12/13/74	.719	.821	.767	.909				
1/16/75	.557	.624	.638	.621	.641			
3/18/75	.712	.651	.611	.601	.747	.557		
5/ 9/75	.742	.721	.705	.750	.808	.563	.758	
5/28/75	.648	.790	.568	.670	.707	.516	.623	.615

Station 2

	5/9/74	5/22/74	10/15/74	10/30/74	11/14/74	12/13/74	1/16/75	2/30/75	3/18/75	4/14/75	5/9/75
5/22/74	.775										
10/15/74	.617	.613									
10/30/74	.744	.703	.731								
11/14/74	.696	.667	.645	.832							
12/13/74	.721	.678	.746	.800	.728						
1/16/75	.708	.724	.650	.715	.632	.700					
2/20/75	.653	.573	.616	.586	.553	.632	.675				
3/18/75	.686	.629	.610	.714	.650	.687	.705	.619			
4/14/75	.727	.641	.639	.761	.727	.713	.726	.607	.780		
5/ 9/75	.645	.673	.596	.675	.699	.759	.654	.596	.663	.749	
5/28/75	.699	.616	.540	.633	.661	.653	.626	.582	.615	.665	.594

Table II-12 (cont.)

Station 3

	5/9/74	5/22/74	10/15/74	10/30/74	11/14/74	12/13/74	1/16/75	3/18/75	5/9/75
5/22/74	.841								
10/15/74	.554	.704							
10/30/74	.621	.754	.755						
11/14/74	.677	.743	.700	.788					
12/13/74	.660	.759	.764	.770	.843				
1/16/75	.618	.771	.657	.667	.661	.733			
3/18/75	.668	.753	.709	.746	.767	.775	.676		
5/ 9/75	.791	.831	.648	.731	.778	.791	.689	.748	
5/28/75	.633	.695	.577	.614	.698	.695	.584	.626	.664

Table II-13

Similarity of species abundance between stations

Canberra Metric Coefficient

Date	Stations 1 & 2	2 & 3	1 & 3
5/ 9/74	.785	.863	.747
5/22/74	.770	.848	.878
10/15/74	.628	.671	.783
10/30/74	.864	.657	.701
11/14/74	-	.807	-
12/13/74	.761	.795	.832
1/16/75	.605	.808	.651
3/18/75	.714	.807	.686
5/ 9/75	.716	.764	.830
5/28/75	.722	.820	.694

Table II-14

Species abundance
Similarity over twelve hour cruises

Canberra Metric Coefficient

February 20, 1975

	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
0800	.691											
0900	.686	.840										
1000	.639	.650	.557									
1100	.627	.728	.670	.655								
1200	.630	.715	.611	.730	.769							
1300	.683	.600	.527	.706	.679	.694						
1400	.621	.674	.637	.659	.779	.701	.709					
1500	.643	.686	.661	.671	.770	.720	.667	.787				
1600	.705	.728	.605	.615	.607	.599	.562	.556	.572			
1700	.649	.670	.629	.641	.730	.610	.657	.696	.704	.574		
1800	.657	.785	.639	.734	.720	.532	.674	.654	.696	.668	.696	
1900	.666	.520	.645	.711	.711	.451	.657	.672	.687	.630	.754	.823

April 14, 1975

	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
0900	.802										
1000	.776	.851									
1100	.713	.767	.872								
1200	.734	.695	.749	.701							
1300	.744	.709	.783	.785	.745						
1400	.767	.772	.791	.763	.739	.817					
1500	.797	.712	.665	.704	.672	.741	.783				
1600	.806	.858	.822	.800	.732	.762	.827	.742			
1700	.762	.792	.795	.815	.690	.779	.832	.741	.897		
1800	.750	.733	.795	.753	.775	.795	.795	.763	.738	.745	
1900	.723	.710	.736	.735	.701	.782	.796	.762	.703	.751	.817

FIGURE CAPTIONS FOR CHAPTER II

Figure II- 1: Cumulative proportions of whole water phytoplankton samples contributed by various classes.

Figure II- 2: Seasonal changes of total cells/ml from whole water phytoplankton samples.

Figure II- 3: Seasonal changes of evenness diversity values for whole water phytoplankton species. Evenness is measured by scaled standard deviation (SDN) of Fager (1972).

Figure II- 4: Seasonal change in abundance of *Calycomonas ovalis* at plankton stations in lower Delaware Bay.

Figure II- 5: Seasonal change in abundance of *Pyramimonas* sp. A at plankton stations in lower Delaware Bay.

Figure II- 6: Seasonal change in abundance of *Cryptomonas acuta* at plankton stations in lower Delaware Bay.

Figure II- 7: Seasonal change in abundance of *Chrysochromulina* sp. at plankton stations in lower Delaware Bay.

Figure II- 8: Seasonal change in abundance of *Skeletonema costatum* at plankton stations in lower Delaware Bay.

Figure II- 9: Seasonal change in abundance of *Katodinium rotundatum* at plankton stations in lower Delaware Bay.

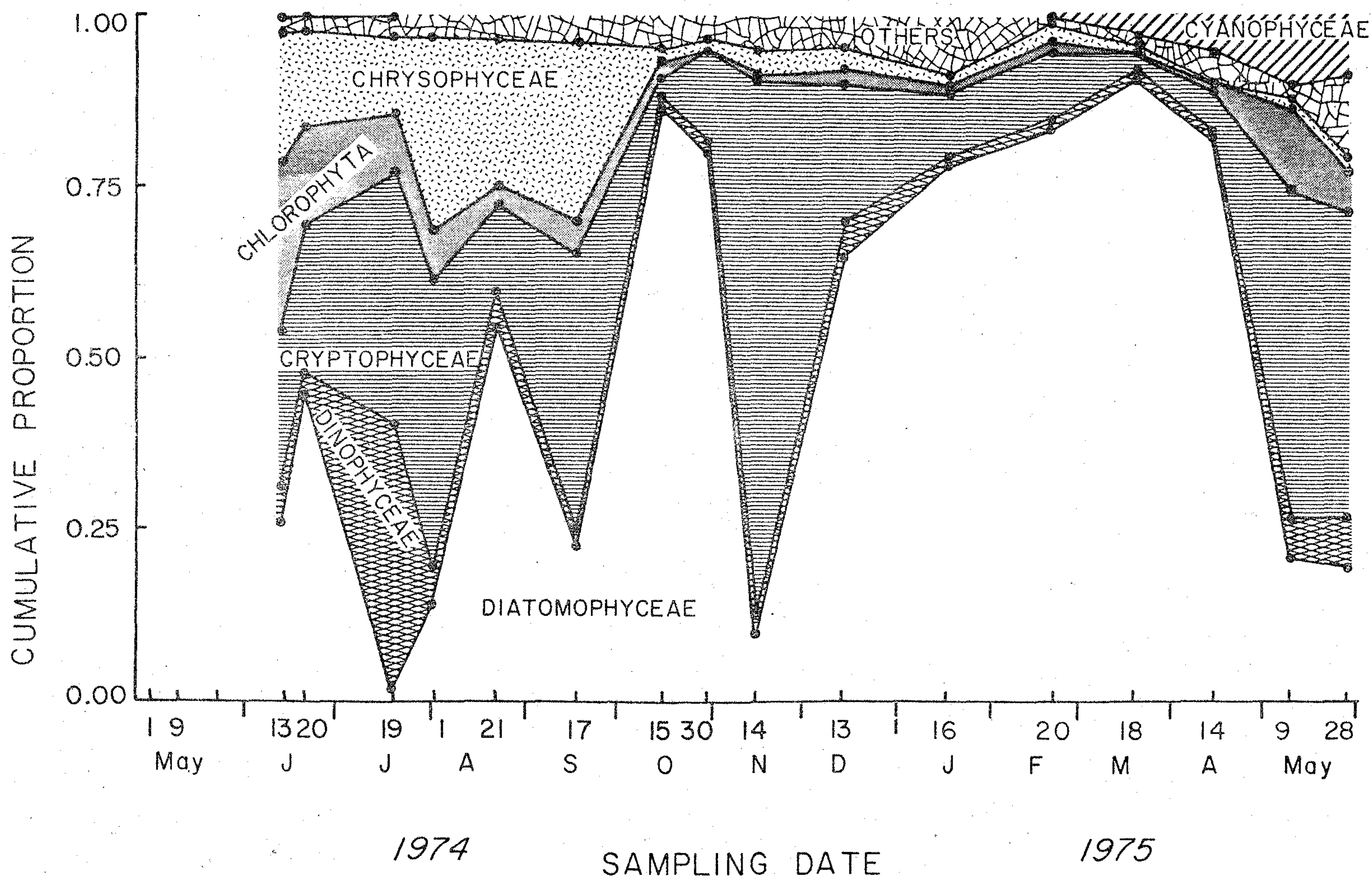
Figure II-10: Classification dendrogram illustrating similarity of whole water phytoplankton samples.

Figure II-11: Classification dendrogram illustrating similarity of nannoplankton species according to the samples in which they occurred. Numbers along abcissa are the last three digits of species code numbers listed in Table II-1.

Figure II-12: Seasonal change in relative abundance of *Nitzschia seriata* from net phytoplankton samples.

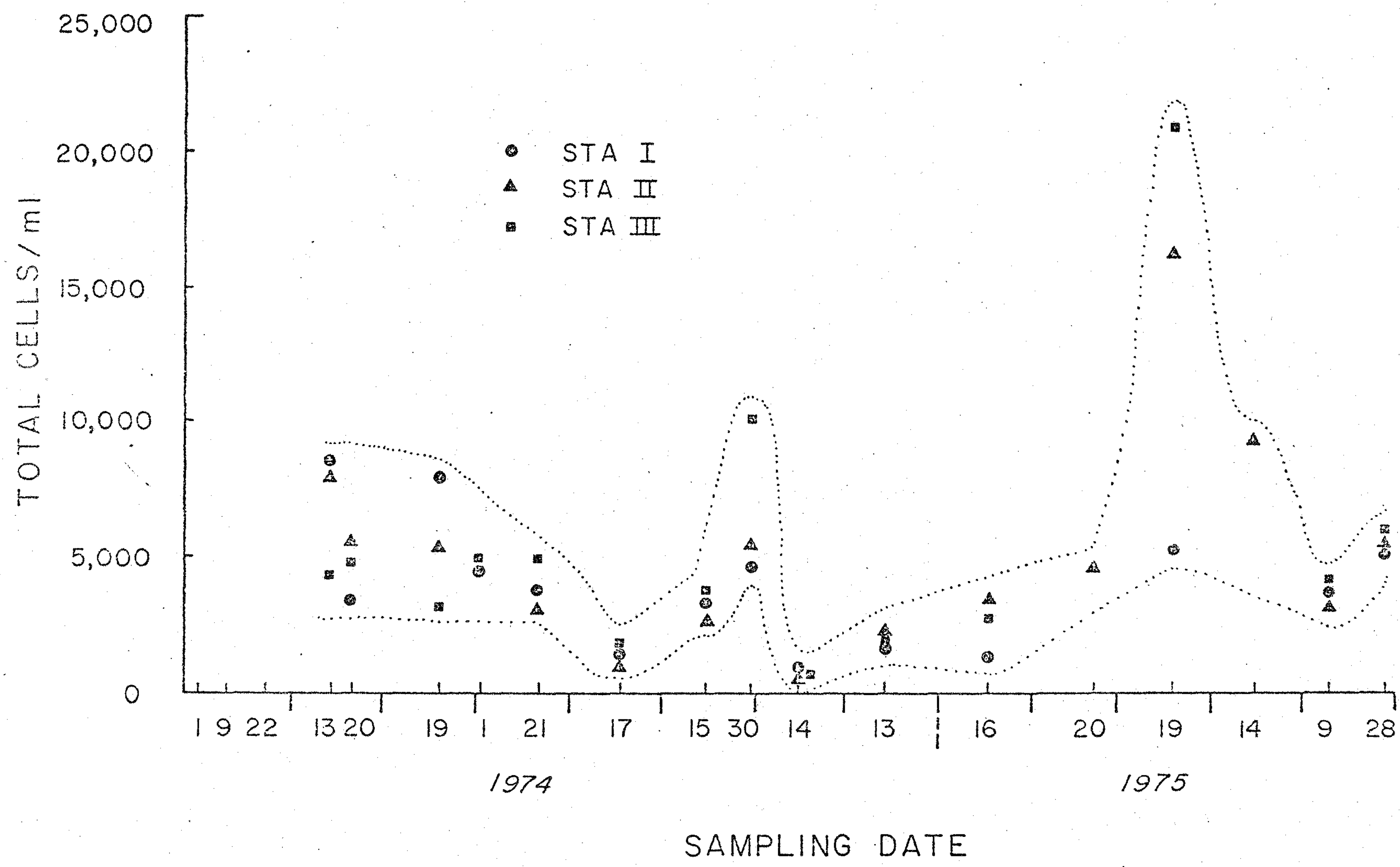
Figure II-13: Seasonal change in relative abundance of *Guinardia flaccida* from net phytoplankton samples.

Figure II-14: Changes in relative abundance of *Guinardia flaccida* in net phytoplankton samples taken during twelve-hour cruises of February 20 and April 14, 1975.



CUMULATIVE PROPORTION
1.00
0.75
0.50
0.25
0.00
CHRYSOPHYCEAE
CHLOROPHYTA
CRYPTOPHYCEAE
DINOPHYCEAE
DIATOMOPHYCEAE
OTHERS
CYANOPHYCEAE
1 9 May
13 20 J
19 J
1 21 A
17 S
15 30 O
14 N
13 D
16 J
20 F
18 M
14 A
9 28 May
1974
SAMPLING DATE
1975

Figure II-1



25,000
20,000
15,000
10,000
5,000
0
TOTAL CELLS/ml
STA I
STA II
STA III
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 19 14 9 28
1974
1975
SAMPLING DATE

Figure II-2

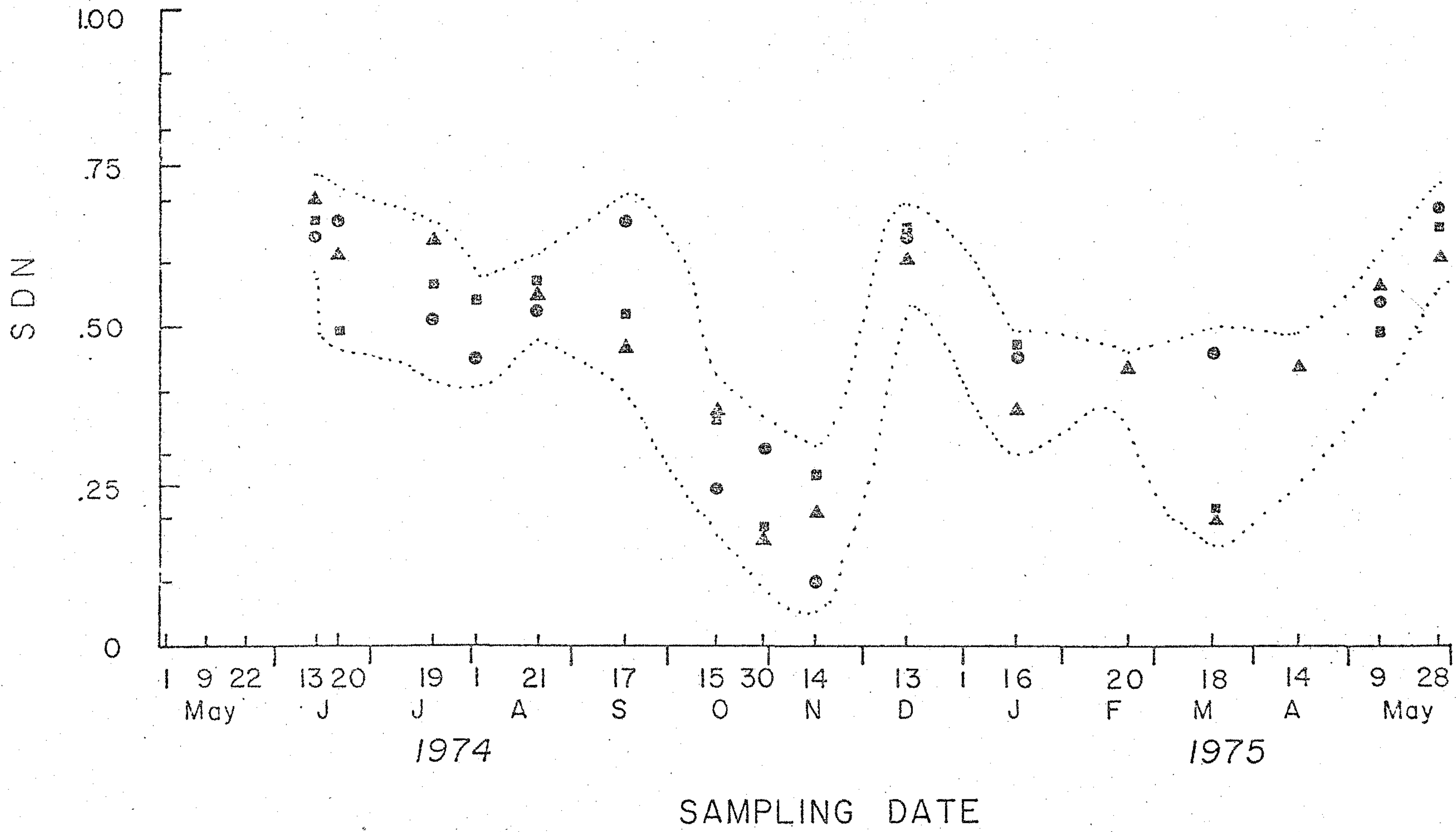

1.00
.75
.50
.25
0
S D N
1 9 22 13 20 19 1 21 17 15 30 14 13 1 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure II-3

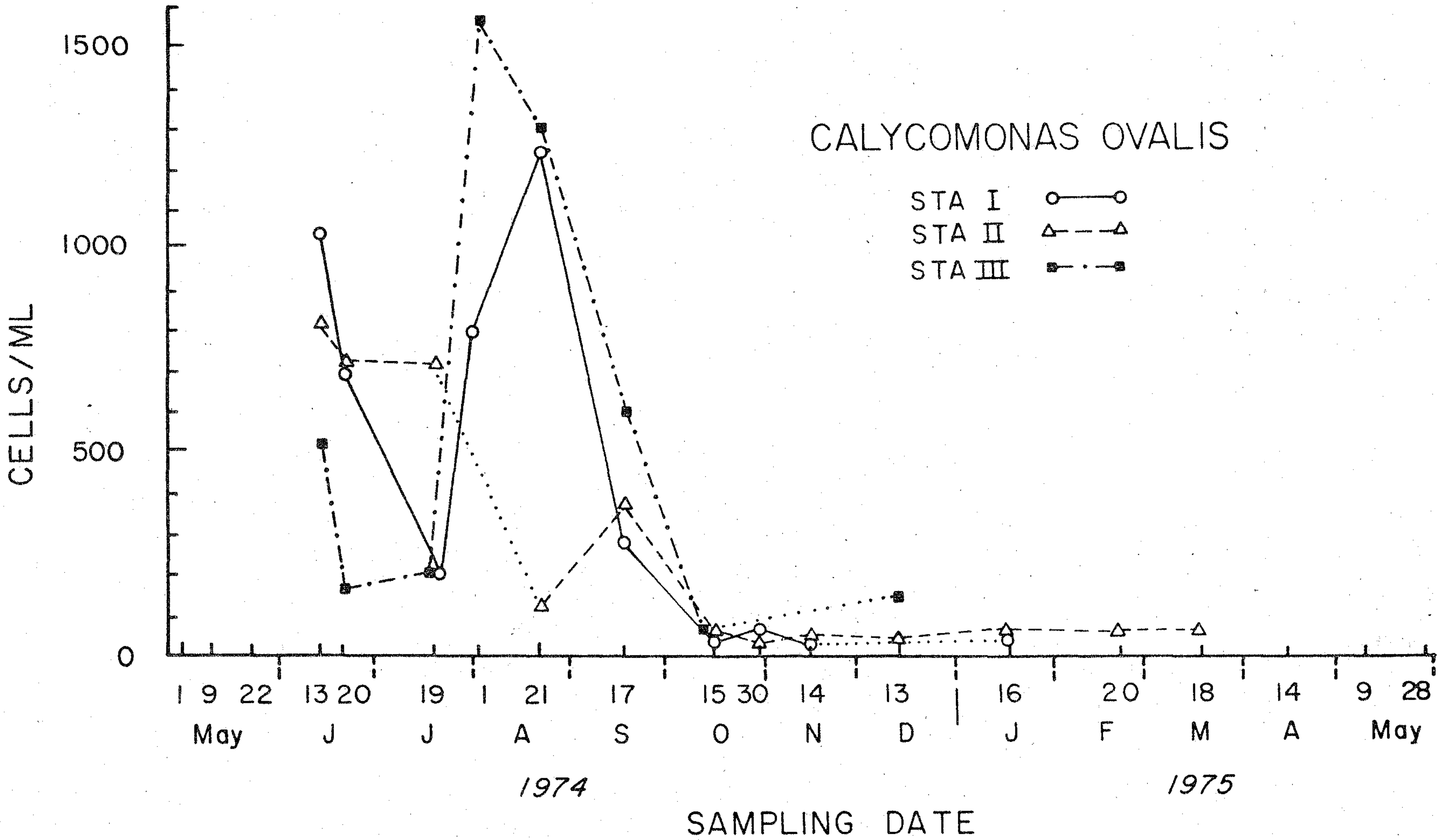

CALYCOMONAS OVALIS
STA I
STA II
STA III
CELLS/ML
1500
1000
500
0
1 9 22
May
13 20
J
19
J
1
21
A
17
S
15 30
O
14
N
13
D
16
J
20
F
18
M
14
A
9 28
May
1974
1975
SAMPLING DATE

Figure II-4

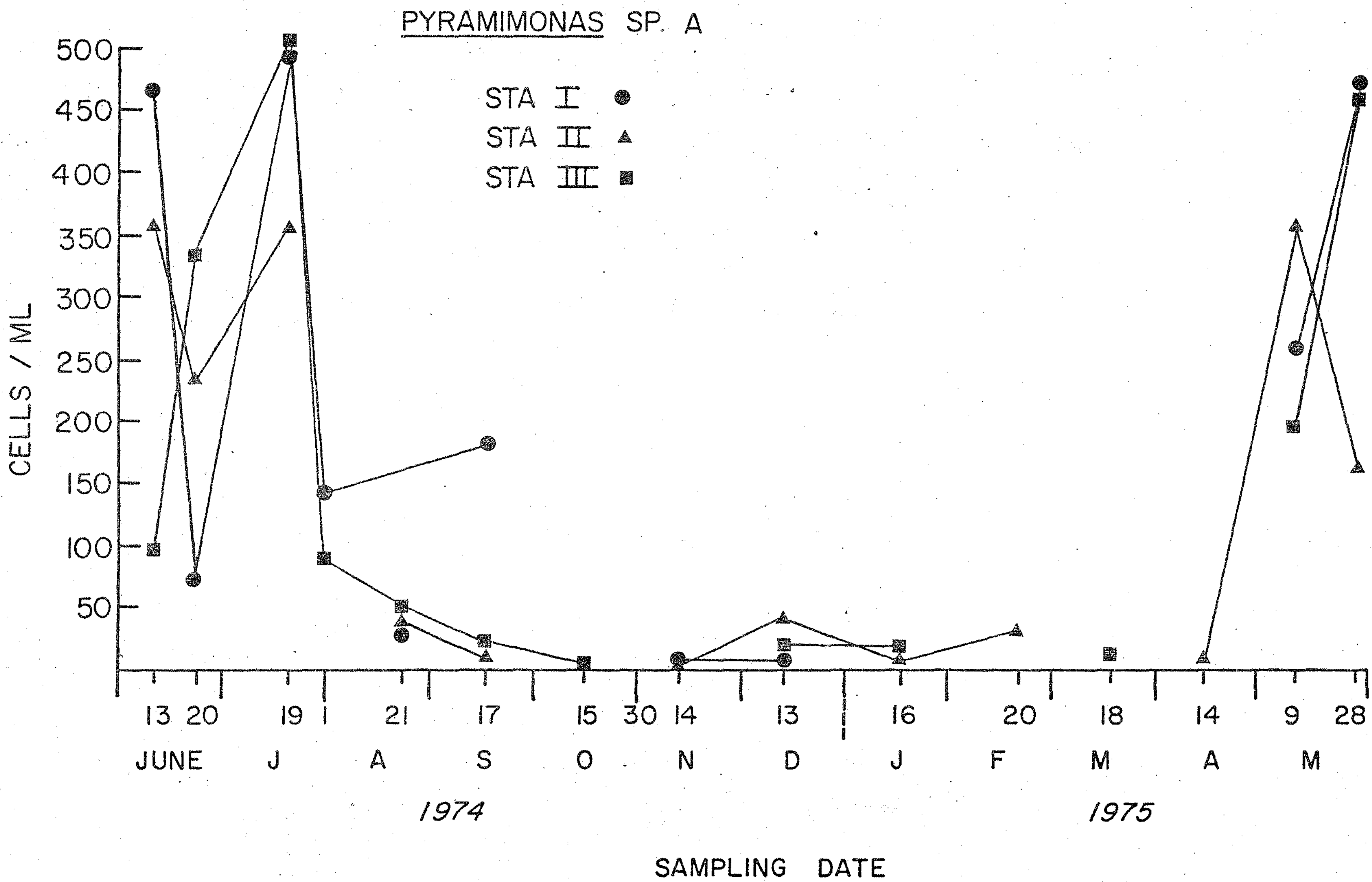

PYRAMIMONAS SP. A
STA I
STA II
STA III
CELLS / ML
500
450
400
350
300
250
200
150
100
50
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure II-5

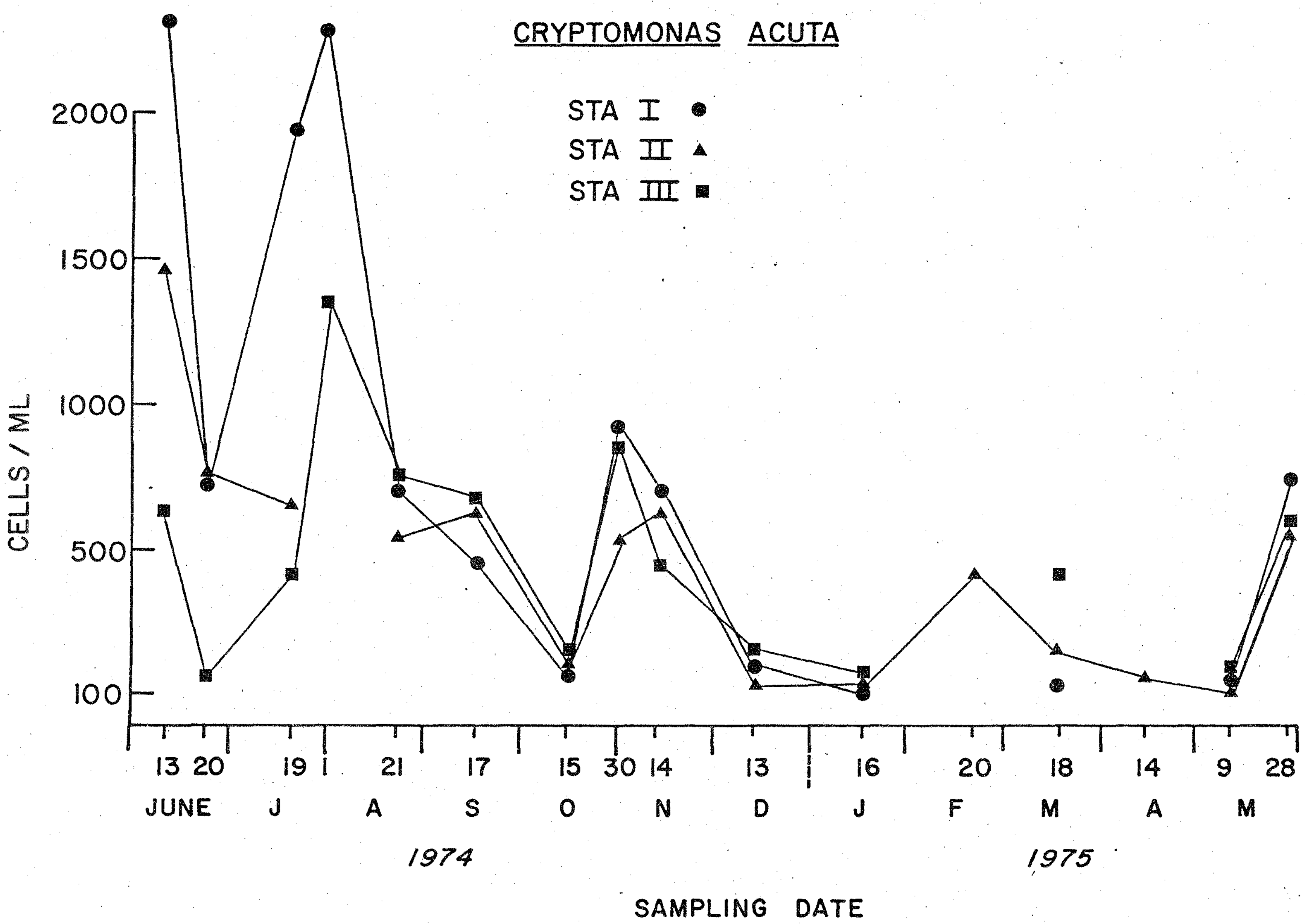

CRYPTOMONAS ACUTA
STA I ●
STA II ▲
STA III ■
CELLS / ML
2000
1500
1000
500
100
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure II-6

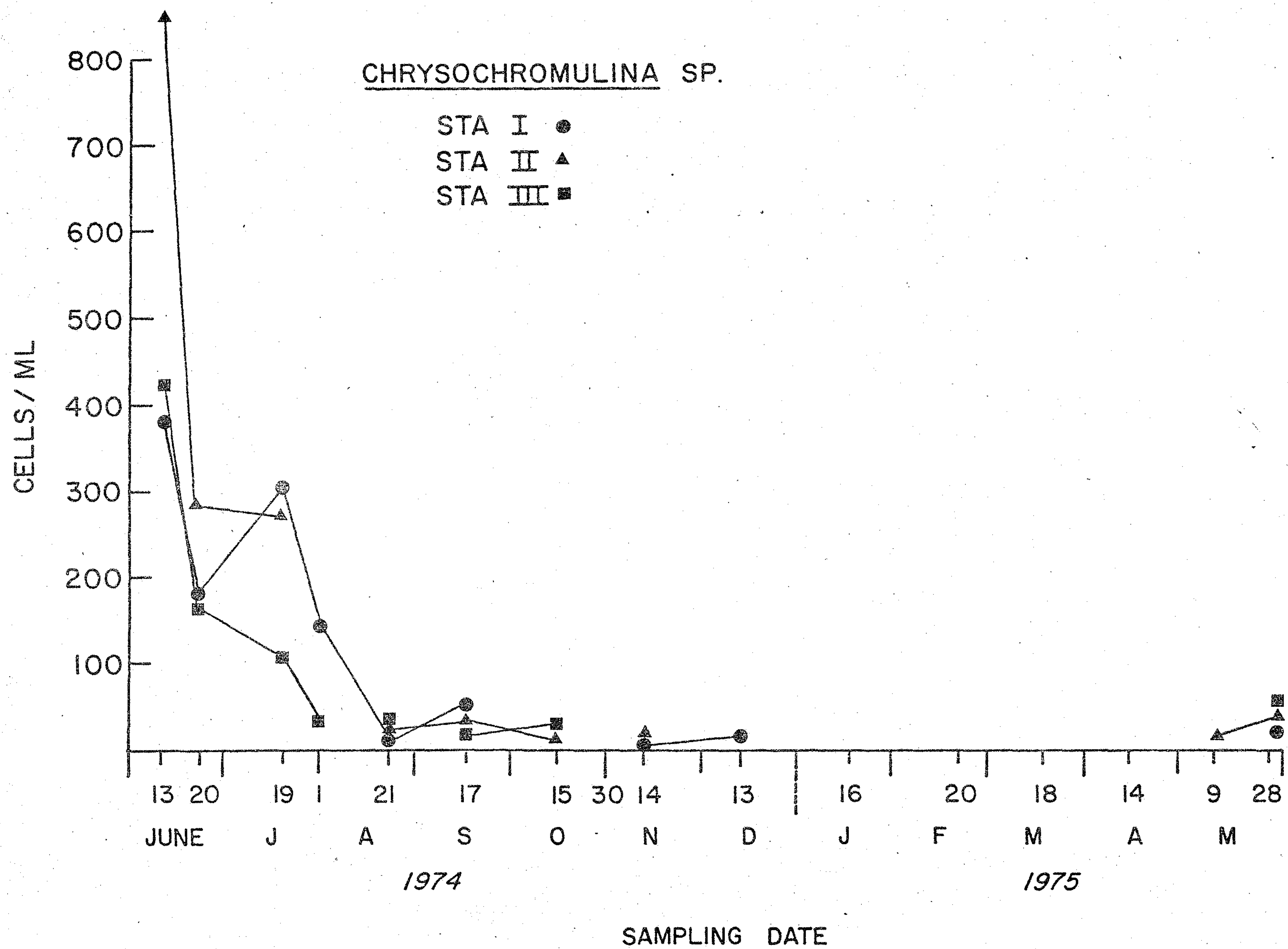

CHRYSOCHROMULINA SP.
STA I
STA II
STA III
CELLS / ML
800
700
600
500
400
300
200
100
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure II-7

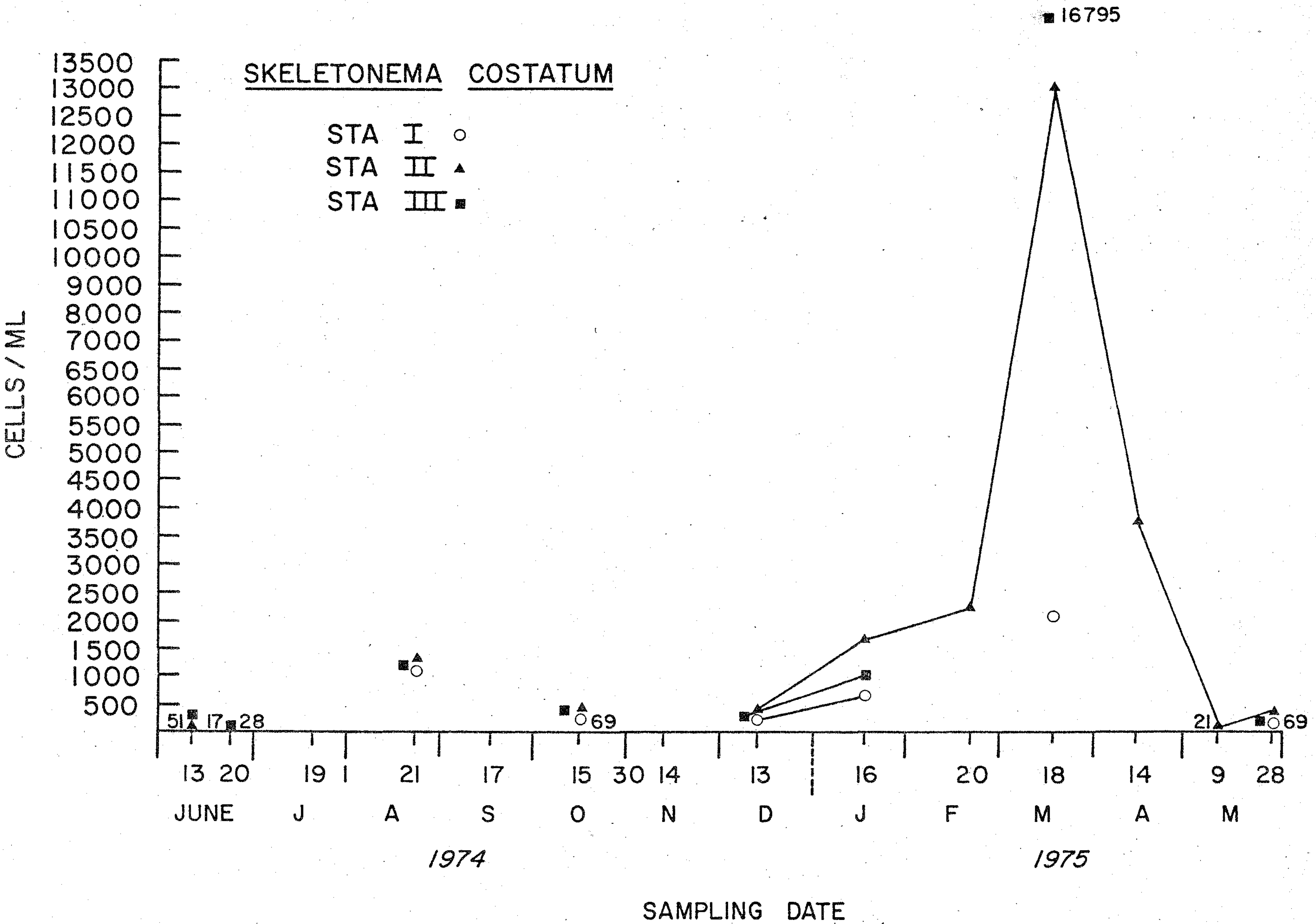

SKELETONEMA COSTATUM
STA I
STA II
STA III
CELLS / ML
13500
13000
12500
12000
11500
11000
10500
10000
9000
8000
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
16795
51
17
28
69
21
69
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure II-8

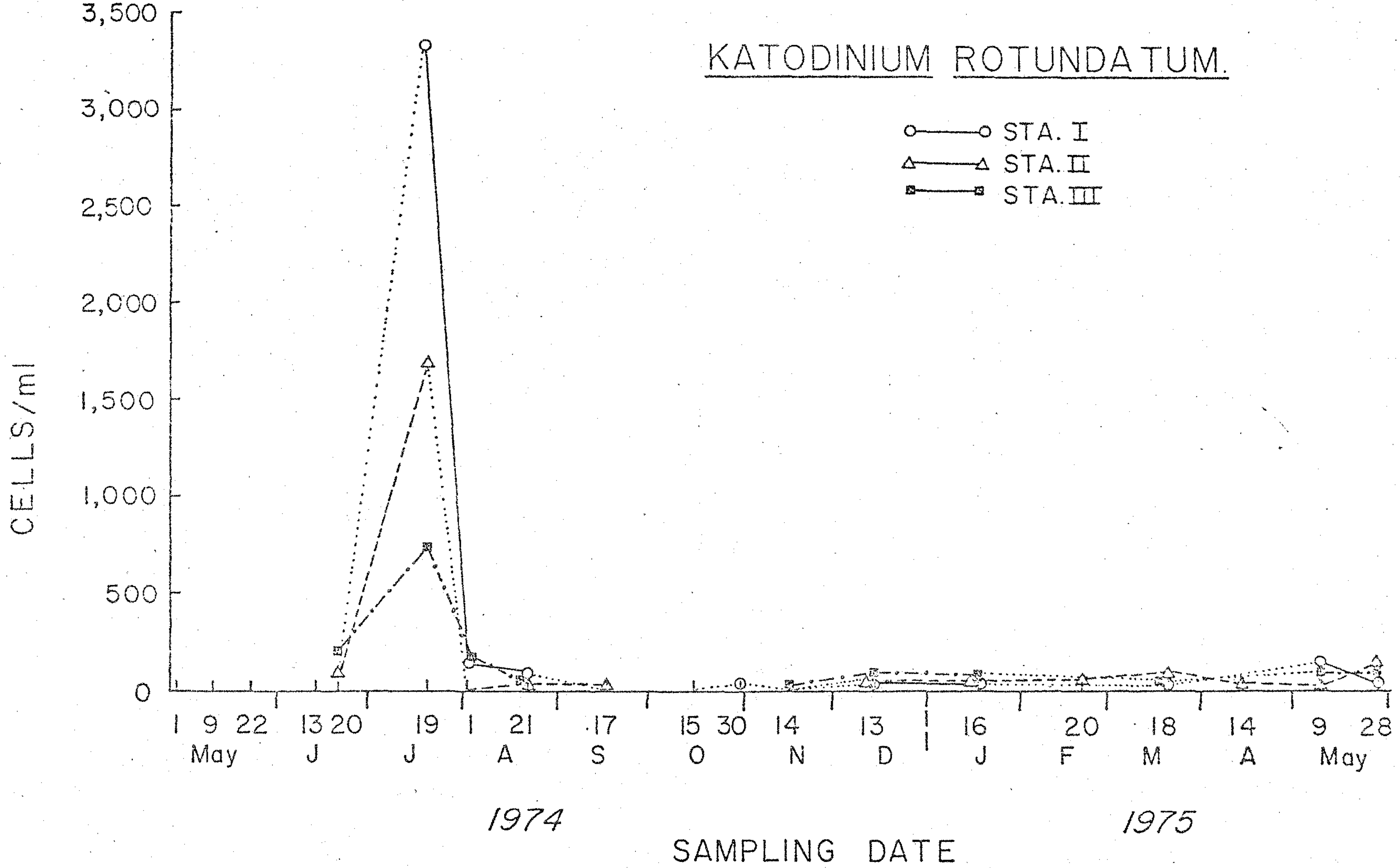
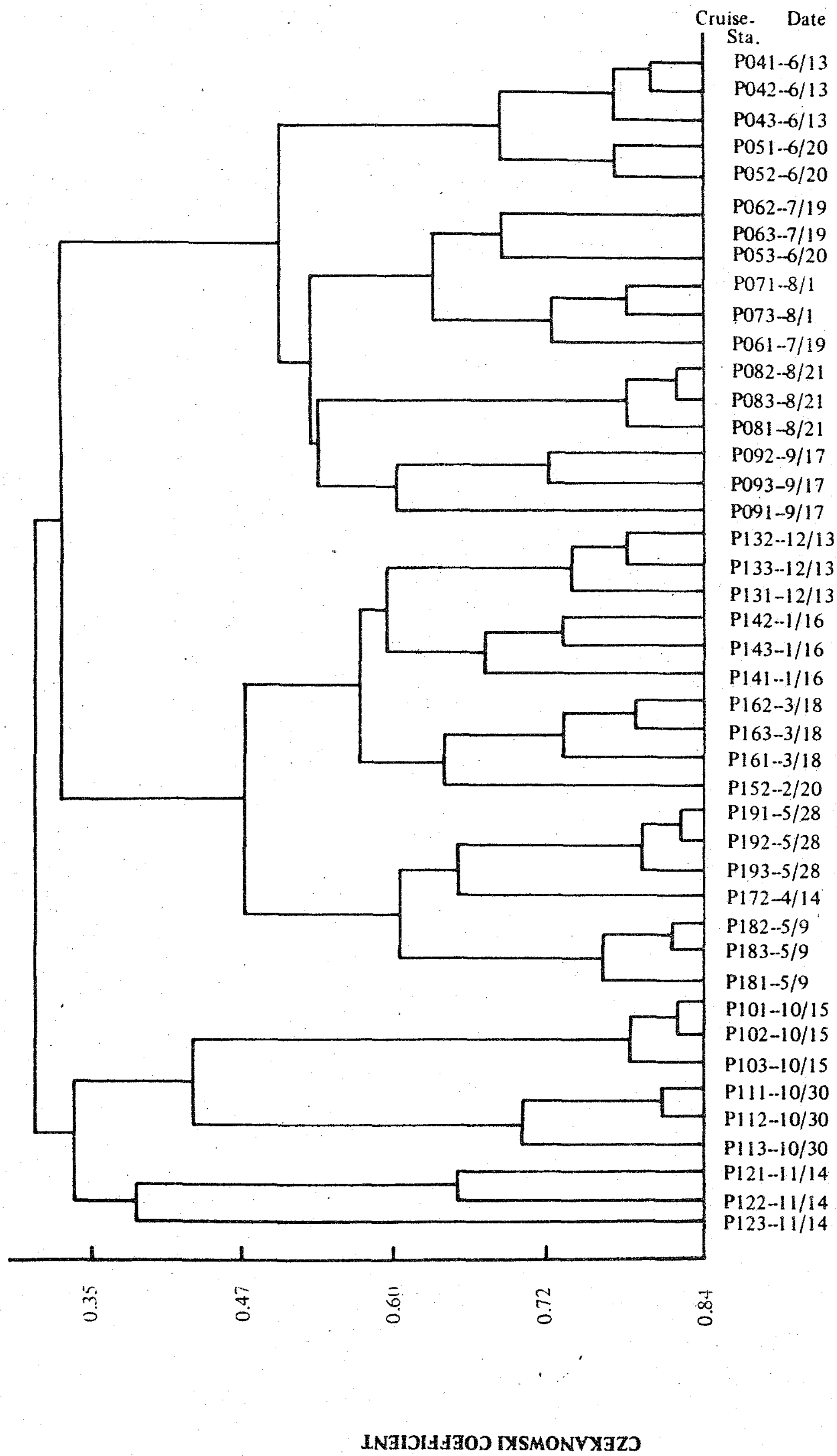

KATODINIUM ROTUNDATUM.
STA. I
STA. II
STA. III
CELLS/ml
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure II-9



Cruise-Sta.
Date
P041--6/13
P042--6/13
P043--6/13
P051--6/20
P052--6/20
P062--7/19
P063--7/19
P053--6/20
P071--8/1
P073--8/1
P061--7/19
P082--8/21
P083--8/21
P081--8/21
P092--9/17
P093--9/17
P091--9/17
P132--12/13
P133--12/13
P131--12/13
P142--1/16
P143--1/16
P141--1/16
P162--3/18
P163--3/18
P161--3/18
P152--2/20
P191--5/28
P192--5/28
P193--5/28
P172--4/14
P182--5/9
P183--5/9
P181--5/9
P101--10/15
P102--10/15
P103--10/15
P111--10/30
P112--10/30
P113--10/30
P121--11/14
P122--11/14
P123--11/14
0.35
0.47
0.60
0.72
0.84
CZEKANOWSKI COEFFICIENT

Figure II-10

Nannoplankton species groups

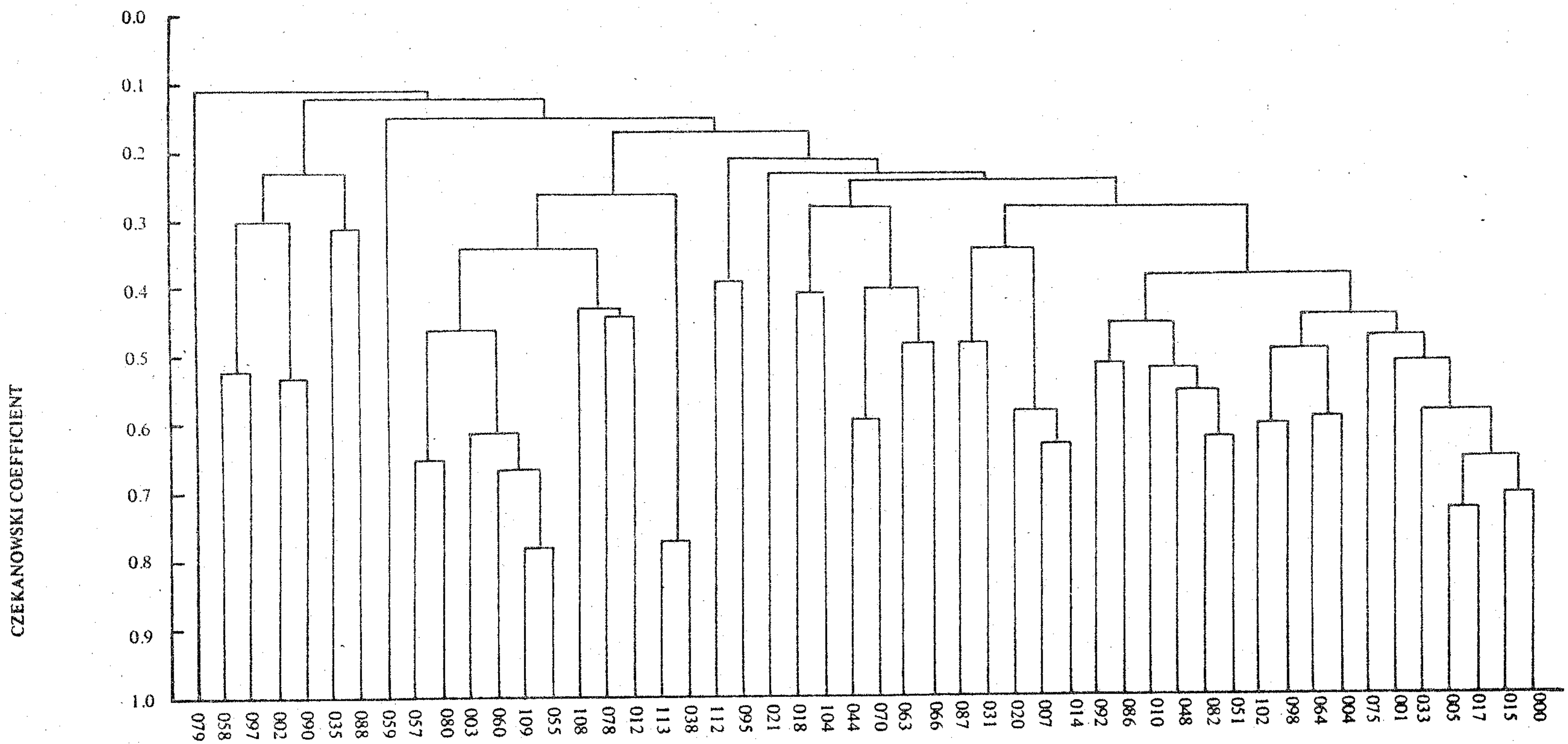


Figure II-11

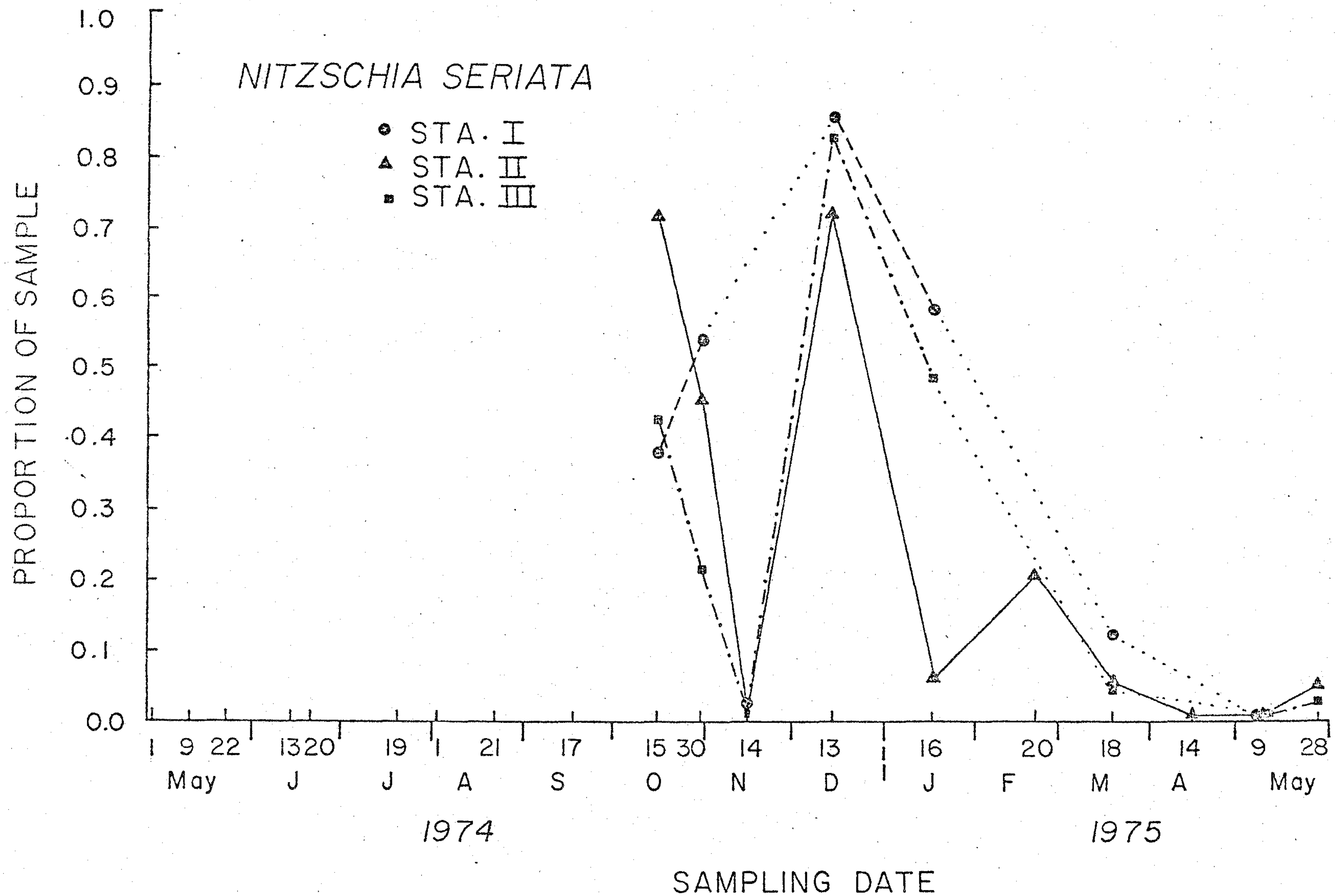

NITZSCHIA SERIATA
STA. I
STA. II
STA. III
PROPORTION OF SAMPLE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 9 22
1320
19
1
21
17
15 30
14
13
16
20
18
14
9 28
May
J
J
A
S
O
N
D
J
F
M
A
May
1974
1975
SAMPLING DATE

Figure II-12

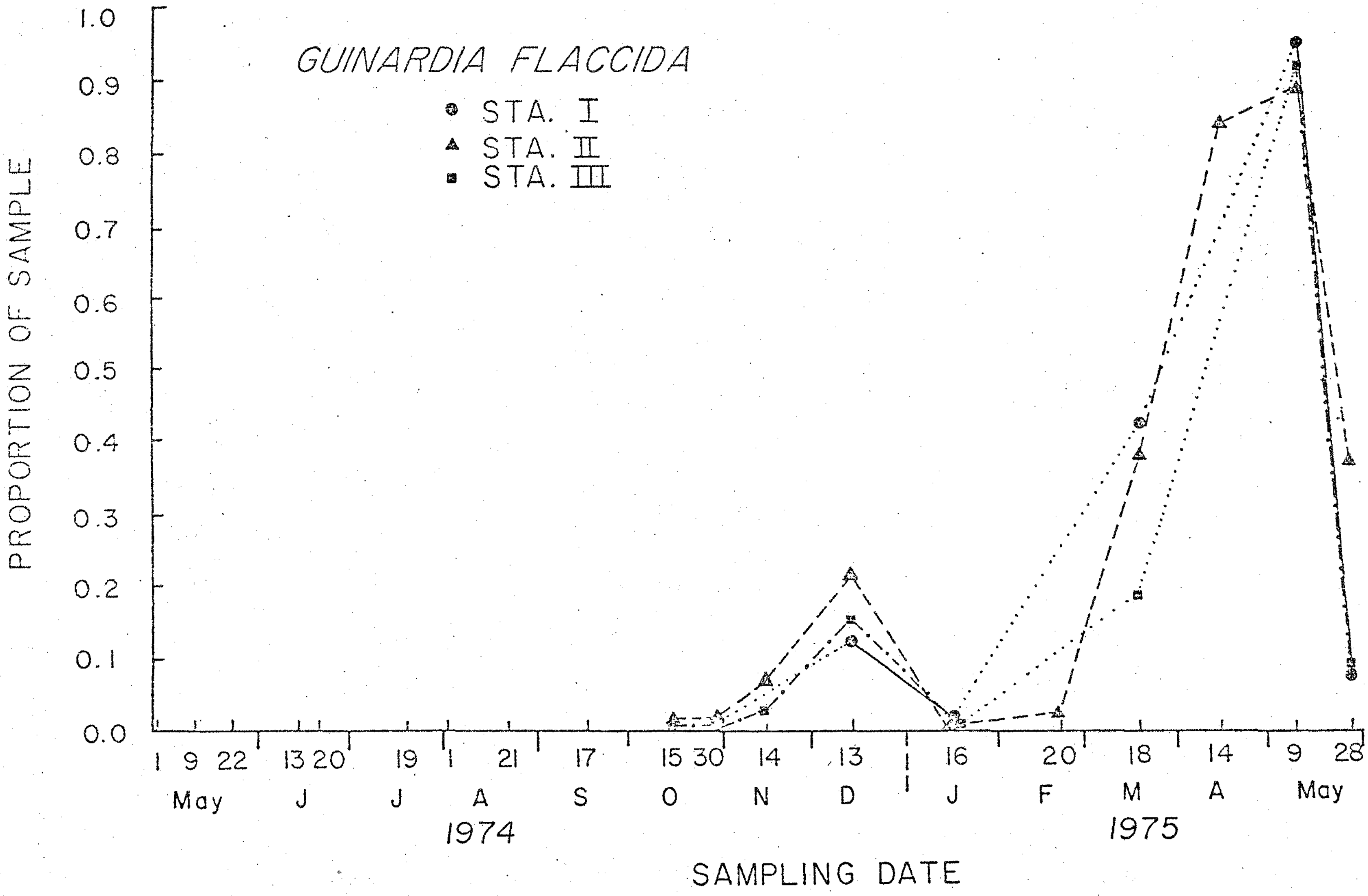

GUINARDIA FLACCIDA
STA. I
STA. II
STA. III
PROPORTION OF SAMPLE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 9 22
13 20
19
1
21
17
15 30
14
13
16
20
18
14
9
28
May
J
J
A
S
O
N
D
J
F
M
A
May
1974
1975
SAMPLING DATE

Figure II-13

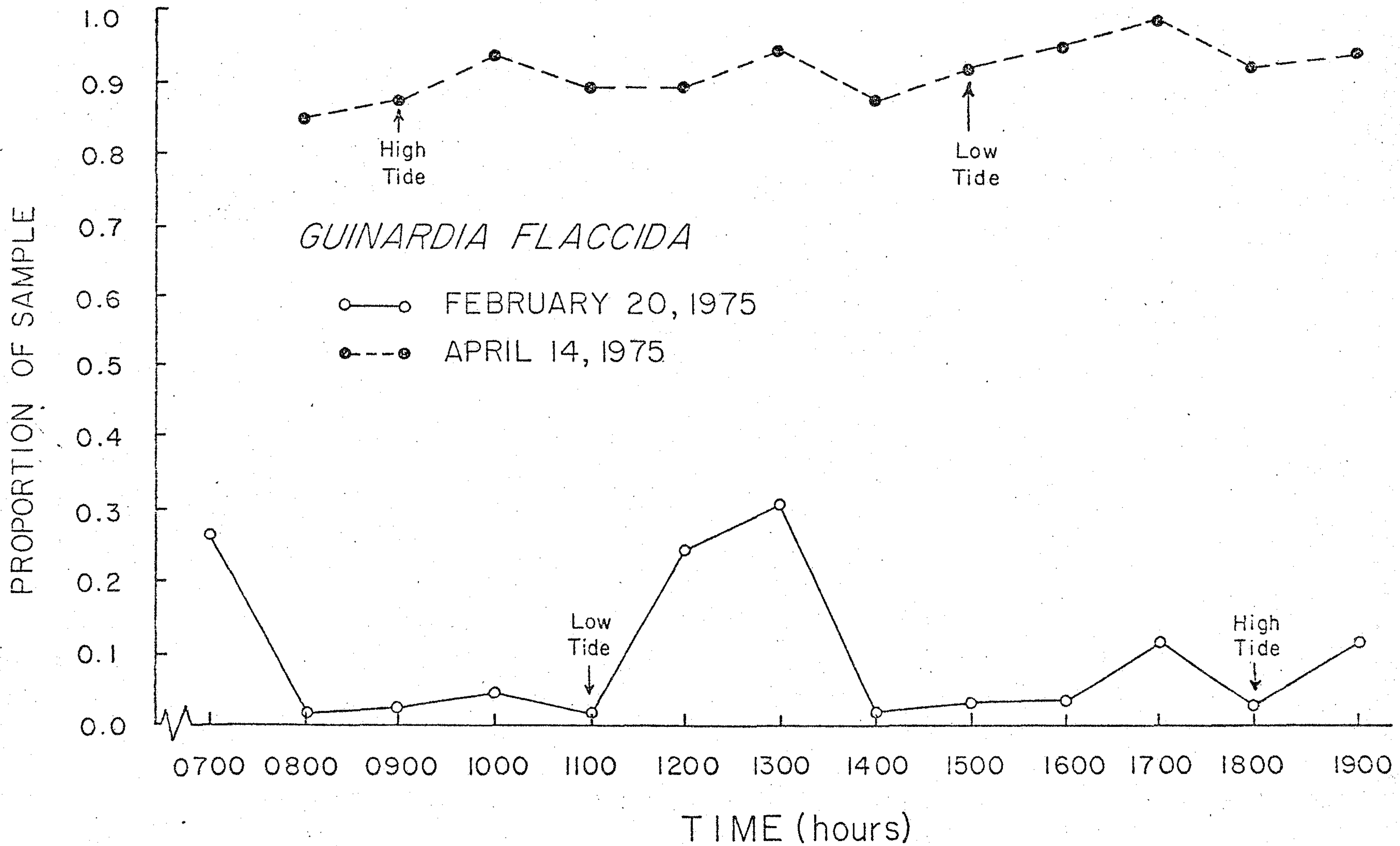

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PROPORTION OF SAMPLE
High
Tide
Low
Tide
GUINARDIA FLACCIDA
FEBRUARY 20, 1975
APRIL 14, 1975
Low
Tide
High
Tide
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
TIME (hours)

Figure II-14

III. ZOOPLANKTON

Rose Lambert
Ann Pembroke

INTRODUCTION

In a review of zooplankton research along the American Atlantic coast, Jeffries and Johnson (1973) stated that the zooplankton from Cape Cod to Cape Hatteras has been studied more or less continuously, in one way or another, since the turn of the century. Because of differences in sampling and in methods for quantifying data, comparisons and syntheses of various authors' research presented a formidable task.

In the Delaware Bay area, several zooplankton studies have been conducted, the more recent of which were in conjunction with environmental problems. These include samples taken in and near the Chesapeake and Delaware Canal (Ferrante, 1971; Raytheon, 1975), along the length of the lower Bay (Cronin, et al., 1962), in the bay mouth region (Deevey, 1960) and in the adjacent coastal waters (Van Engel and Tan, 1965; DuPont, et al., 1972; Sandine and Swiecicki, 1975). Deevey (1960), using six years of samples gathered from 1929-1935, qualitatively analyzed the fauna of the surface waters in the bay and near coastal waters. A fairly coarse mesh [No. 0 (0.515 mm average aperture) or No. 2 (0.342 mm average aperture)] was used which limited collection of smaller copepods and larvae unless net clogging occurred.

Cronin, et al. (1962) quantitatively examined the zooplankton within the bay over a two-year period with a No. 2 net. The entire length of the bay and river, from Philadelphia to Cape Henlopen, was sampled during eight quarterly cruises. They characterized the different zooplankton fauna of different salinity regions. In the region of the present study (which lies in the polyhaline zone), they determined that the principal zooplankton species were: *Centropages typicus*, *C. hamatus*, *Labidocera aestiva*, *Temora longicornis*, *Penilia avirostris*, *Paracalanus parvus*, and *Evadne normanni*.

Zooplankton were collected as part of the baseline studies for the lightering area. These data were also used to examine interactions of the nutrients, phytoplankton, and zooplankton at three stations in this restricted area over one seasonal cycle. This chapter will examine the seasonal cycle of zooplankton species for these three geographically close stations and determine whether any qualitative or quantitative differences occur among them. One station can be considered a deep water station (20 m) while two stations were in relatively shallow water (4 m).

METHODS

The zooplankton stations were the same as those for hydrography and phytoplankton (see earlier chapters). Zooplankton samples were taken with a 30 cm diameter Clarke-Bumpus semi-quantitative plankton sampler fitted with a No. 6 (0.241 mm) plankton net. Two tows were taken at each of the three stations. Sampling was done at the surface and at the bottom; bottom depth was approximately 4 m at Stations 2 and 3 and 20 m at Station 1. Duration of tows was approximately 15 minutes. The plankton samples were preserved in a 1:10 dilution of 40% buffered formalin for later analysis.

To quantify the zooplankton, the total volume of the sample, plankton plus fluid, was recorded. In most cases additional 40%

buffered formalin solution was added to adjust the volume of the sample to an even number. This additional volume added was also recorded. Before taking aliquots, any large organisms such as medusae were removed, and this was noted. In the manner suggested by Frolander (1968) 1 ml aliquots of the plankton sample were taken until a total of 300 individuals or greater had been counted. Prior to removing the aliquots with a Stempel pipette, the samples were vigorously shaken to disperse the organisms.

Most copepods were identified to species using Wilson (1922) and various sheets of the Fisches du Identification published by the Conseil International pour L'Exploration de la Mer. Copepodites were identified to genus in some cases or simply referred to as copepodites. Certain copepods, for example, Corycaeus and Paracalanus, were identified only to genus because of the difficulty in distinguishing among the species. No attempt was made to identify medusae since they were generally badly distorted by the nets and formalin. With respect to the meroplankton, attempts were made to identify to species all crab larvae. Some of the veligers were also identified.

RESULTS

A list of the species found over all samples is given in Table III-1. Eighteen species of copepods and 15 species of decapod larvae were identified from various samples.

Seasonal changes in the total number of individuals/m^3 for each station are shown in Figures III-1 to III-3. Except for Station 1-bottom, there was a minimal number of individuals on August 21, 1974. In general, seasonal maxima for each station and depth did not coincide. However, during the period October 15 to December 13, 1974, there were continual problems with the Clarke-Bumpus meter so it is likely that population densities were overestimated during this time.

The highest zooplankton densities were at Station 1-bottom ($30,395/m^3$ on October 30, 1974). If this value is ignored, the next highest concentration was found at Station 1-top on June 20, 1974 ($21,092/m^3$). Of the 15 collections, Station 1-bottom had the greatest number of individuals seven times. Table III-2 gives the total value of zooplankton individuals per m^3. Values ranged from $58/m^3$ to $30,395/m^3$. The numbers of individuals for all species in all samples are given in Appendix Table AIII-1.

Each station showed two peaks during the year. These common peaks occurred on October 30, 1974 ($12,547$-$30,395/m^3$) and on May 9, 1975 ($10,681$-$14,035/m^3$). In addition, Station 1 had a major population peak on July 19, 1974 ($20,511/m^3$) and Station 3 showed a fairly large peak on August 1, 1974 ($9,432/m^3$). In general, larger concentrations of individuals were found in the bottom waters; this was particularly true for Stations 1 and 3. Notable, however, was the fact in the spring at Stations 2 and 3, the surface samples showed maximum densities at least a month and a half earlier than the respective bottom samples.

The dominant species (the three with the highest numbers of individuals) for each cruise are listed in Table III-3. If the dominant species are compared with the major peaks of abundance for each station, different species were responsible for the maxima at each station. Dominants for the maxima were as follows:

June 20	Station 1-top	*Acartia tonsa*, *Podon* sp., *Neopanope texana* (zoea)
July 19	Station 1-bottom	*A. tonsa*, *Pseudodiaptomus coronatus*
March 19	Station 2-top	*Pseudocalanus minutus*, copepodites
May 9	Station 2-bottom	*Temora longicornis*, *P. minutus*
March 14	Station 3-top	*P. minutus*, copepodites
May 19	Station 3-bottom	*T. longicornis*, *Centropages hamatus*

Differences in occurrence of dominant species can be explained by the fact that the major peak for Station 1 occurred in the summer at a water temperature of approximately 20°C while the population peaks for Stations 2 and 3 occurred in the spring at a water temperature of approximately 5°C. What this does not explain was why the major peaks in population occurred at such different times between the deep water and shallow water stations. One possibility is that sampling in 1974 was begun too late to catch the large Acartia bloom recorded at Station 1. Also not clear was why the surface waters at Stations 2 and 3 had maximum biomass numbers comprising different copepod species at different times than their respective bottom samples.

Table III-4 contains the percent composition of each sample represented by meroplankton, holoplankton, and copepods for each cruise. Only on three occasions did the meroplankton component exceed the holoplankton, and these occurred at the shallow water stations. Generally, meroplankton comprised a larger percentage of the bottom samples than surface samples and the shallow water samples than did the surface samples. The shallow water stations tended to have a larger proportion of meroplankton than did the deep water stations. The large proportion of meroplankton which occurred on July 19, 1974 was mainly due to zoeae of the crab, Neopanope texana, at Station 2 and to Uca zoeae at Station 3 which illustrates the kind of variability that occurred in the meroplankton over a short distance. Veligers of Mytilus edulis were responsible for the large proportion of meroplankton at most stations on January 16. The fairly high percentage of meroplankton reported for May 28, 1975 at the shallow water stations was due to an abundance of fish eggs, Balanus sp. nauplii, and cyprids. Copepods were the largest component of the population throughout most of the year, except when vast numbers of Oikopleura sp. occurred on October 15, 1974. Then the copepods were consistently less than 50% of the sample.

The seasonal cycle of some of the dominant organisms at each station and depth are presented in Figures III-4 to III-9. In some cases where an organism occurred only once as a dominant, its seasonal cycle was not illustrated. For such cases as *Oikopleura* sp. and fish eggs, where the seasonal cycle was similar at all stations, these results were figured once. For graphical convenience, numbers of individuals were converted to proportion of the total sample. However, this distorts the importance of some species, particularly *A. tonsa* in late summer, when almost no plankton was found in the water.

At all stations and depths the copepod, *Acartia tonsa*, dominated most of the summer samples. There was some residual population of *A. tonsa* at some of the stations year-round, but in very low numbers. During the summer months *A. tonsa* was occasionally replaced as the dominant species by *Pseudodiaptomus coronatus* in some of the bottom samples. This replacement occurred on August 1, 1974 for Stations 1 and 2, and on July 19, 1974 at Station 3-bottom. *Pseudodiaptomus* was found only in significant numbers in the bottom samples, and they were found only in the summer and autumn months.

Larvae of bottom invertebrates comprised a significant percent of the population during the summer months. Crab zoeae were particularly abundant in the early summer samples. Cyphonautes larvae (ectoprocts) appeared in early August and disappeared from the samples at the end of October. Veligers identified as *Mytilus edulis* significantly contributed to the zooplankton population during December and January. Polychaete larvae could generally be found in low numbers during any time of the year.

In the spring of 1975, *A. tonsa* was replaced by the copepods, *Centropages hamatus*, *Temora longicornis*, and *Pseudocalanus minutus*. Also, in these same spring samples, but not figured in the graphs, a high percentage of unidentified copepodites was found.

Changes in zooplankton numbers/m^3 during the 12-hour cruises of February 20, 1974 and April 17, 1975 are illustrated in Figures III-10 and III-11. On February 20, 1975 the zooplankton numbers increased in the surface waters and decreased in the bottom waters from the preceding cruise. The peak in zooplankton actually occurred on May 9, 1975, but during the April 17 cruise zooplankton numbers had increased over the first 12-hour cruise by a factor of about three.

Both cruises displayed a similar pattern of higher numbers of individuals in the bottom waters during the day, with migration to surface waters occurring in the afternoon and evening. The significant point here was that during both cruises diurnal vertical migration towards the surface began about 1500 with the zooplankton beginning to leave the surface again about 1900. This large increase in individuals may have been augmented by the tidal regime. This could be true for the first 12-hour cruise where increasing salinity was noted about 1500, but on the second cruise weather conditions prevented the normal tide-related changes. With fairly brisk northeasterly winds blowing, high salinity waters remained in the bay the whole day. As a result, on this second cruise the day was probably spent sampling the same water mass. In the absence of any sizable surface tidal movement, the migration of individuals to the surface occurred at about the same time as previously. This identical migration pattern was again significant because the dominant copepods were different during each cruise (Tables III-5 and III-6). On February 20, 1975, Pseudocalanus minutus, Acartia tonsa, and Temora longicornis were most abundant. On April 17, 1975, the dominant copepods were Centropages hamatus, T. longicornis, and Centropages sp. copepodites.

Cluster analysis techniques were used to assess the presence of recurrent "time-groups" in the zooplankton data. The methods for this analysis are detailed in Appendix I. The dendrogram is given in Figure III-12. Five time-related assemblages were discerned and are listed below with their characteristic species:

Time-Group	Characteristic Species
June	Podon sp. Acartia tonsa Pseudodiaptomus coronatus Centropages hamatus
July-August	Acartia tonsa Pseudodiaptomus coronatus Neopanope texana (zoea) Pinnixa sayana (zoea) copepodites
September-November	Oikopleura sp. Paracalanus spp. veliger larva polychaete larva
December	Acartia tonsa veliger Acartia copepodite
January-May	Centropages hamatus Centropages copepodites Temora longicornis Pseudocalanus minutus

Based on the cluster dendrogram, the stations occupied during any one cruise were more similar amongst themselves than they were to samples taken during other cruises. Often, top and bottom samples at one station were not paired together. This was usually the result of widely differing numbers of individuals in these samples.

DISCUSSION

In the Chesapeake and Delaware Canal, Raytheon (1975) reported that zooplankton abundances increased from January (33,833/m^3) through May (190,105/m^3) and then declined over the following months. In the coastal waters off the mouth of Delaware Bay highest zooplankton numbers were reported in the spring and early summer by DuPont, et al. (1972), in the winter and fall by Van Engel and Tan (1965), and in the spring and fall by Sandine and Swiecicki (1975).

Deevey (1960) found that the greatest numbers of zooplankton occurred in Delaware Bay during the winter-spring period. Cronin, et al. (1962) found that spring and summer numbers exceeded their fall and winter numbers. In this study every station showed consistently high numbers in the winter-spring, and relatively low numbers in August. Another peak may have occurred in the autumn. Plus, there is an indication from Station 1 that spring-summer peak may also occur. Thus, it may be that the bay can annually sustain three major peaks in zooplankton biomass (winter-spring, summer, and fall). This fact would make Delaware Bay distinct from the more northern estuaries where bimodal peaks in biomass occur (Deevey, 1948; Sage and Herman, 1972; Martin, 1965). However, it was not certain whether the October 1974 peak was real or due to mechanical failure.

Deevey (1960), using four years' data did not find a consistent cyclical, annual rhythm in biomass numbers such as had been found in the more northern areas. Her findings and our results suggest that any pattern of rhythmicity which occurs in the latter half of the year is due almost entirely to *A. tonsa* and secondarily to the meroplankton.

A. tonsa was the dominant species from June until October. Its maximum density occurred at Station 1 (17,272/m^3) on June 20, 1974 (water temperature 21°C). Its numbers were drastically reduced in January (water temperature 4.5°C) and at the end of the study in May,

A. tonsa had not reappeared in very large numbers (water temperature 18°C). A similar pattern was noted for A. tonsa in Great Bay, New Jersey (Sandine and Swiecicki, 1975). In this study, A. tonsa occurred as the dominant organism of two major peaks; one occurred in early summer and one in late fall. During the summer A. tonsa generally comprised 50% of the sample. Major biological activities in the water column occurring during the summer-fall period must have been greatly affected by the production of A. tonsa.

The winter-spring peak in zooplankton had a relatively high proportion of Centropages hamatus and Temora longicornis. Also Pseudocalanus minutus was relatively abundant at some stations. These species were also strong winter-spring dominants in the nearby coastal waters in previous years (Van Engel and Tan, 1965; DuPont, et al., 1972). In contrast, even though the summer samples had more species, one species (A. tonsa) comprised the bulk of the samples.

Jeffries (1967) noted the significance of congeneric species replacement in which case the summer-fall species was replaced by a winter-spring species of the same genus. Most authors (Deevey, 1948; Conover, 1956; Jeffries, 1962) noted this replacement with respect to A. tonsa and A. clausi. Deevey (1960) found A. clausi to occur fairly regularly in Delaware Bay, but seldom in as large numbers as A. tonsa. In the present study, A. clausi was first found in low numbers in December 1974 and occurred at its highest density (529/m^3) in April; at no time did this boreal-temperate species approximate the biomass of A. tonsa.

Bowman (1961) pointed out a geographical trend for the A. tonsa - A. clausi replacement. The farther south the area, the less important A. clausi becomes both in numbers and seasonal range. Jeffries' (1967) observation of congeneric species replacement is valid in a narrow latitudinal range where optimal conditions for each species occur during some part of the year.

Jeffries (1967) also suggested congeneric species replacement for Oithona similis - the summer form - and O. brevicornis - the winter form. This was not observed during this study or in the shallow bays of New Jersey (Sandine and Swiecicki, 1975). O. similis was found nearly year-round while O. brevicornis was found only during December to May. Probably due to warmer winter temperatures, the summer form was able to maintain a small population year-round while the winter form was only evident during the shortened winter season. This was additional evidence to suggest that Delaware Bay should not be classed with the more northern estuaries.

The species composition indicated that an incomplete annual cycle was sampled. Sampling began when the warm species, A. tonsa, dominated, and sampling ended when the cold water species, C. hamatus, T. longicornis, and P. minutus dominated. When the data from the first sample were examined, the presence of the same cold water species, probably a declining winter population, was noted. It was the cold water species that dominated the population after the annual winter-spring diatom bloom. Depending on the interpretation of the assemblages obtained from cluster analysis, it is questionable whether C. hamatus, more of a cold-water organism, should be included in the June assemblage.

There was an important difference in distribution of a major species between Cronin, et al. (1962) and our results. Our study area occurred in the polyhaline zone (18-30 o/oo), but, Cronin, et al. (1962) did not list A. tonsa as one of the principal species of this area although it was by far the dominant species in our samples. This difference may be due in part to the fact that a different species composition may exist in the more offshore polyhaline bay waters examined by these authors. On the other hand, the major species may change from year to year.

Salinity data from the two 12-hour cruises demonstrated that the study area was usually always within the polyhaline zone. The fact that none of the estuarine copepod species were found at ebb tide indicated that movement downbay by the estuarine species to this area did not occur. With the occurrence of the more coastal species, particularly C. typicus, it was suggested that the study site was more influenced by the coastal ocean waters than by the river waters (Jacob, 1968). However, the low numbers or absence of most coastal water copepods such as Labidocera and Tortanus suggested that the study area may be in that zone of the estuary where the plankton population can generally, by their reproductive capabilities, maintain themselves (Barlow, 1955).

In examining the annual species succession in Delaware Bay, nearly the same patterns were observed 35 years ago (Deevey, 1960). The dominance of A. tonsa in the summer, with contributions by the warm water cladoceran, Penilia avirostris, and invertebrate larvae was recorded by Deevey (1960). Also, she found the warm water copepod, Corycaeus sp., and Cronin, et al. (1962) found the other warm water species noted in this study, Euterpina acutifrons. Both these copepods contributed significant biomass in November. Deevey (1960) and Cronin, et al. (1962) also noted high numbers of Oikopleura sp. in the fall. In the present study, they dominated the mid-October sample. All studies agree reasonably well on the significant contribution of the cold water species, C. hamatus, P. minutus, and T. longicornis, during the winter-spring period.

Differences were noted in the abundance of the copepods, Paracalanus sp. and P. crassirostris, during the fall. Deevey (1960) and Cronin, et al. (1962) both suggested that Paracalanus spp. were relatively rare in the bay and that they were more prevalent in the coastal waters. But in the present study, Paracalanus sp. was found at all stations in the fall. It was one of the dominant organisms at the end of October. This difference among the studies can probably be explained by the use of a smaller mesh size here, thereby increasing the likelihood of catching Paracalanus.

Deevey also did not record large numbers of veligers in the water in the winter. These were identified in this study as larvae of Mytilus edulis. Densities as high as 3600/m^3 were recorded with the larger numbers of veligers found in the bottom samples. It is likely that what was observed here was not an annual occurrence.

Little variation occurred between species composition and depth. Though there were higher densities and species richness in the bottom samples, the dominant species were similar to those at the surface. One notable exception was the marked vertical distribution of Pseudodiaptomus coronatus, which was found consistently in the bottom samples. Jacobs (1961) has suggested that P. coronatus is not a truly planktonic copepod since it readily clings to the substrate, thus suggesting a reason for its disparate vertical distribution. Also, there was some indication in the same bottom samples that P. coronatus can replace the dominant A. tonsa.

In considering what differences occurred among the stations, the same water mass was probably being sampled at each station. Station 1-bottom consistently had higher numbers of individuals than any other station. This greater abundance of individuals in bottom samples has been previously documented (Cronin, et al., 1962; Herman and Sage, 1972). Using cluster analysis stations generally clustered together within each cruise, showing that they were highly similar. The few exceptions generally occurred when Station 1 was dissimilar to Station 2 and Station 3, or the top samples were dissimilar to the bottom. But this dissimilarity was only noted in two of the 15 cruises. The clusters also illustrated the seasonal trend of high species diversity in the summer and fall, consecutive cruises displaying less similarity than during the winter.

Comparison of Regional Zooplankton Numbers

In terms of total numbers of zooplankton individuals throughout the year, Station 1-bottom was the most productive station. It had the highest mean value of 9311 individuals/m^3. The mean value for all stations was 4649/m^3. Delaware Bay had lower zooplankton numbers than the Sandy Hook area where Sage and Herman (1972) found a mean value of 8502/m^3, which would compare only with the mean for Station 1-bottom. Herman, Mihursky, and McErlean (1968) obtained much lower mean values in the Patuxent Estuary (4325/m^3). Sage and Herman (1972) used a smaller mesh net and Herman, et al. (1968) a larger mesh net than that used in the present area. The Patuxent Estuary is also a lower salinity area. Jeffries (1964) found biomasses in Raritan Bay higher than here, but he used a smaller mesh net and collected the whole length of the bay. Zooplankton densities averaging 44,000 individuals/m^3 were reported for Little Egg Harbor and Brigantine Bays, New Jersey by Sandine and Swiecicki (1975) who used a No. 20 net. Heinle's (1966) study on copepod production showed that any direct comparisons of data require similar sampling techniques. Using a No. 20 net on the Patuxent Estuary, he found densities of copepods, consisting primarily of developmental stages, exceeding 100,000/m^3. It would appear that the densities obtained in this study most nearly approach those found by Burrell (1972) in the York River, Va. estuary.

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Table III-1

List of species obtained in zooplankton samples

Phylum Protozoa	
Order Foraminiferida	
*01009	_Foraminifera_ sp.
01010	_Globergerina_ sp.
Phylum Cnidaria	
	medusa
09012	Ceriantharian larva
Phylum Ctenophora	
02037	Ctenophora sp.
Phylum Ectoprocta	
08026	Cyphonautes larvae
Phylum Annelida	
Class Polychaeta	
04200	polychaete larvae
Phylum Mollusca	
Class Pelecypoda	
05107	veliger
05108	_Mytilus edulis_ Linnaeus 1785 (veliger)
Class Gastropoda	
05109	_Limacina inflata_
	unidentified pteropod
Phylum Arthropoda	
Class Crustacea	
Subclass Branchiopoda	
Order Cladocera	
06014	_Penilia avirostris_ Dana 1849
06015	_Podon_ sp.
06016	_Evadne_ sp.
Subclass Copepoda	
06017	_Acartia clausi_ Giesbrecht 1892
06018	_Acartia tonsa_ Giesbrecht 1892
06019	_Acartia_ (copepodite)
06020	_Calanus finmarchicus_
06021	_Centropages hamatus_ (Lilljeborg 1853)
06022	_Centropages typicus_ Kroyer 1849
06023	_Centropages_ (copepodite)
06024	_Corycaeus_ sp.
06025	_Eucalanus attenuatus_
06026	_Eurytemora affinis_ (Poppe 1880)
06027	_Euterpina acutifrons_ (Dana 1848)

Table III-1 (cont.)

Zooplankton Species List

	Subclass Copepoda (cont.)
06028	*Labidocera aestiva* Wheeler 1889
06047	*Labidocera* (copepodite)
06029	*Microcalanus* sp.
06030	*Oithona brevicornis* Giesbrecht 1891
06031	*Oithona similis* Claus 1866
06032	*Oithona spinirostris* Claus 1863
06033	*Paracalanus* sp.
06034	*Pseudocalanus minutus* (Kroyer 1840)
06035	*Pseudocalanus* (copepodite)
06036	*Pseudodiaptomus coronatus* Williams 1906
06037	*Temora longicornis* (Muller 1792)
06038	*Temora* (copepodite)
06039	*Tortanus discaudatus* (Thompson and Scott 1897)
06040	harpacticoid copepod
06041	copepod nauplii
06042	unidentified copepodite
06043	unidentified copepod
06044	copepod species A
	Subclass Malacostraca
	Order Mysidacea
07142	Mysidacea sp.
	Order Cumacea
07176	*Mancocuma altera* Zimmer 1943
	Order Amphipoda
07179	*Corophium* sp.
07180	*Gammarus* sp.
07181	*Hyperia* sp.
07182	unidentified amphipod
	Order Decapoda
	larvae
	Suborder Natantia
07183	*Palaemonetes* sp. (zoea)
07184	*Crangon septemspinosa* (Say 1918) (zoea)
	Suborder Reptantia
07185	*Callianassa* sp. (zoea)
07186	*Pagurus longicarpus* Say 1817 (zoea)
07187	*Emerita talpoida* (Say 1818) (zoea)
07188	*Ovalipes ocellatus* (Herbst 1799) (zoea)
07189	*Hexapanopeus angustifrons* (Benedict and Rathbun 1891) (zoea)
07190	*Neopanope texana sayi* (Smith 1869) (zoea)

Table III-1 (cont.)

Zooplankton Species List

	Suborder Reptantia (cont.)
07191	*Panopeus herbstii* H. Milne-Edwards 1843 (zoea)
07192	*Pinnixa sayana* Stimpson 1860 (zoea)
07193	*Pinnotheres maculatus* Say 1818 (zoea)
07194	*Uca* sp. (zoea)
07195	*Upogebia affinis* (Say 1818) (zoea)
07196	unidentified crab zoeae and/or megalops
07197	*Cancer irroratus* (zoea)
07198	*Labinia* sp. (zoea)
07199	Reptantia larvae
07200	Nantantia larvae
Subclass Cirripedia	
06045	*Balanus* sp. nauplius
06046	*Balanus* sp. cyprid
Phylum Chaetognatha	
08027	*Sagitta* sp.
Phylum Chordata	
10006	*Oikopleura* sp.
10007	Fish eggs
10008	Fish larvae

*Identification numbers assigned for computer analyses.

Table III-2

Total numbers per m^3 of zooplankton individuals

Date	Station I		Station II		Station III	
	Top	Bottom	Top	Bottom	Top	Bottom
June 20, 1974	21,092	14,755	1,197	3,475	2,953	7,363
July 19, 1974	279	20,511	807	2,824	2,031	2,954
Aug. 1, 1974	1,046	1,971	3,946	805	5,680	9,432
Aug. 21, 1974	121	1,806	59	259	58	-
Sept. 17, 1974	669	4,806	160	1,541	1,128	2,403
Oct. 15, 1974 *	1,745	1,795	1,049	2,616	2,859	5,475
Oct. 30, 1974 *	8,977	30,395	12,547	2,804	4,674	8,259
Nov. 14, 1974	3,325	3,935	2,643	1,780	1,723	1,493
Dec. 13, 1974 *	6,148	7,336	7,545	3,304	7,061	5,444
Jan. 16, 1975	1,303	1,009	1,052	1,644	957	1,046
Feb. 20, 1975 (16t)	-	-	1,908	505	-	-
March 18, 1975	4,145	6,571	5,234	4,375	13,436	4,561
April 14, 1975 (8t)	-	-	3,451	3,686	-	-
May 9, 1975	2,223	14,035	3,146	10,681	5,919	14,587
May 28, 1975	4,565	12,120	391	651	695	1,623
Mean No./m^3	4,279	9,311	3,009	2,730	3,781	5,386

* Values suspect due to Clarke-Bumpus meter malfunction

Table III-3

The three dominant species for each cruise and station

Date	Station I Top	Station I Bottom	Station II Top	Station II Bottom	Station III Top	Station III Bottom
6/20/74	Podon sp.	Acartia tonsa	Acartia tonsa	Acartia tonsa	Acartia tonsa	Acartia tonsa
	Acartia tonsa	Pseudodiaptomus coronatus	Fish eggs	Podon sp.	Podon sp.	Pseudocalanus minutus
	Neopanope texana (L.*)	Centropages hamatus	Podon sp.	Pseudodiaptomus coronatus	Centropages hamatus	Pseudodiaptomus coronatus
7/19/74	Acartia tonsa	Acartia tonsa	Neopanope texana (L.)	Acartia tonsa	Uca sp. (L.)	Pseudodiaptomus coronatus
	Fish eggs	Pseudodiaptomus coronatus	Acartia tonsa	Pseudodiaptomus coronatus	Acartia tonsa	Acartia tonsa
	Pseudodiaptomus coronatus	Labidocera aestiva	Uca sp. (L.)	Pinnixa sayana (L.)	Pseudodiaptomus coronatus	Pinnixa sayana (L.)
8/ 1/74	Acartia tonsa	Pseudodiaptomus coronatus	Acartia tonsa	Pseudodiaptomus coronatus	Acartia tonsa	Acartia tonsa
	copepodites	Acartia tonsa	Fish eggs	Fish eggs	Fish eggs	Pseudodiaptomus coronatus
	Fish eggs	medusa	Centropages copepodites	Limacina inflata	Neopanope texana (L.)	Pinnixa sayana (L.)
8/21/74	Acartia tonsa	Acartia tonsa	Acartia tonsa	Acartia tonsa	Acartia tonsa + Neopanope texana (L.)	-
	Limacina inflata	mysid	Limacina inflata	Limacina inflata	Limacina inflata	-
	copepodites	Pseudodiaptomus coronatus	Neopanope texana (L.)	medusa	Pinnixa sayana	-

Table III-3 (cont.)

Date	Station I		Station II		Station III	
	Top	Bottom	Top	Bottom	Top	Bottom
9/17/74	*Acartia tonsa* *Oikopleura* sp. *Oithona* sp.	*Acartia tonsa* *Pseudodiaptomus coronatus* *Paracalanus* sp.	*Oikopleura* sp. *Acartia tonsa* *Oithona* sp.	*Acartia tonsa* *Pseudodiaptomus coronatus* *Acartia* copepodite	*Acartia tonsa* *Oikopleura* sp. *Penilia avirostris*	*Acartia tonsa* cyphonaute (L.) *Oikopleura* sp.
10/15/74	*Oikopleura* sp. *Paracalanus* sp. *Penilia avirostris*	*Oikopleura* sp. medusa veliger (L.)	*Oikopleura* sp. veliger (L.) *Paracalanus* sp.	*Oikopleura* sp. *Pseudocalanus minutus* *Paracalanus* sp.	*Oikopleura* sp. echinoderm (L.) veliger (L.)	*Oikopleura* sp. *Acartia tonsa* *Pseudocalanus minutus*
10/30/74	*Paracalanus* sp. *Paracalanus crassirostris* veliger (L.)	*Pseudocalanus minutus* *Paracalanus* sp. *Acartia tonsa*	*Acartia tonsa* polychaete (L.) *Paracalanus crassirostris*	*Acartia tonsa* *Paracalanus* sp. polychaete (L.)	*Acartia tonsa* polychaete (L.) *Paracalanus* sp.	*Acartia tonsa* polychaete (L.) *Paracalanus* sp.
11/14/74	*Paracalanus* sp. *Euterpina acutifrons* *Corycaeus* sp.	*Paracalanus* sp. *Corycaeus* sp. veliger (L.)	*Acartia tonsa* veliger (L.) *Euterpina acutifrons*	*Acartia tonsa* veliger (L.) *Paracalanus* sp.	veliger *Acartia tonsa* *Euterpina acutifrons*	veliger *Acartia tonsa* *Paracalanus* sp.
12/13/74	*Acartia tonsa* *Oithona similis* *Acartia* copepodite	*Acartia tonsa* veliger (L.) *Acartia* copepodite	*Acartia tonsa* veliger (L.) *Acartia* copepodite	*Acartia tonsa* Foraminifera veliger (L.)	*Acartia tonsa* *Acartia* copepodite veliger (L.)	*Acartia tonsa* veliger (L.) *Acartia* copepodite

Table III-3 (cont.)

Date	Station I Top	Station I Bottom	Station II Top	Station II Bottom	Station III Top	Station III Bottom
1/16/75	Centropages copepodite	Acartia tonsa	veliger (L.)	veliger (L.)	Acartia tonsa	veliger (L.)
	Centropages typicus	Centropages copepodite	Centropages hamatus	Centropages copepodite	Centropages hamatus	Acartia tonsa
	Centropages hamatus	veliger (L.)	Centropages copepodite	Acartia tonsa	Centropages copepodite	Centropages copepodite
2/20/75	-	-	Temora longicornis	Temora longicornis	-	-
	-	-	Centropages hamatus	Centropages hamatus	-	-
	-	-	Centropages copepodite	Centropages copepodite	-	-
3/18/75	Pseudocalanus minutus	Temora longicornis	Pseudocalanus minutus	Pseudocalanus minutus	Pseudocalanus	Paracalanus sp.
	Centropages hamatus	Pseudocalanus minutus	copepodites	copepodites	copepodites	copepodites
	copepodites	copepodites	Oithona brevicornis	Paracalanus sp.	Paracalanus sp.	Acartia tonsa
4/14/75	-	-	Centropages hamatus	Centropages hamatus	-	-
	-	-	Temora longicornis	Temora longicornis	-	-
	-	-	Acartia clausi	Centropages copepodite	-	-

Table III-3 (cont.)

Date	Station I Top	Station I Bottom	Station II Top	Station II Bottom	Station III Top	Station III Bottom
5/ 9/75	*Temora longicornis* *Centropages hamatus* *Oithona brevicornis*	*Temora longicornis* *Centropages hamatus* *Pseudocalanus minutus*	*Centropages hamatus* *Temora longicornis* copepodite	*Temora longicornis* *Pseudocalanus minutus* *Centropages hamatus*	*Temora longicornis* *Centropages hamatus* *Centropages* copepodite	*Temora longicornis* *Centropages hamatus* *Centropages* copepodite
5/28/75	*Centropages hamatus* *Centropages* copepodite *Centropages typicus*	*Centropages hamatus* *Centropages typicus* *Balanus* sp. (nauplii)	Fish eggs *Centropages hamatus* *Centropages* copepodite	*Balanus* sp. (cyprid) *Centropages* copepodite Fish eggs	*Centropages* copepodite *Centropages hamatus* Fish eggs	*Centropages* copepodite *Oithona similis* *Balanus* sp. (nauplii)

* (L.) = larvae

Table III-4

Holoplankton/meroplankton ratios and percent composition of copepods
(including medusa as meroplankton)

	Station 1				Station 2			
Date	Hol./Mer. Top	% copepods Top	Hol./Mer. Bottom	% copepods Bottom	Hol./Mer. Top	% copepods Top	Hol./Mer. Bottom	% copepods Bottom
6/20/74	72.9/27.02	47.88	97.7 / 2.3	94.49	71.1/28.8	54.8	92.3/ 7.6	71.30
7/19/74	79.9/20.0	79.9	99.6 / 0.4	99.2	39.0/61.0	37.9	95.9/ 4.1	95.7
8/ 1/74	88.8/11.2	88.5	93.6/ 6.4	91.1	92.3/ 7.7	92.3	69.6/30.4	60.7
8/21/74	90.9/ 9.1	71.0	91.4/ 8.6	89.7	76.2/23.8	49.1	71.4/28.6	57.1
9/17/74	98.5/ 1.5	70.2	88.6/ 11.4	82.1	95.0/ 5.0	28.1	92.1/ 7.9	79.4
10/15/74	91.5/ 8.5	36.1	61.1/ 38.9	11.1	86.6/13.4	23.7	87.2/12.8	31.6
10/30/74	89.8/10.2	81.3	84.2/ 15.8	82.3	92.5/ 7.5	92.3	84.0/16.0	78.2
11/14/74	87.7/22.3	83.1	84.1/ 15.9	79.2	85.0/15.0	83.7	83.9/16.1	81.1
12/13/74	84.1/15.9	83.9	66.6/ 23.4	66.3	88.4/11.6	88.4	70.2/29.8	70.2
1/16/75	94.0/ 6.0	94.0	78.0/ 22.0	77.7	60.2/39.8	60.2	50.4/49.6	50.4
2/20/75	-	-	-	-				
(16t)					99.5/ 0.5	99.5	91.8/ 8.2	91.8
3/18/75	99.5/ 0.5	98.8	98.0/ 2.0	93.9	98.2/ 1.8	97.8	92.9/ 7.1	89.0
4/14/75	-	-	-	-				
(8t)					97.7/ 2.3	97.1	93.8/ 6.2	91.6
5/ 9/75	98.6/ 1.4	98.6	99.6/ 0.4	99.0	99.6/ 0.4	99.6	98.9/ 1.1	98.0
5/28/75	90.9/ 9.1	89.7	84.1/ 15.9	83.1	67.7/22.3	58.5	51.6/48.4	43.9

- = Missing data points

Table III-4 (cont.)

Station 3

Date	Hol./Mer. Top	% copepods Top	Hol./Mer. Bottom	% copepods Bottom
6/20/74	96.8/ 3.2	89.1	98.0/ 2.0	95.96
7/19/74	27.6/72.4	27.0	97.2/ 2.8	96.3
8/ 1/74	94.2/ 5.8	94.2	91.3/ 8.7	89.9
8/21/74	50.0/50.0	37.9		
9/17/74	99.7/ 0.3	79.5	82.2/17.8	73.3
10/15/74	80.8/19.2	29.2	86.8/13.2	57.6
10/30/74	90.3/ 9.7	86.9	79.1/20.9	78.4
11/14/74	76.7/23.3	67.9	68.5/31.5	66.6
12/13/74	91.7/ 8.3	91.7	91.1/ 8.9	90.5
1/16/75	89.9/10.1	89.9	58.5/41.5	58.5
2/20/75 (16t)	-	-	-	-
3/18/75	99.0/ 1.0	98.8	99.0/ 1.0	98.8
4/14/75 (8t)	-	-	-	-
5/ 9/75	99.6/ 0.4	99.0	97.5/ 2.5	97.3
5/28/75	74.1/25.9	73.5	78.5/21.5	75.7

FIGURE CAPTIONS FOR CHAPTER III

Figure III- 1: Seasonal changes in total zooplankton numbers at Station 1.

Figure III- 2: Seasonal changes in total zooplankton numbers at Station 2.

Figure III- 3: Seasonal changes in total zooplankton numbers at Station 3.

Figure III- 4: Seasonal changes in relative abundances of dominant zooplankton species Station 1-surface.

Figure III- 5: Seasonal changes in relative abundances of dominant zooplankton species at Station 1-bottom.

Figure III- 6: Seasonal changes in relative abundances of dominant zooplankton species at Station 2-surface.

Figure III- 7: Seasonal changes in relative abundances of dominant zooplankton species at Station 2-bottom.

Figure III- 8: Seasonal changes in relative abundances of dominant zooplankton species at Station 3-surface.

Figure III- 9: Seasonal changes in relative abundances of dominant zooplankton species at Station 3-bottom.

Figure III-10: Changes in total zooplankton numbers during 12-hour cruise of February 20, 1975.

Figure III-11: Changes in total zooplankton numbers during 12-hour cruise of April 14, 1975.

Figure III-12: Classification dendrogram illustrating similarity of zooplankton samples.

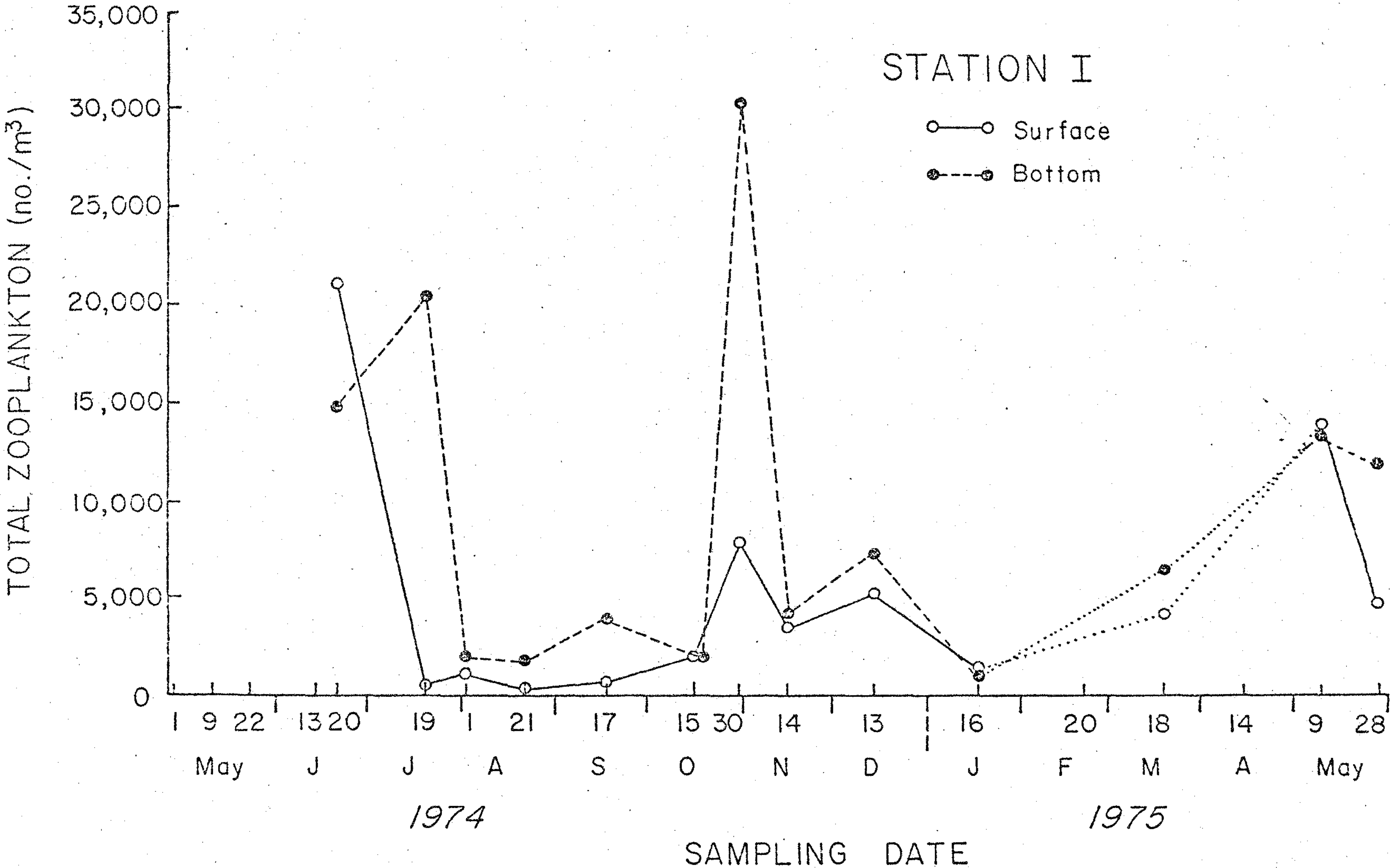

STATION I
Surface
Bottom
TOTAL ZOOPLANKTON (no./m³)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-1

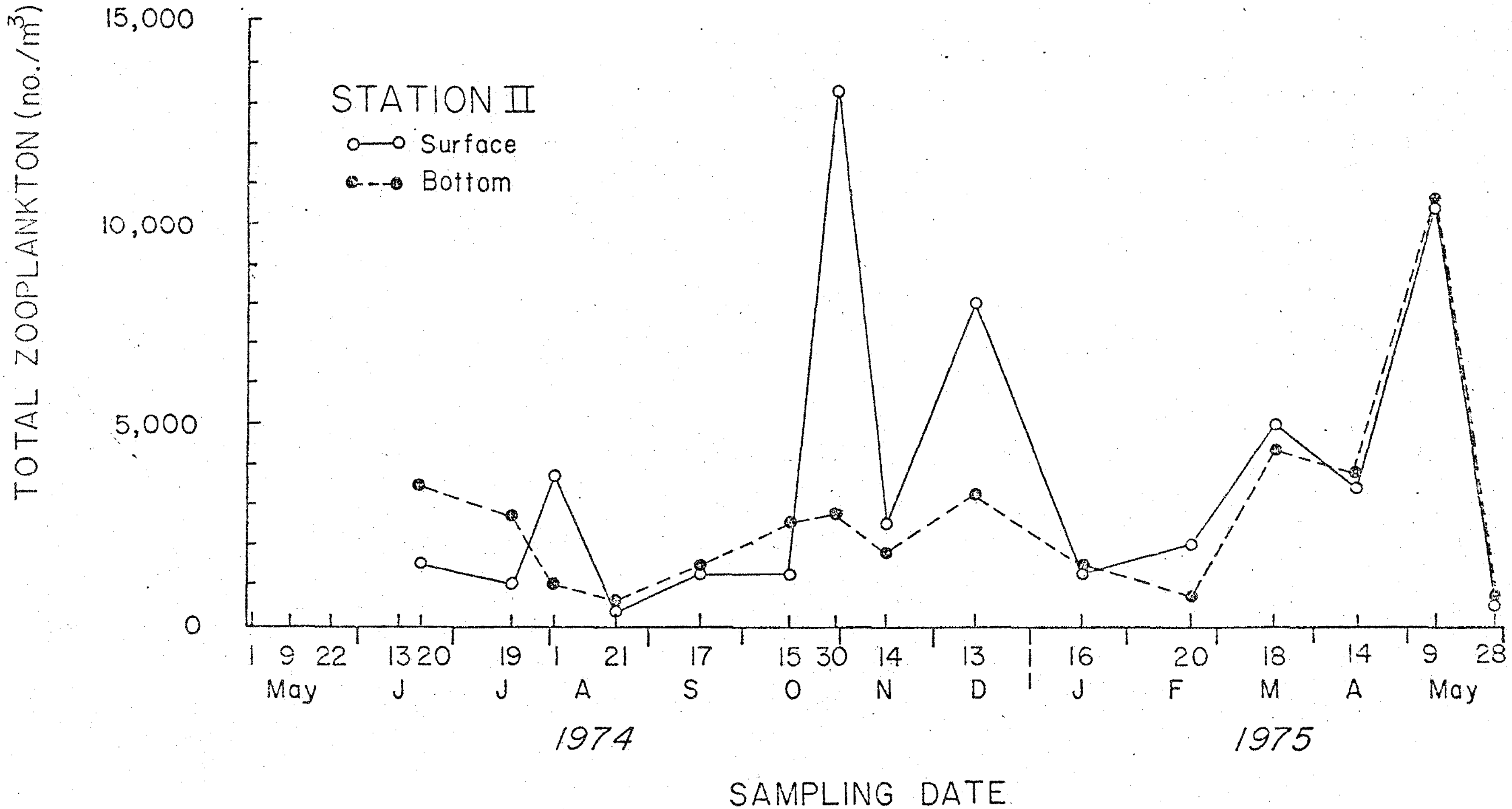

TOTAL ZOOPLANKTON (no./m³)
15,000
10,000
5,000
0
STATION II
Surface
Bottom
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-2

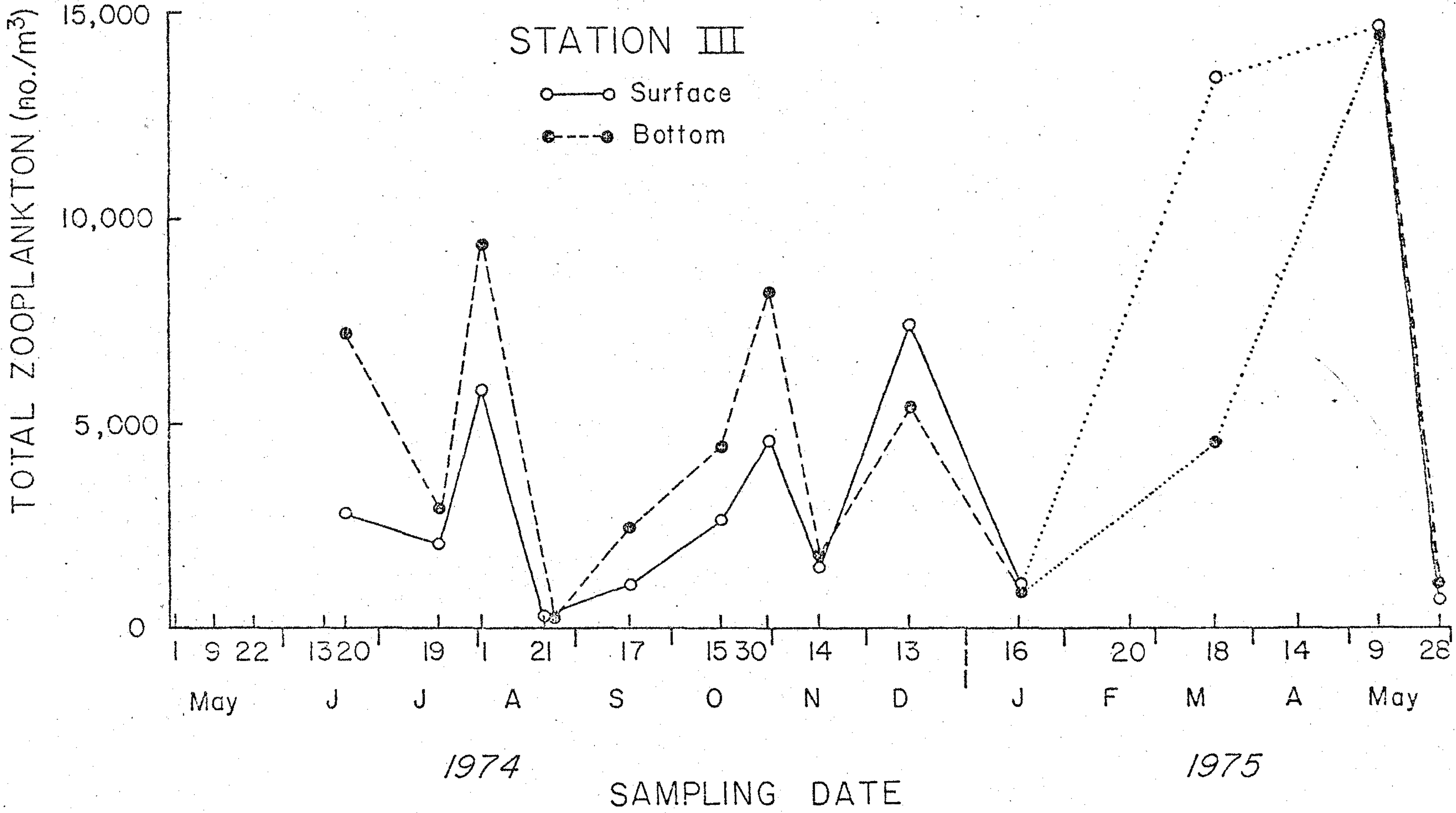

STATION III
Surface
Bottom
TOTAL ZOOPLANKTON (no./m³)
15,000
10,000
5,000
0
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-3

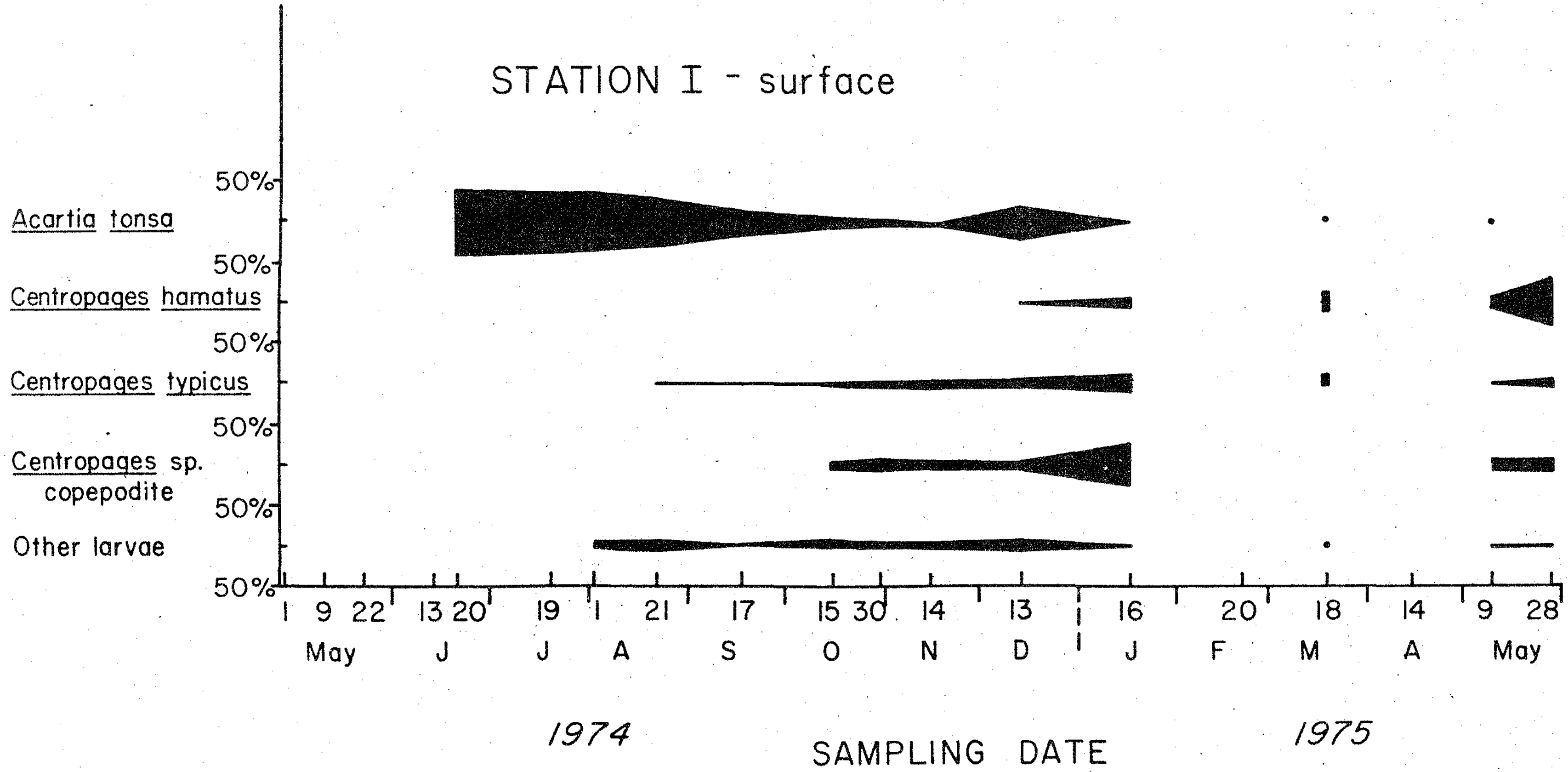

STATION I - surface
50%
Acartia tonsa
50%
Centropages hamatus
50%
Centropages typicus
50%
Centropages sp. copepodite
50%
Other larvae
50%
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-4

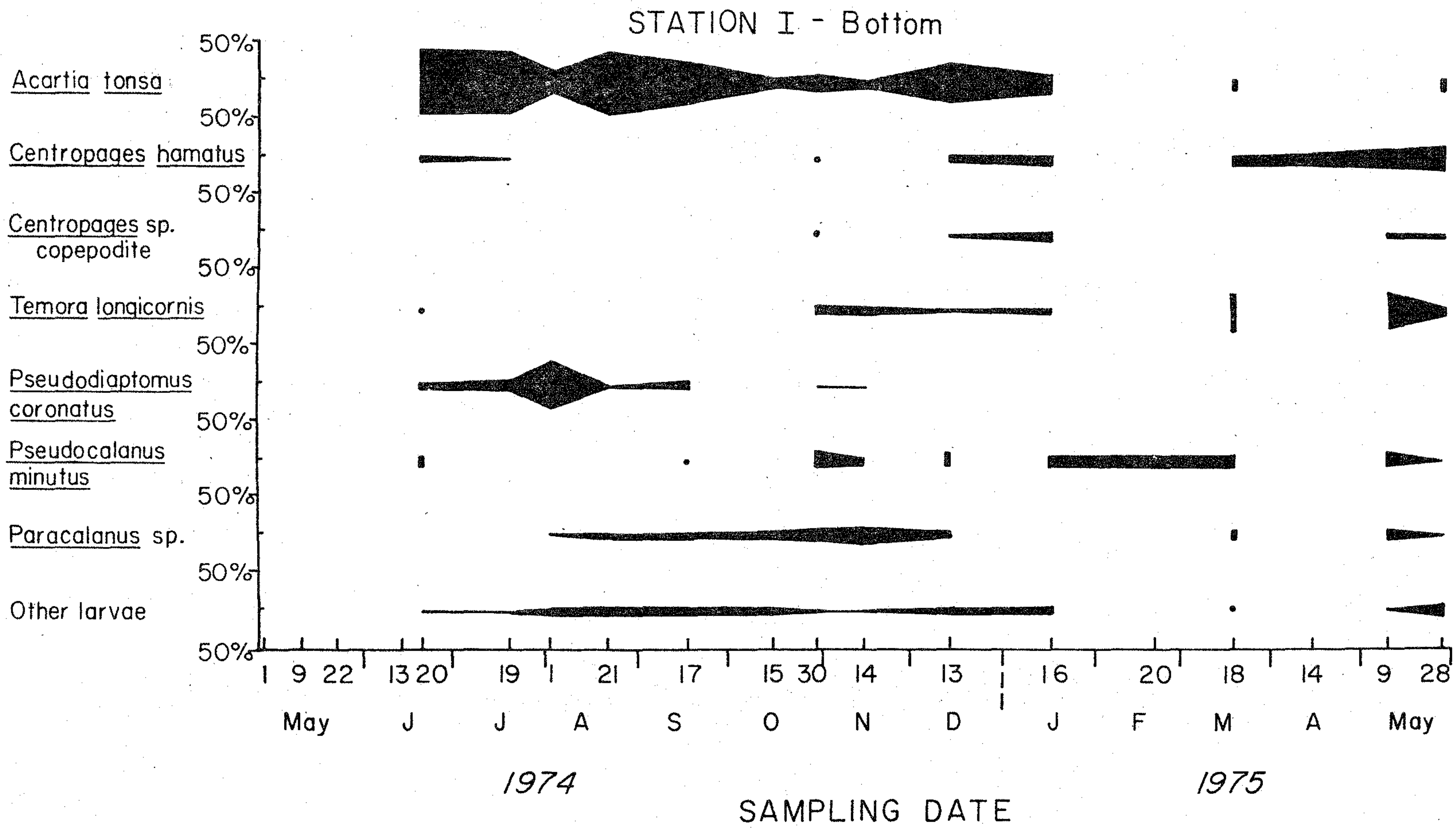

STATION I - Bottom
Acartia tonsa
Centropages hamatus
Centropages sp. copepodite
Temora longicornis
Pseudodiaptomus coronatus
Pseudocalanus minutus
Paracalanus sp.
Other larvae
50%
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-5

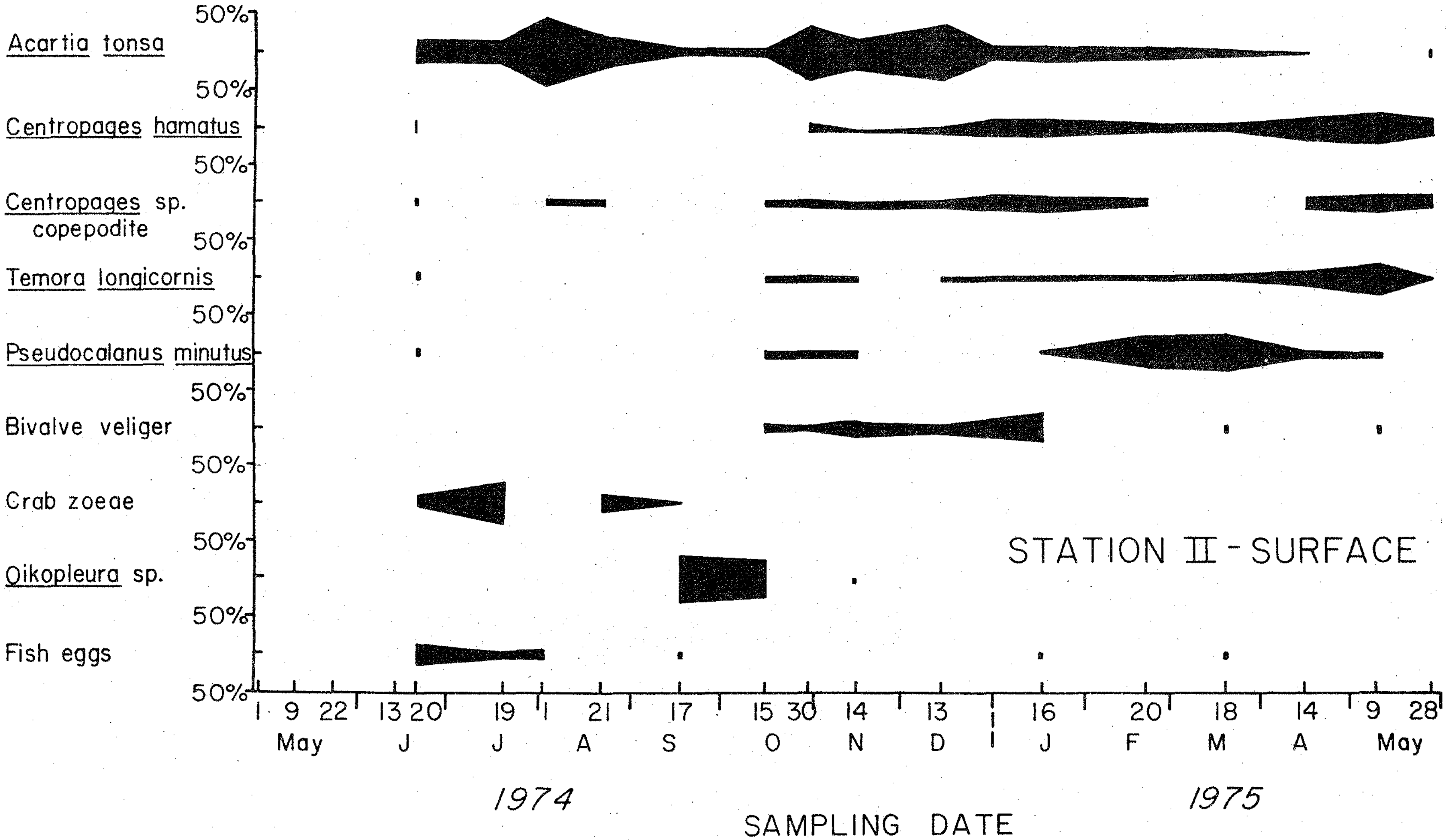
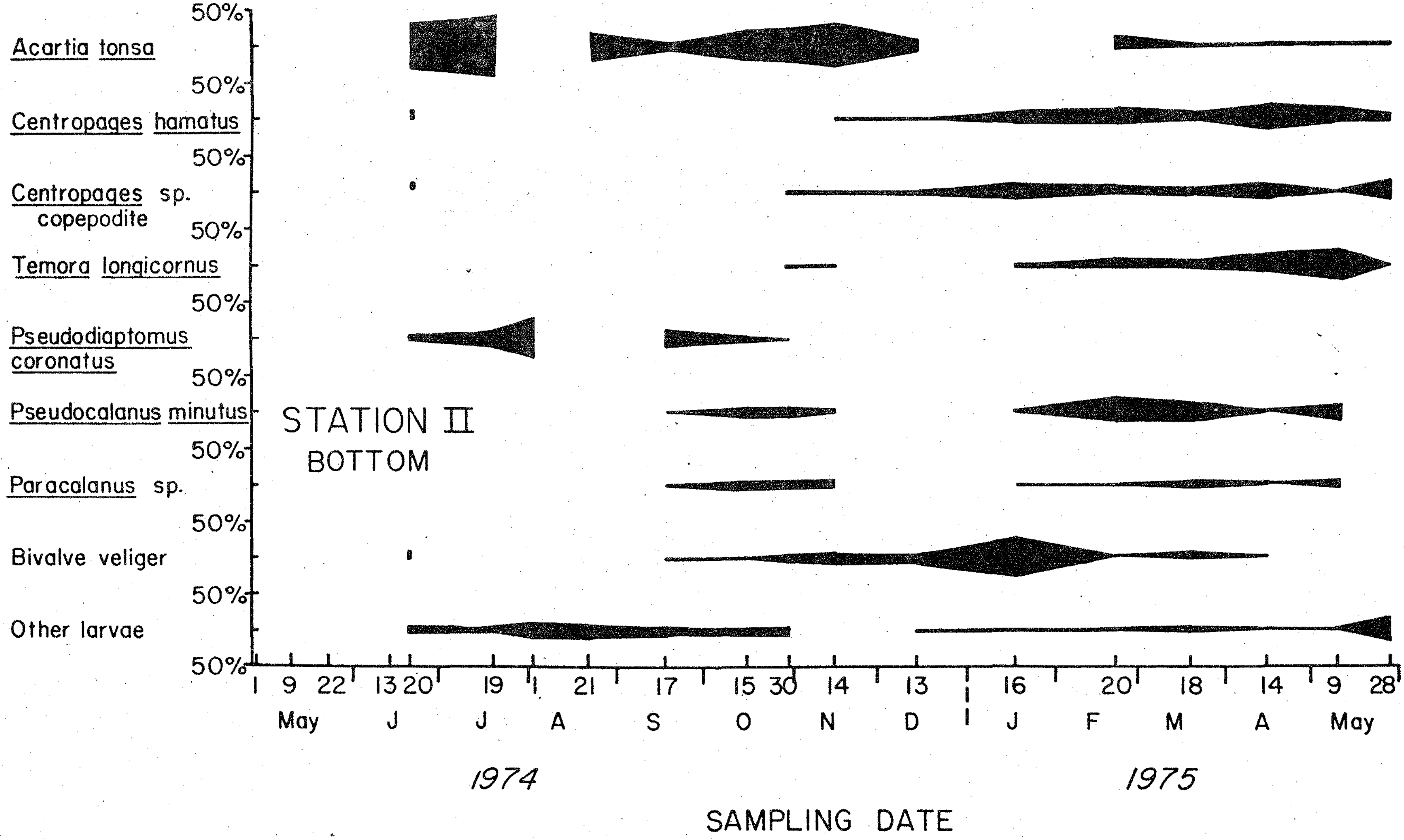
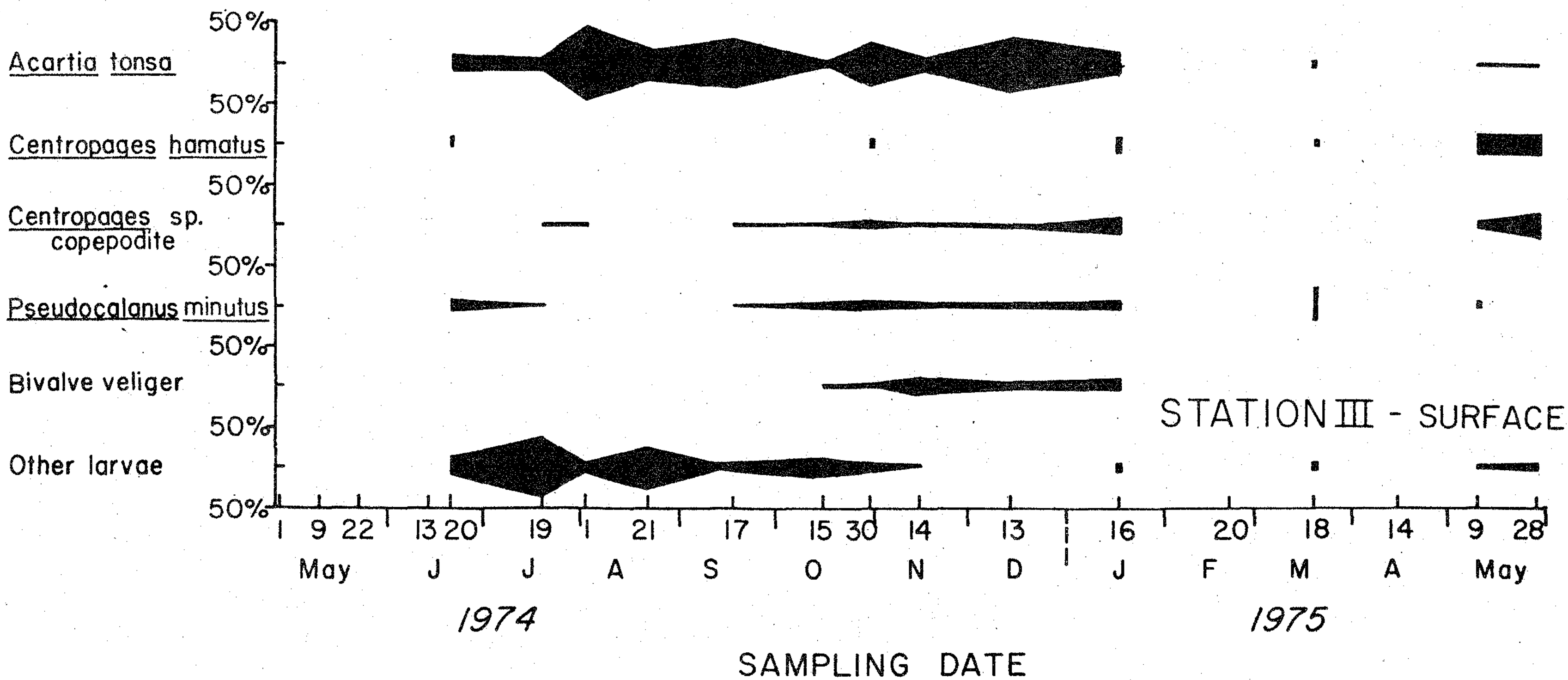

Acartia tonsa
Centropages hamatus
Centropages sp. copepodite
Temora longicornis
Pseudocalanus minutus
Bivalve veliger
Crab zoeae
Oikopleura sp.
Fish eggs
50%
STATION II - SURFACE
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-6



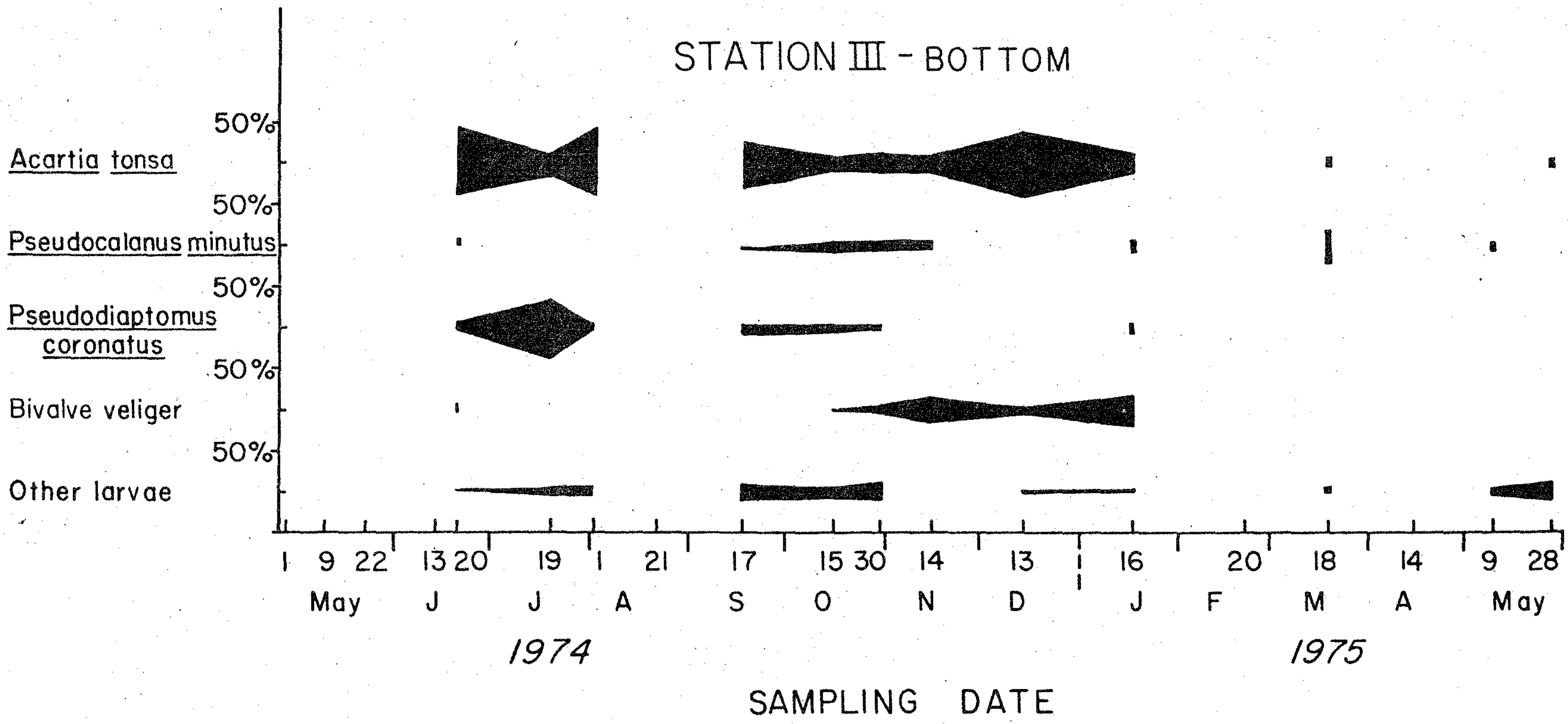
Acartia tonsa
Centropages hamatus
Centropages sp. copepodite
Temora longicornus
Pseudodiaptomus coronatus
Pseudocalanus minutus
Paracalanus sp.
Bivalve veliger
Other larvae
50%
STATION II
BOTTOM
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-7



50%
Acartia tonsa
Centropages hamatus
Centropages sp. copepodite
Pseudocalanus minutus
Bivalve veliger
Other larvae
STATION III - SURFACE
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-8



STATION III - BOTTOM
50%
Acartia tonsa
50%
Pseudocalanus minutus
50%
Pseudodiaptomus coronatus
50%
Bivalve veliger
50%
Other larvae
1 9 22 13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
May J J A S O N D J F M A May
1974
1975
SAMPLING DATE

Figure III-9

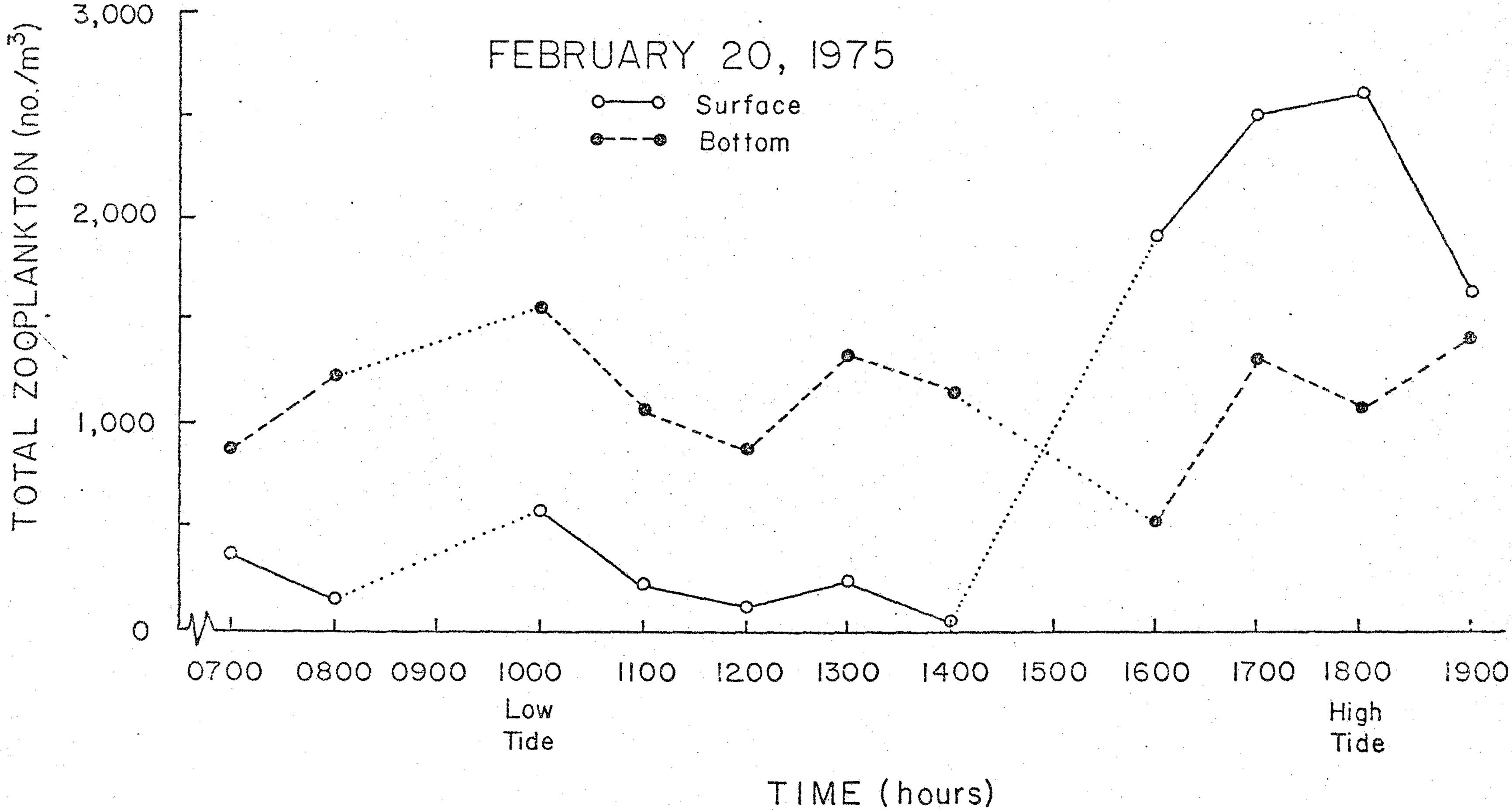


Figure III-10

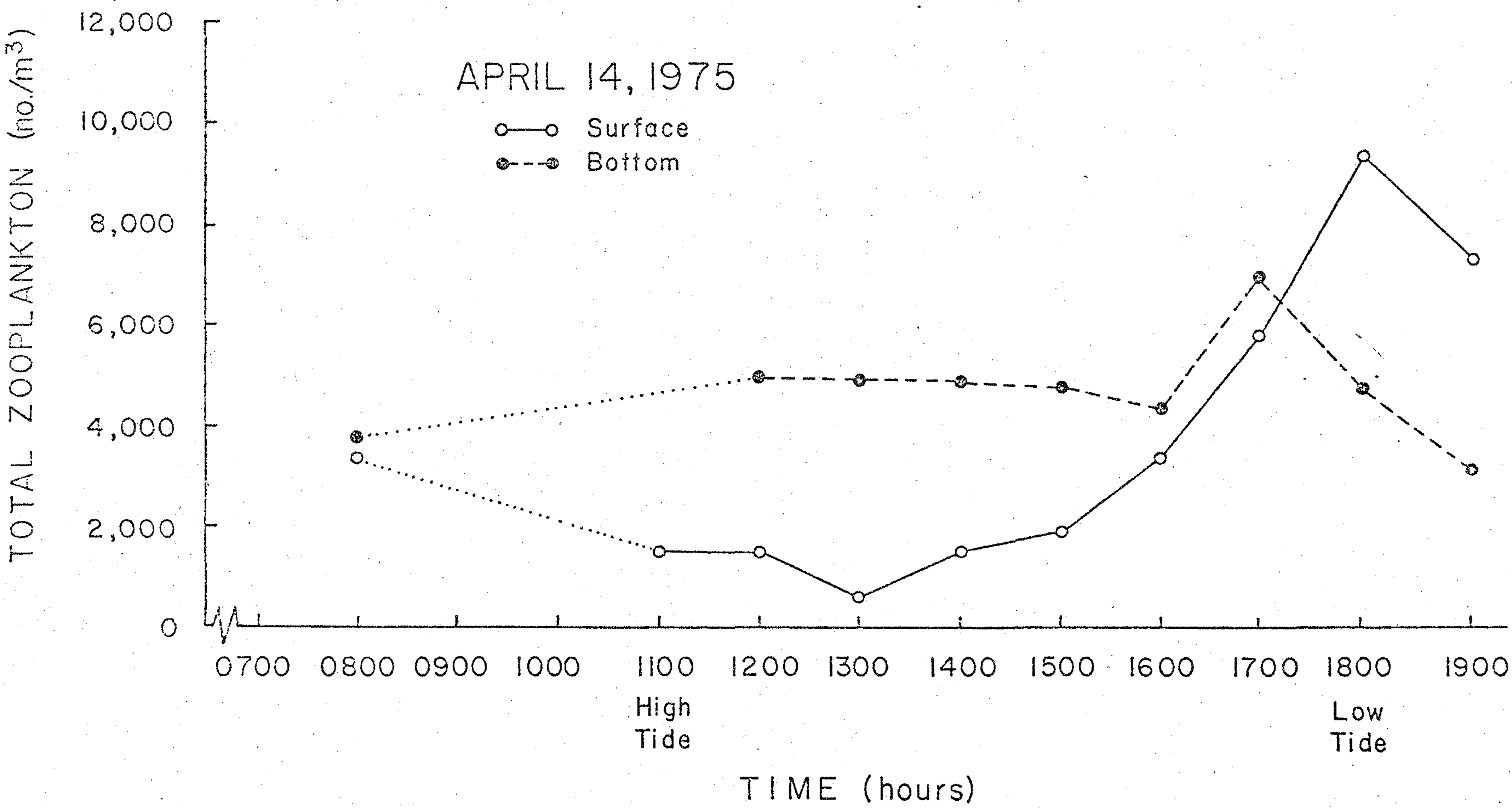


Figure III-11

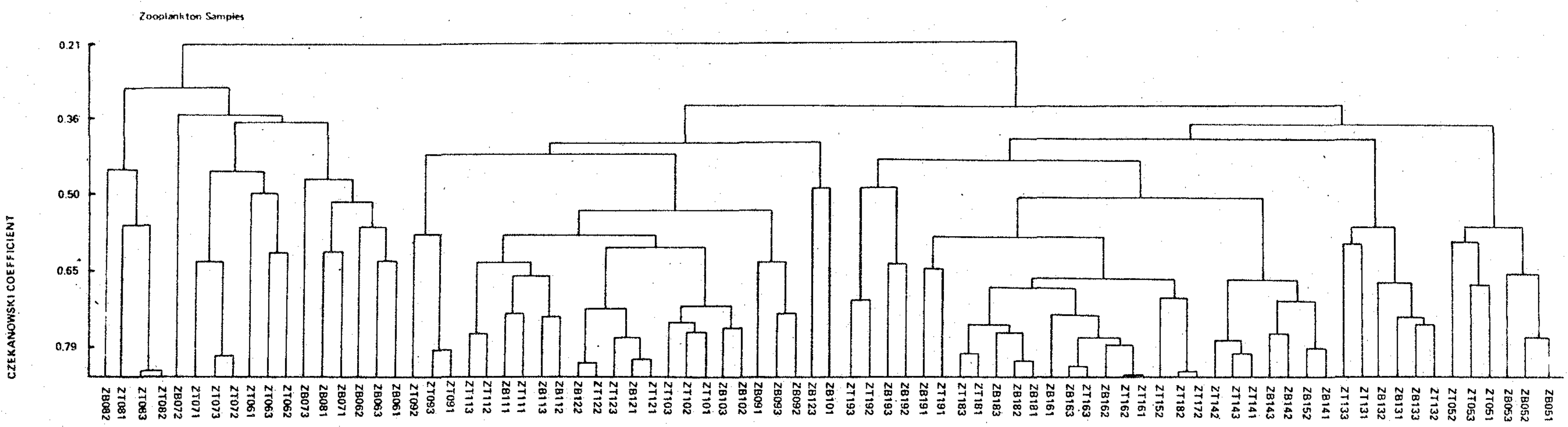


Figure III-12

IV. WATER COLUMN SYNTHESIS

Ann Pembroke

INTRODUCTION

The primary producer-herbivore relationship is an aspect of plankton studies which is receiving considerable attention in the recent literature. For example, Poulet (1973), Hargrave and Geen (1970), Petipa, et al. (1970), Parsons, et al. (1969), and Anraku (1964) examined zooplankton food requirements with natural phytoplankton populations. The influence of zooplankton and phytoplankton on the marine nitrogen and phosphorous cycles was reviewed by Corner and Davis (1971). In all of these studies, there was at least the implication that the interactions were more complex than the scope of their texts would permit. Martin (1965, 1968, 1970) was able to present a much more complete picture for Narragansett Bay by considering the interactions between two components of the phytoplankton-zooplankton relationship: grazing on phytoplankton by herbivorous zooplankters and excretion of ammonia and phosphates by zooplankton.

The intent of this chapter was to synthesize the phytoplankton, zooplankton, and nutrient data collected in Delaware Bay to develop a preliminary view of the base of this estuary's food web. Although zooplankton activity (feeding rate and excretion) was not examined, values for feeding rates obtained in the literature were used to quantify observations made on population data (Anraku, 1964).

PRIMARY PRODUCTION STUDIES

METHODS

Primary production studies were undertaken at Station 2 during four cruises (Feb. 20, April 14, May 9, and May 28, 1974). Net production was determined by the amount of C^{14} taken up during a six-hour incubation period.

Water samples were taken with Nisken bottles from 1, 3, and 5 m. Zooplankton was not removed. Two clear bottles and one dark bottle (125 ml) were filled, injected with C^{14} and suspended at the above depths from 0900-1500 hours. Secchi depths were noted at the start of each experiment.

Upon recovery, samples were Millipore filtered and put in a 50:50 solution of toluene and triton-X100 with 6 gm PPO. They were counted on the wide window C^{14} isoset channel of a Beckman LS-100 scintillation counter.

Production was determined using the following equation:

$$\text{Production (mg C/liter)} = \frac{([CPM_S - CPM_B]/E)\ (1.05)\ (\Sigma CO_2)}{2.22 \times 10^6 \text{ DPM}} \times 10^3$$

where CPM_S = counts per minute for sample

CPM_B = counts per minute for blank = 37

E = efficiency = .94

1.05 = discrimination factor for uptake of C^{14} relative to C^{12} by phytoplankton

ΣCO_2 = total inorganic carbon in sample = 18.7 mg/l (based on sample from May 9)

2.22×10^6 DPM = activity of isotope added to the sample.

These values were then converted to mg C/m^3/hr. The counts (CPM_S) for each of the two light bottles at any depth were averaged to determine one production value. It has been suggested that dark bottle values not be subtracted from light bottles because of poorly understood differences in the metabolism of C^{14} in the light and dark (Morris, et al., 1971). The light bottle value was assumed to represent net production.

The assimilation number was calculated for each group of samples.

$$A.N. = \frac{mg/m^3 \text{ productivity}}{mg/m^3 \text{ chlorophyll a}}$$

The values for chlorophyll a are tabulated in the Hydrography section of this report. The 1 and 5 m assimilation numbers were computed with the top and bottom chlorophyll a values as reported, the 3 m A.N. was calculated using the average of the top and bottom values.

RESULTS AND DISCUSSION

The net primary production values (light bottle values) and the assimilation numbers for all the samples are listed in Table IV-1.

The lowest primary production occurred in February (2.75 to 8.77 mg $C/m^3/hr$) prior to the major Skeletonema - Thalassiosira peak. Surface production was high for the next three experiments (April and May) with the maximum value obtained at the end of May. Only during the April cruise were the 1 m and 3 m production values similar, suggesting a vertical homogeneity of the phytoplankton biomass to 3 m.

The surface assimilation numbers increased between February (1.595) and April (2.925), decreased slightly between April and May (2.505), and increased sharply from early to late May (6.503). The mid- and deep samples showed an increase in A.N. between February and April, but steadily decreased thereafter. The assimilation numbers were similar for all depths during the April experiment (2.447, 2.838, 2.925), indicating again that the vertical distribution of biomass was fairly homogeneous. This was not the case for any of the other cruises. In all instances, the assimilation number (and production) decreased with depth--probably a function of the shallow extinction of light.

Flemer (1970) found that the assimilation numbers in the northern half of the Chesapeake Bay averaged about 3.3 mg C hr^{-1} mg $Chla^{-1}$ from May to November. In the Patuxent River, Flemer and Olmon (1971) computed the A.N. to be 23 g C day^{-1} $(g\ Chla)^{-1}$ (or 1.917 g C hr^{-1} $(g\ Chla)^{-1}$ assuming a 12 hour day) in late June. Stross and Stottlemyer's (1965) values were somewhat higher: 2.35 g C hr^{-1} $(g\ Chla)^{-1}$ in January, 3.44 in March, and 4.65 in June. Our data compare favorably with Flemer's (1970, averaging the May samples) and with Stoss and Stottlemyer's (1965). It appears, then, that the Delaware Bay was similar in production levels to parts of the Chesapeake Bay. This is pursued further in the next section.

NANNOPLANKTON-NUTRIENT RELATIONS

METHODS

The methods for this section were covered in the chapters on hydrography (Chapter I) and phytoplankton (Chapter II).

RESULTS AND DISCUSSION

Since nannoplankton were identified only from the surface samples, their numbers were compared only with surface nutrients. These data are summarized in Table IV-2 and the seasonal trends illustrated in Figures IV-1 to IV-12.

Silicates

Figures IV-4 to IV-6 illustrate the seasonal cycles of diatoms and silicates at each station. The basic pattern was one that would be expected--the silicate concentration decreased as diatom numbers increased. The lowest level of silicates at all stations was associated with the winter-spring Skeletonema bloom. Minimal diatom populations in the summer to early autumn were associated with the increase of silicates to maximal levels.

The relationship of silicate concentration to the phytoplankton populations (numbers transformed to $\log_{10}$) was investigated with the product moment correlation coefficient (Table IV-3). At Stations 1 and 2 the diatoms showed a significant (0.1 and 0.05 levels, respectively) negative correlation with silicates. Neither dinoflagellates nor μ-flagellates showed any relationship to silicates. At Station 2 total phytoplankton was negatively correlated (0.05 level) with silicates, and at Station 3 the influence of silicate was suggested even though the relationship was not significant.

Nitrogen Nutrients

Ammonia

The μ-flagellates apparently did not utilize ammonia as their principal nitrogen source. At each of the stations (Figures IV-7 to IV-9) ammonia concentrations and μ-flagellate numbers followed similar cycles--the levels of each rising and falling coincidentally. Correlations between the two were extremely low (Table IV-3) indicating the lack of any relationship, although the rate of supply and uptake may not be evident from field data that show only changes of standing crop and nutrient concentration over several weeks at a time.

The dinoflagellates occurred in low numbers during most of the year and did not show any significant association with ammonia concentrations (Figures IV-10 to IV-12). The correlation coefficients, although low, were always positive (Table IV-3).

The diatom numbers showed a strong relationship with ammonia concentration, especially at Stations 1 and 2. During November and January both showed small, but steady increases. Despite higher phytoplankton requirements, increased ammonia levels might be attributed to zooplankton excretion which in turn may have been a response to the October Leptocylindrus bloom. In addition, both diatom numbers and ammonia concentration increased in May after the decline of Skeletonema.

The spring bloom reduced ammonia levels to near zero at all three stations in March. At Station 2 in April ammonia reached concentrations of 0.07 μg-at/l but was again depleted by early May. Increased numbers of zooplankton did not replenish this nutrient in quantities sufficient to prolong the phytoplankton bloom. Since both carnivores and herbivores were increasing, the relative grazing pressure was reduced, and consequently, it is likely that depletion of nutrients rather than grazing was responsible in halting the bloom. The correlation of diatoms with ammonia showed a significant negative relationship at Stations 1 and 2 (Table IV-3). At Station 3 the relationship was also negative, but not significant.

Nitrate and Nitrite

There was no significant association between total phytoplankton abundance and nitrate plus nitrite concentration (Table IV-3). Ammonia is generally considered the preferred form of nitrogen for phytoplankton nutrition so that the nitrates and nitrites could be expected to be utilized only when the former nutrient is depleted (Corner and Davis, 1971). According to the data, however, a major component of the phytoplankton, the μ-flagellates, did not show a significant relationship to ammonia concentrations.

It can be seen (Figures IV-7, IV-8, IV-9) that the $NO_3 + NO_2$ cycle was inversely related to the μ-flagellate cycle during most of the year. The increase in $NO_3 + NO_2$ and μ-flagellates seen in May 1975 can probably be attributed to bacterial decomposition of zooplankton and phytoplankton which occurred during the spring diatom blooms. The coincident reduction in June 1974 thus probably marked the end of the 1974 spring bloom.

The correlation coefficients between μ-flagellates and nitrate plus nitrite were always negative and significant at Stations 1 and 3 (Table IV-3). Although dinoflagellate levels were generally insignificant, at Station 3 they showed a negative correlation with $NO_3 + NO_2$ concentrations. This trend was similar to the situation that McAllister, et al. (1961) found in large-scale cultures of natural, coastal phytoplankton populations where dinoflagellates were able to increase only after the nitrates were depleted. This was probably due more to inter-class competition than nitrate requirements. Station 3 had the lowest dinoflagellate levels, especially during the peak in July, and was the only station where this class had a low population early in June. Nitrates and nitrites probably played a very small role in diatom population changes since the correlation coefficients were not significant at any of the stations.

It is difficult to assess the dependence of the Delaware Bay phytoplankton on ammonia in relation to nitrates since the nitrate and nitrite levels were not determined separately. Dugdale and Goering (1967) reported that in natural phytoplankton populations NH_4^+ and NO_3^- were taken up simultaneously, the former more rapidly until nitrates achieved relatively high levels. In monospecific cultures of various algae, only ammonia was utilized until it was reduced to about 1 μg-at-N/ℓ at which point both NO_3^- and NH_4^+ were taken up (Strickland, et al., 1969). This situation occurred at all three stations during or after both the Leptocylindrus (October) and Skeletonema-Thalassiosira (March-early May) blooms. There was usually a corresponding decrease in the nitrate-nitrite levels during these periods. According to McAllister, et al. (1961), however, the growth of Skeletonema (in natural populations) was dependent on nitrate and ceases when this nutrient was depleted. Perhaps, then, the decrease in $NO_3^- + NO_2^-$ concentration following the Delaware Bay blooms represented the utilization of nitrites.

Eppley, et al. (1969) reported half saturation constants for ammonia uptake for Skeletonema costatum and Leptocylindrus danicus of 3.6 ± 0.8, 0.8 ± 0.7, 0.8 ± 0.5, and 3.4 ± 1.4, 3.6 ± 0.8, 0.5 ± 0.4, respectively. If the higher values were correct, then these species probably absorbed ammonia at the half-maximum rate most of the time. If the lower values were more accurate, maximal uptake rates could have been reached. In terms of achieving bloom proportions, however, the uptake rate was not as significant as it might appear. Generally, the half saturation constant for uptake was larger than the growth constant (representing cellular level, Eppley and Thomas, 1969). In other words, cell division can occur at far less than maximal uptake rates. This has been demonstrated in Phaeodactylum tricornutum (Ketchum, 1939), Asterionella japonica, and Chaetoceros gracile (Eppley and Thomas, 1969).

Ortho-Phosphates

There was a general inverse relationship between ortho-phosphates and the total phytoplankton population. Significant negative correlation coefficients were obtained at Stations 2 and 3 (Table IV-3). Ortho-phosphates are the major source of phosphorus in the marine environment, so this relationship would be expected.

Dinoflagellate abundances were too low to reflect a relationship with phosphate values. This nutrient reached a peak level at the time of maximum dinoflagellate numbers in July.

Surprisingly, the μ-flagellates showed no significant correlation to ortho-phosphate concentrations. The phosphate concentrations fluctuated more widely and frequently than did the μ-flagellate densities even during the summer and early fall when the latter reached their peak populations. Either these phytoplankton species required extremely low levels of phosphorus or they were able to utilize other sources of this nutrient [e.g. organic phosphate esters which have been found to be utilizable by Chu (1946) and Harvey (1953)].

Diatoms, however, showed a definite relationship with ortho-phosphates. Correlation coefficients were significantly negative. Although greatly depleted during the Leptocylindrus bloom in October, this nutrient was quickly regenerated. Depletion during the spring Skeletonema bloom was more severe, and regeneration was not as complete by the end of the survey. Depletion of this nutrient and of ammonia presumably contributed to the ending of the vernal flowering. It is, however, difficult to determine when PO_4^{3-} became limiting to population growth. Phytoplankton cells tended to accumulate phosphate as long as it was available regardless of their immediate needs (Goldberg, et al., 1951; Kuenzler and Ketchum, 1962) and continued to divide even after the nutrient has disappeared from the environment (Corner and Davis, 1971).

NANNOPLANKTON-HERBIVORE RELATIONS

METHODS

Feeding types were assigned to zooplankton based on the following studies: Anraku and Omori (1963), Gauld (1966), Jorgenson (1966), Martin (1965), Neunes and Pongolini (1965), Parsons and LeBrasseur (1970), Parsons and Takahashi (1973), Petipa, et al. (1970), and Timonin (1971). For the purposes of this report, animals were considered to be preferential herbivores if: (a) there was no specific information available, (b) there was a discrepancy between authors, or (c) the species was omnivorous. This may have overestimated the number of herbivores, but since the numbers of known herbivores were also high the general proportions were probably realistic.

The feeding classification for the zooplankton species considered in this study is given in Table IV-4. The three most abundant herbivores and phytoplankters for each station are ranked in Tables IV-5 and IV-6, respectively. Table IV-7 lists the values of the herbivore and phytoplankton populations for all samples. Seasonal cycles of each at Stations 1 to 3 are illustrated in Figures IV-13 to IV-15, respectively.

The proportions of herbivores among the zooplankton are listed in Table IV-8. In only seven cases (Aug. 21, Station III; Jan. 16, Stations I and II; April 14, Station II; May 9, Station III; and May 28, Stations I, II, and III) did herbivores represent less than 60% of the zooplankton. The last four dates noted occurred during the period of minimal Acartia tonsa and maximal Centropages hamatus populations. Centropages copepodites were abundant at the end of October and from December to the end of the survey. An increase in herbivores may have been supported by the Leptocylindrus danicus bloom in October and was also coincident with the reproduction of the carnivorous Centropages. Hence, the decline of the herbivore population in the spring may not have been due entirely to the decline of the vernal bloom, but was in part a result of the prior autumnal bloom.

Acartia tonsa was overwhelmingly the most abundant copepod which occurred at each of the stations from June 1974 through January or February 1975 (Table IV-5). At Stations 2 and 3 it appeared among the top three herbivores in May 1974. None of the other important herbivores were dominant as long as A. tonsa. However, all three stations showed a similar pattern of succession. Important peaks included the large number of bivalve veligers in November and again in January and the dominance of copepodites of Pseudocalanus minutus and Temora longicornis during the spring bloom. The latter two species occurred less abundantly year-round than did A. tonsa and possibly used the Skeletonema bloom to repopulate.

The μ-flagellate, Cryptomonas acuta, was always present (Table IV-6). All stations experienced a small Skeletonema burst in late August, a bloom of Leptocylindrus danicus during October and the late winter-spring Skeletonema bloom (codominated by Thalassiosira sp. A) from December through March or April. Dominant species were generally the same although absolute succession varied.

In general, the herbivores at Station 1 exhibited the "typical" lag period of abundance relative to the phytoplankton population (Figure IV-13). There was a phytoplankton peak in July, represented mainly by the dinoflagellate, Katodinium rotundatum, which was not followed by a zooplankton peak. Possibly then, Katodinium was not a suitable food source for the dominant herbivore, Acartia tonsa. Since A. tonsa reproduced year-round, the large population on June 13, 1974 may represent the results of a period of high reproductive activity in the spring followed by a natural population decline in the absence of suitable food.

The relationship of herbivore and phytoplankton abundance patterns were examined using the correlation coefficient in a cross-correlation time series analysis (Table IV-9). Only the values for a maximum of a three-cruise lag are given as longer lag periods gave meaningless results. All computations used $\log_{10}$ transformed abundances.

There were no significant correlations at Station 1. However, the highest positive correlation occurred with no lag for the μ-flagellates and the total phytoplankton and with a one-cruise lag for the diatoms suggesting that diatoms may be a more important food source than μ-flagellates. The absence of significant correlation coefficients may also demonstrate the need for more frequent periodic sampling.

At Station 2 (Fig. IV-14) there was no direct correlation between herbivores and phytoplankton from June 13-September 17, 1974.

Despite high phytoplankton numbers (June-August), zooplankton was low during this period. The increase of the zooplankton population between August 21 and September 17 may have been due to the dominance of Skeletonema and Asterionella on the former date. Further zooplankton increases were associated, as at Stations 1 and 2, with the Leptocylindrus bloom in October. The low zooplankton numbers on November 14 may have been due to patchiness since the values for the dominant Acartia tonsa were similar to each other during the cruises directly preceding and following it.

The dominance of Skeletonema in December (bloom proportions from February through April) may have been instrumental in supporting the veliger outburst in January. This bloom also supported fairly large populations of Pseudocalanus minutus and Temora longicornis (successively) until May 9. At this point, Skeletonema virtually disappeared from the phytoplankton community and was replaced by Chroomonas sp. The latter did not support large zooplankton populations at any of the stations.

During the spring bloom on April 15, herbivore numbers were low, although total zooplankton was of the same order as the previous cruise. The carnivorous copepod, Centropages hamatus, was the dominant zooplankton species. Perhaps predation of C. hamatus on Pseudocalanus allowed Temora to become the dominant herbivore.

None of the correlation coefficients between herbivores and phytoplankton were significant at Station 2. The highest correlation was a negative value when μ-flagellates and herbivores were compared with a two-cruise lag. Even with no lag, however, this correlation was negative, suggesting that the herbivores found here were not depending strongly on μ-flagellates as a food source. The positive correlation found between diatoms and herbivores (largest with a two-cruise lag) suggested that diatoms were the preferred food types.

Between September 1974 and early May 1975 the total phytoplankton and total zooplankton patterns were essentially similar at Stations 2 and 3. Succession during this period may be attributed to the same factors as at Station 2.

During the summer of 1974, however, the total numbers/m^3 at Station 3 resembled neither those at Station 1 nor at Station 2. Both phytoplankton and zooplankton numbers were low. The phytoplankton remained fairly stable, but the herbivore population fluctuated rapidly. The low herbivore numbers reported for July may have been artificial (patchiness or net clogging) since the *Acartia tonsa* population was quite large during both the preceding and following cruises yet was very low in July and there was no large copepodite population to account for the "recruitment" of the species.

There were no significant correlations between herbivores and μ-flagellates at Station 3. There were two large positive correlations between herbivores and diatoms--with no lag and with a two-cruise lag. Thus, the herbivores appeared to be able to respond quickly to changes in diatom numbers, but reached their maximum population densities two cruises after that of the diatoms. Unlike Stations 1 and 2, this also occurred between the herbivores and the total phytoplankton.

An attempt was made to determine the amount of carbon available and the amount which was needed for consumption by herbivores from June 1974 through May 1975. Based on the carbon to cell volume (c/v) relationship established by Mullin, et al. (1966):

$$\log_{10} c/v = -0.24 \log_{10} v - 0.29$$

the carbon content of each of the three most abundant phytoplankton species was determined (Table IV-10). Cell dimensions were taken from the following literature: Butcher (1958, 1964, 1967), Cupp (1943), Lebour (1925), and Wood and Ferguson (1968).

Anraku (1964) studied the feeding rates of _Acartia tonsa_ and _Pseudocalanus minutus_ (two of the most abundant herbivores found in this survey) on the diatom, _Thalassiosira fluviatilis_ (the genus but not the species found in this study), at various temperatures. His results (cells per copepod per day) were converted to carbon copepod^{-1} day^{-1} and then multiplied by the populations of _A. tonsa_ and _P. minutus_ to estimate the carbon required m^{-3} day^{-1} (Table IV-11). The requirements of these two species were separated in this table because they were rarely abundant at the same time.

In Table IV-12, carbon requirements and _A. tonsa_ and _P. minutus_ populations were expressed as proportions of the standing crop of carbon and total herbivore population, respectively. These two zooplankters comprised 50% of the herbivores for the following samples:

	Stations 1	2	3
Dates	6/20/74	6/20/74	6/20/74
	7/19/74	7/19/74	8/ 1/74
	8/21/74	8/ 1/74	9/17/74*
	9/17/74*	8/21/74	12/13/74
	12/13/74	10/30/74	3/18/75
		12/13/74	
		2/20/75	

At other times, the influence on the standing crop of other herbivores (whose nutritional demands are unknown) must be considered to be much greater than that of _A. tonsa_ and _P. minutus_.

Samples (*) corresponded to times when >30% of the living carbon was consumed. This occurred only twice when these species comprised >50% of the herbivores (twice more, Stations 2 and 3, 11/14/74, when they comprised 48 and 24%, respectively. It was likely that during these periods of high carbon requirements, the omnivores which were considered here as herbivores (A. tonsa, Oithona spp., and Temora longicornis) have switched to a carnivorous diet. For the most part, however, the carbon requirements of the A. tonsa and P. minutus populations were quite low, even when these species comprised >80% of the herbivores.

The discussion thus far has been limited to standing crop. Coincidentally, the phytoplankton population reproduces as it is being utilized. The spring assimilation numbers cited in Stross and Stottlemyer (1965) can be used to estimate monthly net production.

If one assumes that the phytoplankton species and environmental parameters at the Patuxent River mouth were similar to our study area, one can postulate that the assimilation numbers maintained their similarity throughout the year (Table IV-13). If copepods ingested particles for a total of 12 hours of each day, a maximum carbon requirement of A. tonsa and P. minutus per hour could be tabulated. Only twice (on Oct. 30 and Dec. 13, when A. tonsa and P. minutus represented 70 and 80%, respectively, of the herbivores at Station 2) was the food requirement more than 3% of the hourly production (Table IV-13).

The food requirements of some of the dominant herbivores in this study in terms of percentage of body weight, and the dates of their dominance are listed in Table IV-14. Acartia and Pseudocalanus had the highest requirements of any of the plankters listed (except, perhaps, Oikopleura which was more massive than the copepods). This indicated that the use of these two species to estimate the food requirements of the herbivores as a whole was reasonable.

Based on the literature, the phytoplankton community in this area was probably sufficiently productive to support the locally dominant herbivores. Poulet (1973) found that Pseudocalanus minutus can feed selectively on size particles (algal cell), ranging from 4-100 μ, which will most efficiently provide its nutritional requirements.

P. minutus, Temora longicornis, Oithona similis, and Acartia tonsa will all feed on μ-flagellates (Hargrave and Geen, 1970) which comprised a large percentage of the total phytoplankton in this area. A. tonsa (Curl and McLeod, 1961), P. minutus, and Oithona sp. (Parsons, et al., 1969) preferred, however, to graze on diatoms when available. Finally, the phytoplankton density was usually found to be greater than the level at which grazing has been found to cease (50-190 μg C/ℓ or (50-190) x 10^9 pg C/m^3; Parsons, et al., 1969). Since there was no significant correlation between herbivore and nannoplankton numbers, the low estimated consumption of primary production and the phytoplankton community must have been adequate to support the dominant herbivores. It could also be concluded that zooplankton grazing had little effect on the phytoplankton population during this study.

Comparisons with other studies are difficult. Martin (1970) performed feeding experiments throughout the year and found that grazing pressure was quite high during the spring and summer in Narragansett Bay. However, the phytoplankton and zooplankton communities in that area were each essentially dominated by one species, Skeletonema costatum and Acartia tonsa. The situation in Delaware Bay was not as simple since no one species of phytoplankton was able to maintain dominance for a long period of time, except in the spring Skeletonema-Thalassiosira bloom. This pattern of continuous dominance replacement was also observed in the zooplankton. As a consequence, the planktonic food web in Delaware Bay may be more complex than in the estuaries to the north, and as well, may be less influenced by periodic perturbations.

ZOOPLANKTON-NUTRIENT RELATIONS

METHODS

The methods for this section were covered in the chapters on hydrography (Chapter I) and zooplankton (Chapter III).

RESULTS AND DISCUSSION

Since most members of the zooplankton community undergo vertical migration, the values for total zooplankton and nutrients were averaged over all depths sampled. These data are given in Table IV-15 and illustrated in Figures IV-16 to IV-18. Table IV-16 lists the correlation coefficients calculated for these relationships.

Ammonia

Zooplankton species can excrete high levels of ammonia. Thus, it was expected that large zooplankton populations would not be accompanied by high ammonia concentrations. This, however, was not the case during this study. At Station 3 there was a significant negative correlation between zooplankton numbers and ammonia levels. Considering the observations on the ammonia-phytoplankton and the herbivore-phytoplankton relationships, the phytoplankton cells could have been utilizing ammonia as it was produced by zooplankton. At Station 3, the herbivore and phytoplankton peaks coincided so that there was an accumulation of ammonia only when both populations were low. The situation was similar at Station 2, but was less pronounced. Martin (1968) observed a similar situation in Narragansett Bay, as did Butler, et al. (1970) in the Clyde Sea area.

Nitrate and Nitrite

Zooplankton influence nitrate-nitrite levels after their death and bacterial decomposition. Petipa, et al. (1970) found that dead zooplankters were decomposed after about two to four days. An inverse relationship between the animals and these nutrients might be anticipated. Graphically, this appeared to be the case at all three stations (Figures IV-16 to IV-18). Although the correlation coefficients were negative for each station, there was a significant correlation (0.05 level) only at Station 1. The zooplankton maintained a fairly stable population between three major peaks at

Station 1 whereas at the other two stations the populations constantly fluctuated. Nitrate and nitrite followed basically the same pattern at all three stations--increased in August to a peak in September and then declined until the end of October, increased again until mid-January and declined from then on. These peaks corresponded with low zooplankton numbers at Station 1 and with fluctuating populations at Stations 2 and 3.

Ortho-Phosphates

In addition to ammonia, zooplankton can excrete substantial amounts of phosphates. Thus, if the zooplankton were a major contributor of phosphates, the peak zooplankton number should coincide with high phosphate concentrations. However, this was not the case during this study. At all three stations there was an inverse relationship (significant correlation only at Station 1). This was due to the fact that the herbivore populations did not (or, appeared not to) lag behind the phytoplankton fluctuations but tended to coincide with the major blooms. This allowed for nutrient build-up only at low zooplankton levels.

Values for nutrient excretion by copepods have been reported in terms of percentage of body weight (e.g. Martin, 1968; Hargrave and Geen, 1968). Dry weights of the zooplankton in this study were not recorded, however, so no estimates of excretion can be made. Corner, et al. (1965) found the excretion rate of *Acartia clausi* to be quite high and attributed this to its small size and high metabolic activity. This can probably be extended to *A. tonsa* as well.

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Table IV-1

Net production values and assimilation numbers at Station 2

Cruise	Depth (m)	Secchi Depth (m)	Net Production (mg C/m^3/hr)	Assimilation Number mg C/hr/mg Chl a
2/20/75	1	2.5	8.77	1.595
	3		3.85	0.62
	5		2.75	0.398
4/14/75	1	1.78	24.58	2.925
	3		21.43	2.838
	5		16.40	2.447
5/ 9/75	1	2.17	17.79	2.505
	3		12.72	1.663
	5		7.90	0.963
5/28/75	1	1.72	27.96	6.503
	3		6.97	0.995
	5		2.99	0.308

Table IV-2

Surface nannoplankton and nutrient values

Station 1	Nannoplankton (cells/ml)				Nutrients (ug-at/l)			
Date (Cruise No.)	μ-flagellates	diatoms	dinoflagellates	Total	Si	NH_3	NO_3+ NO_2	Ortho- PO_4
13 June 1974 (4)	6644	1572	354	8570	6.50	1.5	17.5	0.07
20 June 1974 (5)	2585	1112	56	3753	5.44	1.8	1.2	0.16
19 July 1974 (6)	4233	199	3359	7791	10.2	6.7	4.0	0.72
1 Aug. 1974 (7)	3957	118	174	4249	16.6	2.8	5.0	1.10
21 Aug. 1974 (8)	2087	1599	127	3813	13.2	1.6	12.7	1.11
17 Sept. 1974 (9)	1453	431	42	1926	29.2	4.9	14.1	1.64
15 Oct. 1974 (10)	271	2821	21	3113	4.8	1.0	9.2	0.49
30 Oct. 1974 (11)	1351	3042	21	4414	4.5	1.4	4.8	0.23
14 Nov. 1974 (12)	763	77	14	854	11.2	2.3	4.9	0.98
13 Dec. 1974 (13)	389	570	28	987	7.5	2.8	16.4	0.70
16 Jan. 1975 (14)	139	943	21	1103	11.0	3.8	27.0	0.56
20 Feb. 1975 (15)	-	-	-	-	-	-	-	-
18 March 1975 (16)	232	3848	11	4091	2.6	≃ 0	11.5	0.01
14 April 1975 (17)	-	-	-	-	-	-	-	-
9 May 1975 (18)	1787	555	153	2495	1.1	≃ 0	3.6	0.04
28 May 1975 (19)	3757	1134	162	5053	1.45	1.9	7.3	0.14

Table IV-2 (cont.)

Station 2

Date (Cruise No.)	Nannoplankton (cells/ml) μ-flagellates	diatoms	dinoflagellates	Total	Nutrients (ug-at/l) Si	NH_3	NO_3+ NO_2	Ortho-PO_4
13 June 1974 (4)	5286	1732	491	7509	3.00	1.5	12.7	0.06
20 June 1974 (5)	2894	2468	160	5522	3.13	1.4	0.2	0.20
19 July 1974 (6)	3162	214	1765	5141	12.2	6.1	2.8	0.78
1 Aug. 1974 (7)	-	-	-	-	16.8	1.7	9.2	1.00
21 Aug. 1974 (8)	998	2572	63	3633	9.8	0.7	8.2	0.66
17 Sept. 1974 (9)	1124	341	28	1493	30.0	5.5	12.1	1.52
15 Oct. 1974 (10)	381	2363	1	2745	6.3	1.5	8.4	0.49
30 Oct. 1974 (11)	836	4446	40	5322	3.6	1.1	2.3	0.26
14 Nov. 1974 (12)	729	111	21	861	9.7	2.1	0.1	0.92
13 Dec. 1974 (13)	326	930	63	1319	9.4	2.8	13.1	0.63
16 Jan. 1975 (14)	223	2482	7	2712	10.2	3.1	18.3	0.58
20 Feb. 1975 (15)	585	4203	60	4848	13.7	7.4	18.2	0.36
18 March 1975 (16)	320	15684	97	16011	0.7	≃ 0	9.4	≃ 0
14 April 1975 (17)	904	7247	56	8207	1.40	0.7	10.8	0.06
9 May 1975 (18)	1809	853	105	2767	0.9	≃ 0	1.9	0.02
28 May 1975 (19)	3728	1650	323	5701	2.2	2.7	8.6	0.18

Table IV-2 (cont.)

Station 3

Date (Cruise No.)	Nannoplankton (cells/ml) μ-flagellates	diatoms	dinoflagellates	Total	Nutrients (ug-at/l) Si	NH_3	NO_3+ NO_2	Ortho- PO_4
13 June 1974 (4)	1968	1926	62	3956	3.15	1.4	3.8	0.04
20 June 1974 (5)	2132	2078	254	4464	3.31	1.7	0.2	0.18
19 July 1974 (6)	2246	201	763	3210	16.3	7.6	2.5	0.81
1 Aug. 1974 (7)	3394	1176	223	4793	20.2	2.5	5.0	1.18
21 Aug. 1974 (8)	2270	2647	30	4947	10.7	1.6	8.1	0.87
17 Sept. 1974 (9)	1469	452	28	1949	31.6	5.0	11.2	1.60
15 Oct. 1974 (10)	548	3071	14	3633	7.1	0.6	11.7	0.47
30 Oct. 1974 (11)	1527	8419	42	9988	3.6	1.2	4.4	0.29
14 Nov. 1974 (12)	617	91	21	729	10.0	2.2	4.1	0.93
13 Dec. 1974 (13)	327	800	104	1231	10.4	2.7	13.8	0.58
16 Jan. 1975 (14)	229	2052	14	2295	16.6	4.0	27.5	0.58
20 Feb. 1975 (15)	-	-	-	-	-	-	-	-
18 March 1975 (16)	459	19904	84	20447	0.3	≃ 0	9.7	≃ 0
14 April 1975 (17)	-	-	-	-	-	-	-	-
9 May 1975 (18)	2315	646	129	3090	0.6	≃ 0	1.6	0.03
28 May 1975 (19)	3595	1041	263	4899	2.0	1.3	2.9	0.20

Table IV-3

Correlation of phytoplankton numbers and nutrient concentrations

	Si	NH_3	NO_3 + NO_2	Ortho-PO_4	Degrees of Freedom
			Station 1		
μ-flagellates	.188	.167	-.482(*)	.018	12
diatoms	-.468(*)	-.546*	-.251	-.562*	12
dinoflagellates	.038	.275	-.244	.012	12
Total Phytoplankton	-.244	-.049	-.334	-.366	12
			Station 2		
μ-flagellates	-.144	.031	-.416	-.171	13
diatoms	-.511*	-.776*	.355	-.680*	13
dinoflagellates	-.172	.139	-.228	-.270	13
Total Phytoplankton	-.550*	-.237	.070	-.717*	13
			Station 3		
μ-flagellates	-.040	.010	-.780*	.039	12
diatoms	-.436	-.257	.197	-.509*	12
dinoflagellates	-.153	.245	-.602*	-.091	12
Total Phytoplankton	-.428	-.391	-.190	-.472(*)	12

* significant at 0.05 level
(*) significant at 0.10 level

Table IV-4

Feeding type classification for zooplankton species

Medusa	C *
Ctenophore	C
Cyphonaute larvae	H
Polychaete larvae	H
Veliger	H
Mytilus edulis larvae	H
Limacina inflata	H
Unidentified pteropod	H
Penilia avirostris	H
Podon sp.	H
Evadne sp.	H
Acartia clausi	H
Acartia tonsa	O (H)
Acartia copepodites	O
Centropages hamatus	C
Centropages typicus	C
Centropages copepodites	C
Corycaeus sp.	C
Eucalanus attenuatus	H
Eurytemora affinis	?
Euterpina acutifrons	H
Labidocera aestiva	C
Oithona brevicornis	C-H
Oithona similis	C-H
Oithona spinirostris	C-H
Paracalanus sp.	H
Paracalanus crassirostris	H
Pseudocalanus minutus	H
Pseudocalanus copepodites	H
Pseudodiaptomus coronatus	?
Temora longicornis	O
Temora copepodites	?
Tortanus discaudatus	C
Harpacticoid copepod	?
Copepod nauplii	H
Mysid	bottom feeder
Mancocuma altera	bottom feeder
Amphipods	bottom feeder
Decapod larvae	C
Balanus sp. nauplii	H
Balanus sp. cyprids	H
Sagitta sp.	C
Oikopleura sp.	H

* C = Carnivore; H = Herbivore; O = Omnivore

Table IV-5

Rank of three most dominant herbivorous zooplankton species by sampling date at each station

	1974									1975					
	6/20	7/19	8/1	8/21	8/17	10/15	10/30	11/14	12/13	1/16	2/20	3/18	4/14	5/9	5/28
Station I															
<u>Acartia tonsa</u>	1	1	1	1	1	3			1	1					
<u>Podon</u> sp.	2														
<u>Pseudodiaptomus coronatus</u>	3	2	2	3	2										
<u>Oikopleura</u> sp.		3			3	1									
copepodites			3									3			
<u>Limacina inflata</u>				2											
<u>Paracalanus</u> sp.						2	2	1						3	
<u>Pseudocalanus minutus</u>							1			3		2		2	
Bivalve veligers							3	3							
<u>Euterpina acutifrons</u>								2							
<u>Mytilus edulis</u> veligers									2	2					
<u>Acartia</u> copepodites									3						
<u>Temora longicornis</u>												1		1	2
<u>Balanus</u> nauplii															1
<u>Acartia clausi</u>															3
Station II											*		*		
<u>Acartia tonsa</u>	1	1	1	1	1		1	1	1	2	2				
<u>Podon</u> sp.	2														2
<u>Pseudodiaptomus coronatus</u>	3	2	2		2										
<u>Limacina inflata</u>			3	2											
<u>Oikopleura</u> sp.					3	1									
<u>Oithona similis</u>										3					3
<u>Acartia</u> copepodites									3						
Veligers								2	2						
<u>Mytilus edulis</u> veligers										1					

Table IV-5 (cont.)

	1974									1975					
	6/20	7/19	8/1	8/21**	8/17	10/15	10/30	11/14	12/13	1/16	2/20*	3/18	4/14*	5/9	5/28
Station II (cont.)															
Pseudocalanus minutus						2					1	1	2	2	
Paracalanus sp.						3		3				3		3	
Polychaete larvae				3			2								
Paracalanus crassirostris							3								
Temora longicornis													1	1	
copepodites		3									3	2	3		
Balanus sp. cyprids															1
Station III															
Acartia tonsa	1	2	1	(1)	1	2	1	2	1	1					3
Podon sp.	2														
Pseudocalanus minutus	3											1			
Pseudodiaptomus coronatus		1	2		3										
Limacina inflata		3	3	(2)											
Oikopleura sp.					2	1									
Paracalanus sp.						3	3	3				3		3	
Polychaete larvae							2								
Bivalve veligers								1							
Acartia copepodites									2						
Mytilus edulis veliger									3	2					
Acartia clausi										3					
copepodites												2			
Temora longicornis														1	
Oithona brevicornis														2	
Oithona similis															1
Balanus sp. cyprids															2

* 12-hr. cruises, values averaged over all samples; ** deep sample missing

Table IV-6

Rank of three most dominant phytoplankton species at each station by sampling period

	1974										1975					
	6/13	6/20	7/19	8/1	8/21	9/17	10/15	10/30	11/14	12/13	1/16	2/20	3/18	4/14	5/9	5/28
Station I																
Cryptomonas acuta	1	1	2	1	3	1	2	2	1	2						2
Prasinophyte A	2			3												
Calycomonas ovalis	3	2		2												
Rhizosolenia fragilissima		3			1											
Katodinium rotundatum			1													
Chroomonas sp.			3			2									1	1
Skeletonema costatum					2					1	1		1			
Phaeodactylum tricornutum						3										
Leptocylindrus danicus							1	1								
Unidentified flagellate							3									
Flagellate PZ-10								3	2							
Navicula sp. B									3							
Thalassiosira sp. A										3	2		2			
Cyanophyceae sp. A											3		3		2	
Pyramimonas sp. A															3	
Flagellate D																3
Station II																
Cryptomonas acuta	1	3			3	1	3	2	1	3		3				3
Prasinophyte A	2	2														
Chrysochromulina sp.	3															
Rhizosolenia fragilissima		1														

Table IV-6 (cont.)

	1974										1975					
	6/13	6/20	7/19	8/1	8/21	9/17	10/15	10/30	11/14	12/13	1/16	2/20	3/18	4/14	5/9	5/28
Station II (cont.)																
Katodinium rotundatum			1													
Chroomonas sp.			2												1	1
Calycomonas ovalis			3			2										
Skeletonema costatum					1					1	1	1	1	1		
Asterionella japonica					2											
Phaeodactylum tricornutum						3										
Leptocylindrus danicus							1	1								
Unidentified flagellate							2									
Cryptomonad B								3								
Fragilaria oceanica									2				3			
Flagellate PZ-10									3							
Thalassiosira sp. A										2	2	2	2	2		2
Cyanophyceae sp. A											3			3		
Pyramimonas sp. A															2	
Leptocylindrus minimus															3	
Station III																
Asterionella japonica	1															
Cryptomonas acuta	2			2	3	1		2	1	1						3
Calycomonas ovalis	3			1	2	2										
Rhizosolenia fragilissima		1														
Chroomonas sp.		2	1												1	1
Pyramimonas sp. A		3	3												3	
Katodinium rotundatum			2													
Cerataulina bergonii				3												
Skeletonema costatum					1		3			3	1		1			
Phaeodactylum tricornutum						3										

Table IV-6 (cont.)

	1974										1975					
	6/13	6/20	7/19	8/1	8/21	9/17	10/15	10/30	11/14	12/13	1/16	2/20	3/18	4/14	5/9	5/28
Station III (cont.)																
Leptocylindrus danicus							1	1								
Unidentified flagellate							2									
Cryptomonad B								3								
Flagellate PZ-10									2							
Cryptomonad C									3							
Nitzschia seriata										2						
Thalassiosira sp. A											2		2			
Cyanophyceae sp. A											3				2	2
Fragilaria oceanica													3			

Table IV-7

Total herbivore and nannoplankton population numbers

(herbivores-average of surface and deep samples; nannoplankton-surface values only)

Date			Station I H[1]	Station I N[2]	Station II H	Station II N	Station III H	Station III N
13 June	1974	(4)	-	16,450	-	7,339	-	3,937
20 June	1974	(5)	16,921	3,521	1,952	5,325	4,538	4,430
19 July	1974	(6)	10,316	7,731	1,513	5,121	1,538	3,210
1 Aug.	1974	(7)	1,389	4,249	2,110	-	6,995	4,793
21 Aug.	1974	(8)	886	3,792	115	3,577	-	4,897
17 Sept.	1974	(9)	2,533	1,916	794	1,483	1,538	1,949
15 Oct.	1974	(10)	1,428	3,085	1,635	2,745	3,763	3,626
30 Oct.	1974	(11)	17,948	4,414	7,119	5,322	5,921	9,966
14 Nov.	1974	(12)	3,388	854	2,049	853	1,528	729
13 Dec.	1974	(13)	6,033	994	4,942	1,319	5,969	1,231
16 Jan.	1975	(14)	463	1,311	858	2,961	636	2,565
20 Feb.	1975	(15)	-	-	1,590	4,828	-	-
18 March	1975	(16)	4,177	5,256	4,184	16,323	8,234	20,669
14 April	1975	(17)	-	-	1,639	8,679	-	-
9 May	1975	(18)	6,407	3,119	5,158	2,947	5,644	3,432
28 May	1975	(19)	2,778	5,550	244	5,944	405	6,041

[1]herbivores: no. organisms/m^3; [2]nannoplankton: cells/ml

Table IV-8

The proportion of herbivores in the zooplankton samples. Values were averaged over all depths sampled.

Cruise	Station I	Station II	Station III
20 June	.949	.746	.819
19 July	.893	.675	.879
1 Aug.	.911	.812	.929
21 Aug.	.928	.738	.517
17 Sept.	.953	.953	.898
15 Oct.	.815	.901	.896
30 Oct.	.860	.944	.915
14 Aug.	.934	.930	.952
13 Dec.	.941	.883	.955
16 Jan.	.431	.631	.632
20 Feb.	--	.801	--
18 Mar.	.767	.867	.886
14 Apr.	--	.462	--
9 May	.771	.667	.561
28 May	.256	.439	.280

Table IV-9

Time series correlation coefficients of herbivore-phytoplankton abundances ($\log_{10}$ transformed)

μ-flagellates

	lag	Station 1	df	Station 2	df	Station 3	df
lag	0	.325	11	-.227	13	.095	10
	1	-.061	9	-.269	12	-.036	8
	2	-.199	9	-.451	11	-.207	8
	3	-		-.409	10	-.094	7

Diatoms

	lag	Station 1	df	Station 2	df	Station 3	df
lag	0	.121	11	.145	13	.488	10
	1	.487	9	.171	12	-.405	8
	2	.453	9	.377	11	.571*	8
	3	-		-.045	10	-.227	7

Total phytoplankton

	lag	Station 1	df	Station 2	df	Station 3	df
lag	0	.271	11	.019	12	.315	10
	1	.085	9	.164	12	-.217	8
	2	.015	9	-.044	11	.512	8
	3	-		-		-.556	7

* significant at 0.10 confidence level

Table IV-10

Cell size, shape, and carbon content of the three most abundant nannoplankton species for each cruise and station

	Dimensions (diam. x length; μ)	Shape	Volume (μ^3)	C/V* (pg/μ^3)	Carbon Content per cell (picogramo)
Cryptomonas acuta	4 - 6 x 12 - 15	C	267	.103	28
Chroomonas sp.	3 - 4 x 4 - 8	C	58	.1935	5
Cryptomonad B	4 - 6 x 12 - 15	C	267	.1342	36
Cryptomonad C	3 - 4 x 10 - 14	C	116	.1639	19
Prasinophyte A	3 - 4	S	22	.2442	5
Pyramimonas sp. A	4 - 6 x 5 - 7	C	119	.1629	19
Calycomonas ovalis	3.5 - 4 x 4.5 - 5	C	48	.2025	10
Chrysochromulina sp.	5 - 6	S	87	.1756	15
Katodinium rotundatum	12 - 15	S	1,288	.09196	118
Thalassiosira sp. A	18 - 27	S	5,964	.06375	380
Skeletonema costatum	3 - 20	S	796	.1032	82
Leptocylindrus danicus	7 - 10 x 14 -100	C	3,253	.07362	239
Leptocylindrus minimus	5 - 6 x 40 - 50	C	1,075	.09605	103
Rhizosolenia fragilissima	12 - 20 x 42 - 67	C	11,022	.05495	606
Cerataulina bergonii	11 - 36 x 10 - 36	C	10,253	.05590	573
Fragilaria oceanica	1 - 2 x 8 - 40	C	683	.1071	73
Asterionella japonica	8 - 12 x 30 -150	C	7,110	.06102	434
Navicula sp. B	6 - 8 x 7 - 15	C	406	.01213	5
Nitzschia seriata	6.5 - 7 x 95 -115	C	3,779	.07098	268
? *Phaeodactylum tricornutum*	3 - 4 x 8	C	77	.01808	1
unidentified flagellate	5	S	144	.1555	12
PZ-10 flagellate	5	S	65	.1883	12
Flagellate D	5	S	65	.1883	12
Cyanophyceae sp. A	6 - 7	S	65	.1883	22

C = cylindrical; S = spherical

* from $\log_{10} C/V = -.24 \log_{10} V - .29$ (Mullin, et al., 1966).

Table IV-11

Living carbon contributed by the three most abundant nannoplankton species during each cruise and carbon requirements of _Acartia tonsa_ and/or _Pseudocalanus minutus_*

(picograms C/m^3/day)

Cruise	Station 1 Available Carbon	Station 1 Required Carbon *A. tonsa*	Station 1 Required Carbon *P. minutus*	Station 2 Available Carbon	Station 2 Required Carbon *A. tonsa*	Station 2 Required Carbon *P. minutus*
13 June 1974	741.70×10^{8}	-	-	613.38×10^{8}	-	-
20 June 1974	4398.52×10^{8}	1.532×10^{8}	7.059×10^{8}	12512.14×10^{8}	123.1×10^{8}	1.065×10^{8}
19 July 1974	4534.42×10^{8}	910.9×10^{8}	N	2123.69×10^{8}	122.4×10^{8}	N
1 Aug. 1974	740.10×10^{8}	66.19×10^{8}	N	-	178.2×10^{8}	N
21 Aug. 1974	1245.62×10^{8}	83.58×10^{8}	N	5657.34×10^{8}	8.869×10^{8}	N
17 Sept. 1974	153.40×10^{8}	143.8×10^{8}	$.5327 \times 10^{8}$	221.49×10^{8}	28.89×10^{8}	$.2188 \times 10^{8}$
15 Oct. 1974	5501.44×10^{8}	29.53×10^{8}	1.931×10^{8}	4114.89×10^{8}	14.61×10^{8}	9.220×10^{8}
30 Oct. 1974	7363.69×10^{8}	30.87×10^{8}	86.79×10^{8}	10686.02×10^{8}	734.0×10^{8}	4.698×10^{8}
14 Nov. 1974	202.79×10^{8}	33.70×10^{8}	9.220×10^{8}	243.87×10^{8}	133.6×10^{8}	6.289×10^{8}
13 Dec. 1974	648.92×10^{8}	94.83×10^{8}	N	1132.36×10^{8}	120.2×10^{8}	N
16 Jan. 1975	408.06×10^{8}	3.196×10^{8}	4.696×10^{8}	35885.66×10^{8}	5.454×10^{8}	$.7732 \times 10^{8}$
20 Feb. 1975	-	-	-	8101.28×10^{8}	6.269×10^{8}	21.28×10^{8}
18 March 1975	6788.68×10^{8}	2.366×10^{8}	57.37×10^{8}	16943.88×10^{8}	2.089×10^{8}	132.2×10^{8}
14 April 1975	-	-	-	14397.60×10^{8}	N	20.21×10^{8}
9 May 1975	217.28×10^{8}	N	21.18×10^{8}	405.82×10^{8}	N	26.3×10^{8}
28 May 1975	370.25×10^{8}	N	N	4288.53×10^{8}	N	N

Table IV-11 (cont.)

Station 3

Cruise	Available Carbon	Required Carbon <u>A. tonsa</u>	Required Carbon <u>P. minutus</u>
13 June 1974	4465.86×10^{8}	-	-
20 June 1974	11004.32×10^{8}	337.8×10^{8}	4.310×10^{8}
19 July 1974	1009.51×10^{8}	53.02×10^{8}	N
1 Aug. 1974	5077.24×10^{8}	660.7×10^{8}	N
21 Aug. 1974	1621.16×10^{8}	1.116×10^{8}	N
17 Sept. 1974	258.14×10^{8}	100.9×10^{8}	$.1703\times10^{8}$
15 Oct. 1974	6665.04×10^{8}	64.50×10^{8}	23.30×10^{8}
30 Oct. 1974	19724.98×10^{8}	349.7×10^{8}	9.988×10^{8}
14 Nov. 1974	151.15×10^{8}	44.66×10^{8}	4.896×10^{8}
13 Dec. 1974	858.06×10^{8}	140.9×10^{8}	N
16 Jan. 1975	3362.68×10^{8}	7.667×10^{8}	2.229×10^{8}
20 Feb. 1975	-	-	-
18 March 1975	21576.60×10^{8}	17.18×10^{8}	275.2×10^{8}
14 April 1975	-	-	-
9 May 1975	210.41×10^{8}	N	7.580×10^{8}
28 May 1975	426.98×10^{8}	N	N

N = negligible population
* based on Anraku (1964)

Table IV-12

Carbon required by *Acartia tonsa* and *Pseudocalanus minutus*

Cruise	Station 1 Carbon Required $pgm/m^3 x 10^8$	Station 1 Proportion of Total Carbon	Station 1 Proportion of Herbivore Population	Station 2 Carbon Required $pgm/m^3 x 10^8$	Station 2 Proportion of Total Carbon	Station 2 Proportion of Herbivore Population
June 20, 1974	8.591	.001	.910	124.2	.009	.644
July 19, 1974	910.9	.200	.871	122.4	.057	.797
Aug. 1, 1974	66.19	.089	.470	178.2	-	.833
Aug. 21, 1974	83.58	.067	.930	8.869	.001	.765
Sept. 17, 1974	144.3	.940	.538	29.11	.131	.370
Oct. 15, 1974	31.46	.005	.087	23.86	.005	.138
Oct. 30, 1974	117.7	.016	.315	738.7	.069	.718
Nov. 14, 1974	42.92	.211	.104	139.9	.573	.480
Dec. 13, 1974	94.83	.146	.511	120.2	.106	.791
Jan. 16, 1975	7.892	.005	.395	6.227	.000	.222
Feb. 20, 1975	-	-	-	27.55	.003	.742
March 18, 1975	59.74	.008	.267	134.3	.007	.458
April 14, 1975	-	-	-	20.21	.001	.393
May 9, 1975	21.18	.097	.136	26.30	.064	.210
May 28, 1975	N	N	.108	N	N	.061

Table IV-12 (cont.)

Station 3

Cruise	Carbon Required $pgm/m^3 x 10^8$	Proportion of Total Carbon	Proportion of Herbivore Population
June 20, 1974	342.1	.031	.773
July 19, 1974	53.02	.052	.340
Aug. 1, 1974	660.7	.130	.931
Aug. 21, 1974	1.116	.000	.366
Sept. 17, 1974	101.1	.391	.651
Oct. 15, 1974	87.80	.013	.208
Oct. 30, 1974	359.7	.018	.465
Nov. 14, 1974	49.56	.327	.240
Dec. 13, 1974	140.9	.164	.768
Jan. 16, 1975	9.896	.002	.451
Feb. 20, 1975	-	-	-
March 18, 1975	292.4	.013	.535
April 14, 1975	-	-	-
May 9, 1975	7.580	.017	.058
May 28, 1975	N	N	.101

N = negligible

Table IV-13

Net production, based on assimilation numbers calculated
for the mouth of the Patuxent River
(Stross and Stottlemyer, 1965) (Station II)

Month	Assimilation Number (mg C hr^{-1} mg Chl a^{-1})	Chl a (mg m^{-3})	Net Production (mg C hr^{-1} m^{-3})	Carbon Required by *A. tonsa* and *P. minutus*[2] (mg C hr^{-1} m^{-3})
Jan.	2.35	-	-	.0519
Feb.	(1.595)[1]	5.5	(8.77)	.230[3]
March	2.335	16.7	38.99	1.119
April	(2.925)	8.4	(24.58)	.168
May	4.37, (4.50)	7.77	33.95, (22.88)	.219
June	4.105	8.45	34.69	1.035[3]
July	3.77	15.4	58.06	1.02[3]
Aug.	5.21	17.4	90.65	1.485[3] - .0739[3]
Sept.	2.725	5.0	13.63	.243
Oct.	2.89	13.1	37.86	.199 - 6.156[3]
Nov.	-	2.5	-	1.166
Dec.	1.755	6.5	11.41	1.002[3]

[1] values in parentheses are strictly from this study

[2] value from Table IV-12 divided by 12

[3] months when *A. tonsa* and *P. minutus* comprise >50% of herbivores

Table IV-14

Daily phytoplankton requirements of dominant herbivores
(based on Petipa, et al., 1970)

Species	Percentage of Body Weight Required	Months of Dominance
Acartia	100-140%	June-Feb.
Pseudocalanus	198%	June, Oct., Jan.-May
Paracalanus	45%	Oct.-Nov., March, May
Oithona	140%	Jan., May
copepodites	100-140%	July-Aug., Feb.-April
Oikopleura	60- 70%	July, Oct.
mollusk larvae	2- 30%	Oct.-Jan.
polychaete larvae	2- 30%	Aug., Oct.

Table IV-15

Zooplankton numbers and nutrient concentrations averaged over all depths

Station 1 Date (Cruise No.)	Zooplankton ($no./m^3$)	Nutrients (ug-at/l) NH_3	$NO_3 + NO_2$	Ortho-PO_4
20 June 1974 (5)	17924	2.8	.8	.27
19 July 1974 (6)	10394	7.1	2.6	.70
1 Aug. 1974 (7)	1512	3.1	4.3	1.06
21 Aug. 1974 (8)	967	1.8	11.1	1.06
17 Sept. 1974 (9)	2785	5.0	11.5	1.54
15 Oct. 1974 (10)	1771	1.1	6.9	.50
30 Oct. 1974 (11)	19689	2.1	3.6	.37
14 Nov. 1974 (12)	3632	2.2	4.9	.98
13 Dec. 1974 (13)	6759	2.7	15.7	.69
16 Jan. 1975 (14)	1206	3.0	23.4	.52
20 Feb. 1975 (15)	-	-	-	-
18 March 1975 (16)	5308	.01	7.9	.01
14 April 1975 (17)	-	-	-	-
9 May 1975 (18)	8129	.01	1.4	.07
28 May 1975 (19)	8343	1.5	3.1	.18

Table IV-15 (cont.)

Station 2 Date (Cruise No.)	Zooplankton (no./m^3)	Nutrients (ug-at/l) NH_3	NO_3+ NO_2	Ortho- -PO_4
20 June 1974 (5)	2339	2.7	0.2	.21
19 July 1974 (6)	1817	8.0	2.6	.80
1 Aug. 1974 (7)	2377	2.3	7.4	1.10
21 Aug. 1974 (8)	160	0.8	8.1	.68
17 Sept. 1974 (9)	850	5.4	11.9	1.52
15 Oct. 1974 (10)	1829	1.2	8.0	.52
30 Oct. 1974 (11)	7677	1.0	2.6	.27
14 Nov. 1974 (12)	2211	2.2	0.1	.93
13 Dec. 1974 (13)	5426	2.7	12.9	.63
16 Jan. 1975 (14)	1348	2.9	21.8	.53
20 Feb. 1975 (15)	1879	6.0	10.8	.41
18 March 1975 (16)	4799	.01	8.6	.01
14 April 1975 (17)	3569	0.7	9.9	.06
9 May 1975 (18)	6914	.01	1.2	.04
28 May 1975 (19)	521	1.9	5.1	.18

Table IV-15 (cont.)

Station 3 Date (Cruise No.)	Zooplankton (no./m^3)	Nutrients (ug-at/l) NH_3	NO_3+ NO_2	Ortho- -PO_4
20 June 1974 (5)	5162	1.6	0.2	.20
19 July 1974 (6)	1616	8.1	2.6	.82
1 Aug. 1974 (7)	7556	3.0	5.2	1.26
21 Aug. 1974 (8)	-	1.6	8.6	.87
17 Sept. 1974 (9)	1768	5.1	11.1	1.61
15 Oct. 1974 (10)	4167	1.2	11.8	.48
30 Oct. 1974 (11)	6468	1.0	3.6	.28
14 Nov. 1974 (12)	1608	2.4	5.7	.92
13 Dec. 1974 (13)	6251	2.7	13.6	.58
16 Jan. 1975 (14)	1002	3.6	22.7	.56
20 Feb. 1975 (15)	-	-	-	-
18 March 1975 (16)	8999	.01	9.7	.01
14 April 1975 (17)	-	-	-	-
9 May 1975 (18)	10418	.01	1.2	.03
28 May 1975 (19)	1159	1.6	2.7	.18

Table IV-16

Zooplankton and nutrients
(Zooplankton numbers to log e)

	NH_3	NO_3^-+ NO_2	Ortho $-PO_4$	Degrees of Freedom
Station 1				
Zooplankton	.051	-.584*	-.490(*)	11
Station 2				
Zooplankton	-.192	-.207	-.368	13
Station 3				
Zooplankton	-.580*	-.302	-.353	10

* significant at 0.05 level
(*) significant at 0.10 level

FIGURE CAPTIONS FOR CHAPTER IV

Figure IV- 1: Changes in whole water phytoplankton numbers versus nutrient concentrations at Station 1.

Figure IV- 2: Changes in whole water phytoplankton numbers versus nutrient concentrations at Station 2.

Figure IV- 3: Changes in whole water phytoplankton numbers versus nutrient concentrations at Station 3.

Figure IV- 4: Changes in diatom numbers versus nutrient concentrations at Station 1.

Figure IV- 5: Changes in diatom numbers versus nutrient concentrations at Station 2.

Figure IV- 6: Changes in diatom numbers versus nutrient concentrations at Station 3.

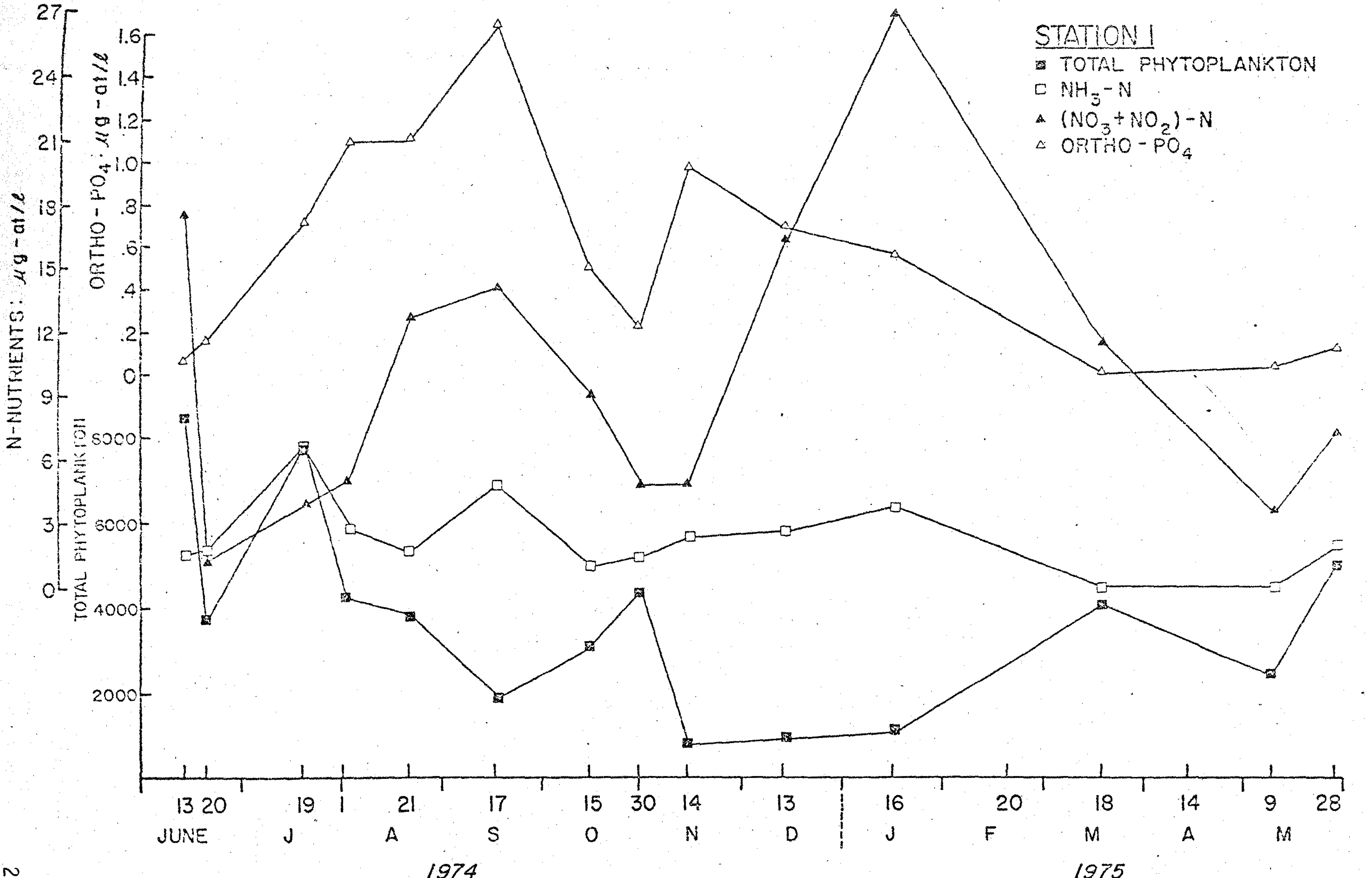
Figure IV- 7: Changes in micro-flagellate numbers versus nutrient concentrations at Station 1.

Figure IV- 8: Changes in micro-flagellate numbers versus nutrient concentrations at Station 2.

Figure IV- 9: Changes in micro-flagellate numbers versus nutrient concentrations at Station 3.

Figure IV-10: Changes in dinoflagellate numbers versus nutrient concentrations at Station 1.

Figure IV-11: Changes in dinoflagellate numbers versus nutrient concentrations at Station 2.


STATION I
TOTAL PHYTOPLANKTON
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
N-NUTRIENTS: µg-at/ℓ
ORTHO-PO_4: µg-at/ℓ
TOTAL PHYTOPLANKTON
27
24
21
18
15
12
9
6
3
0
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
8000
6000
4000
2000
13 20
19
1
21
17
15
30
14
13
16
20
18
14
9
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1974
1975
SAMPLING DATE

Figure IV-1

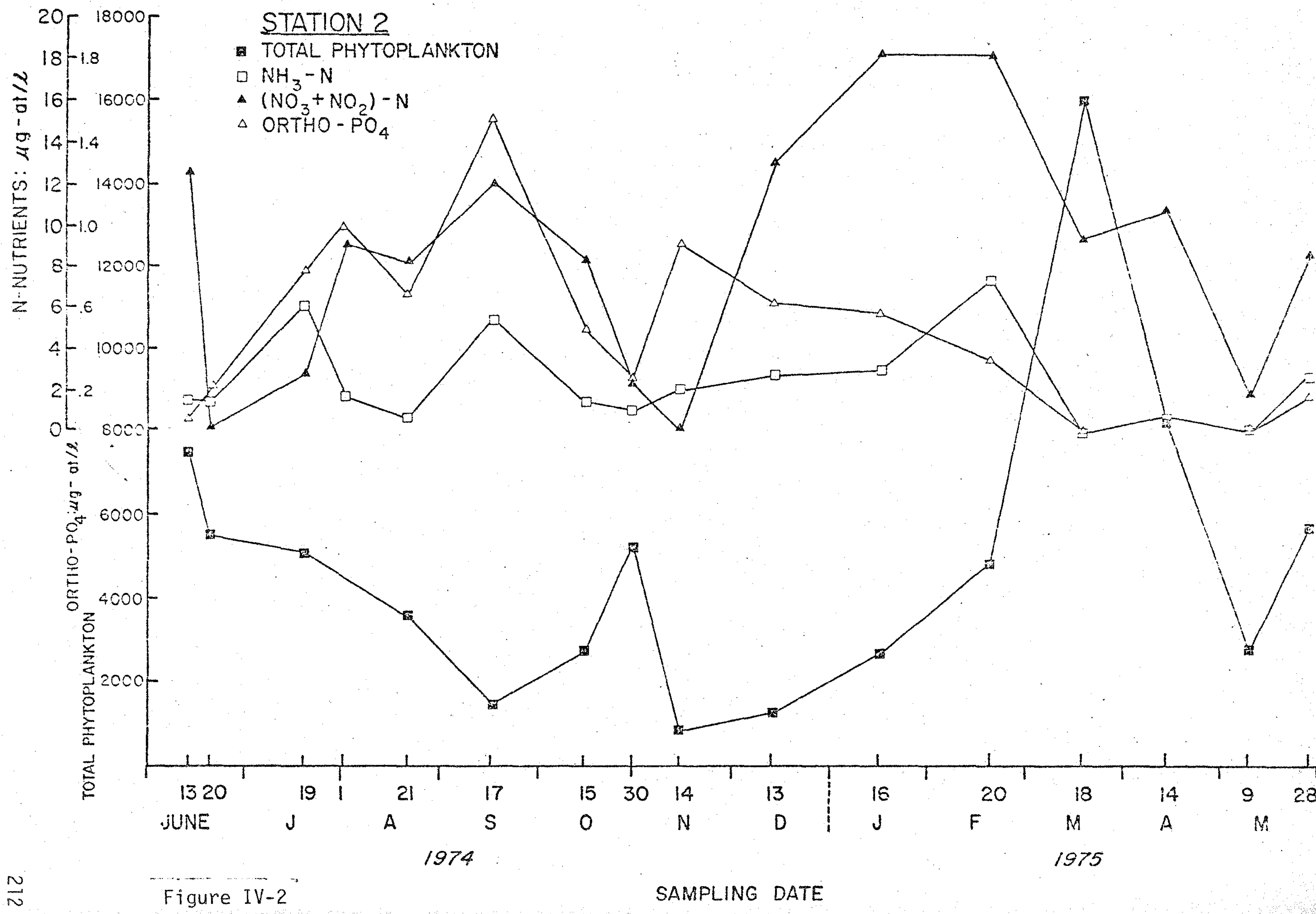

STATION 2
TOTAL PHYTOPLANKTON
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
N-NUTRIENTS: μg-at/ℓ
ORTHO-PO_4 μg-at/ℓ
TOTAL PHYTOPLANKTON
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-2

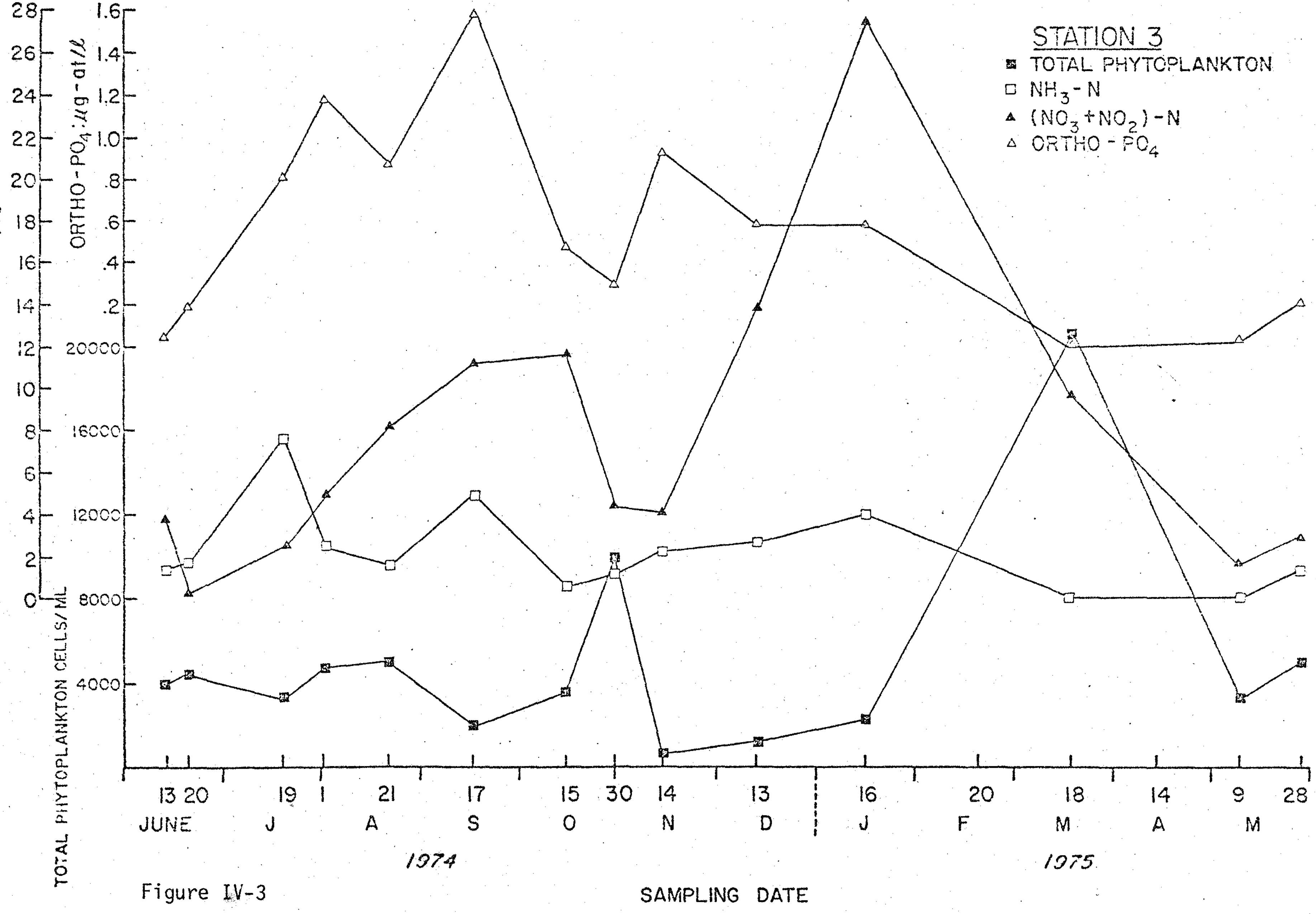
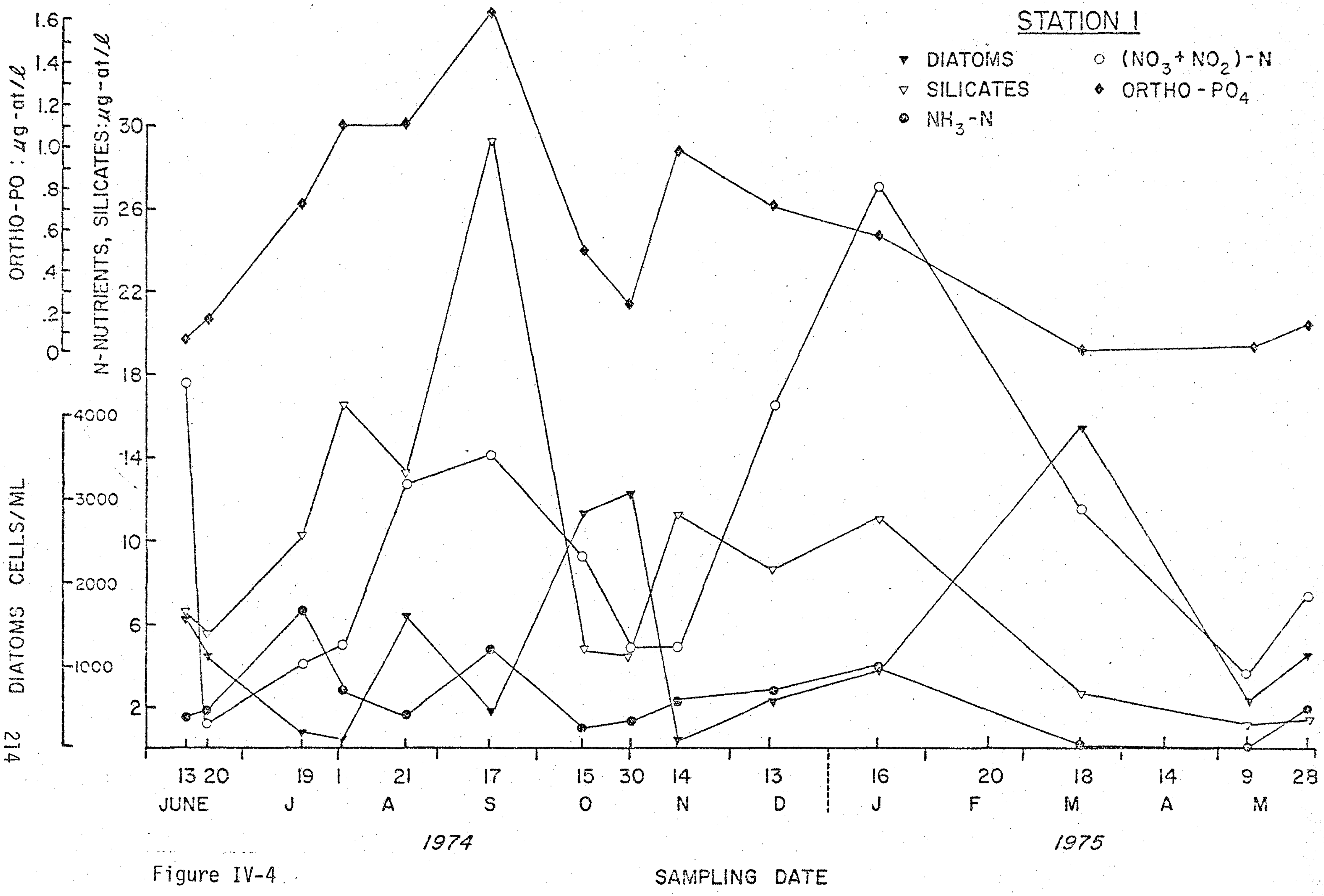

STATION 3
TOTAL PHYTOPLANKTON
NH3 - N
(NO3 + NO2) - N
ORTHO - PO4
N - NUTRIENTS: μg - at/ℓ
ORTHO - PO4: μg - at/ℓ
TOTAL PHYTOPLANKTON CELLS/ML
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1.6
1.4
1.2
1.0
.8
.6
.4
.2
20000
16000
12000
8000
4000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-3



STATION I
DIATOMS
SILICATES
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
ORTHO-PO : µg-at/ℓ
N-NUTRIENTS, SILICATES: µg-at/ℓ
DIATOMS CELLS/ML
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
2
6
10
14
18
22
26
30
1000
2000
3000
4000
13 20
19 1
21
17
15 30
14
13
16
20
18
14
9
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JUNE
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1974
1975
SAMPLING DATE

Figure IV-4

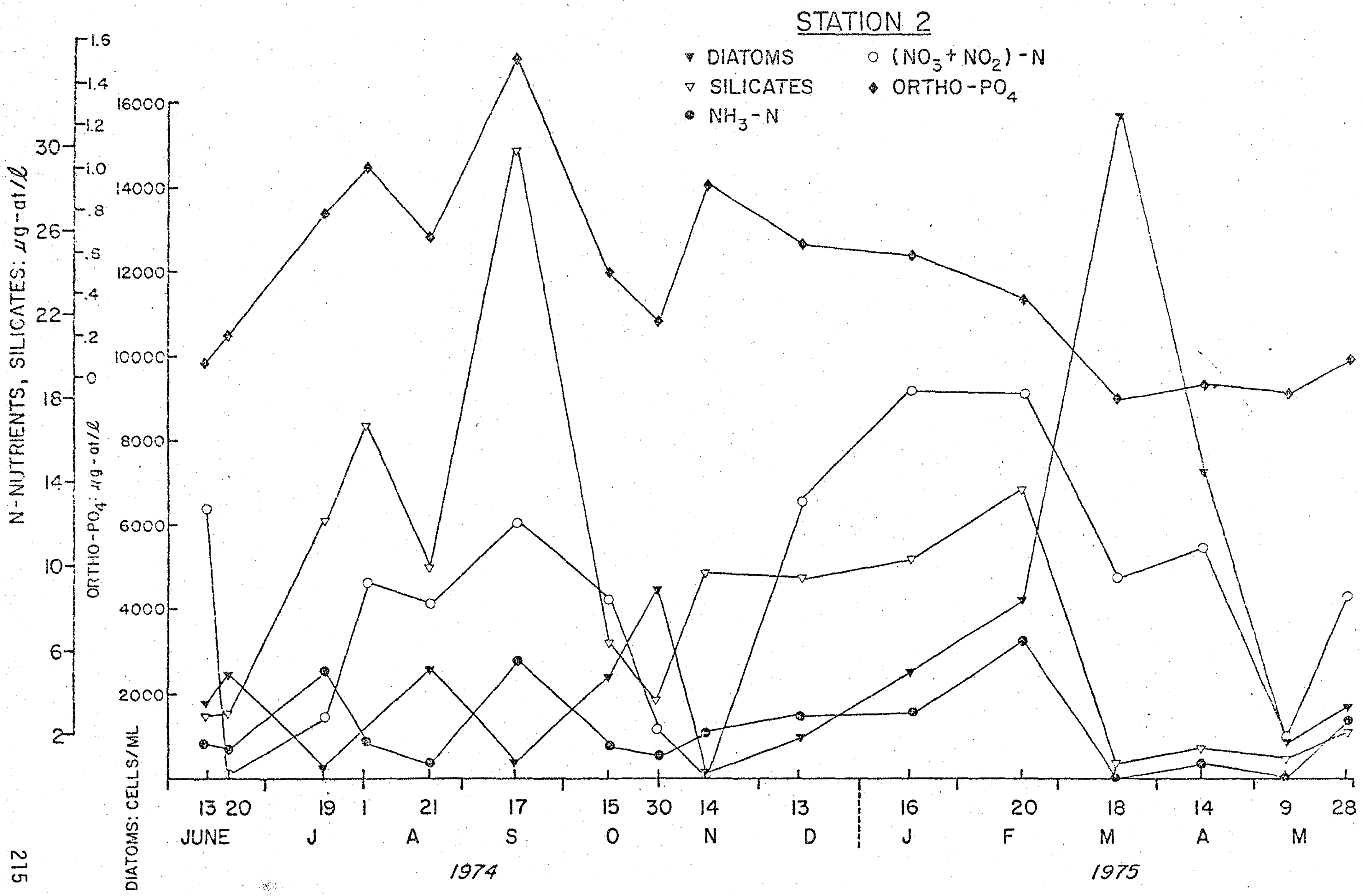

STATION 2
DIATOMS
SILICATES
NH_3-N
$(NO_3 + NO_2)$-N
ORTHO-PO_4
N-NUTRIENTS, SILICATES: μg-at/ℓ
ORTHO-PO_4: μg-at/ℓ
DIATOMS: CELLS/ML
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-5

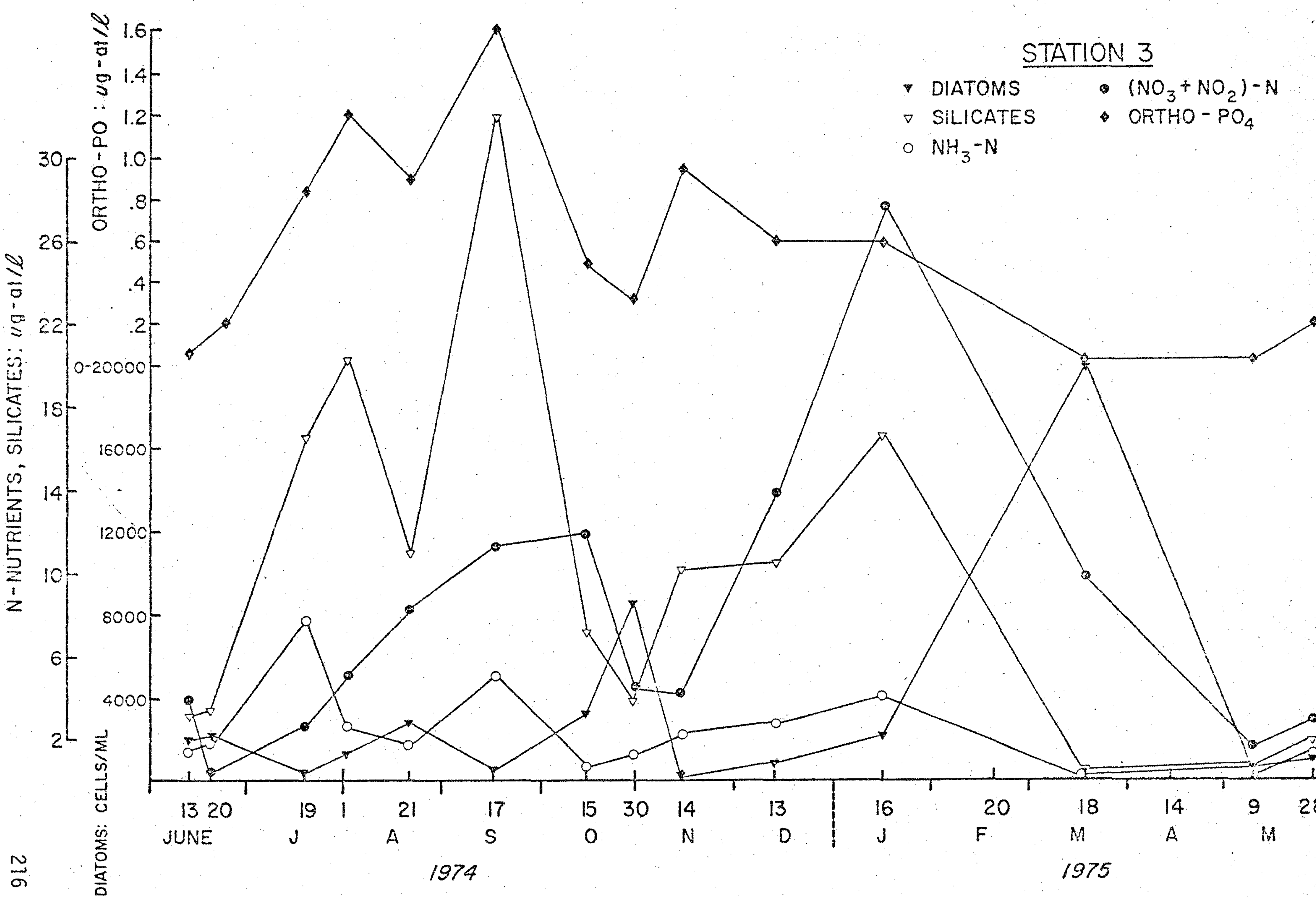

STATION 3
DIATOMS
SILICATES
NH3-N
(NO3+NO2)-N
ORTHO-PO4
ORTHO-PO: ug-at/ℓ
N-NUTRIENTS, SILICATES: ug-at/ℓ
DIATOMS: CELLS/ML
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0-20000
16000
12000
8000
4000
30
26
22
18
14
10
6
2
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-6

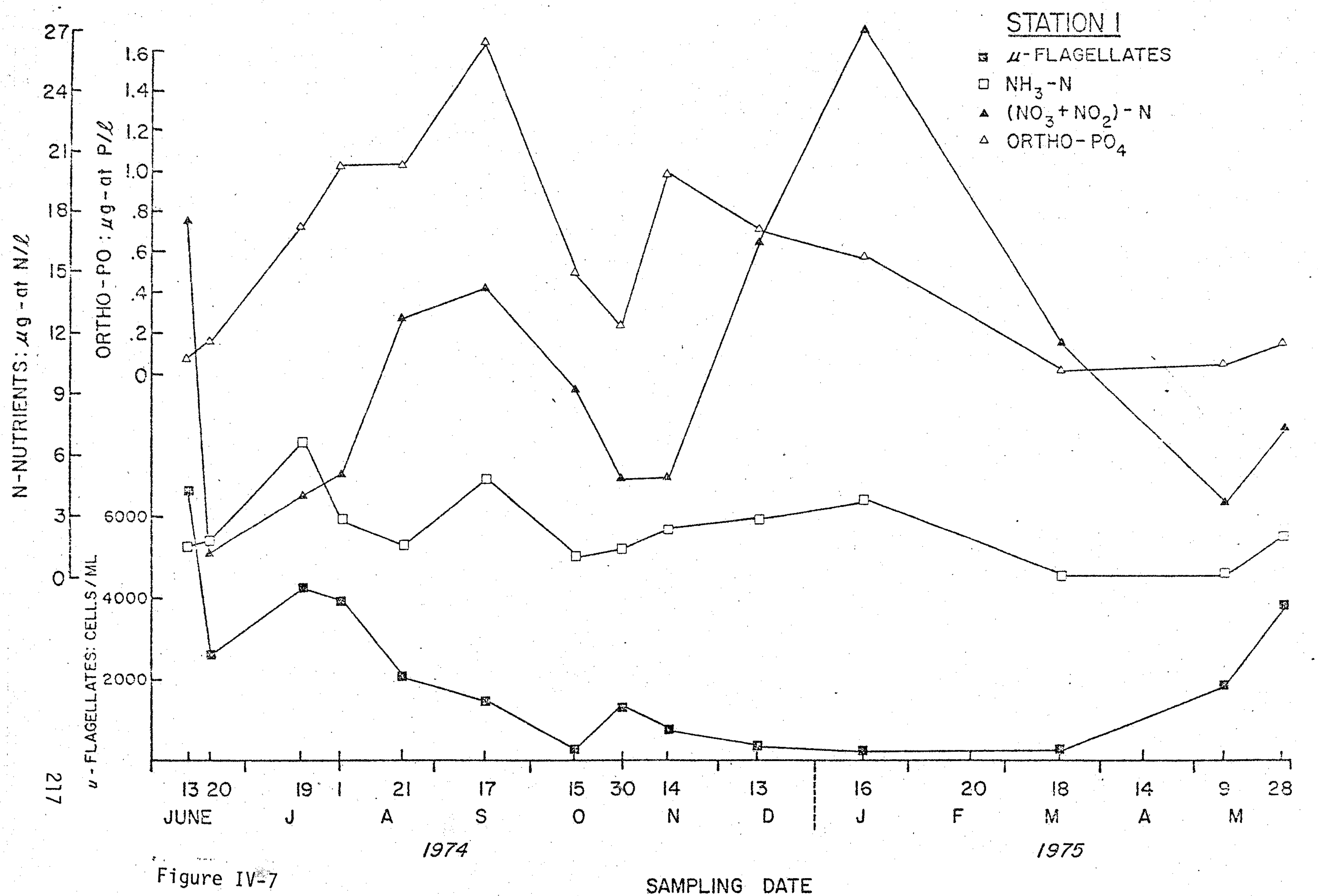

STATION I
μ-FLAGELLATES
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
N-NUTRIENTS: μg-at N/ℓ
ORTHO-PO: μg-at P/ℓ
μ-FLAGELLATES: CELLS/ML
27
24
21
18
15
12
9
6
3
0
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
6000
4000
2000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-7

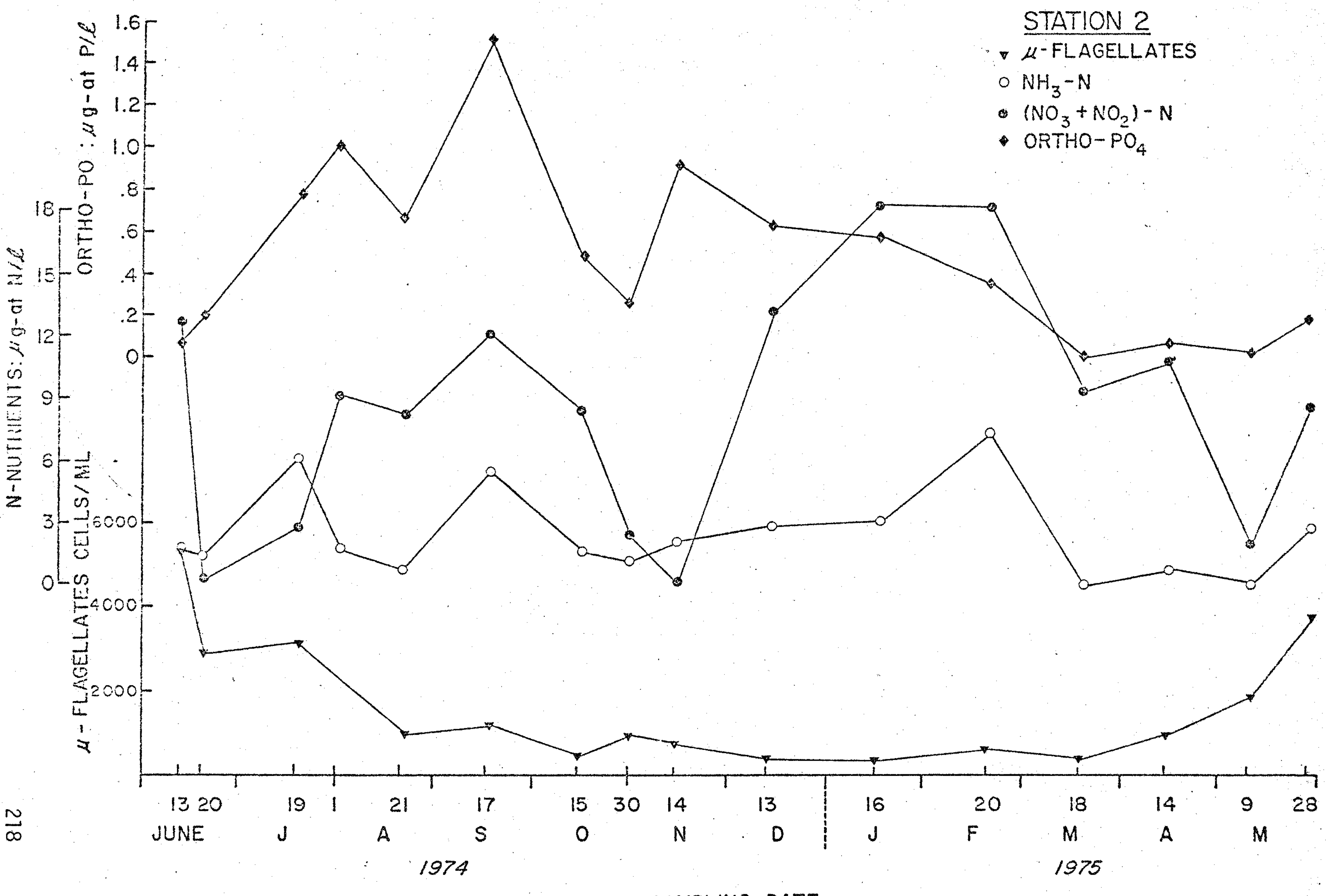

STATION 2
μ-FLAGELLATES
NH3-N
(NO3 + NO2) - N
ORTHO-PO4
ORTHO-PO : μg-at P/ℓ
N-NUTRIENTS: μg-at N/ℓ
μ - FLAGELLATES CELLS/ML
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
18
15
12
9
6
3
0
6000
4000
2000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-8

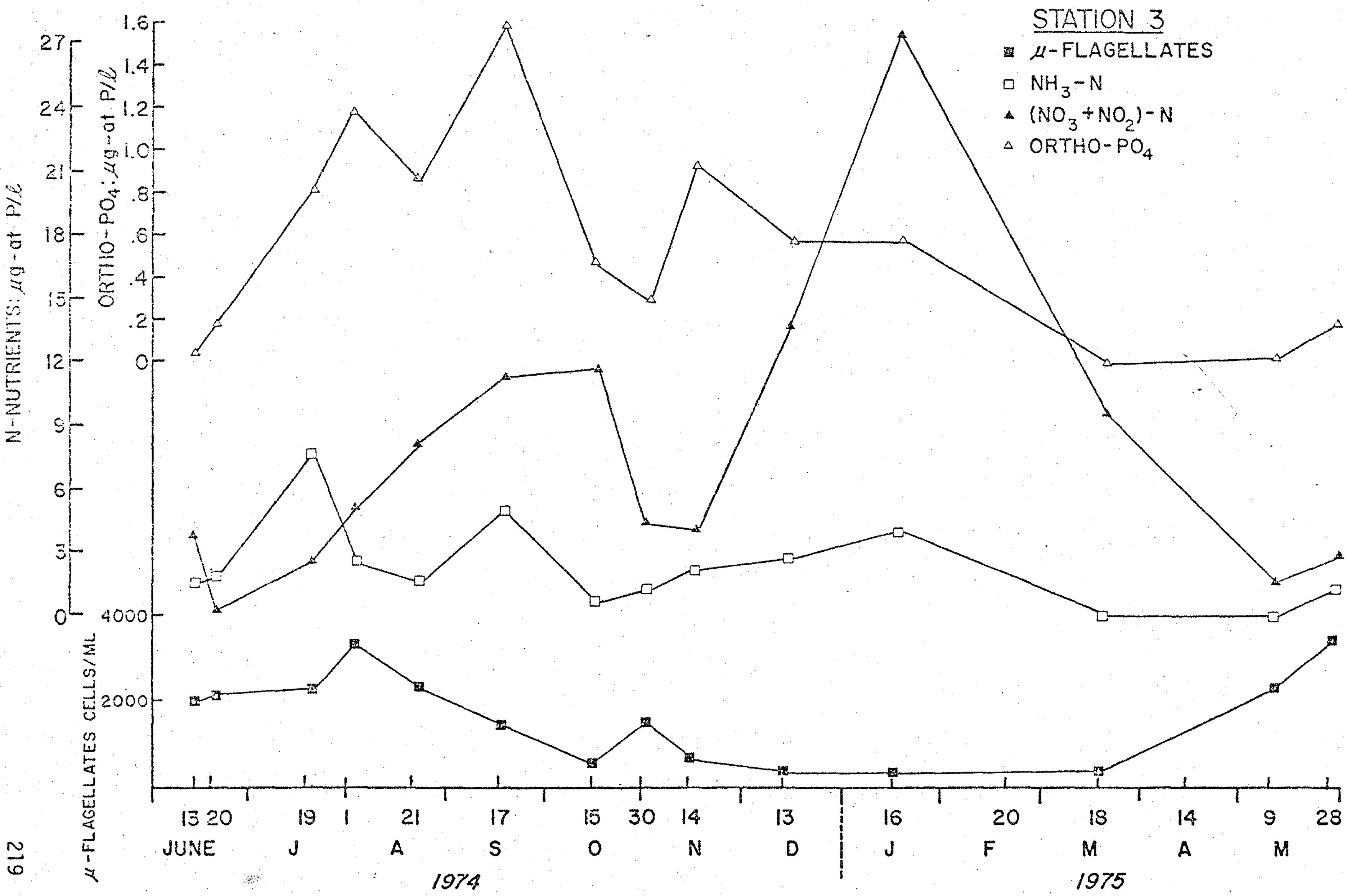

STATION 3
µ-FLAGELLATES
NH3-N
(NO3+NO2)-N
ORTHO-PO4
N-NUTRIENTS: µg-at P/ℓ
ORTHO-PO4: µg-at P/ℓ
µ-FLAGELLATES CELLS/ML
27
24
21
18
15
12
9
6
3
0
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
4000
2000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-9

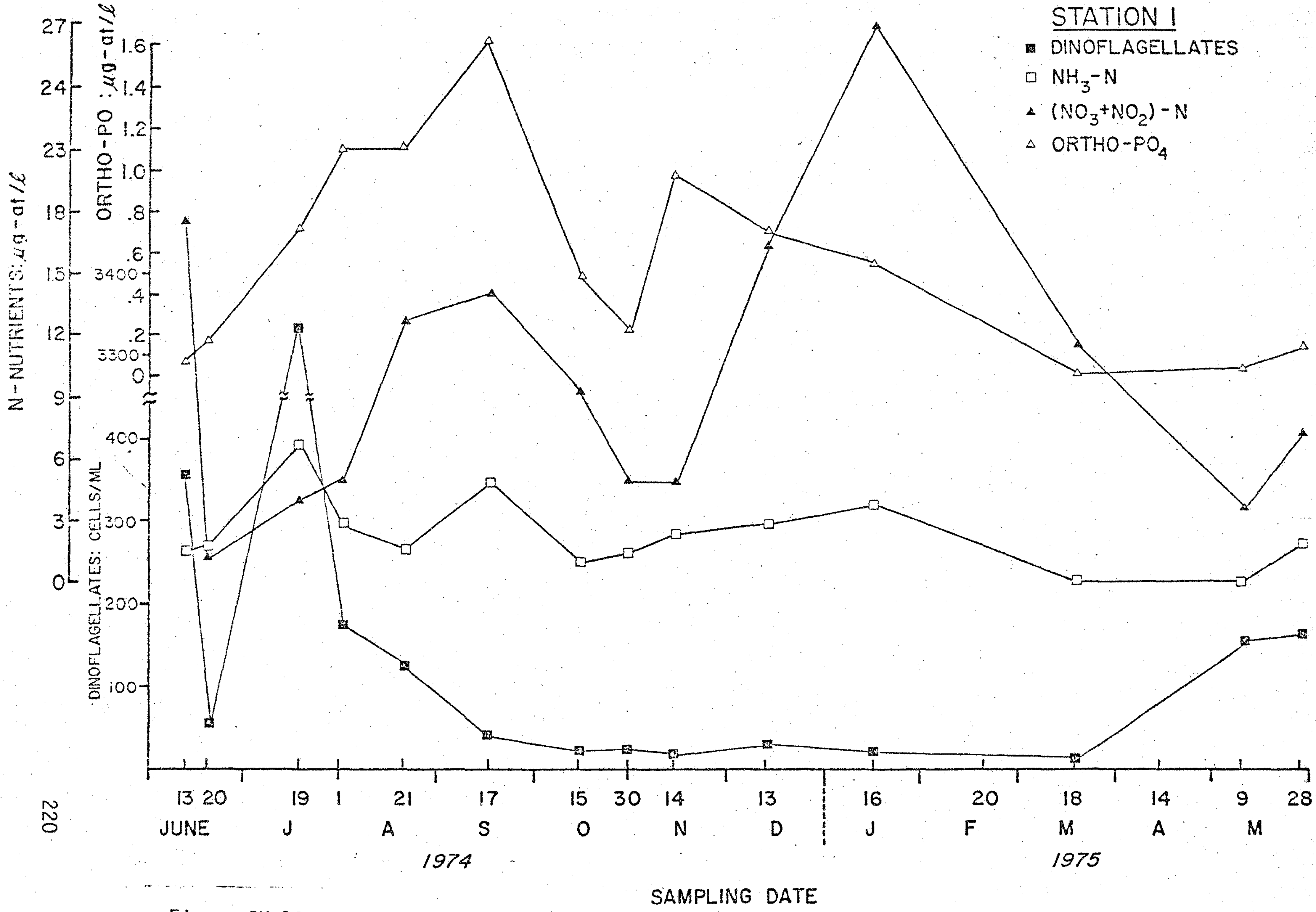

STATION I
DINOFLAGELLATES
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
N-NUTRIENTS: µg-at/ℓ
ORTHO-PO: µg-at/ℓ
DINOFLAGELLATES: CELLS/ML
27
24
23
18
15
12
9
6
3
0
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
3400
3300
400
300
200
100
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-10

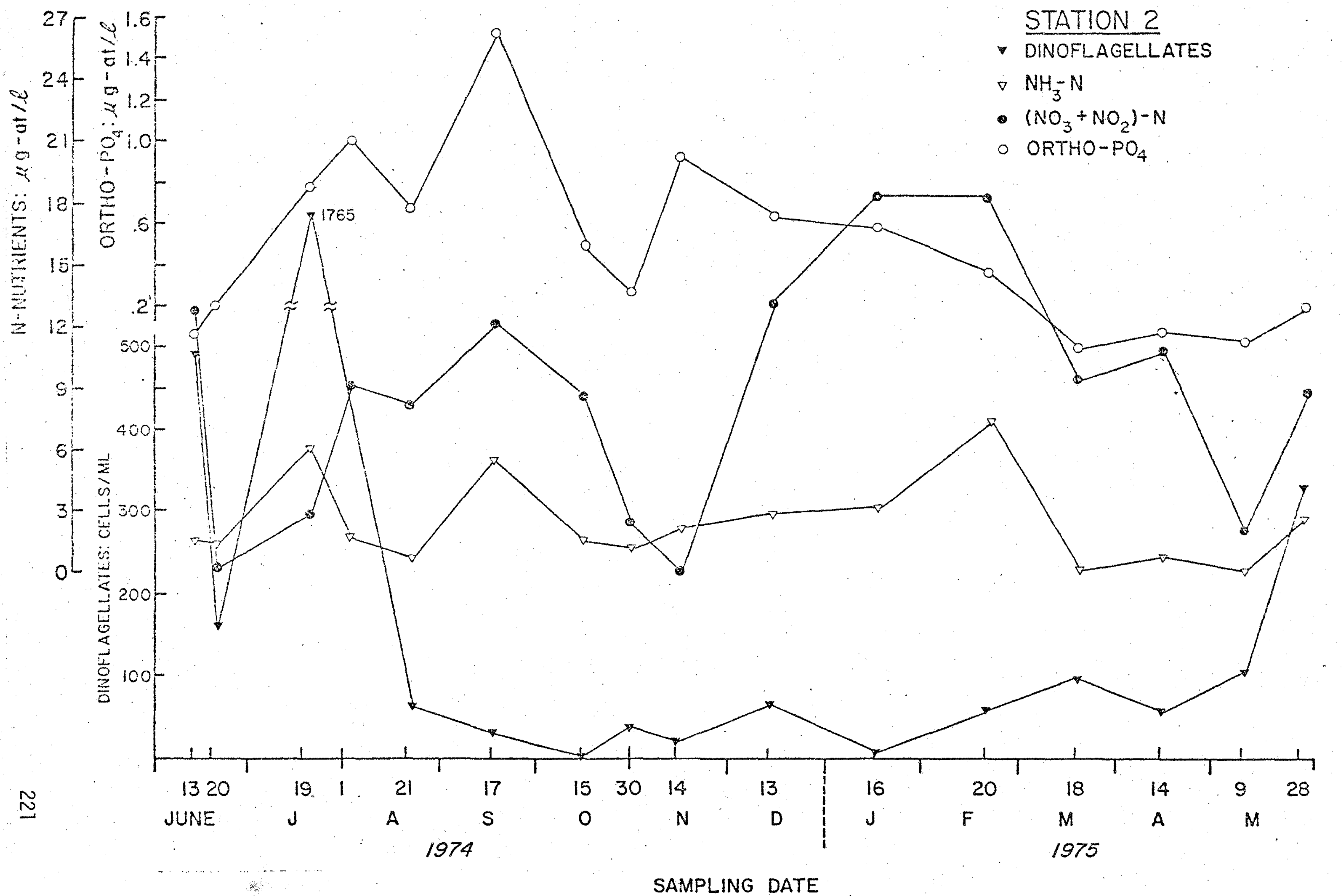
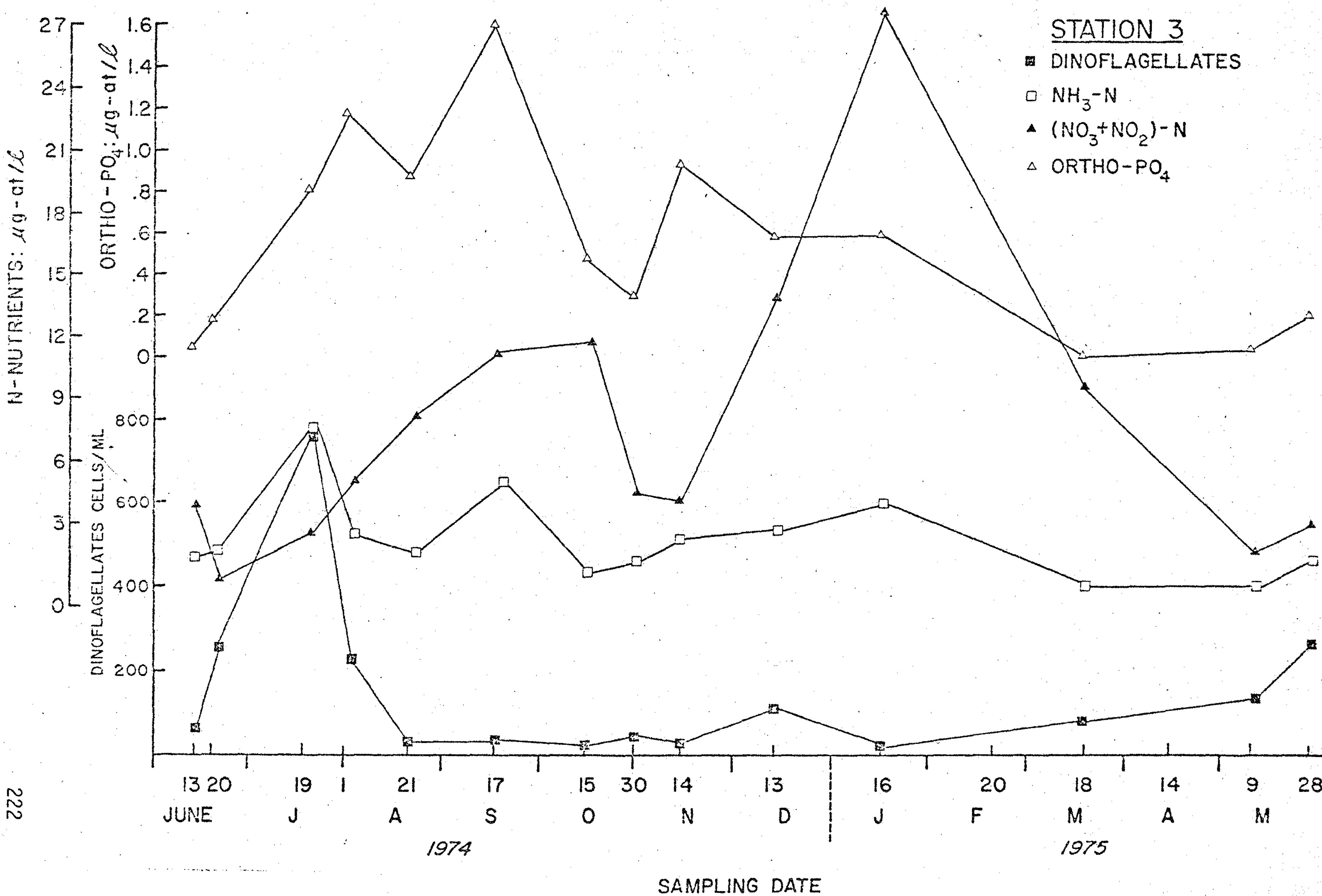
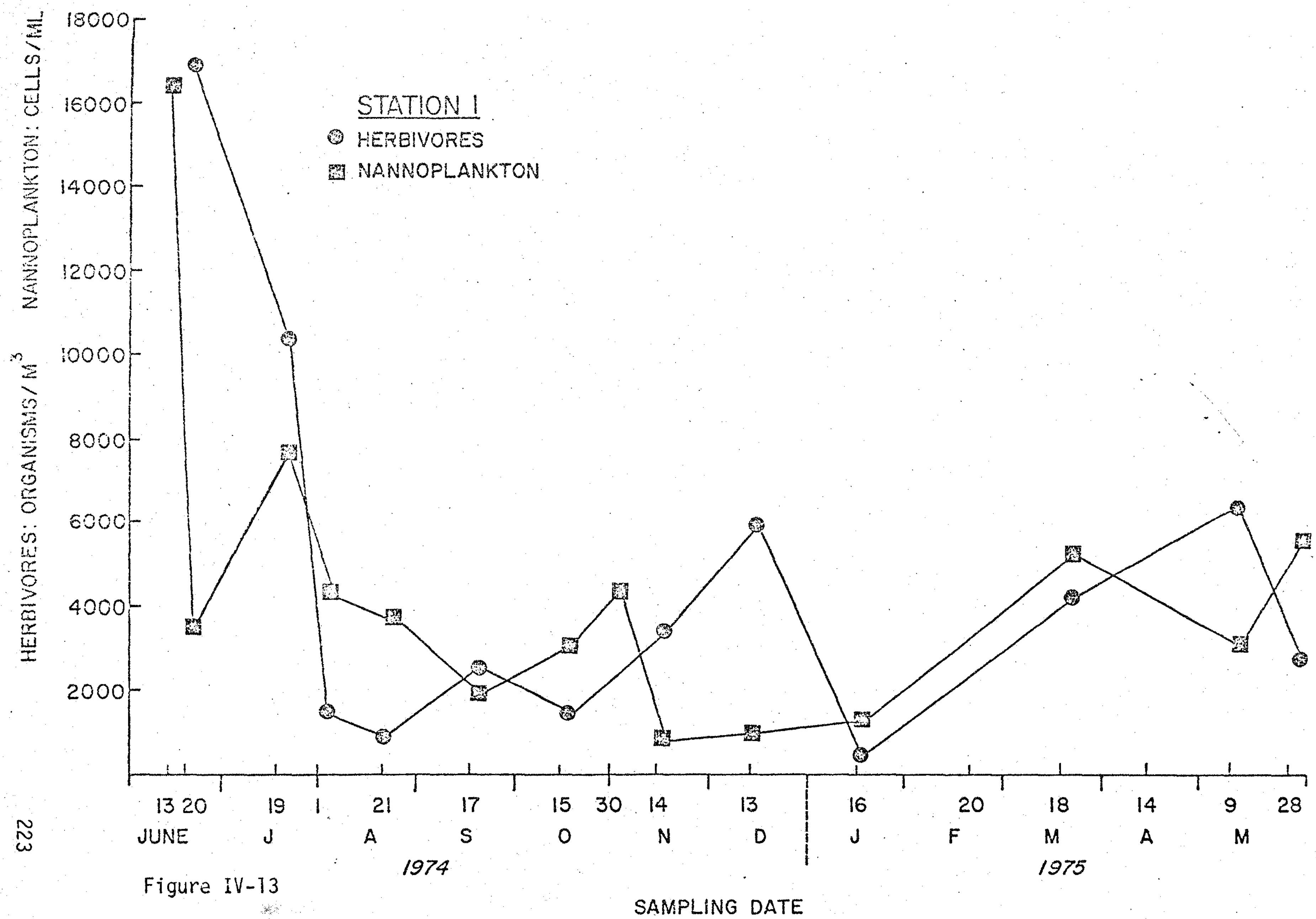

STATION 2
DINOFLAGELLATES
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
N-NUTRIENTS: μg-at/ℓ
ORTHO-PO_4: μg-at/ℓ
DINOFLAGELLATES: CELLS/ML
1765
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-11



STATION 3
DINOFLAGELLATES
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
N-NUTRIENTS: μg-at/ℓ
ORTHO-PO_4; μg-at/ℓ
DINOFLAGELLATES CELLS/ML
27
24
21
18
15
12
9
6
3
0
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
800
600
400
200
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-12



STATION I
HERBIVORES
NANNOPLANKTON
NANNOPLANKTON: CELLS/ML
HERBIVORES: ORGANISMS/ M^3
18000
16000
14000
12000
10000
8000
6000
4000
2000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-13

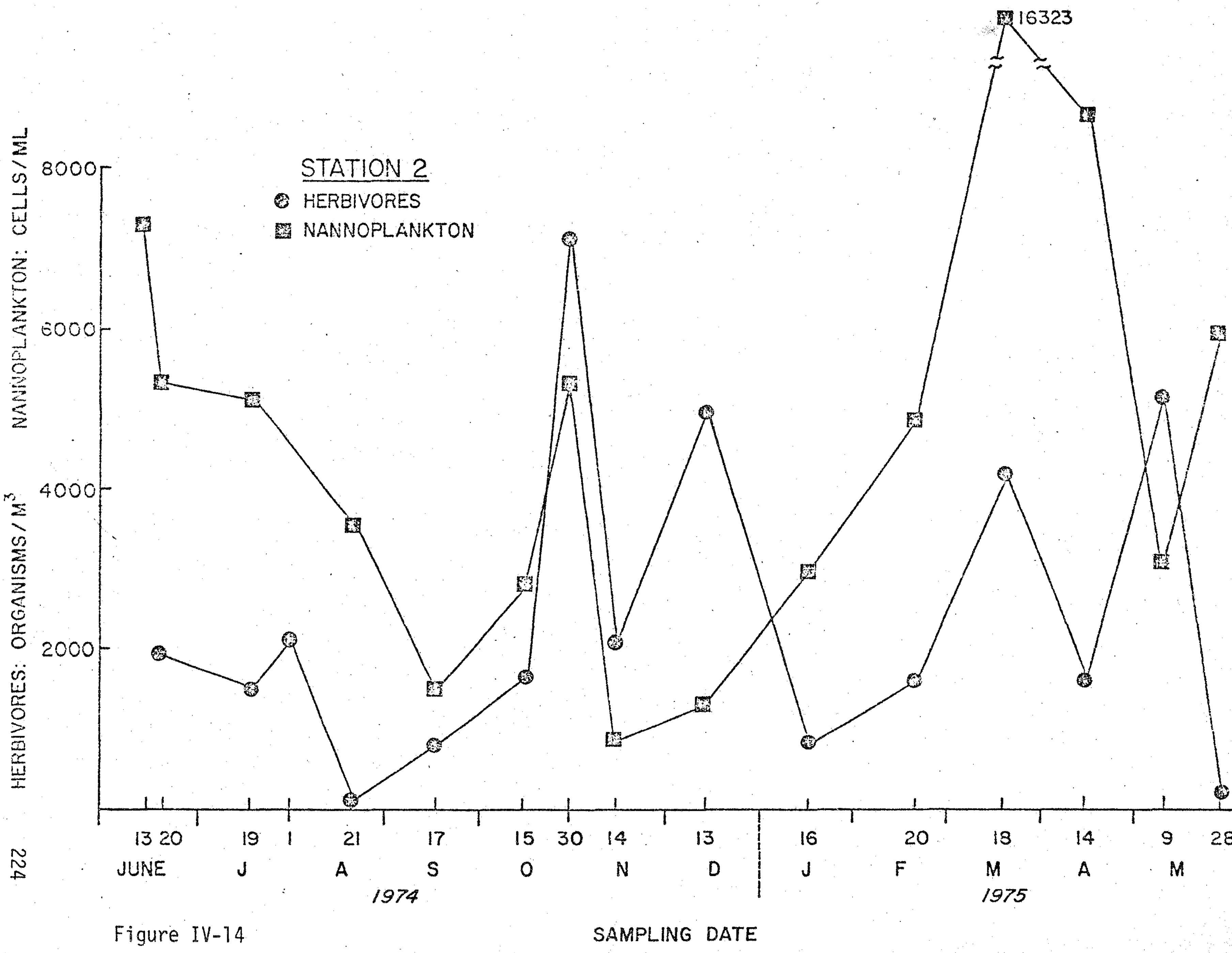
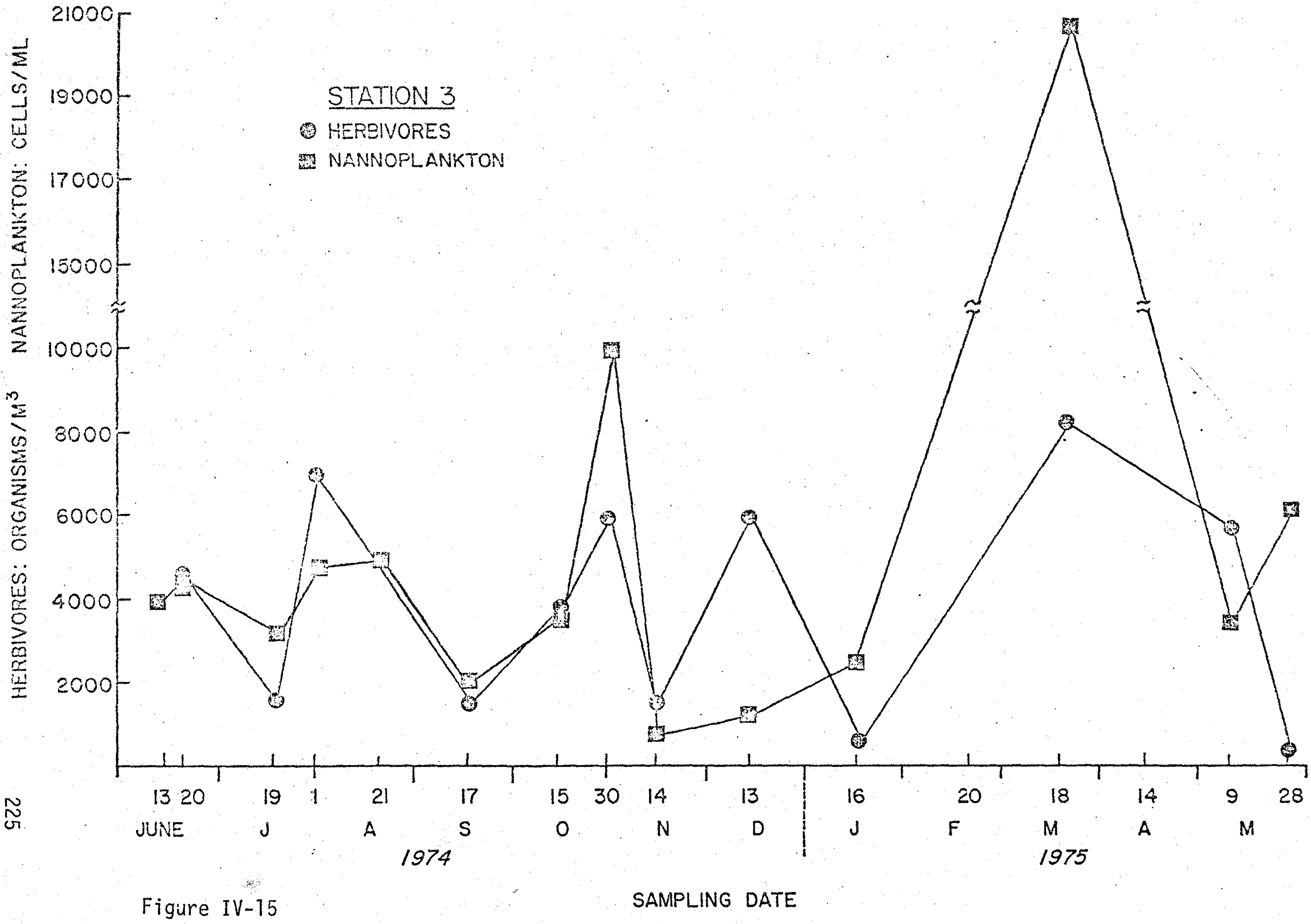

STATION 2
HERBIVORES
NANNOPLANKTON
16323
NANNOPLANKTON: CELLS/ML
HERBIVORES: ORGANISMS/M3
8000
6000
4000
2000
13 20
19
1
21
17
15
30
14
13
16
20
18
14
9
28
JUNE
J
A
S
O
N
D
J
F
M
A
M
1974
1975
SAMPLING DATE

Figure IV-14



STATION 3
HERBIVORES
NANNOPLANKTON
NANNOPLANKTON: CELLS/ML
HERBIVORES: ORGANISMS/M^3
21000
19000
17000
15000
10000
8000
6000
4000
2000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-15

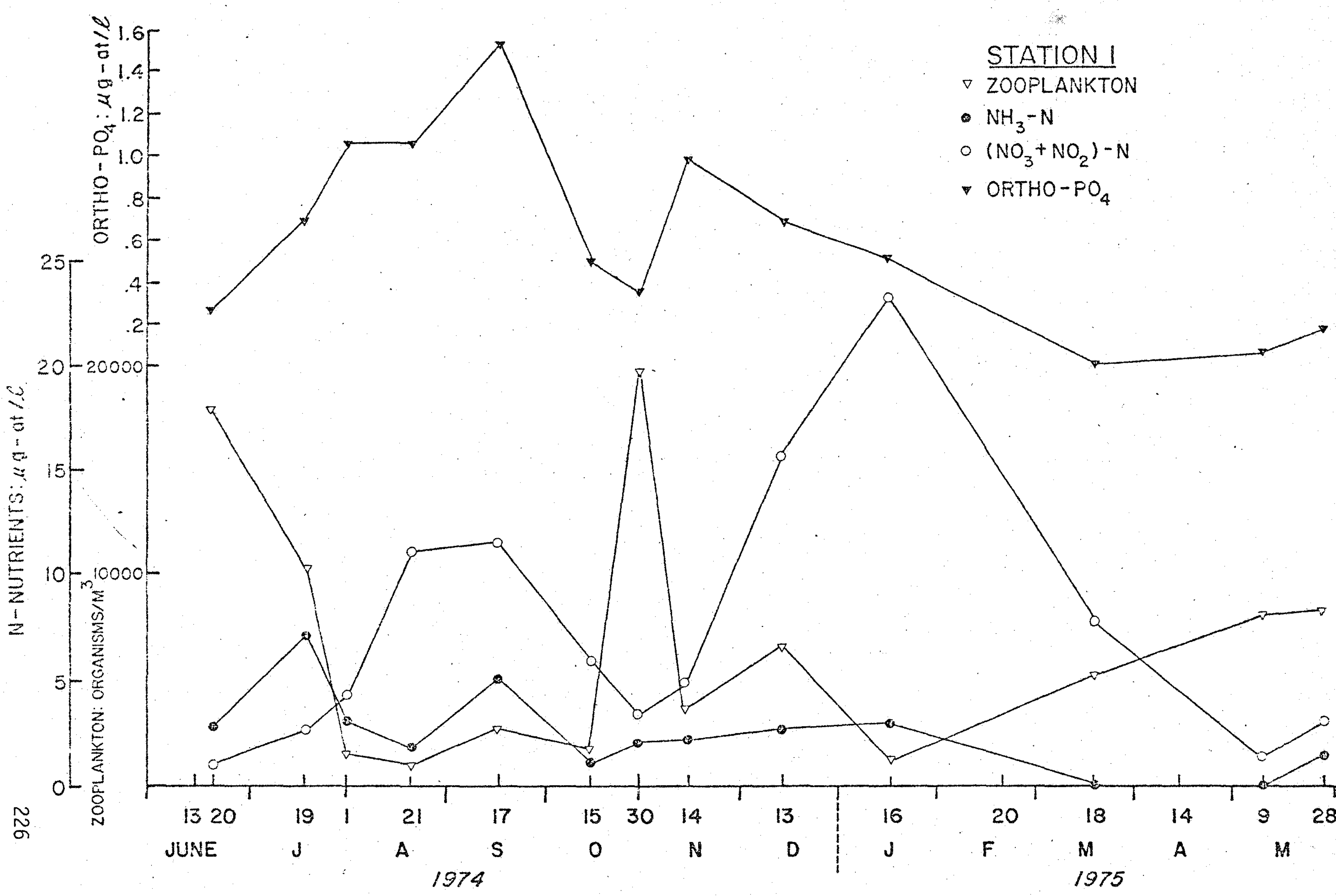

STATION I
ZOOPLANKTON
NH3-N
(NO3+NO2)-N
ORTHO-PO4
ORTHO-PO4: µg-at/ℓ
1.6
1.4
1.2
1.0
.8
.6
.4
.2
N-NUTRIENTS: µg-at/ℓ
25
20
15
10
5
0
ZOOPLANKTON: ORGANISMS/M3
20000
10000
13 20
19
1
21
17
15
30
14
13
16
20
18
14
9
28
JUNE
J
A
S
O
N
D
J
F
M
A
M
1974
1975
SAMPLING DATE

Figure IV-16

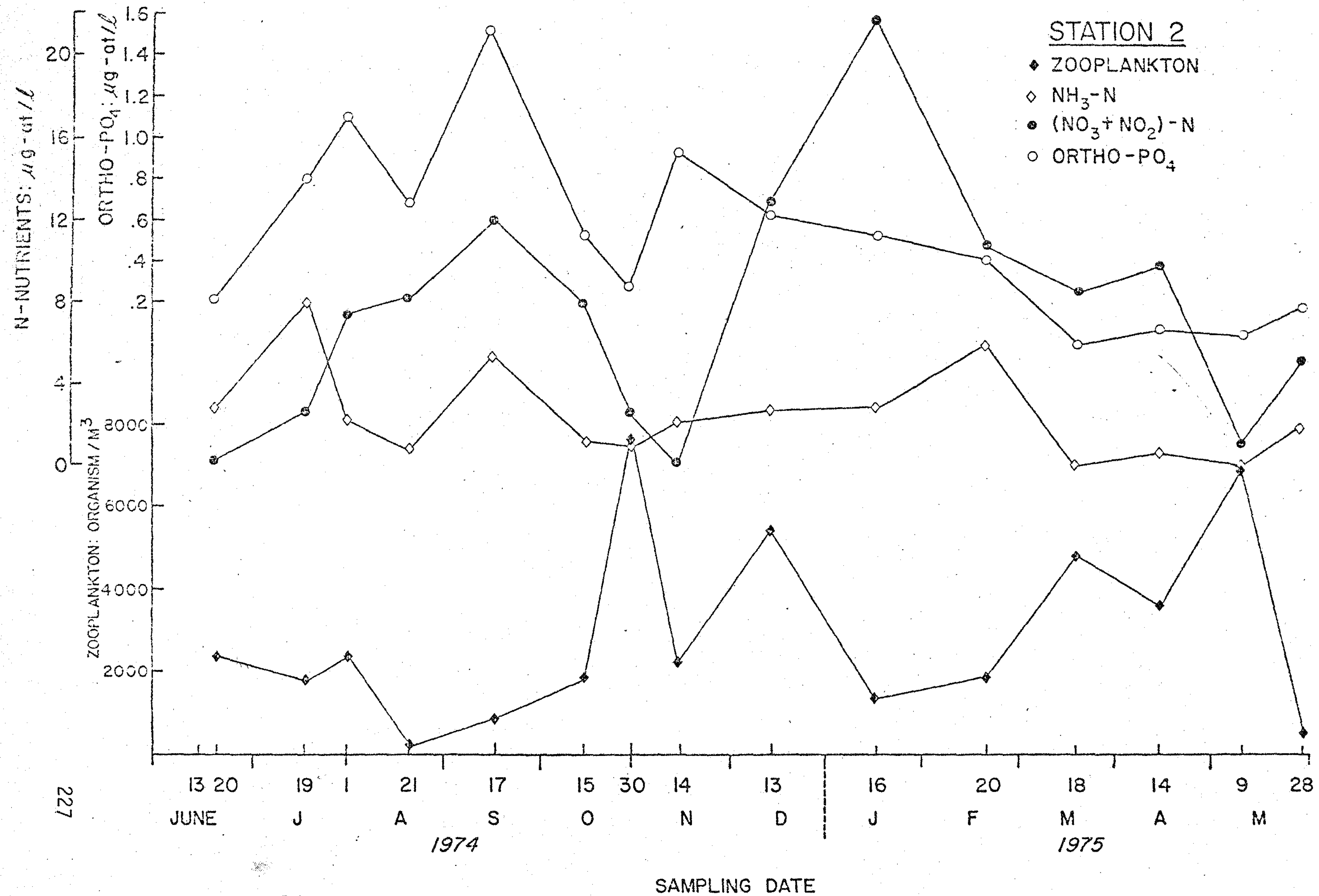

STATION 2
ZOOPLANKTON
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
N-NUTRIENTS: μg-at/ℓ
ORTHO-PO_4: μg-at/ℓ
ZOOPLANKTON: ORGANISM/M^3
0
4
8
12
16
20
.2
.4
.6
.8
1.0
1.2
1.4
1.6
2000
4000
6000
8000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-17

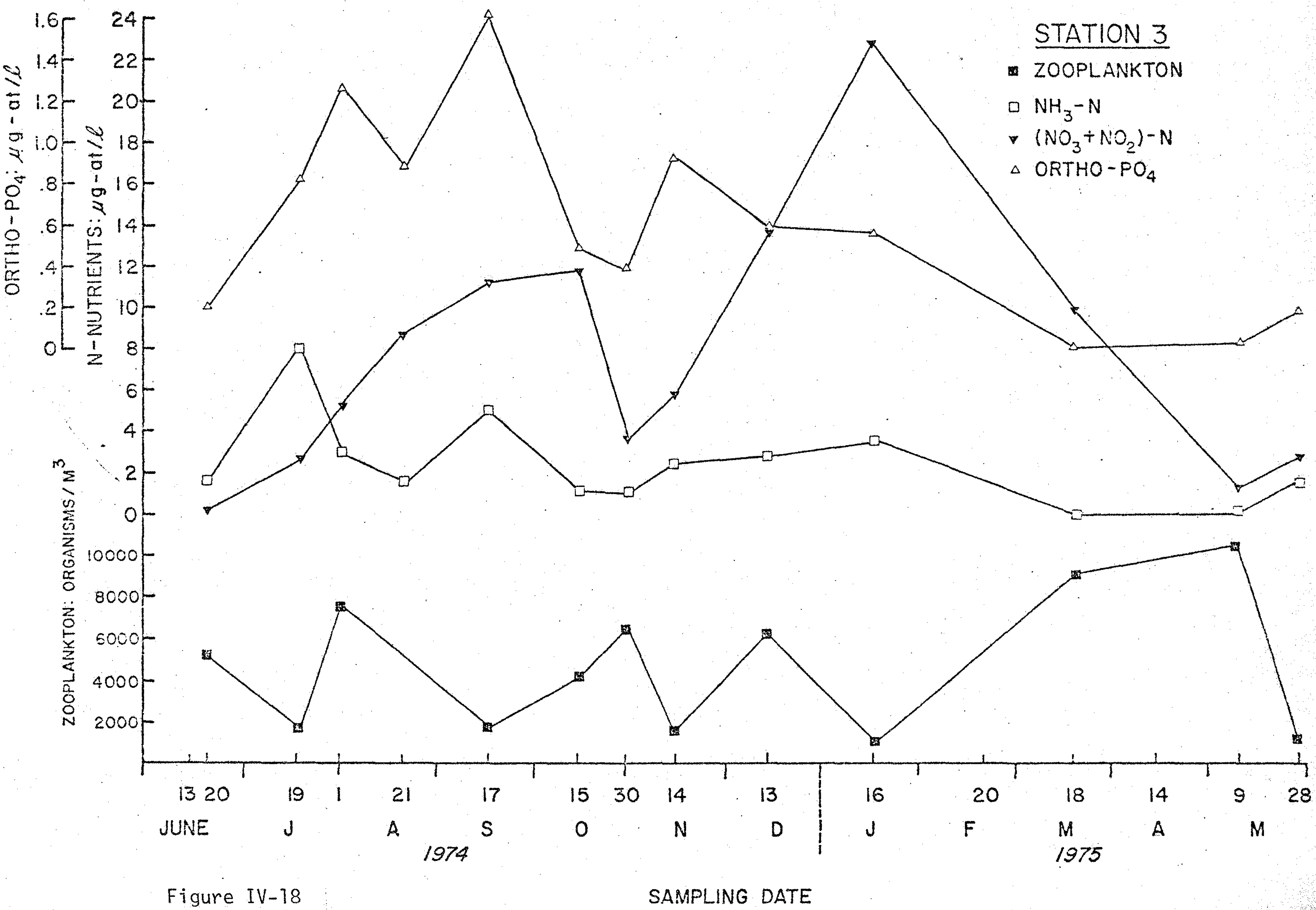

STATION 3
ZOOPLANKTON
NH_3-N
(NO_3+NO_2)-N
ORTHO-PO_4
ORTHO-PO_4: μg-at/ℓ
N-NUTRIENTS: μg-at/ℓ
ZOOPLANKTON: ORGANISMS / M^3
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
24
22
20
18
16
14
12
10
8
6
4
2
0
10000
8000
6000
4000
2000
13 20 19 1 21 17 15 30 14 13 16 20 18 14 9 28
JUNE J A S O N D J F M A M
1974
1975
SAMPLING DATE

Figure IV-18

V. DELAWARE BAY BENTHIC INVERTEBRATE ASSEMBLAGES

Les Watling
Don Maurer
Chris Wethe

INTRODUCTION

While benthic community studies have been conducted in many of the estuaries along the northeastern coast of North America (Sanders, 1956, 1958, 1960; Dean and Haskin, 1964; Phelps, 1964; Rhoads and Young, 1970; O'Connor, 1972; Boesch, 1973; McGrath, 1975), the benthos of Delaware Bay has generally been overlooked. Prior to the turn of the century, marine invertebrates were collected here by J. Leidy and A.E. Verrill. Also, oyster populations and their associated fauna received and continues to receive attention from the Oyster Laboratory of Rutgers University. Faunal studies in the area began with a qualitative examination of species distributions in the Cape May region (Richards, 1929) but were not conducted in a quantitative manner until the survey of Amos (unpublished) in the 1950's. The first published account of benthic assemblages in Delaware Bay was a paper on the associated oyster fauna (Maurer and Watling, 1973). A series of papers dealing with the distribution and ecology of specific taxa were also completed: Amphipoda (Watling and Maurer, 1972a); Hydroids (Watling and Maurer, 1972b); Pelecypoda (Maurer, et al., 1974); Isopoda (Watling, et al., 1974b); and Gastropoda (Leathem and

Maurer, 1975). In addition a few quantitative benthic studies were conducted in restricted areas near the Delaware Bay mouth (Kinner, et al., 1974; Watling, et al., 1974a).

Methods of quantifying benthic data have evolved from describing distributions of numbers per m^2 to utilizing classification and ordination techniques devised for numerical taxonomic (Sneath and Sokal, 1973) or vegetation analysis problems (Williams, et al., 1973; Orloci, 1975). Along the east coast of North America, classification and ordination techniques have been used in Chesapeake Bay (Boesch, 1973), Hadley Harbor, Massachusetts (Parker, 1975), and along the coast of Prince Edward Island, Canada (Hughes and Thomas, 1971a, 1971b).

The purpose of the present study was to determine the composition and distribution of the benthic invertebrate assemblages in Delaware Bay and to investigate the relationships of these assemblages to environmental factors such as sediment and salinity.

METHODS

Sample Procurement and Processing

Transects 1 through 13, ranging from Cape Henlopen-Cape May to off Stow Creek (Figure V-1) were sampled during July and August 1972. Transects 14 through 26, ranging over the same area, were sampled in June and July 1973, giving a total of 207 samples taken over the two years. Each station was sampled once with a 0.1 m^2 Petersen grab. Two aliquots of sediment were taken from each grab for sediment-size analysis. The remaining material was washed over a 1.0 mm mesh sieve with the residue being preserved in 10% buffered formalin. Bottom salinity and dissolved oxygen samples, along with water and sediment temperatures, were taken at every station.

In the laboratory, benthic samples were sorted, identified to species, and their numbers determined. Sediment particle sizes were determined by dry sieving and pipette analysis.

Data Reduction

All species counts were stored on IBM cards for computer analyses. Assemblage distribution and composition were determined by site-group and species-group cluster analysis using both Czekanowski and Canberra metric similarity coefficients and group-average sorting strategy (See Sneath and Sokal, 1973; Clifford and Stephenson, 1975). The details of these techniques and the computer programs used are given in Appendix I.

Sediment Analysis

Sediment grain size analysis was performed according to the procedures outlined by Folk (1968). Sediment samples were wet sieved to separate the coarser material (sand) from the finer material (silt-clay). The sand was dried, disaggregated, and sieved. For most samples a $1/2\phi$ interval set was used. For well-sorted sand a $1/4\phi$ interval was employed to better define the mode. The silt-clay was collected in a one-liter cylinder and the muddy water made up to exactly 1000 ml. After effectively dispersing the suspension using sodium hexametaphosphate, a pipette analysis was run. Pipette withdrawals were made so as to obtain $1/2\phi$ size intervals in the silt range and 1ϕ intervals in the clay range.

RESULTS AND DISCUSSION

Sediment Facies Distribution

Grain Size Measures

Four statistical measures were used to characterize the grain size distribution curves obtained from the grain size analysis

(Folk, 1968). The graphic mean (M_z) was used to define average grain size. The graphic mean is based on the 16th, 50th, and 84th percentiles of the cumulative distribution curve. The uniformity or sorting of the sample was determined by the inclusive graphic standard deviation (σ_i). This measure includes 90% of the grain size distribution in determining sorting. The inclusive graphic skewness (Sk_1) was used to measure asymmetry of the grain size distribution curves. Again, this measure includes 90% of the distribution curve for its computation. The graphic kurtosis (K_g) was employed as a measure of the peakedness of the curve. The measure indicates the degree of departure of the size distribution curve from a normal probability curve as defined by the Gaussian formula. For a normally distributed curve the value of K_g is 1.00. With values greater than 1.00, the central portion of the grain size curve is better sorted than the tails. If the tails are better sorted than the center, the curve is platykurtic and K_g is less than 1.00. Very platykurtic curves are quite often bimodal.

Sediment Classification

To characterize the sediment distribution in Delaware Bay, a classification system incorporating both mean grain size and sorting was devised. This classification emphasized differences in sorting (between shoals and channels) and mean grain size. Five letter codes, A through E, represented coarse to fine mean grain size while five number codes, 1 through 5, represented well-sorted to very poorly-sorted uniformity. The size and sorting ranges represented by the various codes are listed in Table V-1. Only those codes which match sediments found within the bay are shown. Sediment classification groups are presented in Figure V-2.

The division between sediment types B and C were chosen as close to 0.2 mm diameter as possible. This particle diameter divides sediment that is carried and laid down chiefly as bed load from that sediment transported and deposited mainly from suspension (Allen, 1965). The division between sediment types C and D is the sand-silt break. The sorting classification divisions correspond to the classification scale described by Folk (1968). The characteristics of these sediment groupings are described in detail in Appendix II.

Geological Setting

Our understanding of the local geological framework suggests that it is a low-lying sandy coastline undergoing a relatively rapid marine transgression (Kraft, 1971). The principal features of the bathymetry of Delaware Bay are as summarized from Oostdam (1971): 1) an extensive series of shoals in the bay mouth off Cape May; 2) a series of shoals in the lower bay that run parallel to the axis of the estuary; 3) finger-like flood channels extending along and between the shoals; and 4) the main river channel which runs up the axis of the bay into the lower salinity regions. The geological evolution of these features have been elucidated by Weil (1976).

Bay-Wide Sediment Distribution

When sediment distribution patterns for Delaware Bay (Fig. V-2 to V-5) were examined, certain general trends emerged. Coarse sand (A) deposits were predominantly found at the mouth of the bay and in areas of eroded headlands within the bay. These sediments were transported and deposited as bed load. Medium to fine sand (B), together with bed load material but finer and more easily transportable, was carried further up the main channels of the bay by the flood tide currents. This sand formed both channel bottom and shoal deposits in the lower bay. Fine silt and clay (E) was carried into the bay in suspension from the Delaware River. While mainly found in the upper bay and along the Delaware Bay shore, this sediment also occurred at river mouths along the New Jersey shore and at the heads of some deep channels within the bay. Closely associated with the E class material was the coarse silt material (D) found in the quiet waters around the perimeter of the bay as well as along some quiet channel bottoms. The percentage silt-clay distribution (Figure V-5) revealed a continuous band of high silt-clay contents from the upper bay down to at least the Murderkill River. South of the Murderkill there were scattered large patches of sediment ranging from 20 to 70% silt-clay. The other high silt-clay area occurred between Egg Island Point and Cape May Point in the quiet, shallow basin along the New Jersey shore. Both areas corresponded closely to the D and E class sediment areas. The very fine sand (C) deposits, material capable of being carried and redeposited chiefly from suspension, made up large portions of the central bay sediments.

Sediment sorting distribution (Figure V-4) also revealed some trends. Sediment in the poorly sorted channels was sorted by the tidal currents as it was transported up onto the shoals (Weil, 1976). The majority of shoals were well sorted while channel bottoms were poorly sorted. The high silt-clay sediments were also evident as very poorly sorted material around the perimeter of the bay.

Distribution of Organisms

A total of 109 and 125 species were obtained from the 1972 stations (transects 1-13) and 1973 stations (transects 14-26), respectively. These species and their feeding classification are given in Table V-2. The distribution of the species found among the invertebrate phyla was as follows:

Phylum	% Total Species	
	1972	1973
Cnidaria	3.6	0.8
Rhynchocoela	2.8	1.6
Annelida	36.7	39.7
Mollusca	18.3	21.4
Arthropoda	31.2	29.4
Ectoprocta	7.3	6.4
Echinodermata	-	0.8

The species abundances for all stations are listed in Appendix Table AV-1.

There were no significant changes in percent of total species among phyla from one year to the next. The number of species and number of individuals per station was transformed to $\log_e (n + 1)$ and compared to salinity, depth, dissolved oxygen, bottom temperature, water content of sediment, percent clay, percent silt, median grain size, and percent volatiles using the product-moment correlation coefficient (Table V-3). Based on these analyses there was a significant positive association between the number of species and salinity and median sediment size, and significant inverse associations with bottom temperature, percent clay, and percent volatiles in 1972 and 1973, and with water content and percent silt in 1972.

The fact that the number of marine species was positively associated with increasing salinity has been reported from estuaries throughout the world (Carriker, 1967). A similar pattern was observed earlier in Delaware Bay for the epifaunal associates of the oyster (Maurer and Watling, 1973). Based on that work the Woodland Beach area marked the transition zone between mesohaline and oligohaline waters. At that time it was pointed out that any faunal boundaries in Delaware Bay would have to be reevaluated pending studies on the infauna since it had been shown elsewhere that infaunal marine species occur further up the estuary than marine epifaunal species (Sanders, et al., 1965; Carriker, 1967). In the present study, the number of infaunal species markedly declined between the Simon's River and Stow Creek, N.J., which is opposite Woodland Beach, Delaware (this includes transects 12, 13, and 23 to 26; Figure V-6). This region probably occupies a critical position in the hydrography of the Delaware estuary with regard to salinity distribution and the response of the biota to salinity.

Observations concerning the association between benthic invertebrates and temperature and various sediment measures have also been made many times (Allen, 1963; Kinne, 1964; Gray, 1964). Temperature is a major factor controlling directly or indirectly all aspects of the biology of an organism. Since the area is relatively small in area and bay-wide data were only available for the summer, the influence of temperature on species distribution is unclear. As a result, we have tended to place greater emphasis on sediment measures, which are to some degree controlled by local hydrographic conditions. At various times the distribution, composition, and abundance of benthic invertebrates have been correlated with percent clay, percent silt and clay, percent volatiles, median sediment size, and percent water content (Bader, 1954; Sanders, 1956, 1958; Harrison and Wass, 1965; Maurer, 1969). Based on the literature it seems that finer sediment fractions play an important role influencing the ecology of benthic invertebrates. More specifically, encrusted particles and organic-mineral aggregates probably represent significant food resources for the benthos (Johnson, 1974). If Johnson's methods could be formalized and made more feasible, they could provide more valid information about animal-sediment relationships than standard methods of describing sediments.

There were significant positive correlations between number of individuals/m^2 and salinity and median grain size, and significant negative correlations of infaunal densities with percent clay, percent silt, water content, and percent volatiles in 1972. These patterns, with the exception of the salinity relationship, were not detected in 1973 (Table V-3).

The average number of individuals per sample from both sets of transects was 20, or 200 individuals/m^2. Especially noticeable was that at only ten stations of the 207 sampled were there more than 1,000 individuals/m^2 (Table V-4). As can be seen in Table V-5, the density of benthic organisms in Delaware Bay was one or two orders of magnitude lower than that recorded for any other estuary north of Cape Hatteras, including areas, such as Moriches Bay, which are heavily polluted. While our investigations were not designed to provide an explanation for this situation, some visual observations of the Delaware Bay environment provide possible clues. For example, there was a notable, virtually complete lack of attached benthic, macroscopic algae or vascular plants in Delaware Bay. This, in turn, was most likely related to the highly turbid conditions which exist in the bay (see Chapter IV for secchi depths). The absence of macroscopic benthic algae thus deprives the benthic community of a major source of organic material which would be utilized by deposit feeders (Levinton, 1972; Johnson, 1974).

The number of species and number of individuals obtained in each sample are shown in Figures V-6 and V-7. The highest number of species was obtained in the serpulid reef at Station 16-3. Samples with more than ten species occurred in isolated areas in the lower bay where the substratum consisted of fine to coarse sands. Highest densities of individuals also occurred in isolated samples, generally along the lateral regions of the lower bay. Most of the samples represented concentrations of one or two species. For example, 80% of the individuals at Stations 15-8, 18-1, and 18-10 belonged to the bivalve, Gemma gemma. In contrast, at Station 16-3, several species occurred in very high numbers.

The benthic assemblages in Delaware Bay consisted chiefly of deposit-feeders. The percent of the fauna at each station classified as deposit feeders is given in Figure V-8. Of the 207 samples, 75 had more than 75% deposit-feeding individuals while 118 samples possessed at least 50%. The majority of those samples with more than 75% deposit-feeding individuals were located along the Delaware side of Delaware Bay (Figure V-8). If Figure V-8 is compared to Figure V-5, this distribution is only partly explained by the silt-clay content of the sediment. There were several samples with high proportions of deposit-feeders located in areas with less than 20% silt-clay. The reverse situation was also true.

Of the 15 species occurring most frequently in the 1972 samples, only ten were as widespread in 1973 (Table V-6). During both years the bivalve, Tellina agilis, occurred in over half the samples. The two species with the greatest change in occurrence were both bivalves. Ensis directus decreased from 34% in 1972 to 3% in 1973, and Gemma gemma increased from 6% to 25% over the same period.

The distribution of the most widespread species are given in Figures V-9 to V-16. The details of these distributions and their relationships to the sediment facies are outlined below for each species.

Tellina agilis (Figure V-9): This bivalve occurred throughout the lower bay, but its highest concentrations were in the areas where the channels extended into the shoal regions. While T. agilis showed no correlation with sediment descriptors, it was generally not found in sediments whose mean grain size was in the silt or clay range. This trend was noted earlier in a restricted area near the bay mouth (Kinner, et al., 1974).

Heteromastus filiformis (Figure V-10): This polychaete was found most frequently in sediments high in silt-clay sized particles. Thus its distribution excludes most of the lower central portion of the bay.

Glycera dibranchiata (Figure V-11): Although this polychaete was found in low numbers over much of the bay, it occurred in highest numbers in the clean fine sands along the New Jersey portion of the lower central bay.

Nephtys picta (Figure V-12): This polychaete was the only species with a strong depth-dependent distribution. Six of the ten stations with more than one individual and all stations with three or more individuals occurred at depths greater than 20 m. All these stations were characterized by sediments in the medium to coarse sand range.

Mulinia lateralis (Figure V-13): This bivalve is an opportunist which undergoes strongly localized population explosions. During our study it was widely distributed over Delaware Bay, with the highest numbers being found in the fine muddy sands of the upper bay. This region is also characterized by mesohaline bottom waters (see Hydrography chapter).

Protohaustorius wigleyi (Figure V-14): This burrowing amphipod was primarily found in the fine to medium, well to moderately sorted clean sands of the shoals. This animal-sediment association was noted earlier near the bay mouth (Kinner, et al., 1974).

Gemma gemma (Figure V-15): A small bivalve with short siphons, the highest numbers of G. gemma were found in the moderate to high silt-clay habitats of the upper bay and along the margins of the lower bay. These regions were also characterized by mesohaline to lower polyhaline bottom waters.

Nucula proxima (Figure V-16): This deposit-feeding bivalve was found in highest numbers and with greatest frequency along the Delaware side of the lower bay. Most of the stations with high N. proxima densities were located in substrata characterized by fine sands with varying amounts of silt and clay. This species has been considered as characterizing high silt-clay (>50%) facies (Kinner, et al., 1974), but has also been found at very high densities in fine to medium sands (Watling, et al., 1974a).

Distribution of Assemblages

Although we are of the opinion that each species is distributed along a continuum independent of many, if not most, other species, it is possible to define assemblages of species whose distributions overlap to a greater or lesser degree. Cluster analysis techniques can be used to compute the similarity of samples, and groups of samples, with each other, thus producing hierarchic groupings of samples that are similar amongst themselves. The output of such computations is a dendrogram, the significance of whose branching pattern can only be determined by the ecologist (Clifford and Stephenson, 1975). These techniques were used to determine what assemblages existed when the samples were taken in 1972 and 1973.

The dendrograms produced for station groupings in 1972 and 1973 are given in Figures V-17 and V-24, respectively. These dendrograms utilized the Canberra metric similarity measure and the group-average sorting strategy. All species occurring in more than 3% of the samples were included in the analyses. Thus 37 species were considered for the 1972 samples and 53 species for the 1973 samples.

The dendrogram for the 1972 samples appeared to contain nine distinct clusters which were arbitrarily lettered A through I. After the species occurrences and sediment characteristics were reviewed for these groups, they were combined to produce the following assemblages: A, consisting of groups A-E; F; G; H; and I. These assemblages are distributed as in Figure V-18 and their sediment characteristics graphed in Figures V-19 to V-23. The species characterizing these assemblages, the percent of their abundance, and their percent occurrence at stations within the group are outlined below:

Species	% Abundance in Group	% Occurrence at Stations in Group
Assemblage A (54 stations):		
Tellina agilis	80	91
Nephtys picta	98	30
Nassarius trivittatus	90	13
Cancer irroratus	90	11
Trichophoxus epistomus	100	17
Haploscoloplos fragilis	100	7
Glycera capitata	60	33
Ensis directus	34	48
Assemblage F (10 stations):		
Ampelisca abdita	76	40
Nucula proxima	48	30
Streblospio benedicti	39	30
Assemblage F (3 stations):		
Scolecolepides viridis	75	100

Species	% Abundance in Group	% Occurrence at Stations in Group
Assemblage H (11 stations):		
Ensis directus	69	45
Glycera capitata	38	100
Nereis succinea	51	18
Capitella capitata	51	18
Assemblage I (10 stations):		
Heteromastus filiformis	66	100
Melita nitida	74	60
Mulinia lateralis	86	40

Assemblage A occurs throughout the central portion of the lower bay and was characterized by fine to coarse, primarily clean sands that were moderately to poorly sorted (Figure V-19). The bottom waters throughout this region were in both the upper polyhaline and lower polyhaline salinity levels. The sediments at Assemblage F stations were predominantly fine sands to silts and clays and were extremely poorly sorted. The three stations of Assemblage G consisted of two quite different sediment classifications (Figure V-21) and possibly represented an artificial assemblage. Assemblages H and I showed quite similar, strongly heterogeneous sediment patterns. These assemblages appeared to be sufficiently distinct to be considered separately but were contiguous geographically (Figure V-18). The bottom waters in the region of these assemblages were generally mesohaline in nature.

A similar analysis was performed on the samples taken in 1973. In this case four assemblages were produced from the initial 11 groups considered (Figure V-24): assemblage 1, from groups 1 through 4, assemblage 5, from groups 5, 6, and 7; assemblage 8, from groups 8 and 9, and assemblage 10, from groups 10 and 11. The distribution of these assemblages is shown in Figure V-25, and their sediment characteristics in Figures V-26 through V-27. The species characterizing these assemblages, their abundance, and percent occurrence at stations within the assemblage are outlined below:

Species	% Abundance in Group	% Occurrence at Stations in Group
Assemblage 1 (44 stations):		
Tellina agilis	50	95
Glycera dibranchiata	75	34
Heteromastus filiformis	72	32
Protohaustorius wigleyi	90	25
Glycera capitata	69	23
Nepthys picta	60	30
Assemblage 5 (14 stations):		
Tellina agilis	50	93
Nucula proxima	59	43
Paraphoxus spinosus	88	36
Aricidea cerruti	99	29
Glycera americana	86	29
Cancer irroratus	81	29
Pagurus longicarpus	56	29
Assemblage 8 (19 stations):		
Melita nitida	100	42
Polydora ligni	92	53
Neopanope texana sayi	97	32
Nereis succinea	93	32
Corophium simile	100	21
Paracaprella tenuis	100	21
Parapleustes aestuarius	100	21
Crepidula plana	100	21
Eurypanopeus depressus	96	21
Sabellaria vulgaris	95	21
Assemblage 10 (15 stations):		
Mulinia lateralis	77	13
Mya arenaria	99	20

Assemblage 1 extended over much of the same area covered by Assemblage A a year earlier. The sediment characteristics were also largely similar, with the exception of a few stations located in poorly sorted silts and clays (Figure V-26). Assemblage 5 occurred in two large patches along the Delaware side of the lower bay and in two smaller patches along the New Jersey shore. The sediments at these stations were generally fine to medium, moderately sorted sands (Figure V-27). The only distinctly epifaunal assemblage found was Assemblage 8. It was found at several isolated localities throughout all portions of the bay and was characterized by a heterogeneous grouping of sediments (Figure V-28). A similar sediment distribution (Figure V-29) was seen for the more depauperate infaunal Assemblage 10. This assemblage was located almost exclusively in the region of mesohaline bottom waters.

There has been much discussion about the uses of cluster analyses, their output and their interpretation (Clifford and Stephenson, 1975; Farris, 1976). In our analysis of the Delaware Bay fauna, we have used cluster analysis only as a tool to aid in handling the massive amount of data generated by surveys of this kind. The analysis and interpretation of the dendrogram was considered to be the responsibility of the investigator.

As yet, there are no statistically acceptable tests which can be used to determine whether a site-group or species-group, as defined by hierarchial classificatory techniques, should be accepted or rejected (Stephenson, et al., 1974). As a consequence, we established our site-groups using arbitrary criteria of conformity between site-groups and species occurrences. This resolved some of the problems associated with assemblage definition, but still left the matter of scale to be dealt with. Stephenson, et al. (1974) suggested that the size of site-groups would vary among different environments, with topographical micropatterns being of a finer scale in the tropics than in temperature latitudes. This leads one to question the purpose of using classificatory techniques: are they to be used to resolve small-scale patterns or to define assemblages of co-occurring species that may be interacting to form functional units. Since it is unlikely, in our opinion, that the results of these two purposes are necessarily equivalent, one's choice between them must govern not only the interpretation of the dendrogram produced, but also the initial sampling design. In this study our purpose was to define functional assemblages of co-occurring species. However, we feel that in view of the unusually low densities in Delaware Bay, it was not possible to separate the heterogeneity of small-scale topographical patterns from the distribution of functional assemblages.

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Table V-1

Sediment classification scheme used for Delaware Bay sediments

Inclusive graphic standard deviation σ_i (sorting)

0.5ϕ 1.0ϕ 2.0ϕ 3.0ϕ

GRAPHIC MEAN (M_z)	Well Sorted	Moderately to Moderately Well Sorted	Poorly Sorted	Very Poorly Sorted	Very to Extremely Poorly Sorted
Coarse Sand		A2	A3	A4	
1.5ϕ					
Medium to Fine Sand	B1	B2	B3	B4	
2.5ϕ					
Very Fine Sand	C1	C2	C3	C4	
4.0ϕ					
Coarse Silt			D3	D4	D5
6.0ϕ					
Fine Silt and Clay				E4	E5

Table V-2

List of species obtained from transect samples in Delaware Bay during 1972 and 1973

	Feeding Type	Transects 1-13	Transects 14-26
Phylum Cnidaria			
Class Hydrozoa			
Order Hydroida			
Family Hydractiniidae			
Hydractinia echinata (Fleming 1828)	SF		x
Family Campanulariidae			
Hartlaubella gelatinosa (Pallas 1766)	SF	x	
Family Sertulariidae			
Sertularia argentea Linne 1758	SF	x	
Family Plumulariidae			
Schizotricha tenella (Verrill 1874)	SF	x	
Class Anthozoa			
Order Actinaria			
Family Diadumenidae			
Diadumene leucolena (Verrill 1866)	SF	x	
Phylum Rhynchocoela			
Class Anopla			
Order Heteronemertini			
Family Lineidae			
Cerebratulus lacteus (Leidy 1851)	C	x	x
Micrura leidyi	C	x	
Class Unknown			
Nemertea sp.	C	x	x
Phylum Annelida			
Family Ampharetidae			
Asabellides oculatus (Webster 1879)	DF	x	x
Melinna sp. cf. *M. maculata*	DF	x	
Asabellides sp. cf. *A. oculatus*	DF	x	
? *Asabellides*	DF		x
Ampharetidae sp. 1	DF		x
Family Arabellidae			
Arabella iricolor (Montagu 1804)	O		x
Drilonereis longa Webster 1879	O	x	x
Drilonereis magna Webster and Benedict 1887	O		x
Family Capitellidae			
Capitella capitata (Fabricius 1780)	DF	x	x
Heteromastus filiformis (Claparede 1864)	DF	x	x

Table V-2 (cont.)

	Feeding Type	Transects 1-13	Transects 14-26
Family Cirratulidae			
Caulleriella sp. 2	DF		x
Tharyx sp. 2	DF	x	x
Cirriformia sp. cf. *C. grandis*	DF	x	
? Chaetozone	DF		x
Family Eunicidae			
Marphysa sanguinea (Montagu 1815)	DF		x
Family Glyceridae			
Glycera americana Leidy 1855	C	x	x
Glycera capitata Oersted 1843	C		x
Glycera dibranchiata Ehlers 1868	C	x	x
Glycera robusta Ehlers 1868	C	x	
Family Goniadidae			
Glycinde solitaria (Webster 1880)	C	x	x
Family Hesionidae			
Microphthalmus aberrans (Webster and Benedict 1887)	C		x
Family Lumbrineridae			
Lumbrineris acuta (Verrill 1875)	DF	x	
Lumbrineris tenuis (Verrill 1873)	DF	x	x
Lumbrineris sp. cf. *L. tenuis* (Verrill 1873)	DF	x	
Family Magelonidae			
Magelona sp. 1	DF	x	
Magelona sp. 2	DF		x
Magelona sp. 4	DF	x	
Family Maldanidae			
Clymenella sp. cf. *C. torquata* (Leidy 1855)	DF	x	
Family Nephtyidae			
Nephtys bucera Ehlers 1868	O		x
Nephtys picta Ehlers 1868	O	x	x
Family Nereidae			
Nereis (Neanthes) succinea Frey and Leuckart 1847	O	x	x
Family Opheliidae			
Ophelia bicornis Savigny 1818	DF		x
Travisia carnea Verrill 1873	DF		x
Family Orbiniidae			
Haploscoloplos acutus (Verrill 1873)	DF		x
Haploscoloplos fragilis (Verrill 1873)	DF	x	x
Haploscoloplos robustus (Verrill 1873)	DF	x	x
Orbinia ornatus (Verrill 1873)	DF	x	
Scoloplos sp.	DF	x	
Family Paraonidae			
Aricidea sp.	DF		x
Aricidea cerruti Laubier 1967	DF		x
Paradoneis (Paraoinides) lyra Southern 1914	DF	x	

Table V-2 (cont.)

	Feeding Type	Transects 1-13	Transects 14-26
Family Pectinariidae			
Pectinaria gouldii Verrill 1873	DF	x	
Family Phyllodocidae			
Eteone heteropoda Hartman 1951	0	x	x
Eteone lactea Claparede 1868	0		x
Eteone longa (Fabricius 1780)	0		x
Eumida sanguinea (Oersted 1843)	0	x	
Paranaitis kosteriensis (Malmgren 1867)	C		x
Phyllodoce arenae Webster 1880	C		x
Family Polynoidae			
Harmothoe sp. cf. *H. extenuata* (Grube 1840)	C	x	
Harmothoe (Lagisca) extenuata (Grube 1840)	C	x	x
Lepidonotus squamatus (Linnaeus 1756)	C		x
Lepidonotus sublevis Verrill 1873	C	x	x
Family Sabellaridae			
Sabellaria vulgaris Verrill 1873	SF	x	x
Family Sabellidae			
Potamilla reniformis (Leuchart 1849)	SF		x
Family Serpulidae			
Hydroides dianthus (Verrill 1873)	SF		x
Family Sigalionidae			
Sthenelais (denticulatum)	C	x	
Sigalion sp.	C	x	
Family Spionidae			
Polydora ligni Webster 1879	DF	x	x
Polydora socialis (Schmarda 1861)	DF		x
Polydora websteri Hartman 1943	DF		x
Scolecolepides viridis (Verrill 1873)	DF	x	x
Scolelepis squamata (O.F. Muller 1806)	DF		x
Spiophanes bombyx (Claparede 1870)	DF	x	x
Streblospio benedicti Webster 1879	DF	x	x
Family Syllidae			
Exogone verugera (Claparede 1868)	0	x	
Parapionosyllis longicirrata Webster and Benedict 1884)	0		x
Proceraea cornuta (Agassiz 1863)	0		x
Family Terebellidae			
Polycirrus eximius (Leidy 1855)	DF		x
Class Oligochaeta			
Oligochaeta	DF	x	
Phylum Mollusca			
Class Gastropoda			
Order Mesogastropoda			
Family Epitoniidae			
Epitonium rupicola (Kurtz 1860)	C	x	
Family Calyptraeidae			
Crepidula fornicata (Linne 1758)	SF		x
Crepidula convexa Say 1822	SF	x	x
Crepidula plana Say 1822	SF		x

Table V-2 (cont.)

	Feeding Type	Transects 1-13	Transects 14-26
Family Naticacea			
Lunatia heros (Say 1822)	C		x
Order Neogastropoda			
Family Melongenidae			
Busycon carica (Gmelin 1791)	C		x
Family Nassariidae			
Nassarius trivittatus (Say 1822)	C	x	x
Ilyanassa obsoletus (Say 1822)	C	x	x
Family Marginellidae			
Marginella roscida Redfield 1860	C	x	
Order Tectibranchia			
Family Pyramidellidae			
Sayella fusca (C.B. Adams 1839)	ectoparasitic		x
Order Nudibranchia			
Family Corambella			
Dorodella obscura Verrill 1870	C	x	x
Class Bivalvia			
Order Protobranchia			
Family Nuculidae			
Nucula proxima Say 1822	DF	x	x
Yoldia limatula Say 1831	DF	x	x
Order Filibranchia			
Family Arcidae			
Anadara ovalis (Bruguiere 1789)	SF		x
Family Mytilidae			
Geukensia demissa (Dillwyn 1817)	SF		x
Mytilus edulis Linne 1758	SF		x
Family Ostreidae			
Crassostrea virginica (Gmelin 1791)	SF	x	x
Order Eulamellibranchia			
Family Carditidae			
Cyclocardia borealis (Conrad 1831)	SF	x	
Family Leptonidae			
Mysella planulata (Stimpson 1857)	SF		x
Family Veneridae			
Mercenaria mercenaria (Linne 1758)	SF	x	x
Gemma gemma (Totten 1834)	SF	x	x
Family Tellinidae			
Tellina agilis Stimpson 1857	DF	x	x
Macoma balthica (Linne 1758)	DF	x	x
Family Solenidae			
Ensis directus Conrad 1843	SF	x	x
Family Mactridae			
Spisula solidissima (Dillwyn 1817)	SF	x	x
Mulinia lateralis (Say 1822)	SF	x	x
Family Myacidae			
Mya arenaria Linne 1758	SF	x	x

Table V-2 (cont.)

	Feeding Type	Transects 1-13	Transects 14-26
Family Corbulidae			
Corbula contracta Say 1822	SF	x	x
Family Lyonsiidae			
Lyonsia hyalina Conrad 1831	SF	x	x
Family Pandoridae			
Pandora gouldiana Dall 1886	SF		x
Phylum Arthropoda			
Class Merostomata			
Limulus polyphemus (Linne 1758)	C		x
Class Pycnogonida			
Family Pallenidae			
Tanystylum orbiculare Wilson 1878	DF	x	x
Class Crustacea			
Subclass Cirripedia			
Order Thoracica			
Family Balanidae			
Balanus (*Balanus*) *improvisus* Darwin 1854	SF		x
Balanus (*Semibalanus*) *balanoides* (Linne)	SF		x
Subclass Malacostraca			
Order Mysidacea			
Family Mysidae			
Neomysis americana (S.I. Smith 1873)	SF	x	x
Order Cumacea			
Family Diastylidae			
Oxyurostylis smithi Calman 1912	DF		x
Order Isopoda			
Family Anthuridae			
Cyathura polita (Stimpson 1855)	O	x	x
Ptilanthura tenuis Harger 1878	O		x
Cyathura burbancki Frankenberg 1965	O		x
Family Idoteidae			
Chiridotea nigrescens Wigley 1961	DF		x
Edotea triloba (Say 1818)	DF		x
Order Amphipoda			
Family Ampeliscidae			
Ampelisca abdita Mills 1964	DF	x	x
Ampelisca verrilli Mills 1967	DF	x	x
Family Ampithoidae			
Ampithoidae sp.	DF	x	
Family Aoridae			
Lembos smithi (Holmes 1905)	DF		x
Family Bateidae			
Batea catharinensis Fr. Muller 1865	DF	x	
Family Corophiidae			
Corophium insidiosum Crawford 1937	DF	x	x
Corophium lacustre Vanhoffen 1911	DF	x	
Corophium tuberculatum Shoemaker 1934	DF	x	x
Erichthonius brasiliensis Dana 1853	DF	x	x

Table V-2 (cont.)

	Feeding Type	Transects 1-13	Transects 14-26
Family Corophiidae (cont.)			
Unciola irrorata Say 1818	DF	x	
Unciola serrata Shoemaker 1945	DF	x	x
Unciola dissimilis Shoemaker 1945	DF	x	
Corophium simile Shoemaker 1934	DF	x	x
Family Gammaridae			
Gammarus mucronatus Say 1818	DF	x	x
Elasmopus laevis (Smith 1871)	DF		x
Melita nitida Smith 1873	DF	x	x
Family Haustoriidae			
Parahaustorius attenuatus Bousfield 1965	DF	x	
Parahaustorius longimerus Bousfield 1965	DF	x	
Protohaustorius wigleyi Bousfield 1965	DF	x	x
Protohaustorius deichmannae Bousfield 1965	DF	x	
Acanthohaustorius millsi Bousfield 1965	DF	x	x
Acanthohaustorius intermedius Bousfield 1965	DF		x
Family Lysianassidae			
Lysianopsis alba Holmes 1905	DF	x	
Family Phoxocephalidae			
Paraphoxus spinosus Holmes 1903	DF		x
Trichophoxus epistomus (Shoemaker 1938)	DF	x	
Family Pleustidae			
Parapleustes aestuarius Watling and Maurer 1973	DF	x	x
Family Stenothoidae			
Parametopella cypris (Holmes 1905)	DF		x
Family Caprellidae			
Paracaprella tenuis Mayer 1903	SF	x	x
Order Decapoda			
Family Crangonidae			
Crangon septemspinosa (Say 1818)	DF	x	x
Family Callianassidae			
Callianassa sp. cf. C. atlantica	DF	x	
Family Paguridae			
Pagurus longicarpus Say 1817	DF	x	x
Family Cancridae			
Cancer irroratus Say 1817	C	x	x
Family Xanthidae			
Xanthid sp.	C	x	
Eurypanopeus depressus (Smith 1869)	C	x	x
Neopanope texana sayi (Smith 1869)	C	x	x
Rhithropanopeus harrisi (Gould 1841)	C		x
Family Pinnotheridae			
Pinnotheres maculatus Say 1818	commensal		x
Pinnixa sayana Stimpson 1860	DF	x	x

Table V-2 (cont.)

	Feeding Type	Transects 1-13	Transects 14-26
Phylum Ectoprocta			
Class Gymnolaemata			
Order Ctenostomata			
Family Alcyonidiidae			
Alcyonidium polyoum (Hassall 1841)	SF	x	x
Alcyonidium verrilli Osburn 1912	SF		x
Family Nolellidae			
Anguinella palmata Van Beneden 1844	SF	x	
Family Flustrellidae			
Flustrellidra hispida (Fabricius 1780)	SF	x	
Family Vesiculariidae			
Bowerbankia gracilis Leidy 1855	SF	x	
Family Triticellidae			
Triticella elongata (Osburn 1912)	SF	x	
Order Cheilostomata			
Family Membraniporidae			
Membranipora tenuis Desor 1848	SF	x	x
Membranipora tuberculata (Bosc 1802)	SF		x
Conopeum tenuissimum (Canu 1908)	SF	x	x
Family Electridae			
Electra hastingsae Marcus 1938	SF	x	x
Family Schizoporellidae			
Schizoporella errata (Watess 1878)	SF		x
Family Microporellidae			
Microporella ciliata (Pallas 1766)	SF		x
Phylum Echinodermata			
Class Echinoidea			
Order Diadematoida			
Family Echinarachnidae			
Echinarachnius parma (Lamark 1816)	SF		x

Table V-3

Correlation between Number of Species and Number of Individuals in Relation to Environmental Factors

Number of Species

	1972			1973			Combined		
	R	F	N	R	F	N	R	F	N
Salinity	0.43*	22.7	102	0.44*	23.4	96	0.37*	32.3	198
Depth	0.06	0.43	105	0.09	0.98	99	0.11	2.5	204
Dissolved Oxygen	0.06	0.37	101	-0.07	0.59	99	-	-	-
Bottom Temperature	-0.24*	6.2	103	-0.22*	4.8	96	-0.27	15.4	199
% H_2O in Sediment	-0.53*	41.8	104	-	-	-	-	-	-
% Clay	-0.48*	31.4	104	-0.21*	4.5	100	-0.33	25.4	204
% Silt	-0.36*	15.8	104	-0.14	2.1	96	-0.26	14.4	200
50% mm	0.34*	13.5	104	0.04	0.17	96	0.12	3.3	200
% Volatiles	-0.55*	45.1	104	-0.20*	4.1	96	-0.35	28.6	200

Number of Individuals

	1972			1973			Combined		
	R	F	N	R	F	N	R	F	N
Salinity	0.35*	14.5	103	0.25*	6.49	97	0.25	14.1	200
Depth	0.11	0.01	105	-0.07	0.52	101	-0.06	0.73	206
Dissolved Oxygen	0.06	0.46	101	0.1	1.16	99	-	-	-
Bottom Temperature	-0.07	0.64	104	-0.06	0.44	100	-0.20	8.55	204
% H_2O in Sediment	-0.43*	24.1	104	-	-	-	-	-	-
% Clay	-0.37*	17.0	104	-0.16	2.7	96	-0.22	10.8	200
% Silt	-0.27*	8.38	104	-0.02	0.05	96	-0.13	3.7	200
50% mm	0.23*	5.79	104	-0.04	0.21	96	0.07	1.1	200
% Volatiles	-0.43*	23.9	104	-0.15	2.4	96	-0.23	11.3	200

*Significant at = 0.5; R = Product-Moment Correlation Coefficient; F = F Factor; N = Number of Observations.

Table V-4

Density of benthic organisms in relation to sediment classification

Sediment Classification	No. Stations	Average No. Individuals per m^2	Average No. Species	Stations Omitted	No. Individuals per m^2	No. Species
A-2	13	180	4	None	-	-
A-3	15	250	8	None	-	-
B-1	8	160	5	18- 1	9350	9
				20- 7	4640	10
B-2	14	360	6	7- 7	6330	6
				21- 6	2340	10
B-3	17	250	6	None	-	-
B-4	5	140	6	None	-	-
C-1	31	180	5	None	-	-
C-2	17	180	4	15- 8	6500	18
C-3	25	240	5	24- 4	6330	5
D-4	16	260	5	16- 3	30440	31
				18-10	37990	5
D-5	1	60	3	16-11	1290	13
E-5	20	100	3	12- 1	3550	2

Table V-5

Average density of organisms at various locations along the east coast of North America

Location	Average No. Individuals per m^2	Source
Pocasset River, Massachusetts	67,000	Sanders, et al., 1965
Charlestown Pond, Rhode Island	30,000	Phelps, 1964
Long Island Sound	16,000	Sanders, 1956
Buzzards Bay, Massachusetts Station R	9,000	Sanders, 1960
Buzzards Bay, Massachusetts All Stations	4,000	Sanders, 1958
Mystic River, Connecticut	3,000	Rowe, et al., 1972
Moriches Bay, New York	1,300	O'Connor, 1972
Cape Cod Bay, Massachusetts	15,000	Young and Rhoads, 1971
Shallow Shelf off Long Island, New York	700	Steimle and Stone, 1973
Chesapeake Bay, eel grass beds, Virginia	14,000	Orth, 1973
Delaware Bay	200	This Study

Table V-6

Most frequently occurring species in transect samples

1972 Species	1972 Percent Occurrence	1973 Species	1973 Percent Occurrence
Tellina agilis	62	Tellina agilis	57
Ensis directus	34	Heteromastus filiformis	28
Glycera dibranchiata	29	Gemma gemma	25
Heteromastus filiformis	24	Glycera dibranchiata	24
Nephtys picta	18	Mulinia lateralis	21
Mulinia lateralis	16	Nucula proxima	21
Neomysis americana	16	Nephtys picta	16
Protohaustorius wigleyi	14	Protohaustorius wigleyi	14
Nemertea sp.	12	Glycera capitata	14
Nucula proxima	12	Nemertea sp.	13
Pagurus longicarpus	9	Mytilus edulis	12
Trichophoxus epistomus	9	Polydora ligni	12
Melita nitida	9	Nassarius trivittatus	10
Streblospio benedicti	9	Melita nitida	9
Nassarius trivittatus	8	Haploscoloplos fragilis	9

FIGURE CAPTIONS FOR CHAPTER V

Figure V- 1: Map of Delaware Bay showing transect sampling stations.

Figure V- 2: Sediment classification groups in Delaware Bay.

Figure V- 3: Mean grain size (M_z) of Delaware Bay sediment samples.

Figure V- 4: Sorting coefficient of Delaware Bay sediment samples.

Figure V- 5: Percent silt and clay in Delaware Bay sediment samples.

Figure V- 6: Total number of species in Delaware Bay transect samples.

Figure V- 7: Total number of individuals in Delaware Bay transect samples.

Figure V- 8: Percent deposit-feeders in Delaware Bay transect samples.

Figure V- 9: Distribution of <u>Tellina agilis</u> in Delaware Bay. 5070 is the computer code number for this species.

Figure V-10: Distribution of <u>Heteromastus filiformis</u> in Delaware Bay.

Figure V-11: Distribution of <u>Glycera dibranchiata</u> in Delaware Bay.

Figure V-12: Distribution of <u>Nephtys picta</u> in Delaware Bay.

Figure V-13: Distribution of <u>Mulinia lateralis</u> in Delaware Bay.

Figure V-14: Distribution of <u>Protohaustorius wigleyi</u> in Delaware Bay.

Figure V-28: Sediment characteristics of samples in benthic faunal assemblage 8.

Figure V-29: Sediment characteristics of samples in benthic faunal assemblage 10.

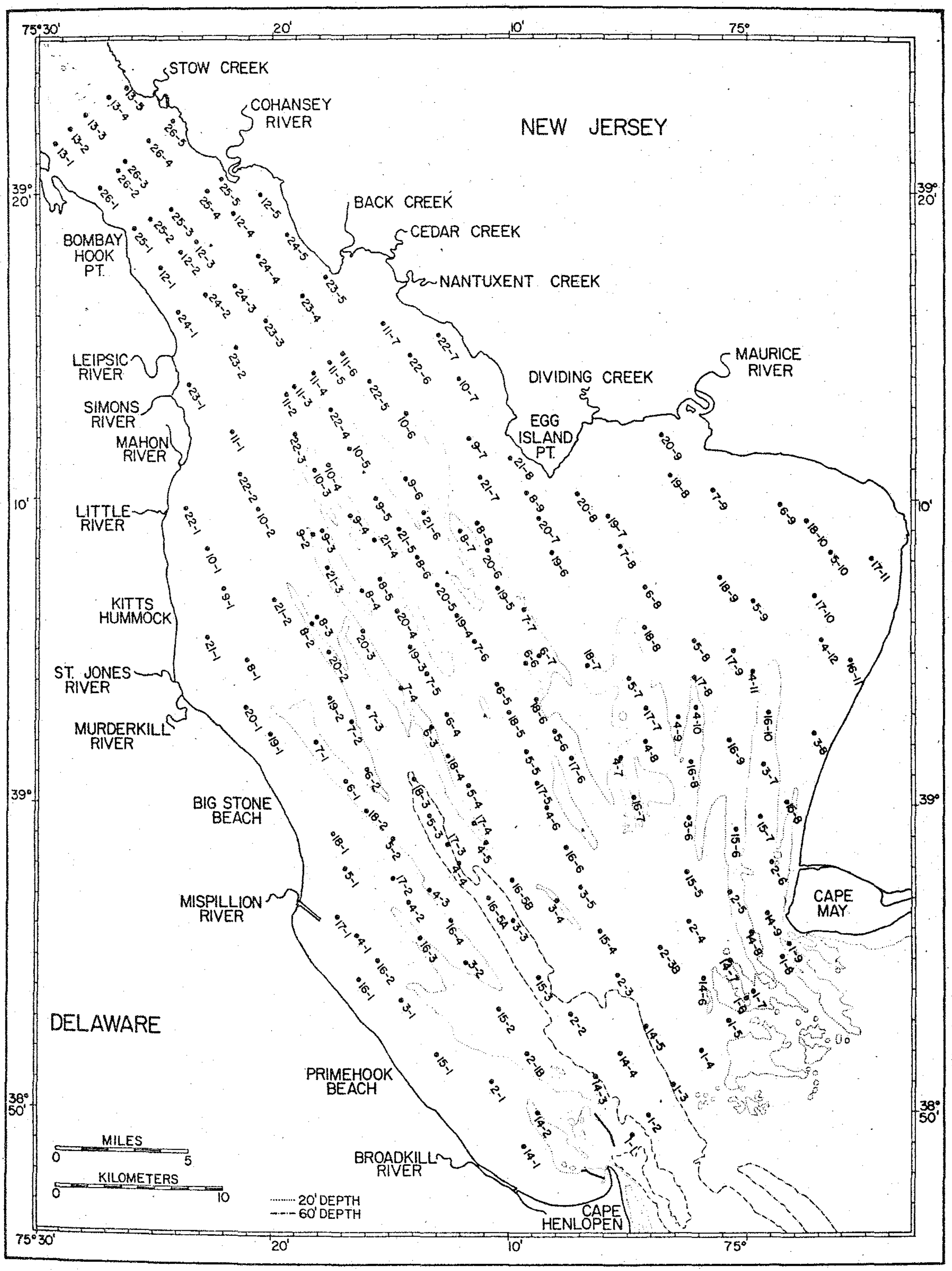
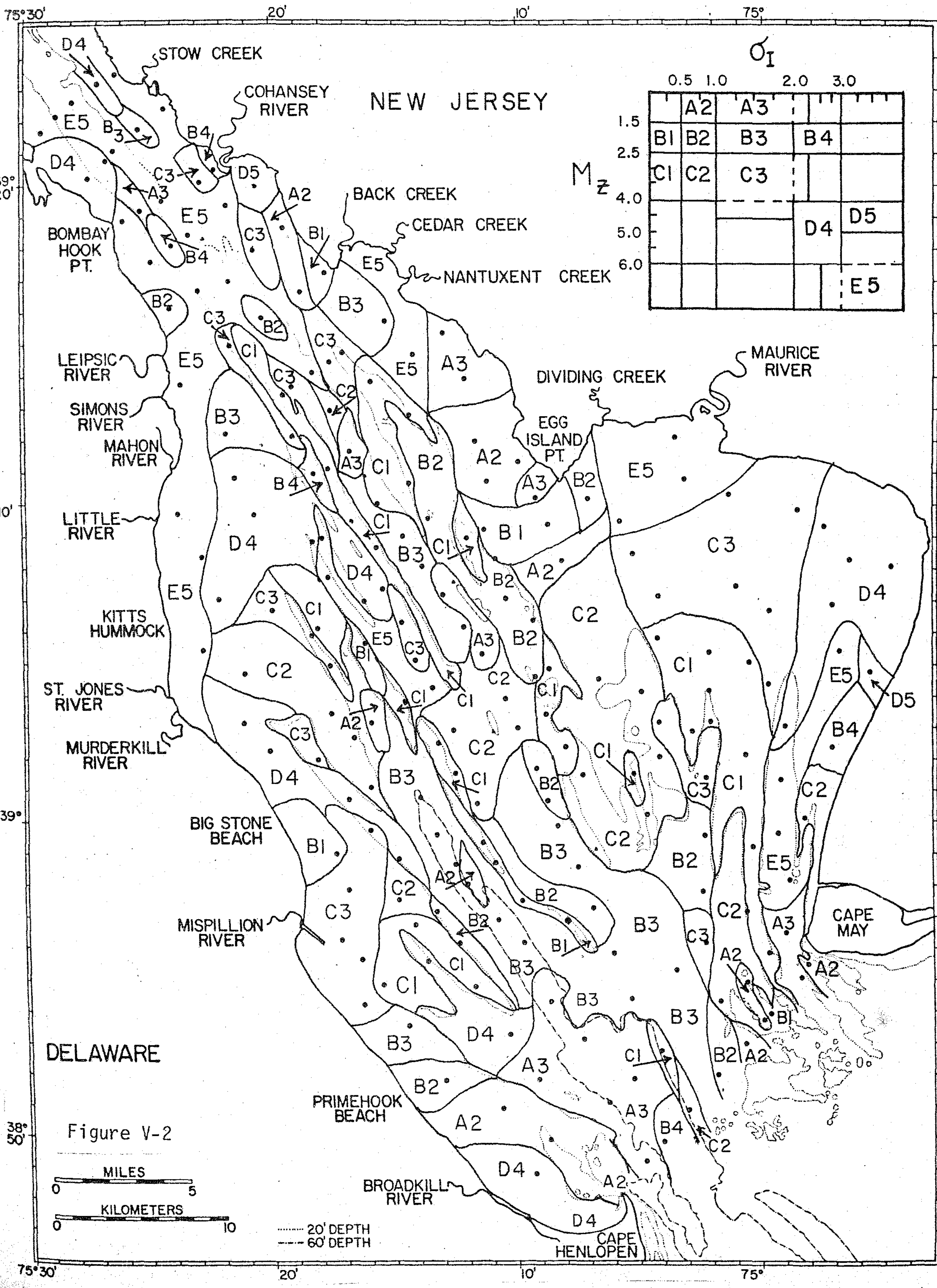
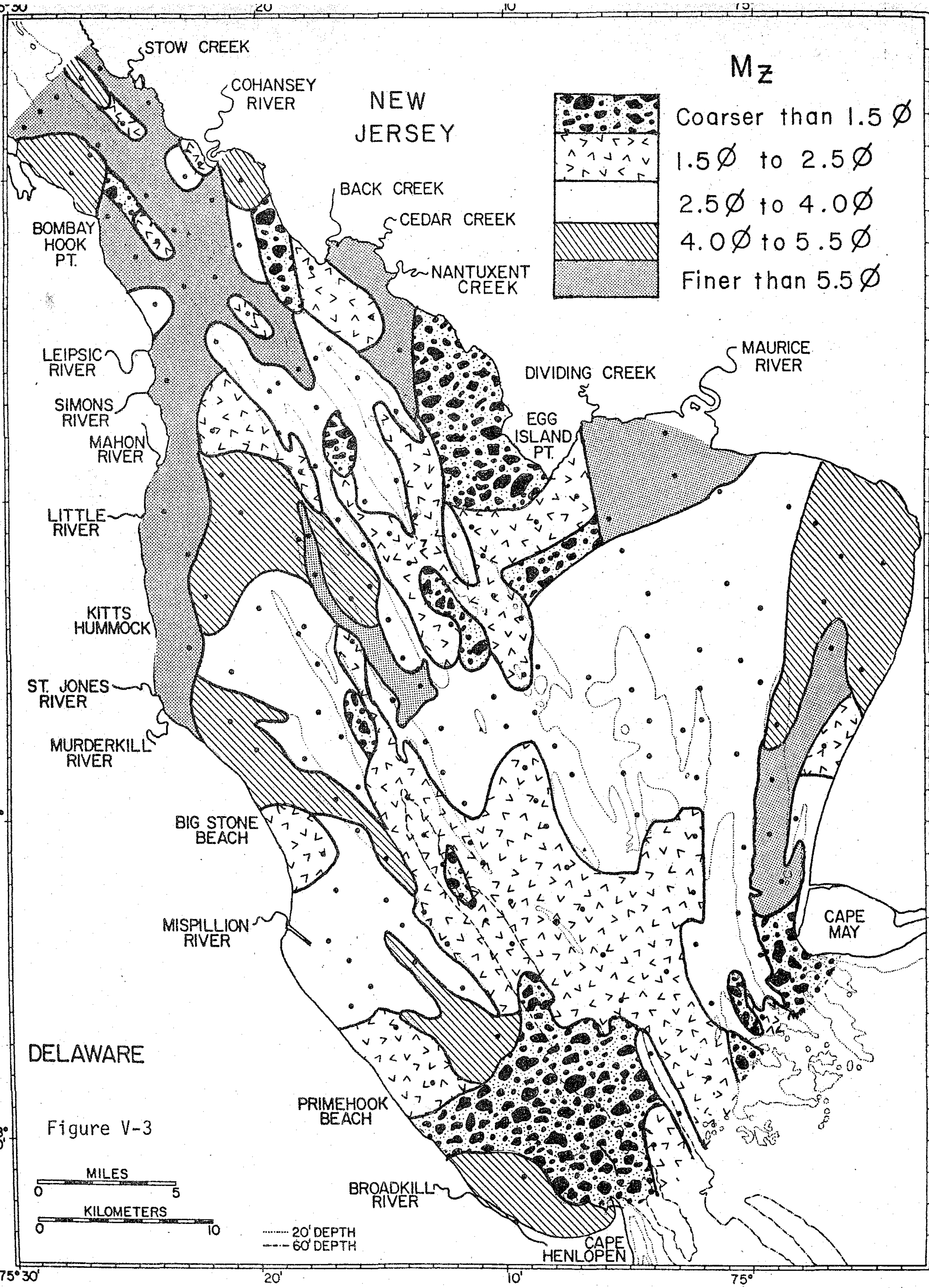

NEW JERSEY
DELAWARE
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
CAPE MAY
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'

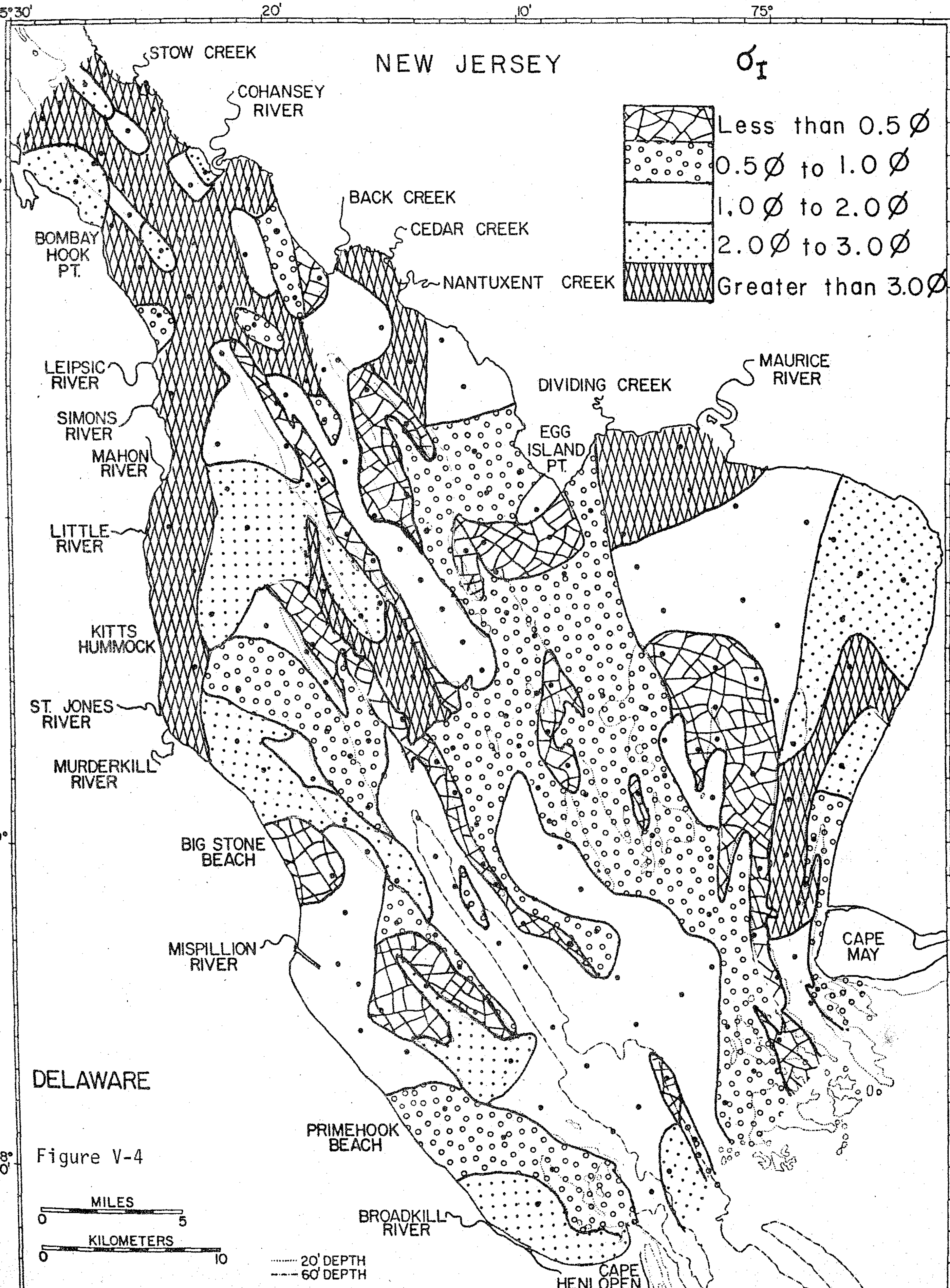
Figure V-1


75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
NEW JERSEY
DELAWARE
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
CAPE MAY
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
σ_I
0.5
1.0
2.0
3.0
M_z
1.5
2.5
4.0
5.0
6.0
A2
A3
B1
B2
B3
B4
C1
C2
C3
D4
D5
E5
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
Figure V-2



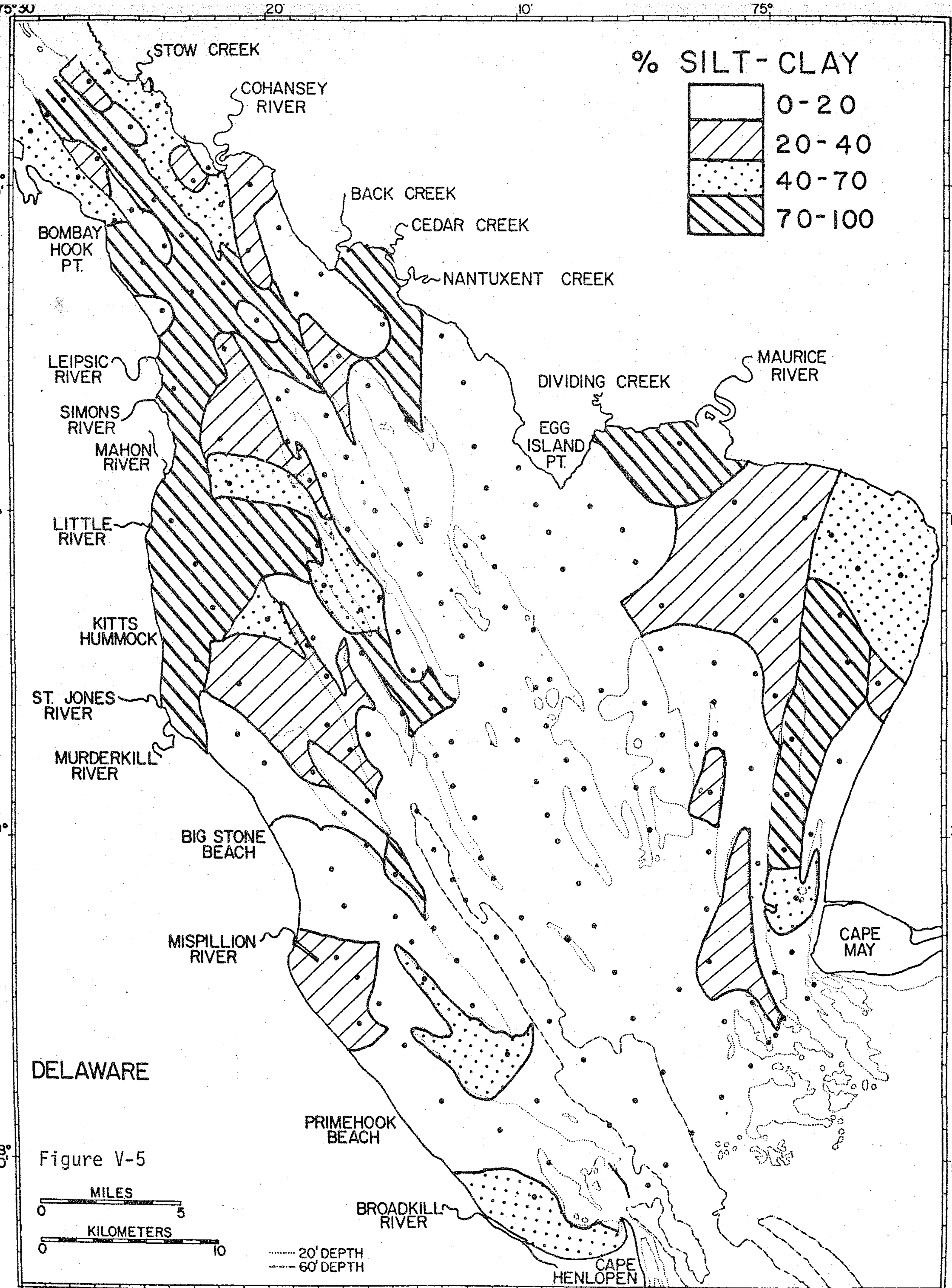
75°30'
20'
10'
75°
Mz
Coarser than 1.5 Ø
1.5 Ø to 2.5 Ø
2.5 Ø to 4.0 Ø
4.0 Ø to 5.5 Ø
Finer than 5.5 Ø
NEW JERSEY
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
39° 20'
10'
39°
38° 50'
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

Figure V-3



75°30'
20'
10'
75°
NEW JERSEY
σ_I
Less than 0.5 Ø
0.5 Ø to 1.0 Ø
1.0 Ø to 2.0 Ø
2.0 Ø to 3.0 Ø
Greater than 3.0 Ø
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
39° 20'
10'
39°
38° 50'
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

Figure V-4



75°30'
20'
10'
75°
% SILT-CLAY
0-20
20-40
40-70
70-100
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
BIG STONE BEACH
MISPILLION RIVER
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
39° 20'
10'
39°
38° 50'
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

Figure V-5

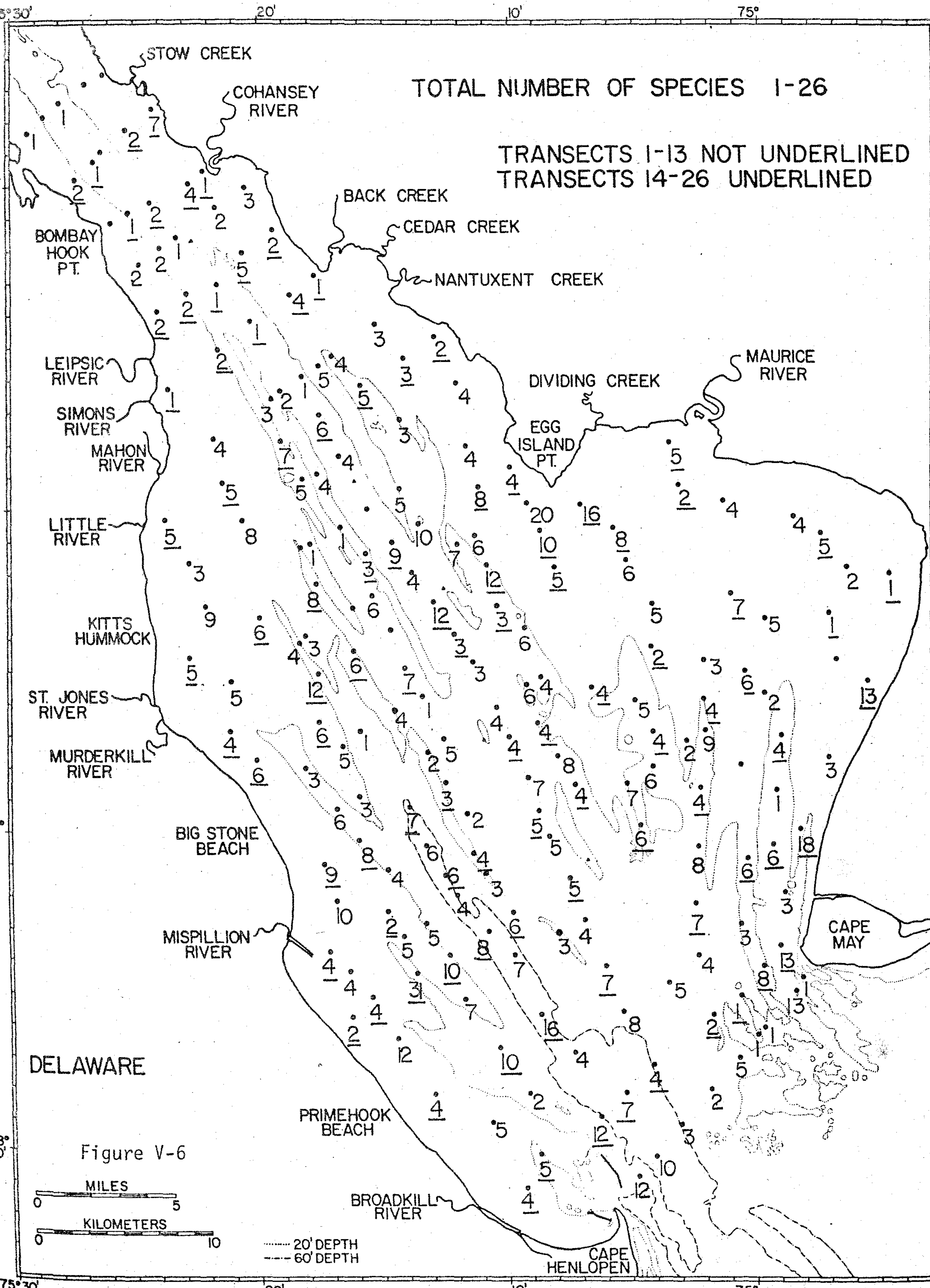
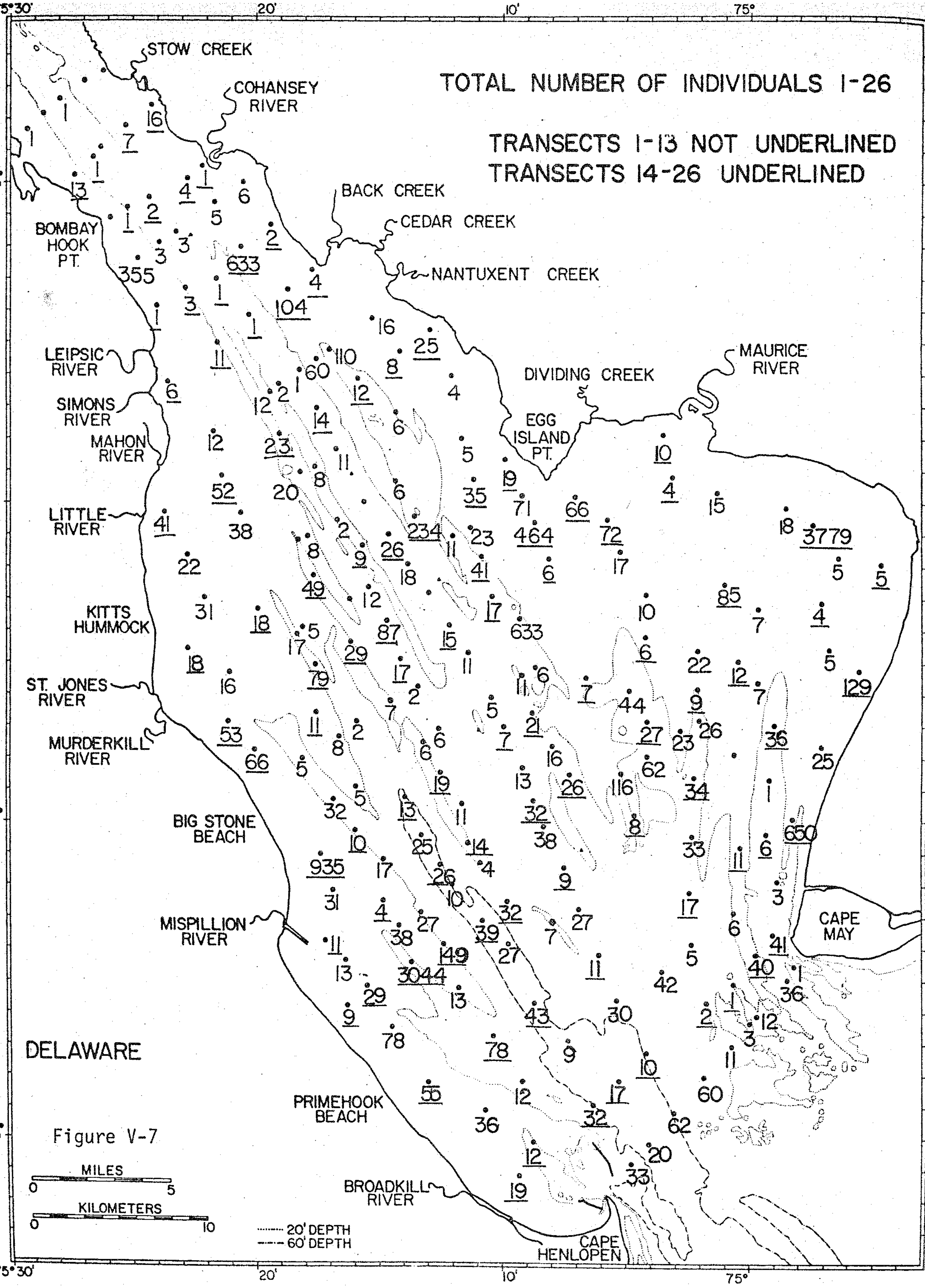
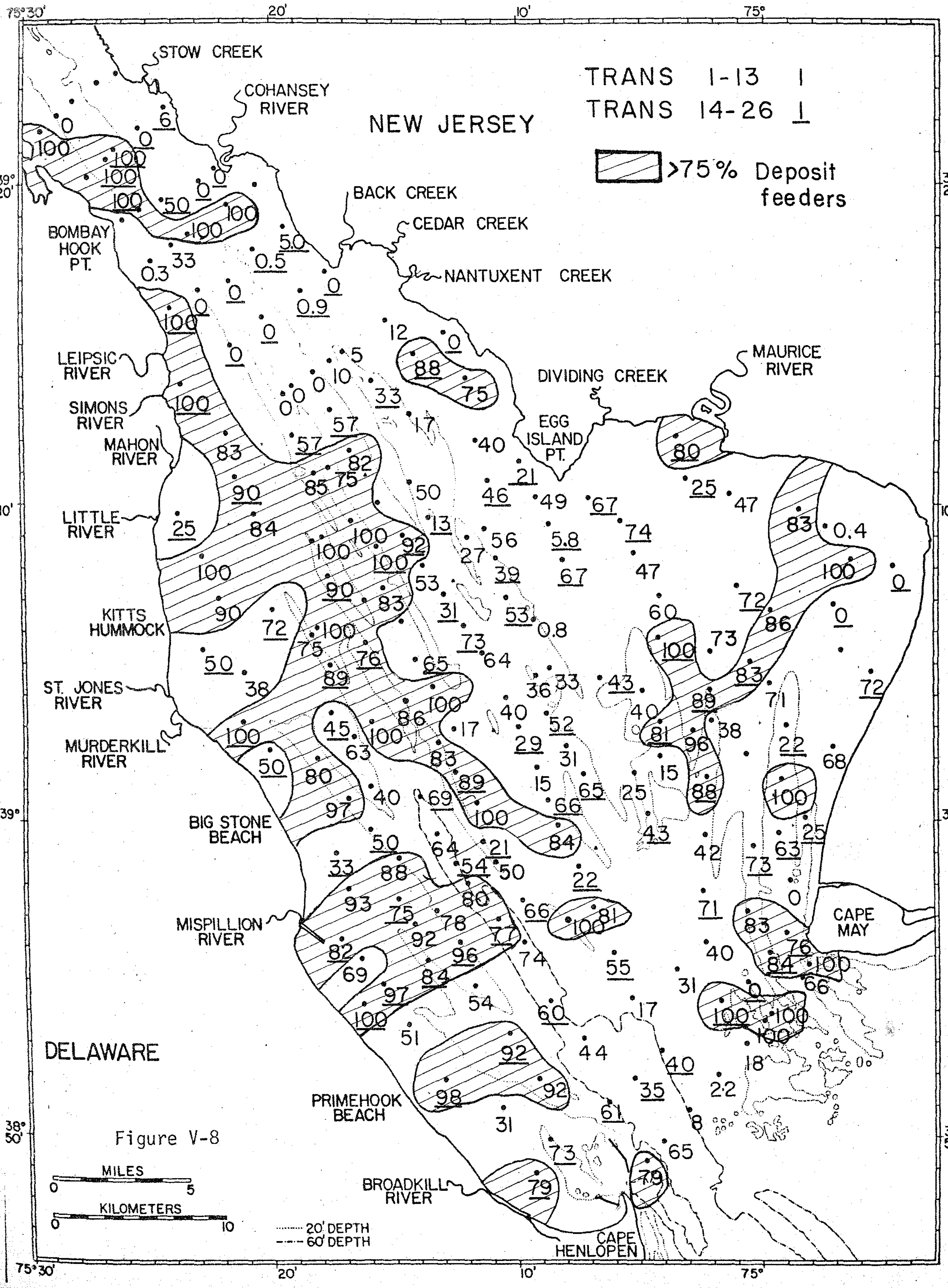

TOTAL NUMBER OF SPECIES 1-26
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

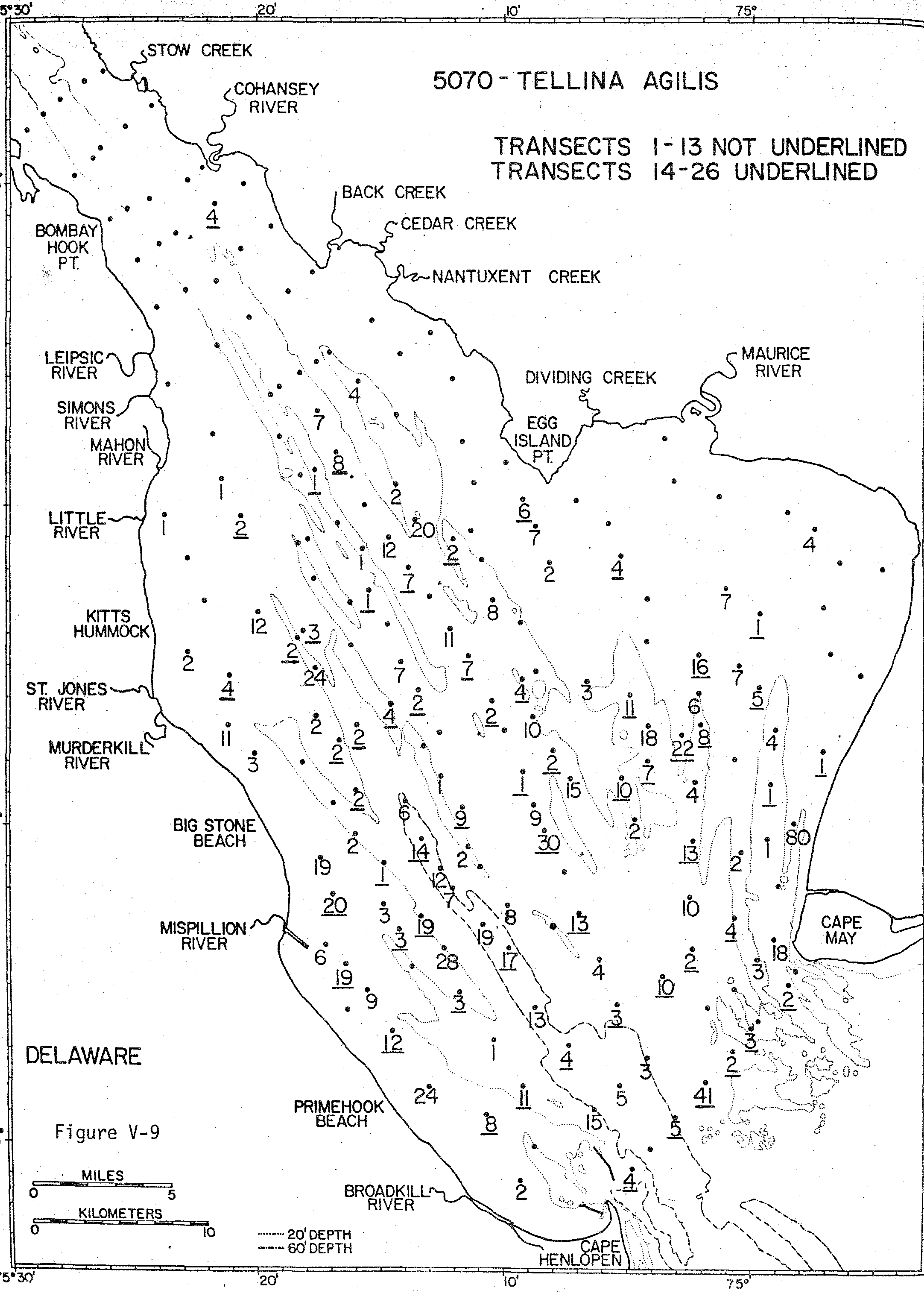
Figure V-6


TOTAL NUMBER OF INDIVIDUALS 1-26
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
DIVIDING CREEK
EGG ISLAND PT.
MAURICE RIVER
CAPE MAY
DELAWARE
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
Figure V-7



75°30'
20'
10'
75°
STOW CREEK
COHANSEY RIVER
NEW JERSEY
TRANS 1-13 I
TRANS 14-26 I
>75% Deposit feeders
39° 20'
BACK CREEK
CEDAR CREEK
BOMBAY HOOK PT.
NANTUXENT CREEK
LEIPSIC RIVER
MAURICE RIVER
DIVIDING CREEK
SIMONS RIVER
EGG ISLAND PT.
MAHON RIVER
10'
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
39°
BIG STONE BEACH
MISPILLION RIVER
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
38° 50'
MILES
0
5
KILOMETERS
0
10
BROADKILL RIVER
20' DEPTH
60' DEPTH
CAPE HENLOPEN

Figure V-8


5070 - TELLINA AGILIS
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
DIVIDING CREEK
EGG ISLAND PT.
MAURICE RIVER
CAPE MAY
DELAWARE
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
Figure V-9

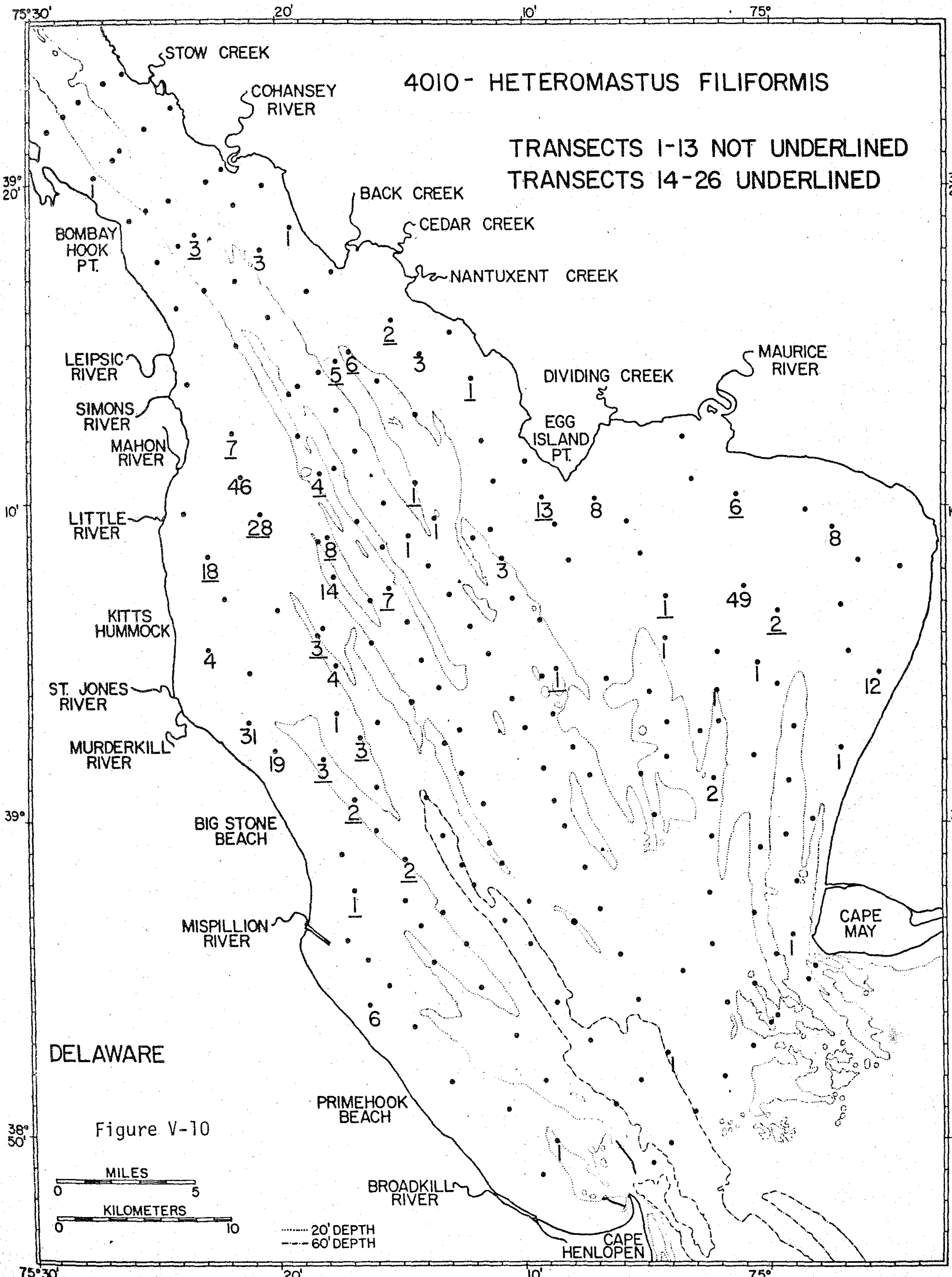

4010- HETEROMASTUS FILIFORMIS
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

Figure V-10

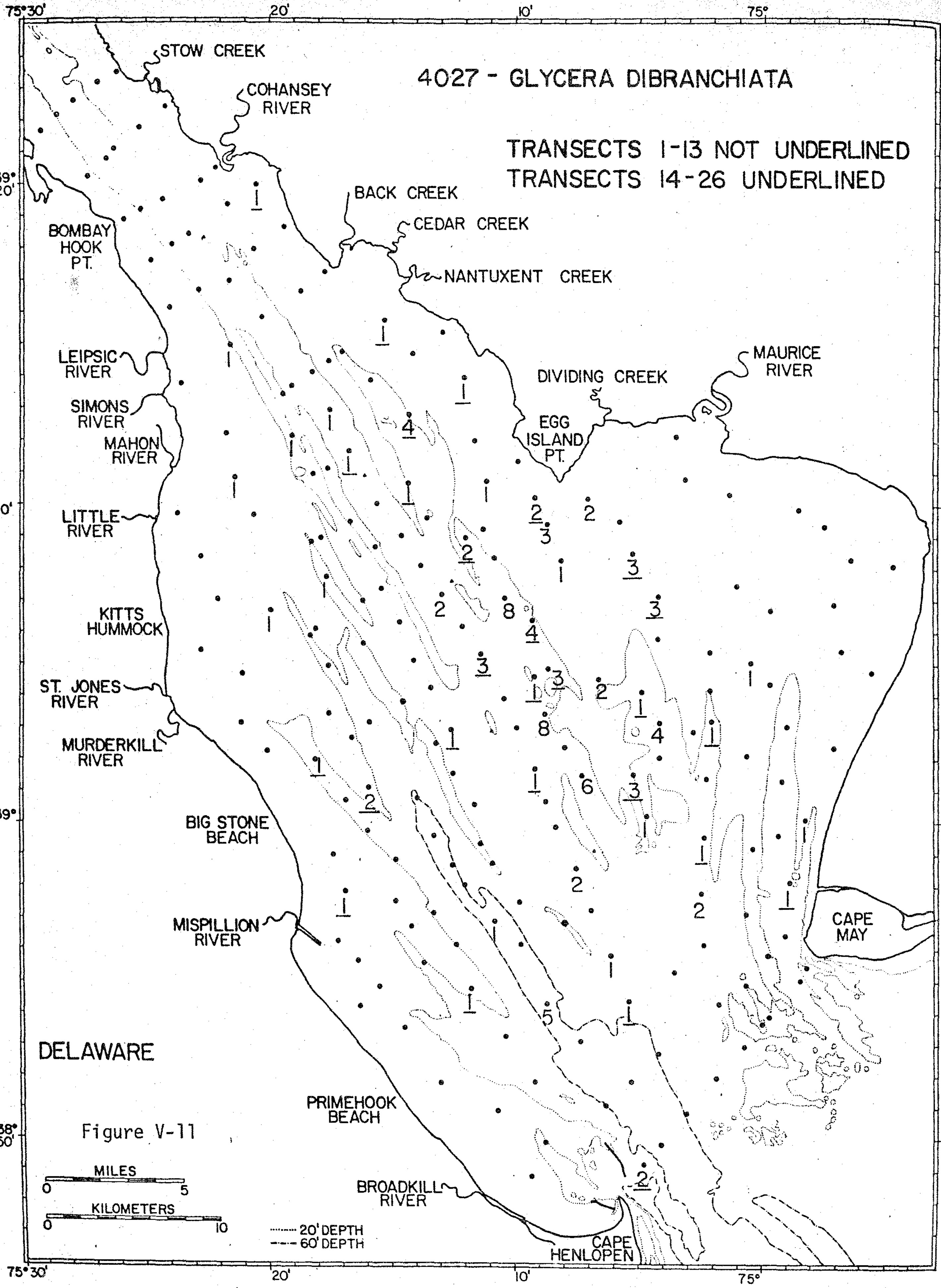
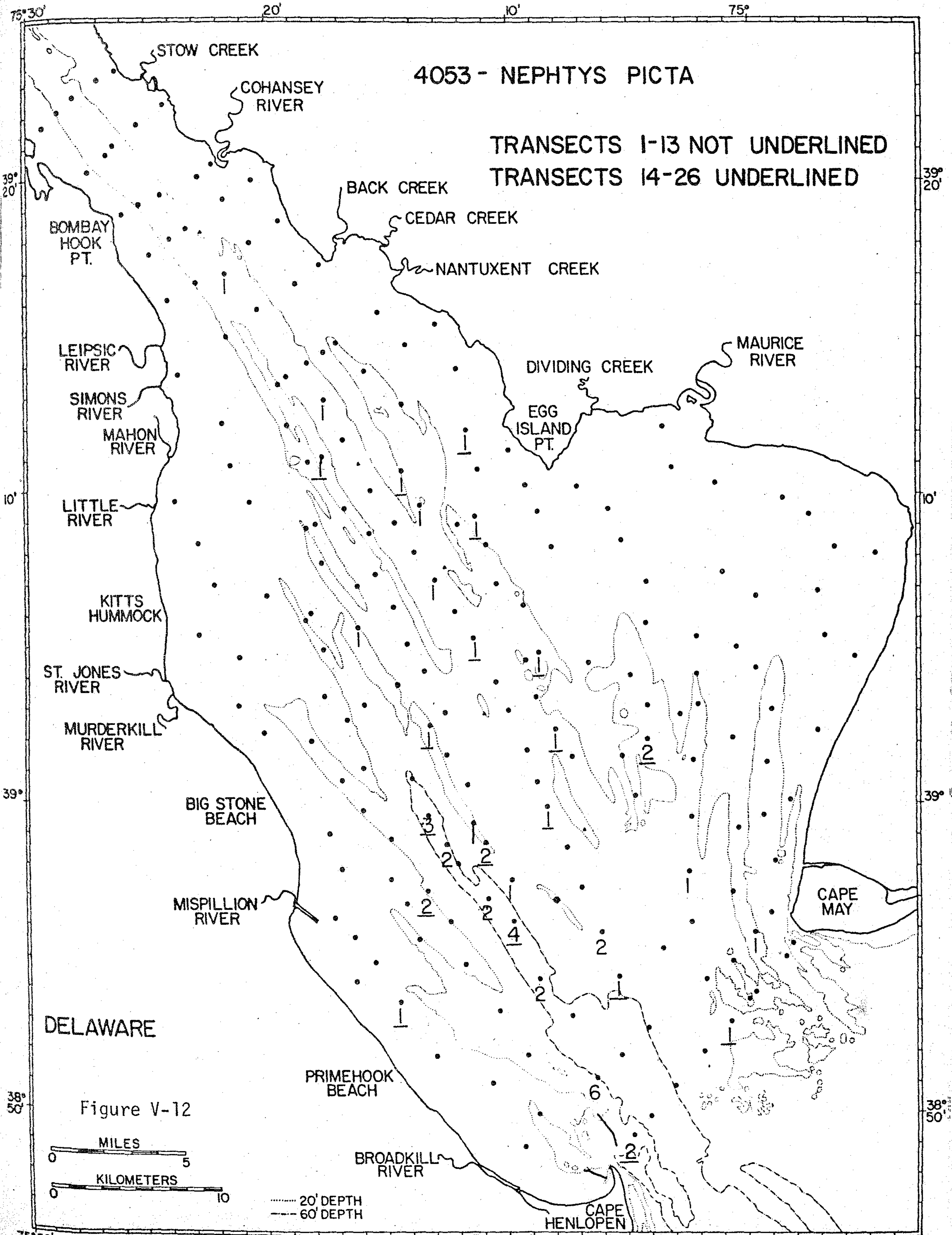
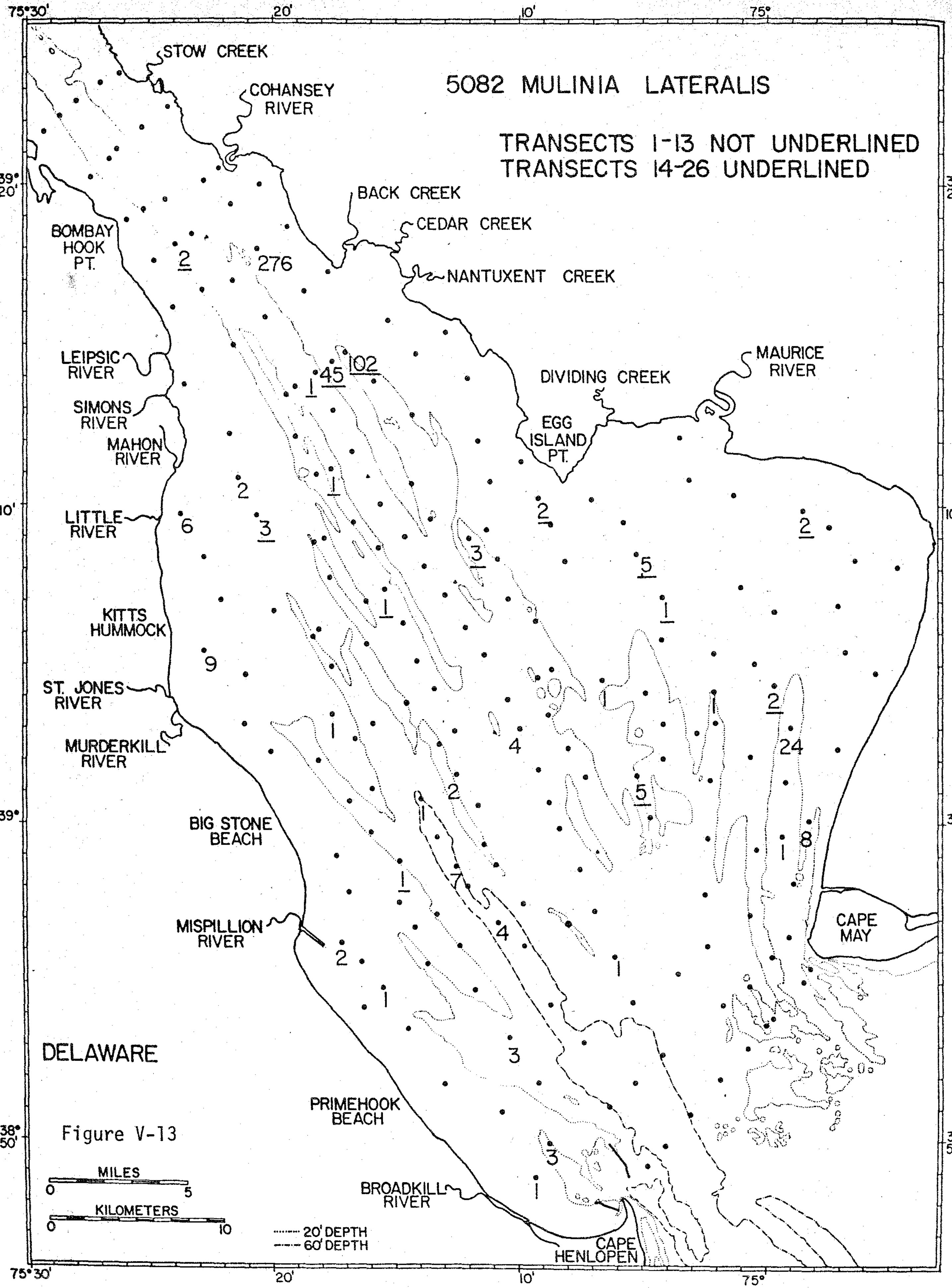
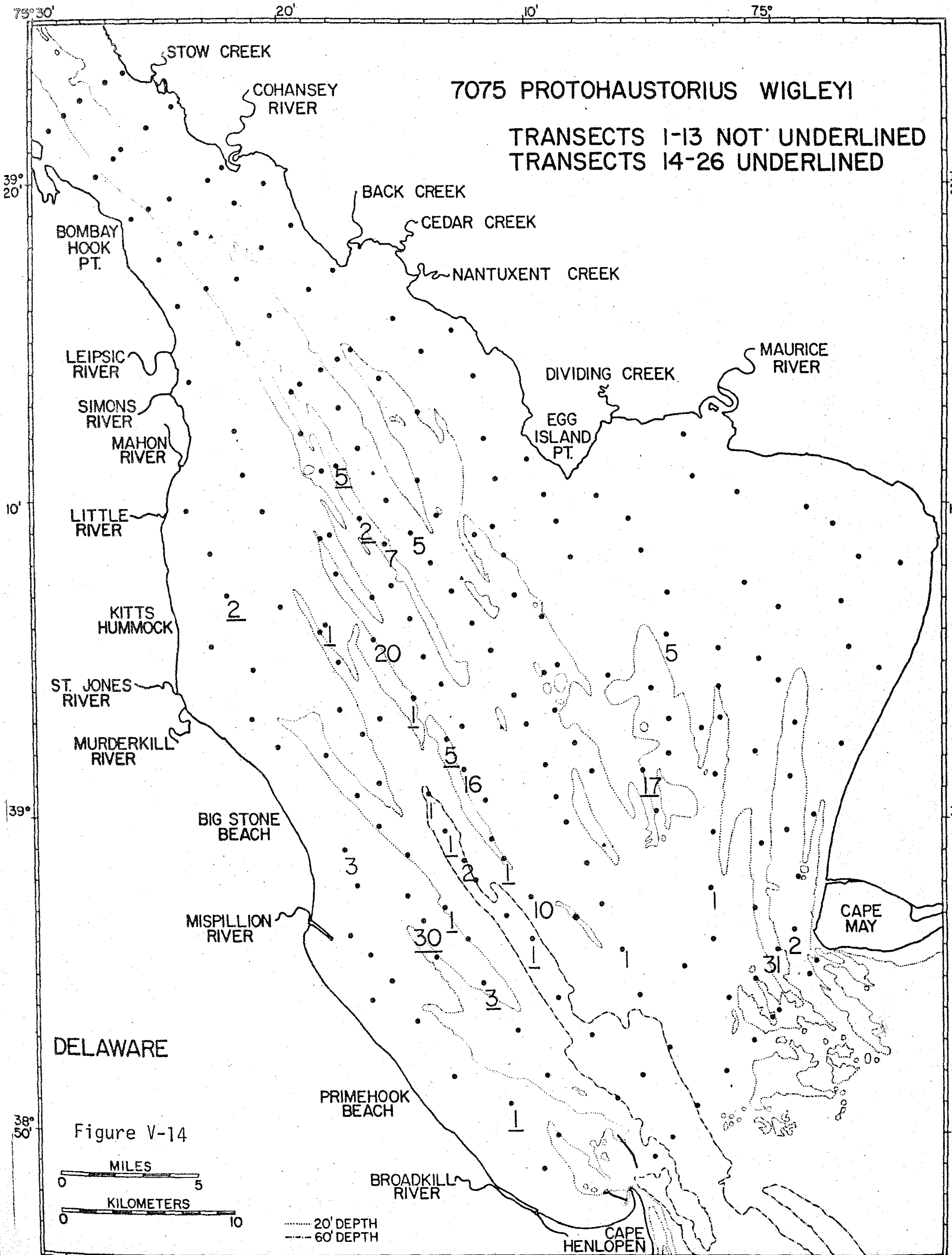

4027 - GLYCERA DIBRANCHIATA
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
CAPE MAY
DELAWARE
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

Figure V-11

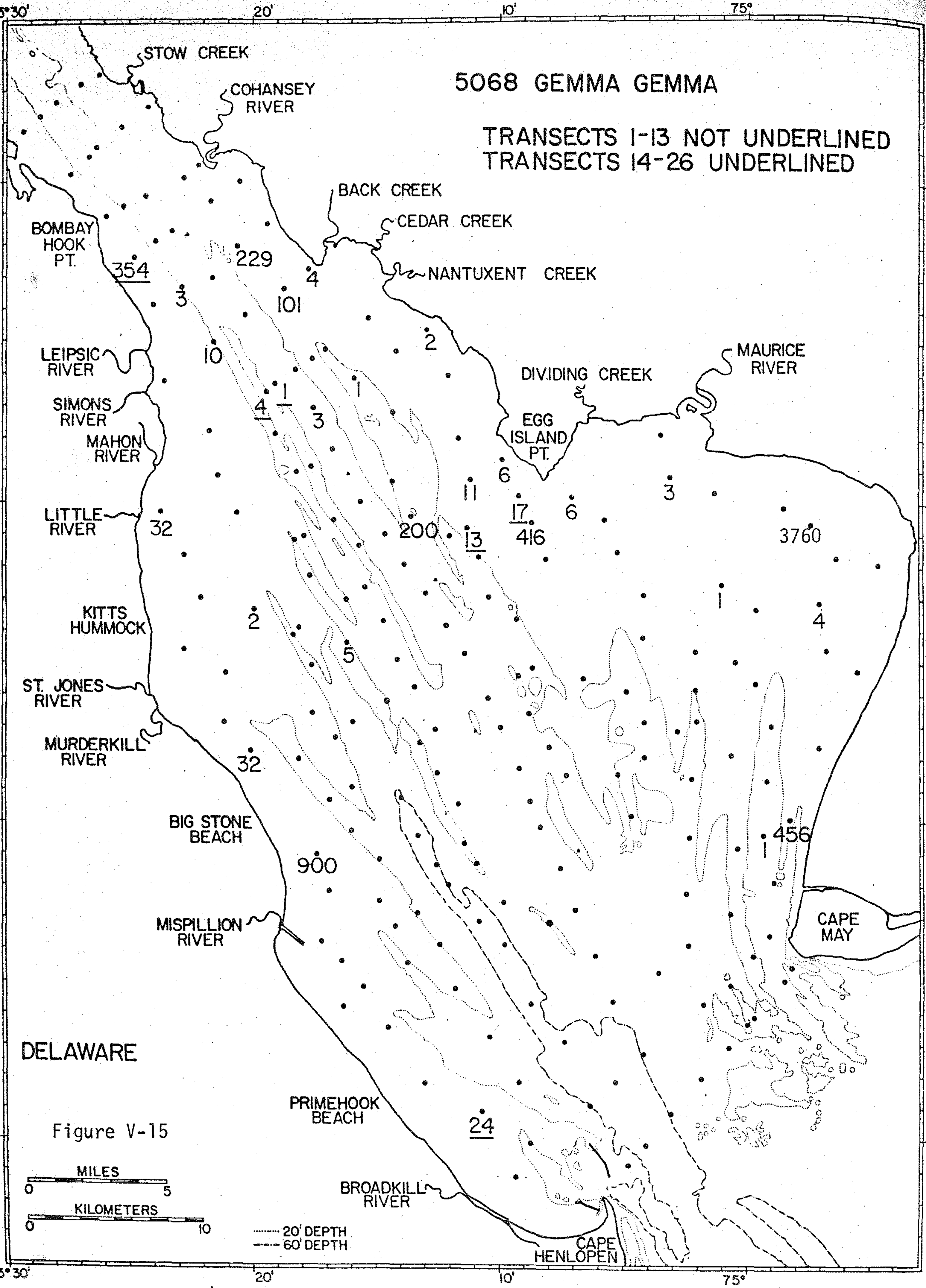

4053 - NEPHTYS PICTA
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
Figure V-12


5082 MULINIA LATERALIS
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
CAPE MAY
DELAWARE
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
Figure V-13



7075 PROTOHAUSTORIUS WIGLEYI
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
DIVIDING CREEK
EGG ISLAND PT.
MAURICE RIVER
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

Figure V-14


5068 GEMMA GEMMA
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
CAPE MAY
DELAWARE
229
354
4
3
101
2
10
1
4
1
3
6
11
17
6
3
32
200
13
416
3760
1
4
2
5
32
456
1
900
24
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
Figure V-15

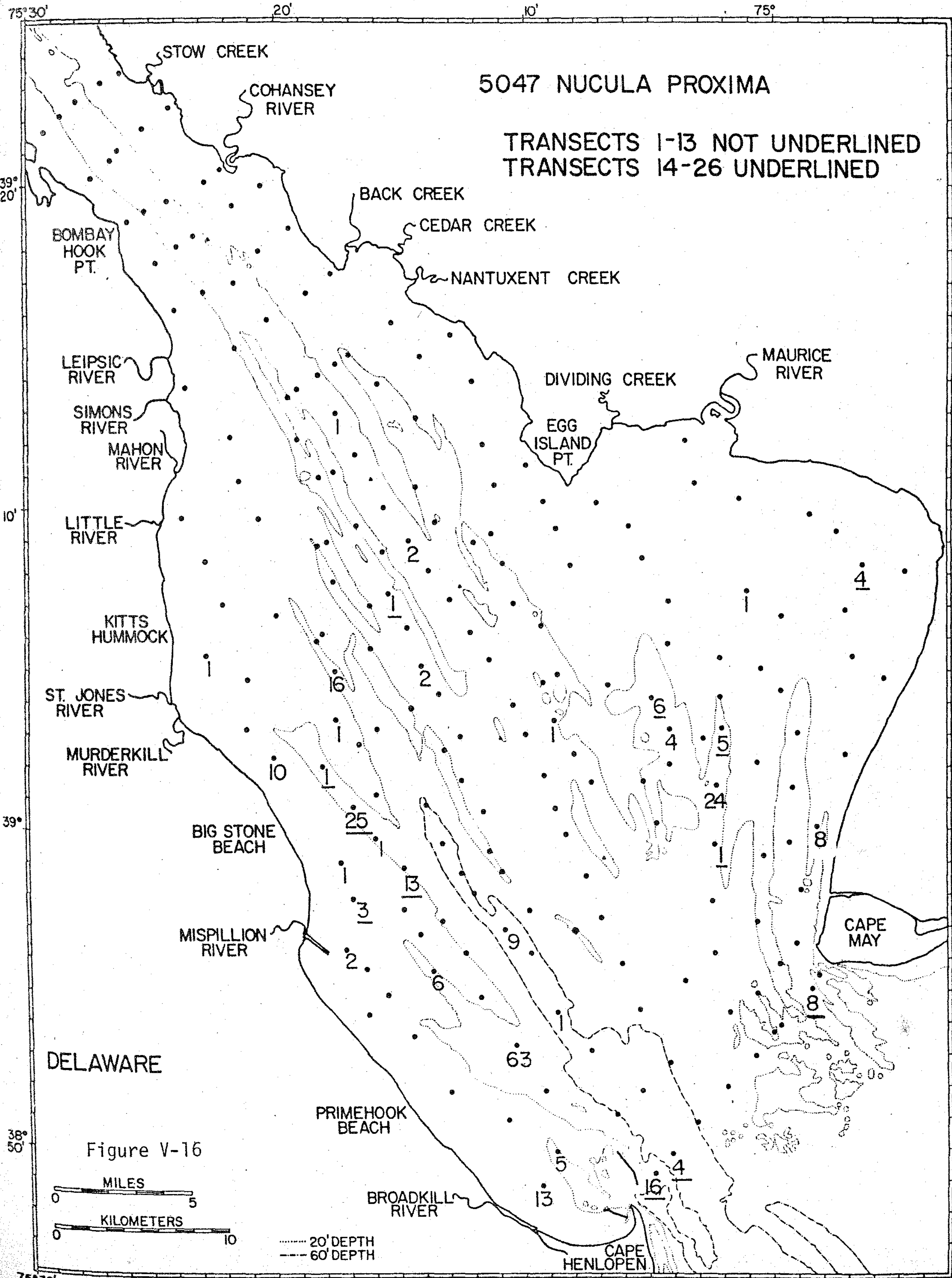
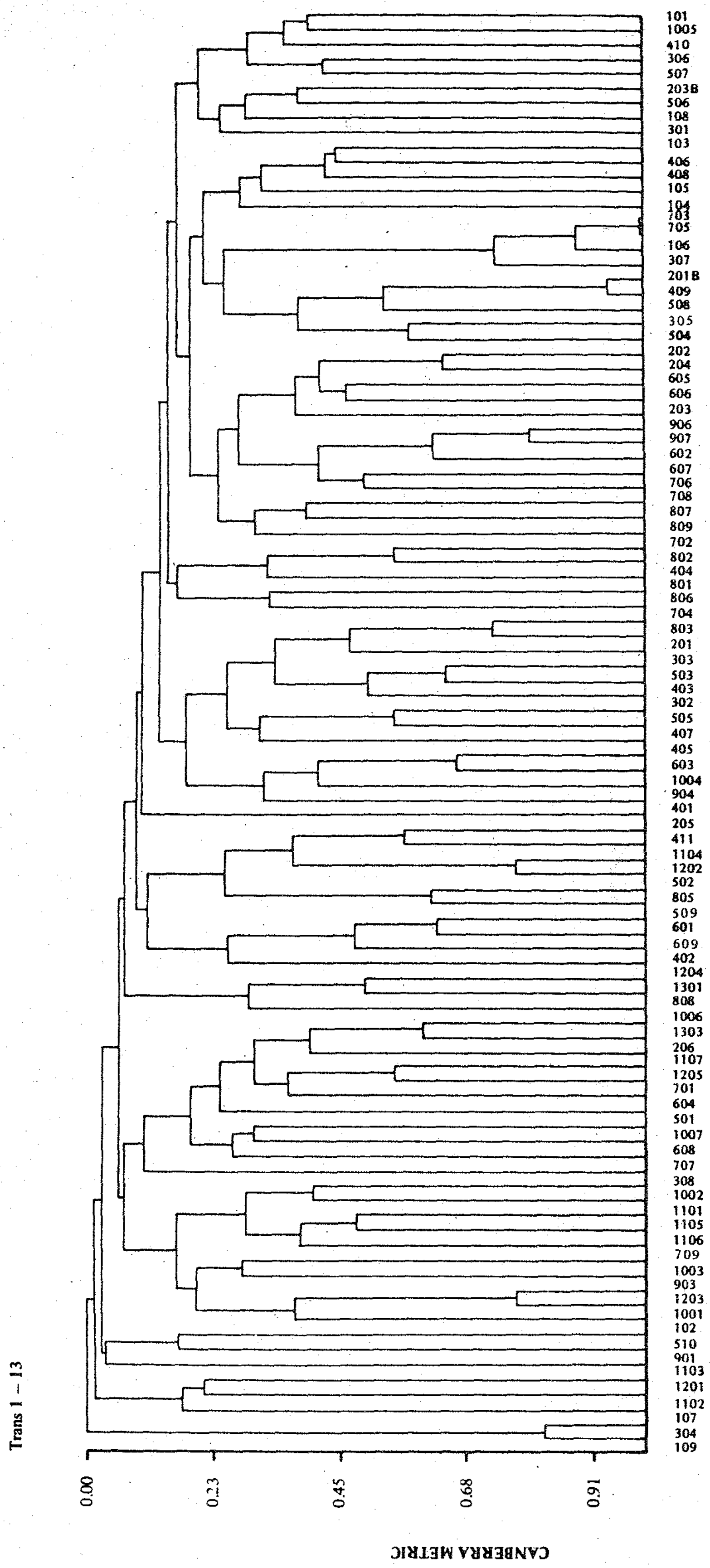
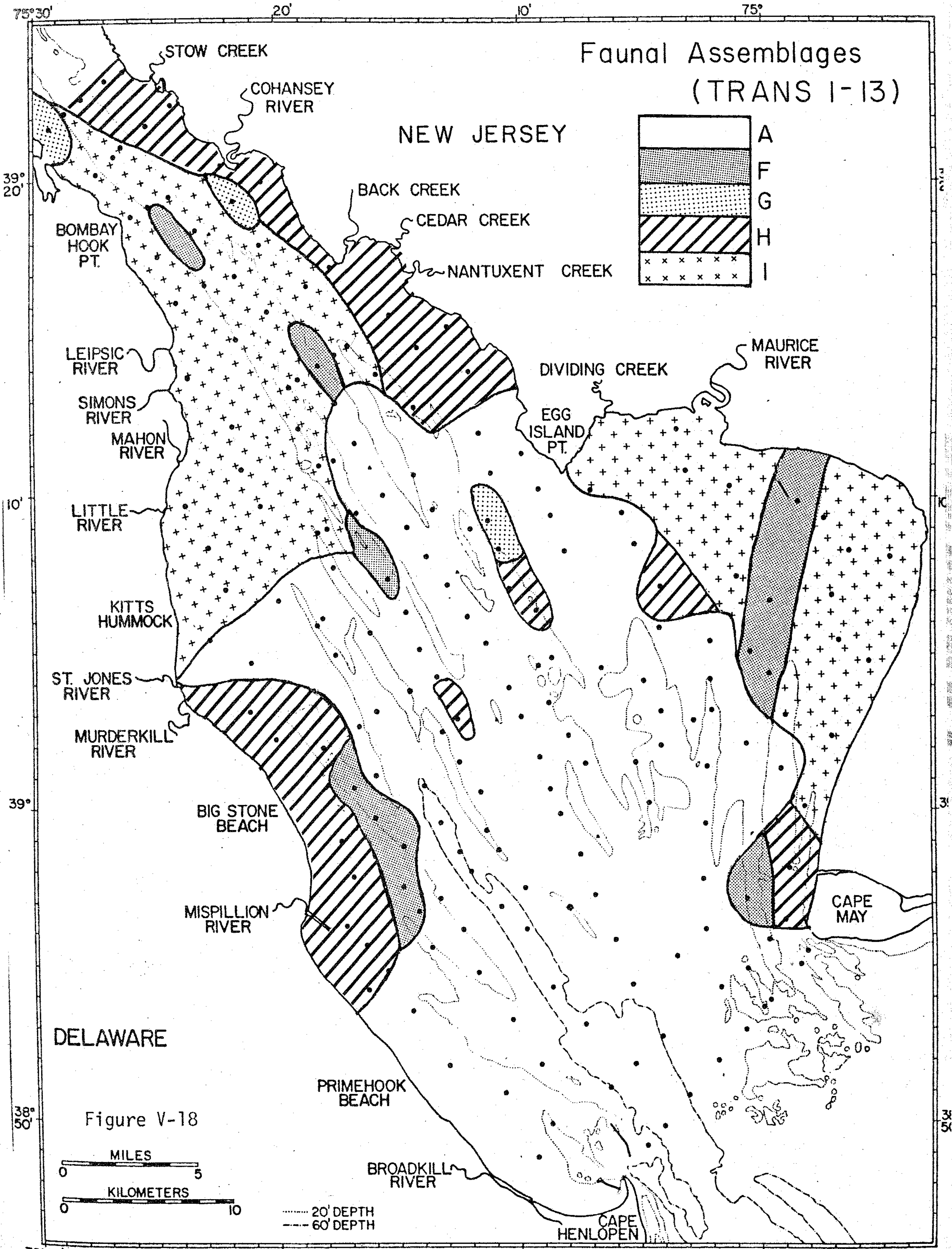

5047 NUCULA PROXIMA
TRANSECTS 1-13 NOT UNDERLINED
TRANSECTS 14-26 UNDERLINED
75°30'
20'
10'
75°
39° 20'
10'
39°
38° 50'
STOW CREEK
COHANSEY RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
BOMBAY HOOK PT.
LEIPSIC RIVER
SIMONS RIVER
MAHON RIVER
DIVIDING CREEK
MAURICE RIVER
EGG ISLAND PT.
LITTLE RIVER
KITTS HUMMOCK
ST. JONES RIVER
MURDERKILL RIVER
BIG STONE BEACH
MISPILLION RIVER
CAPE MAY
DELAWARE
PRIMEHOOK BEACH
BROADKILL RIVER
CAPE HENLOPEN
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH

Figure V-16



Trans 1 – 13
101
1005
410
306
507
203B
506
108
301
103
406
408
105
104
703
705
106
307
201B
409
508
305
504
202
204
605
606
203
906
907
602
607
706
708
807
809
702
802
404
801
806
704
803
201
303
503
403
302
505
407
405
603
1004
904
401
205
411
1104
1202
502
805
509
601
609
402
1204
1301
808
1006
1303
206
1107
1205
701
604
501
1007
608
707
308
1002
1101
1105
1106
709
1003
903
1203
1001
102
510
901
1103
1201
1102
107
304
109
0.00
0.23
0.45
0.68
0.91
CANBERRA METRIC

Figure V-17


75°30'
20'
10'
75°
Faunal Assemblages
(TRANS 1-13)
A
F
G
H
I
NEW JERSEY
STOW CREEK
COHANSEY
RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
DIVIDING CREEK
MAURICE
RIVER
EGG
ISLAND
PT.
BOMBAY
HOOK
PT.
LEIPSIC
RIVER
SIMONS
RIVER
MAHON
RIVER
LITTLE
RIVER
KITTS
HUMMOCK
ST. JONES
RIVER
MURDERKILL
RIVER
BIG STONE
BEACH
MISPILLION
RIVER
CAPE
MAY
DELAWARE
PRIMEHOOK
BEACH
BROADKILL
RIVER
CAPE
HENLOPEN
39°
20'
10'
39°
38°
50'
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
Figure V-18

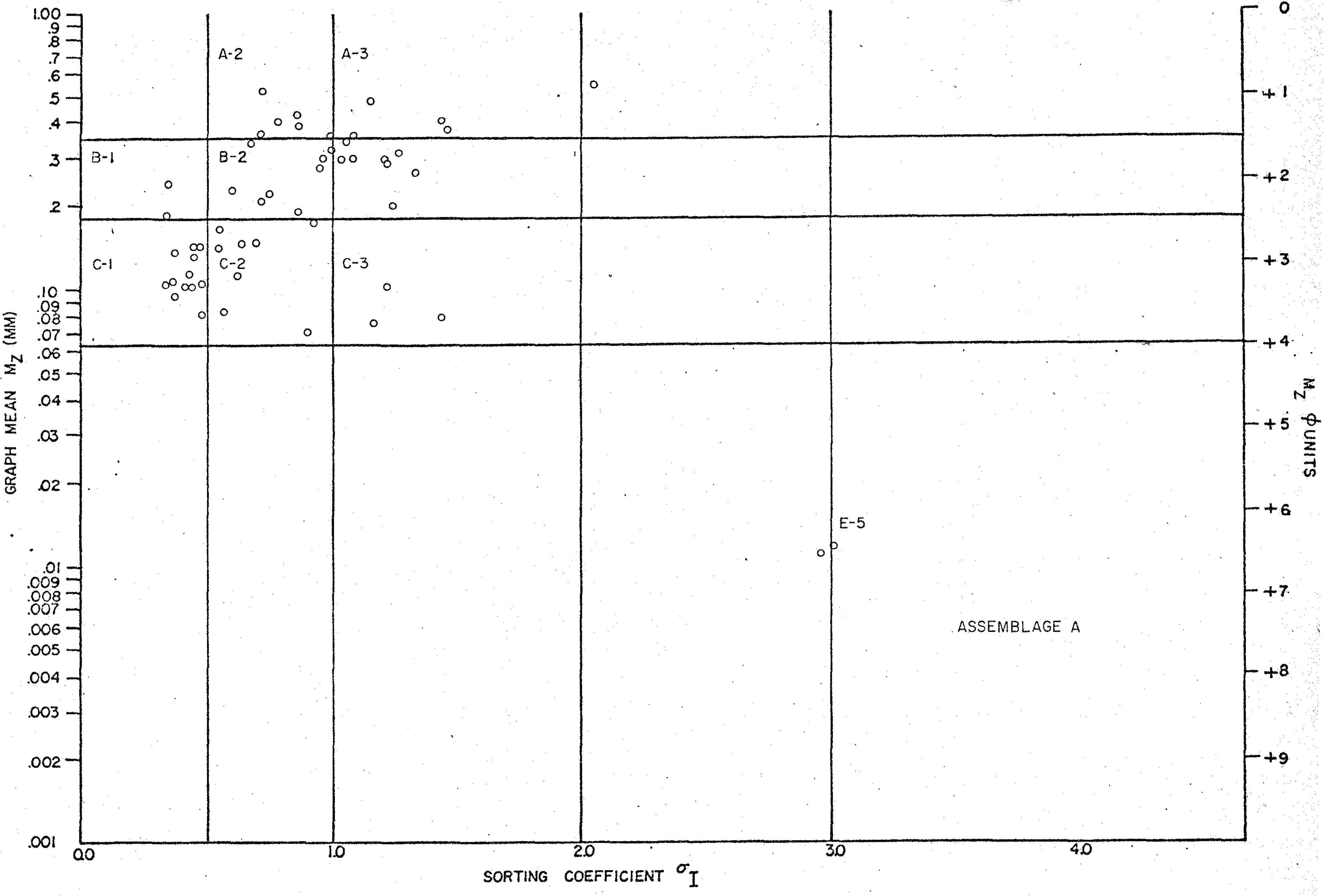
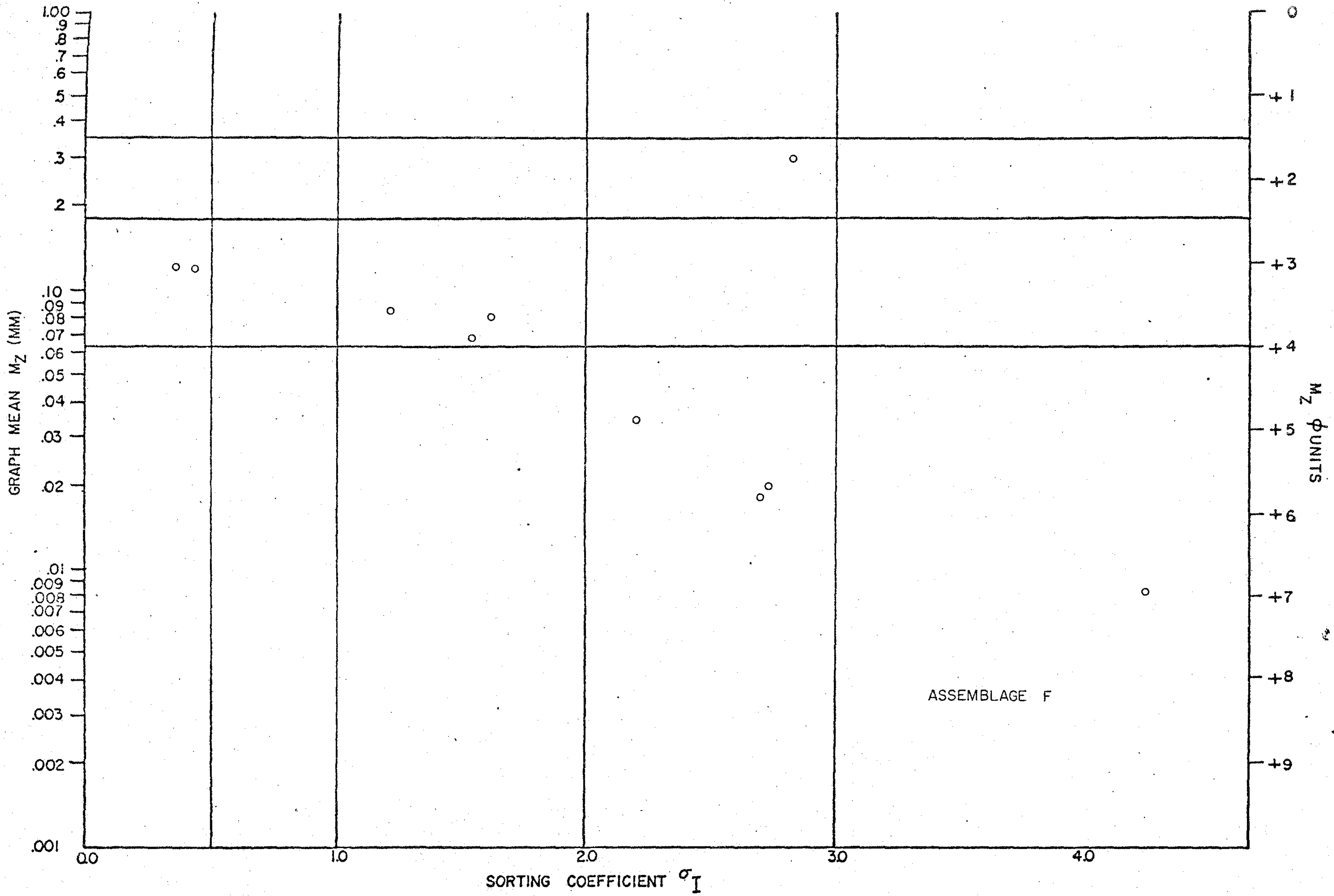

GRAPH MEAN M_Z (MM)
1.00
.9
.8
.7
.6
.5
.4
.3
.2
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
.009
.008
.007
.006
.005
.004
.003
.002
.001
A-2
A-3
B-1
B-2
C-1
C-2
C-3
E-5
ASSEMBLAGE A
0.0
1.0
2.0
3.0
4.0
SORTING COEFFICIENT σ_I
0
+1
+2
+3
+4
+5
+6
+7
+8
+9
M_Z ϕ UNITS

Figure V-19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1.0
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4.0
SORTING COEFFICIENT σ_I
M_Z ϕ UNITS
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+1
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+4
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+8
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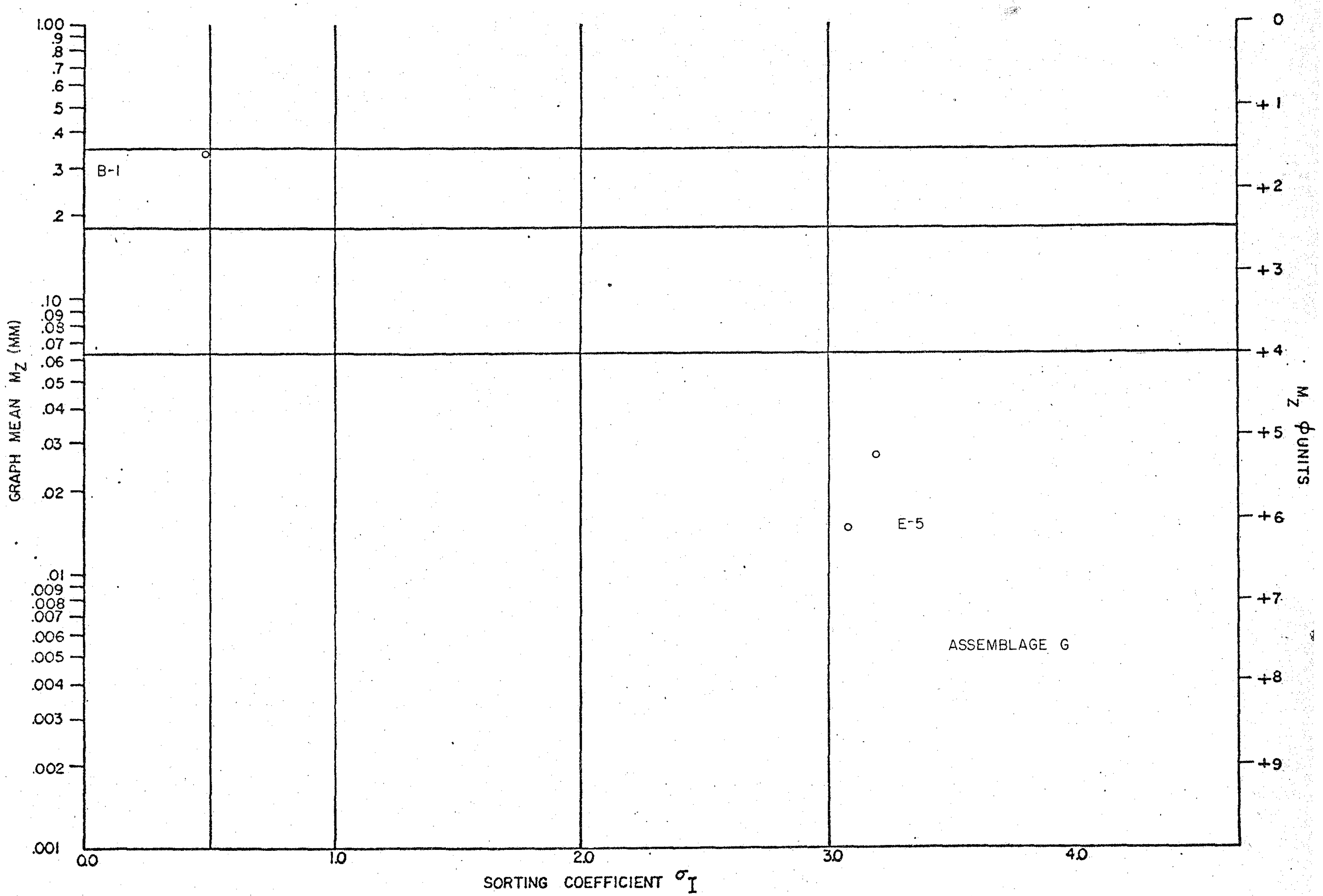
ASSEMBLAGE F

Figure V-20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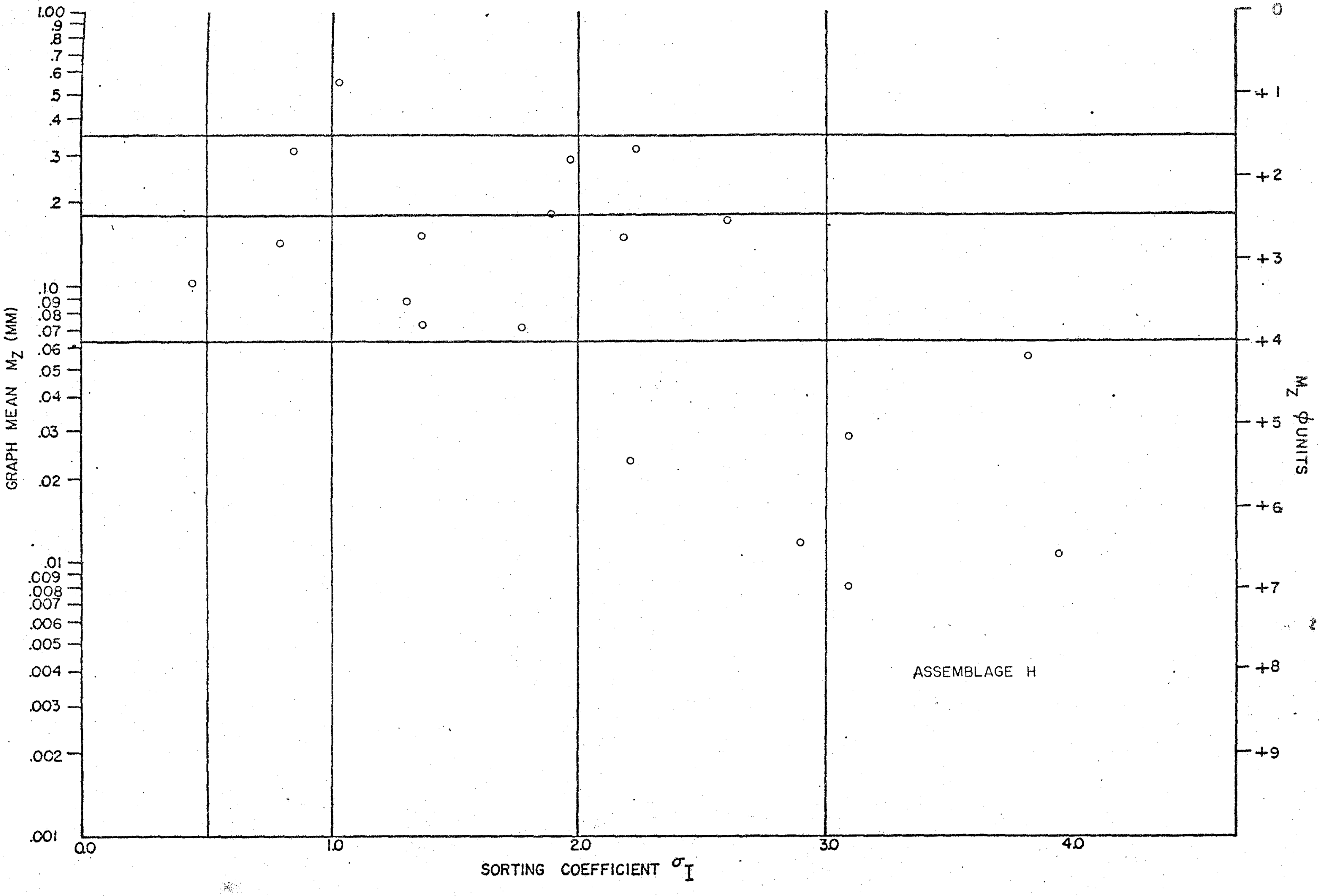
1.0
2.0
3.0
4.0
SORTING COEFFICIENT σ_I
B-1
E-5
ASSEMBLAGE G
0
+1
+2
+3
+4
+5
+6
+7
+8
+9
M_Z ϕ UNITS

Figure V-21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SORTING COEFFICIENT σ_I
M_Z ϕ UNITS
0
+1
+2
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+6
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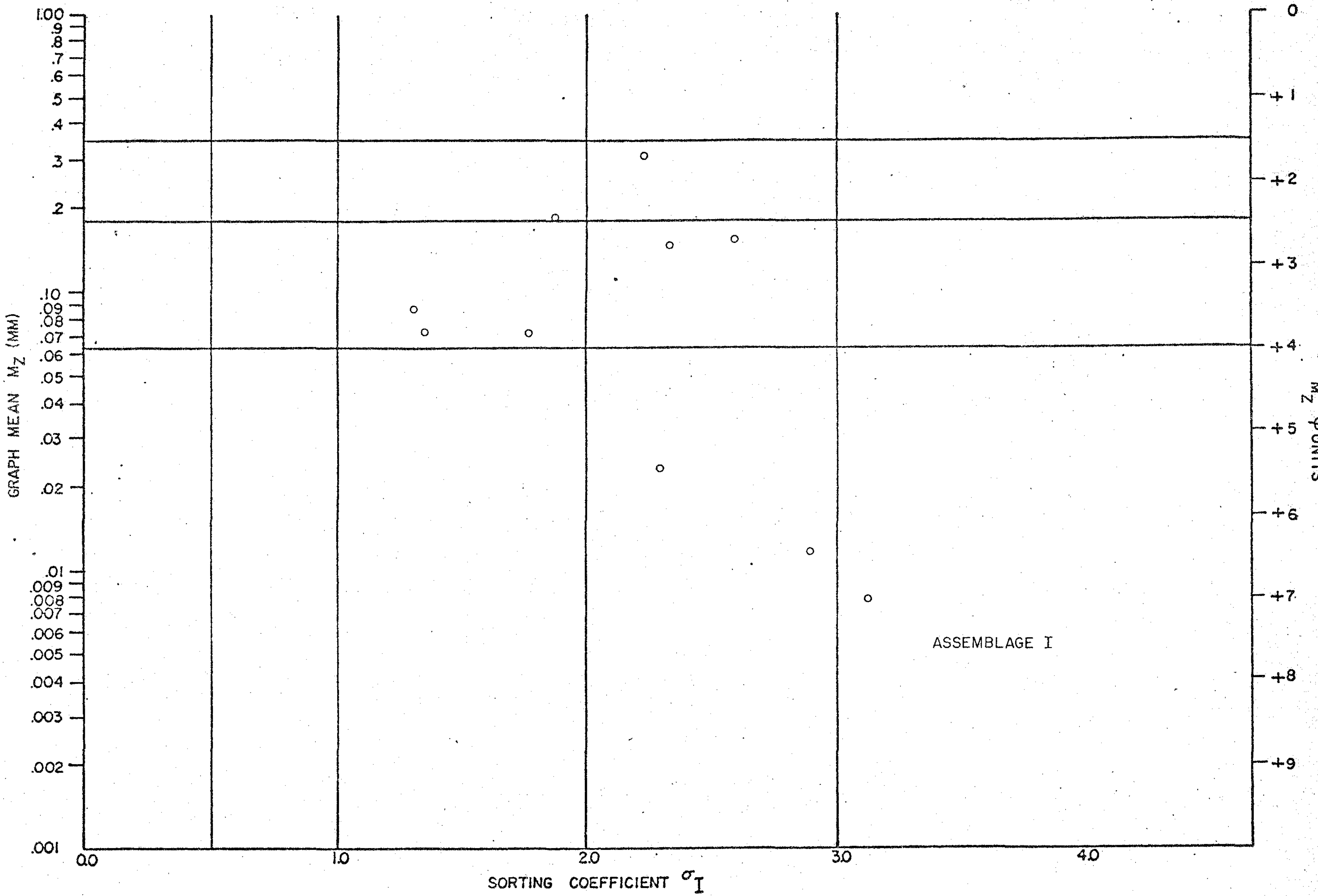
+9
ASSEMBLAGE H

Figure V-22



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GRAPH MEAN M_Z (MM)
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SORTING COEFFICIENT σ_I
0
+1
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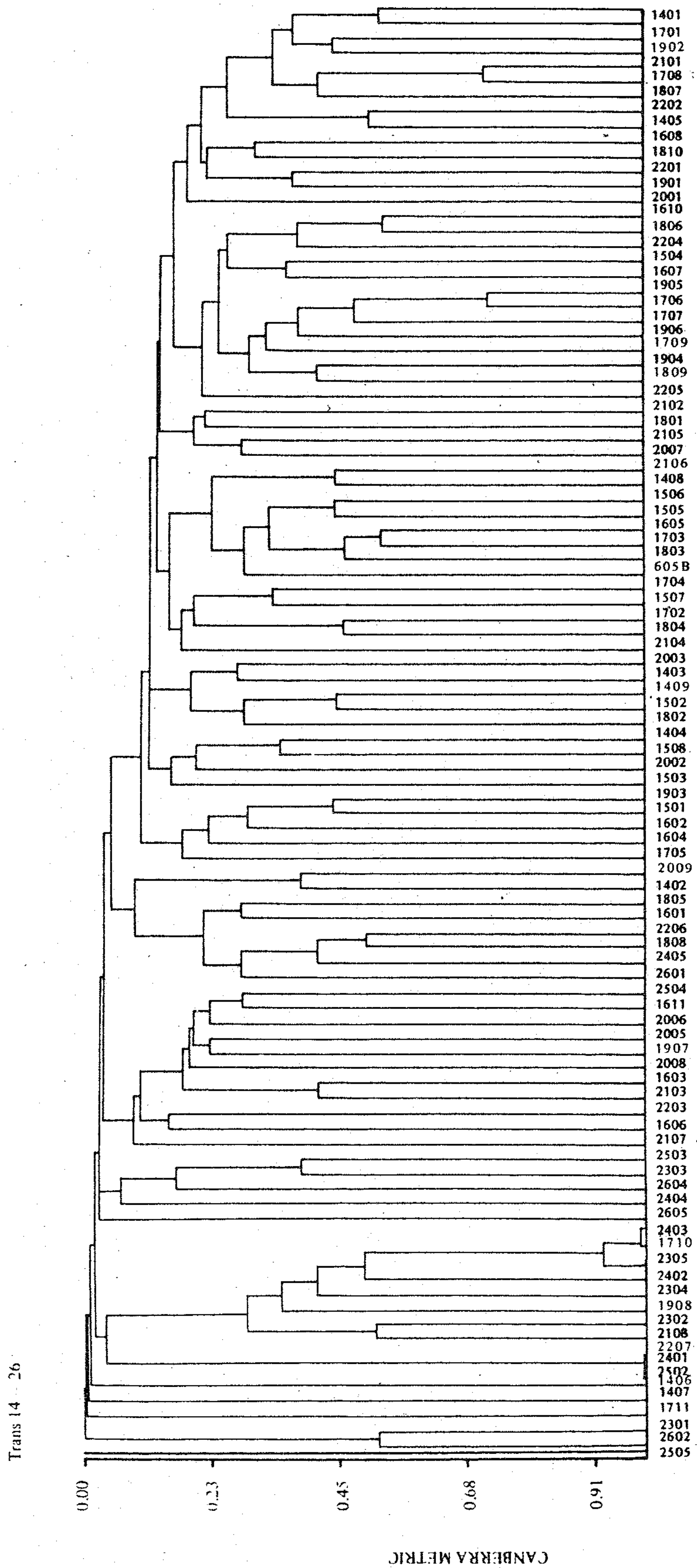
+9
M_Z ϕ UNITS
ASSEMBLAGE I

Figure V-23


Trans 14 - 26
1401
1701
1902
2101
1708
1807
2202
1405
1608
1810
2201
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2001
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1806
2204
1504
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2007
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2104
2003
1403
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2002
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2009
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1601
2206
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2405
2601
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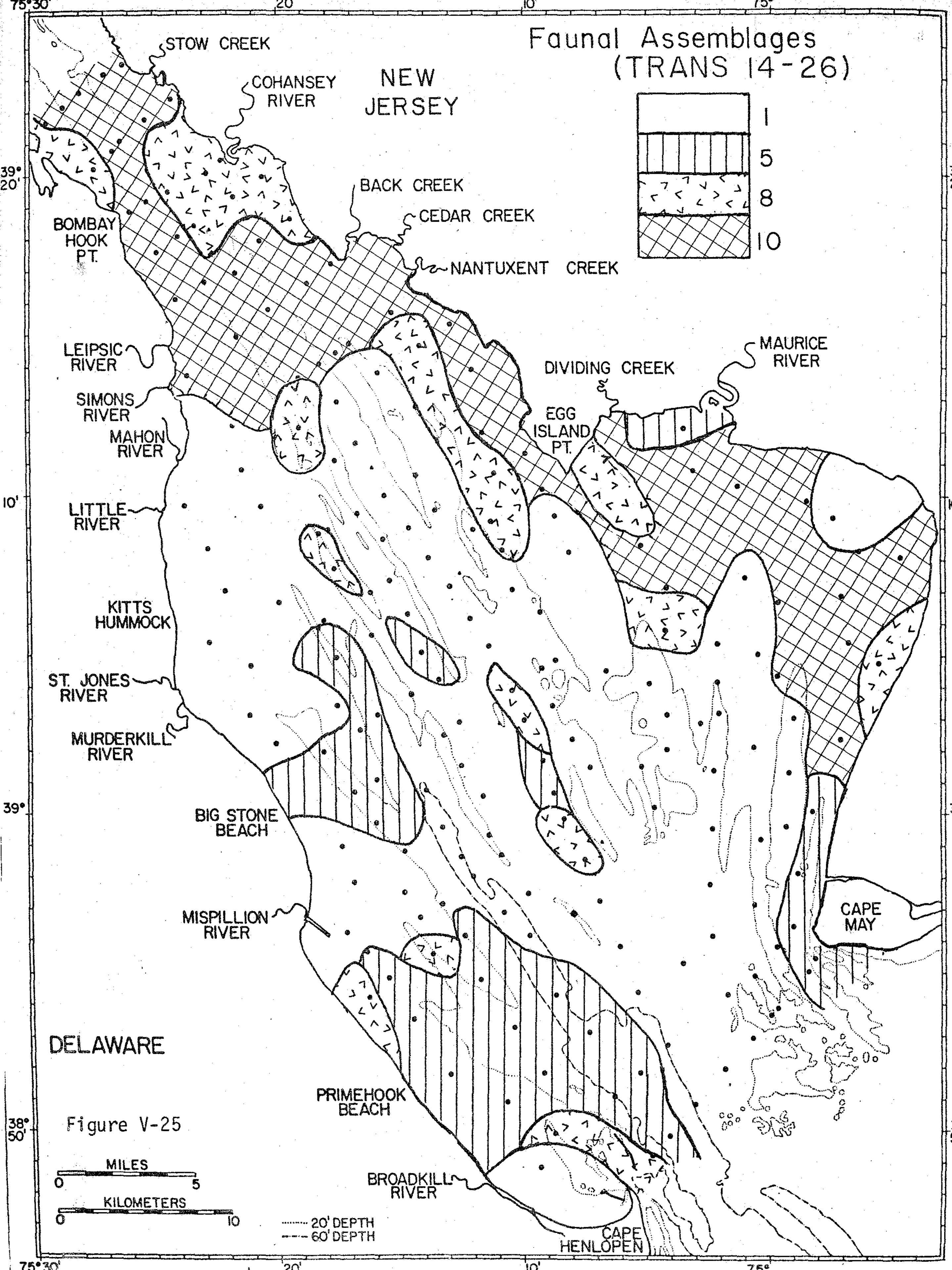
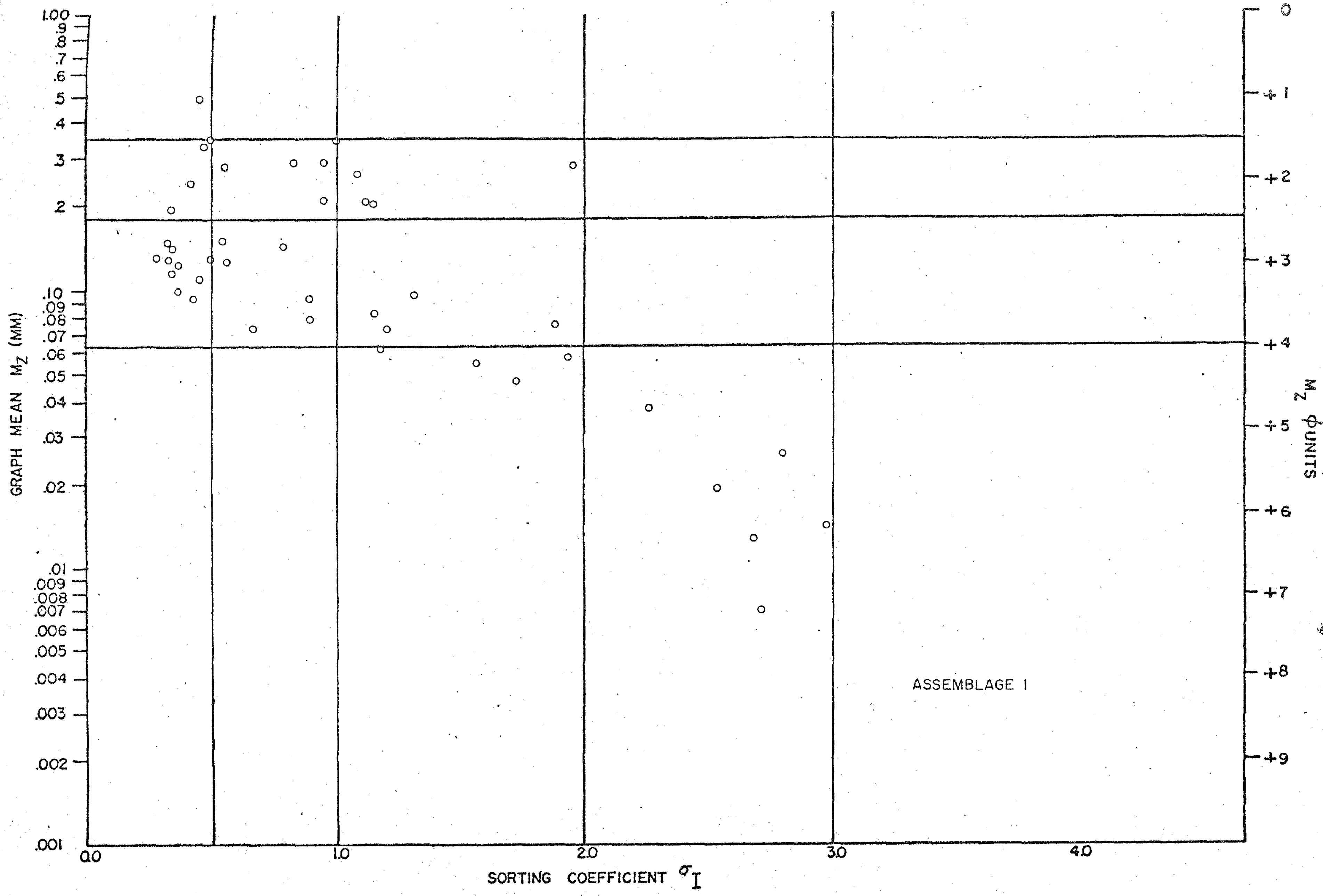
1611
2006
2005
1907
2008
1603
2103
2203
1606
2107
2503
2303
2604
2404
2605
2403
1710
2305
2402
2304
1908
2302
2108
2207
2401
2502
1406
1407
1711
2301
2602
2505
0.00
0.23
0.45
0.68
0.91
CANBERRA METRIC

Figure V-24



Faunal Assemblages
(TRANS 14-26)
1
5
8
10
NEW
JERSEY
STOW CREEK
COHANSEY
RIVER
BACK CREEK
CEDAR CREEK
NANTUXENT CREEK
MAURICE
RIVER
DIVIDING CREEK
EGG
ISLAND
PT.
BOMBAY
HOOK
PT.
LEIPSIC
RIVER
SIMONS
RIVER
MAHON
RIVER
LITTLE
RIVER
KITTS
HUMMOCK
ST. JONES
RIVER
MURDERKILL
RIVER
BIG STONE
BEACH
MISPILLION
RIVER
CAPE
MAY
DELAWARE
PRIMEHOOK
BEACH
BROADKILL
RIVER
CAPE
HENLOPEN
MILES
0
5
KILOMETERS
0
10
20' DEPTH
60' DEPTH
75°30'
20'
10'
75°
39°
20'
10'
39°
38°
50'

Figure V-25



GRAPH MEAN M_Z (MM)
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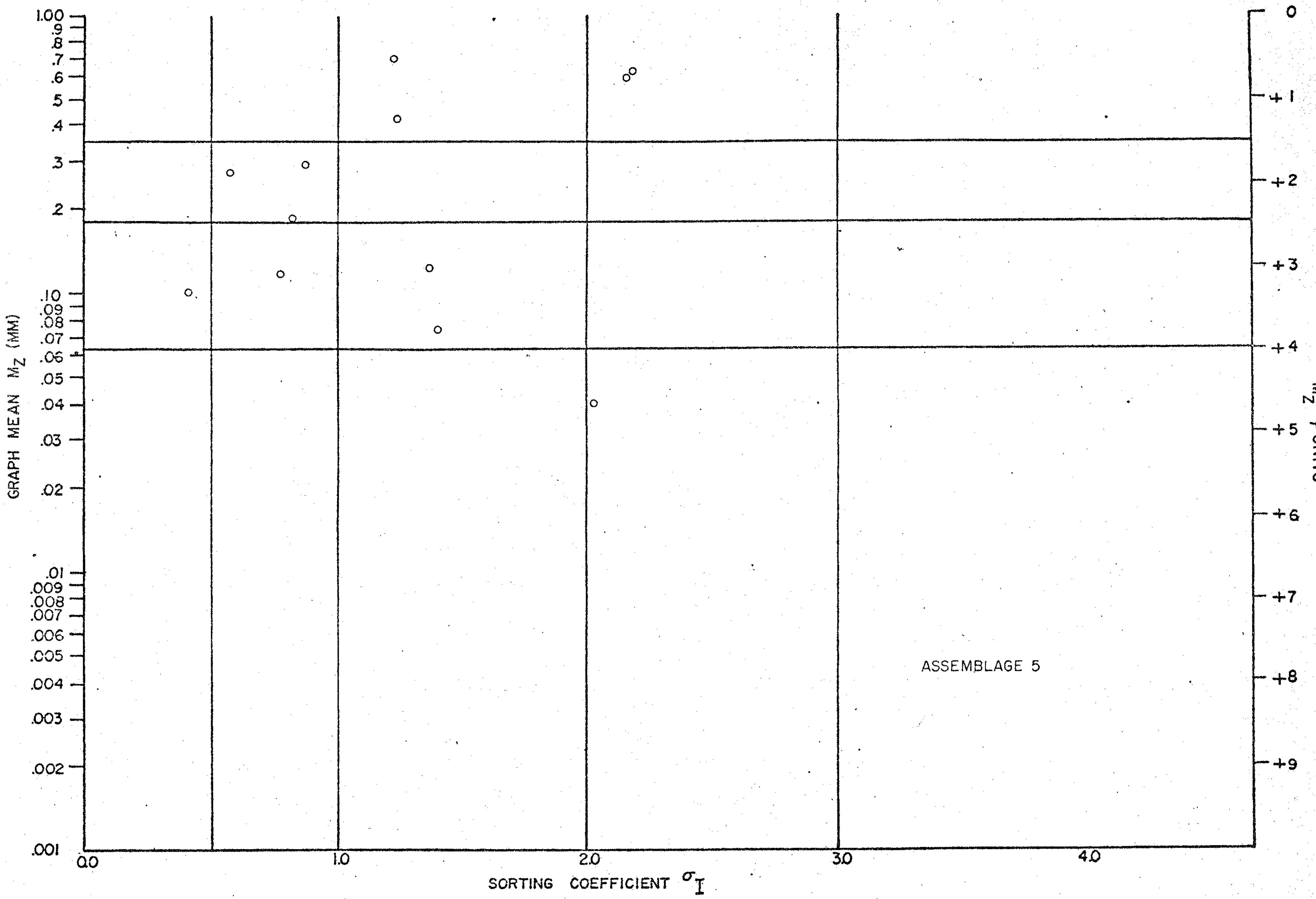
4.0
SORTING COEFFICIENT σ_I
M_Z ϕ UNITS
0
+1
+2
+3
+4
+5
+6
+7
+8
+9
ASSEMBLAGE 1

Figure V-26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.001
GRAPH MEAN M_Z (MM)
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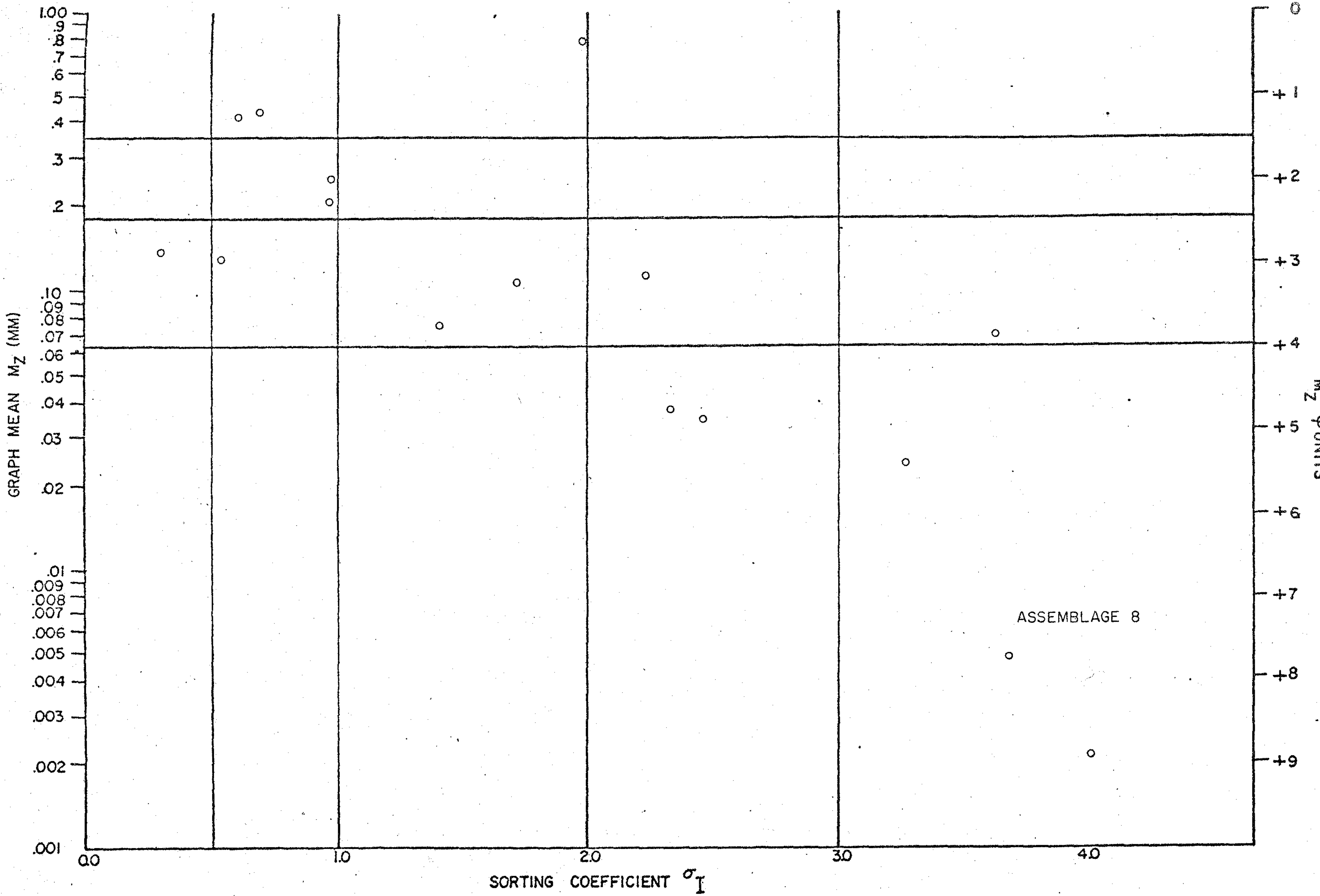
+2
+3
+4
+5
+6
+7
+8
+9
M_Z ϕ UNITS
0.0
1.0
2.0
3.0
4.0
SORTING COEFFICIENT σ_I
ASSEMBLAGE 5

Figure V-27



GRAPH MEAN M_Z (MM)
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SORTING COEFFICIENT σ_I
0
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+5
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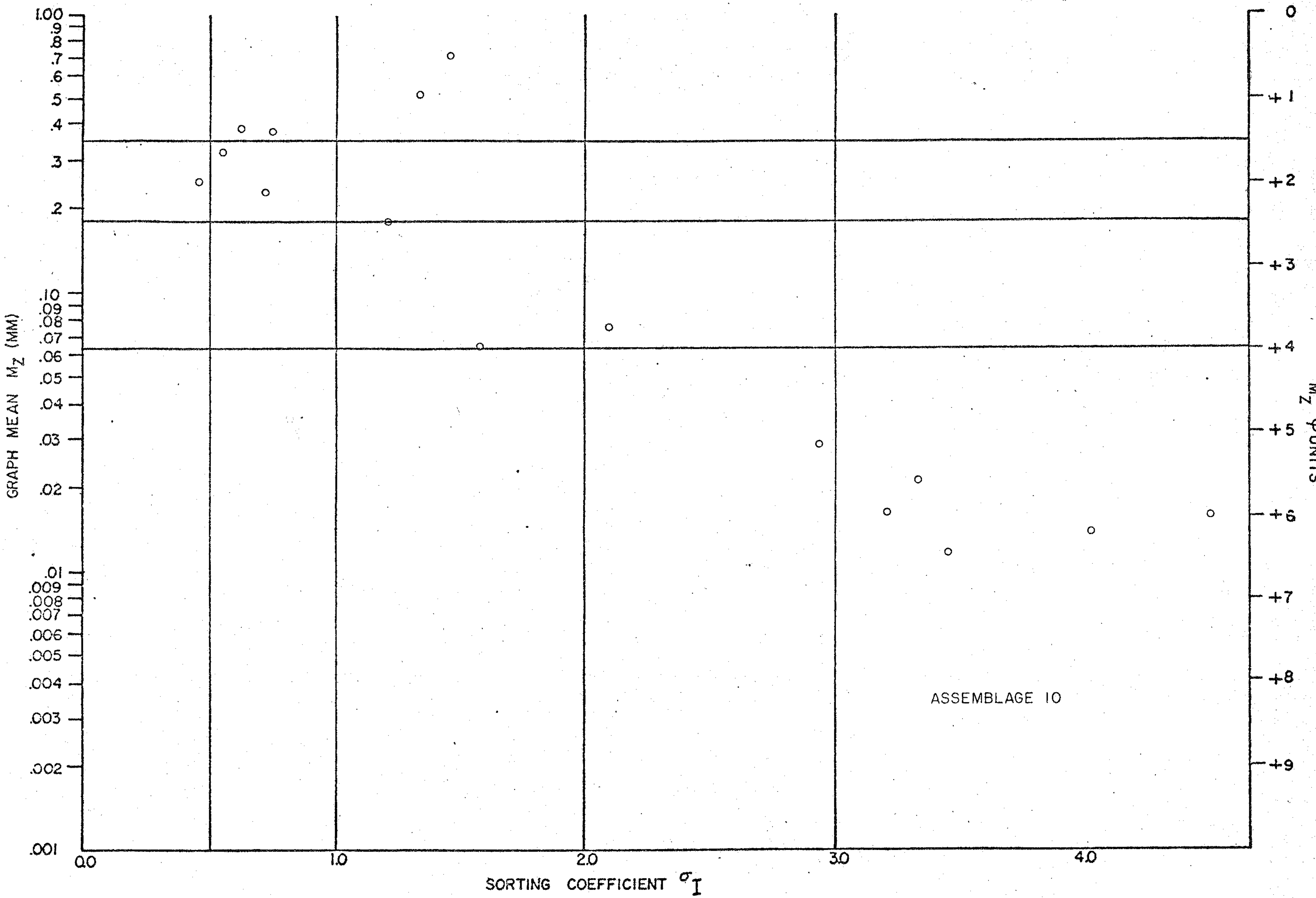
+8
+9
M_Z ϕ UNITS
ASSEMBLAGE 8

Figure V-28


GRAPH MEAN M_Z (MM)
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4.0
SORTING COEFFICIENT σ_I
M_Z ϕ UNITS
0
+1
+2
+3
+4
+5
+6
+7
+8
+9
ASSEMBLAGE 10

Figure V-29

VI. SEASONAL CHANGES OF BENTHIC INVERTEBRATE ASSEMBLAGES IN THE LIGHTERING AREA

Wayne Leathem
Chris Wethe
Les Watling

INTRODUCTION

Animal-sediment associations and their seasonal variations are important aspects of marine ecology and are especially important in relation to activities such as coastal engineering projects which require extensive dredging and spoil disposal. A thorough knowledge of these associations is necessary prior to any evaluation of the effects of such projects, which have the potential to dramatically change the nature of the sediments and significantly alter the fauna (Maurer and Wang, 1973; Maurer, et al., 1974a; Cronin, et al., 1970; Saila, et al., 1972).

The response of invertebrates to sediment and the interaction between animal and sediment has been the subject of many studies (Johnson, 1970; Sanders, 1960; Young and Rhoads, 1971; Kinner, et al., 1974). Rhoads and Young (1970), Rhoads (1973), Sanders (1958), and Bloom, et al. (1972) discussed the distribution of feeding types and their association with sediment size and stability. The stability in species composition of a community over time has been examined by Lie and Evans (1973), Boesch (1973), and Watling (1975).

The purpose of this study was to provide a baseline that could be used to assess the future biological effects of a proposed oil terminal to be located in the Delaware Bay anchorage area off Big Stone Beach, Delaware and of oil lightering from that area. A thirteen-month study (May 8, 1974 - May 6, 1975) was conducted to obtain seasonal data on the benthic macroinvertebrates. Research was undertaken to: (1) identify benthic invertebrates from four different substrata in and around the anchorage area, (2) determine whether there were any recurring dominant groups of species or any patterns associated with trophic groups at different stations, and (3) to accurately define the species composition, distribution, and abundance throughout the seasons.

METHODS

During 1974-1975 an intensive sampling program was implemented in and around the Delaware Bay oil tanker lightering area (39°58'N latitude and 75°13'W longitude). A preliminary survey was conducted to determine the nature of the sediments in the area. Four different substrata were identified over which ten stations were established (Figure VI-1): sandy shoal (Stations 1, 4, 6); muddy sands (5, 7, 10); a mixed coarse and fine silty sand (2, 3); and a calcareous serpulid reef (8, 9). Each station was sampled five times on a quarterly basis (May, August, and November 1974, February and May 1975) with three replicates being taken each time with a 0.1 m^2 Petersen grab. Two aliquots of sediment were taken from each grab for grain-size analysis. The remaining material was washed through a 1.0 mm mesh sieve and the residue was preserved in 10% buffered formalin. Salinity, dissolved oxygen, water, and sediment temperatures were taken at every station.

In the laboratory, benthic samples were sorted, identified to species, and counted. Sediments were dry sieved and pipette analysis was used to determine the silt and clay fractions.

RESULTS AND DISCUSSION

Sediment Analysis

The sediments found at the ten quarterly sampling stations followed a pattern similar to the bay-wide samples (Chapter V). Well sorted sand was associated with shoals, coarse skewed, poorly sorted sands were located within tidal channels, and very poorly sorted muddy sands occurred in quiet deep water areas. The sediment classification system used for the bay-wide stations was employed for the quarterly samples also. The procedures for grain size analysis were the same as described in the previous chapter. An outline of major sediment parameters is given in Appendix Table AVI-1.

The shoal sediment at Station 1 was a well sorted medium to fine sand. Variation in skewness occurred among samples within quarters and between quarters. While skewness was variable, mean grain size and sorting were extremely consistent. Over the first four quarterly samplings, M_z varied only from 1.93ϕ to 2.29ϕ while sorting ranged between 0.29ϕ and 0.37ϕ. These sediments were all in the B-1 classification range.

Stations 2 and 3 exhibited some variation in sediment type ranging among classifications A-3, A-4, and B-3. A composite description would yield a poorly sorted gravelly medium sand. With minor exceptions they were coarse and strongly coarse skewed samples.

The sediments at Station 4 were generally well sorted very fine sands and normally had positive (fine) skewness values. One February and one May sample contained 20% silt-clay (high for this station) and each were therefore poorly sorted (classified as C-3) and strongly fine skewed.

Stations 5, 7, 8, and 9 were grouped since they possessed similar sediment classification. These sediments were poorly to very poorly sorted very fine muddy sands. These samples may be classified as C-3, D-3, or D-4 and were strongly fine skewed. Average values for Stations 5 through 9 of the mean grain size (M_z) ranged from 3.99 to 4.14, the sorting (σ_i) increased from 1.42 to 1.86 and the percentage of silt-clay in the samples increased from 34% to 43%.

The sediment at Station 6 was a well sorted medium to fine sand that was strongly fine skewed (B-1). Mean grain size (M_z) varied from 2.05ϕ to 2.37ϕ and sorting (σ_i) was within the range 0.32ϕ to 0.44ϕ.

Station 10 was similar to Stations 5, 7, 8, and 9. It, however, had a higher silt-clay content and was therefore a very poorly sorted fine sandy mud. All samples were strongly fine skewed. Sample classifications ranged among C-3, D-3, and D-4. Except for its higher silt-clay content, Station 10, with average mean grain size and sorting values of 4.17 and 1.64, respectively, would have received the same classification as Stations 5, 7, 8, and 9.

Composition of Fauna by Feeding Type

A total of 180 species of benthic invertebrates were collected. A complete list of species with feeding type is included in Table VI-1.

The percent composition of the fauna by feeding type for all quarterly samples combined (Table VI-2) revealed that deposit-feeders dominated all stations except 3, 8, and 9. These latter stations were characterized by two suspension feeders, either Mytilus edulis, Hydroides dianthus, or both. Station 5 had the largest percentage (97.40%) of deposit feeders. This was due almost exclusively to the large numbers of Nucula proxima found at this station (Table VI-3).

The suspension feeders, except at Station 4, comprised a greater percent of the fauna, in all samples combined, than did the carnivores or omnivores. Generally the carnivores and omnivores were about equal in percent composition. The carnivores ranged from 0.12% at

Station 5 to 13.42% at Station 4. The omnivores ranged from 0.0% at Station 5 to 4.14% at Station 9.

Table VI-4 contains the percent composition of the fauna by feeding type in each sample and a total percent composition per station per quarter. Station 1 was dominated by deposit feeders with the greatest percentage (97.7%) occurring in February. May 1974 and August 1975 were the only quarters during which Station 1 contained suspension feeders. The 22.2% in the November sample, 1-3, represented the highest percentage of omnivores at any one station for all quarters, while the 11.8% for the quarter of May 1975 was the highest quarterly proportion of omnivores.

The deposit feeders remained dominant at Station 2. This was due primarily to the abundance of *Tellina agilis* and *Spio setosa*. The carnivore, *Glycera dibranchiata*, accounted for 44% of the fauna in sample 2-3 in February; otherwise the percentage of carnivores remained low.

An increase in abundance of *Mytilus edulis* during the August quarter resulted in the unusual dominance of suspension feeders at Station 3; during the other quarters the fauna was dominated by the deposit-feeding *Spio setosa* and *Tellina agilis*. Station 4 was also a deposit feeder dominated assemblage. However, in August and February the station recorded unusually high percentages of carnivores due to increases in the abundance of the polychaete, *Glycera* spp.

Station 5 was dominated in all quarters by the deposit-feeding bivalves, *Nucula proxima* and *Tellina agilis*, with *N. proxima* having the greatest abundance in all but the May 1974 quarter.

Stations 6, 7, and 10 were all dominated by deposit feeders with the most equal distribution between suspension and deposit feeders occurring at Station 10 during May 1974. Station 6 during the February quarter consisted of 100% deposit feeders.

The individuals at the serpulid assemblage Stations 8 and 9 were generally evenly distributed among the deposit and suspension feeders. The dominance by the suspension feeders was a result of the abundance of Mytilus edulis and Hydroides dianthus, while the Corophiidae spp. maintained the dominance of the deposit feeders. The May 1974 sample 9-2 consisted of 96.65% suspension feeders which was their largest percentage in any one sample for all quarters. The 90.07% for the quarter was also the largest quarterly total for a suspension feeder.

Evenness Diversity

Samples combined within a quarter possessing 25 or more individuals of a designated feeding type were evaluated in terms of Fager's (1972) scaled standard deviation evenness measure values (Table VI-5). Values of this index (SDN) near 1.00 indicate a lack of dominance and thus an even distribution of individuals among the species in the feeding type. Values near zero indicate a skewed distribution and thus strong dominance (Fager, 1972). Our experience has indicated that a minimum of 25 individuals within a feeding type is necessary to make the SDN values statistically reliable.

SDN values computed for all feeding types in the same quarter showed that the deposit feeders generally were the group with the most even composition. The carnivores, in turn, had higher evenness values than the suspension feeders, while the omnivores tended to be the most skewed group. In many samples (28) the deposit feeders were the only group to have enough individuals for computation. Generally when this occurred the SDN values had a tendency to be skewed, suggesting a dominance in this feeding category by one or two species.

Dominance Index

In addition to examining which feeding types dominated the various stations during each quarter, species dominance was evaluated using McNaughton's (1967) dominance index (Table VI-6). The changes in the dominance structure at each of the ten stations are summarized below:

Station 1

The haustoriid amphipod, Parahaustorius longimerus, was the dominant species throughout the year with several species present as minor subdominants. The dominance index averaged, 0.83, indicating that the assemblage at this station was dominated by one species.

Station 2

The spionid polychaete, Spio setosa, was the dominant species during the warm months, whereas the bivalve, Tellina agilis, was dominant in November and February. Occasionally, the polychaetes, Spiophanes bombyx and Mediomastus ambiseta, were significant as subdominant species. During May and August 1974, the assemblage was characterized by pairs of species which occurred as codominants in the samples. With the winter decrease in numbers of Spio setosa, the samples were strongly dominated by Tellina agilis or Glycera dibranchiata. In May 1975, the assemblage was recolonized with high numbers of Spio setosa and Mytilus edulis.

Station 3

The structure of the community here was similar to that at Station 2, except that at this station the Mytilus edulis assemblage completely replaced the Spio setosa - Tellina agilis assemblage in August 1975. Otherwise T. agilis was again dominant by February and S. setosa strongly recolonized the area during the following spring.

Station 4

This station showed a continuous replacement of dominant species beginning with Protohaustorius wigleyi in May 1974, shifting to Tellina agilis in August, then to a combination of T. agilis and Trichophoxus epistomus over the winter. In the spring, the area was strongly dominated by Nucula proxima. The greatest dominance shown by any one species (>0.80) was that of Protohaustorius wigleyi.

Station 5

This station showed a strongly skewed dominance distribution (Dominance Index >0.90) during the months when Nucula proxima was prevalent (August and November 1974 and May 1975). Tellina agilis occurred as a dominant in May 1974 and persisted as a subdominant during the periods of high N. proxima abundance.

Station 6

As Station 5 was a predominantly bivalve assemblage, this station was characterized by haustoriid amphipods. Except in the February 1975 samples, no one species was strongly dominant over the others. Also noticeable was the gradual replacement, from May to November 1974, of Acanthohaustorius millsi with Parahaustorius longimerus, and the latter with Protohaustorius wigleyi.

Station 7

This station, like several already considered, showed a replacement of dominant species from month to month over the whole sampling period. Noticeable also, was the lack of clear-cut dominance of any one species in the three samples taken in May 1974. In general, this assemblage was dominated by bivalves and polychaetes, with only one crustacean (Ampelisca verrilli) contributing significantly.

Stations 8 and 9

These two stations were positioned to sample an existing reef of calcareous serpulid tubes. This assemblage is probably not continuous as the variability in dominant species in the May 1974 samples would suggest. From August to February, the increase in the proportion of living Hydroides dianthus individuals obtained probably reflected recent recolonization and active construction of the reef. The following May, the entire region was over-run with recently set Mytilus edulis, causing a shift in the dominance structure of the assemblage.

Station 10

This station had a variable dominance structure, but was essentially a Nucula proxima - Mulinia lateralis assemblage from May to November 1974. With the increase in numbers of Ampelisca verrilli in February 1975, this assemblage shifted to one dominated by A. verrilli and N. proxima.

Cluster Analysis

Cluster analysis techniques using a group average sorting strategy with the Czekanowski similarity coefficient were used to find those stations which had the most similar groups of species (Figures VI-2 to VI-6). Species with less than 10% occurrence were eliminated from consideration in order to minimize the possibility of misclassifying samples.

The station groups for each quarter are summarized in Table VI-7. Five station groups which consistently appeared were Stations 1 and 6, 2 and 3, 5, 7 and 10, 8 and 9, with Station 4 clustering separately. Station 9 clusters with 5 and 10 in May 1974 due to the dominance of Asabellides oculatus and Mytilus edulis and the low numbers of Nucula proxima at Stations 5 and 10 during this quarter. The dominance of Nucula proxima is also the controlling factor for the clustering of Station 7 with Stations 5 and 10 in August.

Cluster techniques employing the Czekanowski similarity coefficient were also used to determine which species groupings were present during each quarter (Figures VI-7 to VI-11). These groups are summarized in Table VI-8. There were five major species groupings. Group A predominantly consisted of haustoriid amphipods found at Stations 1 and 6. Group B was composed primarily of deposit-feeding bivalves and polychaetes (Nucula proxima, Tellina agilis, Yoldia limatula, Asabellides oculatus, and Scoloplos robustus) found at Stations 5 and 10 with a few from Station 7. The majority of species in Group D were from Stations 8 and 9. These species included Hydroides dianthus and Mytilus edulis as dominants with many associates among the serpulid tubes and byssal threads (xanthid crabs, Unciola serrata, Corophium simile, Harmothoe extenuata, Nereis succinea, and Marphysa sanguinea). These three groups were found consistently during all five quarters. Group E consisted primarily of species from Stations 2, 3, and 4 and was not found in May 1974. This group contained species (Glycera spp. and Nephtys picta) whose sediment tolerances include the stations in Group B, but they were not dominant at those stations. The Group E stations were characterized by coarser sands than those in Group B. Group C was the only group which appeared in only one quarter. It was found at Stations 2 and 3 in May 1974 and consisted primarily of the polychaete family Spionidae. Stations 2 and 3 species were represented quite frequently in all except Group A.

Animal-Sediment Relations

Studies involving benthic invertebrates have revealed that certain assemblages recur and that species within these assemblages exhibit sediment preferences (Thorson, 1957). The combination of grain size and the distribution of the silt-clay content was an important factor influencing animal-sediment associations in this study.

Examination of Appendix Table AVI-1 shows that Stations 4, 5, and 8 were similar in grain size ($M_z\phi$) values and clustered together according to their structural measures (Figure VI-12). The silt-clay differences at Stations 4 and 5 were 2% and 20%, respectively, suggesting that the difference in species composition at these stations was not due to grain-size alone but was influenced by the silt-clay fraction. This is further supported by the tendency for Stations 5, 7, and 10 to cluster together based on species composition (Table VI-7).

The data from this study supported that of McNulty, et al. (1962) and Bloom, et al. (1972) in that the deposit feeders predominated in sediments containing a wide range of silt and clay (0.5 to 70.8%). Excluding the conditions at Stations 3, 8, and 9 where Mytilus and Hydroides trapped fine particles, the suspension feeders were dominant in sediments having an average median grain size of 0.055 mm. This is finer than the optimum median grain size of 0.18 mm reported by Sanders (1958), 0.174 mm by Bloom, et al. (1972), or that (0.4 mm) of McNulty, et al. (1962).

The relatively high abundance of carnivores at Station 4 and their small proportion at Stations 1 and 6 suggested that the difference in these shoal assemblages may be due to the smaller median grain size (0.088 mm) and the greater percentage of silt-clay (12%) at Station 4 than occurs at Stations 1 and 6, which have a median grain size of 0.25 mm and a silt-clay fraction of 1%.

The occurrences of the dominant species, M. edulis, N. proxima, and H. dianthus, may be explained on the basis of their sediment preferences. M. edulis was abundant at Stations 3, 8, and 9 due to the availability of hard substrata (pebbles, shell, calcareous tubes), which provided a place for byssal thread attachment. The deposit-feeding N. proxima appeared at Stations 5, 7, and 10 which were characterized by a combination of fine sand and high silt-clay content. The initial setting preference of H. dianthus at Stations 8 and 9 is not clearly understood because no coring was done in this study. The reef, however, evidently maintains itself above the accumulating silt level by continually constructing new tubes upon the older structures.

The species associated with these dominants, with the possible exception of the N. proxima assemblage, cannot be entirely explained on the basis of sediment associations. Their occurrence may be more dependent on the niches and biological interactions provided by the dominant organisms.

As reported for the region near the mouth of Delaware Bay (Kinner, et al., 1974), T. agilis was again the most widespread species. Except for the shoal Stations 1 and 6, T. agilis was the only organism to occur in at least 50% of the samples at all stations. Our data also agrees with Mills' (1964, 1967a, b) that sediment particle size was important for tube-building ampeliscids and that sediments with 10-30% silt-clay were ideal for this activity.

Benthic Communities and Assemblages

Mills' (1969) defined a community as "a group of organisms occurring in a particular environment, presumably interacting with each other and the environment, and separable by means of ecological survey from other groups." Johnson (1970), Bloom, et al. (1972), and Boesch (1973) supported Mills' view. Bloom, et al. (1972) stated that the lack of a consistent multi-species dominance pattern combined with overwhelming dominance by one species tends to invalidate the use of the Petersen community concept. Boesch (1973) did not assign Petersen community types to assemblages in Chesapeake Bay. Based on our data in and around the Delaware Bay lightering area, Petersen community types were not evident. Moreover, a number of our dominant species have been found elsewhere in various habitats: Nucula proxima (Sanders, 1958; Driscoll and Brandon, 1973; Young, 1971; Watling, et al., 1974; Kinner, et al., 1974); Mytilus edulis (Steimle and Stone, 1973; Hughes and Thomas, 1971; Maurer, et al., 1974b); Haustoriidae species (Howard and Dorjes, 1972); Ampelisca species (Thorson, 1957; Sanders, 1958; Boesch, 1973); and Tellina species (Trevallion, 1971; Maurer, 1967; Kinner, et al., 1974; O'Connor, 1972).

For Delaware Bay as a whole the situation differs somewhat. There are large oyster beds which are known to be inhabited by a relatively constant group of species (Maurer and Watling, 1973), many of which have also been found in the serpulid assemblage. Although these beds contain pockets of mud and muddy shell with mixtures of infaunal and epifaunal species, the major constituents of these associations are epifaunal species which have siblings or congeners in estuaries throughout temperate latitudes (Hedgpeth, 1957; Carriker, 1967).

Our cluster analysis studies from Chapter V indicated the presence of one group of species (characterized by *Tellina agilis*, *Nephtys picta*, and *Glycera capitata*) which inhabited the same widespread region of the bay for two years. On a finer scale, however, as the sediment composition changed at selected stations, different groups of species emerged. Other factors, such as the success of *Mytilus edulis* larvae in the plankton during January to March, caused substantial changes in the composition of the soft bottom assemblages at certain stations. It is not unlikely that these changes observed at the lightering area also occurred throughout the bay.

Because of their structural composition and geological continuity it is easier to identify the oyster community as a separate entity than it is to delimit boundaries in the soft bottoms where the physical changes are very subtle. As a result, the oyster beds and reef assemblages more easily qualify as a Petersen-type community than do soft bottom areas. Thus it appears that the bay is composed of a mosaic of species groups, which range on one hand from a well-defined, epifaunal oyster and reef community to, on the other hand, widely distributed species groups (assemblages) whose dominant species in any one microhabitat change seasonally and/or annually. It is our opinion that the combination of these assemblages, viewed over a longer time period and on an estuary-wide scale, represents a community which corresponds to the Mills' (1969) concept and which may satisfy the criteria of the Petersen-Thorson concept.

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Table VI-1

Total species list from quarterly samples

		Feeding Type*
	Phylum Porifera	
	Class Demospongiae	
	Order Poecilosclerina	
1003	Microciona prolifera (Ellis and Solander 1786)	SF
1008	Halichondria sp. cf. H. bowerbanki Burton 1930	SF
	Order Hadromerina	
1006	Cliona celata Grant 1826	SF
	Phylum Cnidaria	
	Class Hydrozoa	
	Order Hydroida	
2002	Tubularia crocea	SF
2007	Hydractinia echinata (Fleming 1828)	SF
2023	Campanularia sp.	SF
2021	Sertularia argentea Linne 1758	SF
	Class Anthozoa	
	Order Madreporaria	
2034	Astrangia danae Agassiz 1847	SF
	Phylum Rhynchocoela	
	Class Anopla	
	Order Heteronemertini	
3006	Zygeupolia rubens (Coe 1895)	C
	Class Enopla	
	Order Bdellonemertini	
3014	Nemertea sp.	C
3016	Flatworm A	C
	Phylum Annelida	
	Family Ampharetidae	
4001	Ampharete acutifrons Grube 1860	DF
4002	Asabellides oculatus (Webster 1879)	DF
	Family Arabellidae	
4006	Driloneris longa Webster 1879	O
4007	Driloneris magna Webster and Benedict 1887	O
	Family Capitellidae	
4009	Capitella capitata (Fabricius 1780)	DF
4010	Heteromastus filiformis (Claparede 1864)	DF
4011	Mediomastus ambiseta (Hartman 1947)	DF

Table VI-1 (cont.)

	Family Cirratulidae	
4015	*Caulleriella* sp. 2	DF
4140	*Cirratulidae* sp.	DF
4018	*Tharyx* sp. 2	DF
4178	*Chaetozone* sp.	DF
4172	*Chaetozone* sp. 1	DF
	Family Dorvilleidae	
4021	*Schistomeringos rudolphi* (delle Chiaje 1828)	DF
4153	*Schistomeringos caecus* (Webster and Benedict 1884)	DF
	Family Eunicidae	
4023	*Marphysa sanguinea* (Montagu 1815)	DF
	Family Flabelligeridae	
4024	*Pherusa affinis* (Leidy 1855)	DF
	Family Glyceridae	
4025	*Glycera americana* Leidy 1855	C
4026	*Glycera capitata* Oersted 1843	C
4027	*Glycera dibranchiata* Ehlers 1868	C
	Family Goniadidae	
4028	*Glycinde solitaria* (Webster 1880)	C
4029	*Goniadella gracilis* (Verrill 1873)	C
	Family Hesionidae	
4030	*Podarke obscura* Verrill 1873	C
	Family Lumbrineridae	
4033	*Lumbrineris acuta* (Verrill 1875)	DF
	Family Magelonidae	
4040	*Magelona* sp. 2	DF
	Family Maldanidae	
4045	*Clymenella torquata* (Leidy 1855)	DF
4183	*Maldanidae* sp. 1	DF
	Family Nephtyidae	
4051	*Nephtys bucera* Ehlers 1868	O
4052	*Nephtys incisa* Malmgren 1865	O
4053	*Nephtys picta* Ehlers 1868	O
	Family Nereidae	
4055	*Nereis* (*Neanthes*) *succinea* Frey and Leuckart 1847	O
	Family Onuphidae	
4057	*Diopatra cuprea* (Bosc 1802)	DF
	Family Orbiniidae	
4063	*Haploscoloplos acutus* (Verrill 1873)	DF
4064	*Haploscoloplos fragilis* (Verrill 1873)	DF
4065	*Haploscoloplos robustus* (Verrill 1873)	DF
4142	*Scoloplos* sp.	DF
	Family Paraonidae	
4141	*Aricidea* sp.	DF
4071	*Aricidea cerruti* Laubier 1967	DF

Table VI-1 (cont.)

	Family Pectinariidae	
4076	*Pectinaria gouldii* Verrill 1873	DF
	Family Phyllodocidae	
4077	*Eteone heteropoda* Hartman 1951	O
4079	*Eteone longa* (Fabricius 1780)	O
4080	*Eumida sanguinea* (Oersted 1843)	O
4083	*Paranaitis speciosa* (Webster 1880)	C
4084	*Phyllodoce arenae* Webster 1880	C
4085	*Phyllodoce maculata* (Linnaeus 1767)	C
	Family Polynoidae	
4152	*Harmothoe (Lagisca) extenuata* (Grube 1840)	C
4090	*Lepidametria commensalis* Webster 1879	C
4091	*Lepidonotus squamatus* (Linnaeus 1756	C
4092	*Lepidonotus sublevis* Verrill 1873	C
	Family Sabellaridae	
4093	*Sabellaria vulgaris* Verrill 1873	SF
	Family Serpulidae	
4101	*Hydroides dianthus* (Verrill 1873)	SF
	Family Sigalionidae	
4104	*Sthenelais limicola* (Ehlers 1864)	C
4105	*Sthenelais boa* (Johnston 1833)	C
	Family Spionidae	
4106	*Dispio uncinata* Hartman 1951	DF
4107	*Paraprionospio pinnata* (Ehlers 1901)	DF
4108	*Polydora caulleryi* Mesnil 1879	DF
4109	*Polydora concharum* Verrill 1880	DF
4110	*Polydora ligni* Webster 1879	DF
4111	*Polydora socialis* (Schmarda 1861)	DF
4117	*Spio setosa* Verrill 1873	DF
4118	*Spiophanes bombyx* (Claparede 1870)	DF
4119	*Streblospio benedicti* Webster 1879	DF
	Family Syllidae	
4125	*Proceraea cornuta* (Agassiz, 1863)	O
4131	*Syllis gracilis* Grube 1840	O
	Family Terebellidae	
4134	*Amphitrite ornata* (Leidy 1855)	DF
4137	*Polycirrus eximius* (Leidy, 1855)	DF
Class Oligochaeta		
4400	Oligochaeta A	DF
4401	Oligochaeta B	DF
Phylum Sipunculida		
4700	Sipunculida sp.	DF

Table VI-1 (cont.)

	Phylum Mollusca	
	Class Gastropoda	
	Order Mesogastropoda	
5099	*Hydrobia totteni* Morrison 1954	C
5012	*Crepidula fornicata* (Linne 1758)	SF
5013	*Crepidula convexa* Say 1822	SF
5014	*Crepidula plana* Say 1822	SF
5015	*Polinices duplicatus* (Say, 1822)	C
	Order Neogastropoda	
5022	*Anachis avara* (Say 1822)	C
5023	*Mitrella lunata* (Say 1826)	C
5027	*Nassarius trivittatus* (Say 1822)	C
5029	*Marginella roscida* Redfield 1860	C
	Order Tectibranchia	
5098	*Acteocina canaliculata* (Say 1822)	C
5031	*Acteon punctostriatus* (C.B. Adams 1840)	C
5032	*Haminoea solitaria* (Say 1822)	C
5040	*Turbonilla interrupta* (Totten 1835)	C
	Class Polyplacophora	
	Order Nudibranchia	
5044	*Dorodella obscura* Verrill 1870	C
5110	*Cuthona concinna* (Alder and Hancock 1843)	C
5111	*Doto coronata* (Gmelin 1791)	C
	Class Bivalvia	
	Order Protobranchia	
5047	*Nucula proxima* Say 1822	DF
5048	*Yoldia limatula* Say 1831	DF
	Order Filibranchia	
5050	*Anadara ovalis* (Bruguiere 1789)	SF
5053	*Mytilus edulis* Linne 1758	SF
5055	*Anomia simplex* Orbigny 1842	SF
	Order Eulamellibranchia	
5066	*Mercenaria mercenaria* (Linne 1758)	SF
5069	*Petricola pholadiformis* (Lamarck 1818)	SF
5070	*Tellina agilis* Stimpson 1857	DF
5076	*Donax variabilis* Say 1822	SF
5079	*Siliqua costata* Say 1822	SF
5080	*Ensis directus* Conrad 1843	SF
5081	*Spisula solidissima* (Dillwyn 1817)	SF
5082	*Mulinia lateralis* (Say 1822)	SF
5091	*Lyonsia hyalina* Conrad 1831	SF
5093	*Pandora gouldiana* Dall 1886	SF

Table VI-1 (cont.)

	Phylum Arthropoda	
	Class Pycnogonida	
6003	_Tanystylum orbiculare_ Wilson 1878	DF
	Class Crustacea	
6009	_Balanus (Balanus) improvisus_ Darwin 1854	SF
	Order Mysidacea	
	Family Mysidae	
7002	_Neomysis americana_ (S.I. Smith 1873)	SF
7145	_Heteromysis formosa_ S.I. Smith 1873	SF
	Order Cumacea	
	Family Bodotriidae	
7175	_Leptocuma minor_ Calman 1912	DF
7176	_Mancocuma altera_ Zimmer 1943	DF
	Family Diastylidae	
7009	_Oxyurostylis smithi_ Calman 1912	DF
	Order Isopoda	
	Family Idoteidae	
7026	_Chiridotea tuftsi_ (Stimpson 1883)	DF
7028	_Edotea triloba_ (Say 1818)	DF
	Order Amphipoda	
	Family Ampeliscidae	
7035	_Ampelisca abdita_ Mills 1964	DF
7036	_Ampelisca vadorum_ Mills 1963	DF
7037	_Ampelisca verrilli_ Mills 1967	DF
	Family Aoridae	
7042	_Lembos smithi_ (Holmes 1905)	DF
7043	_Microdeutopus gryllotalpa_ Costa 1853	DF
	Family Bateidae	
7047	_Batea catharinensis_ Fr. Muller 1865	DF
	Family Corophiidae	
7051	_Corophium insidiosum_ Crawford 1937	DF
7053	_Corophium tuberculatum_ Shoemaker 1934	DF
7054	_Erichthonius brasiliensis_ Dana 1853	DF
7055	_Unciola irrorata_ Say 1818	DF
7056	_Unciola serrata_ Shoemaker 1945	DF
7057	_Unciola dissimilis_ Shoemaker 1945	DF
7058	_Corophium simile_ Shoemaker 1934	DF
7059	_Siphonoecetes smithianus_ Rathbun 1905	DF
	Family Gammaridae	
7068	_Elasmopus laevis_ (Smith 1871)	DF
7070	_Melita nitida_ Smith 1873	DF
	Family Haustoriidae	
7072	_Parahaustorius attenuatus_ Bousfield 1965	DF
7073	_Parahaustorius holmesi_ Bousfield 1965	DF
7074	_Parahaustorius longimerus_ Bousfield 1965	DF

Table VI-1 (cont.)

7075	*Protohaustorius wigleyi* Bousfield 1965	DF
7078	*Acanthohaustorius millsi* Bousfield 1965	DF
7172	*Bathyporeia parkeri* Bousfield 1973	DF
7174	*Bathyporeia quoddyensis* Shoemaker 1949	DF
7173	*Acanthohaustorius shoemakeri* Bousfield	DF
	Family Lysianassidae	
7086	*Lysianopsis alba* Holmes 1905	DF
	Family Oedicerotidae	
7091	*Synchelidium americanum* Bousfield 1973	DF
	Family Phoxocephalidae	
7092	*Paraphoxus spinosus* Holmes 1903	DF
7093	*Trichophoxus epistomus* (Shoemaker 1938)	DF
7094	*Phoxocephalus holbolli* (Kroyer 1842)	DF
	Family Pleustidae	
7095	*Parapleustes aestuarius* Watling and Maurer 1973	DF
7100	*Orchestia grillus* Bosc 1802	DF
	Family Caprellidae	
7105	*Caprella equilibra* Say 1818	SF
7106	*Paracaprella tenuis* Mayer 1903	SF
	Order Decapoda	
	Family Crangonidae	
7111	*Crangon septemspinosa* (Say 1818)	DF
	Family Callianassidae	
7113	*Upogebia affinis* (Say 1818)	DF
7148	*Callianassa* sp. cf. *C. atlantica*	DF
	Family Paguridae	
7115	*Pagurus longicarpus* Say 1817	DF
	Family Porcellanidae	
7149	*Euceramus praelongus* Stimpson 1860	DF
	Family Cancridae	
7121	*Cancer irroratus* Say 1817	C
	Family Xanthidae	
7146	*Xanthid* sp.	C
7124	*Neopanope texana sayi* (Smith 1869)	C
7125	*Panopeus herbsti* H. Milne-Edwards 1834	C
7127	*Hexapanopeus angustifrons* (Benedict and Rathbun 1891)	C
	Family Pinnotheridae	
7144	*Pinnotheres maculatus* Say 1818	Commensal
7129	*Pinnixa retinens* Rathbun 1818	DF
7130	*Pinnixa sayana* Stimpson 1860	DF
7147	*Pinnixa* sp.	DF
7132	*Sesarma reticulatum* (Say 1817)	C

Table VI-1 (cont.)

	Phylum Ectoprocta	
	Class Gymnolaemata	
	Order Ctenostomata	
8002	Alcyonidium polyoum (Hassall 1841)	SF
8009	Triticella elongata (Osburn 1912)	SF
	Order Cheilostomata	
8012	Membranipora tenuis Desor 1848	SF
8013	Membranipora tuberculata (Bosc 1802)	SF
8014	Conopeum tenuissimum (Canu 1908)	SF
8015	Conopeum truitti Osburn 1944	SF
8018	Electra monostachys Marcus 1938	SF
8022	Cryptosula pallasiana (Moll 1803)	SF
8023	Schizoporella errata (Watess 1878)	SF
	Phylum Echinodermata	
	Class Asteroidea	
	Order Forcipulata	
9008	Starfish (juv.)	?
	Class Ophiuroidea	
	Order Ophiurida	
9003	Amphioplus abditus (Verrill)	DF
	Class Echinoidea	
	Order Dendrochirota	
9007	Thyone briareus (LeSueur 1824)	DF

* SF = Suspension Feeder
DF = Deposit Feeder
C = Carnivore
O = Omnivore

Table VI-2

Percent composition of fauna by feeding type from all quarterly samples combined

Station	Deposit Feeders (%)	Suspension Feeders (%)	Carnivores (%)	Omnivores (%)
1	86.90	8.23	1.22	3.65
2	73.17	23.17	2.61	1.05
3	46.84	45.39	5.33	2.44
4	58.00	2.62	13.42	1.54
5	97.40	0.55	0.12	0.00
6	90.47	5.68	0.45	3.40
7	76.18	16.81	2.97	4.04
8	26.64	65.24	4.66	3.44
9	33.48	55.79	6.59	4.14
10	80.58	14.90	4.17	0.35

Table VI-3

Relative abundance and frequency of occurrence of dominant species at each station

Station	Species	Percent of Fauna	Percent Occurrence	No. of Individuals
1	*Parahaustorius longimerus*	65.8	100.0	216
2	*Spio setosa*	53.18	60.0	1,462
	Tellina agilis	8.80	100.0	242
3	*Mytilus edulis*	43.79	53.3	879
	Spio setosa	26.65	66.7	535
	Tellina agilis	7.62	87.6	153
	Unciola serrata	1.14	60.0	23
	Nephtys picta	0.99	53.3	20
4	*Protohaustorius wigleyi*	22.83	26.7	148
	Tellina agilis	20.21	93.3	131
	Nucula proxima	18.36	40.0	119
	Glycera capitata	4.78	66.7	31
5	*Nucula proxima*	95.45	93.3	21,393
	Tellina agilis	1.73	93.3	389
	Ensis directus	0.45	60.0	101
6	*Parahaustorius longimerus*	38.18	73.3	168
	Acanthohaustorius millsi	23.63	80.0	104
	Protohaustorius wigleyi	18.86	73.3	83
7	*Nucula proxima*	22.76	46.7	107
	Ampelisca verrilli	18.93	73.3	89
	Mulinia lateralis	14.46	60.0	68
	Tellina agilis	12.97	66.7	61
	Nephtys incisa	3.19	60.0	15
8	*Mytilus edulis*	51.15	60.0	13,904
	Unciola serrata	10.40	100.0	2,827
	Hydroides dianthus	9.57	93.3	2,601
	Corophium simile	5.87	100.0	1,596
	Sabellaria vulgaris	3.13	93.3	852
	Eumida sanguinea	2.95	66.7	804
	Xanthid sp.	2.62	100.0	714
	Nucula proxima	1.77	86.7	483
	Lembos smithi	1.28	86.7	348
	Polycirrus eximius	1.14	80.0	310
	Polydora ligni	1.13	60.0	309
	Asabellides oculatus	1.12	93.3	305

Table VI-3 (cont.)

Station	Species	Percent of Fauna	Percent Occurrence	No. of Individuals
8	Mediomastus ambiseta	1.05	66.7	288
	Crepidula plana	0.61	53.3	166
	Lepidonotus squamatus	0.45	86.7	125
	Nereis succinea	0.40	93.3	109
	Marphysa sanguinea	0.40	86.7	109
	Heteromastus filiformis	0.40	80.0	111
	Polydora socialis	0.38	60.0	104
	Neopanope texana sayi	0.34	86.7	95
	Mercenaria mercenaria	0.31	80.0	86
	Glycinde solitaria	0.23	60.0	65
	Melita nitida	0.15	66.7	41
	Tellina agilis	0.10	86.7	29
	Ampelisca abdita	0.08	53.3	24
	Podarke obscura	0.07	53.3	21
9	Mytilus edulis	29.27	66.7	3,322
	Hydroides dianthus	22.93	80.0	2,603
	Unciola serrata	8.41	73.3	955
	Corophium simile	5.68	66.7	645
	Mediomastus ambiseta	3.47	80.0	394
	Nucula proxima	3.26	93.3	370
	Xanthid sp.	2.99	80.0	340
	Eumida sanguinea	2.82	66.7	321
	Sabellaria vulgaris	2.53	73.3	288
	Polycirrus eximius	2.37	80.0	269
	Heteromastus filiformis	2.15	93.3	245
	Asabellides oculatus	1.70	93.3	194
	Nereis succinea	1.15	66.7	131
	Lembos smithi	0.97	53.3	111
	Glycinde solitaria	0.84	93.3	96
	Mercenaria mercenaria	0.68	73.3	78
	Marphysa sanguinea	0.56	73.3	64
	Lepidonotus squamatus	0.37	53.3	42
	Harmothoe extenuata	0.30	60.0	35
	Oxyurostylis smithi	0.30	53.3	35
	Tellina agilis	0.23	66.7	27
10	Nucula proxima	51.84	100.0	435
	Ampelisca verrilli	8.93	86.7	75
	Mulinia lateralis	6.67	73.3	56
	Tellina agilis	6.19	86.7	52
	Yoldia limatula	1.78	66.7	15

Table VI-4

Percent composition of fauna by feeding type for each sample

	Feeding	Station			Total for	Station			Total for	Station			Total for
Quarter	Type	1-1	1-2	1-3	Quarter	2-1	2-2	2-3	Quarter	3-1	3-2	3-3	Quarter
	DF*	71.4	60.0	100.0	74.0	84.62	96.77	97.83	93.10	81.25	78.79	81.83	80.59
May	SF*	14.3	40.0	0.0	21.7	5.13	3.23	0.00	2.59	6.25	9.09	9.00	7.77
1974	C*	0.0	0.0	0.0	0.0	10.25	0.00	2.17	4.31	12.50	12.12	4.54	10.67
	O*	14.3	0.0	0.0	4.3	0.00	0.00	0.00	0.00	0.00	0.00	4.54	0.97
	DF	80.0	85.0	90.0	84.9	91.00	72.42	68.18	85.72	10.60	37.05	10.32	13.61
August	SF	18.2	15.0	4.0	12.7	3.00	20.69	13.64	6.23	83.90	44.68	79.69	77.79
1974	C	0.0	0.0	4.0	1.2	4.00	6.89	18.18	6.59	4.59	12.90	9.06	7.19
	O	1.8	0.0	2.0	1.2	2.00	0.00	0.00	1.46	0.91	5.37	0.93	1.41
	DF	100.0	95.2	77.8	91.0	95.16	93.34	93.16	93.85	82.89	64.00	42.43	68.26
Nov.	SF	0.0	0.0	0.0	0.0	3.23	5.00	2.74	3.59	0.00	0.00	21.21	5.56
1974	C	0.0	4.8	0.0	1.3	1.61	1.66	4.10	2.56	14.70	20.00	15.15	15.87
	O	0.0	0.0	22.2	7.7	0.00	0.00	0.00	0.00	2.94	16.00	21.21	10.31
	DF	100.0	93.7	100.0	97.7	91.66	92.30	55.55	84.79	82.04	79.05	86.36	82.55
Feb.	SF	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	2.33	0.00	0.79
1975	C	0.0	0.0	0.0	0.0	8.33	7.69	44.44	15.21	12.82	0.00	9.09	7.14
	O	0.0	6.3	0.0	2.3	0.00	0.00	0.00	0.00	5.12	18.60	4.54	9.52
	DF	100.0	85.7	66.6	82.3	83.87	50.37	83.18	68.51	29.72	66.68	38.10	68.60
May	SF	0.0	0.0	0.0	0.0	13.23	45.19	15.98	28.58	23.03	32.36	50.00	29.27
1975	C	0.0	0.0	16.7	5.9	2.01	2.58	0.42	1.74	0.29	0.24	2.38	0.75
	O	0.0	14.3	16.7	11.8	0.89	1.86	0.42	1.17	1.16	0.72	9.52	1.38

Table VI-4 (cont.)

Quarter	Feeding Type	Station 4-1	Station 4-2	Station 4-3	Total for Quarter	Station 5-1	Station 5-2	Station 5-3	Total for Quarter	Station 6-1	Station 6-2	Station 6-3	Total for Quarter
May 1974	DF	83.33	94.95	98.22	95.22	100.00	56.53	44.78	53.79	98.44	100.00	92.73	96.10
	SF	8.33	4.04	0.00	2.99	0.00	42.03	54.48	45.33	0.00	0.00	7.27	3.12
	C	0.00	0.00	0.00	0.00	0.00	1.44	0.74	0.88	0.00	0.00	0.00	0.00
	O	8.33	1.01	1.78	1.79	0.00	0.00	0.00	0.00	1.56	0.00	0.00	0.78
August 1974	DF	53.32	63.80	68.90	62.72	99.55	99.98	98.86	98.89	84.62	81.82	84.63	84.10
	SF	6.67	10.34	0.00	5.93	0.45	0.02	0.14	0.11	7.69	15.15	11.53	11.36
	C	33.33	25.86	28.88	29.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	O	6.66	0.00	2.22	1.69	0.00	0.00	0.00	0.00	7.69	3.03	3.84	4.54
Nov. 1974	DF	93.87	81.17	52.15	70.83	100.00	99.62	99.31	99.67	89.29	78.58	83.34	85.19
	SF	1.53	0.00	0.00	0.90	0.00	0.04	0.00	0.02	0.00	0.00	0.00	0.00
	C	5.34	17.39	21.73	10.76	0.00	0.34	0.69	0.31	0.00	7.14	8.33	3.70
	O	1.52	1.44	4.34	1.79	0.00	0.00	0.00	0.00	10.71	14.28	8.33	11.11
Feb. 1975	DF	64.27	42.86	53.33	53.50	75.00	87.50	80.01	68.43	100.00	100.00	100.00	100.00
	SF	14.29	0.00	0.00	4.65	0.00	12.50	28.57	13.16	0.00	0.00	0.00	0.00
	C	21.42	50.00	46.66	39.53	25.00	0.00	14.28	15.78	0.00	0.00	0.00	0.00
	O	0.00	7.14	0.00	2.32	0.00	0.00	7.14	2.63	0.00	0.00	0.00	0.00
May 1975	DF	95.00	88.24	65.00	87.63	99.98	98.26	99.77	99.90	95.00	100.00	100.00	97.73
	SF	0.00	0.00	5.00	1.03	0.02	0.87	0.23	0.07	5.00	0.00	0.00	2.27
	C	5.00	11.76	30.00	11.34	0.00	0.87	0.00	0.03	0.00	0.00	0.00	0.00
	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VI-4 (cont.)

Quarter	Feeding Type	Station			Total for Quarter	Station			Total for Quarter	Station			Total for Quarter
		7-1	7-2	7-3		8-1	8-2	8-3		9-1	9-2	9-3	
May 1974	DF	100.00	66.67	77.78	86.67	46.13	67.99	45.45	49.08	12.25	4.16	67.65	8.23
	SF	0.00	16.67	11.11	6.67	42.78	14.19	32.02	39.01	83.86	95.46	20.59	90.07
	C	0.00	16.66	11.11	6.66	10.25	14.52	9.16	10.59	1.48	0.28	11.76	0.91
	O	0.00	0.00	0.00	0.00	0.84	3.30	3.43	1.32	2.41	0.00	0.00	0.79
August 1974	DF	60.35	47.80	72.89	62.37	61.42	74.65	47.36	62.20	36.04	45.77	54.00	42.63
	SF	36.21	40.58	22.03	33.33	18.56	10.91	34.90	22.27	49.28	40.27	43.31	44.92
	C	0.00	0.00	0.00	0.00	19.78	13.56	6.87	14.37	9.55	12.63	6.23	8.36
	O	3.44	4.34	5.08	4.30	0.24	0.88	2.71	1.16	5.13	1.33	4.20	4.09
Nov. 1974	DF	68.44	83.45	90.00	79.25	41.43	48.54	43.03	45.84	51.36	57.48	65.94	55.81
	SF	10.52	4.16	0.00	5.66	42.57	38.07	41.73	39.86	31.98	32.83	12.22	27.10
	C	5.26	4.16	0.00	3.77	12.21	9.05	7.91	9.36	11.71	8.95	12.22	11.49
	O	15.78	8.33	10.00	11.32	3.79	4.34	7.33	4.94	4.95	0.74	9.62	5.60
Feb. 1975	DF	80.00	90.70	96.00	92.06	51.86	42.09	62.86	49.59	61.00	70.39	82.42	65.33
	SF	10.00	2.33	4.00	2.27	45.69	50.74	19.81	41.30	20.95	13.33	9.25	18.64
	C	5.00	4.65	0.00	3.40	4.95	3.46	5.87	4.64	9.34	7.40	8.33	8.21
	O	5.00	2.32	0.00	2.27	1.02	3.71	11.46	4.47	8.71	8.88	0.00	7.82
May 1975	DF	84.10	77.50	93.55	84.36	2.49	9.35	18.97	8.27	13.91	17.22	29.68	16.24
	SF	11.36	5.00	3.23	6.96	95.23	84.17	73.24	87.39	77.41	73.84	60.83	74.94
	C	4.54	12.50	0.00	6.08	1.34	1.35	1.47	0.84	4.07	6.03	5.34	4.60
	O	0.00	5.00	3.22	2.60	0.94	5.13	6.32	3.50	4.61	2.91	4.15	4.22

Table VI-4 (cont.)

Quarter	Feeding Type	Station 10-1	Station 10-2	Station 10-3	Total for Quarter
May 1974	DF	73.32	62.17	16.67	55.26
	SF	16.92	31.08	83.33	38.12
	C	10.76	6.75	0.00	6.62
	O	0.00	0.00	0.00	0.00
August 1974	DF	78.74	75.00	90.70	77.68
	SF	17.02	25.00	6.98	20.30
	C	2.12	0.00	1.16	1.01
	O	2.12	0.00	1.16	1.01
Nov. 1974	DF	93.11	91.87	91.56	92.23
	SF	1.15	5.81	1.41	2.87
	C	5.74	2.32	5.63	4.50
	O	0.00	0.00	1.40	0.40
Feb. 1975	DF	84.00	73.92	92.86	84.23
	SF	4.00	8.70	3.57	5.26
	C	8.00	8.69	3.57	6.57
	O	4.00	8.69	0.00	3.94
May 1975	DF	87.14	90.33	80.00	86.01
	SF	12.86	9.67	7.50	10.46
	C	0.00	0.00	2.50	0.70
	O	0.00	0.00	10.00	2.83

* DF = Deposit Feeder; SF = Suspension Feeder; C = Carnivore; O = Omnivore.

Table VI-5

Quarterly scaled evenness diversity values by feeding type for each station

Station	Feeding Type	May 1974			August 1974			November 1974			February 1975			May 1975		
		SDN*	Sp*	I*	SDN	Sp	I	SDN	Sp	I	SDN	Sp	I	SDN	Sp	I
1	DF	-	-	-	.165	8	140	.402	10	71	.000	5	44	-	-	-
2	DF	.554	19	109	.490	21	233	.249	9	183	-	-	-	.071	17	1448
	SF	-	-	-	-	-	-	-	-	-	-	-	-	.026	4	609
	C	-	-	-	-	-	-	-	-	-	-	-	-	.500	7	37
	O	-	-	-	-	-	-	-	-	-	-	-	-	.071	3	25
3	DF	.604	11	83	.479	22	111	.727	19	86	.012	6	104	.076	12	546
	SF	-	-	-	.019	5	662	-	-	-	-	-	-	.005	6	233
	C	-	-	-	.396	10	61	-	-	-	-	-	-	-	-	-
4	DF	.055	6	159	.453	11	73	.535	8	193	-	-	-	.381	11	85
	C	-	-	-	.692	4	35	-	-	-	-	-	-	-	-	-
5	DF	.611	10	121	.015	4	10562	.011	2	5610	.614	10	26	.041	8	5551
	SF	.193	4	102	-	-	-	-	-	-	-	-	-	-	-	-
6	DF	.556	4	123	.341	7	148	.545	6	46	.000	3	38	.559	6	41
7	DF	.688	12	26	.193	7	116	.178	10	42	.393	6	79	.457	13	97
	SF	-	-	-	.000	2	62	-	-	-	-	-	-	-	-	-
8	DF	.553	26	1440	.532	27	1066	.539	29	1235	.328	27	2262	.524	33	1514
	SF	.202	7	1145	.232	7	379	.395	6	170	.299	7	1884	.018	6	13086
	C	.407	9	311	.359	10	246	.541	15	382	.255	10	210	.532	14	223
	O	.149	5	39	-	-	-	.279	4	145	.010	2	204	.112	4	527

Table VI-5 (cont.)

Station	Feeding Type	May 1974			August 1974			November 1974			February 1975			May 1975		
		SDN	Sp	I	SDN	Sp	I	SDN	Sp	I	SDN	Sp	I	SDN	Sp	I
9	DF	.634	21	134	.643	21	1927	.665	24	602	.671	21	668	.674	25	538
	SF	.319	5	1469	.168	10	1987	.279	7	290	.457	6	193	.103	7	2392
	C	-	-	-	.422	8	328	.635	17	123	.431	12	93	.565	11	147
	O	-	-	-	.514	3	181	.128	3	60	.295	3	81	.240	4	135
10	DF	.649	16	100	.179	7	163	.096	5	225	.438	7	64	.395	6	121
	SF	.811	3	69	.104	4	30	-	-	-	-	-	-	-	-	-

*SDN = Fager's (1972) scaled standard deviation
Sp = Number of species
I = Number of individuals

Table VI-6

Proportions of the two most abundant species and dominance index for each sample

Station 1

Species	May 1974 1-1	May 1974 1-2	May 1974 1-3	August 1974 1-1	August 1974 1-2	August 1974 1-3	November 1974 1-1	November 1974 1-2	November 1974 1-3
	Proportion			Proportion			Proportion		
Parahaustorius longimerus	.571	.400	1.00	.655	.750	.660	.933	.333	
Several Species*	.143	.100							
Mulinia lateralis				.164	.150				
Elasmopus laevis						.120			
Others (Arthropoda)							.033		
Nucula proxima								.476	
Magelona sp. 2									.259
Nephtys picta									.222
Dominance Index	.714	.500	1.00	.819	.900	.780	.966	.809	.481

Species	February 1975 1-1	February 1975 1-2	February 1975 1-3	May 1975 1-1	May 1975 1-2	May 1975 1-3	Dominance Frequency**
	Proportion			Proportion			
Parahaustorius longimerus	.944	.750	1.00	.500	.429	.667	11
Others		.063				.167	
Mulinia lateralis							
Elasmopus laevis							
Others (Arthropoda)							
Nucula proxima	.055			.500	.429		3
Magelona sp. 2							
Nephtys picta							
Dominance Index	.999	.813	1.00	1.00	.858	.834	

Table VI-6 (cont.)

Station 2	May 1974			August 1974			November 1974		
	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3
Species	Proportion			Proportion			Proportion		
Spiophanes bombyx	.256		.239						
Tellina agilis	.231	.258	.283		.172		.850	.524	.699
Spio setosa		.452		.423		.227			
Mediomastus ambiseta				.264		.159			
Several Species					.138		.030		
Nephtys picta								.238	
Nucula proxima									.110
Glycera dibranchiata									
Mytilus edulis									
Dominance Index	.487	.710	.522	.687	.310	.386	.880	.762	.809

	February 1975			May 1975			Dominance Frequency
	2-1	2-2	2-3	2-1	2-2	2-3	
	Proportion			Proportion			
Spiophanes bombyx	.125						1
Tellina agilis	.625	.384					7
Spio setosa				.774	.458	.771	6
Mediomastus ambiseta							
Several Species			.111				
Nephtys picta							
Nucula proxima		.230					
Glycera dibranchiata			.444				1
Mytilus edulis				.123	.440	.156	
Dominance Index	.750	.614	.555	.897	.898	.927	

Table VI-6 (cont.)

Station 3 Species	May 1974 3-1	May 1974 3-2	May 1974 3-3	August 1974 3-1	August 1974 3-2	August 1974 3-3	November 1974 3-1	November 1974 3-2	November 1974 3-3
	Proportion			Proportion			Proportion		
Spio setosa	.417	.273							
Tellina agilis	.167		.364						
Several Species		.152	.136					.120	.152
Mytilus edulis				.821	.391	.804			
Mediomastus ambiseta				.078	.109		.191		
Lysianopsis alba							.206		
Polydora socialis								.160	
Sabellaria vulgaris									.212
Glycera capitata									
Nephtys picta									
Glycera dibranchiata									
Xanthid sp.						.032			
Dominance Index	.584	.425	.500	.899	.500	.836	.397	.280	.364

Species	February 1975 3-1	February 1975 3-2	February 1975 3-3	May 1975 3-1	May 1975 3-2	May 1975 3-3	Dominance Frequency
	Proportion			Proportion			
Spio setosa				.700	.609	.167	4
Tellina agilis	.795	.767	.739				4
Several Species							
Mytilus edulis				.227	.313	.476	4
Mediomastus ambiseta							
Lysianopsis alba							1
Polydora socialis							1
Sabellaria vulgaris							1
Glycera capitata	.077						
Nephtys picta		.163					
Glycera dibranchiata			.065				
Xanthid sp.							
Dominance Index	.872	.930	.804	.927	.922	.643	

Table VI-6 (cont.)

Station 4	May 1974			August 1974			November 1974		
	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3
	Proportion			Proportion			Proportion		
Protohaustorius wigleyi	.833	.869	.911						
Several Species	.083	.040							
Tellina agilis			.036	.400	.241	.386	.427		
Glycera dibranchiata				.200					
Nucula proxima					.172		.336	.203	
Glycera capitata						.227			
Trichophoxus epistomus								.493	.364
Scoloplos robustus									.182
Acteocina canaliculata									
Dominance Index	.916	.909	.947	.600	.413	.613	.763	.696	.546

	February 1975			May 1975			
	4-1	4-2	4-3	4-1	4-2	4-3	Dominance
	Proportion			Proportion			Frequency
Protohaustorius wigleyi							3
Several Species	.143	.142					
Tellina agilis			.400	.113	.118	.273	6
Glycera dibranchiata		.214					1
Nucula proxima				.597	.647		2
Glycera capitata						.182	
Trichophoxus epistomus	.500						3
Scoloplos robustus							
Acteocina canaliculata			.200				
Dominance Index	.643	.357	.600	.710	.765	.455	

Table VI-6 (cont.)

Station 5 Species	May 1974 5-1	May 1974 5-2	May 1974 5-3	August 1974 5-1	August 1974 5-2	August 1974 5-3	November 1974 5-1	November 1974 5-2	November 1974 5-3
	Proportion			Proportion			Proportion		
Tellina agilis	.500	.188	.142	.011	.008	.015	.003	.005	.011
Capitella capitata	.454								
Ensis directus		.333	.455						
Nucula proxima				.986	.991	.983	.996	.991	.982
Ampelisca verrilli									
Dominance Index	.954	.521	.597	.997	.999	.998	.999	.996	.993

Species	February 1975 5-1	February 1975 5-2	February 1975 5-3	May 1975 5-1	May 1975 5-2	May 1975 5-3	Dominance Frequency
	Proportion			Proportion			
Tellina agilis	.250			.022	.126	.117	2
Capitella capitata							
Ensis directus			.214				3
Nucula proxima	.188	.250	.143	.977	.800	.864	9
Ampelisca verrilli		.375					1
Dominance Index	.438	.625	.357	.999	.926	.981	

Table VI-6 (cont.)

Station 6	May 1974			August 1974			November 1974		
	6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3
Species	Proportion			Proportion			Proportion		
Acanthohaustorius millsi	.469	.445	.436			.240			
Parahaustorius longimerus	.375	.445	.364	.590	.667	.510		.286	.250
Acanthohaustorius shoemakeri				.128					
Spisula solidissima					.152				
Protohaustorius wigleyi							.464	.214	.500
Several Species							.143		
Dominance Index	.844	.890	.800	.718	.819	.750	.607	.500	.750

	February 1975			May 1975			Dominance
	6-1	6-2	6-3	6-1	6-2	6-3	Frequency
	Proportion			Proportion			
Acanthohaustorius millsi				.300	.571		4
Parahaustorius longimerus				.350		.294	5
Acanthohaustorius shoemakeri							
Spisula solidissima							
Protohaustorius wigleyi	1.00	.846	1.00		.429	.588	6
Several Species		.077					
Dominance Index	1.00	.923	1.00	.650	1.00	.882	

Table VI-6 (cont.)

Station 7 Species	May 1974 7-1	7-2	7-3	August 1974 7-1	7-2	7-3	November 1974 7-1	7-2	7-3
	Proportion			Proportion			Proportion		
Asabellides oculatus	.267								
Acanthohaustorius millsi	.200								
Glycera capitata		.286							
Several Species		.143							
Tellina agilis			.222						
Scoloplos robustus			.333						
Nucula proxima				.466	.464	.559			
Mulinia lateralis				.345	.406	.220			
Ampelisca verrilli							.368	.625	.600
Others (polychaetes)							.156	.083	
Pectinaria gouldii									.200
Ampelisca abdita									
Yoldia limatula									
Spio setosa									
Dominance Index	.467	.429	.555	.811	.870	.779	.524	.708	.800

Species	February 1975 7-1	7-2	7-3	May 1975 7-1	7-2	7-3	Dominance Frequency
	Proportion			Proportion			
Asabellides oculatus							1
Acanthohaustorius millsi							
Glycera capitata							1
Several Species							
Tellina agilis				.273	.425	.594	3
Scoloplos robustus							1
Nucula proxima	.400		.160				4
Mulinia lateralis							
Ampelisca verrilli	.400	.581	.640				5

Table VI-6 (cont.)

Station 7 (cont.)	February 1975			May 1975			
	7-1	7-2	7-3	7-1	7-2	7-3	Dominance
	Proportion			Proportion			Frequency
Others (polychaetes)							
Pectinaria gouldii							
Ampelisca abdita		.279					
Yoldia limatula				.182	.150		
Spio setosa						.156	
Dominance Index	.800	.860	.800	.455	.575	.750	

Table VI-6 (cont.)

Station 8	May 1974			August 1974			November 1974		
	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3
Species	Proportion			Proportion			Proportion		
Mytilus edulis	.371								
Corophium simile	.216	.140				.235	.134		
Unciola serrata		.156	.121	.220				.154	.118
Crepidula plana			.211						
Hydroides dianthus				.265	.088	.303	.333	.273	
Asabellides oculatus					.522				
Sabellaria vulgaris									.332
Eumida sanguinea									
Nucula proxima									
Dominance Index	.587	.296	.432	.485	.610	.538	.667	.427	.450

	February 1975			May 1975			Dominance Frequency
	8-1	8-2	8-3	8-1	8-2	8-3	
	Proportion			Proportion			
Mytilus edulis				.935	.837	.709	4
Corophium simile							
Unciola serrata	.319	.265	.418				2
Crepidula plana							1
Hydroides dianthus	.324	.361	.140	.012			6
Asabellides oculatus							1
Sabellaria vulgaris							1
Eumida sanguinea					.048		
Nucula proxima						.086	
Dominance Index	.643	.626	.558	.947	.885	.795	

Table VI-6 (cont.)

Station 9	May 1974			August 1974			November 1974		
	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3
Species	Proportion			Proportion			Proportion		
Hydroides dianthus	.816			.412	.348	.369	.308	.207	
Polydora ligni	.061								
Mytilus edulis		.953							
Asabellides oculatus		.015	.294						
Nucula proxima			.265					.244	
Unciola serrata				.103	.097	.155			
Corophium simile							.169		.148
Mediomastus ambiseta									.115
Others (polychaetes)									
Dominance Index	.877	.968	.559	.515	.445	.524	.477	.451	.263

	February 1975			May 1975			Dominance Frequency
	9-1	9-2	9-3	9-1	9-2	9-3	
	Proportion			Proportion			
Hydroides dianthus				.053	.081		5
Polydora ligni							
Mytilus edulis				.703	.653	.591	4
Asabellides oculatus							
Nucula proxima		.281	.343			.068	3
Unciola serrata	.156	.111					
Corophium simile							1
Mediomastus ambiseta	.145						
Others (polychaetes)			.167				
Dominance Index	.301	.392	.510	.756	.734	.659	

Table VI-6 (cont.)

Station 10 Species	May 1974 10-1	10-2	10-3	August 1974 10-1	10-2	10-3	November 1974 10-1	10-2	10-3
	Proportion			Proportion			Proportion		
Asabellides oculatus	.185	.189							
Others (Arthropods)	.108								
Others (Molluscs)		.149							
Mytilus edulis			.667						
Mulinia lateralis			.143	.149	.212			.058	
Nucula proxima				.681	.560	.744	.851	.860	.789
Tellina agilis						.093			
Acteocina punctulata							.057		
Several Species									
Ampelisca verrilli									
Ampelisca abdita									
Nephtys incisa									
Dominance Index	.293	.338	.810	.830	.772	.837	.908	.918	.845

Species	February 1975 10-1	10-2	10-3	May 1975 10-1	10-2	10-3	Dominance Frequency
	Proportion			Proportion			
Asabellides oculatus							2
Others (Arthropods)							
Others (Molluscs)							
Mytilus edulis							1
Mulinia lateralis							
Nucula proxima		.174		.386	.655	.750	9
Tellina agilis			.357				
Acteocina punctulata							
Others	.080						
Ampelisca verrilli	.600	.304	.464		.172		3
Ampelisca abdita				.314			
Nephtys incisa						.100	
Dominance Index	.680	.478	.821	.700	.827	.850	

Table VI-6 (cont.)

Station 10 (cont.)	February 1975 10-1	February 1975 10-2	February 1975 10-3	May 1975 10-1	May 1975 10-2	May 1975 10-3	Dominance Frequency
	Proportion			Proportion			
Several Species	.080						
Ampelisca verrilli	.600	.304	.464		.172		3
Ampelisca abdita				.314			
Nephtys incisa						.100	
Dominance Index	.680	.478	.821	.700	.827	.850	

* Several Species - more than one species having the same proportion value.

**Dominance Frequency - Number of times proportion was highest out of all samples.

Table VI-7

Summation of cluster classification of station vs. species

Quarter	Station Groupings							
May 1974	1 & 6		2 & 3		10 & 5 & 9	8	7	4
August 1974	1 & 6		2 & 3		10 & 5 & 7	8 & 9		4
November 1974	1 & 6		2	3	10 & 5	8 & 9	7	4
February 1975	1	6	2 & 3		10 & 5 & 7	8 & 9		4
May 1975	1 & 6		2 & 3		5 & 10	8 & 9		7 & 4

Table VI-8

Summation of cluster classification of species groups

Group	May 1974	Stations	August 1974	Stations	November 1974	Stations
A	*Parahaustorius longimerus*	6, 1	*Parahaustorius longimerus*	1, 6	*Parahaustorius longimerus*	1
	Protohaustorius wigleyi	4			*Protohaustorius wigleyi*	6
	Nephtys bucera	4, 6	*Nephtys bucera*	6, 1	*Nephtys bucera*	6, 4
	Acanthohaustorius millsi	6	*Acanthohaustorius millsi*	6		
	Bathyporeia parkeri	6				
			Ampelisca abdita	1, 8		
B	*Nucula proxima*	8, 5,10	*Nucula proxima*	5,10, 7	*Nucula proxima*	5,10, 8
	Tellina agilis	5, 3, 9	*Tellina agilis*	5, 4, 8	*Tellina agilis*	2, 5
	Mulinia lateralis	9,10, 5	*Mulinia lateralis*	7, 1	*Mulinia lateralis*	10, 2
	Ensis directus	5,10	*Ensis directus*	5		
	Ampelisca verrilli	10, 5, 9	*Ampelisca verrilli*	8, 7,10	*Ampelisca verrilli*	7
	Asabellides oculatus	9,10, 5				
	Yoldia limatula	5,10	*Yoldia limatula*	10, 7		
	Scoloplos robustus	10, 7				
			Scoloplos fragilis	10		
			Nephtys incisa	7		
					Acteocina canaliculata	10, 4
C	*Streblospio benedicti*	8, 9	NO SPECIES GROUP		NO SPECIES GROUP	
	Glycera dibranchiata	2, 3, 9				
	Spio setosa	3, 2, 8				
	Spiophanes bombyx	2, 3, 4				
D	*Marphysa sanguinea*	8	*Marphysa sanguinea*	9, 8	*Marphysa sanguinea*	8, 9
	Nereis succinea	8, 9	*Nereis succinea*	9, 8	*Nereis succinea*	8
	Polydora socialis	8			*Polydora socialis*	9, 8
	Polycirrus eximius	8	*Polycirrus eximius*	9	*Polycirrus eximius*	9, 8
	Unciola serrata	8	*Unciola serrata*	9, 8	*Unciola serrata*	8, 9
	Harmothoe extenuata	8	*Harmothoe extenuata*	3, 8, 9		
	Corophium simile	8	*Corophium simile*	9, 8	*Corophium simile*	8, 9

Table VI-8 (cont.)

Group	February 1975	Stations	May 1975	Stations
A cont.	Parahaustorius longimerus	1	Parahaustorius longimerus	6, 1, 7
	Protohaustorius wigleyi	6	Protohaustorius wigleyi	6
			Acanthohaustorius millsi	6
B cont.			Nucula proxima	5, 8, 9
			Tellina agilis	5, 7, 2
	Mulinia lateralis	7, 5,10		
			Ensis directus	8, 9, 2
	Ampelisca verrilli	7,10	Ampelisca verrilli	10, 7
			Yoldia limatula	7,10
			Nephtys incisa	10, 7
	Glycera americana	5, 9,10		
			Spio setosa	2, 3
			Mytilus edulis	8, 9, 2
			Ampelisca abdita	10, 5
C cont.	NO SPECIES GROUP		NO SPECIES GROUP	
D cont.	Marphysa sanguinea	8, 9	Marphysa sanguinea	9, 8
	Nereis succinea	9, 8	Nereis succinea	8, 9
			Polydora socialis	8, 9
	Polycirrus eximius	8, 9	Polycirrus eximius	8, 9
	Unciola serrata	8, 9	Unciola serrata	8, 9
			Harmothoe extenuata	8, 2, 9
	Corophium simile	8, 9	Corophium simile	8, 9
	Polydora ligni	8		
	Xanthid sp.	8	Xanthid sp.	8, 9
	Hydroides dianthus	8, 9	Hydroides dianthus	9, 8
	Heteromastus filiformis	9	Heteromastus filiformis	9, 8
	Sabellaria vulgaris	8, 9	Sabellaria vulgaris	8, 9
	Oxyurostylis smithi	8, 9	Oxyurostylis smithi	8, 9, 3
	Glycinde solitaria	9	Glycinde solitaria	8, 9

Table VI-8 (cont.)

Group	May 1974	Stations	August 1974	Stations	November 1974	Stations
D	Polydora ligni	8, 9			Polydora ligni	8, 9
cont.	Xanthid sp.	8	Xanthid sp.	9, 8	Xanthid sp.	8, 9
	Hydroides dianthus	9, 8	Hydroides dianthus	9, 8	Hydroides dianthus	9, 8
	Heteromastus filiformis	8, 9	Heteromastus filiformis	9	Heteromastus filiformis	8
	Mytilus edulis	8,10, 9	Mytilus edulis	3, 8, 9		
	Sabellaria vulgaris	8			Sabellaria vulgaris	8
	Oxyurostylis smithi	8, 9, 2				
	Capitella capitata	8, 5, 9				
	Glycinde solitaria	10, 9	Glycinde solitaria	9, 4	Glycinde solitaria	8, 9
			Asabellides oculatus	8, 9	Asabellides oculatus	8, 9
			Streblospio benedicti	9, 2		
			Lembos smithi	8, 9	Lembos smithi	8, 9
			Neopanope texana sayi	9, 8		
			Erichthonius brasiliensis	9, 8		
			Melita nitida	9, 8	Melita nitida	8, 9
			Lepidonotus sublevis	9, 8		
			Oligochaeta sp.	9, 8	Oligochaeta sp.	9, 8
			Eumida sanguinea	9, 8	Eumida sanguinea	9, 8
			Mediomastus ambiseta	9, 2, 8	Mediomastus ambiseta	8, 9
			Lepidonotus squamatus	9, 8, 3	Lepidonotus squamatus	8, 9
			Mercenaria mercenaria	9, 8	Mercenaria mercenaria	8, 9
			Elasmopus laevis	9, 1	Elasmopus laevis	8, 9
			Glycera americana	9, 3, 2	Glycera americana	9, 2, 8
			Spio setosa	2		
			Aricidea cerruti	2, 3		
			Scoloplos robustus	4, 7, 3		
			Nemertea sp.	4, 2		
					Phyllodoce arenae	8, 9
					Podarke obscura	9, 8
					Crepidula plana	8, 9
					Pectinaria gouldii	9, 8, 7
					Pagurus longicarpus	9, 8, 3
					Sthenelais boa	8, 9

Table VI-8 (cont.)

Group	February 1975	Stations	May 1975	Stations
D	*Asabellides oculatus*	9, 8	*Asabellides oculatus*	8, 9
cont.			*Streblospio benedicti*	9
	Lembos smithi	8, 9		
			Neopanope texana sayi	8, 9
	Eumida sanguinea	8, 9	*Eumida sanguinea*	8, 9, 2
	Mediomastus ambiseta	9, 8	*Mediomastus ambiseta*	8, 9
	Lepidonotus squamatus	8, 9	*Lepidonotus squamatus*	8, 9
	Mercenaria mercenaria	9, 8	*Mercenaria mercenaria*	9, 8
			Nemertea sp.	9, 2, 8
	Phyllodoce arenae	9		
			Podarke obscura	8, 9
	Crepidula plana	8, 9	*Crepidula plana*	8, 2, 3
			Sthenelais boa	8, 9
	Nucula proxima	9, 8		
	Ampelisca abdita	7, 8		
	Edotea triloba	9, 8		
			Cirratulidae sp.	8, 9
E			*Glycera americana*	2, 5, 8
cont.	*Glycera capitata*	4, 3	*Glycera capitata*	4, 7, 3
	Glycera dibranchiata	4, 3, 2	*Glycera dibranchiata*	4, 2, 7
	Nephtys picta	3, 2,10	*Nephtys picta*	8, 6, 7
	Tellina agilis	3, 2, 4		
	Acteocina canaliculata	4, 5, 8		
			Capitella capitata	3, 2, 7
			Spiophanes bombyx	4, 2, 3

Table VI-8 (cont.)

Group	May 1974	Stations	August 1974	Stations	November 1974	Stations
E	No Species Group		*Glycera americana*	9, 2, 3		
			Spio setosa	2, 3		
			Aricidea cerruti	2, 3		
			Scoloplos robustus	4, 7, 2	*Scoloplos robustus*	4, 3, 2
			Nemertea sp.	4, 2	*Nemertea* sp.	4, 9, 3
					Glycera capitata	4, 8
					Pinnixa sp.	8, 4, 3
					Trichophoxus epistomus	4
					Glycera dibranchiata	9, 3
					Nephtys picta	2, 1, 3

Figure VI-1: Map showing location of quarterly sampling stations near anchorage area in Delaware Bay.

Figure VI-2: Dendrogram showing relationships of samples taken in May 1974. Czekanowski similarity coefficient and group-average sorting strategy was used.

Figure VI- 3: Dendrogram showing relationships of samples taken in August 1974.

Figure VI- 4: Dendrogram showing relationships of samples taken in November 1974.

Figure VI- 5: Dendrogram showing relationships of samples taken in February 1975.

Figure VI- 6: Dendrogram showing relationships of samples taken in May 1975.

Figure VI- 7: Dendrogram showing species relationships in May 1974 samples. Species names associated with code numbers can be found in Table VI-1.

Figure VI- 8: Dendrogram showing species relationships in August 1974 samples. Species names associated with code numbers can be found in Table VI-1.

Figure VI- 9: Dendrogram showing species relationships in November 1974 samples. Species names associated with code numbers can be found in Table VI-1.

Figure VI-10: Dendrogram showing species relationships in February 1975 samples. Species names associated with code numbers can be found in Table VI-1.

Figure VI-11: Dendrogram showing species relationships in May 1975 samples. Species names associated with code numbers can be found in Table VI-1.

Figure VI-12: Dendrogram showing relationship of sediment samples from quarterly stations.

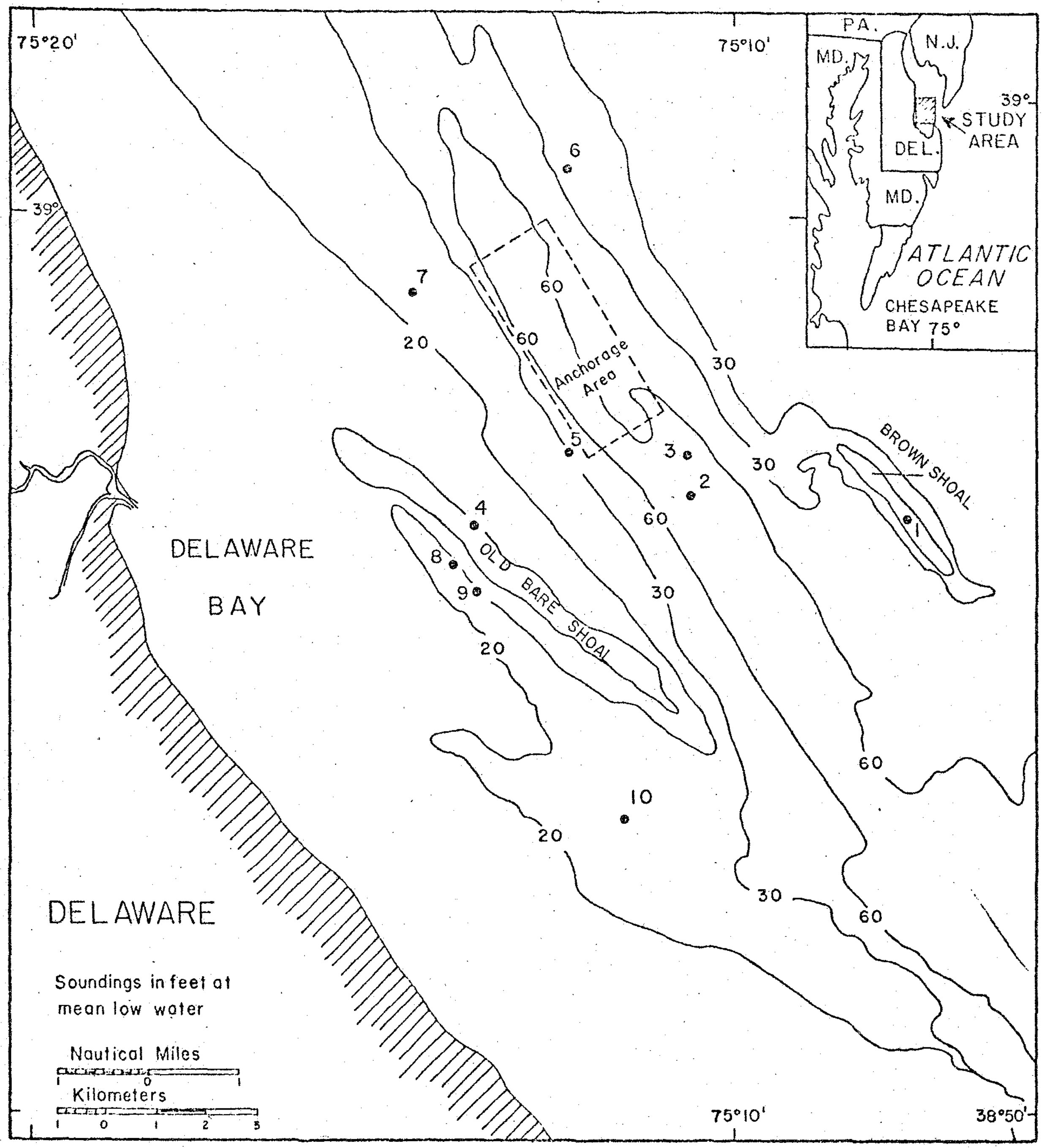

75°20'
75°10'
39°
PA.
N.J.
MD.
39°
STUDY
AREA
DEL.
MD.
ATLANTIC
OCEAN
CHESAPEAKE
BAY
75°
6
7
60
20
60
Anchorage
Area
30
5
3
30
2
BROWN SHOAL
1
4
60
DELAWARE
8
OLD BARE SHOAL
30
BAY
9
20
60
10
20
30
60
DELAWARE
Soundings in feet at
mean low water
Nautical Miles
Kilometers
75°10'
38°50'

Figure VI-1

May 1974 Quarterly

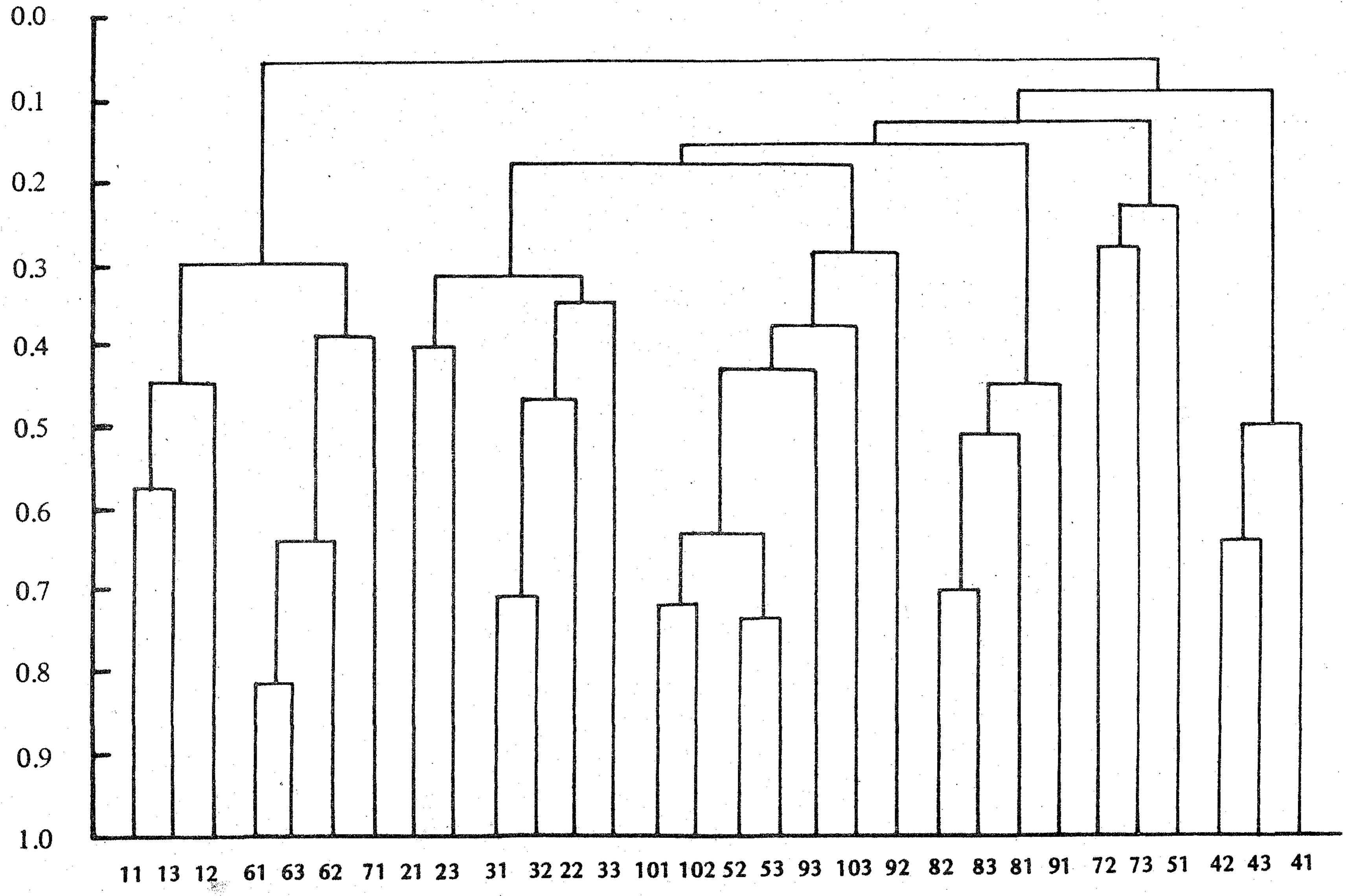


Figure VI-2

August 1974 Quarterly

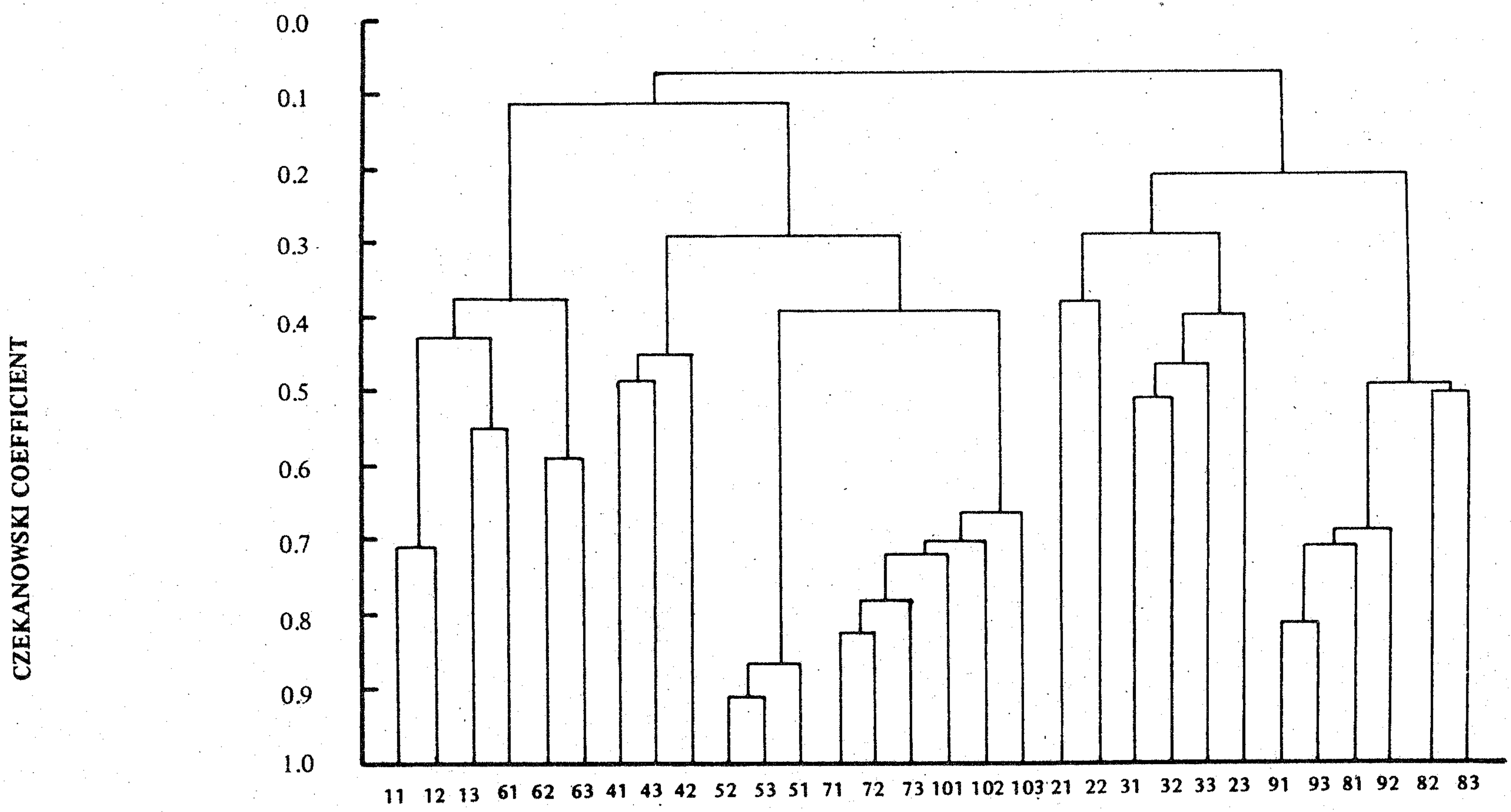


Figure VI-3

November 1974 Quarterly

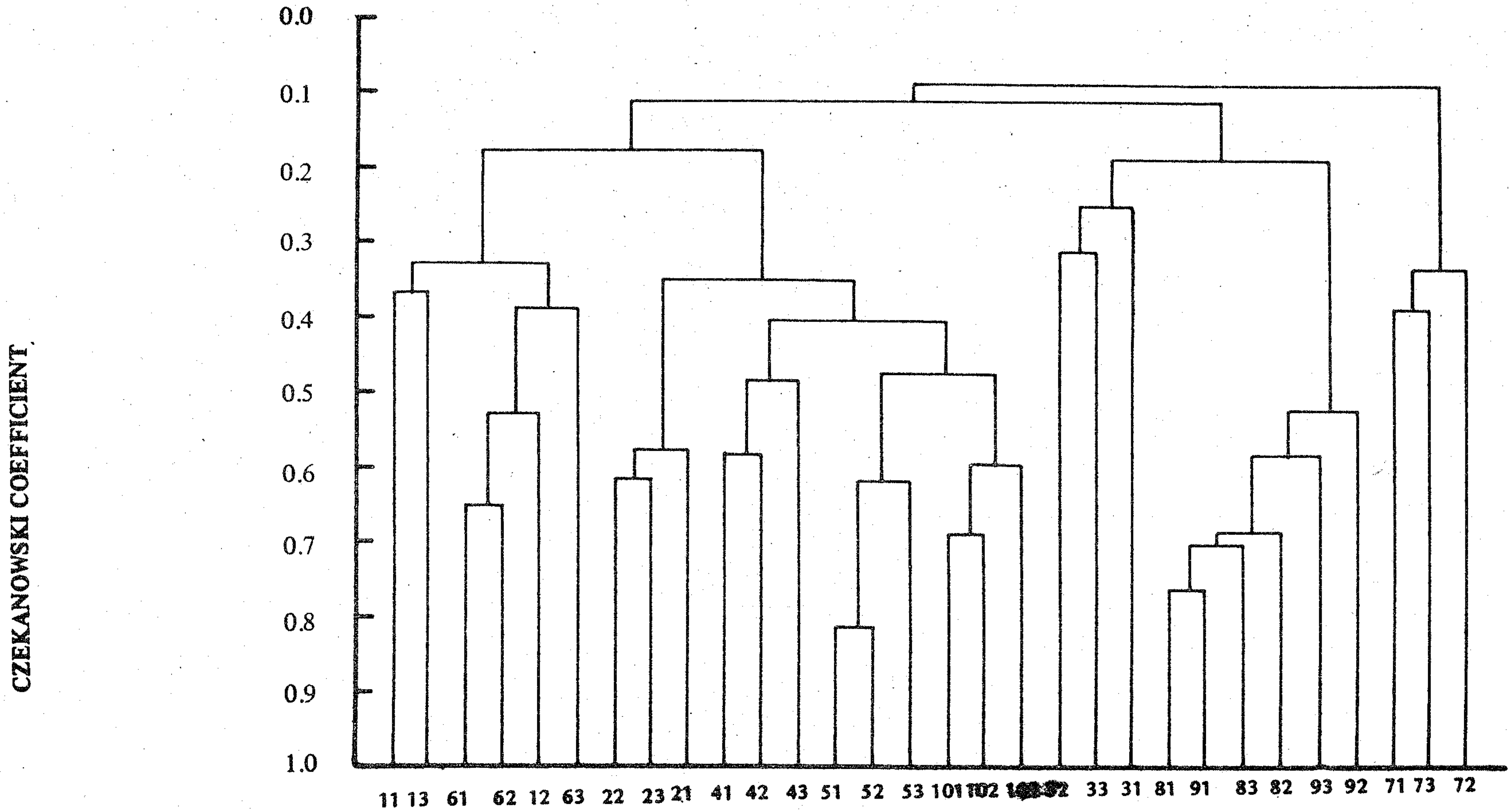


Figure VI-4

February 1975 Quarterly

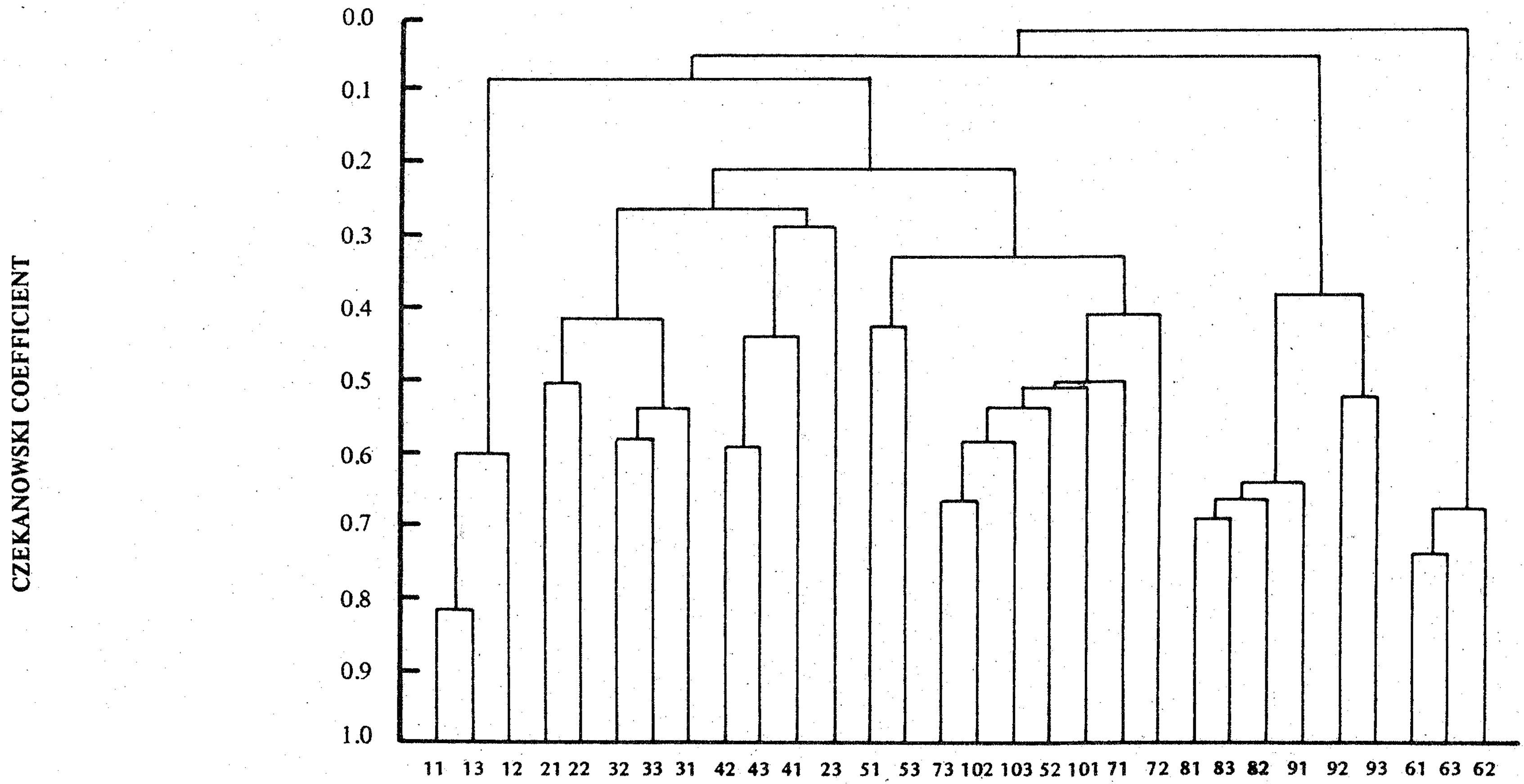


Figure VI-5

May 1975 Quarterly

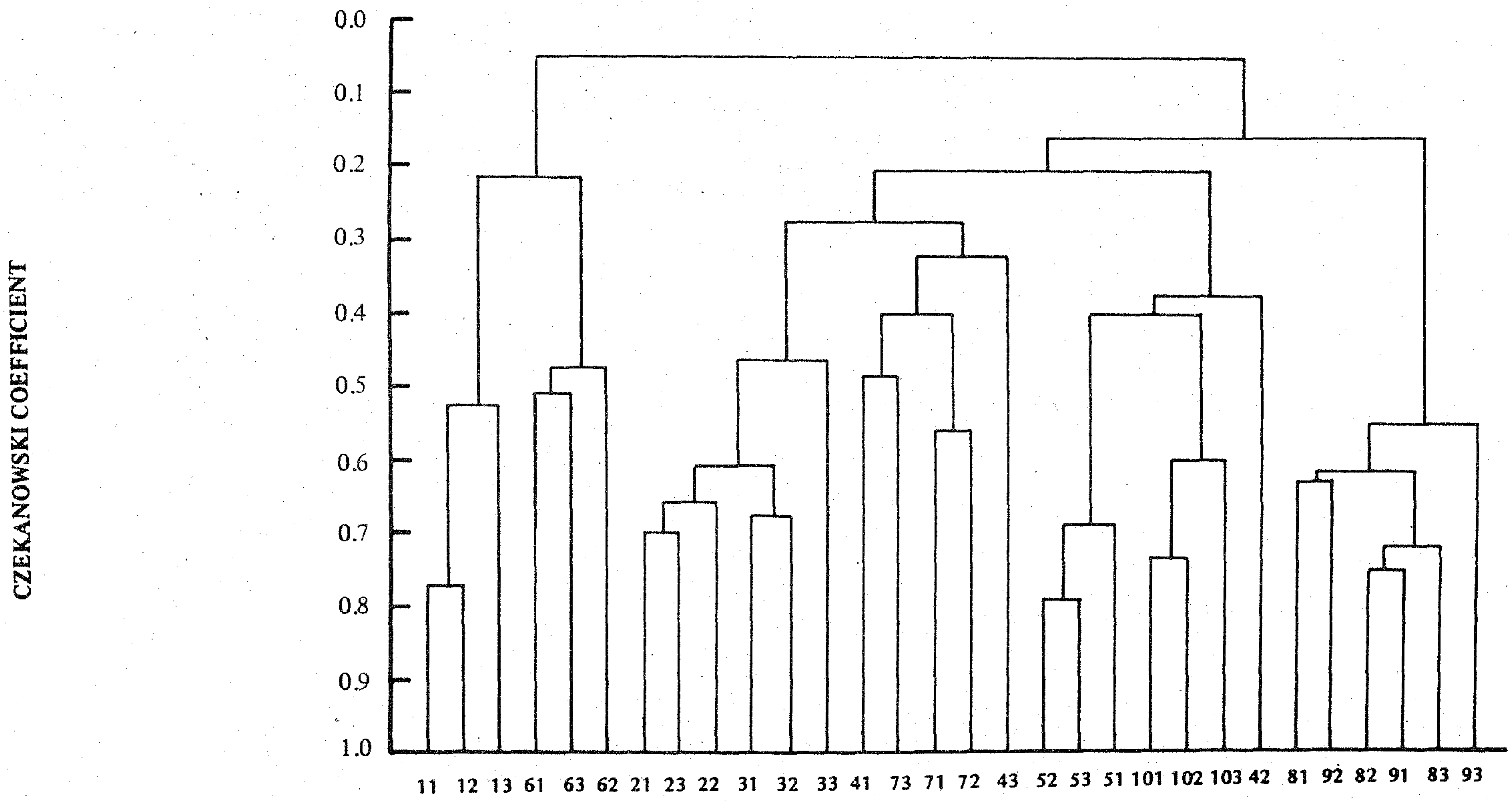


Figure VI-6

May 1974 — Quarterly — Species

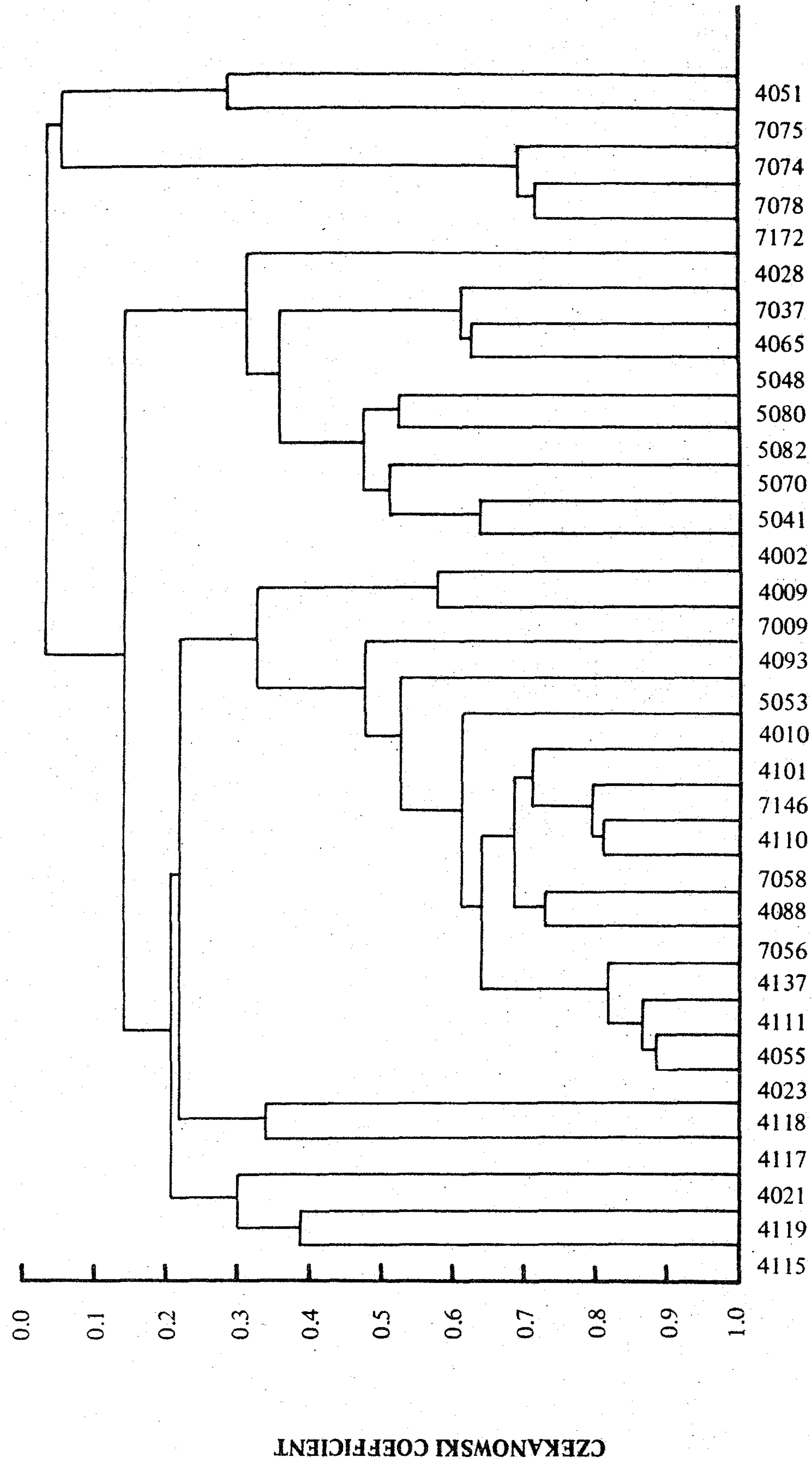
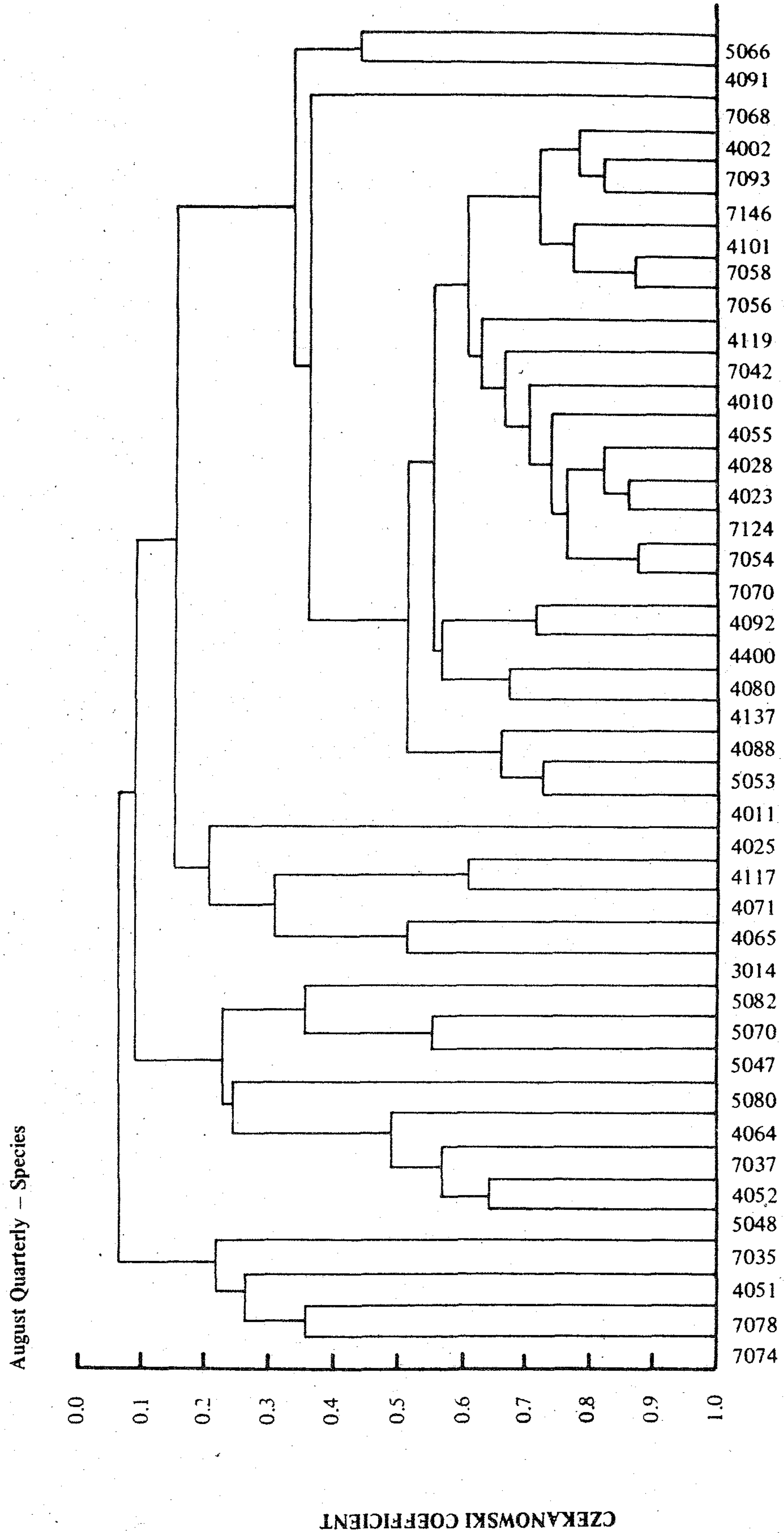


Figure VI-7



August Quarterly – Species
5066
4091
7068
4002
7093
7146
4101
7058
7056
4119
7042
4010
4055
4028
4023
7124
7054
7070
4092
4400
4080
4137
4088
5053
4011
4025
4117
4071
4065
3014
5082
5070
5047
5080
4064
7037
4052
5048
7035
4051
7078
7074
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
CZEKANOWSKI COEFFICIENT

Figure VI-8

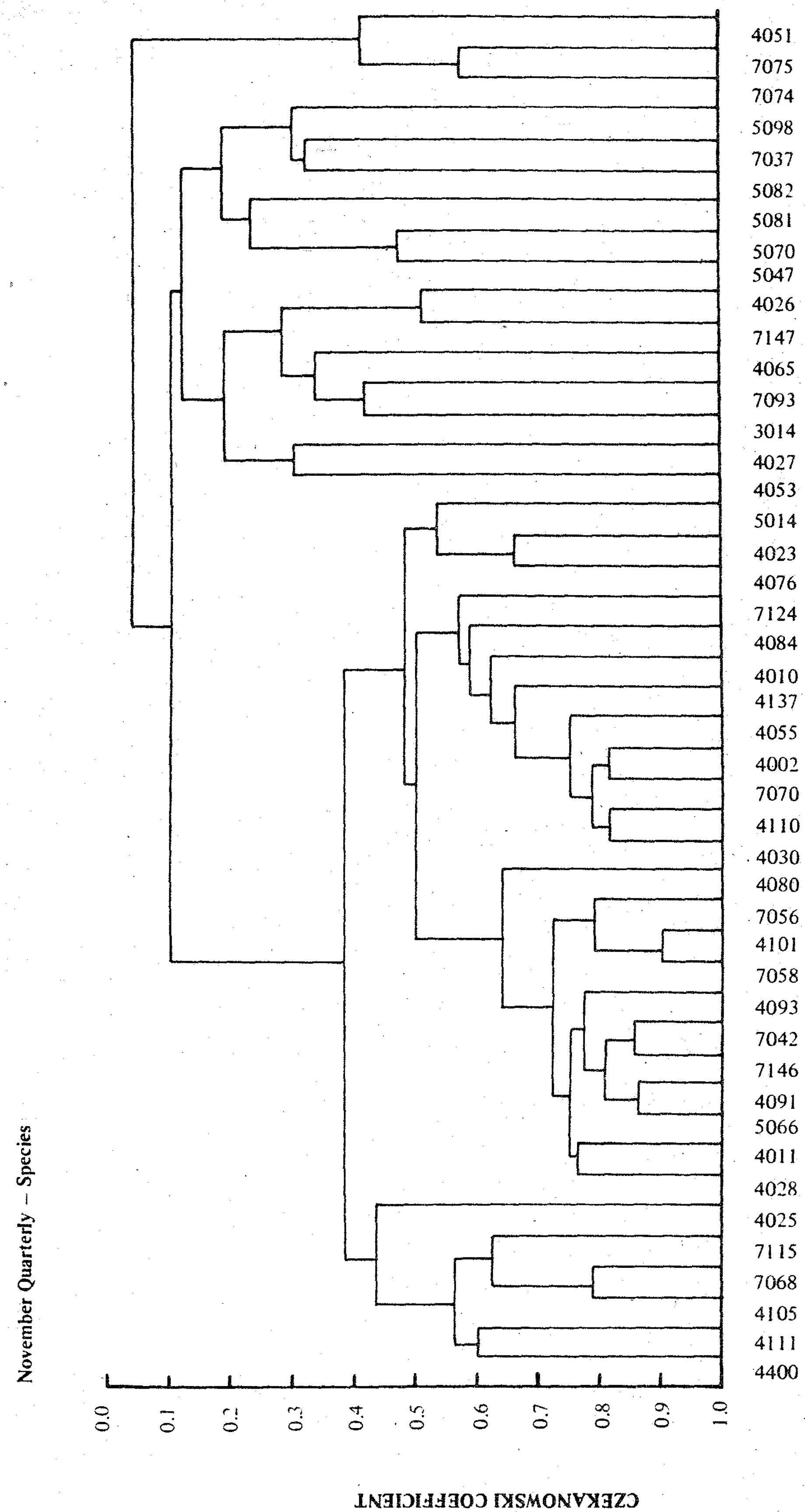

November Quarterly — Species
4051
7075
7074
5098
7037
5082
5081
5070
5047
4026
7147
4065
7093
3014
4027
4053
5014
4023
4076
7124
4084
4010
4137
4055
4002
7070
4110
4030
4080
7056
4101
7058
4093
7042
7146
4091
5066
4011
4028
4025
7115
7068
4105
4111
4400
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
CZEKANOWSKI COEFFICIENT

Figure VI-9

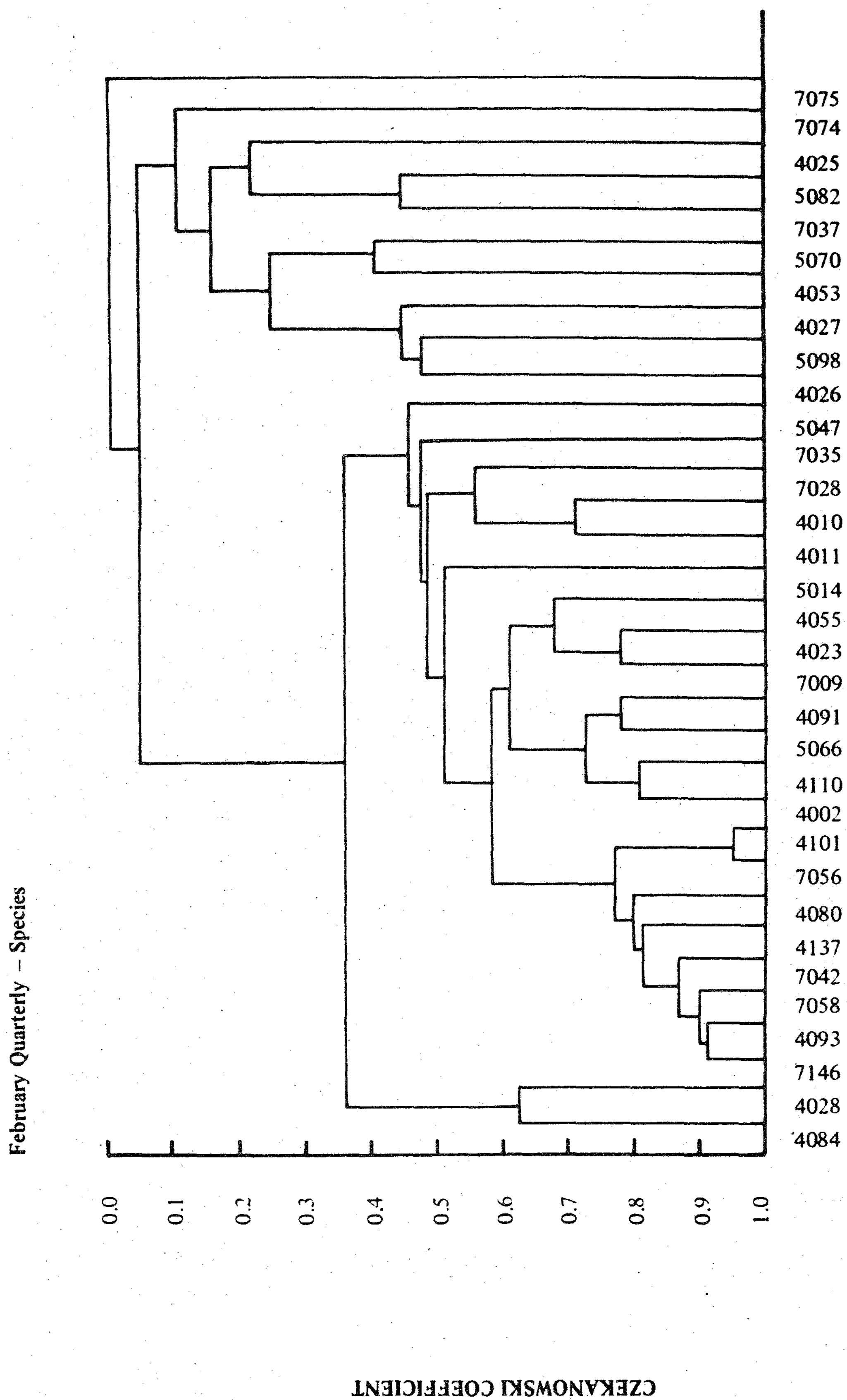

February Quarterly – Species
7075
7074
4025
5082
7037
5070
4053
4027
5098
4026
5047
7035
7028
4010
4011
5014
4055
4023
7009
4091
5066
4110
4002
4101
7056
4080
4137
7042
7058
4093
7146
4028
4084
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
CZEKANOWSKI COEFFICIENT

Figure VI-10

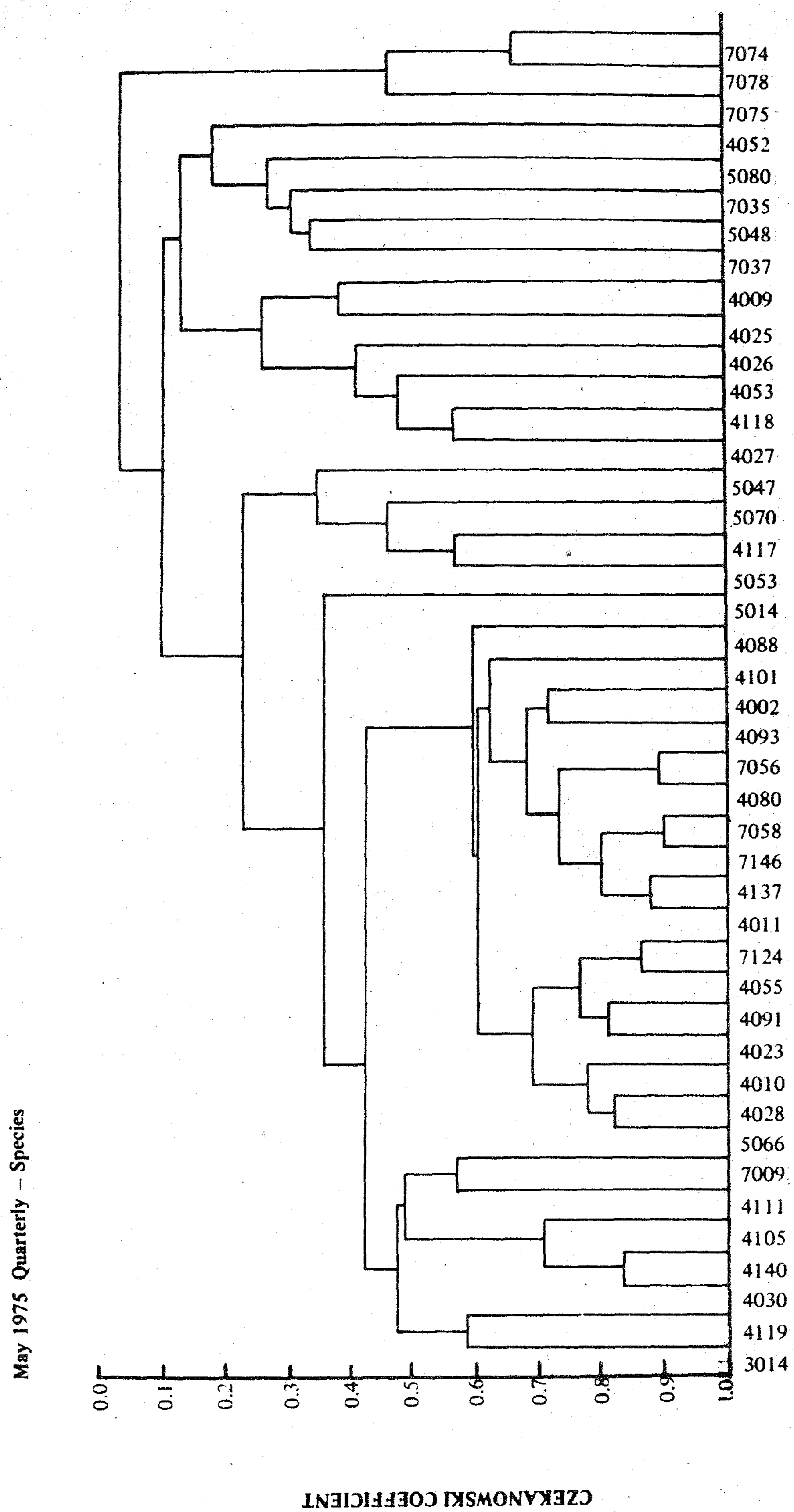
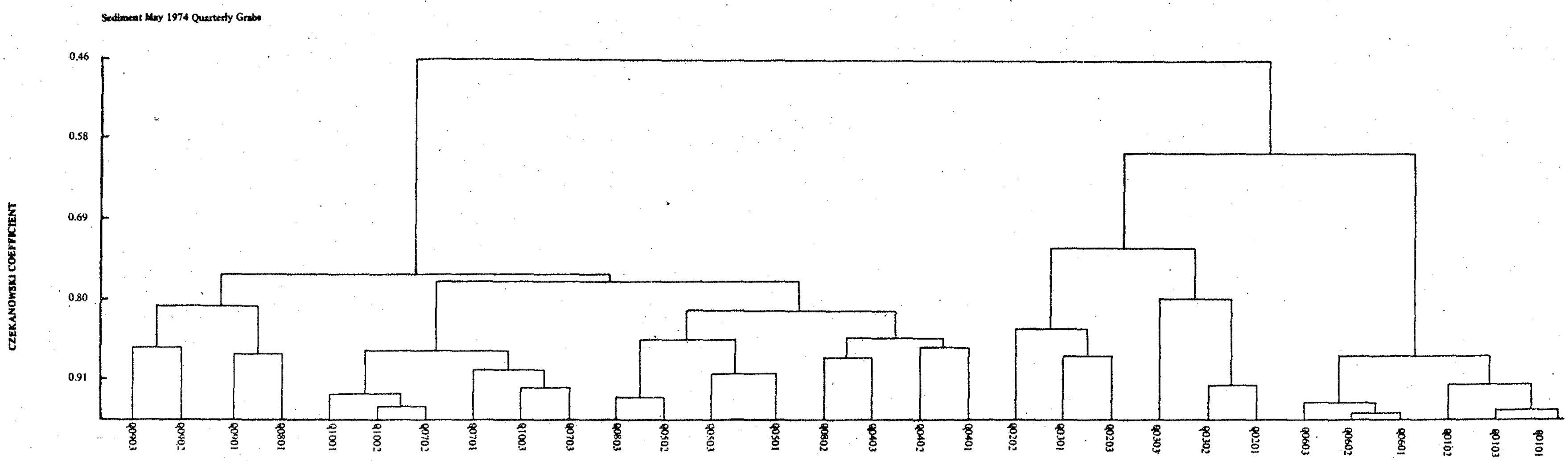

May 1975 Quarterly — Species
7074
7078
7075
4052
5080
7035
5048
7037
4009
4025
4026
4053
4118
4027
5047
5070
4117
5053
5014
4088
4101
4002
4093
7056
4080
7058
7146
4137
4011
7124
4055
4091
4023
4010
4028
5066
7009
4111
4105
4140
4030
4119
3014
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
CZEKANOWSKI COEFFICIENT

Figure VI-11



Sediment May 1974 Quarterly Grabs
CZEKANOWSKI COEFFICIENT
0.46
0.58
0.69
0.80
0.91
Q0903
Q0902
Q0901
Q0801
Q1001
Q1002
Q0702
Q0701
Q1003
Q0703
Q0803
Q0502
Q0503
Q0501
Q0802
Q0403
Q0402
Q0401
Q0202
Q0301
Q0203
Q0303
Q0302
Q0201
Q0603
Q0602
Q0601
Q0102
Q0103
Q0101

Figure VI-12

VII. METHODOLOGICAL BENTHIC STUDIES

Peter Kinner
Les Watling

INTRODUCTION

This research was undertaken to determine whether, using scales of relative abundance, it was possible to accurately assess the structure of benthic assemblages using dredge samples. Benthic surveys using dredges are relatively common, but analyses of the data were restricted to the use of presence-absence coefficients. In some cases no analyses were attempted because of the prevalent view in ecology that strictly quantitative data were required before valid conclusions could be drawn. We believe some excellent benthic research has not been fully exploited due to this dogma.

Because of increased human activities in coastal regions there has been a steadily increasing interest in marine ecology and, as well, with the passage of the National Environmental Policy Act, management agencies are requiring baseline and monitoring assessments of potentially impacted environments (Council on Environmental Quality, 1974). Benthic invertebrates have been consistently used in these studies because they are generally abundant, widespread, relatively easy to collect and identify, and generally cannot move over great enough distances to avoid adverse conditions (Filice, 1959; Wass, 1967).

As with other branches of ecology, studies of the marine benthos began with what were essentially descriptive accounts (Petersen, 1918; Stickney, 1959; Hanks, 1964) progressed from relatively simple (Sanders, 1958, 1960; Wieser, 1960) to more sophisticated analyses (Fenchel, 1969; Lie and Kelley, 1970; Johnson, 1970; Hughes and Thomas, 1971; Fager, 1972) and is presently becoming increasingly theoretical (Sanders, 1968; Rhoads and Young, 1970).

However, it must be noted that quantitative studies of this type require significant expenditures of time and money. It is also clear that environmental changes occur so rapidly management agencies must respond almost instantly to establish pollution standards or to develop monitoring guidelines. In general, quantitative samples require a large processing time (sorting, identifying, counting, weighing) which may range from 6 to 20 man-hours per sample (Barnard and Jones, 1960; Maurer and Watling, unpublished). It is this investment which has made quantitative samples so valuable in defining and testing ecological principles in the marine benthic environment. However, time constraints often force management agencies to make decisions prior to the completion of a quantitative study or the agency must delay its decisions until such studies are complete, which often causes the cost of a project to be increased substantially.

There seems to be a need, therefore, to develop methods of examining benthic assemblages which are able to accurately detect changes in their structure and which are relatively rapid and inexpensive. Some approaches to the problem have already been made (Cowell, 1971; Moore, 1971, 1974). Field (1970) and Stephensen, et al. (1970) used dredge samples in their studies of the application of numerical classification techniques to the analysis of species distribution patterns. Field's (1970) work was of particular importance in that it utilized relative abundance values on a scale similar to that used on this project. Moore (1974) obtained a similar picture of the kelp fauna using presence, absence, and quantitative methods. Greg-Smith (1971) has discussed the use of qualitative data in terrestrial plant ecology and now feels the bulk of interpretable information lies in qualitative differences.

To examine the possible use of qualitative data and its sensitivity to community change, an evaluation of four different substrata (sand, muddy-sand, polymodal sediment, and a calcareous serpulid assemblage) was undertaken using both quantitative and qualitative methods. A comparison of these samples and the cost of each of the two efforts will hopefully provide a background for agencies to judge whether qualitative efforts may be a rapid, economical method of obtaining valid data on benthic community structure. It is our hypothesis that information from dredge samples can provide an alternative to management agencies without sacrificing significant information about benthic community structure.

METHODS

After a preliminary survey of the bottom in the study area, four stations were established: 1) a sandy shoal sediment (Station 4), 2) a muddy sand (Station 5), 3) a polymodal sediment (Station 3), 4) a calcareous serpulid (Station 9) (Figure VII-1). Each of these stations was sampled with three different dredges during the period July 15-26, 1974. The three dredges that were used were a sled dredge with a flat blade (Figure VII-2), a modified oyster dredge with 6.25 cm long teeth (Figure VII-3), and a modified Menzies dredge with a 5 cm wide blade mounted at a 45° angle (Figure VII-4). Each of the dredges was equipped with a 1 mm Nitex cloth bag to prevent material from being washed through. This was covered on the outside with a 5 cm stretch mesh fishing net and chafing material to prevent damage to the bag. The mouth of the dredges were 1 m in width and 20 cm in height. Three bars were placed upright in the mouth of each dredge to prevent Limulus polyphemus and other large animals or debris from clogging the opening.

Twenty dredge hauls were taken with each of the dredges at each of the four stations. A dredging time of thirty seconds was always sufficient to fill the Nitex bag. The contents of the dredge were placed into a container and one gallon of material randomly taken as a sample. At Station 4 (sandy shoal) and Station

5 (muddy sand), the one-gallon sample was sieved over a 1 mm screen and the residue preserved in 10% buffered formalin. The polymodal sediment (Station 3) and serpulid assemblage (Station 9) samples were not sieved because of the coarseness of the material, but were preserved in 10% buffered formalin.

In the laboratory, the dredge samples were washed over a series of sieves (2 mm, 1 mm, 0.5 mm, 0.25 mm). For the purposes of this study the material on the two finer sieves was not included in any further analyses. The remaining material was placed in plexiglass trays and examined with a M-5 Wild dissecting microscope. All species were identified and a running tally of their abundances was kept. The abundance of each species was recorded as a relative abundance index value (RAIV). The initial RAIV scale used was: rare (value of _1_), 1-3 individuals; present (_3_), 4-10 individuals; common (_5_), 11-49 individuals; abundant (_7_) >50 individuals. The importance of using a RAIV scale such as this is that no more than 50 individuals of any species need to be counted. Colonial forms were given a value on the basis of the number of colonies present (as for most bryozoans), or as an estimate of solid substratum colonized (for example, with hydroids), following the methods of Boudouresque (1971).

Later it became apparent that our initial scale was unresponsive to situations where there were several species, all of whose abundances were greater than 50 individuals, and some with hundreds or thousands of individuals. Following the suggestion of Stephenson, et al. (1974), who used a cube-root transformation for their data, we decided upon a scale which was based on intervals of n^3. However, rather than assigning an arbitrary value to this scale, we used as our RAIV the mid-points of each interval. Thus, the scale was (1^3) 1 individual, value of _1_; (2^3) 2-8 individuals, _5_; (3^3) 9-27 individuals, _18_; (4^3) 28-64 individuals, _46_; (5^3) 65-125 individuals, _95_; (6^3) 126-216 individuals, _171_; (7^3) >217 individuals, _280_. Using this scale, a maximum of 217 individuals had to be enumerated. Ten of the samples from Stations 2, 4, and 5 have been recounted to compare this scale with the initial one. The results of this analysis will be reported elsewhere.

It should be noted here also that all dredge samples were counted in the sequence in which they were taken. Since we were interested in estimating the structure of an assemblage, it was our intent to determine the number of samples required to make this estimate. This is essentially a species-area curve problem, the statistical analysis of which is still developing, especially among plant ecologists.

On August 6, 1974 following the completion of the dredge sampling, 20 replicate grab samples were taken on each of the four bottom types using a 0.1 m^2 Petersen grab. The samples were washed over a 1 mm sieve and the residue was preserved in 10% buffered formalin. A sediment sample was taken from each grab. In the laboratory the samples were sorted, and the organisms identified to species and counted. The sediment samples were dry sieved and the silt-clay fraction was determined by pipette analysis (Folk, 1968).

RESULTS

A total of 146 species were collected at the four stations with the Petersen grab (Table VII-1). Nine phyla were represented. The largest group was the polychaetes with 58 species, arthropods were next with 43 species, and the molluscs were third with 22 species. From the dredge hauls 111 species were recorded from the same nine phyla that were present in the grab samples (Tables VII-1, VII-2). Forty-seven additional species were also identified from the dredge samples. The most notable additional increases in species were in the phyla Cnidaria, Ectoprocta, and Echinodermata which are normally epifaunal groups. The polychaetes and arthropods were once again the two largest groups represented. There were also larger numbers of molluscan species (31) in the dredge hauls than in the grab samples.

The analysis of the comparability of dredge and grab samples in each of the four substrata attempted to answer two questions: 1) What were the dominant species collected by the different sampling devices? 2) What was the community structure and how many grab or dredge samples were required to characterize that structure?

The dominant species were defined by a Biological Index Value of 0.5 (McCloskey, 1971). This index ranks species within a sample and sums the ranks across all the replicates, giving weight to occurrences over many samples, and lessening the effect of extreme dominance in a few samples. Rare species were considered to be those that had two occurrences or less and the label 'secondary species' was given to any species not in either of the other two categories.

The answer to the second question was evaluated by: 1) examining in which replicates species first occurred, 2) finding out how the abundance of dominant species varied throughout the 20 grab and dredge hauls, 3) examining the community to ascertain where the structure no longer changed with the addition of species in the succeeding replicate samples, 4) evaluating the patchiness of the communities by computer classification of the samples.

Station 4

The sediment had a size distribution that was very repeatable for all 20 replicate grabs. The composite histogram (Figure VII-5) indicated that the sediment at this station was a well-sorted, very find muddy sand (Folk, 1968). The majority of the material in these samples can be suspended and transported in the water column. Since Station 4 was near the crest of Old Bare Shoal, winnowing by wave action probably reduced the amount of mud found in these samples.

A total of 36 species was collected with the Petersen grab at Station 4. Three of the species were bryozoans, Electra monostachys, Triticella elongata, and Alcyonidium polyoum, and were not included in the quantitative analysis of the samples. The 20 grab samples collected a total of 651 individuals with a mean of 32.6 individuals and 10.7 species per sample (0.1 m^2) (Table VII-3). Eight species had biological index values greater than 0.50 and thus were classified as dominant species. The most important of these was the bivalve, Tellina agilis, with an index value of 0.98. Over the 20 grab samples T. agilis averaged 10.7 individuals/0.1 m^2. Glycera capitata (index value of 0.87) was the second-most important species and averaged 4.1 individuals/0.1 m^2. Scoloplos fragilis (0.77), Ampelisca verrilli (0.78), Glycera dibranchiata (0.68), Spiophanes bombyx (0.60), Mulinia lateralis (0.55), and Nemertea sp. (0.51) were the other dominant species.

The cumulative number of species found in the 20 grab samples at Station 4 is given in Figure VII-6. Previously unrecorded species were accumulated up to the eighteenth grab samples. Fourteen grabs were taken before 90% of the species were obtained although 51% of the species were present in the first five grabs. The eight dominant species were all collected in the first two samples, seven in sample 1 and one in sample 2. The secondary species were added one at a time in grabs two through seven. The rare species were responsible for the slow accumulation of species after grab 7. At grab seven 66.7% of the total species had been collected, but only 42.1% of the rare species. The cumulative average number of individuals obtained as the replicate grabs are combined is also given in Figure VII-6. The average number of individuals, and thus the estimate of total numbers per m^2, stabilized after nine grabs had been taken.

Trends in the cumulative average number of individuals of the four major species at Station 4 (Tellina agilis, Glycera capitata, Scoloplos fragilis, and Ampelisca verrilli) were examined (Figure VII-7). Tellina agilis showed a continual increase up to replicate 15 (11.2 individuals/0.1 m^2) where the average density leveled off between 10.4 and 10.9 individuals per 0.1 m^2 for the last five replicate grabs. Glycera capitata showed only a small variation in the average number of individuals (5.0-3.9/0.1 m^2) throughout the entire complement of replicate samples. From replicates 10 to 20 the variation in density was even smaller (4.2-3.9/0.1 m^2). The other polychaete species, S. fragilis, increased from replicate grab 1 to 7 (5.1/0.1 m^2) and then gradually the average number of individuals decreased over the remaining samples to 3.4/0.1 m^2. Ampelisca verrilli did not change substantially over all the replicate samples.

In order to establish how many grabs were required to accurately estimate the structure of the assemblage, the cumulative proportions of the dominant species were graphed against the replicate samples (Figure VII-8). At grab 1 the dominants, T. agilis, G. capitata, S. fragilis, and A. verrilli represented 77.8% of the total fauna. By grab 7 this proportion had decreased to 65.5% of the fauna which was only 2.0% higher than the proportion recorded in grab 20. The total variation between grab 7 and grab 20 was 2.5%. The individual dominants showed the same trends over the 20 replicates. Tellina agilis decreased from grab 1 (44.4%) to grab 9 (27.3%) and then increased very gradually to 32.7%. Glycera capitata decreased from 22.2% (grab 1) to 11.8% (grab 13) before increasing slightly to 12.4% (grab 20). Scoloplos fragilis achieved its maximum proportion to 17.7% (grab 6) and then decreased over the remaining grabs to 10.3%. Ampelisca verrilli varied somewhat initially, then stabilized between 6.0-6.4% before increasing over the last five replicates to 8.1%. The other 29 species of invertebrates accounted for 36.5% of the fauna at the end of 20 replicate samples.

Fifty-three species (17 more than the grabs) were collected in the 20 replicated dredge hauls at Station 4. The dredge hauls had a mean of 16.0 species and a mean relative abundance value for each sample of 36.8. Eight of the species were classified as dominant species, 19 secondary, and 26 rare. The most important species was again Tellina agilis with a biological index value of 0.96 (Table VII-3). The second-most important species collected by the dredge was Neomysis americana (0.92) which was considered a rare species in the grab samples. Neomysis americana is a vagile organism and probably avoided the grab. Two other species, the polychaetes Asabellides oculatus (0.84) and the bivalve Ensis directus (0.61), which also were not dominants in the grab samples, had biological index values greater than 0.50 in the dredge samples. The remaining four species, Mulinia lateralis (0.88), Ampelisca verrilli (0.83), Glycera capitata (0.71), and Scoloplos fragilis (0.62) occurred in the dredge hauls in a dominance order different from that of the grab samples (Table VII-3).

Figure VII-9 shows the addition of species by replicate dredge haul. Sixty-six percent of all the species are present by the seventh dredge haul and 90% by dredge number 13. Additional species were obtained until dredge number 17. The eight dominant species were taken in the first two hauls which were similar to the grabs. The 19 secondary species occurred in dredge hauls 1 to 9 while the last of the 26 rare species was obtained in dredge 17. A comparison of the average number of species per replicate for both the grabs and dredges indicates that the dredge always sampled a greater number of species (Figure VII-10).

The cumulative proportions (obtained from relative abundance value scores) of the dominant species were also examined over the 20 dredge hauls. The proportion of the total sample consisting of dominant species at dredge 2 was only 0.2% less than the value of 60.4% recorded in replicate haul 20 (Figure VII-11). The estimate at dredge replicate two was more accurate and occurred earlier than the estimate made at grab replicate 7. The proportions of four of the dominant species decreased over the dredge replicates (A. oculatus, G. capitata, M. lateralis, A. verrilli) while N. americana increased and T. agilis remained virtually the same.

A classification program was employed to ascertain how similar were the replicate grabs and dredge hauls. The clustering strategy used group average sorting and the similarity measure was Czekanowski's coefficient (See Appendix I). All of the grabs clustered together at a similarity value of 0.419 (Figure VII-12). None of the initial clusters were formed between succeeding grab samples. The classification program was then used to compute the similarity between species over all samples. Two species, Spio setosa and Heteromastus filiformis, clustered at 1.00 indicating that they occurred with nearly equal abundance in the same samples; however, the similarity level was 0.02 before all the species became one group. The eight dominant species did not cluster into one group until the 0.55 similarity level. The addition of new rare species until replicate 18 tended to extend the species clusters to very low similarity values.

The dendrogram for the Station 4 dredge hauls suggested four groupings (Figure VII-13): replicates 1, 6, 3, 20, 11, 4, 12, and 16; replicates 2, 10, 15, and 14; replicates 5, 18, 13, and 17; and replicates 7, 8, and 9. The latter was the only instance where three successive samples clustered together; however, the similarity value of the grouping (0.55) was not particularly high. All the dredge replicates became one group at a level (0.50) somewhat higher than for the grabs. The tendency toward patchiness was still present.

Station 5

The sediment at Station 5 which was located in 9 m of water on the edge of Old Bare Shoal was a poorly sorted, muddy, very fine sand. These sediments appeared similar to Station 4, but on closer examination there were several significant differences in the skewness, sorting, and modality demonstrated by the grain size distribution (Figure VII-14). The grain size distribution was strongly fine skewed. While both Stations 4 and 5 had pronounced single modes in the very fine sand range, closer inspection revealed that Station 5 actually had two modes. Although similar, one was between +3.0ϕ and +3.25ϕ and the other was between +3.5ϕ and +3.75ϕ.

Forty species were collected with the grab at Station 5. There were four colonial species, Membranipora tenuis, Electra monostachys, Alcyonidium polyoum, and Alcyonidium sp., which were not included in the numerical analyses. The 20 grabs produced 74,019 individuals for a mean of 3,701 per sample (0.1 m^2). Each sample contained an average of 6.9 species. Only three species, Nucula proxima, Tellina agilis, and Ensis directus, were classified as dominants (Table VII-4). Ten species were secondary and 26 rare. Nucula proxima had a biological index value of 1.0 (the maximum possible value). This species totally dominated the fauna and had densities up to 14,233/ 0.1 m^2 in the samples examined. The average number of N. proxima collected in each grab was 3649.1 individuals/0.1 m^2. Tellina agilis was the second-most dominant species with an index of 0.97, and E. directus, a third bivalve, had an index of 0.83.

Species appeared in samples up to grab 19 although several grabs did not contain previously unrecorded species (Figure VII-15). All dominant species were present in the initial grab. The seven secondary species all occurred by grab 5 while the 26 rare species occurred intermittently from the first to the nineteenth grab (Figure VII-15). Fifty percent of the species were recorded by the fifth grab and 88.9% by the fourteenth sample.

The cumulative average number of individuals by replicate sample is also given in Figure VII-15. The highest cumulative mean value of 4,038 was recorded at grab 17 which had an unusually large number of individuals of N. proxima. The graph shows an increase of approximately 3,000 individuals per sample from grab 5 to grab 17. To obtain an estimate for Station 5 within 75% of the maximum density required 16 grab samples.

The cumulative average abundance of the three dominant species over the 20 grab samples is given in Figure VII-16. The trend for N. proxima almost paralleled that for the cumulative average total number of individuals for each sample (Figure VII-15). There was a consistent increase in the mean density value for N. proxima from sample 5 to 17. Nucula proxima occupied 94% of the total fauna in grab 1 and 98.5% after 20 replicates. Tellina agilis averaged from 37 to 47 individuals per grab over the 20 replicate samples. The average number of individuals of T. agilis was 42.2/ 0.1 m^2. Ensis directus varied by only one individual/0.1 m^2 sample in 20 replicates and over the last 19 samples the change was less than 0.75. The mean value for 20 samples was 2.9/0.1 m^2.

The dredge samples at Station 5 collected 43 species with an average of 11.7 species per dredge haul. The average relative abundance value for each species in the dredge samples was 33.6. Eight species were dominants, ten were secondary, and 25 rare. Nucula proxima was the dominant organism with an index value of 1.0. Tellina agilis had a value of 0.90, and Ensis directus was 0.73, both lower values than for the grab samples. Five other species were classified as dominants in the dredge hauls but were not significant in the grabs. Crangon septemspinosa (0.88) and Neomysis americana (0.79) are both vagile arthropods that may easily be missed by the grab. Nephtys incisa (0.67) was the only important species of polychaete in the grab or dredge hauls. It was never present in excessively high numbers (RAIV of 3 or less), but was present in 15 of the 20 samples. The remaining two dominants were the bivalves, Mulinia lateralis (0.56) and Yoldia limatula (0.55).

All eight dominant species occurred in the first dredge replicate (Figure VII-17). The ten secondary species first appeared in replicates 1 through 4 and the rare species in various replicates. Ninety percent of the species were present in the first seven grabs. Only rare species were recorded in the last 16 grabs.

The cumulative average numbers of species in the grabs and dredges showed a gradual decrease in both sampling devices from replicates 5 to 20 (Figure VII-18). The graphs for replicates 15-20 were almost parallel with the dredges having approximately 5 species more than the grabs.

The proportions of the dominant species in each of the replicates were computed by taking the RAIV number as a percentage of the total RAIV for the sample. The cumulative proportion for the dominants after 20 replicate dredge hauls was 72.7% (Figure VII-19). The proportions were fairly stable after dredge 8 with the exceptions of N. proxima and T. agilis which increased together approximately 5% over the remaining 13 replicates. The dominant species exhibited the following RAIV proportions: N. proxima 20.5%, T. agilis 13.1%,

C. septemspinosa 11.2%, N. americana 10.0%, E. directus 5.6%, N. incisa 4.0%, M. lateralis 4.5%, and Y. limatula 3.7%. The remainder of the fauna accounted for 27.3% of the total relative abundance values.

Cluster analyses of the grab replicates at Station 5 indicated that all of the samples became one group at a similarity level of 0.621 (Figure VII-20). Three distinct groupings were present with two samples (17 and 19) not being a part of any other group. The first group, which contained replicates 4 and 5, had reduced numbers of N. proxima (437 and 445/0.1 m^2, respectively), and had Nephtys picta, Glycera americana, Oxyurostylis smithi, Mulinia lateralis, and the three dominant species in common. A second grouping, replicates 1, 3, and 9 had 926, 991, and 1,689 N. proxima respectively. The third and largest group had three very high level clusters between replicates 6 and 11 (0.94), 18 and 20 (0.94), and 7 and 8 (0.93). In general, the clusters were very dependent on the numbers of the dominant N. proxima for the formation of the groups. This was strongly evident in the analysis for species groups. Nucula proxima and T. agilis were in their own cluster and were not linked with any other species until their linkage with the Ensis group (at 0.09) which had formed at 0.40 and consisted of Yoldia limatula, Nephtys picta, Nemertea sp., and Mulinia lateralis.

The dredge haul dendrogram (Figure VII-21) indicated the highest similarity between two replicates was found with dredge samples 15 and 16 (0.851). Three small groupings of stations were identified: group 1--replicates 8, 13, 6, 17, and 4; group 2--replicates 3, 11, 10, 15, 16, and 20; group 3--replicates 2, 3, and 4. The groupings contain similar RAIV values for the top two dominants. The Groups 1-3 were divided more on the basis of number of species present in the replicates. Group 1 replicates all had 10-13 species; Group 2 replicates had the lowest number of species, 6-10; and Group 3 had the highest number of species, 16-21. The Group 3 clusters were generally lower in similarity than the other groups, which may be a function of higher numbers of rare species in the replicate samples.

Station 3

The sediment at Station 3 had a complex size distribution (Figure VII-22). There are three major particle size modes which contribute to the confusion of values. The primary mode between 2.5ϕ and 3.0ϕ dominated the samples. This sand mode matched the mode found in the samples from Lower Middle and Brown Shoals in Delaware Bay. The second mode was in the gravel size range between -3.0ϕ and -3.5ϕ. Its presence is responsible for the negative (coarse) skewness of most of the samples. The third mode, in the silt range, occurred between 5.0ϕ and 5.5ϕ. The grain size represented by this mode was probably indicative of the predominant size of the suspended material.

Eighty-six species were collected in the 20 replicate grab samples at Station 3. Nine species were colonial (Appendix Table AVII-1). The average number of species per grab was 25.0; the total number of individuals was 6,660, and the average 333.0 per sample (Table VII-5). Twelve species were dominant, 33 secondary, and 31 rare. This station was the first at which the number of rare species did not exceed the numbers of secondary species in the grab samples.

Mytilus edulis was the dominant species with an index of 0.95 and an average density of 245.5/0.1 m^2. Mediomastus ambiseta was the next most dominant species (0.90) with an average of 13.5 individuals/0.1 m^2 and Lysianopsis alba was third (0.85) with 10.9 individuals/0.1 m^2.

Previously unrecorded species were added over 19 grab samples with 50.0% of the species being accumulated by grab 3 and 91.0% by grab 15 (Figure VII-23). The 12 dominant species occurred in the first two grab samples while it required 14 samples to account for all secondary species. It should be noted that there was a larger number of both dominant and secondary species at this station than at either of the previous strictly infaunal stations. The combination of sediment and the epifaunal nature of the blue mussel (Mytilus edulis) provided many additional niches for a greater number of species and individuals.

The cumulative average of the number of individuals per grab is given in Figure VII-23. There was a tremendous increase from replicate 1 (32 individuals/sample) to replicate 3 (428 individuals/sample). The average value for the whole 20 replicates was 333.0 which was only 71.2% of the highest value and 77.8% of the first peak at replicate 3. The 12 dominant species contributed 93.4% and *Mytilus edulis* 73.8% of the individuals over the 20 replicates.

The abundances of the five most dominant species were cumulatively averaged over the 20 replicate samples (Figure VII-24). *Mytilus edulis* was not found in replicate 1 but by replicate 3 the species had an average of 353.7 individuals/grab. Another peak occurred at grab 11 when 706 individuals were added. From grab 11 to grab 20 there was a decrease to the final mean value of 245.6/0.1 m^2. All of the other four species varied considerably less over the last nine samples with three of the species, *L. alba*, *H. extenuata*, and Xanthidae sp., changing by less than one individual.

The cumulative proportion of the five most dominant species showed a large increase from the first (25.0% of the fauna) to the second replicate (84.9%) primarily because of the addition of *M. edulis* (Figure VII-25). By replicate 3 the top five dominants achieved their highest proportion, 92.2%. The dominance structure varied only 6.4% from grabs 2 through 20.

The dredge hauls at Station 3 collected 89 species with an average of 33.0 species per haul. The average total RAIV for the 20 hauls was 83.9. A total of 19 species were classified as dominants (Table VII-5), 38 were secondary, and 32 were rare. Only 6 of the 19 dominants from the dredge hauls were similar to those in the grabs. Five colonial species, *Alcyonidium polyoum*, *Schizoporella errata*, *Electra monostachys*, *Membranipora tenuis*, and *Conopeum tenuissimum* were dominant dredge species, but could not be quantified using normal abundance methods. Neomysis americana and Crangon septemspinosa, both vagile forms, also were not dominant in the grab samples.

All 89 species were not recorded until the 19th dredge haul (Figure VII-26). Fifty-five percent of the species were identified by dredge 2 and 91% by dredge 15. The 19 dominant species were present in hauls 1 and 2. Most (94.7%) secondary species were obtained by dredge 7, but the remaining 2 species were not found until replicates 13 and 14.

A comparison of the average number of species per sample over the 20 replicates indicated that the grabs again did not sample as many species as did the dredge hauls (Figure VII-27). As can be seen from the list of dominants (Table VII-5), colonial species are a significant part of the fauna at Station 3 and account for much of this difference.

The cumulative proportions of the six most dominant species from the dredge samples presented a considerably different picture of the community from that obtained with the grabs. The dominance of M. edulis was reduced by the relative abundance system and the other five species had correspondingly larger proportions. The initial dredge haul was a good estimate of the proportions after accumulating 20 dredge hauls. The dominant species proportions did not change significantly since M. edulis increased only slightly more than 1% over the 20 dredges and M. ambiseta and P. eximius decreased slightly.

Cluster analysis of the grabs at Station 3 showed three fairly distinct groupings (Figure VII-28). The first group contained 14 of the 20 replicates, each of which consisted of the dominants and high numbers of M. edulis. Three additional samples, 13, 15, and 16, became part of the group at a lower similarity level. Replicate 16 possessed no M. ambiseta or A. oculatus and replicate 15 had only 15 M. edulis with no N. succinea.

Three small groups were evident in the dredge cluster dendrogram (Figure VII-29). Samples 13, 20, 3, and 9 made up Group 1. Group 2 contained replicates 4, 5, 6, 7, 8, and Group 3 replicates 15, 16, 14, 17, and 11. The similarity value of the entire cluster was substantially higher than the grab replicates for this station.

Station 9

This station was located in an area containing large numbers of calcareous tubes constructed by the polychaete, Hydroides dianthus. The assemblage was not a continuous structure, but rather separate clumps spread over an approximately 1 km^2 area. The sediment regime discussed below was found around, under, and in between the calcareous worm tubes. Numerous other animals, i.e. M. edulis, P. ligni, live attached to the surface of these tubes. Due to preservation problems only 19 grabs were processed from this station.

The sediment at Station 9 was a very poorly sorted, very fine muddy sand. There were traces of coarse sand in some of the samples which came from a stratum underlying the serpulids. While it was difficult to determine the effects that the animals living in the assemblage have on altering the sediment size distribution, it was important to note that medium and coarse sands were generally absent from the samples.

Eighty-six species (12 colonial, see Appendix Table AVII-11) were collected by the Petersen grab in the serpulid assemblage. The 20 replicate grabs collected 9,608 individuals, a mean of 480.4 individuals per sample. An average of 33 species were found in each grab. Twenty-two species were classified as dominant, 33 as secondary, and 31 as rare (Table VII-6).

Asabellides oculatus, a deposit-feeding polychaete, had the highest biological index value (0.94) and also the highest average number of individuals (24.7). The following two dominants, Mediomastus ambiseta (0.93) and Nucula proxima (0.91), were also infaunal species. Of the five next most dominant species, two more, Heteromastus filiformis (0.88) and Streblospio benedicti (0.85), were infaunal, while three others, Unciola serrata (0.90), Xanthidae sp. (0.85), Corophium simile (0.81), lived on, between, or in the Hydroides tube structure. Ten of the remaining 14 dominant species were basically epifaunal, while four were infaunal.

All the dominant species were recorded in the first three grabs (Figure VII-30), 18 were in grab 1, 3 in grab 2, and 1 in grab 3. The 33 secondary species were recorded by grab 8 and the rare species by grab 18. The initial three grabs accounted for 60.5% of the total species and 12 grabs accounted for 90.7%. As in all the preceding substrates, the rare species required a large number of grabs before they were all accumulated.

The change in average number of individuals per grab as replicates are accumulated is given in Figure VII-30. The first grab contained 465 individuals, 96.8% of the cumulative average at replicate 20, but only 82.7% of the mean value (562/0.1 m^2) at grab 14. The mean value at grab 8 (491/0.1 m^2) was 87.3% and at grab 11 (501/0.1 m^2) 89.1% of the maximum. Both of these average values exceeded the final average value at grab 20 of 480/0.1 m^2.

The change in average number of individuals over the 20 replicates for the six most dominant species is given in Figure VII-31. Three of the species, Xanthidae sp., M. ambiseta, and C. simile, increased in average abundance over the first 16 replicates before declining through grabs 17-19. The average number of Asabellides oculatus stabilized by grab 7 and then decreased slightly over the remaining samples. Hydroides dianthus numbers varied considerably with a high peak at grab 1 of 171 individuals/0.1 m^2 followed by a sharp decline to grab 10 (44 individuals/0.1 m^2). This change, followed by another small increase in numbers through grab 14 suggests that the distribution of this species is very heterogeneous. The variation in numbers of individuals of Unciola serrata was erratic through the first 11 grabs and exhibited a gradual decline from grabs 16 to 19. Unciola serrata and Corophium simile found in the vacated tubes of Hydroides, increased their abundances in the grabs where H. dianthus decreased. The infaunal polychaete, M. ambiseta, which lived in the substrate surrounding the Hydroides tubes, had its greatest numbers of individuals where H. dianthus was absent or markedly reduced. This was a further indication of the patchiness of the tubes.

The species which comprised the largest proportion of the fauna over the 20 grabs was U. serrata (15.5%), while H. dianthus comprised 12.1% and C. simile 10.6% (Figure VII-32). The six dominants comprised an average of 73.2% of the fauna in the first two grabs, but only 62.9% after 20 samples. The variation between grab 3 and grab 19 was only 4.1%, indicating grab 3 may be a good estimate of the community structure. Most of the changes were probably due to heterogeneity in the distribution of these species.

Of the ninety-one species collected with the dredge at Station 9, 27 were dominants, 39 were rare, and 25 were secondary. The average number of species per haul was 34.7 and the average RAIV for each sample was a very high 125.7 (Table VII-6). The high RAIV was a function primarily of the large number of dominant species and secondarily of the high species richness. Station 3 had a similar average number of species per haul (Table VII-5), but the average RAIV for each sample was 41 points lower.

Thirteen of the 27 species classified as dominant in the dredge hauls were also dominant in the grab samples. Four dominant species from the dredge hauls (Cliona celata, Microciona prolifera, Conopeum tenuissimum, Alcyonidium polyoum) were not considered in the grab analysis because they were colonial. A number of other species, Polydora ligni, Oligochaete B, Odostomia dianthophila, were very small and may have been overlooked during the grab sorting process. There was also in the dredge samples an increased number of epifaunal species in the role of dominants with some of the infaunal species, notably Nucula proxima, Mercenaria mercenaria, Petricola pholadiformis, and Glycinde solitaria, being absent. The first two dominants on the grab list, Asabellides oculatus and Mediomastus ambiseta, were 23 and 14 respectively on the dredge list.

Initial species occurrences were recorded in all dredge samples except 14 (Figure VII-33). Fifty-three percent of the species were present in the first two dredge samples, but 16 hauls were required to obtain 90% of the total species. The 27 dominant species were recorded in hauls 1 and 2 while the secondary species were obtained in dredges 1-5, 7, 8, and 15.

The average number of species per sample for both the grabs and dredge hauls indicated for the first time that the grabs exceeded the dredge hauls in species per replicate. The dredge samples initially exceeded the grabs, but there was an increase in species per grab sample from replicate 4 to 9 (Figure VII-34). This rise is coincident with the increased abundances of the infaunal species in the grabs and the decrease in numbers in H. dianthus (Figure VII-31). The final average number of species per sample was 33.3 for the 19 grabs and 34.7 for the 20 dredge hauls.

The proportions of the six most dominant species varied by less than 2% over the 20 dredge samples. Hydroides dianthus comprised 5.6% of the fauna after 20 samples as did U. serrata and C. simile. M. edulis made up 5.45% of the fauna; N. succinea, 5.0%; E. sanguinea, 5.3%; and S. vulgaris, 5.3%. The total percentage of the fauna occupied by the dominant species was therefore rather stable.

Cluster analysis of the replicate grabs for Station 9 produced one large and one small group of samples (Figure VII-35). The large group can be subdivided utilizing the distribution of some of the dominant species. Replicates 14, 15, 9, 10, 12, 6, and 13 formed a subgroup which was basically epifaunal in nature. Replicates 8, 17, 16, and 18 had reduced numbers of one or more of the major dominants along with high numbers of N. proxima or M. ambiseta and S. benedicti.

This group also was less epifaunal. A small group was formed by replicates 11, 19, and 5 which all lacked or had less than five H. dianthus individuals. Replicate 20 had no epifaunal dominants and had the lowest species richness.

The species cluster helped to substantiate the patchiness observed in the rest of the analysis of Station 9. Three small groups were formed, two epifaunal and one infaunal. The infaunal grouping was composed initially of N. proxima, A. oculatus, and later P. eximius, S. benedicti, M. ambiseta, G. solitaria, and H. filiformis (at a similarity level of 0.79). The first epifaunal group was small, containing only H. dianthus, U. serrata, C. simile, and Xanthidae sp. The first epifaunal group joined the infaunal group at 0.741 similarity. The second epifaunal group consisted of M. edulis, M. sanguinea, S. vulgaris, N. succinea, N. texana sayi, and E. sanguinea joined the other subgroups at 0.67. At that point 19 of the 22 dominant species were present. Only T. agilis, M. mercenaria, and P. pholadiformis were absent. They were added at a similarity value of 0.47. There were three groups which had separate ecological requirements. These groups were probably detected because the grab simultaneously sampled both epifaunal and infaunal groups.

The dendrograms produced for the dredge haul replicates (Figure VII-36) were far more compact, with the lowest similarity being 0.69. The differences in the groupings were more dependent on small variations among the epifaunal species than with epifaunal-infaunal differences. It was pointed out earlier that the most abundant infaunal dominant was fourteenth on the dominance list for the dredge hauls. The dredge hauls have apparently reduced the patchiness of distributions and emphasized the epifaunal organism. Part of the response must also be a function of the scale used. Since the scale varies only from 1 to 7, any differences are not going to be very great.

Cost Analysis

One proposed result of this study was to determine whether the total cost for handling dredge samples was any lower than for grab samples. Cost estimates depend on many variables, such as boat time (which itself is dependent on number of samples, distance between sampling stations, and depth of water, weather conditions) and salary scales. Consequently, we decided to focus on the number of hours involved. Since the 20 grab or dredge samples per station were taken in close proximity, the hours of boat time for obtaining either type of sample did not differ substantially. Major differences were noted in the laboratory, however.

Altogether 256 man-hours were spent sorting and 288 man-hours identifying (a total of 544 man-hours) the 80 grab samples, an average of almost 7 man-hours/sample. In processing the dredge samples, there were three advantages: the taxa were, by this time, quite familiar; the sorting and identifying was done simultaneously by the same person; and not all individuals had to be counted. Thus, only 218 man-hours were spent on the 80 dredge samples, an average of 2.7 man-hours/sample. In using our new scale, which requires counting more individuals, the average time increased to 4.5 man-hours/sample. It must be pointed out here, too, that because of the relatively depauperate condition of Delaware Bay's benthic fauna, the actual number of hours are probably low. However, we submit that the proportion of time spent processing dredge versus grab samples will remain the same regardless of faunal densities. Because of this substantial difference in process time between grab and dredge samples and the degree of information obtained from dredge samples, with refinement this method may have promise as an economical and valid tool to apply to benthic pollution problems.

DISCUSSION

Moore (1974) stated that there appears to be no reason why repetitive qualitative surveys over a period of time cannot be used to satisfactorily survey a given area. The data analyses would provide information on assemblage shifts and local variability, and would not be subject to quantitative fluctuations. In order to substantiate Moore's claim, one must be able to find, using qualitative and quantitative methods, a high correspondence between the numbers and types of species collected, the proportions of the dominant species, and estimates of the overall community structure.

At all of the sampling stations (Station 3, polymodal; Station 4, sandy shoal; Station 5, muddy; Station 9, calcareous) a greater number of species was collected with the dredge than with the grab (Tables VII-3, 4, 5, 6). However, the additional species collected by the dredge were 5 or less except at Station 4 where the difference was 17. The average number of species per sample was also always greater in dredge samples with the difference being less than 9 species and the largest difference occurring at Station 3.

For each set of replicates at a station the number of dominant species was always at least equal or greater in the dredge samples. At Station 5 there were three dominant species from the grabs and eight from the dredges. Similarly 12 and 22 dominants were found in the grab samples from Station 3 and Station 9, respectively, while 19 and 27 dominants, respectively, were collected from the dredge hauls. At Station 4 the same number of dominant species were present in each replicate set, but there were replacement and reordering differences. The increased number of dominants can be attributed in part to the area sampled with the dredge relative to the grab and also to the use of McCloskey's index to define the dominant species. McCloskey's (1971) Biological Index substantially increases the relative importance of a species which occurs in low numbers over many samples. When the dredge was pulled over a given time period, any number of species patches of varying size could have been crossed. The greater the number of species patches the higher would be a given biological index value for a rare or secondary species. Since the maximum value of 1.0 cannot be exceeded, the effect was to push more species into higher classifications (dominants and secondaries).

Another reason for the increase in the number of species was the inclusion of colonial species in the dredge sample evaluations. One of the advantages of the RAIV method was that it provides a way to evaluate the relative contribution of colonial groups to the structure of the community. These groups were routinely evaluated in terms of biomass; however, other spatial estimates were difficult to incorporate into quantitative analysis.

A very important aspect of comparing grab samples and dredge samples was the reordering of species and the establishment of formerly rare species high within the dominance structure. The samples at Station 9 showed significant reordering of species. In the grab samples, three species, all infaunal deposit feeders, *Asabellides oculatus*, *Mediomastus ambiseta*, and *Nucula proxima*, were the most dominant species with *Heteromastus filiformis*, *Streblospio benedicti*, and *Glycinde solitaria* also important. The dredge hauls ranked only epifaunal forms as the 12 most dominant species with *M. ambiseta* being fourteenth and *A. oculatus* twenty-third. A smaller, but less significant, reordering occurred in Station 4 with *Glycera capitata* and *Scoloplos fragilis* being placed lower and *Mulinia lateralis* higher. This reordering of species can alter the investigator's concept of the community to the point of emphasizing different trophic groups and suggesting competition for a different suite of resources.

There was a similar pattern of the previously unrecorded occurrence of species as the 20 replicate grab and dredge samples were accumulated. Between 13 and 16 samples were required to obtain 90% of the total species present at all stations except Station 5 where only 7 dredge hauls were needed. All the dominant species occurred in the first two grab and dredge samples except at Station 9 where three dredge hauls were required to obtain all 27 dominants. Lie (1968) found in Puget Sound that 75 to 80% of the total species collected in ten samples were present in five samples. He further indicated that the additional species occurring in the last sample comprised about 3% of the total species found in the ten samples. Our results were similar with only rare species appearing after replicate 10 in both dredge and grab samples. All five secondary species recorded after replicate 10 were in substrata with abundant epifaunal microhabitats. Our data also were similar to those of Lie (1968) in having the dominant species all present in the initial three samples.

An examination of the dominant species proportions indicated that each substratum needed to be treated individually. The samples from the sandy shoal sediments at Station 4 indicated that the dredge gave a much earlier (replicate 2) and more accurate estimation of the distribution of individuals among the species observed at replicate 20 than did the grab samples (replicate 7). Of the species common to both sampling devices, the proportions of the dominant species in the dredge samples were smaller than in quantitative samples. In the other sediments there was an even greater exaggeration of this problem. The grab and dredge samples at Station 5 and Station 3 where overwhelmingly dominant species were present (N. proxima, Station 5, and M. edulis, Station 3) were the least compatible and of no value for comparisons. The scaling process (RAIV) used for the dredge samples had reduced the domination by one species considerably and presented the other dominant species as relative codominants. As noted in the Introduction, we have devised a new scale which should be more responsive to larger differences at the "abundant" end of the range. The results of analyses performed with the new scale will be reported elsewhere.

The use of cluster analysis of samples and species to evaluate patchiness and species groupings indicated that grab samples sampled small groups of species associated with particular substratum characteristics. The grab samples of Station 9 best exemplified this phenomenon with three species groups, two epifaunal and one infaunal, forming separately and then combining at a similarity of 0.67. At that point 19 of the 22 dominant species were present. The dominant species at Station 4 clustered at 0.55 from two groups (Group I--Nemertea sp., Mulinia lateralis; Group 2--Glycera capitata, G. dibranchiata, T. agilis, and Ampelisca verrilli). The smaller groups of species such as Heteromastus filiformis and Spio setosa which clustered at high similarity levels (1.0) were rare species and joined the cluster formed by the dominant species at low similarity values. In the muddy sand the two major species, N. proxima and T. agilis, formed a species group that was separate from the other species. Ensis directus, the other dominant, was the nucleus for a group containing many of the rare and secondary species. Not until level 0.09 similarity did these groups cluster together.

The clusters formed from the dredge samples joined at higher similarity levels in all cases, an indication that the dredge reduced the patchiness and/or that the closeness of the scale values did not allow major patches to be discerned. The dredge replicate sample groups were generally more dependent on differences in species proportions as opposed to the presence or absence of important species.

Moore (1974) stated that three factors contribute to efficiency of the qualitative approach: 1) faunal homogeneity, 2) the number of species, and 3) resources (time, manpower, and money) saved. Our work immediately points to the amount of time and manpower saved using qualitative methods. In a short-term effort such as this approximately 300 man-hours were saved using the dredge and relative abundance methods. This saving could be increased markedly once the RAIV scale is adjusted so that the faunal probabilities are more accurately represented, and thus fewer dredge samples would be required. Moore (1974) believed that a species complement ≥ 30

would provide enough information for a good analysis without sacrificing content since the relative information gained from quantitative data probably varies inversely with the species richness. Moore also found that qualitative data will detect differences in homogeneous faunal groups, but we have demonstrated that its applicability in heterogeneous situations may also be appropriate depending on the degree of resolution required.

Our results have shown that at "coarse" levels of community analysis, dredge data will give an adequate picture of an assemblage regardless of substratum. These assemblages were distinct enough that comparison of the fauna would allow a reasonable differentiation. The work done by Field (1970) using a scale similar to ours indicated that approximations of earlier work in False Bay, South Africa, could be achieved by means of a dredge and relative abundance data. The question that arises then is how much data is lost dealing with community structure when dredge data is used. Some pollution studies (Maurer, et al., 1974; Watling, et al., 1973) indicate that shifts in community structure and changes in dominance can be quite small. It is our impression that more rigorous statistical methods are needed to establish the point at which the level of information no longer changes with the addition of more samples. Further evaluation of new methods of scaling is also necessary in order to better fit the dredge data to the probability curves for the quantitative samples. Refinement of these methods will add clarity to the evaluation of community structure and shifts that may be occurring in that structure.

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Table VII-1

Species list for the replicated grabs and dredge hauls

	Grabs	Dredges
Phylum Porifera		
Class Demospongiae		
Order Poecilosclerina		
Microciona prolifera (Ellis and Solander 1786)	x	x
Order Halichondrina		
Halichondria bowerbanki Burton, 1930		
Order Hadromerina		
Cliona celata Grant 1826	x	x
Porifera sp.	x	
Phylum Cnidaria		
Class Hydrozoa		
Order Hydroida		
Tubularia crocea (L. Agassiz 1862)		x
Hydractinia echinata (Fleming 1828)	x	x
Podocoryne carnea Sars 1846		x
Class Anthozoa		
Order Gorgonacea		
Metridium senile (Linne 1758)		x
Phylum Platyhelminthes		
Class Turbellaria		
Flatworm A		x
Phylum Rhynchocoela		
Class Anopla		
Order Heteronemertini		
Zygeupolia rubens (Coe 1895)	x	x
Cerebratulus lacteus (Leidy 1851)	x	x
Nemertea sp.	x	x
Phylum Annelida		
Family Ampharetidae		
Ampharete acutifrons Grube 1860	x	x
Asabellides oculatus (Webster 1879)	x	x
Family Arabellidae		
Drilonereis longa Webster 1879	x	x
Family Capitellidae		
Capitella capitata (Fabricius 1780)	x	
Heteromastus filiformis (Claparede 1864)	x	x
Mediomastus ambiseta (Hartman 1947)	x	x

Table VII-1 (cont.)

	Grabs	Dredges
Family Cirratulidae		
Caulleriella sp. 2		x
Chaetozone setosa Malmgren 1867	x	
Cirratulidae sp.	x	x
Tharyx sp. 2	x	x
Tharyx sp. 1		x
Chaetozone sp. 1	x	x
Chaetozone sp. 2	x	x
Chaetozone sp. 3	x	x
Chaetozone sp. 4	x	
Family Dorvilleidae		
Schistomeringos rudolphi (delle Chiaje 1828)	x	x
Schistomeringos caecus (Webster and Benedict 1884)	x	
Family Eunicidae		
Marphysa sanguinea (Montagu 1815)	x	x
Family Flabelligeridae		
Pherusa affinis (Leidy 1855)	x	x
Family Glyceridae		
Glycera americana Leidy 1855	x	x
Glycera capitata Oersted 1843	x	x
Glycera dibranchiata Ehlers 1868	x	x
Family Goniadidae		
Glycinde solitaria (Webster 1880)	x	x
Family Hesionidae		
Podarke obscura Verrill 1873	x	x
Family Maldanidae		
Clymenella spp.	x	
Family Nephtyidae		
Nephtys incisa Malmgren 1865	x	x
Nephtys picta Ehlers 1868	x	
Family Nereidae		
Nereis arenaceodonta Moore 1903	x	
Nereis (Neanthes) succinea Frey and Leuckart 1847	x	x
Family Opheliidae		
Travisia carnea Verrill 1873	x	
Family Orbiniidae		
Orbinia ornatus (Verrill 1873)	x	
Scoloplos acutus (Verrill 1873)	x	
Scoloplos fragilis (Verrill 1873)	x	x
Scoloplos robustus (Verrill 1873)	x	x
Scoloplos sp.		x
Family Paraonidae		
Aricidea sp.		x
Aricidea cerruti Laubier 1967	x	x

Table VII-I (cont.)

	Grabs	Dredges
Family Pectinariidae		
Pectinaria gouldii Verrill 1873	x	x
Family Phyllodocidae		
Eteone heteropoda Hartman 1951	x	x
Eteone longa (Fabricius 1780)	x	
Eumida sanguinea (Oersted 1843)	x	x
Paranaitis speciosa (Webster 1880)	x	
Phyllodoce arenae Webster 1880	x	x
Phyllodoce maculata (Linnaeus 1767)	x	x
Family Polynoidae		
Harmothoe (Lagisca) extenuata (Grube 1840)	x	x
Lepidametria commensalis Webster 1879		x
Lepidonotus squamatus (Linnaeus 1756)	x	x
Lepidonotus sublevis Verrill 1873	x	x
Lepidonotus (juv.)		x
Family Sabellaridae		
Sabellaria vulgaris Verrill 1873	x	x
Family Serpulidae		
Hydroides dianthus (Verrill 1873)	x	x
Family Sigalionidae		
Sthenelais limicola (Ehlers 1864)	x	
Sthenelais boa (Johnston 1833)	x	x
Family Spionidae		
Paraprionospio pinnata (Ehlers 1901)		x
Polydora concharum Verrill 1880	x	x
Polydora ligni Webster 1879	x	x
Polydora socialis (Schmarda 1861)	x	x
Scolelepis squamata (O.F. Muller 1806)	x	x
Spio setosa Verrill 1873	x	x
Spiophanes bombyx (Claparede 1870)	x	x
Streblospio benedicti Webster 1879	x	x
Family Syllidae		
Parapionosyllis longicirrata (Webster and Benedict 1884)		x
Pionosyllis sp.	x	
Proceraea cornuta (Agassiz 1863)	x	x
Syllis gracilis Grube 1840	x	x
Family Terebellidae		
Amphitrite ornata (Leidy 1855)	x	
Polycirrus eximius (Leidy 1855)	x	x
Class Oligochaeta		
Oligochaeta A	x	x
Oligochaeta B	x	x

Table VII-1 (cont.)

	Grabs	Dredges
Phylum Mollusca		
Class Gastropoda		
Order Mesogastropoda		
Triphora nigrocincta (C.B. Adams 1839)	x	
Hydrobia totteni Morrison 1954		x
Crepidula fornicata (Linne 1758)	x	x
Crepidula convexa Say 1822	x	x
Crepidula plana Say 1822	x	x
Order Neogastropoda		
Urosalpinx cinerea (Say 1822)		x
Anachis avara (Say 1822)	x	x
Mitrella lunata (Say 1826)	x	x
Busycon carica (Gmelin 1791)		x
Busycon canaliculatum (Linne 1758)	x	x
Nassarius trivittatus (Say 1822)	x	x
Ilyanassa obsoletus (Say 1822)		x
Marginella roscida Redfield 1860	x	x
Order Tectibranchia		
Acteocina canaliculata (Say 1822)		x
Sayella fusca (C.B. Adams 1839)		x
Turbonilla interrupta (Totten 1835)	x	x
Odostomia dianthophila Wells and Wells 1961	x	x
Class Polyplacophora		
Order Neoloricata		
Chaetopleura apiculata (Say 1830)		x
Order Nudibranchia		
Nudibranchia sp.		x
Class Bivalvia		
Order Protobranchia		
Nucula proxima Say 1822	x	x
Yoldia limatula Say 1831	x	x
Order Filibranchia		
Anadara ovalis (Bruguiere 1789)		x
Mytilus edulis Linne 1758	x	x
Crassostrea virginica (Gmelin 1791)	x	
Order Eulamellibranchia		
Mysella planulata (Stimpson 1857)		x
Mercenaria mercenaria (Linne 1758)	x	x
Petricola pholadiformis (Lamarck 1818)	x	x
Tellina agilis Stimpson 1857	x	x
Siliqua costata Say 1822		x
Ensis directus Conrad 1843	x	x
Spisula solidissima (Dillwyn 1817)		x
Mulinia lateralis (Say 1822)	x	x
Corbula contracta Say 1822	x	x
Lyonsia hyalina Conrad 1831	x	x

Table VII-1 (cont.)

	Grabs	Dredges
Phylum Arthropoda		
Class Merostomata		
Limulus polyphemus (Linne 1758)	x	
Class Crustacea		
Subclass Ostracoda		
Parasterope pollex	x	
Order Thoracica		
Balanus (Balanus) improvisus Darwin 1854		x
Order Stomatopoda		
Squilla empusa Say 1818	x	
Order Mysidacea		
Mysid sp.	x	
Neomysis americana (S.I. Smith 1873)	x	x
Bowmaniella dissimilis (Coifman 1937)	x	
Heteromysis formosa S.I. Smith 1873	x	x
Order Cumacea		
Oxyurostylis smithi Calman 1912	x	x
Order Isopoda		
Cyathura polita (Stimpson 1855)		x
Cyathura burbancki Frankenberg 1965	x	x
Edotea triloba (Say 1818)	x	x
Erichsonella filiformis (Say 1818)	x	x
Order Amphipoda		
Ampelisca macrocephala Liljeborg 1852		x
Ampelisca abdita Mills 1964	x	x
Ampelisca verrilli Mills 1967	x	x
Ampithoidae sp.		x
Lembos smithi (Holmes 1905)	x	x
Microdeutopus gryllotalpa Costa 1853	x	
Batea catharinensis Fr. Muller 1865	x	
Cerapus tubularis Say 1818		x
Corophium acherusicum Costa 1857		x
Corophium tuberculatum Shoemaker 1934	x	x
Erichthonius brasiliensis Dana 1853	x	x
Unciola irrorata Say 1818		x
Unciola serrata Shoemaker 1945	x	x
Corophium simile Shoemaker 1934	x	x
Corophium bonelli	x	x
Gammarus mucronatus Say 1818	x	
Elasmopus laevis (Smith 1871)	x	x
Melita nitida Smith 1873	x	x
Neohaustorius biarticulatus Bousfield 1965		x
Microprotopus raneyi Wigley 1966		x
Lysianopsis alba Holmes 1905	x	x
Synchelidium americanum Bousfield 1973	x	x
Paraphoxus spinosus Holmes 1903	x	x

Table VII-1 (cont.)

	Grabs	Dredges
Order Amphipoda (cont.)		
Trichophoxus epistomus (Shoemaker 1938)	x	x
Parametopella cypris (Holmes 1905)		x
Caprella equilibra Say 1818		x
Paracaprella tenuis Mayer 1903	x	
Order Decapoda		
Crangon septemspinosa (Say 1818)	x	x
Callianassa atlantica (Smith 1874)	x	x
Pagurus longicarpus Say 1817	x	x
Pagurus pollicaris Say 1817	x	x
Euceramus praelongus Stimpson 1860	x	
Ovalipes ocellatus (Herbst 1799)		x
Cancer irroratus Say 1817	x	x
Xanthid sp.	x	x
Neopanope texana sayi (Smith 1869)	x	x
Paneopeus herbsti H. Milne-Edwards 1834	x	x
Hexapanopeus angustifrons (Benedict and Rathbun 1891)	x	
Pinnotheres maculatus Say 1818	x	
Pinnixa sayana Stimpson 1860	x	x
Pinnixa sp.	x	x
Sesarma cinereum (Bosc 1801)		x
Libinia sp. (juv.)		x
Libinia dubia H. Milne-Edwards 1834		x
Libinia emarginata Leach 1815	x	x
Phylum Ectoprocta		
Class Gymnolaemata		
Order Ctenostomata		
Alcyonidium polyoum (Hassall 1841)	x	x
Alcyonidium verrilli Osborn 1912	x	x
Alcyonidium mammillatum Alder 1857		x
Alcyonidium sp.	x	
Bowerbankia gracilis Leidy 1855	x	x
Triticella elongata (Osburn 1912)	x	x
Order Cheilostomata		
Membranipora tenuis Desor 1848	x	x
Membranipora tuberculata (Bosc 1802)		x
Conopeum tenuissimum (Canu 1908)	x	x
Conopeum truitti Osburn 1944	x	x
Electra monostachys (Marcus 1938)	x	x
Cryptosula pallasiana (Moll 1803)		x
Schizoporella errata (Watess 1878)	x	x
Schizoporella biaperta (Michelin 1841-1842)		x
Microporella ciliata (Pallas 1766)		x
Cribulina punctata (Hassall 1841)	x	

Table VII-1 (cont.)

	Grabs	Dredges
Phylum Echinodermata		
Class Asteroidea		
Order Forcipulata		
Asterias forbesi (Desor 1848)		x
Starfish (juv.)		x
Class Ophiuroidea		
Order Ophiurida		
Amphioplus abditus (Verrill)	x	x
Class Echinoidea		
Order Diadematoida		
Arbacia punctulata (Lamarck 1816)		x
Order Clypeasteroida		
Echinarachnius parma (Lamarck 1816)		x
Class Holothuroidea		
Order Dendrochirota		
Thyone briareus (LeSueur 1824)	x	

Table VII-2

Species by phylum for grabs and dredge hauls

	Rhynchocoela	Annelida Oligochaeta/ Polychaeta	Mollusca	Arthropoda	Cnidaria	Ectoprocta	Echinodermata	Tubularia	Porifera
Grabs	3	2/58	22	43	1	11	2	1	3
TOTAL--146									
Dredges (same as grabs)	3	2/44	19	29	1	9	1	1	2
TOTAL--111									
Additional Species		8	12	15	3*	5*	4*		
TOTAL--158									

*denotes increases in epifaunal groups

Table VII-3

Grab-dredge species comparisons at Station 4

Grab			Dredge		
Dominant Species	Biological Index No.	Average No. Individuals	Dominant Species	Biological Index No.	Average RAIV
Tellina agilis	.98	10.7	*Tellina agilis*	.96	4.5
Glycera capitata	.87	4.1	*Neomysis americana*	.92	4.95
Scoloplos fragilis	.77	3.4	*Mulinia lateralis*	.88	4.7
Ampelisca verrilli	.78	2.7	*Asabellides oculatus*	.84	3.65
Glycera dibranchiata	.68	1.8	*Ampelisca verrilli*	.83	2.4
Spiophanes bombyx	.60	1.2	*Glycera capitata*	.71	2.12
Mulinia lateralis	.55	1.6	*Scoloplos fragilis*	.62	1.2
Nemertea sp.	.51	1.1	*Ensis directus*	.61	1.1
Total Species		36	Total Species		53
Colonial		3			
Number of Dominant Species		8	Number of Dominant Species		8
Number of Rare Species		19	Number of Rare Species		26
Average No. Species/Grab		10.7	Average No. Species/Dredge		16.0
Average No. Individuals/Grab		32.6	Average RAIV/Dredge		36.8

Table VII-4

Grab-dredge species comparisons at Station 5

Grab			Dredge		
Dominant Species	Biological Index No.	Average No. Individuals	Dominant Species	Biological Index No.	Average RAIV
Nucula proxima	1.0	3649.1	*Nucula proxima*	1.0	6.9
Tellina agilis	.97	42.2	*Tellina agilis*	.90	4.4
Ensis directus	.83	2.9	*Crangon septemspinosa*	.88	3.8
			Neomysis americana	.79	3.4
			Ensis directus	.73	1.9
			Nephtys incisa	.67	1.4
			Mulinia lateralis	.56	1.5
			Yoldia limatula	.55	1.3
Total Species		40	Total Species		43
Colonial		4			
Number of Dominant Species		3	Number of Dominant Species		8
Number of Rare Species		26	Number of Rare Species		25
Average No. Species/Grab		6.9	Average No. Species/Dredge		11.7
Average No. Individuals/Grab		3701.0	Average RAIV/Dredge		33.6

Table VII-5

Grab-dredge species comparisons at Station 3

Grab

Dominant Species	Biological Index No.	Average No. Individuals
Mytilus edulis	.95	245.6
Mediomastus ambiseta	.90	13.5
Lysianopsis alba	.85	10.9
Harmothoe extenuata	.82	11.15
Xanthidae sp.	.82	11.5
Polycirrus eximius	.82	4.3
Nereis succinea	.73	4.0
Spio setosa	.72	2.4
Asabellides oculatus	.70	2.4
Aricidea cerruti	.62	2.7
Crepidula convexa	.56	1.8
Streblospio benedicti	.52	0.8

Dredge

Dominant Species	Biological Index No.	Average RAIV
Mytilus edulis	.99	7.0
Mediomastus ambiseta	.94	5.0
Nereis succinea	.93	4.3
Polydora ligni	.93	6.2
Harmothoe extenuata	.93	6.3
Polycirrus eximius	.90	3.7
Electra monostachys	.86	3.7
Lysianopsis alba	.86	3.4
Alcyonidium polyoum	.84	3.2
Crepidula plana	.78	3.4
Eteone heteropoda	.77	2.1
Nucula proxima	.75	1.8
Eumida sanguinea	.75	2.3
Xanthidae sp.	.74	2.0
Schizoporella errata	.65	1.3
Neomysis americana	.89	2.4
Crangon septemspinosa	.59	1.2
Membranipora tenuis	.58	1.6
Conopeum tenuissimum	.50	1.6

Table VII-5 (cont.)

Grab		Dredge	
Total Species	85	Total Species	89
Colonial	9		
Number of Dominant Species	12	Number of Dominant Species	19
Number of Rare Species	31	Number of Rare Species	32
Average No. Species/Grab	25.0	Average No. Species/Dredge Haul	33.0
Average No. Individuals/Grab	333.0	Average RAIV/Dredge Haul	83.9

Table VII-6

Grab-dredge species comparisons at Station 9

Grab			Dredge		
Dominant Species	Biological Index No.	Average No. Individuals	Dominant Species	Biological Index No.	Average RAIV
Asabellides oculatus	.94	24.7	Hydroides dianthus	.96	7.0
Mediomastus ambiseta	.93	44.4	Unciola serrata	.96	7.0
Nucula proxima	.91	18.7	Corophium simile	.96	7.0
Unciola serrata	.90	78.5	Mytilus edulis	.96	6.9
Heteromastus filiformis	.88	13.8	Eumida sanguinea	.95	6.7
Xanthidae sp.	.85	34.5	Sabellaria vulgaris	.95	6.7
Streblospio benedicti	.85	19.7	Nereis succinea	.93	6.3
Corophium simile	.81	51.0	Xanthidae sp.	.86	5.1
Polycirrus eximius	.80	16.5	Odostomia dianthophila	.83	5.6
Glycinde solitaria	.79	12.1	Lembos smithi	.84	4.3
Marphysa sanguinea	.77	6.3	Harmothoe extenuata	.80	4.5
Nereis succinea	.77	9.5	Polydora ligni	.81	3.8
Hydroides dianthus	.74	61.2	Paraphoxus spinosa	.77	4.6
Neopanope texana sayi	.72	6.6	Erichthonius brasiliensis	.75	3.9
Eumida sanguinea	.69	11.6	Mediomastus ambiseta	.75	3.9
Mercenaria mercenaria	.69	3.8	Elasmopus laevis	.74	3.6
Mytilus edulis	.66	10.1	Cliona celata	.70	4.4
Erichthonius brasiliensis	.65	5.0	Lepidonotus squamatus	.67	2.6
Tellina agilis	.65	3.1	Oligochaete B	.66	3.2
Lepidonotus squamatus	.59	4.7	Streblospio benedicti	.66	1.8
Sabellaria vulgaris	.58	8.5	Conopeum tenuissimum	.63	2.6
Petricola pholadiformis	.51	1.3	Crepidula plana	.63	2.3
			Asabellides oculatus	.59	1.6
			Microciona prolifera	.57	2.7
			Marphysa sanguinea	.56	2.1
			Alcyonidium polyoum	.55	2.1
			Mitrella lunata	.52	0.95

Table VII-6 (cont.)

Grab		Dredge	
Total Species	86	Total Species	91
Colonial	12		
Number of Dominant Species	22	Number of Dominant Species	27
Number of Rare Species	31	Number of Rare Species	39
Average No. Species/Grab	33.3	Average No. Species/Dredge Haul	34.7
Average No. Individuals/Grab	480.4	Average RAIV/Dredge Haul	125.7

FIGURE CAPTIONS FOR CHAPTER VII

Figure VII- 1: Sampling stations for the dredging and grab collections in Delaware Bay. Only Stations 3, 4, 5, and 9 were sampled during this study.

Figure VII- 2: Sled dredge with 1 m wide opening and 1 mm mesh bag for collecting the samples encased in a protective external net.

Figure VII- 3: Hard bottom dredge with 1 m wide opening and 1 mm mesh bag for collecting samples encased in a protective external net.

Figure VII- 4: Modified Menzies dredge with a 1 m wide opening and a 1 mm mesh bag for collecting samples encased in a protective external net.

Figure VII- 5: Grain-size frequency distribution for the combined 20 sediment samples collected at Station 4 with the Petersen grab.

Figure VII- 6: The cumulative average number of individuals and the cumulative number of species by category for the 20 replicate grab (0.1 m^2) samples at Station 4 (sand).

Figure VII- 7: The cumulative average number of individuals/0.1 m^2 for the 20 replicate grab samples of the four most dominant species collected at Station 4 (sand).

Figure VII- 8: The cumulative percentages of the fauna for the four most dominant species collected in 20 replicate grabs at Station 4 (sand).

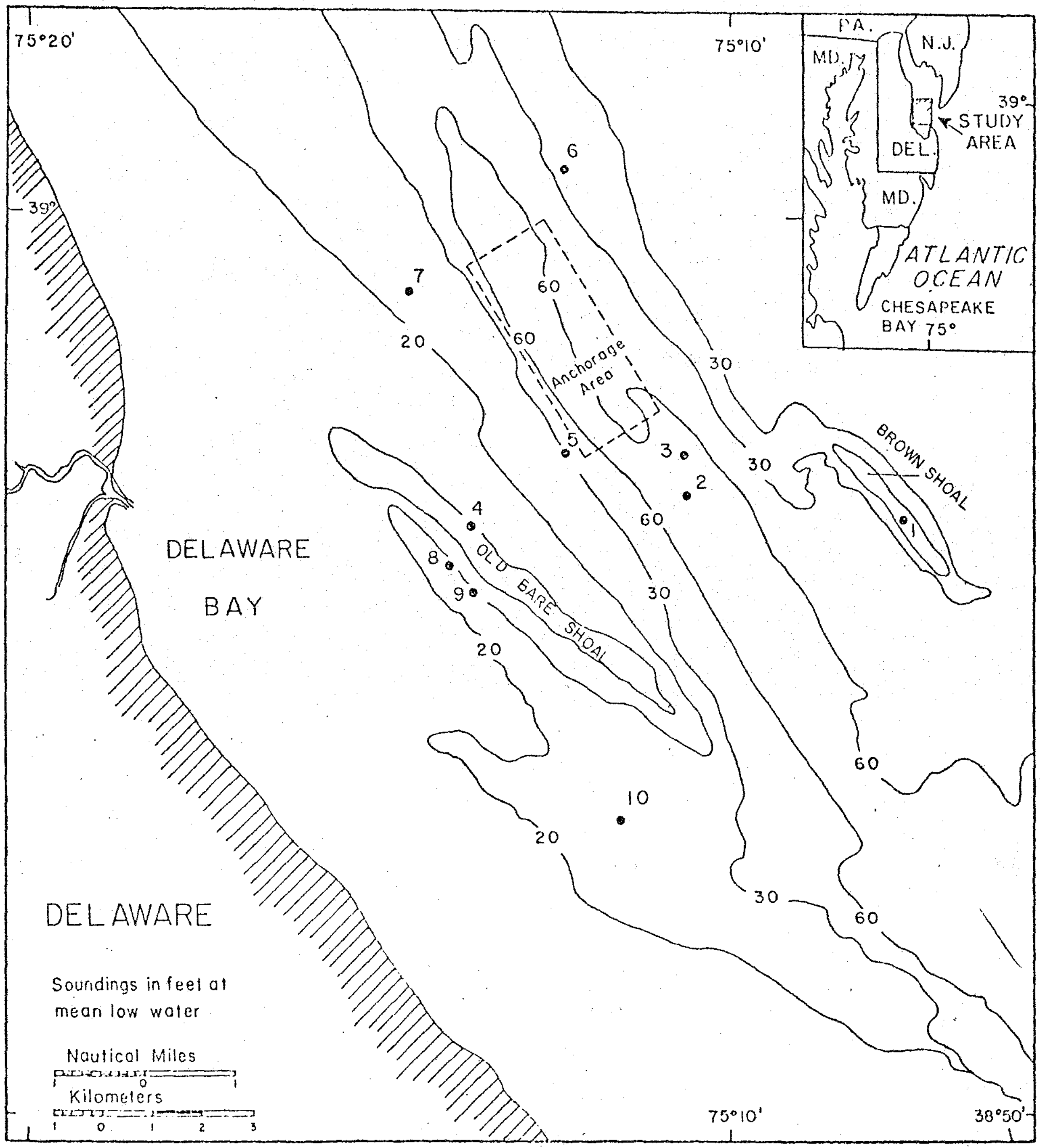

75°20'
75°10'
39°
P.A.
N.J.
MD.
39°
STUDY AREA
DEL.
MD.
ATLANTIC OCEAN
CHESAPEAKE BAY
75°
6
7
60
60
Anchorage Area
20
30
30
5
3
2
BROWN SHOAL
1
4
60
DELAWARE
BAY
8
9
OLD BARE SHOAL
30
20
60
10
20
30
60
DELAWARE
Soundings in feet at mean low water
Nautical Miles
Kilometers
1 0 1 2 3
75°10'
38°50'

Figure VII-1

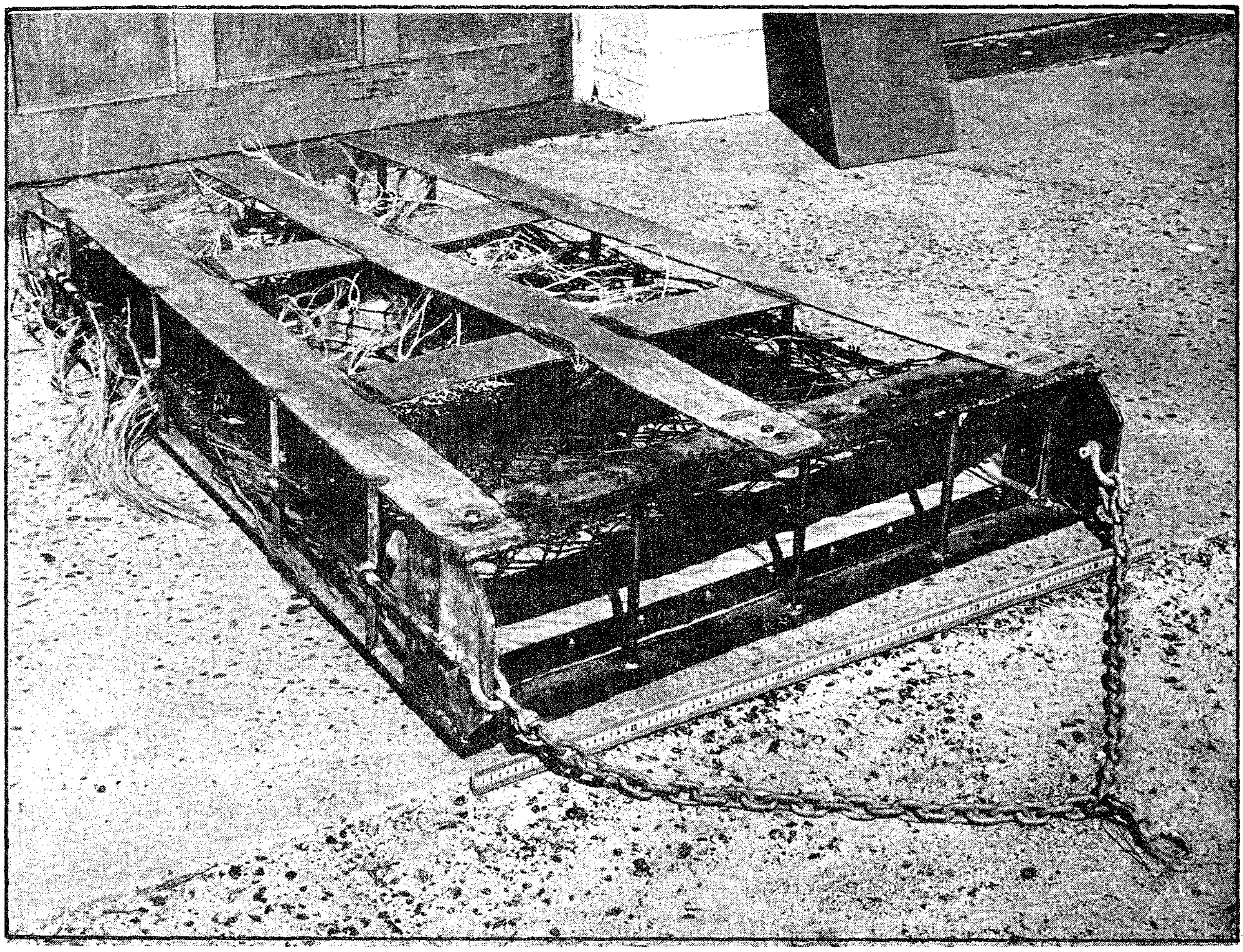


Figure VII-2

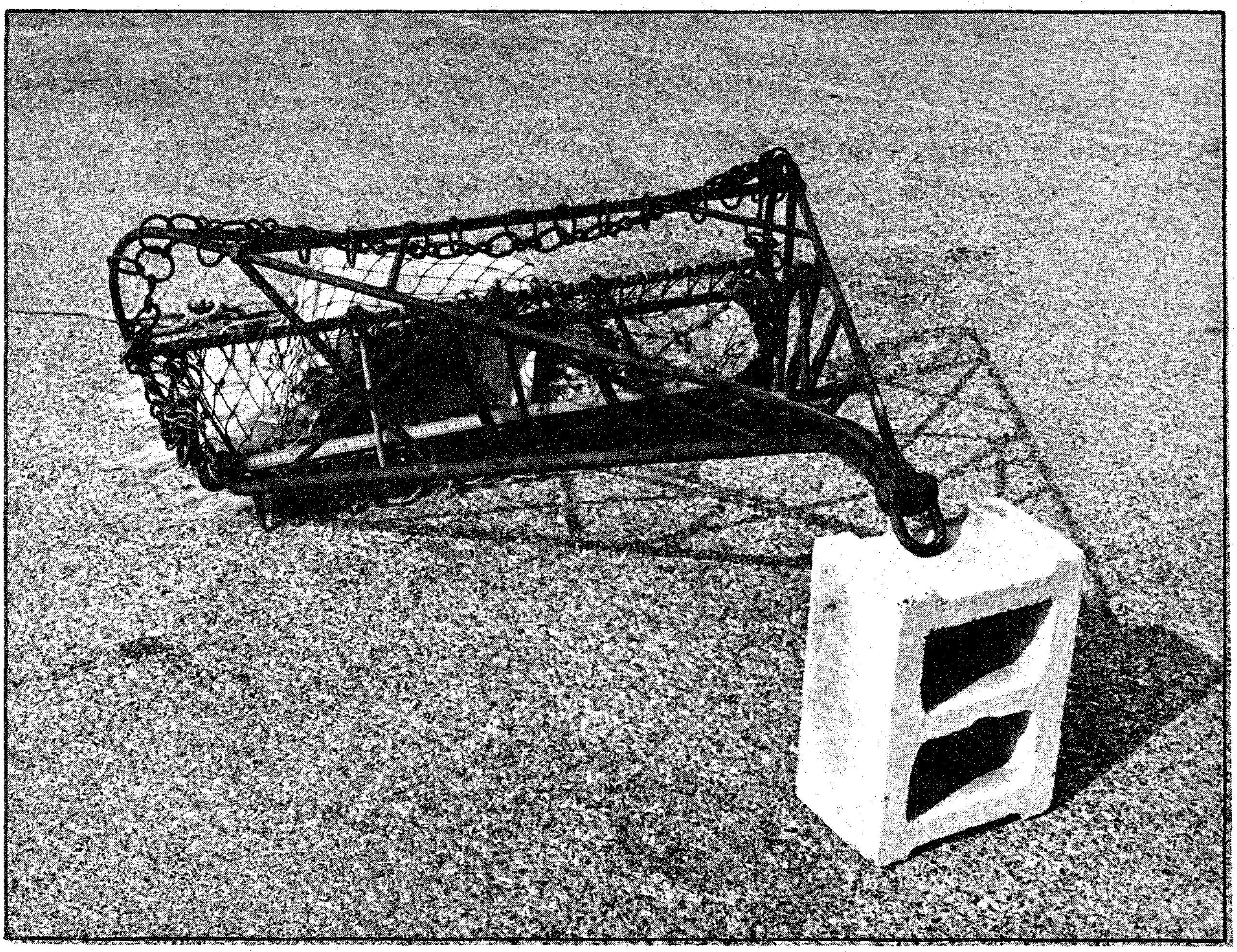


Figure VII-3

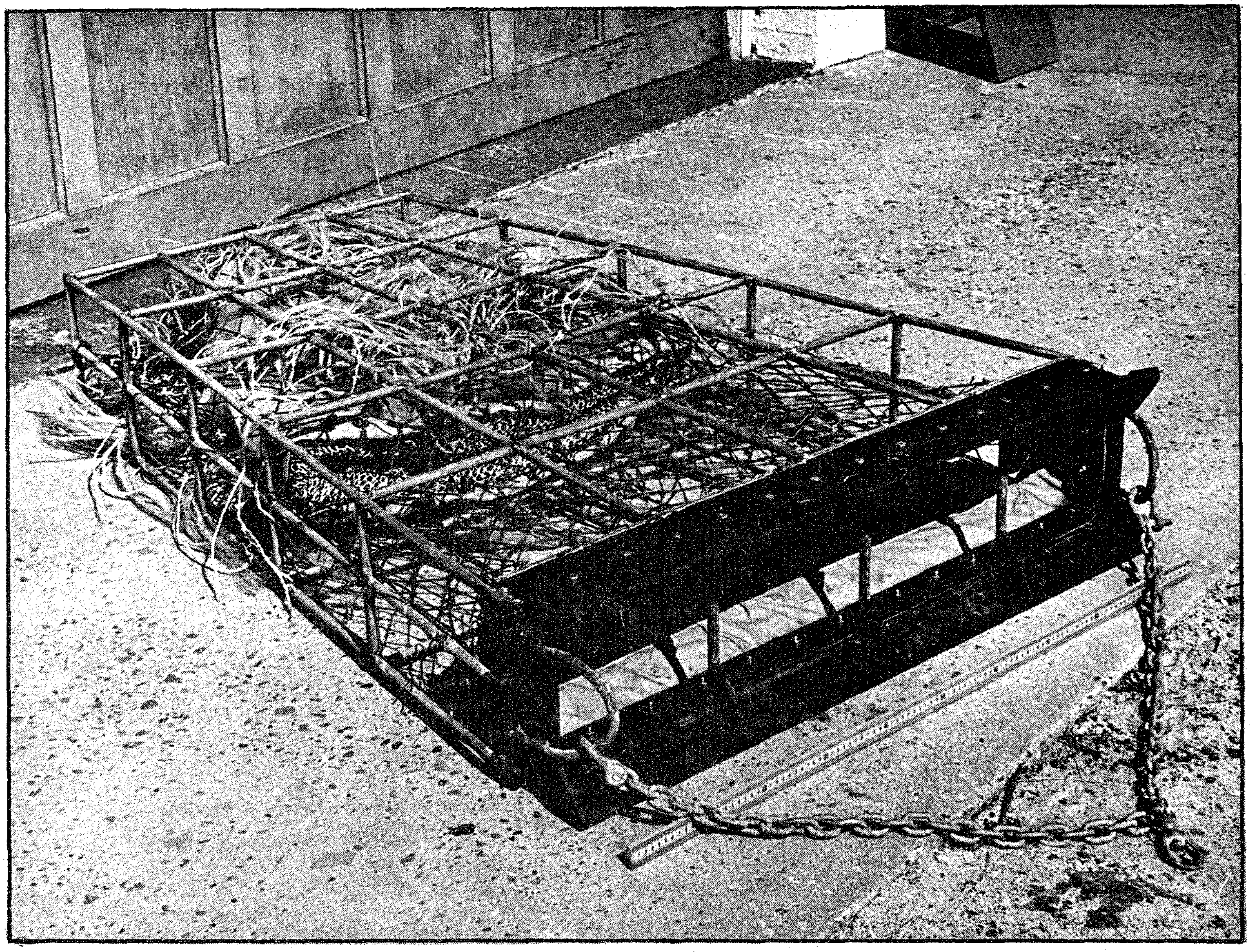
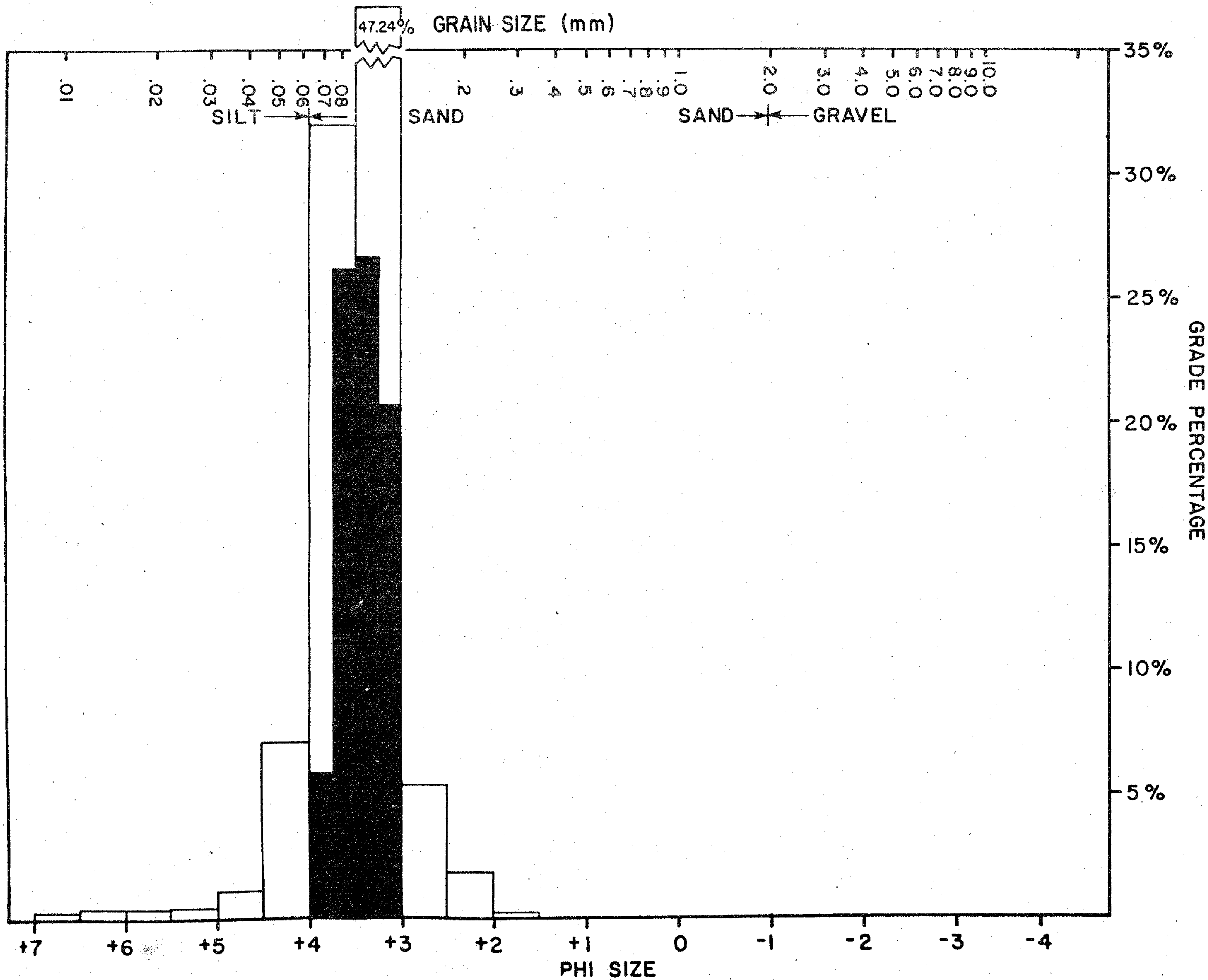
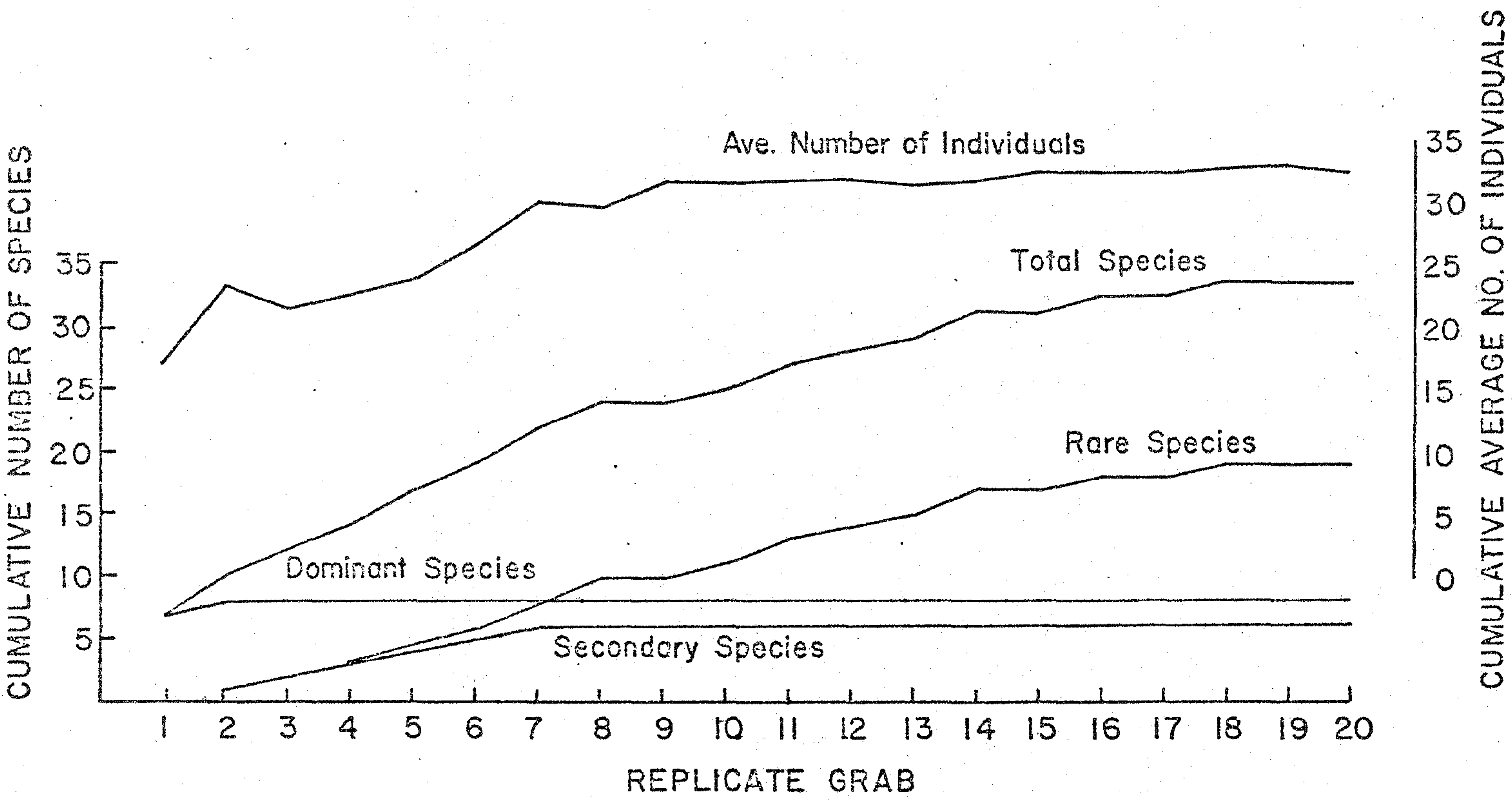


Figure VII-4



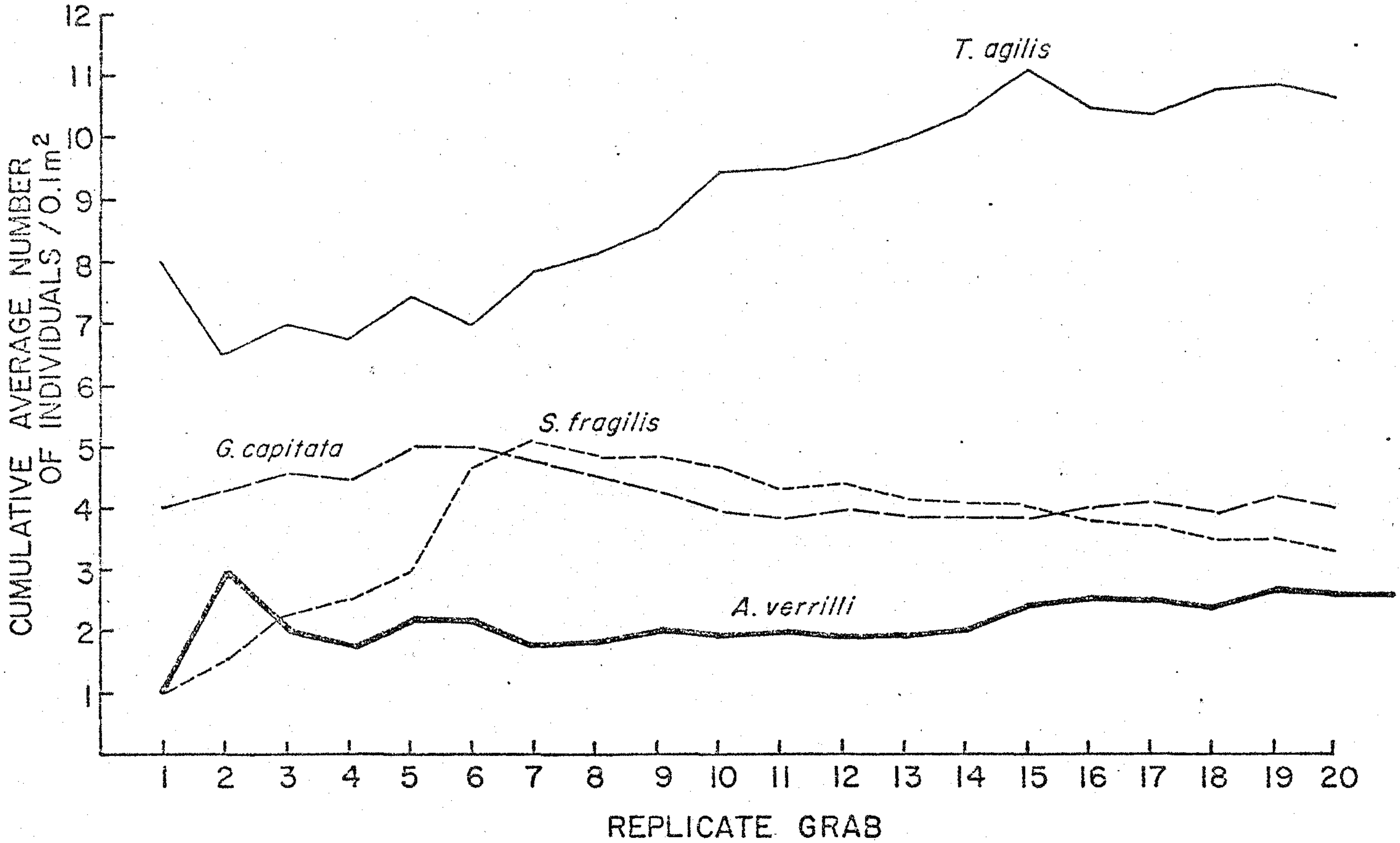
47.24%
GRAIN SIZE (mm)
.01
.02
.03
.04
.05
.06
.07
.08
.2
.3
.4
.5
.6
.7
.8
.9
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
SILT
SAND
SAND
GRAVEL
35%
30%
25%
20%
15%
10%
5%
GRADE PERCENTAGE
+7
+6
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
PHI SIZE

Figure VII-5



Ave. Number of Individuals
Total Species
Rare Species
Dominant Species
Secondary Species
CUMULATIVE NUMBER OF SPECIES
35
30
25
20
15
10
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
REPLICATE GRAB
CUMULATIVE AVERAGE NO. OF INDIVIDUALS
35
30
25
20
15
10
5
0

Figure VII-6



T. agilis
G. capitata
S. fragilis
A. verrilli
CUMULATIVE AVERAGE NUMBER OF INDIVIDUALS / 0.1m²
REPLICATE GRAB
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
1 2 3 4 5 6 7 8 9 10 11 12

Figure VII-7

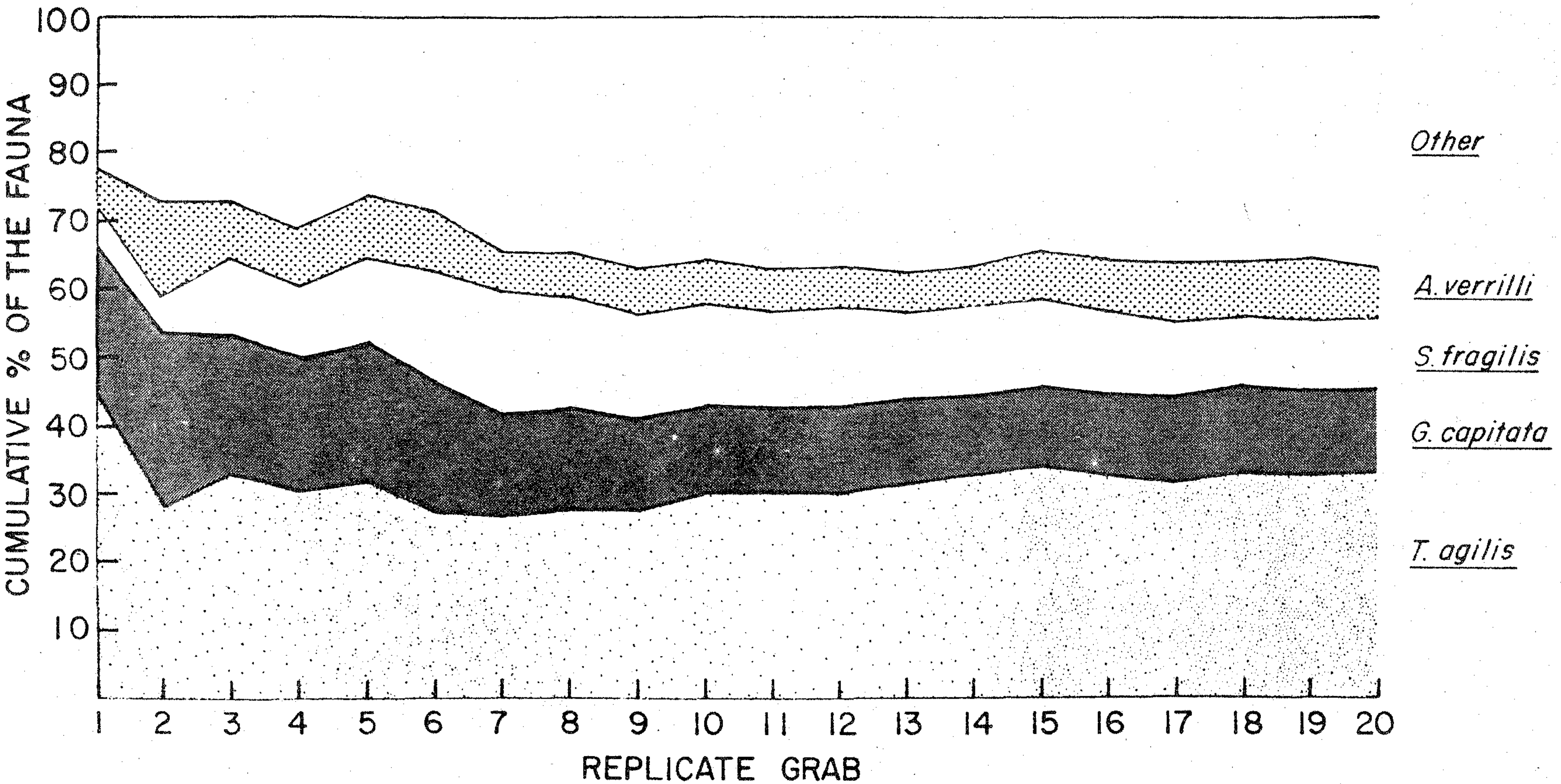

CUMULATIVE % OF THE FAUNA
100
90
80
70
60
50
40
30
20
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
REPLICATE GRAB
Other
A. verrilli
S. fragilis
G. capitata
T. agilis

Figure VII-8

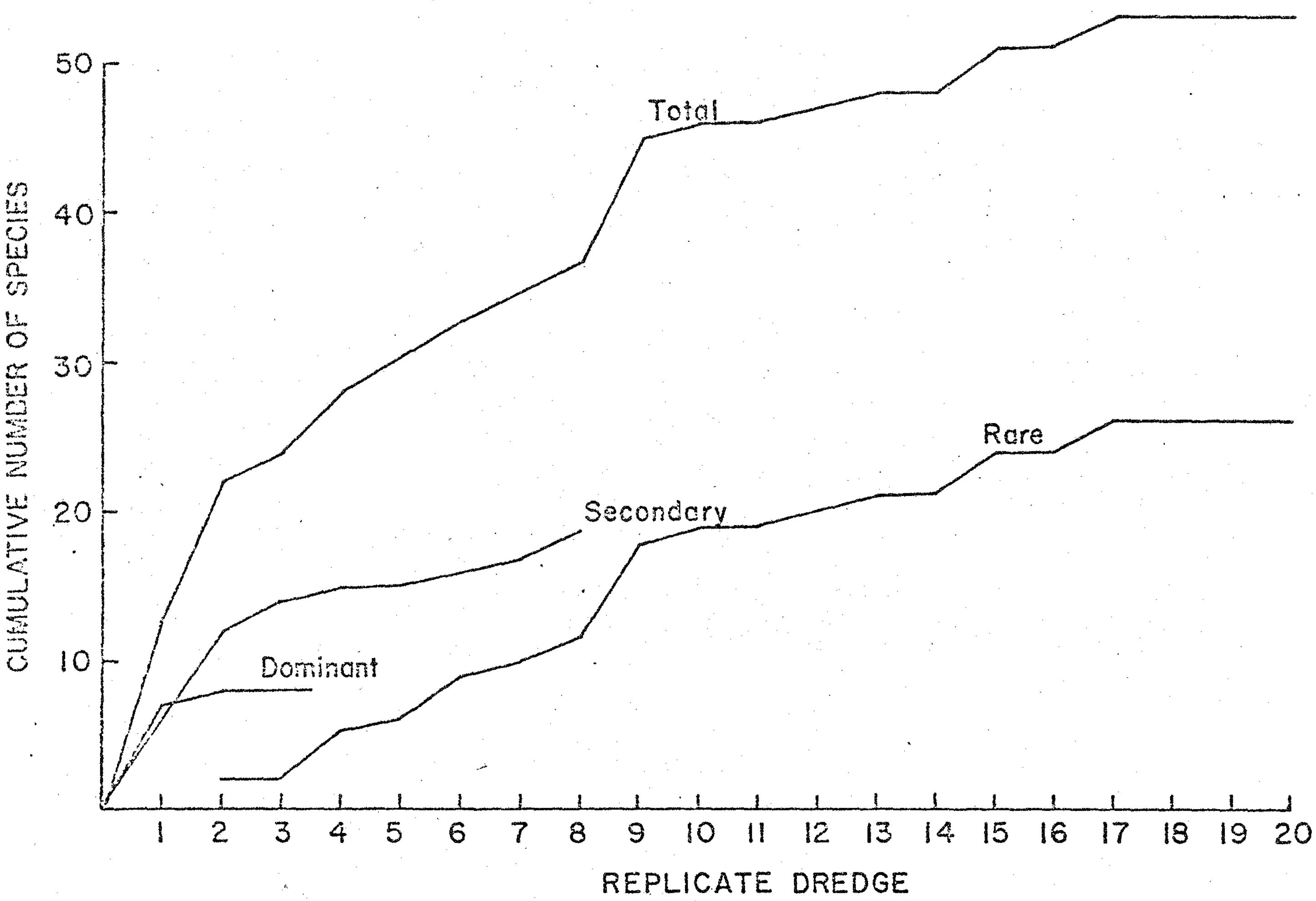

Total
Secondary
Dominant
Rare
CUMULATIVE NUMBER OF SPECIES
10
20
30
40
50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
REPLICATE DREDGE

Figure VII-9

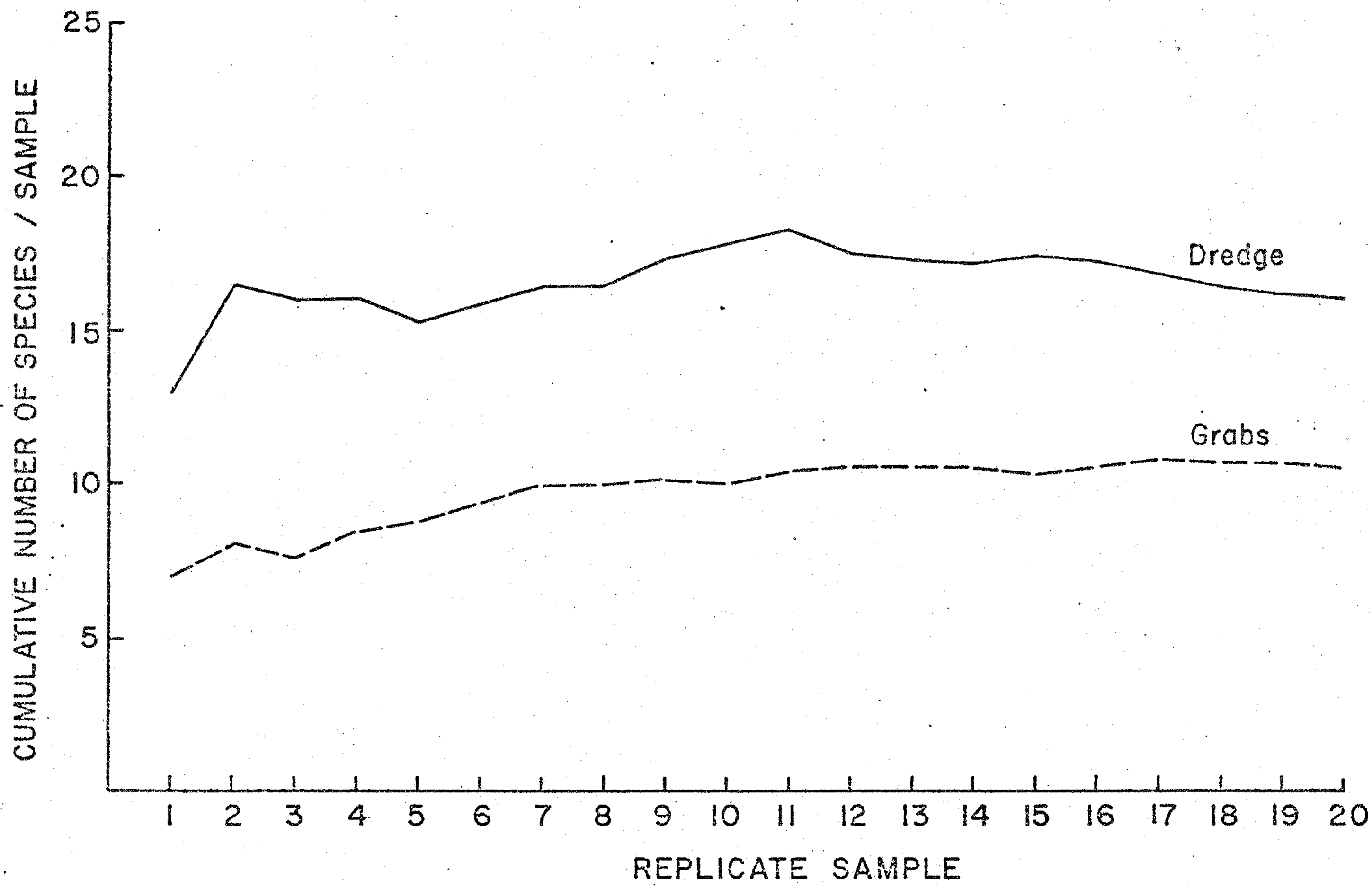


Figure VII-10

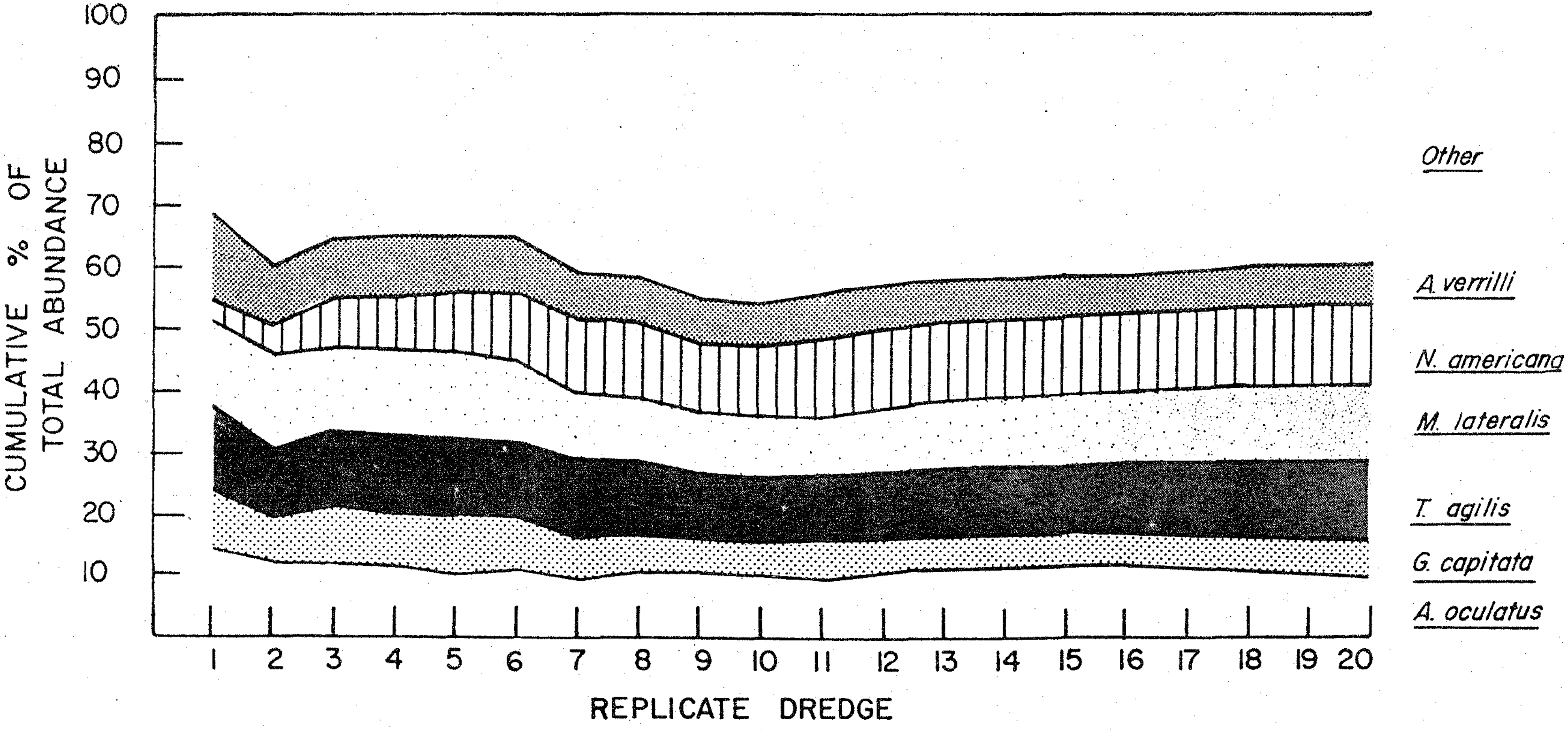


Figure VII-11

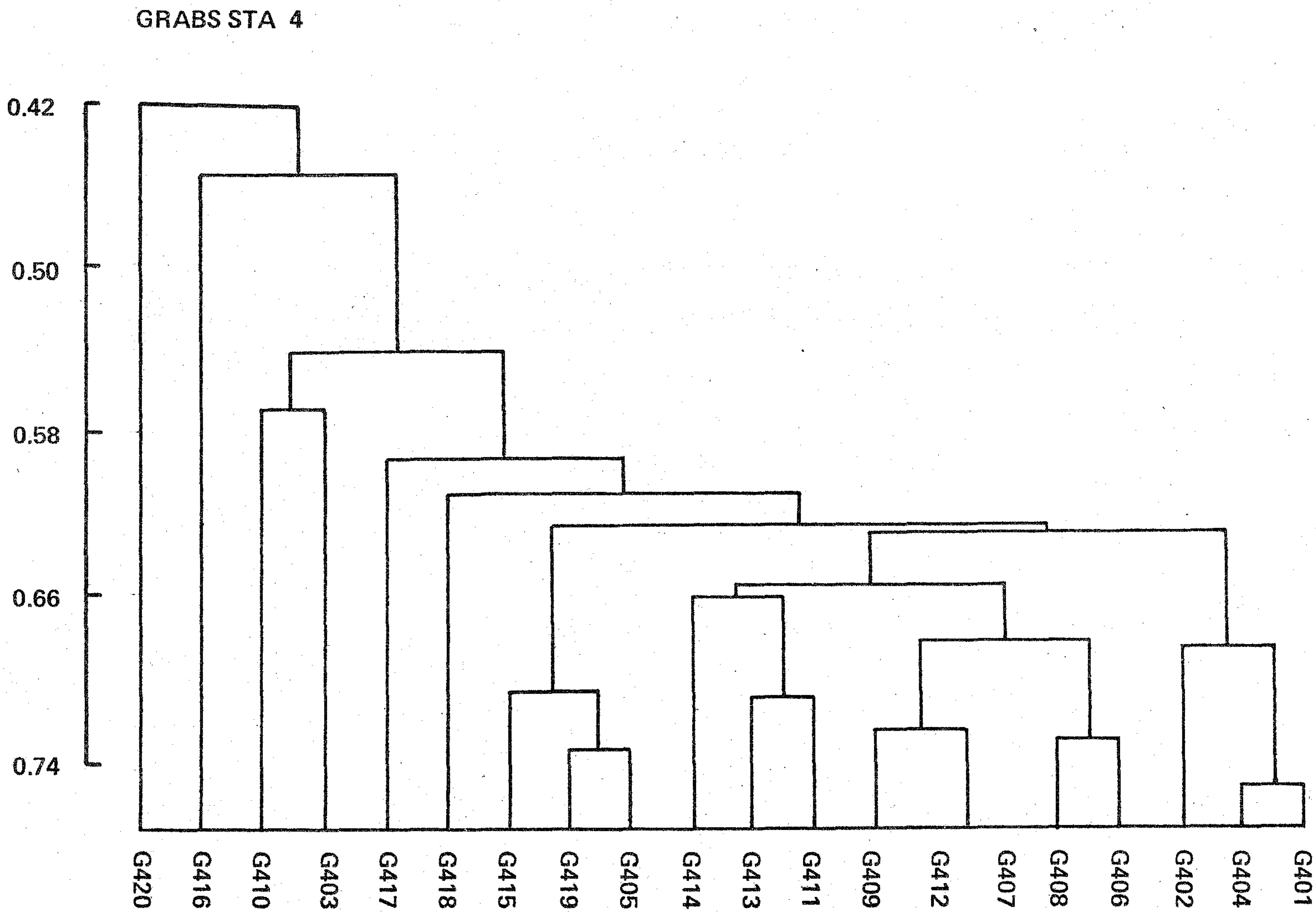


Figure VII-12

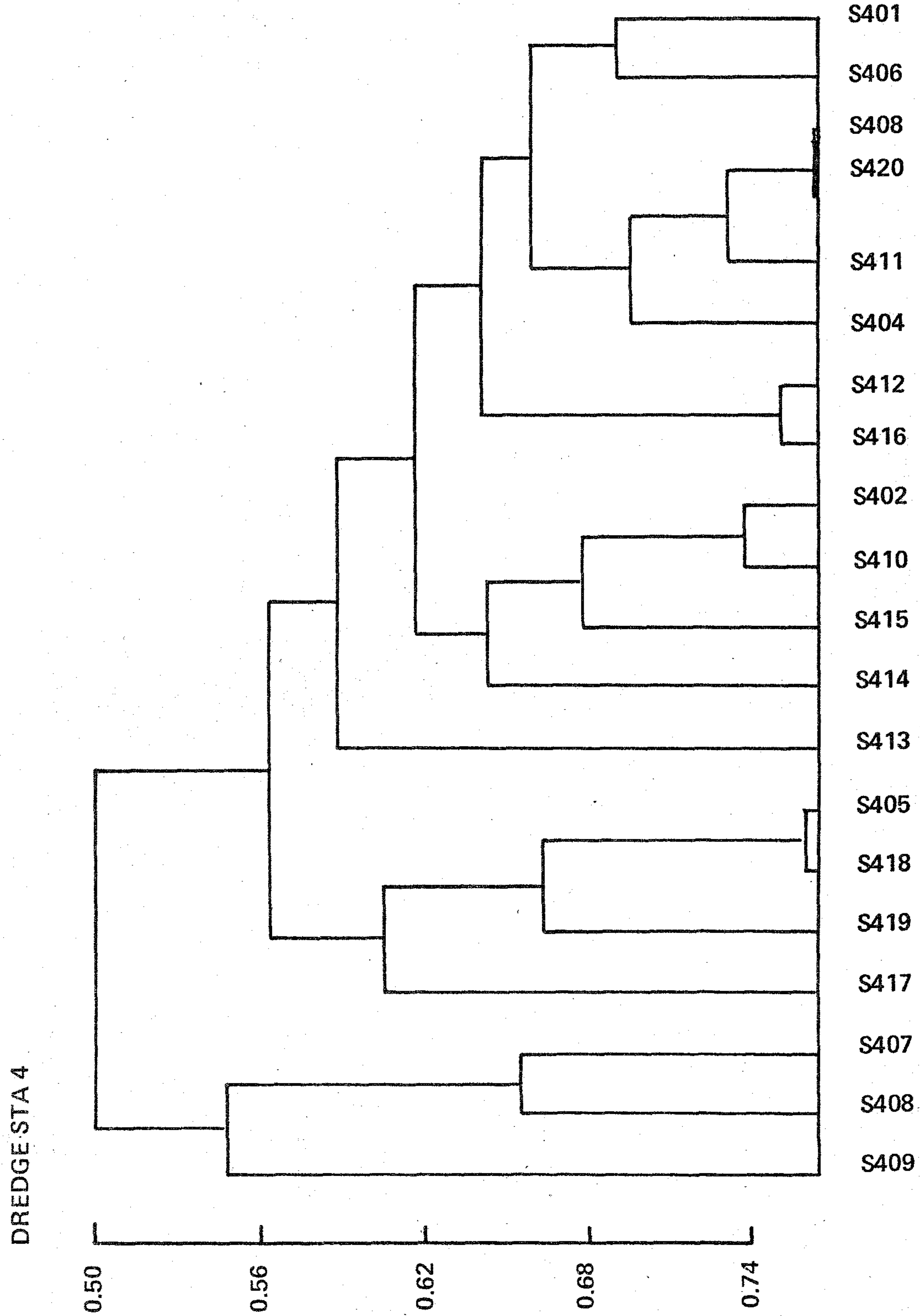


Figure VII-13

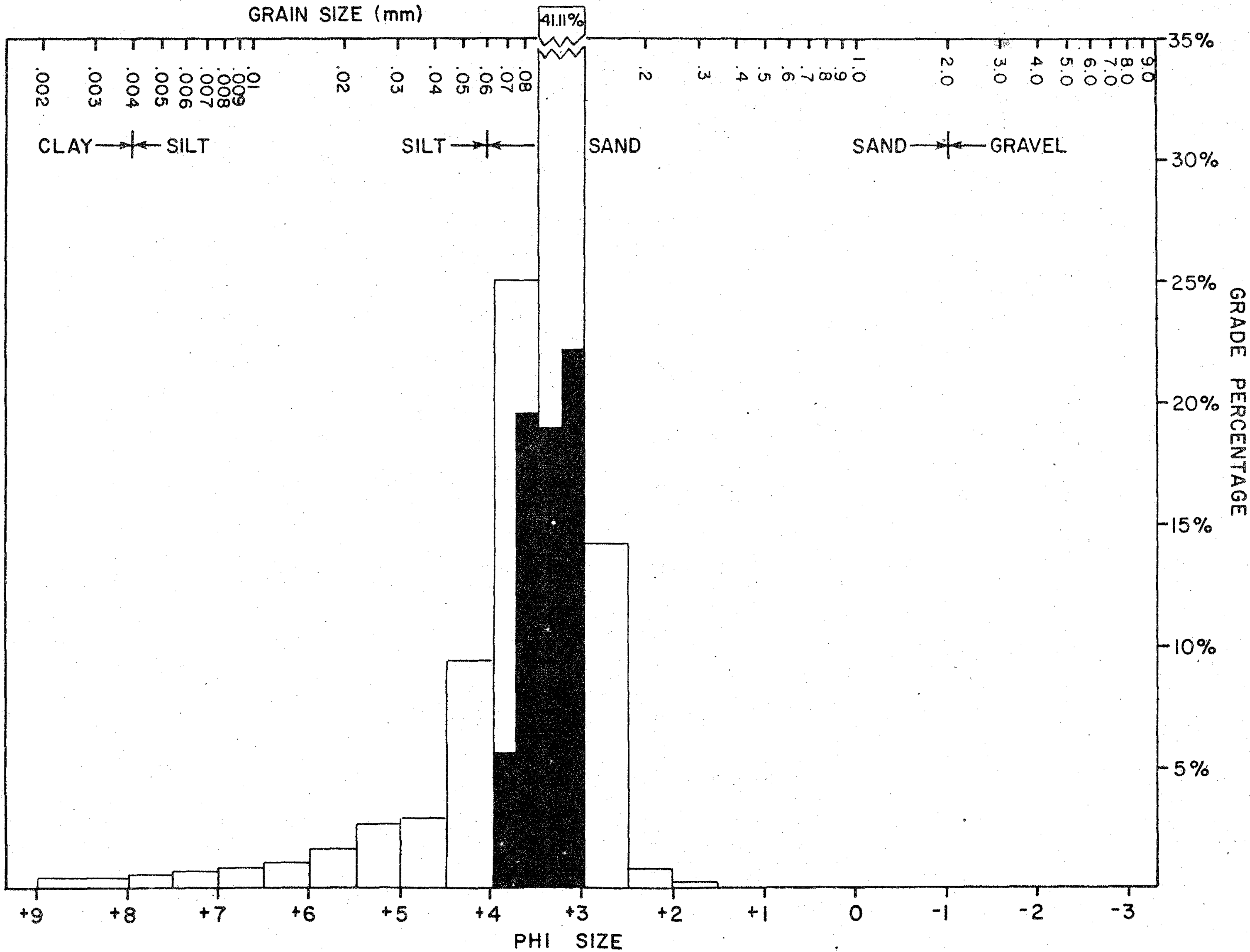


Figure VII-14

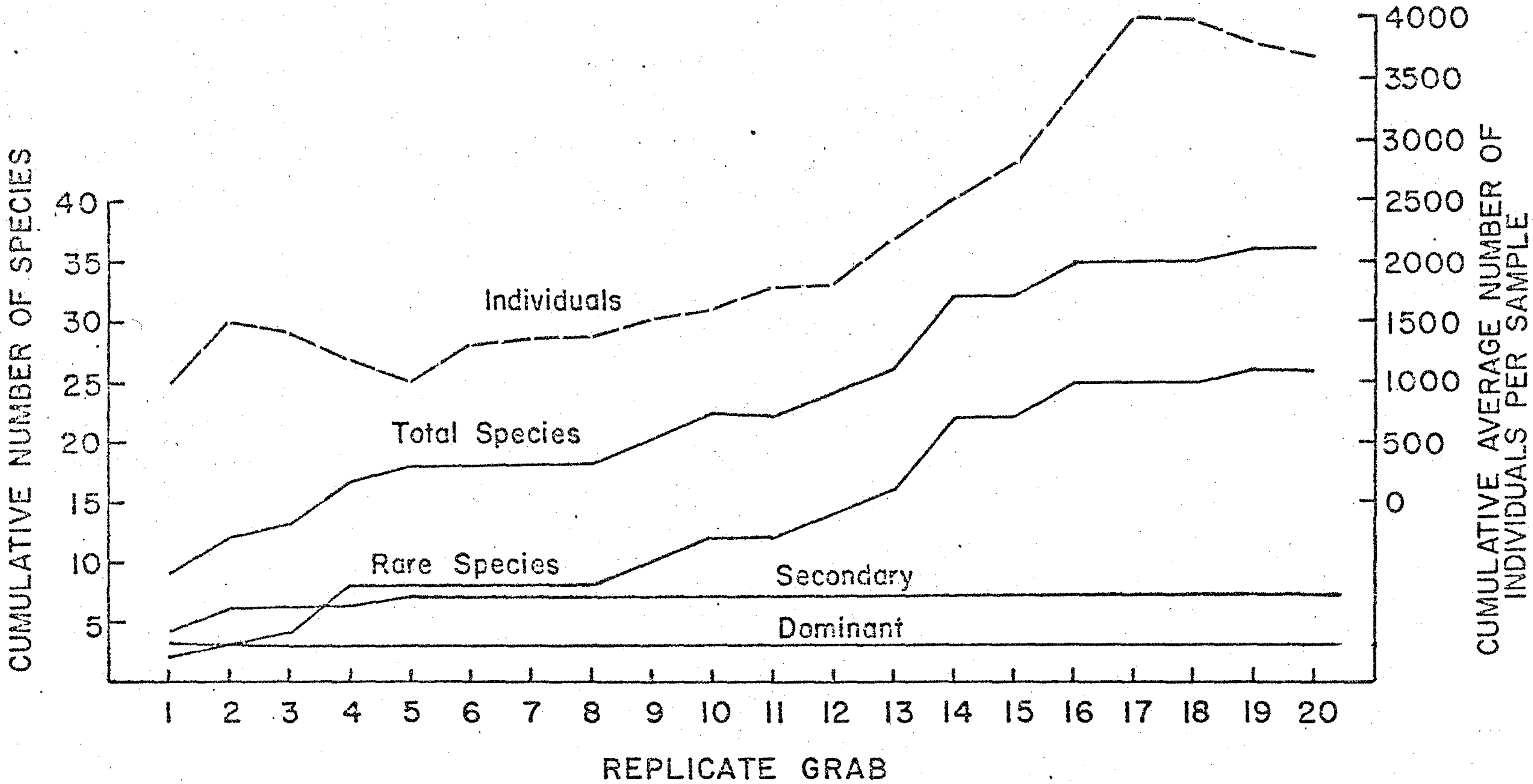


Fig VII - 15

Figure VII-15

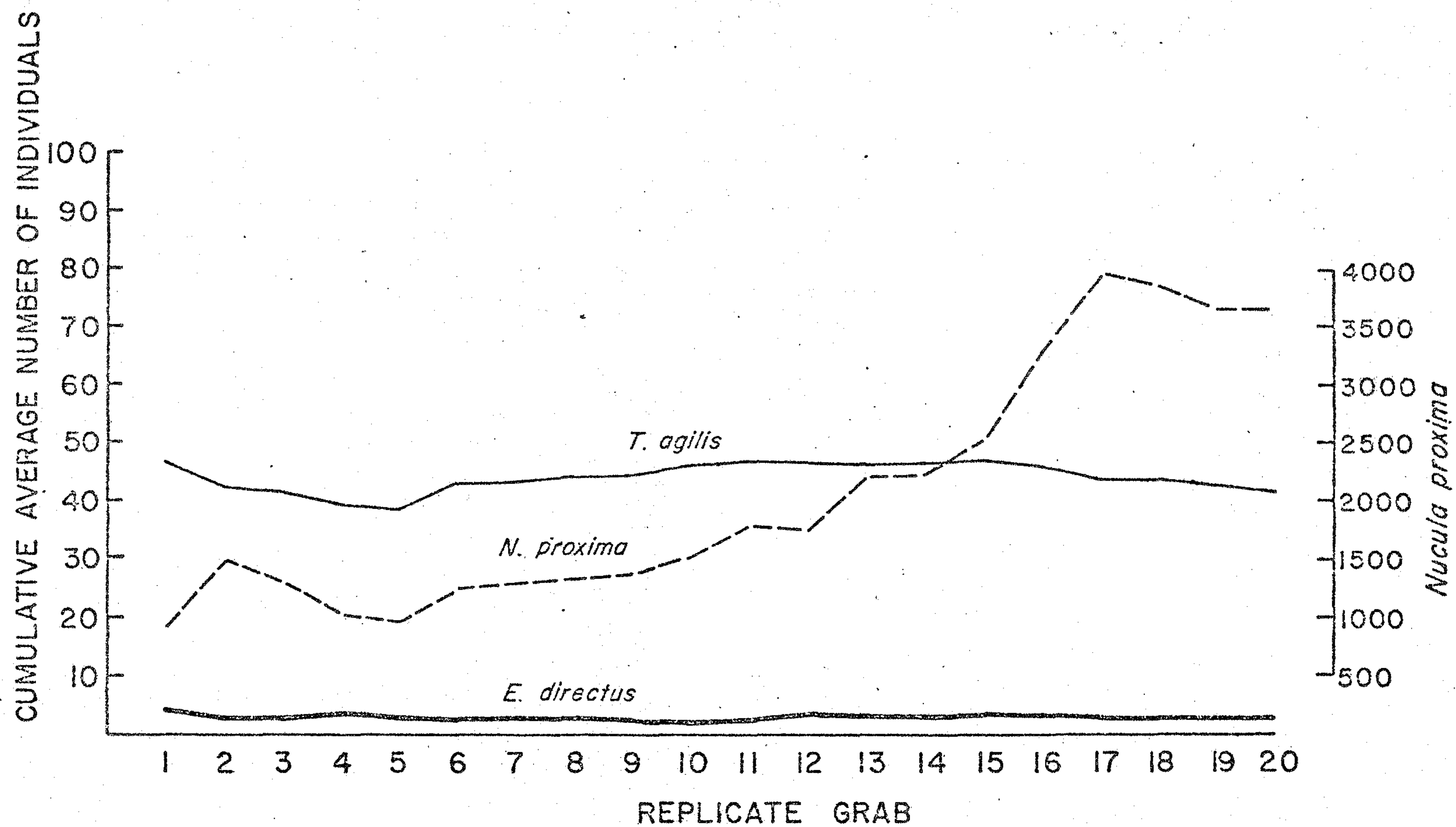


Figure VII-16

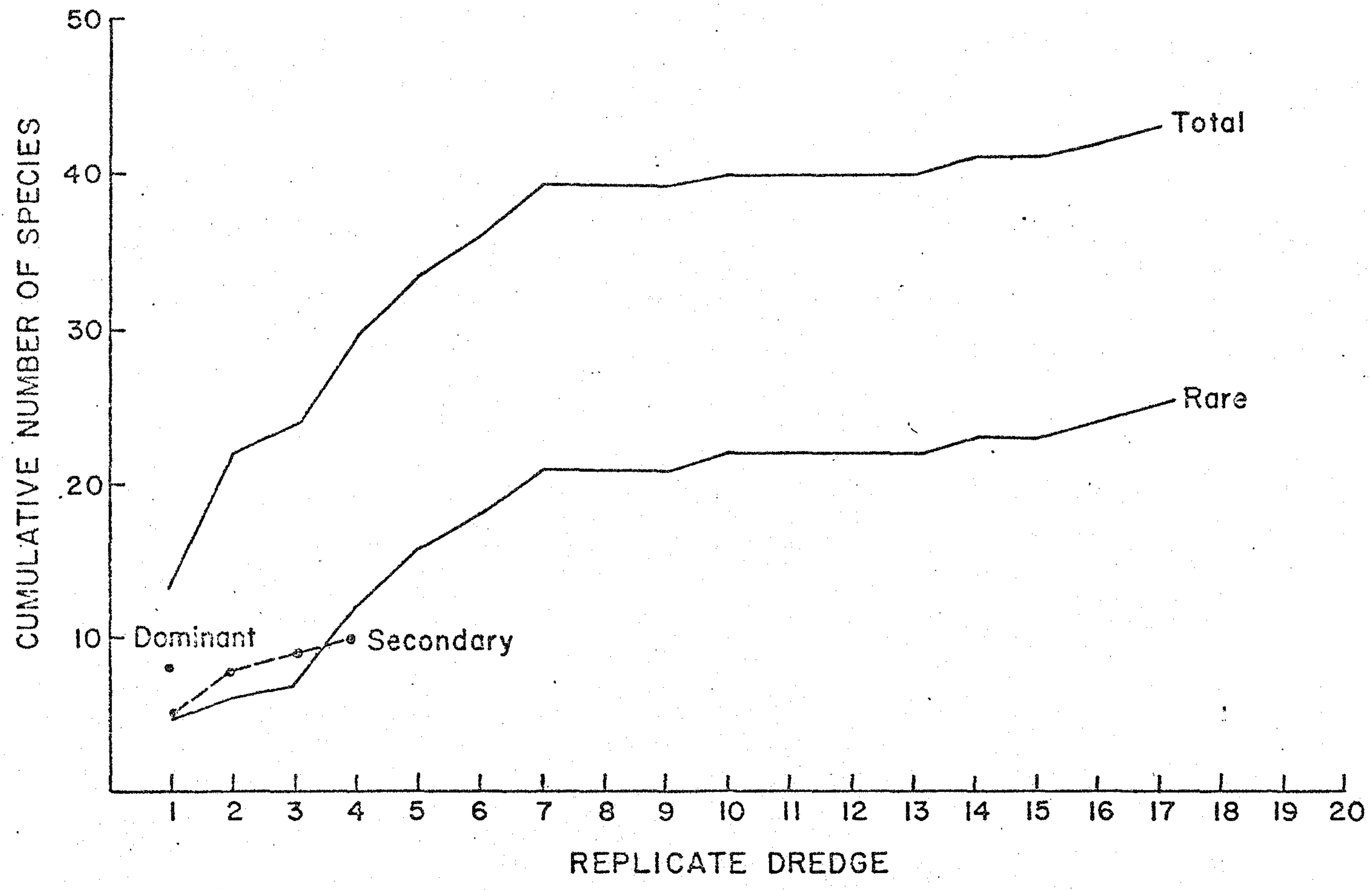


Figure VII-17

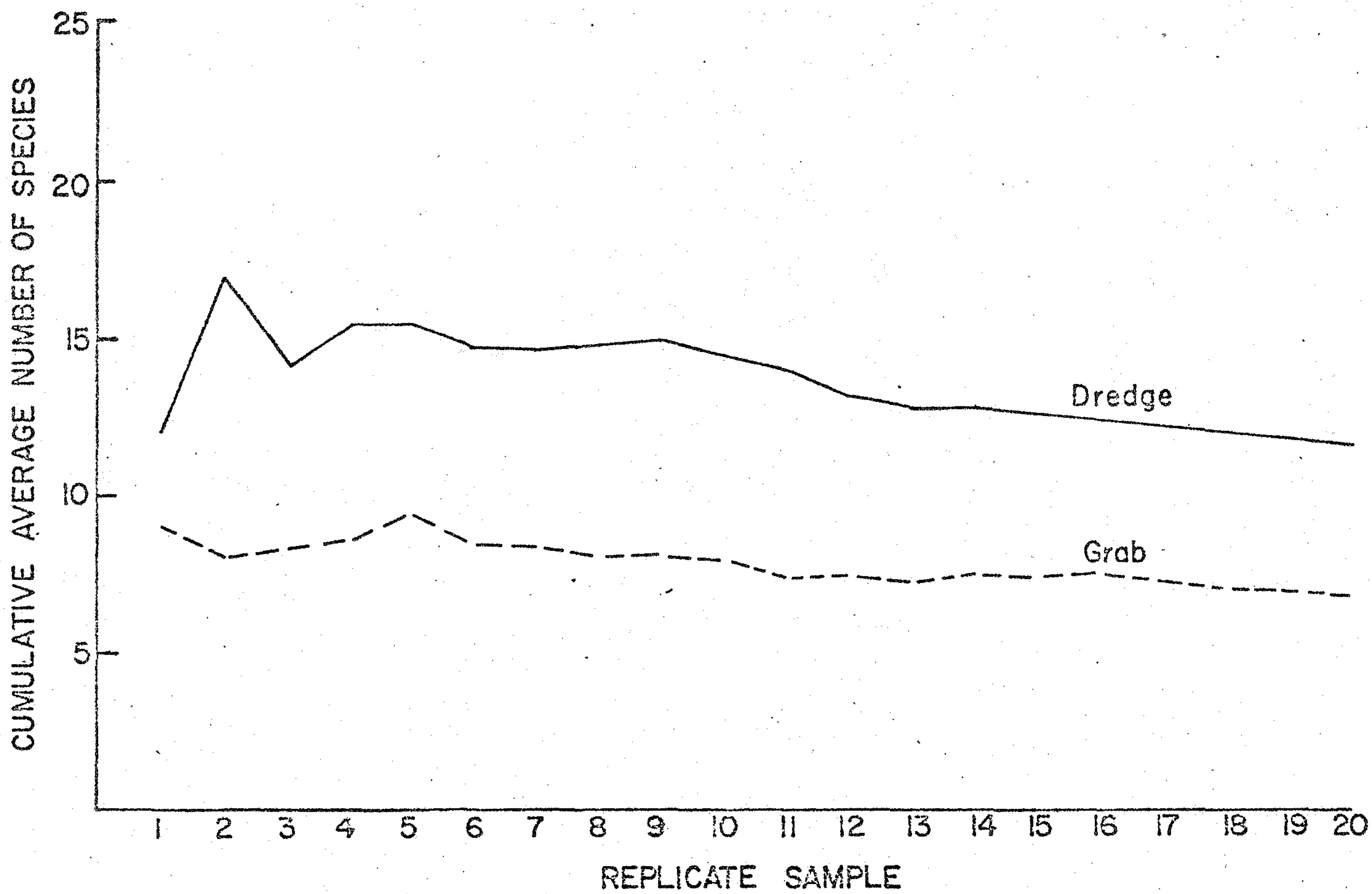


Figure VII-18

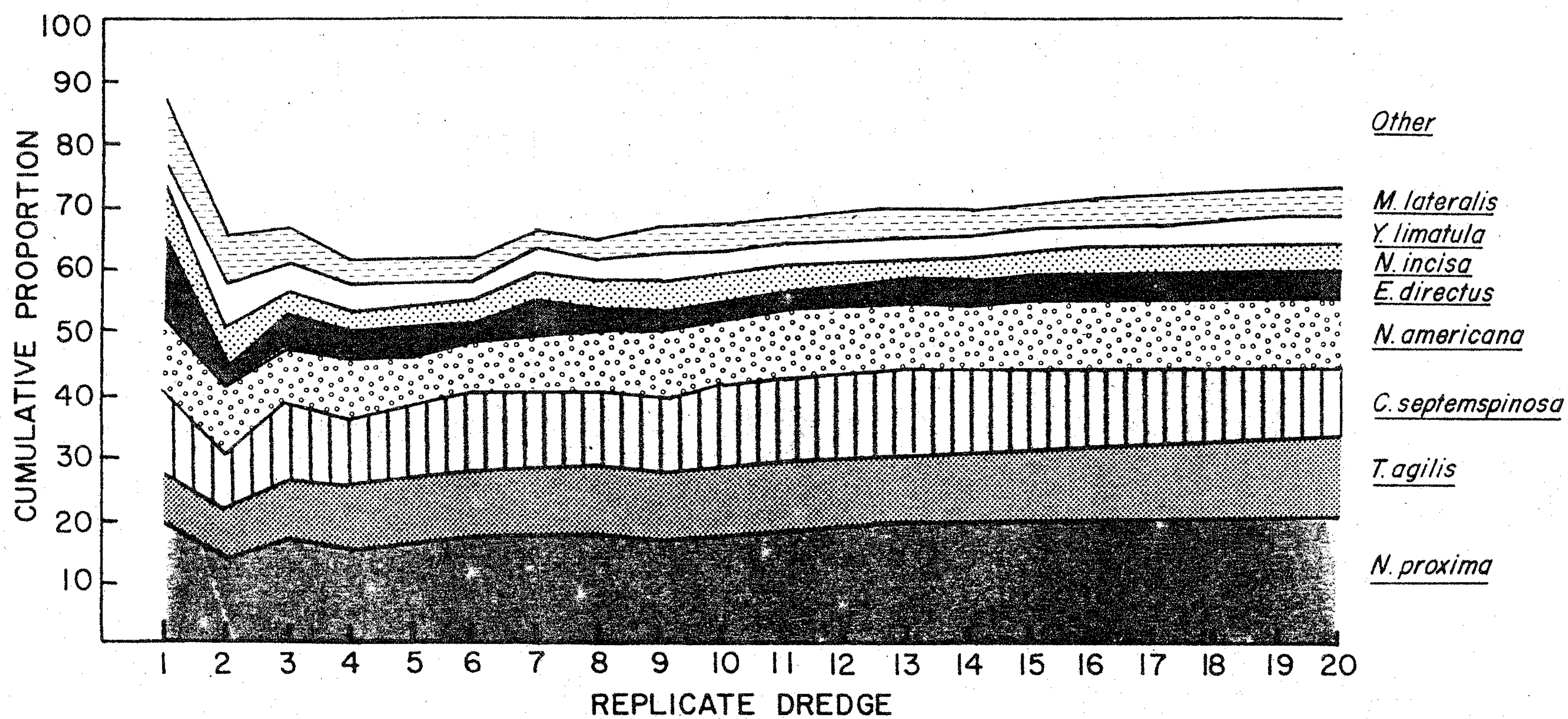


Figure VII-19

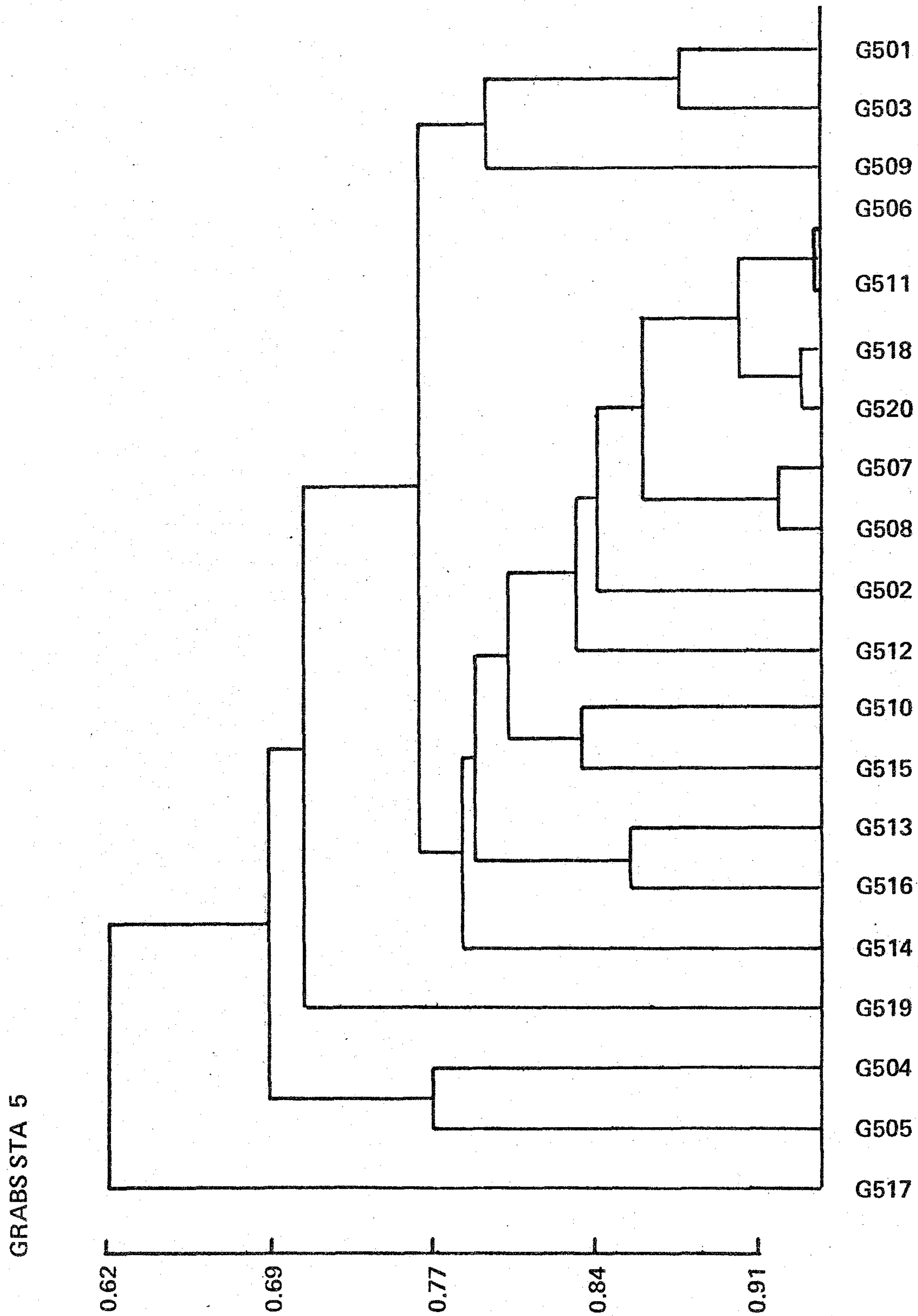


Figure VII-20

Dredge Sta. 5

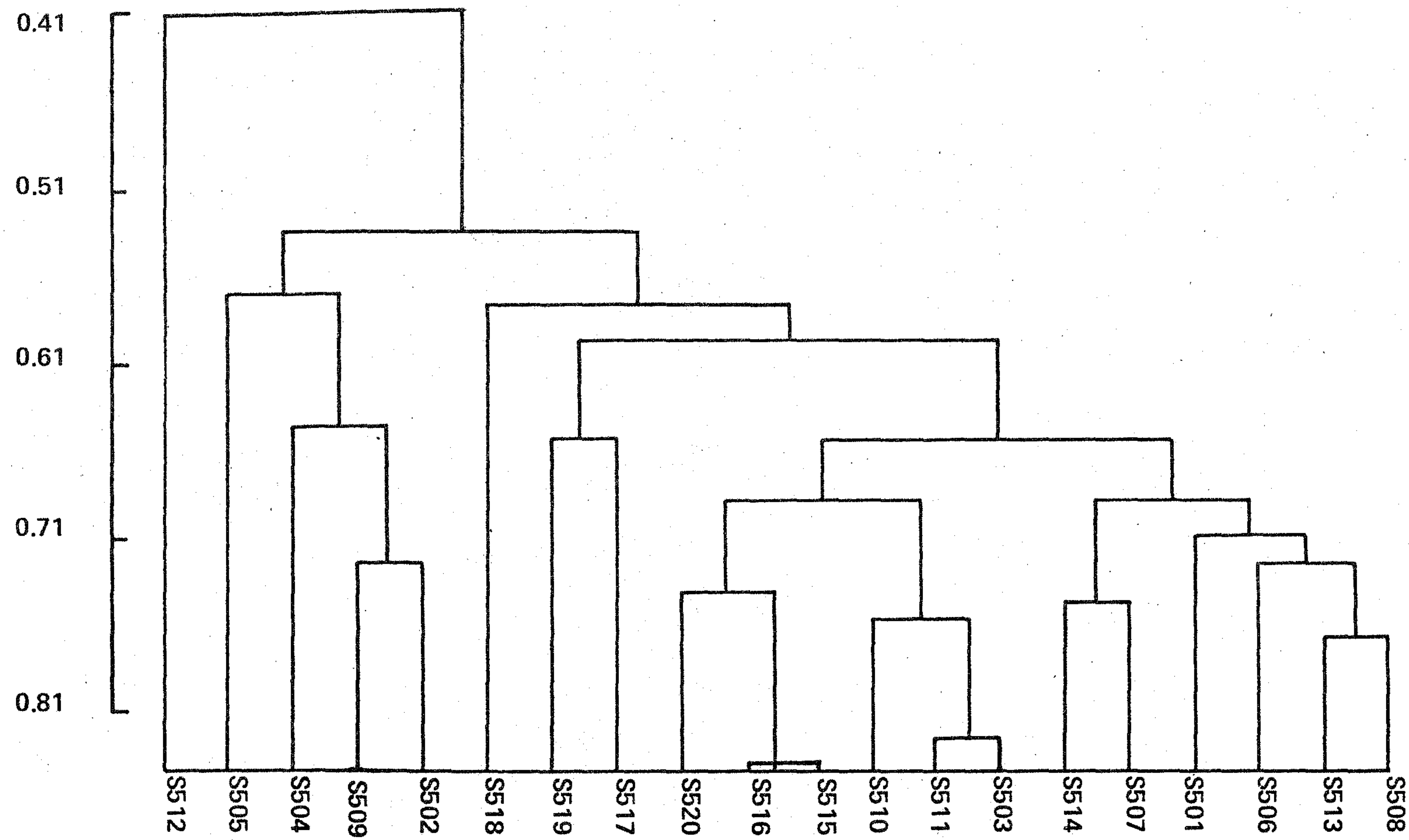


Figure VII-21

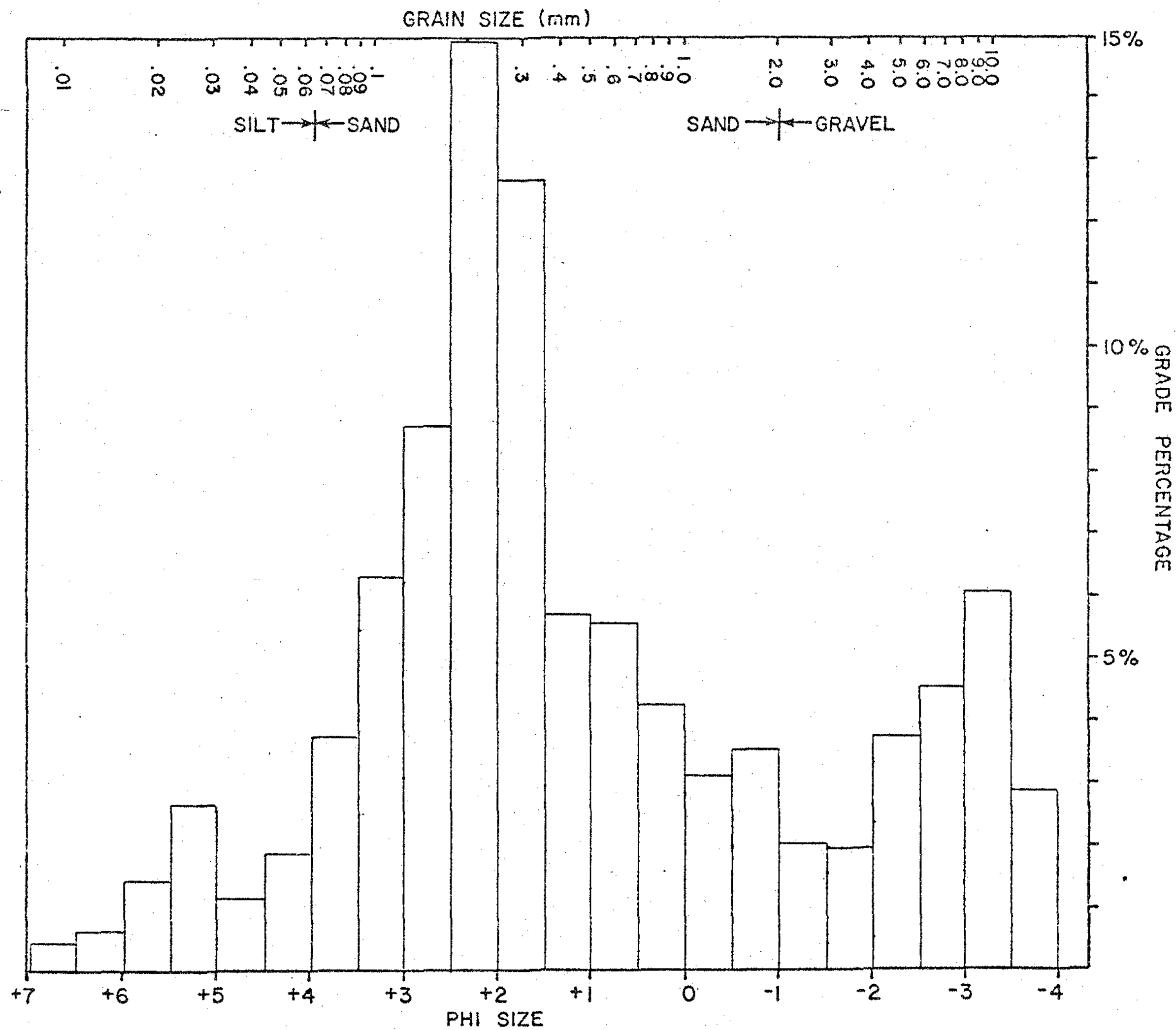


Figure VII-22

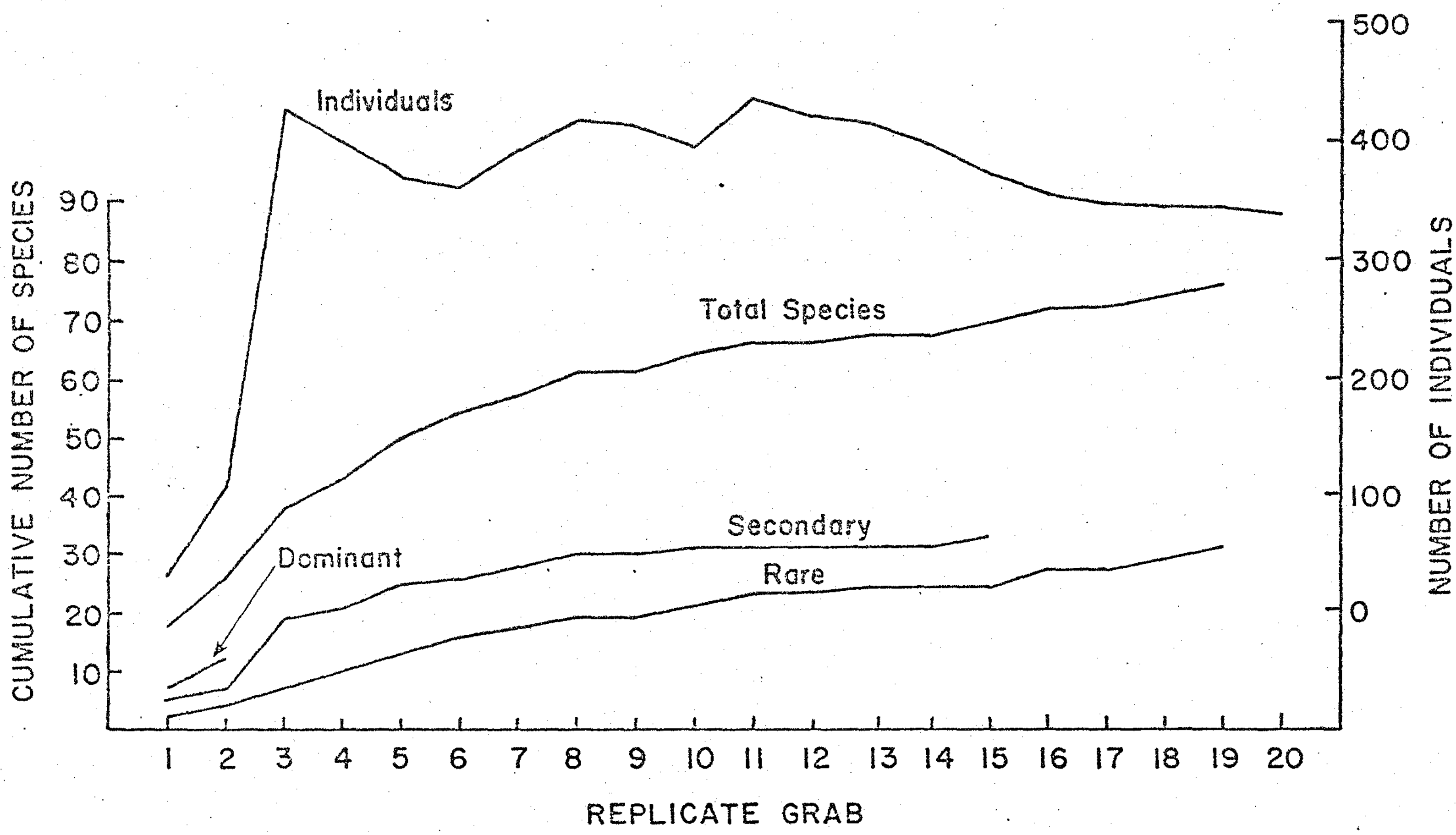


Figure VII-23

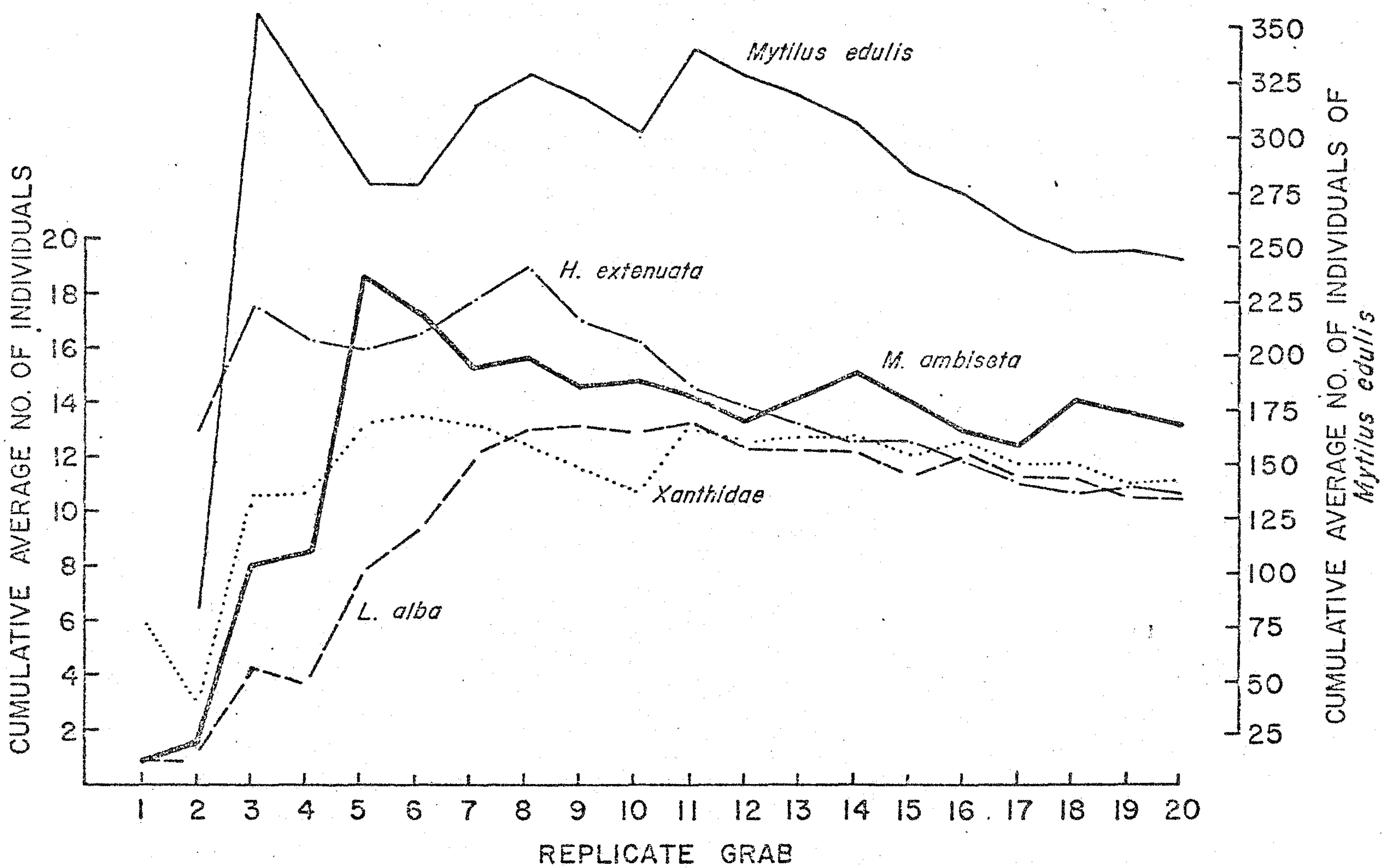


Figure VII-24

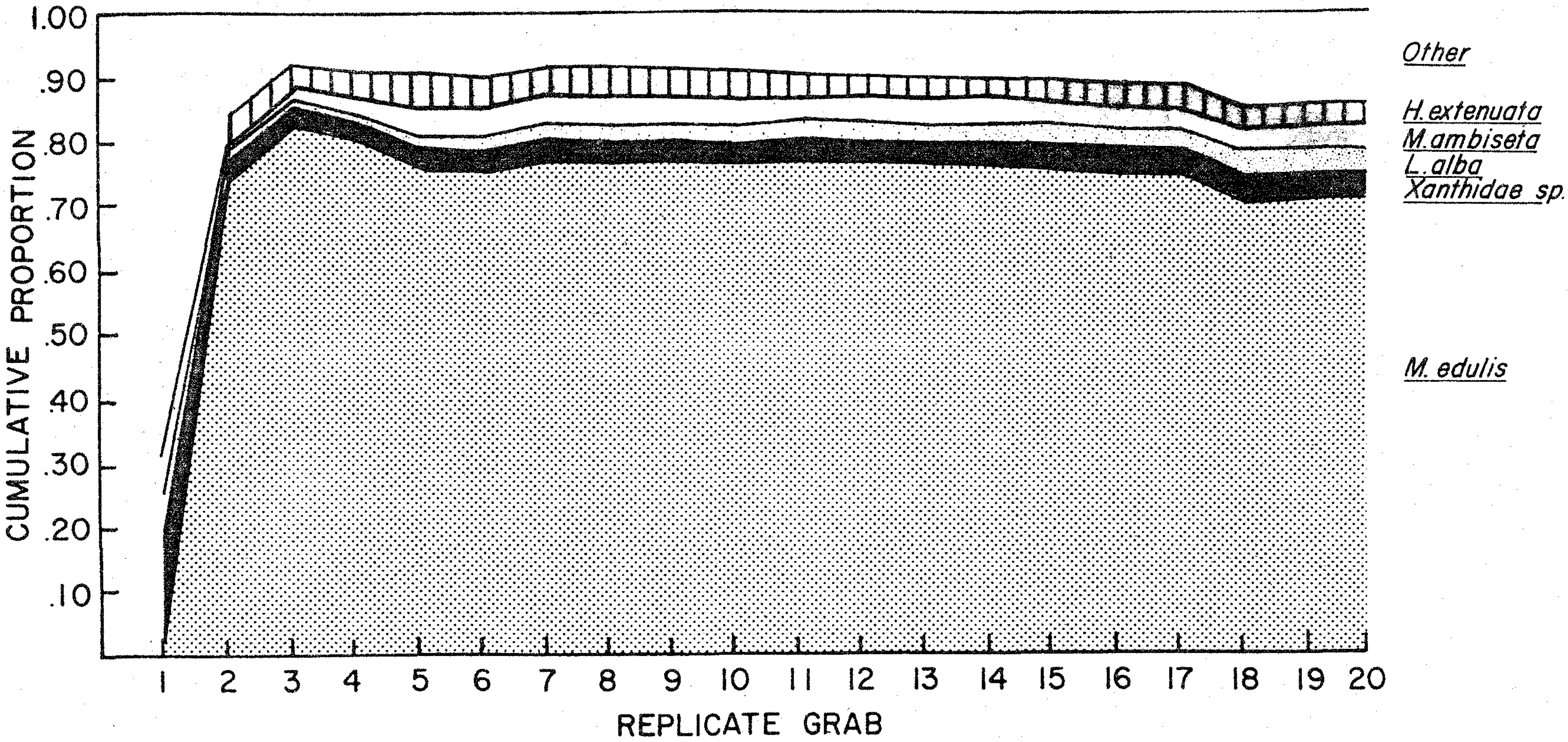


Figure VII-25

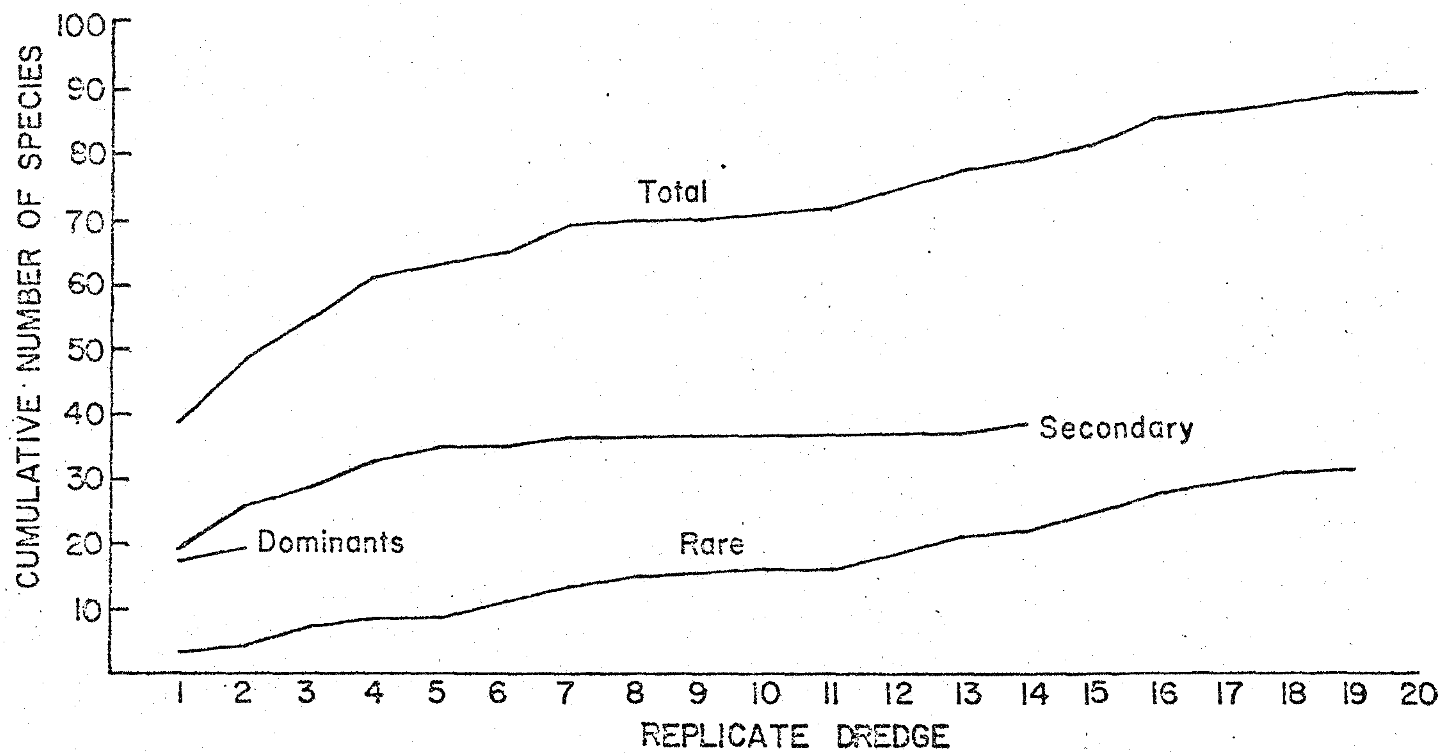


Figure VII-26

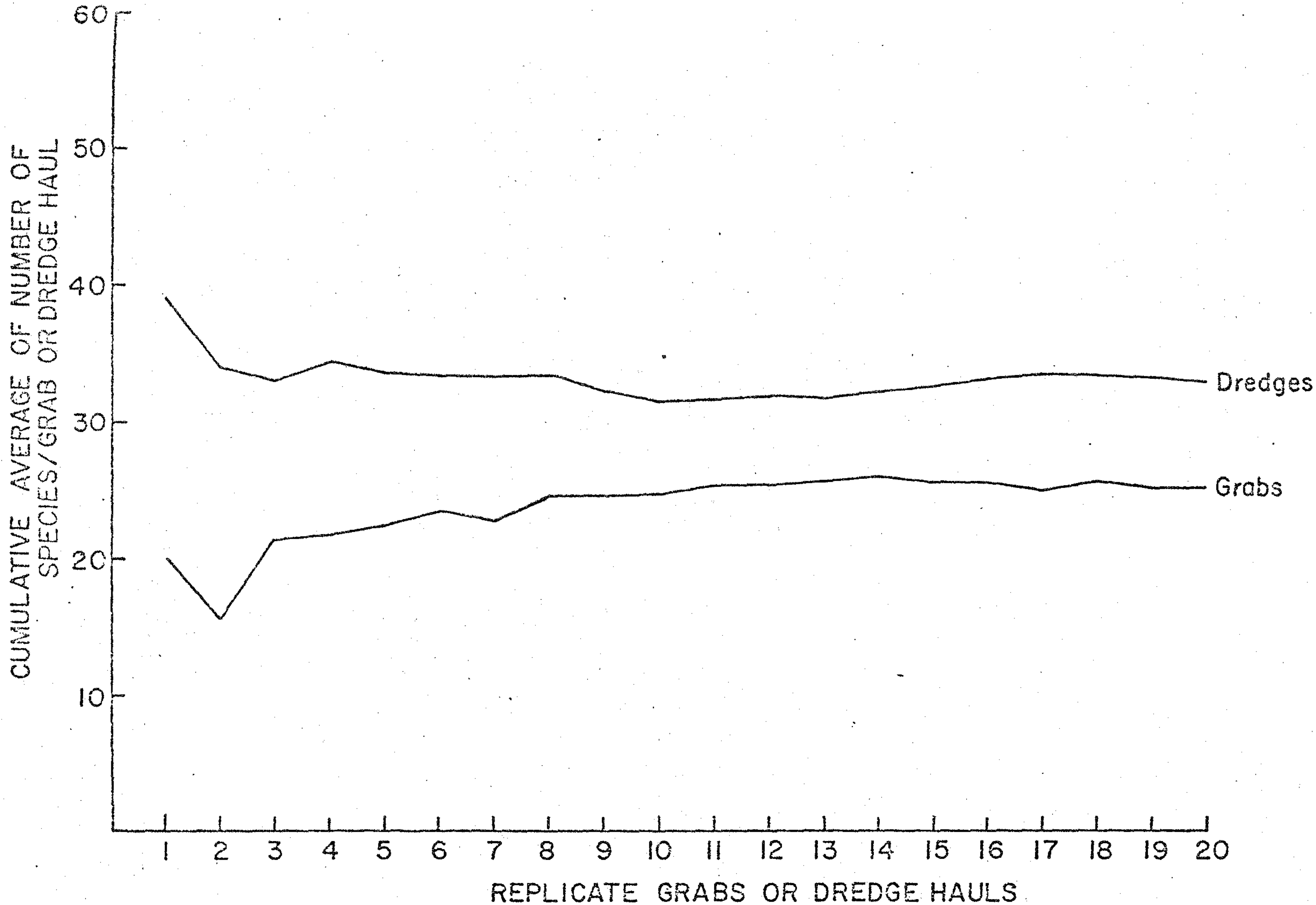


Figure VII-27

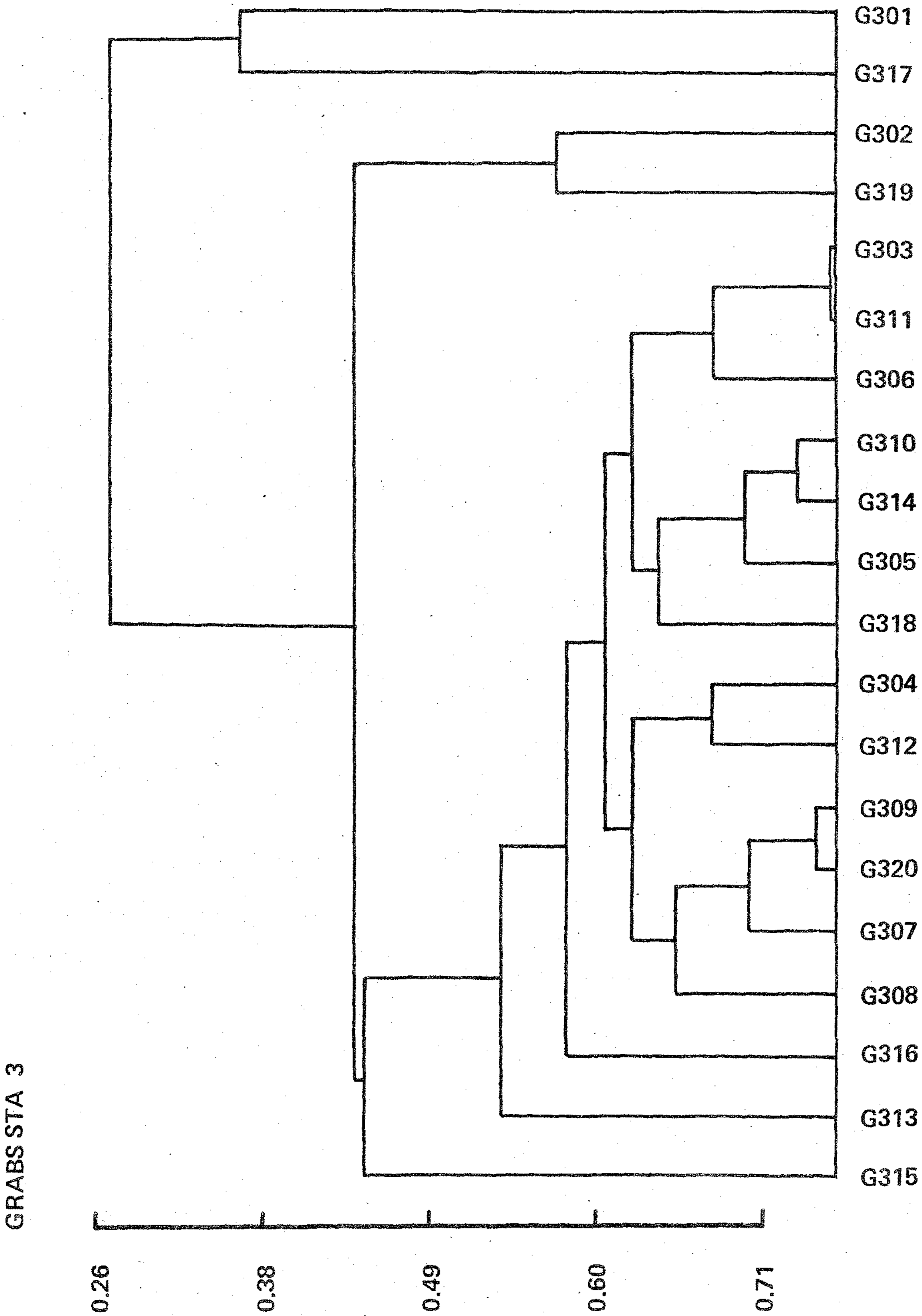


Figure VII-28

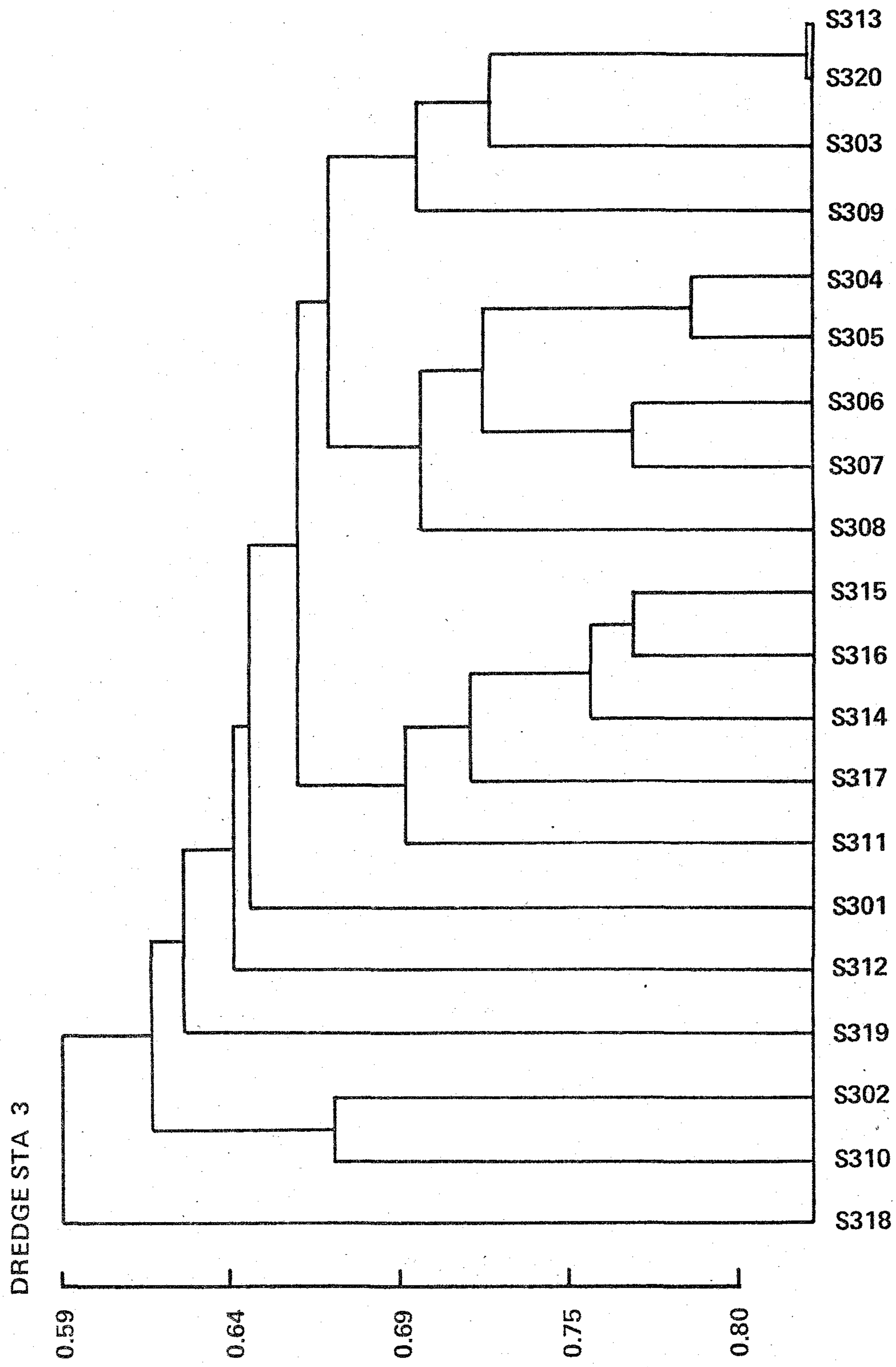


Figure VII-29

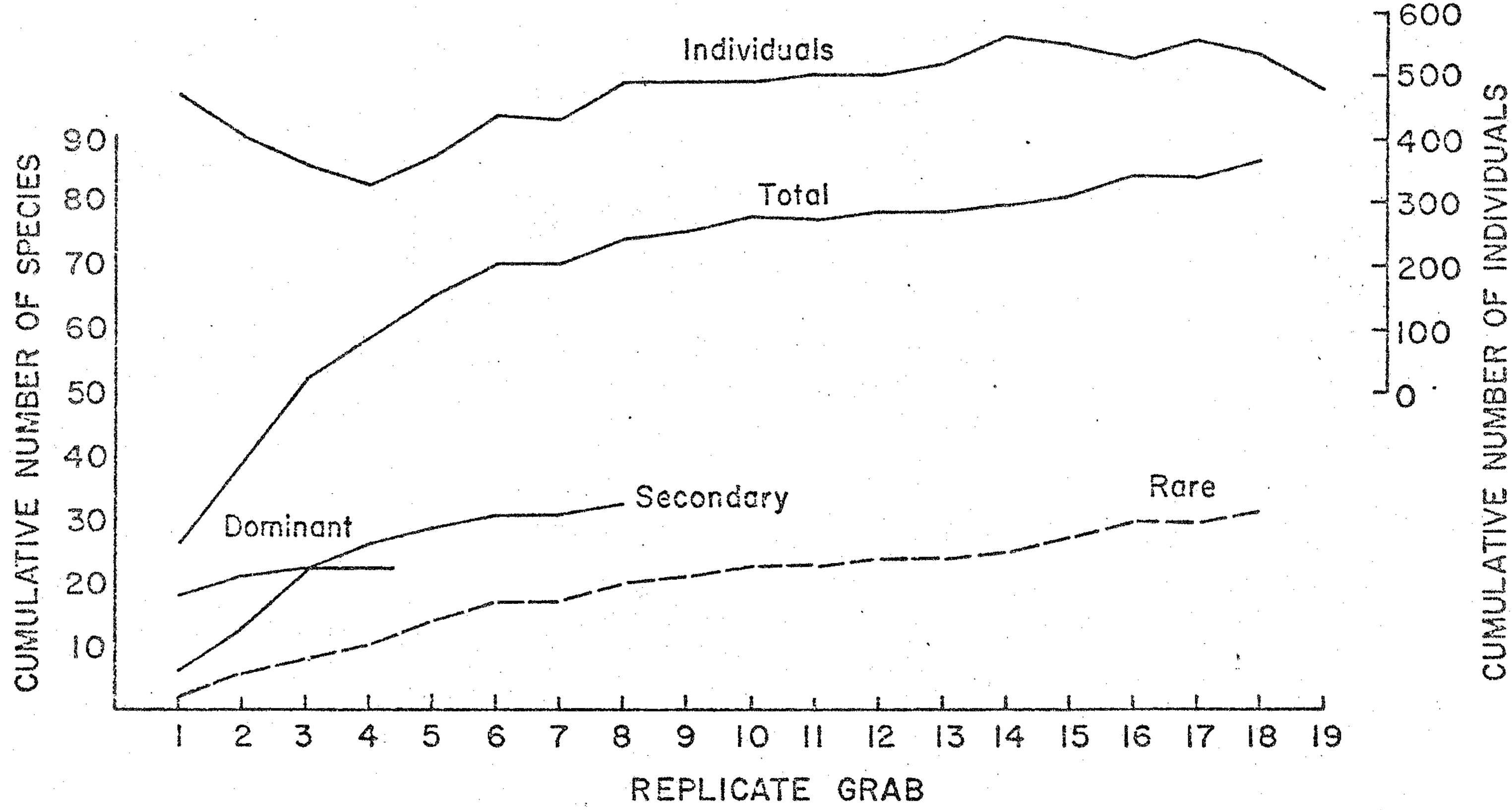


Figure VII-30

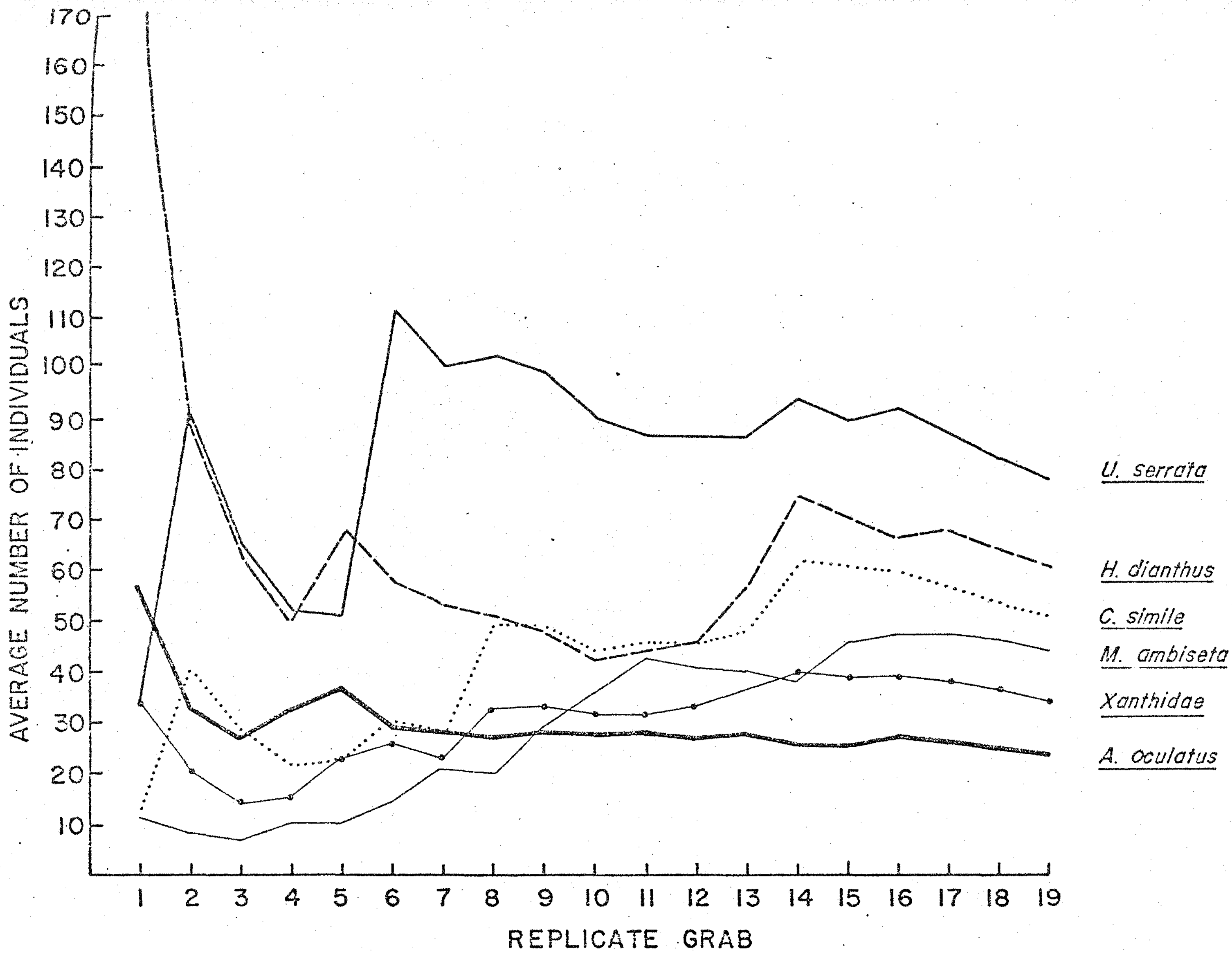


Figure VII-31

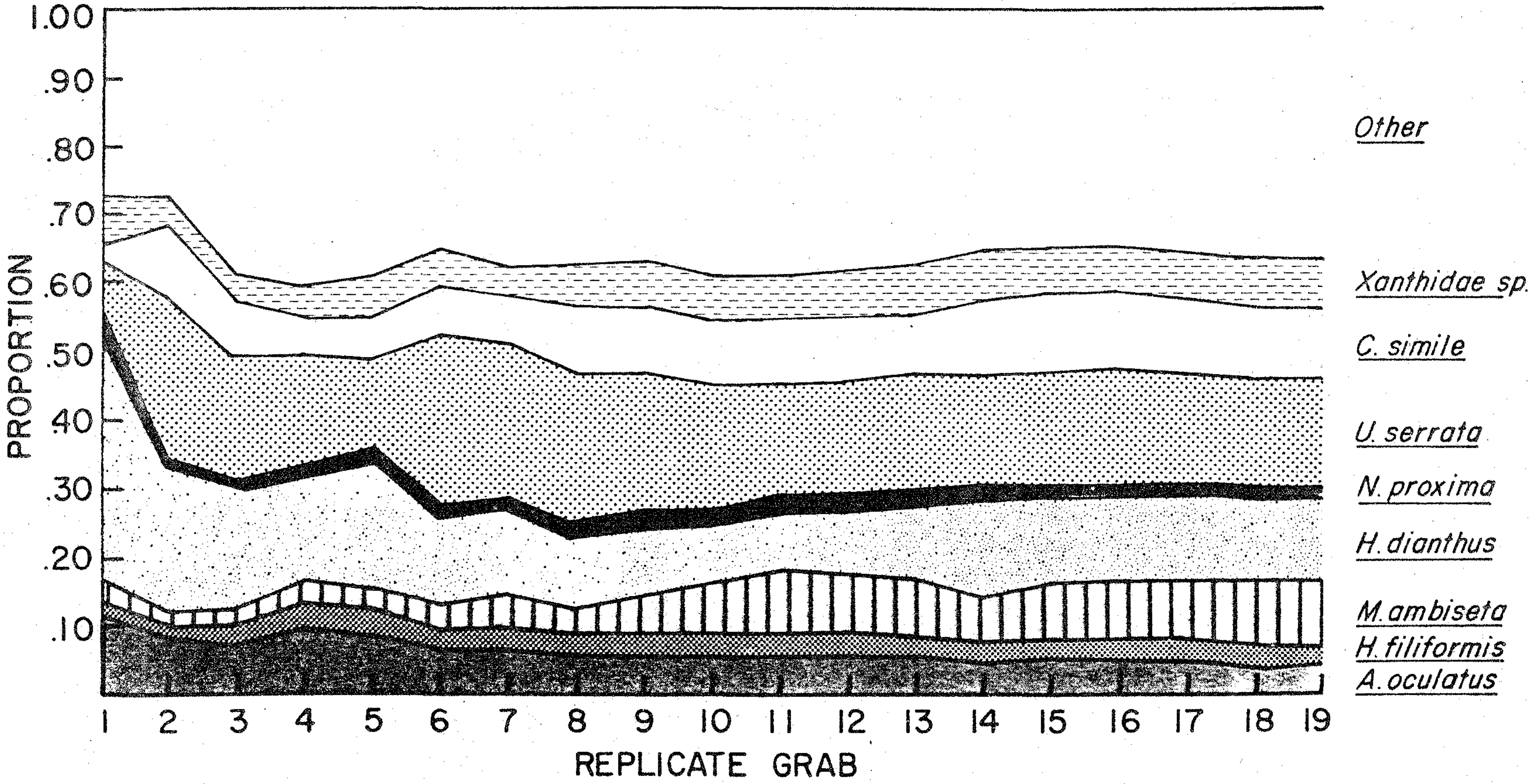


Figure VII-32

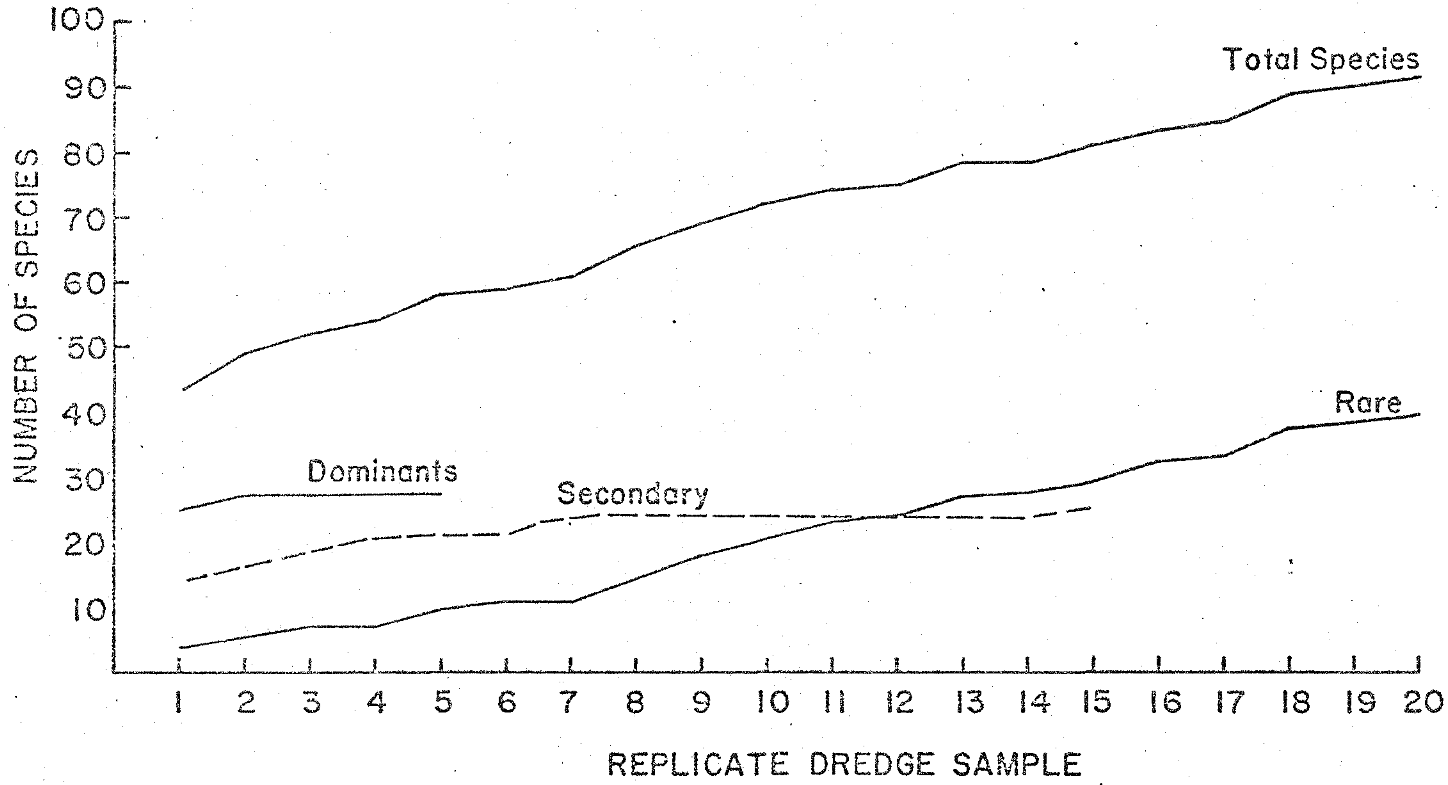


Figure VII-33

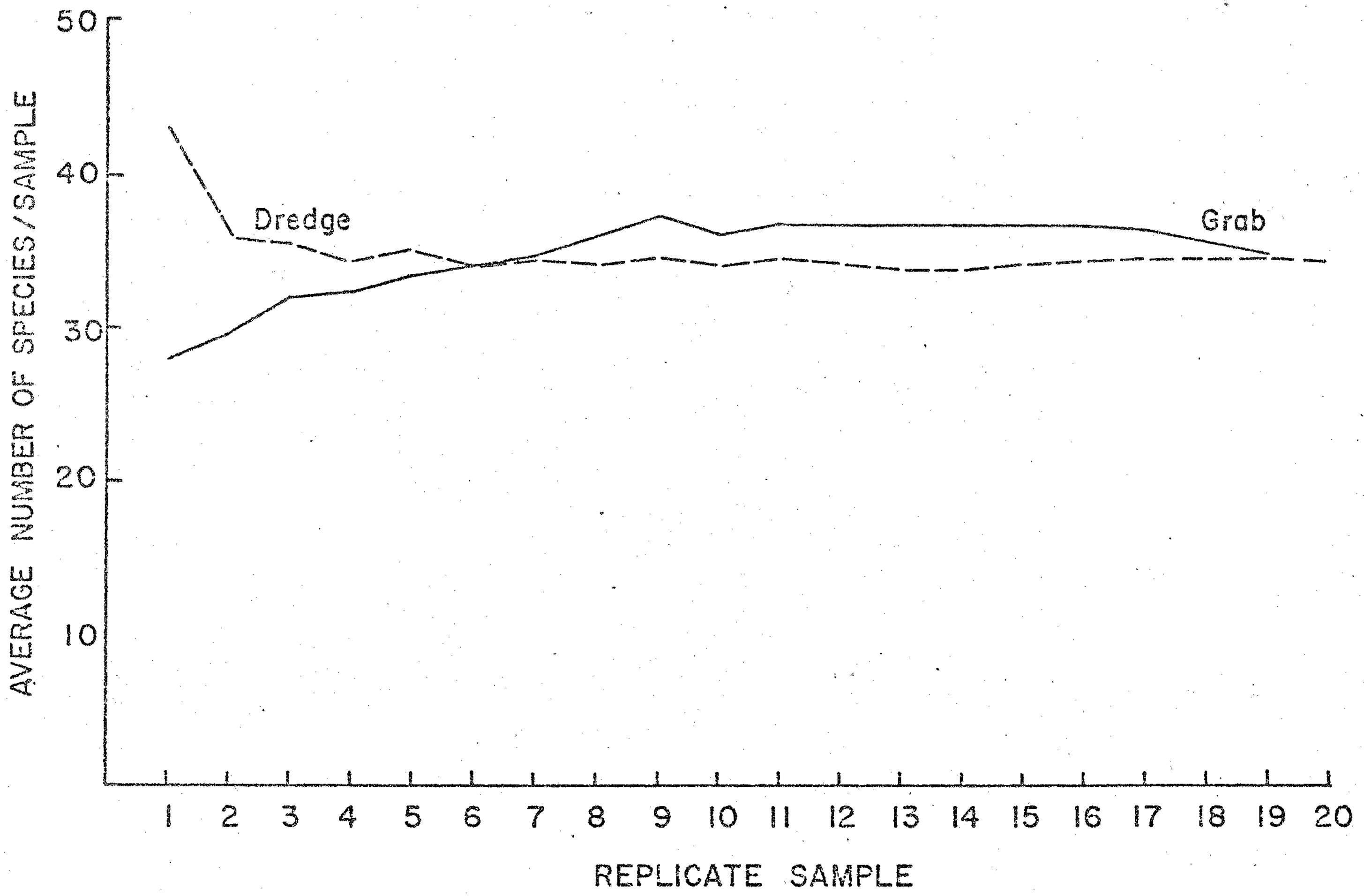


Figure VII-34

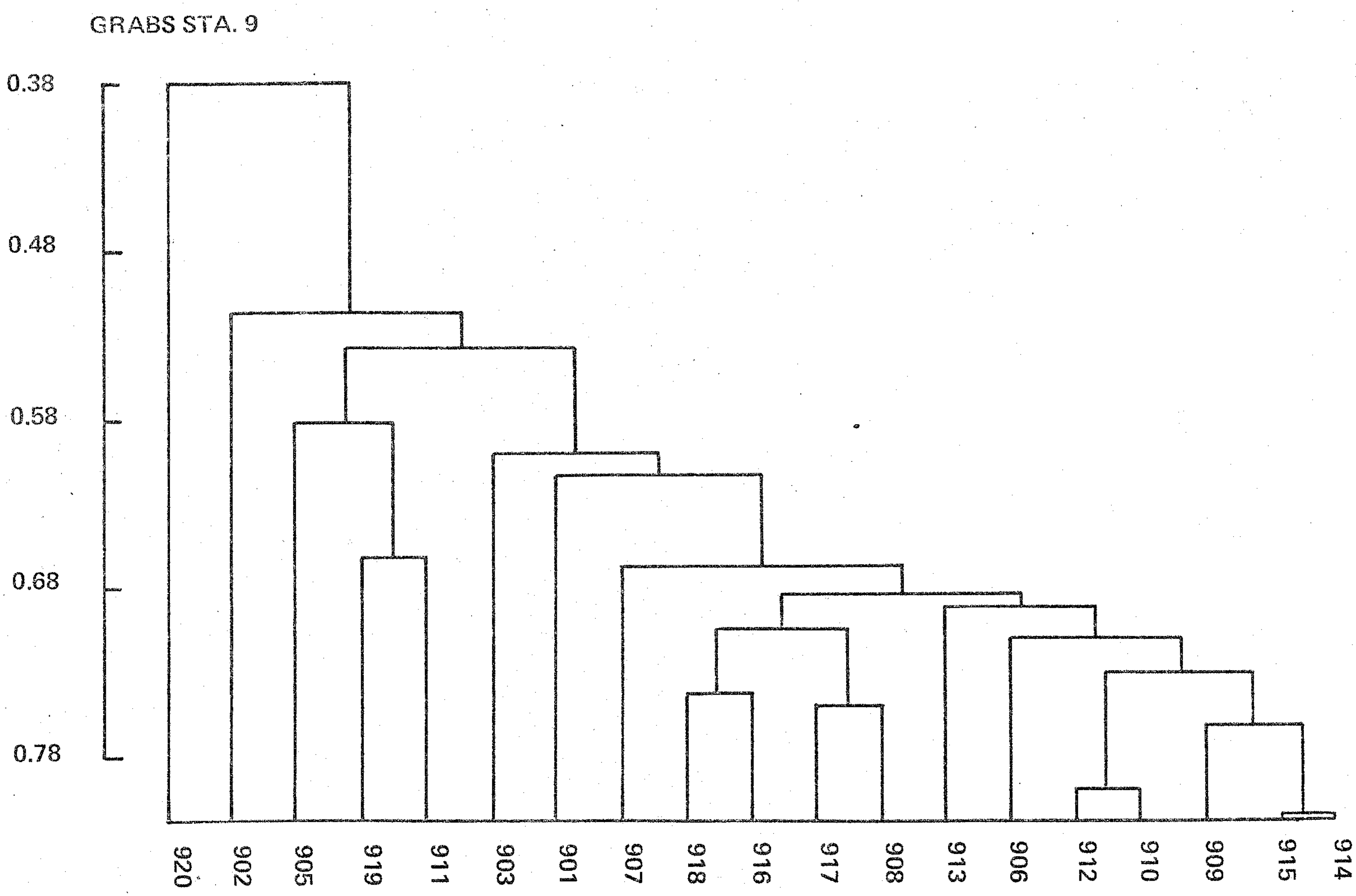


Figure VII-35

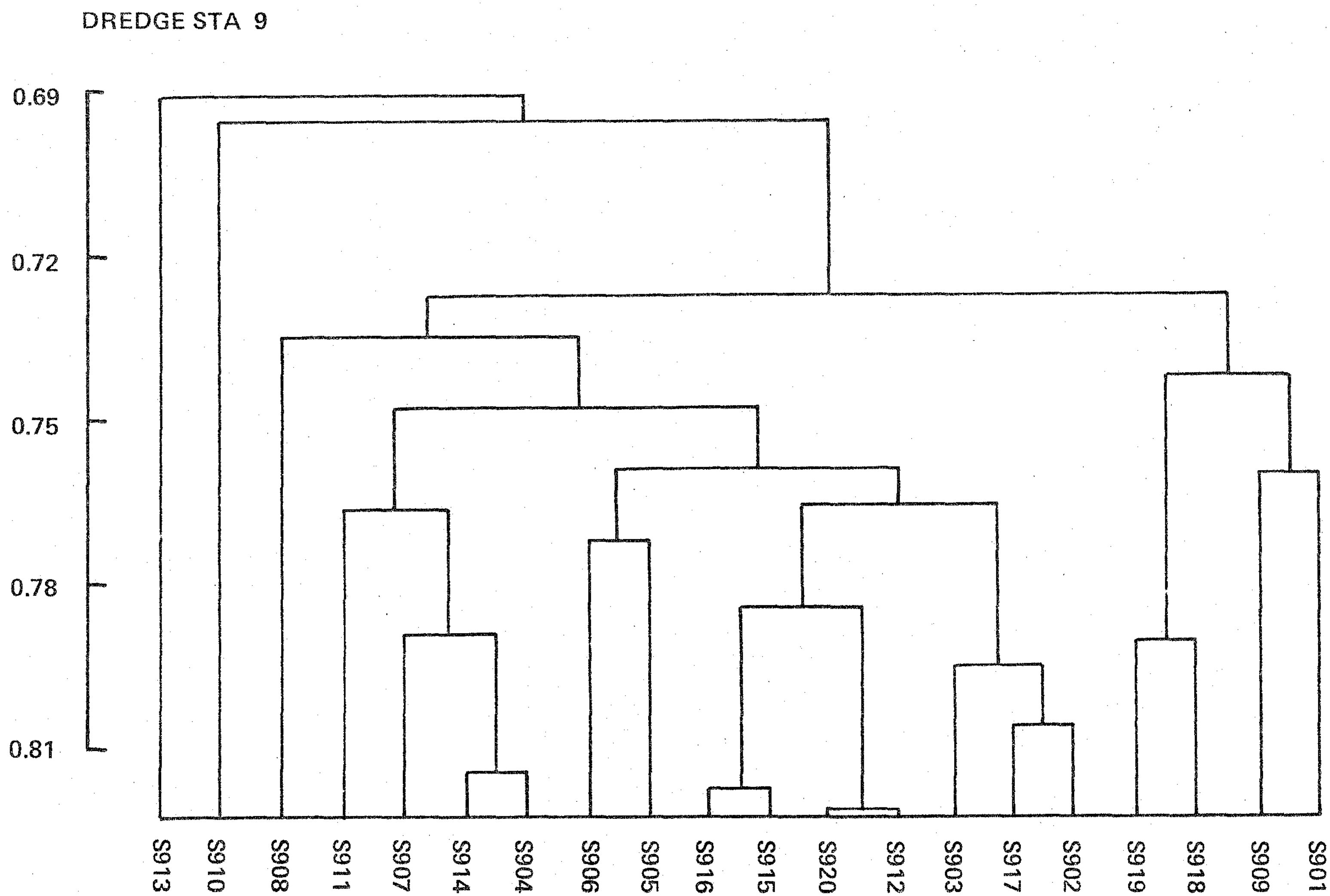


Figure VII-36

APPENDIX I

HIERARCHIAL CLUSTER ANALYSIS PROGRAM

This is a hierarchial classification program designed initially for use in numerical taxonomy or ecological assemblage analysis. The body of the program was obtained from Dr. Don Boesch of the Virginia Institute of Marine Science. It was adapted for use on the Burroughs system and then further modified for our specific needs by Ms. Liz Gontarz, Mr. John Gorton, and Mr. Henry Lind. A summary of the concepts employed in this program can be found in Williams, 1971 (Ann. Rev. Ecol. Systematics 2: 303-326).

The input to the program consists of a series of station (sample, OTU, etc.) names, each followed by a listing of species (attributes, character states) codes and their respective quantities. The program generates a dendrogram of similar stations or species following the operational sequence outlined below:

1. The controlling data for the operations that follow are first read. These data are as follows:

a. On the first card:

Columns	Code	Format	Operation
1- 5	MRGLM	I5	This is the number of samples (stations) to be considered as one group. This program is set up for MRGLM = 1 (Note: This value must be right justified).
6-10	ICEN	I5	This specifies the clustering strategy to be used. See later note for values. (This value must be right justified).
11-15	JPAR	I5	This specifies the similarity coefficient to be used. See later note for values. (This value must be right justified).
16-20	LTFORM	I5	This determines whether the data are to be log-transformed before being used in the similarity analyses. If 0, abundances are untransformed; if 1, abundances transformed by natural logarithms. Values must be right justified.
21-25	IFLIP	I5	This specifies the arrangement of the matrix. If 0, rows are species and columns are stations and clustering is by stations. If 1, the matrix is turned 90 degrees and clustering is by species. This value must be right justified.

Columns	Code	Format	Operation
26-30	IDROP	I5	This specifies the cut-off level, below which a species will not be allowed to contribute to the formation of clusters. The cut-off level is equivalent to the percent occurrence of a species. If no value is specified, a default value of 10% is used. In this case, any species occurring at 10% or less of the stations is removed from the matrix before the initial similarity matrix is constructed. This value must be right justified.
31-40	BETA	F10.5	This value is a variable to be specified only when flexible clustering is to be used. Its significance will be outlined below.
41-70	ALPHA	5A6	This is an alphanumeric label of the user's choosing which will be printed out as typed.

b. On the second card:

Columns	Format	Use
1- 4	F4.0	X-dimension of plot in inches.
5- 8	F4.0	Y-dimension of plot in inches.
11-46	7A5	Title for Y-axis of plot.

Columns	Format	Use
78	I1	Leave 0 or blank if plot is desired; enter 1 to suppress the plot.
79-80	I2	Leave blank to use Cal-Comp plotter (Column 78 must also be 0 or blank) or to suppress plotter if Column 78 is a 1; enter 09 to get a Tektronix plot.

2. Special Notes on Controlling Data:

a: If JPAR is given a negative value, all data and similarity matrices will be printed.

b: If IDROP is given a negative value, only the original data matrix will be printed. If a negative IDROP is used, JPAR must also be negative.

c: If IFLIP is given a value of 1, the data matrix will not be printed, but the similarity matrix is still printed.

3. Subroutine SIMARR is called. This subroutine reads the data and computes the similarity matrix on which all further operations are based.

a. The data are arranged on the cards as follows:

Columns 1- 5: Station name, A format, right justified;
6-10: blank;
11-15: species code, integer formed, right justified;
16-20: species abundance, integer format, right justified.

The remaining species codes and their abundances, using alternate sets of five columns each, are then listed across the card. If further cards are needed, the first ten columns are left blank and the rest of the card is as already indicated.

b. The data are read and arranged into matrix form according to the value of IFLIP.

c. The percent occurrence of each species over all stations is computed.

d. Those species whose percent occurrence is less than or equal to the value of IDROP are then removed from the matrix and the matrix is adjusted accordingly. The species dropped and their percent occurrence are printed for future reference.

e. The similarity matrix is then computed using the revised data matrix and the similarity coefficient specified by JPAR.

4. Subroutine SEARCH is then called. This subroutine examines the similarity matrix for maximum or minimum values, depending on the attributes of the similarity coefficient used. Only one pair of stations (or species) can be fused at one time.

5. The program now sets up a series of arrays which contain lists of the station (or species) names which have been clustered and the levels at which these clusters occurred. This is used as input to the plotting subroutine SYMDEN.

6. Subroutine REORD is called. This subroutine combines the units clustered into one individual (also referred to as a group) and creates a set of new properties for that individual (group). The basis of this operation is the clustering strategy specified by ICEN.

The algorithm used in this program uses the formula for linear combinatorial strategies developed by Lance and Williams (1967, Computer Journal 9: 373-380). This formula has three variables, α, B, and Y, which are specified for all clustering strategies except that called "flexible." For this last strategy, a value of B must be specified, and is usually given as -0.25 (B must be between 1.0 and -1.0).

7. If there are more than two station (species) groups left to be clustered, subroutine SEARCH is called. This loop from SEARCH to REORD to SEARCH is used until two station (species) groups remain. The program then joins these last two groups and prints their level of similarity along with the statement "ALL ONE GROUP."

8. Subroutine SYMDEN is then called. This subroutine, obtained from Dr. F. James Rohlf (State University of New York, Stony Brook), contains the instructions needed to plot the dendrogram.

9. Similarity coefficients. This program contains nine similarity coefficients, any one of which can be used in the classification routines by specifying the appropriate JPAR value. These values, their respective coefficients, and a reference source for each are given below.

JPAR	Coefficient	Source
1	Standard Distance	Orloci, L., 1967. J. Ecol. 55: 193-206.
2	Product-Moment Correlation	Any standard statistics text.
3	Fager	Fager, E.W., & J.A. McGowan, 1963. Science 140: 453-460.
4	Jaccard	Orloci, L., 1972. Amer. Midl. Nat. 88: 28-55.
5	Sorenson	Looman, J., and J.B. Campbell, 1960. Ecology 41: 409-416.
6	Webb	Unknown.

JPAR	Coefficient	Source
7	Kendall	Looman, J., & J.B. Campbell, 1960. Ecology 41: 409-416.
8	Czekanowski	Williams, W.T., J.M. Lambert, and G.N. Lance, 1966. J. Ecol. 54: 427-445.
9	Canberra Metric	Stephenson, W., W.T. Williams, and S.D. Cook, 1972. Ecological Monogr. 42: 387-415.

10. Sorting Strategies. This program, as indicated previously, has the capability of joining groups by using any one of five sorting strategies, stipulated by the appropriate ICEN value. For a discussion of the properties of these strategies, the following should be consulted: Williams, W.T., 1971, Ann. Rev. Ecol. Systematics 2: 303-326; Stephenson, W., et al., 1972, Ecol. Monogr. 42: 387-415; Sneath, P.H.A., and R.R. Sokal, 1973, Numerical Taxonomy, W.H. Freeman & Co. The ICEN values and their respective sorting strategies, are as follows:

ICEN	Strategy
0 or blank	Unweighted pair grouping (group average).
1	Weighted pair grouping (centroid).
2	Nearest neighbor (single linkage).
3	Furthest neighbor (complete linkage).
4	Median grouping.
5	Flexible (B must be specified).

11. Deck Set-up. To run this program through the Burroughs system at the University of Delaware Computing Center, the following card set-up is needed:

Work-Flow Language Cards (See computer consultants).

Data Deck

Control Card for Data (See paragraph 1).

Control Card for Plotting Routine (See paragraph 1).

Data Cards (See paragraph 3).

End Job Card.

```
$RESET FREE
$SET AUTOBIND
FILE  8=FILE8,UNIT=REMOTE
FILE  1(TITLE=SCRATCH,MAXRECSIZE=3,BLOCKSIZE=300,AREASIZE=100,
    1 FLEXIBLE=TRUE,KIND=DISKPACK)
C
      DIMENSION COXXXX(9,5),CENXXX(6,6),Y(45),X(36),
     1          SCRAT1(150),SCRAT2(150)
      COMMON IDENT,ICARD,LAT,LON,IDATE,ITIME,ITEMP,ISALN,IDPTH,NTAXA,
     1        MAGNI,METHD,LINEC,LINLM,IPRT,ICRD,INVST,NN,NSP,JX,
     2        ANIND,AX(9),
     3        NMTAX(200,2),INPUT(80),IUSER(30),
     4        HEADR(30,3),IHD,OUTPU(20),IOUT
      COMMON/DAT/STATN(150),TAXNM(100),NIND(150),RA(100,150)
      COMMON/ICLU/M(150),KOUN,ICEN
      COMMON/SIM/R(150,150)
      REAL LEVEL(152),LEV(150),LAB(150)
        REAL MIN,MAX
      DIMENSION IXX(100)
      DIMENSION ALPH(5)
      DIMENSION DIS(11175),A(150),B(150),LIST(150),D(150)
      REAL IPR(150),LIPR,L2PR
      DIMENSION MAXER(3)
       DIMENSION LISTS(150,150),CNT(150),LACT(150)
      EQUIVALENCE (HEADR(1,1),ALPH(1))
      DATA MAXER/'0.0','0.33','1.0'/
      DATA IDEOF/'9999'/
      DATAY/
     1'ORLOCCI''S STANDARD DISTANCE  ',
     2'PRODUCT MOMENT CORRELATION    ',
     3'FAGER''S                      ',
     4'JACCARD''S                    ',
     5'SORENSEN''S                   ',
     6'WEBB''S                       ',
     7'KENDALL''S                    ',
     8'CZEKANOWSKI''S                ',
     9'CANBERRA METRIC               '/
      K=0
      NFOUND=0
      DO 198 I=1,9
      DO 198 J=1,5
      K=K+1
      COXXXX(I,J)=Y(K)
 198  CONTINUE
      DATA X/
     1'UNWEIGHTED PAIR GROUP(GROUP AVE)     ',
     2'WEIGHTED PAIR(CENTROID) GROUPING     ',
     3'NEAREST NEIGHBOR GROUPING            ',
     4'FURTHEST NEIGHBOR GROUPING           ',
     5'MEDIAN GROUPING                      ',
     6'FLEXIBLE(USING BETA)                 '/
      L=0
      DO 199 I=1,6
      DO 199 J=1,6
      L=L+1
      CENXXX(I,J)=X(L)
```

```
  199 CONTINUE
  989 LINLM=45
      READ(5,1,END=990) MRGLM,ICEN,JPAR,LTFORM,IFLIP,IDROP,BETA,ALPH
      READ(5,3333)XDIM,YDIM,IXX(1),IXX(2),IXX(3),IXX(4),IXX(5),IXX(6)
 3333 FORMAT(F4.1,F4.1,2X,6A6)
    1 FORMAT(6I5,F10.5,5A6)
      DO 172 I=1,50
  172 LACT(I)=2
      IF(IDROP.EQ.0) IDROP=10
      IF(MRGLM .GT. 200)GO TO 990
      IPAR=IABS(JPAR)
      NCOEF=1
      IF(IPAR .EQ. 1)NCOEF=0
      ICARD=150
C
C     CALL SUBROUTINE TO PRINT AND COMPUTE DATA MATRICES  AND SIMILARITY
      CALL SIMARR(JPAR,LTFORM,R,IFLIP,IDROP)
      DO 700 JW=1,NSTA
      DO 703 JX=JW+1,NSTA
      CT=CT+1
      DIS(CT)=R(JW,JX)
  703 CONTINUE
      NP=(NSTA*(NSTA-1))/2
C SUBROUTINE CALL MIST AND DEBUG WRITE REMOVED FROM HERE 4/30
  700 CONTINUE
      IF(IDROP.LT.0) GO TO 990
      NST=NN
  203 FORMAT(1H1)
      DO 201 IKE=1,10
  201 WRITE(6,202)
  202 FORMAT(1H0)
      IF(IFLIP.NE.0) GO TO 950
      WRITE(6,70)ALPH,NST,NSP
   70 FORMAT(23X,'CLUSTERING RESULTS USING LINKAGE METHOD'/ 29X,'(SOKAL
     1 AND SNEATH 1963)'//25X,5A6/28X,I4,' SAMPLES ',2X,I4,' SPECIES'/)
      GO TO 1399
C
C     PRINT OUTPUT HEADINGS
 950  WRITE(6,71) ALPH
 71   FORMAT(23X,' CLUSTERING RESULTS FLIPPED', 10X,5A6)
 1399  CONTINUE
      II=3
      IF (IPAR .EQ. 6) II=2
      IF (NCOEF .EQ. 0)II=1
  300 WRITE(6,302)MAXER(II)
      IF (MAXER(II).EQ.'0.0') TTMAX=0.0
      IF (MAXER(II).EQ.'0.33') TTMAX=0.33
      IF (MAXER(II) .EQ. '1.0') TTMAX=1.0
  302 FORMAT(25X, 'MAX VALUE OF SIMILARITY COEFF =',A4)
  305 WRITE(6,307)(CENXXX(ICEN+1,J),J=1,6)
  307 FORMAT(25X,'CLUSTERING STRATEGY IS ',6A6)
  220 WRITE(6,310)(COXXXX(IPAR,J),J=1,5)
  310 FORMAT(25X,'SIMILARITY COEFFICENT IS ',5A6)
  200 CONTINUE
      WRITE(6,100)
  100 FORMAT(1H1,15X,'NO. GRPS',24X, 'CLUSTERS'/ 33X, 'LEVEL',6X,'GROUPS
     1', 16X,'SAMPLES INCLUDED'/)
      DO 50 I=1,NST
```

```
   50 M(I)=I
C
C     CALL SUBROUTINE TO SEARCH SIMILARITY MATRIX FOR MAXIMUM OR MINIMUM
C     (CALLED TOP).  FIND ROW AND COLUMN OF SIMILARITY M VALUE(=I,J)
C     IN THIS  VERSION, USE ONLY ONE PAIR  AT A TIME, IGNORING TIES.
   26 CALL SEARCH(NN,NCOEF,TOP,I,J)
C
C     NOW HAVE FOUND ROW AND COLUMN WITH MAXIMUM SIMILARITY VALUES, NOW
C     CLUSTER FROM I AND J.
   31 DO 52 IZ=1,150
   52 IPR(IZ)=0
      KOUN=1
      KNGR=NN-1
   21 DO 170 LL=1,NST
      IF(M(LL) .EQ. I)GO TO 151
  170 CONTINUE
      SAVEI=I
      I=LL
      LIPR=IDEOF
      GO TO 152
  151 LIPR=STATN(LL)
      SAVEI=I
      I=LL
  152 DO 153 LL=1,NST
      IF (M(LL) .EQ. J)GO TO 154
  153 CONTINUE
      SAVEJ=J
      J=LL
      L2PR=IDEOF
      GO TO 55
  154 L2PR=STATN(LL)
      SAVEJ=J
      J=LL
C    THIS CODE CREATES 2 ARRAYS(LAB,LEVEL)
C    WHICH ARE TO BE FED INTO THE DENDOGRAM
C    PLOTTING ROUTINE,SMYDEN. LAB IS AN ARRAY
C    OF STATION NAMES ARRANGED IN THE ORDER
C    THAT THEY ARE TO BE PRINTED ALONG ONE AXIS
C    OF THE PLOT. LEVEL IS AN ARRAY OF LEVELS
C    AT WHICH EACH STATION JOINS THE REST.
      IF(NLISTS .EQ.0) GO TO 120
C    SEE WHETHER I IS IN A LIST ALREADY
      NACT1=0
C    FIND AN ACTIVE LIST THEN TEST
      DO 123 LIM=1,NLISTS
      NACT1=NACT1+1
  142 GO TO (140,141),LACT(NACT1)
  141 NACT1=NACT1+1
      GO TO 142
  140 LIMIT=CNT(NACT1)
      DO 123 LIM2=1,LIMIT
      IF (I.EQ.LISTS(NACT1,LIM2)) GO TO 124
  123 CONTINUE
C    NO MATCH ON I
      MI=2
      GO TO 126
C    MATCH ON I
  124 MI=1
```

```
  126 NACT2=0
C     SEE WHETHER J IS IN A LIST ALREADY
C     FIND AN ACTIVE LIST THEN TEST
      DO 127 LJM=1,NLISTS
      NACT2=NACT2+1
  145 GO TO (143,144),LACT(NACT2)
  144 NACT2=NACT2+1
      GO TO 145
  143 LIMIT=CNT(NACT2)
      DO 127 LJM2=1,LIMIT
      IF(J.EQ.LISTS(NACT2,LJM2)) GO TO 128
  127 CONTINUE
C     NO MATCH ON J
      MJ=2
      GO TO 1500
C     MATCH ON J
  128 MJ=1
C     RULES FOR CREATING LISTS
C     1. IF NEITHER HAVE MATCHES SET UP NEW LIST CONTAINING BOTH MEMBERS
C     2. ONE MATCHES - ADD NON-MATCHING ELEMENT TO LIST CONTAINING
C        MATCHING ELEMENT
C     3. BOTH MATCH - ADD CONTENTS OF LIST CONTAINING LARGER ELEMENT
C        TO END OF LIST CONTAINING SMALLER ELEMENT
 1500 IF (MI.EQ.2.AND.MJ.EQ.2) GO TO 129
      IF (MI.EQ.1.AND.MJ.EQ.2) GO TO 130
      IF (MI.EQ.2.AND.MJ.EQ.1) GO TO 133
      IF (MI.EQ.1.AND.MJ.EQ.1) GO TO 131
      GO TO 132
C        SET UP FIRST LIST
  120 LISTS(1,1)=I
      LISTS(1,2)=J
      LEV(I)=TOP
      LEV(J)=TOP
      NLISTS=1
      CNT(1)=2
      LACT(1)=1
      GO TO 150
C     FOLLOW RULE 1
C        FIND FIRST INACTIVE LIST
  129 CONTINUE
      NACT=1
  147 GO TO (148,146),LACT(NACT)
  148 NACT=NACT+1
      IF (NACT.GT.50) WRITE(6,175) MI,MJ,NLISTS,LACT,I,J
  175 FORMAT(' MI,MJ ',2I3,10X,'NO. ACTIVE LISTS ',I5//
     $ ' STATUS OF LISTS'/50I2//' I,J ',2I5/)
      GO TO 147
  146 NLISTS=NLISTS+1
      LISTS(NACT,1)= I
      LISTS(NACT,2)= J
      CNT(NACT)=2
      LEV( I)=TOP
      LEV( J)=TOP
      LACT(NACT)=1
      GO TO 150
C     FOLLOW  RULE 2
  130 CNT(NACT1)=CNT(NACT1)+1
      LISTS(NACT1,CNT(NACT1))= J
```

```
      LEV( J)=TOP
      GO TO 150
C     FOLLOW RULE 2
  133 CNT(NACT2)=CNT(NACT2)+1
      LISTS(NACT2,CNT(NACT2))= I
      LEV( I)=TOP
      GO TO 150
C     FOLLOW RULE 3
  131 CONTINUE
      MMMM=CNT(NACT1)+CNT(NACT2)
      IF(STATN( I).LT.STATN( J)) GO TO 134
      IX=NACT1
      IY=NACT2
      GO TO 158
  134 IX=NACT2
      IY=NACT1
  158 ISTRT=CNT(IX)+1
      LEV(LISTS(IY,1))=TOP
      LO=1
      DO 135 LOOP=ISTRT,MMMM
      LISTS(IX,LOOP)=LISTS(IY,LO)
      LISTS(IY,LO)=0
      LO=LO+1
  135 CONTINUE
      CNT(IY)=0
      CNT(IX)=MMMM
      NLISTS=NLISTS-1
      LACT(IY)=2
      GO TO 150
  132 WRITE(6,157)  I, J
  157 FORMAT(1X,'COMBO OF  I=',I3,' AND  J=',I3,' FELL THRU RULES FOR C
     $REATING LISTS')
      CALL EXIT
  150 CONTINUE
C
C     NOW MUST SET UP IDENTITIES OF NEW INDIVIDUALS(CLUSTERS)
C      COMPUTE NEW SIMILARITY INDEX
      I=SAVEI
      J=SAVEJ
   55 CALL REORD(NN,NSP,NST,BETA,I,J)
      DO 16 K=1,NST
      IF  (M(K)  .NE. I)GO TO 16
   22 IPR(KOUN)=STATN(K)
      KOUN=KOUN+1
   16 CONTINUE
      KOUN=KOUN-1
C
C      THE VARIOUS FORMAT STATEMENTS ARE INCLUDED FOR NUMERIC OR ALPHA
C      OUTPUT
      IF  (IFLIP .NE. 0) GO TO 960
      WRITE(6,18)KNGR,TOP,L1PR,L2PR,(IPR(L),L=1,KOUN)
   18 FORMAT(/15X,I5,10X,F8.4,1X,A6,' AND',A6,4X,10(A6,'.')/(57X,10(A6
     1,',')))
      GO TO 961
  960  WRITE(6,918) KNGR, TOP,L1PR,L2PR,(IPR(L),L=1,KOUN)
 918  FORMAT(/15X,I5,10X,F8.4,1X,I6,' AND ',I6,4X,10(I6,'.')/(57X,10(I6
     1,',')))
 961  IF(NN.GE.2) GO TO 26
```

```
   25 WRITE(6,27)TOP
   27 FORMAT(/19X,'1',10X,F8.4,19X,'ALL ONE GROUP')
      NACT=1
  165 GO TO (162,163),LACT(NACT)
  163 NACT=NACT+1
      GO TO 165
  162 CONTINUE
      NS=CNT(NACT)
      DO 167 I=1,NS
      JP=LISTS(NACT,I)
      LAB(I)=STATN(JP)
      LEVEL(I)=LEV(JP)
  167 CONTINUE
      GO TO 989
 1880 CONTINUE
      GO TO 989
  990 WRITE(6,28)
   28 FORMAT(4H1END)
      MIN=LEV(NST)
      MAX=LEV(1)
      CALL PLTSRT('HEAD',-9)
       WRITE(6,98)
   98 FORMAT(1X,'HAVE REACHED PLOTTING ROUTINE')
      CALL SYMDEN(NST,LAB,LEVEL,SCRAT1,SCRAT2,MIN,MAX,XDIM,YDIM,IXX
     *,TTMAX)
      CALL PLOT(0,0,-9)
      STOP
      END
      SUBROUTINE SIMARR(IPAR,JSELC,R,IFLIP,IDROP )
C
C   THIS  SUBROUTINE READS THE DATA AND PERFORMS HOUSEKEEPING ON IT,
C        AND PRINTS IN MATRIX FORMAT.  THEN IT CALCULATES SIMILATIRY INCIC
C        CZEKANOWSKI, FAGER, JACCARD, SORENSON, WEBB, KENDALL, AND ORLOCI'
C        STANDARD DISTANCE AND PRODUCT MOMENT CORRELTION.
C
      REAL KE,JA
      COMMON IDENT,ICARD,LAT,LON,IDATE,ITIME,ITEMP,ISALN,IDPTH,NTAXA
      COMMON MAGNI,METHD,LINEC,LINLM,IPRT,ICRD,INVST,NSTA,NSPEC,JX
      COMMON ANINO,AX(9)
      COMMON NMTAX(200,2),INPUT(80),IUSR(30)
      COMMON/DAT/STATN(150),TAXNM(100),NIND(150),ICNT(100,150)
      DIMENSION SM(9)
      DIMENSION LTME(100),STN(150,150),CHNG(150)
      DIMENSIONNNOC(150),IPOC(150)
      DIMENSION HDR(2)
      DIMENSION TAX(7),ABUND(7)
      DIMENSION R(ICARD,ICARD)
      DIMENSION RENUM(200)
      DIMENSION NUM(200),TAG(200),SHUFFL(200),CROSS(150,175)
      EQUIVALENCE(SM(1),SD),(SM(2),PM),(SM(3),FA),(SM(4),JA),(SM(5),SO),
     *               (SM(6),WE),(SM(7),KE),(SM(8),CZ),(SM(9),CM)
      DATA HDR/' UN','LOG'/
      DATA IOEOF/'9999'/,ISWT/0/
      DATA LIM/100/
      DATA DUM/' '/
      ISELC=IABS(JSELC)
      GO TO 20
      ENTRY SIMIL(JSELC)
```

```
      ISFLC=IABS(JSFLC)
      GO TO 10
      ENTRY DATARR
      ISFLC=-1
   10 IPAR=0
   20 CONTINUE
      JDROP=ABS(IDROP)
      DO 1500 I=1,150
      DO 1500 J=1,150
      STN(I,J)='        '
 1500 CONTINUE
      NSTA=1
      NSPEC=1
C
C     THE FOLLOWING ROUTINE READS THE DATA AND ARRANGES THE ORIGINAL  AF
C     THE NORMAL OR FLIPPED CONFIGURATION.
      READ(5,602) STA,(TAX(I),ABUND(I),I=1,7)
  602 FORMAT(C5,5X,14I5)
      STA=CONCAT(STA,DUM,47,47,8)
      STATN(1)=STA
       SHUFFL(1)=TAX(1)
      NIND(NSTA)=NIND(NSTA)+1
      ICNT (1,1) =ABUND(1)
      NUM(1)=ABUND(1)
      CROSS(1,1)=1
      WRITE(6,9037) STA
 9037 FORMAT(1X,'XXX',A6)
      M=2
 8006 DO 8000 J=M,7
      IF(ABUND(J).EQ.0) GO TO 8009
      NIND(NSTA)=NIND(NSTA)+1
      DO 8001 I=1,NSPEC
      IF (TAX(J).NE. SHUFFL(I)) GO TO 8001
      GO TO 8050
 8001 CONTINUE
      NSPEC=NSPEC+1
      SHUFFL(NSPEC)=TAX(J)
      WRITE(6,623)NSTA,I,ABUND(J)
  623 FORMAT(1X,3I5)
 8050 WRITE (1) NSTA,I,ABUND(J)
      CROSS(NSTA,I)=CROSS(NSTA,I)+1
 8000 CONTINUE
 8009 READ(5,602,END=8005) STA,(TAX(I),ABUND(I),I=1,7)
      STA=CONCAT(STA,DUM,47,47,8)
      M=1
      IF (STA.IS.'        ') GO TO 8006
      NSTA=NSTA+1
      STATN(NSTA)=STA
      WRITE(6,9037) STA
      GO TO 8006
C
C   TEST EACH SPECIES TO SEE THAT IT OCCURS IN MORE THAN IDROP % OF THE
C
 8005 NRSPEC=0
       WRITE(6,1930) IDROP
      DO 8016 I=1,NSPEC
      SUM=0.
      DO 9077 J=1,NSTA
```

```
      SUM=SUM+CROSS(J,I)
 9077 CONTINUE
      PERC=(SUM/NSTA)*100.
      IF (PERC.GT.IDROP) GO TO 8007
      TAG(I)=2
      WRITE(6,8003) SHUFFL(I),PERC
 8003 FORMAT(' SPECIES ',I5,' DROPPED',5X,F5.0,' PERCENT')
      GO TO 8016
C
C   STORES NAMES, COUNTS OF SPECIES NOT DROPPED
C
 8007 TAG(I)=1
      NRSPEC=NRSPEC+1
      TAXNM(NRSPEC)=SHUFFL(I)
      RENUM(I)=NRSPEC
 8016 CONTINUE
      NSPEC=NRSPEC
      REWIND 1
 8011 CONTINUE
      READ(1,END=300) NSTA,CRIT ,KOUNT
      I=RENUM(CRIT)
      GO TO (8010,8011),TAG(CRIT)
 8010 CONTINUE
      GO TO (8014,8015),IFLIP+1
C  IFLIP=0
 8014 ICNT(I,NSTA)=ICNT(I,NSTA)+KOUNT
      GO TO 8011
C  IFLIP=1
 8015 ICNT(NSTA,I)=ICNT(NSTA,I)+KOUNT
      GO TO 8011
C
C     THE FOLLOWING ROUTINE REORDERS THE SPECIES AND STAION LABES IN THE
C     OF  A FLIP COMMAND.
 300  IF(IFLIP.EQ.0) GO TO 1931
      DO 1950 J=1,NSPEC
      CHNG(J)=TAXNM(J)
 1950  CONTINUE
      DO 1953 JJ=1,NSTA
      TAXNM(JJ)=STATN(JJ)
 1953  CONTINUE
      DO 1952 J=1,NSPEC
      STATN(J)=CHNG(J)
 1952 CONTINUE
 1900 NS=NSPEC
      NT=NSTA
      NSTA=NS
      NSPEC=NT
        GO TO 1310
 1931  CONTINUE
C
C     THE FOLLOWING ROUTINE  PRINTS THEE DATA AS READ FROM THE CARDS AND
C     _ED IN A MATRIX FORM
      IF(IPAR.GT.0) GO TO 1310
      WRITE(6,1210)
      DO1206 K=1,NSPEC,10
      DO 1206 K=1,NSPEC,10
      M=K+9
      IF(M.GT.NSPEC) M=NSPEC
```

```
      WRITE(6,1216)(TAXNM(L),L=K,M)
 1216 FORMAT(/20X,10I10)
      DO 1205 I=1,NSTA
      WRITE(6,1203) STATN(I),(ICNT(J,I),J=K,M)
 1203 FORMAT(/5X,A6,9X,10I10)
 1205 CONTINUE
      WRITE(6,1210)
 1210 FORMAT(1H1)
 1206 CONTINUE
 1310  LL=0
 1930 FORMAT(//' CUTOFF LEVEL FOR OMISSION IS LESS THAN OR EQUAL TO ',
     1 I5,' PERCENT OCCURRANCE')
 1301 IF(IPAR.GT.0) GO TO 1300
      IF(IDROP.LT.0) GO TO 900
      IF(IFLIP.NE.0) GO TO 1300
      WRITE (6,1210)
      WRITE(6,1226)
 1226 FORMAT(' THE FOLLOWING SPECIES WERE FOUND AT THE STATIONS LISTED')
      DO 1227 N=1,NSPEC,10
      M=N+9
      IF(M.GT.NSPEC) M=NSPEC
       WRITE(6,1217) (TAXNM(L),L=N,M)
      WRITE(6,2218)(NNOC(L),L=N,M)
 2218 FORMAT(/' NO. OF OCCURRANCES ',10I10)
      WRITE(6,1899) (IPOC(L),L=N,M)
 1899 FORMAT(' PERCENT OCCURRANCE ',2X,10I10///)
 1217 FORMAT(20X,10I10)
      DO 1229 L=1,LL
      WRITE(6,1250) (STN(K,L),K=N,M)
 1250  FORMAT(/20X,10A10)
 1229 CONTINUE
      WRITE(6,1210)
 1227 CONTINUE
C
C     THE FOLLOWING ROUTINE SCANS THE REVISED MATRIX AND LISTS THE STATI
C     EACH SPECIES WHICH WAS FOUND AT IT.
      LL=0
      DO 1599 J=1,150
      DO 1599 L=1,150
      STN(J,L)=0
 1599  CONTINUE
      DO 1230 J=1,NSTA
      L=0
      DO 1235 K=1,NSPEC
      IF(ICNT(K,J).EQ.0) GO TO 1235
      L=L+1
      STN(J,L)=TAXNM(K)
      IF(L.GT.LL) LL=LL+1
 1235 CONTINUE
 1230 CONTINUE
      WRITE (6,1236)
 1236 FORMAT(' ',' THE FOLLOWING STATIONS CONTAINED THE SPECIES LISTED')
      DO 1237 J=1,NSTA,10
      M=J+9
      IF (M.GT.NSTA) M=NSTA
      WRITE(6,1251)(STATN(K),K=J,M)
 1251 FORMAT(/20X,10A10///)
      DO 1239 L=1,LL
```

```
      WRITE(6,1216) (STN(JJ,L),JJ=J,M)
 1239 CONTINUE
      WRITE(6,1210)
 1237 CONTINUE
 1300 IF(ISELC.LT.0) GO TO 900
      LINEC=LINLM
      S=NSPEC
      K=NSTA-1
      DO 700 I=1,K
      IF (IPAR .GT. 0)GO TO 375
      WRITE(6    ,351)
  351 FORMAT('0')
      LINEC=LINEC+2
      IF (K-1 .GT. 20)LINEC=LINLM
C
C     BELOW, COUNT CO-OCCURRING SPECIES BETWEEN TWO STATIONS. CALL IT'C'
C   ALSO COMPUTE ABUNDANCE COMPARISONS FOR CZEKANOWSI'S MEASURE.
C   ALSO COMPUTE ABUNDANCE MEASURES FOR STANDARD DISTANCE AND PRODUCT-
C   MOMENT CORRELATION.
  375 L=I+1
      DO 700 J=L,NSTA
      IC=0
      DIF=0.0
      SUM=0.0
      COM=0.0
      AVEA=NIND(I)
      AVEA=AVEA/S
      AVEB=NIND(J)
      AVEB=AVEB/S
      RMSA=0.0
      RMSB=0.0
      SDSUM=0.0
      SSA=0.0
      SSB=0.0
      SS=0.0
      NTAXA=0
      NTAXB=0
      DO 450 N=1,NSPEC
      IF (ISELC .GT.0) GO TO 420
      X=ICNT(N,I)
      Y=ICNT(N,J)
      GO TO 430
  420 ISELC=1
      X=ALOG(FLOAT(ICNT(N,I)+1))
      Y=ALOG(FLOAT(ICNT(N,J)+1))
  430 RMSA=RMSA+X**2
      RMSB=RMSB+Y**2
      SDSUM=SDSUM+X*Y
      SA=X-AVEA
      SB=Y-AVEB
      SSA=SSA+SA**2
      SSB=SSB+SB**2
      SS=SS+SA*SB
      ABSXY=ABS(X-Y)
      XPLUSY=X+Y
      IF (XPLUSY .GT. 0)COM=COM+ABSXY/XPLUSY
      DIF=DIF+ABSXY
      SUM=SUM+XPLUSY
```

```
      JTEST=Y*10.0
      ITEST=X*10.0
      IF (ITEST .NE. 0)ITEST=1
      IF (JTEST .NE. 0)JTEST=1
      NTAXA=NTAXA+ITEST
      NTAXB=NTAXB+JTEST
      IC=IC+ITEST*JTEST
  450 CONTINUE
      RMS=SQRT(RMSA)*SQRT(RMSB)
      IF (NTAXA*NTAXB .NE. 0)GO TO 475
      DO 465 N=2,9
  465 SM(N)=0.0
      SD=1.0
      GO TO 485
  475 A=MIN0(NTAXA,NTAXB)
      B=MAX0(NTAXA,NTAXB)
      C=IC
      PM=SS/SQRT(SSA*SSB)
      SD=1.0-(SDSUM/RMS)
      CM=1.0-COM/(A+B-C)
      CZ=1.0-DIF/SUM
      JA=C/(A+B-C)
      FA=C/SQRT(A*B)-1.0/(2.0*SQRT(B))
      WE=C/(A+B+C)
      SO=2.0*C/(A+B)
      IF(IFLIP.NE.0) GO TO 901
      IF (IPAR.NE.7) GO TO 901
      KE=(C*(S-A-B+C)-(A-C)*(B-C))/SQRT(A*(S-A)*B*(S-B))
      GO TO 485
901    KE=1.0
  485 IF (IPAR .GT. 0)GO TO 600
      IF (LINEC-LINLM)550,500,500
500   IF(IFLIP.NE.0) GO TO 1888
      WRITE(6    ,505)NSPEC,NSTA,HDR(ISELC+1)
  505 FORMAT(1H1,5X,'SIMILARITY MEASURES',14X,'THERE ARE ',I4,' SPECIES
     *IN ',I3,'STATIONS',10X,A3,'-TRANSFORMED ABUNDANCE')
      GO TO 1887
1888  WRITE(6,505) NSTA,NSPEC,HDR(ISELC+1)
1887  WRITE(6    ,507)
  507 FORMAT(1H0,2X,
     1'STATIONS     NUMBER OF TAXA  FAGER    JACCARD   SORENSON  KENDALL
     2    WEBB   CZEKANOWSKI CANBERRA  STANDRD PRODUCT' / 3X,
     3'A       B         A- B  SHARED',62X,'METRIC   DISTANCE  MOMENT' /
     4    111X,'CORREL. ' /)
      LINEC=6
550   IF(IFLIP.NE.0) GO TO 601
      WRITE(6    ,555)STATN(I),STATN(J),NTAXA,NTAXB,IC,FA,JA,SO,KE,WE,CZ,
     *                        CM,SD,PM
      LINEC=LINEC+1
555   FORMAT(1H ,A6,'_',A6,3X,I4,'_',I3,I4,9F10.4)
      GO TO 1602
601   WRITE(6,556) STATN(I),STATN(J), NTAXA,NTAXB,IC,FA,JA,SO,KE,WE,CZ,
     1 CM,SD,PM
556   FORMAT(1H,I6,'_',I6,3X,I4,'_',I3,I4,9F10.4)
      LINEC=LINEC+1
1602   IF(IPAR.EQ.0) GO TO 700
  600 N=IABS(IPAR)
      R(I,J)=SM(N)
```

```
      R(J,I)=SM(N)
      R(I,I)=1.0
  700 CONTINUE
  900 LINEC=LINLM
      RETURN
      END
      SUBROUTINE REORD(NN,NSP,NST,BETA,I,J)
C     THIS ROUTINE REORDERS DATA MATRIX AND COMPUTES THE PROPERTIES OF NE
C     INDIVIDUAL ( A CLUSTER) FORMED DURING THE LAS CYCLE
C    ICEN CONTROLS THE COMPUTIATION OF THE VALUES FOR EACH PROPERTY.
      COMMON/ICLU/M(150),KOUN,ICEN
      COMMON/SIM/R(150,150)
      IF((6-ICEN)*ICEN .LE. 0)GO TO 150
      ALPHAI=0.5
      GO TO (10,20,30,40,50),ICEN
   10 BETA=0.0
      GO TO 60
   20 BETA=0.0
      GAMMA=-0.5
      GO TO 65
   30 BETA=0.0
      GAMMA=.5
      GO TO 65
   40  BETA=-0.25
      GO TO 60
C    BETA IS AN ARGUMENT FOR THE FLEXIBLE STRATEGY.
   50 IF (BETA .GT. 1.0)BETA=1.0
      ALPHAI=ALPHAI-(BETA/2.0)
   60 GAMMA=0.0
   65 ALPHAJ=ALPHAI
      GO TO 155
  150 BETA=0.0
      GAMMA=0.0
      K1=0
      K2=0
      DO 151 LU=1,NST
      IF (M(LU) .EQ. I)K1=K1+1
      IF (M(LU) .EQ. J)K2=K2+1
  151 CONTINUE
      ALPHAI=FLOAT(K1)/FLOAT(K1+K2)
      ALPHAJ=FLOAT(K2)/FLOAT(K1+K2)
  155 CONTINUE
      BETEMP=BETA*R(I,J)
      DO 102 K=1,NN
      A=R(I,K)
      B=R(J,K)
      R(I,K)=ALPHAI*A+ALPHAJ*B+BETEMP+GAMMA*ABS(A-B)
      R(K,I)=R(I,K)
  102 CONTINUE
      NUTS=NN-1
      IF (J .GT. NUTS)GO TO 108
      ISW=1
      ASSIGN 200 TO ITRAP
  175 DO 250 L=J,NUTS
      DO 250 K=1,NN
      GO TO ITRAP,(200,225)
  200 R(K,L)=R(K,L+1)
      GO TO 250
```

```
 225    R(L,K)=R(L+1,K)
  250 CONTINUE
      IF (ISW .NE. 1)GO TO 108
      ASSIGN 225 TO ITRAP
      ISW=2
      GO TO 175
  108 DO 105 L=1,NST
      IF (M(L) .EQ. J)M(L)=I
      IF (M(L) .GT. J) M(L)=M(L)-1
  105 CONTINUE
      NN=NN-1
      RETURN
      END
      SUBROUTINE SEARCH (N,NCOEF,TOP,II,JJ)
C
C   THIS ROUTINE SEARCHES SIMILARITY MATRIX(S) FOR MAXIMUM OR MINIMUM
C   VALUE, DEPENDING ON VALUE OF NCOEF  THE RESULT OF SEARCH IS TOP.
      COMMON/SIM/S(150,150)
      TOP=S(1,2)
      II=1
      JJ=2
      IF (NCOEF .EQ. 0)GO TO 2
      NUT=N-1
      DO 4 I=1,NUT
      IMP=I+1
      DO 4 J=IMP,N
      IF (TOP .GE. S(I,J))GO TO 4
      TOP=S(I,J)
      II=I
      JJ=J
    4 CONTINUE
      RETURN
    2 NUT=N-1
      DO 7 I=1,NUT
      IMP=I+1
      DO 7 J=IMP,N
      IF (TOP .LE. S(I,J))GO TO 7
      TOP=S(1,2)
      II=I
      JJ=J
    7 CONTINUE
      RETURN
       END
      SUBROUTINE SYMDEN(N,LAB,LEV,XC,YC,YMIN,YMAX,XDIM,YDIM,IXX
     *,TTMAX)
C N      = NUMBER OF OBJECTS
C LAB     = LIST OF OBJECT LABELS(OF LENGTH N)
C LEV      =  LIST OF CLUSTERING LEVELS(N-1 NUMBERS BUT LEV(N) US USED)
C **NOTE LEV IS DESTROYED BY THIS PROGRAM
C XC     = SCRATCH ARRAY TO HOLD X-COORDINATES
C YC     = SCRATCH ARRAY TO HOLD Y-COORDINATES
C  MIN    = VALUE OF VARIABLE CIRRESPONDING TO THE LEAST SIMILARITY
C XDIM =  THE X LENGTH OF THE PLOT
C YDIM =  THE Y LENGTH OF THE PLOT
C IXX =  THE LIST TO BE PRINTED ON THE AXIS
C TTMAX= MAX VALUE OF SIMILARITY COEFF- USED IN PRINTING AXIS
      REAL NUM(152)
      REAL LAB(N),LEV(152),XC(N),YC(N)
```

```
      DIMENSION IXX(100)
      YMIN=10000000
      YMAX=-10000000
      DO 81 I=1,N
      IF(LEV(I) .GT.YMAX)YMAX=LEV(I)
      IF(LEV(I) .LE.YMIN)YMIN=LEV(I)
   81   CONTINUE
      RMAX=YMAX
      RMIN=YMIN
      WRITE(6,31)(LEV(I),I=1,N)
      WRITE(6,32)(LAB(I),I=1,N)
   32  FORMAT(1X,20(A6))
   31 FORMAT(1X,20F6.4)
   75 FORMAT('  MAX=',F4.2,'  MIN =',F4.2)
      DO 401 I=1,N
  401 NUM(I)=I
      IF(XDIM.EQ.0) XDIM=8.5
      IF(YDIM .EQ.0) YDIM=5.0
      FACT=YDIM-.6
       CALL FACTOR(FACT)
      DX=XDIM/(FACT*(N+3))
      DO 39 I=1,N-1
   39 LEV(I)=LEV(I+1)
       LEV(N)=YMIN
   41 YRANGE=YMAX-YMIN
      YHIGH=-1.
C FOR EACH OBJECT DRAW A VERTICAL LINE AND LABEL
      DO 100 IC=1,N
      C=IC*DX
      Y=LEV(IC)
       Y=(Y-YMIN)/YRANGE
       LEV(IC)=Y
C HEIGHT = CURRENT LEV OR PREVIOUS (WHICHEVER IS THE LARGEST)
      IF(Y.GT.YHIGH) YHIGH=Y
      CALL PLOT(C,YHIGH,3)
       CALL PLOT(C,1.,2)
       CALL SYMBOL(C,1.,1/(10*FACT),LAB(IC),90,6)
       XC(IC)=C
      YC(IC)=YHIGH
      YHIGH=Y
  100 CONTINUE
      CALL FACTOR(1)
      IF (TTMAX .EQ.1)
     *CALL AXIS((N+4)*DX*FACT-.5,0,IXX,-36,FACT,90,
     *RMIN,(RMAX-RMIN)/FACT)
      IF (TTMAX .EQ.0)
     *CALL AXIS((N+4)*DX*FACT-.5,0,IXX,-36,FACT,90,
     *RMAX,-1*(RMAX-RMIN)/FACT)
      CALL FACTOR(FACT)
C DRAW THE REST OF THE DENDROGRAM
      ISTART=1
      X=0.
      LEV(N+1)=0
      XC(N+1)=0
      YC(N+1)=-.1
  150 NM1=N
      DO 200 I=ISTART,NM1
      IC=I
```

```
      IF(LEV(I).GE.LEV(I+1)) GO TO 230
 200    CONTINUE
 230  Y=YC(IC)
C DRAW HORIZONTAL LINE
      IF(X.EQ.XC(IC+1)) GO TO 240
      IF (XC(IC).EQ.0) GO TO 38
      CALL PLOT(XC(IC),Y,3)
      IF (XC(I+1).EQ.0) GO TO 38
      CALL PLOT(XC(IC+1),Y,2)
      GO TO 250
      IF (XC(IC).EQ.0) GO TO 38
  240  CALL PLOT(XC(IC),Y,2)
C DRAW VERTICAL LINE AT CENTER OF HORIZONTAL LINE
 250  X=(XC(IC)+XC(IC+1))/2.
      XC(IC+1)=X
      IF (X.EQ. 0) GO TO 38
      CALL PLOT(X,Y,3)
      Y=LEV(IC+1)
      IF(IC-1.EQ.0) GO TO 25
       IF(IC.GT.ISTART.AND.LEV(IC-1).GT.Y)Y=LEV(IC-1)
  25   YC(IC+1)=Y
      IF (X.EQ.0) GO TO 38
      CALL PLOT(X,Y,2)
      IF (Y.EQ.-.1) GO TO 38
C DELETE ENTRY IC AND SLOSE UP SPACE
      ISTART=ISTART+1
      IF(IC.LT.(ISTART))GO TO 350
      DO 300 I=ISTART,IC
      II=IC-I+ISTART
      LEV(II)=LEV(II-1)
      XC(II)=XC(II-1)
      YC(II)=YC(II-1)
 300  CONTINUE
C LOOP BACK UP  IF NOT DONE
  350 IF(ISTART .LE.(NM1)) GO TO 150
   38 CALL PLOT((N+4)*DX+3/FACT,0,3)
       RETURN
      END
```

APPENDIX II

CHARACTERISTICS OF SEDIMENT GROUPINGS IN DELAWARE BAY

A-2: Moderately to Moderately Well-Sorted Coarse Sand

The sediments within this classification were among the coarsest found within the bay. Sands of this grain size were most likely transported as bed load material (Allen, 1965). Skewness varied from very coarse to very fine skewed, indicating areas of both erosion and deposition.

The coarse skewed stations (1-5, 1-6, and 1-9) on the shoulders of Middle and Prissy Wicks Shoals near the mouth of the bay were indicative of strong tidal current erosion. The two strongly coarse skewed stations (7-3 and 23-4) within the bay area were bimodal. The major medium sand mode was coupled with a smaller very coarse sand mode to produce a deceptive numerical skewness value. The medium sand mode in Station 7-3 was derived from the Lower Middle Shoal and mixed with the coarse sand present in the depression. Bimodal Station 23-4 off Ben Davis Point was a mixture of medium sand (similar to adjacent station 23-5) and very coarse sand similar to Station 24-5.

Station 4-4 occurred in deep water within the Big Stone Anchorage area. The strongly fine skewed sediment indicated an area of deposition (adjacent stations are also fine skewed).

The remaining stations in the classification (2-1, 9-7, 14-7, 19-6, 21-7, 21-8, and 24-5) were found in shallow waters around the perimeter of the bay. Skewness values ranged from +0.112 to -0.110 and did not indicate any significant erosions or depositional trends.

A-3: Poorly Sorted Coarse Sand

The sediments within this group were similar to A-2. In general they contain more gravel than A-2 and were not as well sorted. They were found in deeper waters where tidal currents had less effect and waves were less able to sort the sediments.

Six of the 15 stations in this group occurred at the mouth of the bay in the deep channel to the Anchorage area. The only three fine skewed stations (1-1, 2-1B, and 2-2) as well as one near symmetrical (14-4) and two strongly coarse skewed stations (14-3 and 15-3) occurred in the channel. There was no apparent pattern to the skewness values and they probably related to local erosion and deposition within the deep channel.

Two coarse skewed stations (1-8 and 14-9) were located in Bay Shore Channel. These were near the mouth of the bay and were probably subjected to erosion by tidal currents.

Three stations in the main shipping channel were subjected to various erosional forces including dredging. Stations 7-6 and 20-5, located adjacent to Miah Maull Shoal Light, and Station 10-5, adjacent to Cross Ledge Light, were all coarse skewed.

The remaining stations (8-9, 10-7, 22-7, and 25-2) were located around the perimeter of the bay and had skewness ranges from near symmetrical to strongly coarse.

B-1: Well Sorted Medium to Fine Sand

These sediment stations were found on shoals or in shallow water. These sands are easily erodible and are transported as bed load material. Being in shallow water, they are likely to be sorted and winnowed by both tidal currents and wave action.

Five stations were located along the Lower Middle and Brown Shoals down the middle of the bay (3-4, 4-5, 16-5B, 17-4, and 20-3). In addition, one station (1-7) occurred on Middle Shoal at the mouth of the bay. These were near symmetrical to fine skewed deposits. They were very susceptible to erosion and redeposition.

The remaining four stations were found in shallow near-shore waters. Among these was the one coarse skewed station (18-1) off Big Stone Beach. The other three stations (8-8, 20-7, and 23-5) had grain size distributions that are near-symmetrical.

B-2: Moderately to Moderately Well Sorted Medium to Fine Sand

Sediments in this group were in the same size range as B-1, but were not as well sorted and are found in somewhat deeper water. These sediments are easily erodible and are carried as bed load material on the shoulders of some of the shoals.

Stations 3-6 and 15-5 were fine skewed sediments deposited adjacent to Crow Shoal. Stations 4-3 and 16-4 were very fine skewed sediments deposited on the shoulder of Old Bare Shoal. The three remaining fine skewed stations (6-6, 7-7, and 19-5) were adjacent to Miah Maull Shoal. All these stations had sediments which are deposited by the tidal currents. Station 1-4 adjacent to Overfalls Shoal and Station 21-6 on the edge of Cross Ledge had near symmetrical grain size distributions. Two additional near symmetrical stations (5-5 and 17-5) occurred in the shipping channel adjacent to Brandywine Shoal. With the tidal currents occurring at these stations, the skewness values probably signified areas of active erosion and redeposition.

Station 3-5 adjacent to Brown Shoal was the only coarse skewed station associated with a shoal deposit. Its size distribution indicated that the finer shoal sands are being added to the coarser sands in the deep water adjacent to the shoal.

Station 23-3 was a coarse skewed deposit in the main channel in the upper part of the bay. Stations 15-1, 20-8, and 24-1 were near symmetrical and coarse skewed sediments in shallow water near the shore.

B-3: Poorly Sorted Medium to Fine Sand

Sediments in this group were in the same size range and had similar transport characteristics as groups B-1 and B-2. The majority of these stations occurred in deep water with eight stations in the main shipping channels and five in the channel to Big Stone Anchorage. The stations in this group were near symmetrical to strongly fine skewed.

The lower bay main channel stations (2-3, 2-3B, 15-4, and 16-6) had near symmetrical size distributions while Station 4-6, in the channel adjacent to Brandywine Shoal, was fine skewed. The stations in the channel adjacent to Miah Maull Shoal were of mixed skewness with 19-4 and 21-5 being fine skewed and 8-6 near symmetrical. With the periodic dredging operations in the upper part of the channel it was difficult to ascribe any significance to the skewness values. There were no erosional or depositional trends in the lower bay channels.

The five anchorage channel stations (3-3, 5-3, 16-5A, 17-3, and 18-3) became increasingly more fine skewed moving toward the head of this channel. The three strongly fine skewed stations at the top of the channel indicated that this was a depositional area with the sediments probably being carried up the channel as bed load material.

The four remaining stations (3-1, 11-1, 11-7, and 26-4) were scattered around the perimeter of the bay.

B-4: Very Poorly Sorted Medium to Fine Sand

Only five stations were represented under this classification. While similar to B-3, they were much more poorly sorted and they contained up to 10% gravel.

Station 1-2 was a gravelly muddy medium sand (Folk, 1968) in a deep channel at the mouth of the bay. The fine skewed grain size distribution was attributed to the quantity of mud present in the sample.

Station 10-3, the coarse skewed sample in this group, was a gravelly muddy fine sand. This station appeared to have a fine sand mode derived from Joe Flogger Shoal mixed with a sand and gravel stratum. Since the station was in a channel adjacent to the shoal, the area was quiet enough to allow mud to settle out also.

Station 12-2 was a gravelly muddy medium sand. It is located in relatively deep water between the ship channel and Bombay Hook Point Shoal. Its strongly fine skewed size distribution depended on the quantity of mud that has settled out of the water column.

Station 25-5 was a gravelly muddy fine sand. It was located adjacent to a marsh shore. It was a fine skewed sediment because of its high mud content.

C-1: Well Sorted Very Fine Sand

Most sediments in this group were found on shallow water shoals. These sands were easily eroded and were fine enough to be transported as suspended material (Allen, 1965). All 31 stations had positive (fine) skewness values indicating, generally, depositional areas.

These sediments were found on Joe Flogger Shoal (Stations 9-4, 10-4, 11-2, and 21-4), the upper portion of the Lower Middle

Shoal (Stations 6-3, 7-4, and 18-4), Old Bare Shoal (Stations 3-2, 4-2, and 16-2), and Cross Ledge (Stations 9-5, 9-6, 10-6, and 22-5). The largest grouping of stations occurred along the shoal on the west side of Bay Shore Channel starting from Crow Shoal at the bay mouth and ending in the area of Deadman Shoal. Stations 2-5, 4-9, 4-10, 5-8, 14-8, 15-6, 16-9, 17-8, 17-9, and 18-8 were included in this group. The C-1 station in deepest water (14-5) was located in the main channel near the mouth of the bay. The only strongly fine skewed sample (Station 8-3) was located on an unnamed shoal west of Blake Channel. The remaining stations (4-7, 5-6, 6-7, and 18-6) were located on shoals adjacent to Brandywine Shoal.

C-2: Moderately to Moderately Well Sorted Very Fine Sand

While in the same size range as C-1, this group of stations was located in deeper water. Since it is not as well sorted as C-1, it contained some bed load material mixed with sediment that was transported in suspension.

Stations located on top of shoals such as Hawknest (6-1, 7-2, 8-1, and 19-2), Middle Shoal (14-6), and the southern tip of Fishing Crale Shoal (15-8) were fine or strongly fine skewed indicating depositional environments. Stations on the shoulder of the Lower Middle Shoal (5-4 and 6-4) and on the sides of shoals east of Brandywine Shoal (4-8, 5-7, 16-7, 17-6, and 18-7) had skewness values ranging from coarse skewed through strongly fine skewed. This indicated areas of active sediment erosion and redeposition. Stations 6-5 and 18-5 in the main channel next to Fourteen Foot Bank and the deep water station (1-3) at the mouth of the bay near Overfalls Shoal derived their sediments from the adjacent shoals.

C-3: Poorly Sorted Very Fine Sand

Exclusive of two bimodal samples, the sediments in this group were strongly fine skewed. These depositional environmental samples occurred in deep areas at the heads of some channels and between shoals and in relatively quiet waters around the perimeter of the bay.

The bimodal samples (Stations 19-3 and 20-4) occurred in Blake Channel adjacent to Joe Flogger Shoal. Very fine sand from the shoal is mixing with the coarse sand at the bottom of the channel to produce an apparently coarse skewed sediment.

The deep water samples occurred at the heads of channels on both sides of Hawknest Shoal (Stations 7-1, 8-2, and 21-2), at the head of Blake Channel (Stations 22-3 and 23-2), below Ben Davis Shoal (Stations 11-5 and 11-6), in the main channel adjacent to Joe Flogger Shoal (Station 11-3), and at the head of channels east of Brandywine Shoal (Stations 16-8 and 17-7). The very fine sands from the shoals adjacent to these stations are being deposited in these deep water areas.

The remaining stations in this group were located in 7 to 10 feet of water near the mouth of the Mispillion River (4-1, 5-1, 16-1, 17-1, and 18-2), the Maurice River (4-11, 5-9, 6-8, 6-9, 7-8, and 18-9), and the Cohansey River (24-4 and 25-4).

D-4: Very Poorly Sorted Sandy Coarse Silt

These quiet water deposits consisted of sediments that have been transported as suspended material. With one exception (Station 17-10) they were strongly fine skewed samples attesting to the depositional environments in which they were located. Stations were located at the heads of Bay Shore Channel (Station

16-10), Blake Channel (Stations 8-4, 8-5, and 9-2), and the channel adjacent to Old Bare Shoal (Stations 15-2 and 16-3). The remaining stations in this group were found in several locations in 5 to 10 feet of water adjacent to both shores of the bay.

D-5: Extremely Poorly Sorted Gravelly Sandy Coarse Silt

The two stations in this group were located near the shore. Station 12-5 was near the Cohansey River and Station 16-11 was north of Cape May. They were a combination of the coarser sand stations and the finer silt-clay stations on either side of their locations.

E-5: Very to Extremely Poorly Sorted Silt and Clay

These sediments were similar to Station D-4, only they contained less sand and were more poorly sorted. The majority of stations occurred in the upper bay between Bombay Hook Point and the Cohansey River with a line of stations hugging the Delaware shore down to the Murderkill River. The sediments at these stations were derived mainly from the suspended load of the Delaware River and material associated with adjacent marshes. Stations 7-5, 9-3, and 21-3 were located in sections of Blake Channel and Stations 2-6, 3-7, and 15-7 were located in Bay Shore Channel. The strongly fine skewed sediments have settled out in the quiet, deep waters of these two channels. The remaining stations were adjacent to the Maurice River mouth (Station 19-8) and the Back-Cedar, Nantuxent Creek outflow (Station 22-6) along the New Jersey shore.

APPENDIX TABLES

Table AI-1

Temperature at benthic stations obtained during quarterly cruises

Stations	May 1974 T	May 1974 B	Aug. 1974 T	Aug. 1974 B	Nov. 1974 T	Nov. 1974 B	Feb. 1975 T	Feb. 1975 B	May 1975 T	May 1975 B
1	12.4	12.4	-	24.2	-	15.0	-	3.9	-	11.2
2	13.0	12.5	24.1	24.4	14.4	14.9	3.6	3.8	11.6	11.2
3	12.8	12.4	24.7	24.3	14.9	14.8	3.6	3.8	11.7	10.2
4	-	13.0	-	-	-	15.1	-	3.1	-	11.8
5	13.4	12.3	24.9	24.6	15.0	14.8	-	3.4	11.9	10.3
6	-	13.4	-	25.0	-	15.1	-	3.6	-	-
7	13.6	12.6	25.3	24.9	15.1	14.8	3.4	3.6	12.2	11.2
8	14.0	13.2	25.3	25.0	15.6	15.1	3.6	3.6	12.8	11.9
9	13.6	12.5	25.4	24.7	15.4	15.1	3.0	2.9	12.8	12.2
10	13.8	13.2	25.2	24.6	15.4	14.9	3.3	3.2	13.0	11.9

Table AI-2

Salinity at benthic stations
obtained during quarterly cruises

Stations	May 1974	Aug. 1974	Nov. 1974	Feb. 1975	May 1975
Surface					
1	28.4	-	-	-	-
2	26.7	29.3	28.0	27.6	25.2
3	26.8	29.2	28.3	27.2	25.2
4	-	-	-	-	-
5	25.5	28.9	28.7	29.1	24.2
6	-	-	-	-	-
7	25.4	28.7	27.7	25.3	22.8
8	25.7	29.6	28.0	25.3	24.8
9	25.5	29.6	27.9	25.2	25.2
10	26.1	29.6	28.8	26.1	26.7
Bottom					
1	29.0	29.9	29.9	29.4	27.8
2	28.1	29.8	29.9	29.1	30.7
3	29.3	29.0	29.4	28.8	30.5
4	25.8	29.6	28.5	26.2	24.1
5	29.5	29.5	29.2	26.2	30.1
6	26.4	28.9	28.7	26.3	23.5
7	27.7	28.6	28.5	27.4	26.1
8	25.4	29.6	28.6	25.3	25.5
9	26.3	29.6	28.5	25.3	25.7
10	26.7	29.7	29.5	26.2	25.7

Table AI-3

Dissolved oxygen at benthic stations obtained during quarterly cruises

Station	May 1974 T	May 1974 B	Aug. 1974 T	Aug. 1974 B	Nov. 1974 T	Nov. 1974 B	Feb. 1975 T	Feb. 1975 B	May 1975 T	May 1975 B
1	7.38	8.31	-	6.13	-	6.00	-	10.54	-	10.13
2	4.61	7.07	5.45	6.10	8.45	7.19	-	10.40	10.38	10.09
3	7.65	6.02	6.81	6.06	7.87	7.02	10.74	10.64	10.13	9.55
4	-	6.57	-	5.97	-	7.36	-	10.98	-	10.18
5	5.29	3.66	6.41	5.06	7.58	6.99	10.95	10.48	10.21	9.65
6	-	7.53	-	3.56	-	7.55	-	11.04	-	10.08
7	6.98	4.54	6.26	5.10	9.61	7.21	10.98	10.67	10.46	9.69
8	5.79	4.62	3.14	3.67	8.40	7.61	11.17	11.12	10.87	9.96
9	5.94	4.51	6.52	4.06	8.37	8.16	11.20	11.20	10.92	9.96
10	6.95	5.19	4.24	3.98	6.82	6.97	11.64	11.04	10.46	10.04

Table AII-1

Whole water phytoplankton counts for cruises 4 through 19

Date: June 13, 1974 Cruise No.: 4

Species	Station I	Station II	Station III
	Abundance (cells/ml)		
Cryptomonas acuta	2306	1491	616
Calycomonas ovalis	1037	806	532
Prasinophyte A	1713	1236	199
Phaeodactylum tricornutum	792	611	366
Chrysochromulina sp.	398	894	431
Ankistrodesmus sp.	273	171	32
Kirchneriella sp.	97	56	5
Navicula sp. B	9	9	19
Prorocentrum minimum	125	329	14
Asterionella japonica	190	431	977
Pyramimonas sp. A	454	352	93
Coscinodiscus sp.	14	14	9
unidentified flagellate	162	-	-
silicoflagellate	60	-	-
Ochromonas sp.	9	-	-
Cyclotella sp.	431	384	273
Rhizosolenia fragilissima	56	116	69
Chroomonas sp.	19	125	-
Prorocentrum scutellum	5	14	-
Chlamydomonas sp. A	134	9	14
Pseudopedinella pyriforme	28	32	9
Gyrodinium sp. A	5	-	5
Rhizosolenia setigera	23	-	32
Navicula sp.	9	5	-
Exuviaella apora	5	-	-
Cylindrotheca closterium	5	9	14
Chaetoceros sp.	28	69	37
Exuviaella baltica	37	-	-
Ceratium tripos	5	23	23
Gymnodinium ? roseostigma	23	-	-
Gymnodinium ? aurantium	5	-	5
Gyrodinium ? metum	79	-	-
Synedra sp.	5	-	5
Thalassionema nitzschioides	5	-	-
coccolith	14	-	37
Gymnodinium sp. A	5	-	-
Amphora sp.	5	-	-

Table AII-1 (cont.)

Date: June 13, 1974 Cruise No.: 4 (cont.)

Abundance (cells/ml)

Species	Station I	Station II	Station III
Nitzschia seriata	-	14	9
Skeletonema costatum	-	51	79
Tetraselmis sp. A	-	74	-
Dinoflagellate sp. A	-	125	-
Diploneis sp.	-	5	-
Navicula sp. A	-	14	-
Diatom 1-E	-	-	5
Navicula sp. C	-	-	14
Pennatae sp.	-	-	9
Cerataulina bergonii	-	-	9
Leptocylindrus minimus	-	-	5

Table AII- 1 (cont.)

Date: June 20, 1974 Cruise No.: 5

Species	Abundance (cells/ml) Station I	Station II	Station III
Cryptomonas acuta	722	735	178
Rhizosolenia fragilissima	681	2024	1802
Chrysochromulina sp.	176	291	161
Calycomonas ovalis	695	707	76
Prasinophyte A	440	818	-
Cerataulina bergonii	157	118	34
Phaeodactylum tricornutum	46	21	25
Cyclotella sp.	120	62	-
Skeletonema costatum	28	-	17
Gymnodinium sp. B	28	14	-
Rhizosolenia setigera	5	7	8
silicoflagellate	9	-	-
Ceratium tripos	14	35	25
unidentified flagellate	199	-	-
Rhizosolenia delicatula	14	69	76
Nitzschia seriata	9	21	-
Ebria tripartita	9	7	-
Pyramimonas sp. A	74	236	330
Chaetoceros sp.	32	83	17
Chroomonas sp.	65	-	1354
Leptocylindrus danicus	5	-	-
Navicula sp. B	5	7	17
Thalassionema nitzschioides	5	-	17
Prorocentrum minimum	5	7	17
Navicula sp. A	5	-	8
Tetraselmis sp. A	5	-	8
Asterionella japonica	-	7	-
Dinoflagellate sp. A	-	7	-
Katodinium rotundatum	-	90	195
Pennatae sp.	-	7	17
Cylindrotheca closterium	-	14	-
Coscinodiscus sp.	-	21	25
Surirella sp.	-	7	-
Prorocentrum scutellum	-	7	-
Pseudopedinella pyriforme	-	-	17
Gymnodinium sp. A	-	-	17
Euglena sp. A	-	-	8
Raphoneis amphiceros	-	-	8
Paralia sulcata	-	-	17

Table AII-1 (cont.)

Date: July 19, 1974 Cruise No.: 6

Species	Abundance (cells/ml) Station I	Station II	Station III
Cryptomonas acuta	1929	673	416
Chroomonas sp.	944	1051	1060
Katodinium rotundatum	3345	1693	728
Prasinophyte A	180	-	-
Pyramimonas sp. A	500	367	513
Pseudopedinella pyriforme	69	51	28
Olisthodiscus sp.	28	-	-
Thalassionema nitzschioides	69	31	62
Tetraselmis sp. A	14	-	21
Coscinodiscus sp.	28	-	-
Cyclotella sp.	42	-	-
Prorocentrum minimum	14	-	-
Chrysochromulina sp.	305	286	104
Calycomonas ovalis	208	734	104
Euglena sp. A	56	-	-
Coscinodiscus sp.	-	102	55
Paralia sulcata	-	31	21
Gymnodinium sp. A	-	31	14
Navicula sp. C	-	20	7
Cocconeis sp.	-	20	-
Gymnodinium simplex	-	41	21
Navicula sp.	-	10	14
Navicula sp. B	-	-	7
Phaeodactylum tricornutum	-	-	21
Rhizosolenia delicatula	-	-	7
Rhizosolenia fragilissima	-	-	7

Table AII- 1 (cont.)

Date: August 1, 1974 Cruise No.: 7

Species	Station I	Station II	Station III
	Abundance (cells/ml)		
Cryptomonas acuta	2300	-	1398
Calycomonas ovalis	826	-	1591
Chrysochromulina sp.	143	-	48
Thalassionema nitzschioides	26	-	125
Euglena sp. A	92	-	87
Prasinophyte A	270	-	106
Katodinium rotundatum	133	-	154
Pyramimonas sp. A	143	-	96
Rhizosolenia fragilissima	26	-	174
Prorocentrum minimum	31	-	29
Asterionella japonica	5	-	-
Cerataulina bergonii	41	-	790
Navicula sp. B	5	-	-
Tetraselmis sp. A	117	-	48
Chroomonas sp.	56	-	10
Gyrodinium ? *metum*	10	-	-
Diatom 1-E	10	-	-
Pseudopedinella pyriforme	10	-	10
Navicula sp.	5	-	19
Glenodinium danicum	-	-	10
Prorocentrum micans	-	-	10
Leptocylindrus minimus	-	-	29
Navicula sp. C	-	-	19
Cyclotella sp.	-	-	10
Coscinodiscus sp.	-	-	10
Gymnodinium sp. A	-	-	10
Prorocentrum scutellum	-	-	10

Table AII-1 (cont.)

Date: August 21, 1975 Cruise No.: 8

Species	Abundance (cells/ml) Station I	Station II	Station III
Skeletonema costatum	1083	1095	1566
Cryptomonas acuta	722	568	733
Calycomonas ovalis	1274	180	1318
Nitzschia seriata	78	21	30
Cerataulina bergonii	35	14	-
Pyramimonas sp. A	28	35	40
Asterionella japonica	142	1060	614
Euglena sp. A	21	166	79
Exuviaella compressa	14	-	-
Pseudopedinella pyriforme	7	-	-
Katodinium rotundatum	85	21	30
Thalassionema nitzschioides	50	97	40
Leptocylindrus danicus	85	14	-
Coscinodiscus radiatus	21	7	-
Gyrodinium ? grossestriatum	7	-	-
Cylindrotheca closterium	7	97	79
Chrysochromulina sp.	21	14	20
Coscinodiscus sp.	28	76	50
Schroderella delicatula	21	-	-
Paralia sulcata	28	21	99
Cocconeis sp.	14	14	-
Navicula sp.	14	14	10
Brachiomonas submarina	7	21	-
Gymnodinium sp.	21	42	-
Tetraselmis sp. A	7	-	-
Streptotheca thamensis	7	-	20
Prasinophyte A	-	14	30
Biddulphia sp.	-	7	-
Biddulphia regia	-	7	-
Rhizosolenia fragilissima	-	14	10
Lithodesmium undulatum	-	7	20
Navicula sp. C	-	7	-
Navicula sp. D	-	-	89
Pleurosigma sp.	-	-	10
Navicula sp. B	-	-	10

Table AII-1 (cont.)

Date: September 17, 1974 Cruise No.: 9

Species	Station I	Station II	Station III
	Abundance (cells/ml)		
Cryptomonas acuta	472	638	686
Pyramimonas sp. A	180	14	21
Calycomonas ovalis	305	416	644
Coscinodiscus sp.	28	21	21
Phaeodactylum tricornutum	319	125	166
Chrysochromulina sp.	56	42	7
Cyclotella sp.	14	7	104
Chroomonas sp.	361	-	-
Thalassionema nitzschioides	42	55	49
Gymnodinium simplex	28	-	-
silicoflagellate	14	-	-
Cylindrotheca closterium	14	-	-
Euglena sp. A	69	14	7
Navicula sp. C	14	-	-
Paralia sulcata	-	14	49
Leptocylindrus danicus	-	49	21
Prorocentrum scutellum	-	14	7
Navicula sp. B	-	35	7
Katodinium rotundatum	-	7	-
Grammatophora marina	-	14	-
Raphoneis amphiceros	-	7	-
Navicula sp. A	-	7	-
Pleurosigma sp.	-	7	-
Prorocentrum minimum	-	7	-
Prasinophyte A	-	-	97
Navicula sp.	-	-	14
Navicula sp. D	-	-	21
coccolith	-	-	7
Gymnodinium sp.	-	-	14
Gyrodinium spirale	-	-	7

Table AII-1 (cont.)

Date: October 15, 1974 Cruise No.: 10

Species	Abundance (cells/ml) Station I	Station II	Station III
Leptocylindrus danicus	2280	1691	2259
Chaetoceros decipiens	69	49	28
Rhizosolenia delicatula	7	14	14
Nitzschia seriata	49	76	111
Asterionella japonica	21	49	42
Thalassiosira ? gravida	21	69	49
Rhizosolenia fragilissima	97	76	55
Cyclotella sp.	104	76	83
Cryptomonas acuta	139	132	194
Calycomonas ovalis	21	55	49
unidentified flagellate	111	187	284
Rhizosolenia stolterfolthii	55	62	69
Rhizosolenia setigera	21	-	7
Skeletonema costatum	69	118	215
Cerataulina bergonii	28	55	62
Gyrodinium spirale	7	-	-
Gymnodinium ? arcticum	14	-	-
Chrysochromulina sp.	-	7	14
Navicula membranacea	-	7	-
Paralia sulcata	-	7	28
Navicula sp. A	-	7	-
Navicula sp. D	-	7	-
Noctiluca scintillans	1	1	-
Navicula sp. B	-	-	21
Coscinodiscus sp.	-	-	14
Pyramimonas sp. A	-	-	7
Amphora sp.	-	-	7
Gymnodinium sp. A	-	-	14
Thalassionema nitzschioides	-	-	7

Table AII-1 (cont.)

Date: October 30, 1974 Cruise No.: 11

Species	Station I	Station II	Station III
	Abundance (cells/ml)		
Leptocylindrus danicus	2959	4386	8078
Cryptomonas acuta	929	530	888
Calycomonas ovalis	83	20	-
Flagellate PZ-10	263	133	167
Nitzschia seriata	55	40	180
Noctiluca scintillans	7	10	-
Navicula membranacea	7	10	28
Navicula sp. D	21	10	-
Cryptomonad B	76	153	472
Katodinium rotundatum	14	-	-
Gyrodinium spirale	-	10	-
Gymnodinium sp. A	-	20	-
Chaetoceros sp.	-	-	14
Coscinodiscus sp.	-	-	28
Exuviaella sp.	-	-	14
Navicula sp. E	-	-	97
Thalassionema nitzschioides	-	-	14
Glenodinium rotundum	-	-	14
Gyrodinium sp.	-	-	14

Table AII-1 (cont.)

Date: November 14, 1974 Cruise No.: 12

Species	Abundance (cells/ml) Station I	Station II	Station III
Cryptomonas acuta	700	631	471
Cyclotella sp.	7	-	-
Peridinium trochoideum	7	-	-
Calycomonas ovalis	7	21	-
Pyramimonas sp. A	7	7	-
Chrysochromulina sp.	7	7	-
Coscinodiscus sp.	7	-	35
Flagellate PZ-10	42	55	83
Navicula sp. B	35	7	-
Noctiluca scintillans	7	14	-
Leptocylindrus danicus	7	-	-
Navicula sp. D	14	-	-
Thalassionema nitzschioides	7	-	-
Gymnodinium ? aurantium	-	7	-
Fragilaria oceanica	-	83	-
Cocconeis sp.	-	7	-
Coscinodiscus lineatus	-	7	-
Ochromonas sp.	-	7	7
Pleurosigma	-	7	-
Cryptomonad C	-	-	49
Paralia sulcata	-	-	7
Navicula membranacea	-	-	14
Navicula sp.	-	-	7
Thalassiosira sp. A	-	-	14
Phaeodactylum tricornutum	-	-	14
Katodinium rotundatum	-	-	21
coccolith	-	-	7

Table AII-1 (cont.)

Date: December 13, 1974 Cruise No.: 13

Species	Abundance (cells/ml) Station I	Station II	Station III
Cryptomonas acuta	215	180	243
Nitzschia seriata	76	125	229
Flagellate PZ-10	55	35	21
Thalassionema nitzschioides	35	14	49
Rhizosolenia delicatula	14	-	7
Thalassiosira sp. A	104	201	146
Asterionella japonica	21	7	7
Katodinium rotundatum	28	42	90
Euglena sp. A	7	7	-
Cryptomonad C	42	7	14
Navicula sp.	7	-	-
Ankistrodesmus sp.	14	-	-
Skeletonema costatum	236	388	215
Pyramimonas sp. A	7	62	14
Fragilaria oceanica	42	35	-
Ochromonas sp.	28	28	21
Guinardia flaccida	7	55	42
Chrysochromulina sp.	14	-	-
Chaetoceros simplex	7	-	-
Navicula sp. B	7	14	-
Rhizosolenia fragilissima	7	7	14
Rhizosolenia alata	14	14	14
Chrysodidymus gracilis	7	-	-
Raphoneis amphiceros	-	7	-
Gyrodinium ? metum	-	7	-
Paralia sulcata	-	21	35
Coscinodiscus lineatus	-	28	35
Calycomonas ovalis	-	7	7
Thalassiosira nordenskioldii	-	14	-
Prorocentrum minimum	-	14	-
coccolith	-	-	7
Leptocylindrus danicus	-	-	7
Gyrodinium spirale	-	-	7
Peridinium trochoideum	-	-	7

Table AII- 1 (cont.)

Date: January 16, 1975 Cruise No.: 14

Species	Station I	Station II	Station III
	Abundance (cells/ml)		
Cyanophyceae sp. A	208	270	270
Skeletonema costatum	665	1733	1234
Thalassiosira sp. A	215	554	603
Cryptomonas acuta	111	139	180
Nitzschia seriata	7	55	21
Asterionella japonica	21	35	69
Thalassionema nitzschioides	14	-	28
Katodinium rotundatum	21	7	14
Flagellate D	21	-	-
Calycomonas ovalis	7	14	-
Chaetoceros simplex	7	-	-
Chaetoceros decipiens	14	-	-
Cerataulina bergonii	-	7	-
Navicula sp.	-	7	7
Thalassiosira nordenskioldii	-	14	7
Pyramimonas sp. A	-	7	14
Navicula membranacea	-	14	-
Cryptomonad B	-	14	-
Euglena sp. A	-	7	-
Leptocylindrus danicus	-	7	-
Navicula sp. B	-	14	-
Cryptomonad C	-	21	35
Ochromonas sp.	-	21	-
Chaetoceros sp.	-	21	-
Paralia sulcata	-	7	-
Fragilaria oceanica	-	14	76
Cyclotella sp.	-	-	7

Table AII- 1 (cont.)

Date: February 20, 1975 Cruise No.: 15

Species	Abundance (cells/ml) Station I	Station II	Station III
Skeletonema costatum	-	2250	-
Thalassiosira sp. A	-	1615	-
Cryptomonas acuta	-	426	-
Guinardia flaccida	-	10	-
Gymnodinium sp.	-	10	-
Ochromonas sp.	-	69	-
Pyramimonas sp. A	-	30	-
Rhizosolenia delicatula	-	30	-
Navicula sp. B	-	20	-
Chaetoceros sp.	-	20	-
Cylindrotheca closterium	-	10	-
Asterionella japonica	-	99	-
Katodinium rotundatum	-	50	-
Calycomonas ovalis	-	30	-
Coscinodiscus sp.	-	10	-
Fragilaria oceanica	-	109	-
Flagellate PZ-10	-	30	-
Navicula sp.	-	20	-
Cyclotella sp.	-	10	-

Table AII-1 (cont.)

Date: March 18, 1975   Cruise No.: 16

Species	Station I	Station II	Station III
	Abundance (cells/ml)		
Skeletonema costatum	2268	13269	16795
Thalassiosira sp. A	1229	1513	2040
Guinardia flaccida	74	97	125
Flagellate PZ-10	74	28	14
Cyanophyceae sp. A	1176	250	236
Cryptomonas acuta	147	278	431
Ankistrodesmus sp.	11	-	-
Asterionella japonica	84	194	139
Thalassionema nitzschioides	32	-	14
Diploneis sp.	11	-	-
Rhizosolenia delicatula	63	111	69
Cerataulina bergonii	11	-	14
Cylindrotheca closterium	11	14	-
Chaetoceros simplex	21	-	-
Rhizosolenia setigera	11	-	14
Raphoneis amphiceros	11	-	-
Actinoptychus undulatus	11	-	-
Leptocylindrus danicus	11	-	14
Katodinium rotundatum	11	97	56
Calycomonas ovalis	-	14	-
Fragilaria oceanica	-	430	527
Ponchetia sp.	-	14	-
Chaetoceros sp.	-	14	-
Thalassiosira nordenskioldii	-	28	97
Gyrodinium sp.	-	-	14
Paralia sulcata	-	-	56
Glenodinium rotundum	-	-	14
Pyramimonas sp. A	-	-	14

Table AII-1 (cont.)

Date: April 14, 1975 Cruise No.: 17

Species	Station I	Station II	Station III
	Abundance (cells/ml)		
Skeletonema costatum	-	3984	-
Thalassiosira sp. A	-	2901	-
Katodinium rotundatum	-	14	-
Cryptomonas acuta	-	167	-
Chroomonas sp.	-	264	-
Flagellate D	-	403	-
Cyanophyceae sp. A	-	486	-
Guinardia flaccida	-	139	-
Raphoneis amphiceros	-	14	-
Pyramimonas sp. A	-	14	-
Asterionella japonica	-	14	-
Navicula septentrionalis	-	111	-
Navicula sp. E	-	14	-
Cryptomonad B	-	28	-
Exuviaella compressa	-	14	-
Amphora sp.	-	14	-
Cryptomonad C	-	28	-
Rhizosolenia delicatula	-	28	-
Gyrodinium sp. A	-	28	-
Actinoptychus undulatus	-	14	-
Rhizosolenia setigera	-	14	-

Table AII-1 (cont.)

Date: May 9, 1975   Cruise No.: 18

Species	Abundance (cells/ml) Station I	Station II	Station III
Cylindrotheca closterium	14	-	-
Asterionella japonica	21	7	14
Cryptomonas acuta	166	118	180
Chroomonas sp.	1344	1213	1719
Pyramimonas sp. A	256	353	222
Katodinium rotundatum	139	49	97
Leptocylindrus minimus	249	270	166
Cerataulina bergonii	166	215	139
Cryptomonad C	21	83	69
Cyanophyceae sp. A	624	215	374
Thalassiosira sp. A	42	83	49
Guinardia flaccida	49	173	208
Gymnodinium sp. A	7	-	-
Gymnodinium ? *punctatum*	7	42	21
Paralia sulcata	14	-	-
Navicula sp. B	-	7	7
Chrysochromulina sp.	-	14	-
Glenodinium rotundum	-	7	7
Rhizosolenia delicatula	-	28	7
Ankistrodesmus sp.	-	21	-
Skeletonema costatum	-	21	-
Gyrodinium sp.	-	7	-
Navicula sp.	-	7	-
Rhizosolenia setigera	-	7	-
Gyrodinium spirale	-	7	-
Ochromonas sp.	-	7	-
Chaetoceros sp.	-	28	42
Chlorococcales sp. A	-	-	125
Goniaulax spinifera	-	-	14
Rhizosolenia fragilissima	-	-	14

Table AII-1 (cont.)

Date: May 28, 1975 Cruise No.: 19

Species	Abundance (cells/ml) Station I	Station II	Station III
Cryptomonas acuta	740	646	598
Chroomonas sp.	1653	2201	1926
Pyramimonas sp. A	474	167	490
Thalassiosira sp. A	670	1052	586
Cyanophyceae sp. A	509	263	742
Cerataulina bergonii	35	155	72
Cryptomonad C	139	203	275
Flagellate D	670	383	574
Euglena sp. A	12	-	12
Katodinium rotundatum	46	120	60
Gyrodinium sp. A	116	203	179
Ankistrodesmus sp.	23	24	24
Cyclotella sp.	243	191	-
Phaeodactylum tricornutum	12	36	24
Guinardia flaccida	35	36	48
Paralia sulcata	12	-	96
Calycomonas ovalis	23	-	-
Fragilaria oceanica	46	24	-
Chrysochromulina sp.	23	48	24
Amphora sp.	12	-	-
Skeletonema costatum	69	132	167
Chlamydomonas sp. A	-	12	-
Eutreptia sp.	-	12	24
Rhizosolenia delicatula	-	12	12
Tetraselmis sp.	-	12	-
Asterionella japonica	-	12	-
Ochromonas sp.	-	-	12
Navicula sp. B	-	-	24
Gymnodinium punctatum	-	-	12
Scenedesmus sp.	-	-	24
Pyramimonas sp. B	-	-	12
Rhizosolenia setigera	-	-	12
Gymnodinium simplex	-	-	12

Table AII-2

Occurrence of net phytoplankton species by station over the year

Station I

Species	1974 5/9	1974 5/22	1974 10/15	1974 10/30	1974 11/14	1974 12/13	1975 1/11	1975 3/18	1975 5/9	1975 5/28
Ceratium furca							.011			.005
Ceratium fusus	.002*	.014					.008			.060
Ceratium macroceros		.002								.005
Ceratium tripos	.327	.937						.022		.559
Noctiluca sp.				.430						.003
Peridinium depressum				.017			.004			
Phalacroma sp.							.002	.002		
Biddulphia favus										
Biddulphia granulata	.002	.007		.002		.002		.004		.016
Chaetoceros sp. A			.011							
Chaetoceros sp. B			.099				.004			
Chaetoceros sp. C							.002			
Chaetoceros sp. D	.062									
Coscinodiscus spp.		.002	.005	.004		.002	.002			.003
Ditylum brightwelli			.002				.006			
Guinardia flaccida						.123	.002	.433	.984	.055
Planktoniella sol										
Rhizosolenia alata							.002	.004		.003
Rhizosolenia delicatula			.491					.011		
Rhizosolenia setigera	.094							.026	.002	.005
Rhizosolenia stolterfothii			.002							
Rhizosolenia styliformis				.007		.004		.004	.002	
Skeletonema costatum										
Thalassiosira spp.	.316						.019	.221	.007	
Asterionella japonica	.167	.029					.116	.114	.004	.005
Gyrosigma spencerii										
Nitzschia closterium										
Nitzschia seriata		.007	.383	.540		.858	.591	.120		.011
Plagiogramma vanheurckii										

Table AII- 2 (cont.)

Station I

Species	1974						1975			
	5/9	5/22	10/15	10/30	11/14	12/13	1/11	3/18	5/9	5/28
Thalassionema nitzschioides							.108			
Thalassiothrix fraeunfeldii			.007				.011	.124	.018	
sp. C										
sp. D										
sp. E										
sp. F										
sp. G										
sp. H										
sp. I										
sp. J										
sp. K										
sp. L										
sp. M										.263

* value represents proportion of total cells counted

Table AII- 2(cont.)

Station II

Species	1974						1975					
	5/9	5/22	10/15	10/30	11/14	12/13	1/11	2/20				
								0700	0800	0900	1000	1100
Ceratium furca							.004	.002	.018	.015	.005	.012
Ceratium fusus	.014	.005					.002	.007	.063	.049	.012	.059
Ceratium macroceros											.005	
Ceratium tripos	.211	.311						.005	.018	.010		.008
Noctiluca sp.				.497	.843							
Peridinium depressum			.016	.002	.002							
Phalacroma sp.		.002										
Biddulphia favus	.003				.006							
Biddulphia granulata	.051	.037	.016	.007	.017	.006	.035	.002	.045	.049	.007	.032
Chaetoceros sp. A												
Chaetoceros sp. B			.104							.020		.008
Chaetoceros sp. C			.009							.015	.012	.032
Chaetoceros sp. D												
Coscinodiscus spp.	.005		.069	.006	.023	.004	.028		.013	.010	.007	.016
Ditylum brightwelli			.018					.002		.015		.004
Guinardia flaccida			.005	.006	.073	.212		.268	.018	.030	.045	.012
Planktoniella sol												
Rhizosolenia alata					.006	.009	.015		.013	.010	.010	.008
Rhizosolenia delicatula											.186	.040
Rhizosolenia setigera	.249					.002		.032	.013	.015	.015	.024
Rhizosolenia stolterfothii												
Rhizosolenia styliformis			.002		.017	.002		.018		.005	.007	.008
Skeletonema costatum							.496					.012
Thalassiosira spp.	.111		.007								.010	.095
Asterionella japonica	.341	.595	.023			.019	.009	.378	.281	.177	.394	.202
Gyrosigma spencerii												
Nitzschia closterium											.002	
Nitzschia seriata	.016	.037	.726	.482	.008	.740	.088	.110	.339	.443	.176	.372
Plagiogramma vanheurckii												

Table AII- 2 (cont.)

Station II

Species	1974						1975					
	5/9	5/22	10/15	10/30	11/14	12/13	1/11	2/20				
								0700	0800	0900	1000	1100
Thalassionema nitzschioides		.010	.012				.093	.059	.071	.079	.025	.003
Thalassiothrix fraeunfeldii			.007			.004	.229	.005	.085	.059	.015	.016
sp. C												
sp. D								.037				
sp. E								.069			.040	
sp. F									.022			
sp. G											.025	
sp. H												
sp. I												
sp. J												
sp. K												
sp. L		.002										
sp. M		.002			.002							

Table AII-2 (cont.)

Station II

Species	1975												
	2/20								3/18	4/14			
	1200	1300	1400	1500	1600	1700	1800	1900		0800	0900	1000	1100
Ceratium furca	.009	.009	.003	.003		.012	.011	.009					
Ceratium fusus	.002	.009	.015	.045		.024	.051	.028				.002	.004
Ceratium macroceros						.002	.003	.002	.001				
Ceratium tripos	.011	.002	.003	.013		.009	.032	.007				.002	.002
Noctiluca sp.													
Peridinium depressum		.002	.003										
Phalacroma sp.													
Biddulphia favus										.002			
Biddulphia granulata	.022	.005	.020	.008	.113	.012	.131	.054	.012	.010	.030	.002	.004
Chaetoceros sp. A								.005					
Chaetoceros sp. B			.020	.027		.005							
Chaetoceros sp. C	.007	.002	.030	.035			.005	.005					
Chaetoceros sp. D													
Coscinodiscus spp.	.009	.002	.008		.031	.002	.027	.014			.016	.002	.004
Ditylum brightwelli		.002	.003	.011	.005	.005							
Guinardia flaccida	.263	.305	.013	.032	.031	.112	.019	.115	.383	.839	.876	.932	.881
Planktoniella sol										.002			
Rhizosolenia alata	.002	.002	.008	.008	.015	.005	.005	.005	.003		.009	.005	.006
Rhizosolenia delicatula	.061	.055	.005	.029		.007							
Rhizosolenia setigera	.015	.018	.023	.027	.010	.031	.003	.016	.012	.004	.007	.007	.008
Rhizosolenia stolterfothii													
Rhizosolenia styliformis	.002	.009	.013	.005		.007	.005	.002					
Skeletonema costatum	.009								.347	.125	.023	.030	.042
Thalassiosira spp.	.072	.101	.101	.061		.095	.067	.052	.160	.015	.016	.016	
Asterionella japonica	.300	.261	.244	.222		.337	.283	.323					.012
Gyrosigma spencerii		.002											
Nitzschia closterium	.002	.007	.003	.005									
Nitzschia seriata	.154	.147	.325	.243	.144	.124	.227	.141	.051				
Plagiogramma vanheurckii						.040					.021		

Table AII- 2 (cont.)

Station II

Species	1975												
	2/20								3/18	4/14			
	1200	1300	1400	1500	1600	1700	1800	1900		0800	0900	1000	1100
Thalassionema nitzschioides		.018	.098	.134		.040	.067	.068					
Thalassiothrix fraeunfeldii	.041	.021	.108	.086	.521	.128	.051	.155	.022				
sp. C									.009				
sp. D					.082								
sp. E		.018			.046		.016						.036
sp. F													
sp. G													
sp. H			.088										
sp. I				.055									
sp. J						.002							
sp. K													
sp. L										.002			
sp. M													

Table AII- 2 (cont.)

Station II

1975

Species	4/14								5/9	5/28
	1200	1300	1400	1500	1600	1700	1800	1900		
Ceratium furca										
Ceratium fusus	.002	.002					.002			.134
Ceratium macroceros										.030
Ceratium tripos		.005						.002	.009	.299
Noctiluca sp.										.003
Peridinium depressum										
Phalacroma sp.										
Biddulphia favus				.002						.003
Biddulphia granulata	.002	.009	.002	.019	.009	.007	.005	.007	.011	.079
Chaetoceros sp. A								.002		
Chaetoceros sp. B										
Chaetoceros sp. C										
Chaetoceros sp. D										
Coscinodiscus spp.			.002	.006	.009	.002	.002	.002	.002	.037
Ditylum brightwelli										
Guinardia flaccida	.883	.957	.881	.931	.954	.977	.942	.957	.915	.110
Planktoniella sol				.002						
Rhizosolenia alata					.002	.002			.002	.116
Rhizosolenia delicatula										
Rhizosolenia setigera	.013	.014	.018	.009	.005		.002	.019	.002	.021
Rhizosolenia stolterfothii										
Rhizosolenia styliformis		.002	.004	.006			.012	.005	.009	
Skeletonema costatum									.030	
Thalassiosira spp.	.010		.081		.011					
Asterionella japonica		.011	.011	.017	.007	.009			.002	.027
Gyrosigma spencerii										
Nitzschia closterium	.002								.002	
Nitzschia seriata	.013			.009			.037	.005		
Plagiogramma vanheurckii										.018

Table AII-2 (cont.)

Station II

1975

Species	4/14 1200	1300	1400	1500	1600	1700	1800	1900	5/9	5/28
Thalassionema nitzschioides									.005	
Thalassiothrix fraeunfeldii	.008									.003
sp. C										
sp. D										
sp. E	.065									
sp. F										
sp. G										
sp. H										
sp. I										
sp. J										
sp. K										
sp. L										
sp. M									.002	.113

Table AII- 2 (cont.)

Station III

Species	1974 5/9	1974 5/22	1974 10/15	1974 10/30	1974 11/14	1974 12/13	1975 1/11	1975 3/18	1975 5/9	1975 5/28
Ceratium furca							.009			
Ceratium fusus	.002	.002					.005		.005	.135
Ceratium macroceros										.030
Ceratium tripos	.104	.259					.002		.014	.263
Noctiluca sp.				.012	.912					
Peridinium depressum			.015							
Phalacroma sp.										
Biddulphia favus	.002									.039
Biddulphia granulata	.046	.071			.002	.002	.069		.009	.161
Chaetoceros sp. A										
Chaetoceros sp. B			.154							
Chaetoceros sp. C										
Chaetoceros sp. D										
Coscinodiscus spp.	.002	.002	.022		.034	.005	.007		.002	.028
Ditylum brightwelli			.002			.002	.007			
Guinardia flaccida	.002				.018	.146		.192	.945	.056
Planktoniella sol										
Rhizosolenia alata			.005		.002	.005	.011	.002		.067
Rhizosolenia delicatula			.356	.761						
Rhizosolenia setigera	.207									.087
Rhizosolenia stolterfothii										
Rhizosolenia styliformis				.001	.029	.002			.002	.009
Skeletonema costatum								.557		
Thalassiosira spp.	.126							.184	.005	
Asterionella japonica	.482	.563					.011			
Gyrosigma spencerii										
Nitzschia closterium										
Nitzschia seriata		.096	.420	.223		.822	.483	.039		.026
Plagiogramma vanheurckii										.017

Table AII- 2 (cont.)

Station III

Species	1974						1975			
	5/9	5/22	10/15	10/30	11/14	12/13	1/11	3/18	5/9	5/28
<u>Thalassionema nitzschioides</u>			.005	.027			.137			
<u>Thalassiothrix fraeunfeldii</u>				.002	.002	.016	.204			.009
sp. C										
sp. D										
sp. E										
sp. F										
sp. G							.021	.025		
sp. H	.057									
sp. I										
sp. J										
sp. K										
sp. L										
sp. M			.002							.069

Table AII-3

Surface Net Phytoplankton

February 20, 1975
Station II

Time:	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
Species													
Ceratium tripos	.005	.018	.010	-	.008	.011	.002	.003	.013	-	.009	.032	.007
Ceratium fusus	.007	.063	.049	.012	.059	.022	.009	.015	.045	-	.024	.051	.028
Biddulphia granulata	.002	.045	.049	.007	.032	.022	.005	.020	.008	.113	.012	.131	.054
Rhizosolenia setigera	.032	.013	.015	.015	.024	.015	.018	.023	.027	.010	.031	.003	.016
Asterionella japonica	.378	.281	.177	.394	.202	.300	.261	.244	.222	-	.337	.283	.323
Nitzschia seriata	.110	.339	.443	.176	.372	.154	.147	.325	.243	.144	.124	.227	.141
Thalassionema nitzschioides	.059	.071	.079	.025	.043	-	.018	.098	.134	-	.040	.067	.068
Ditylum brightwelli	.002	-	.015	-	.004	-	.002	.003	.011	.005	.005	-	-
Thalassiothrix frauenfeldii	.005	.085	.059	.015	.016	.041	.021	.108	.086	.521	.128	.051	.155
Rhizosolenia styliformis	.018	-	.005	.007	.008	.002	.009	.013	.005	-	.007	.005	.002
Guinardia flaccida	.268	.018	.030	.045	.012	.263	.305	.013	.032	.031	.112	.019	.115
Ceratium furca	.002	.018	.015	.005	.012	.009	.009	.003	.003	-	.012	.011	.009
sp. D	.037	-	-	-	-	-	-	-	-	.082	-	-	-
sp. E	.069	-	-	.040	-	-	.018	-	-	.046	-	.016	-
Coscinodiscus spp.	-	.013	.010	.007	.016	.009	.002	.008	-	.031	.002	.027	.014
Chaetoceros sp. B	-	-	.020	-	.008	-	-	.020	.027	-	.005	-	-
Chaetoceros sp. C	-	-	.015	.012	.032	.007	.002	.030	.035	-	-	.005	.005
Rhizosolenia alata	-	.013	.010	.010	.008	.002	.002	.008	.008	.015	.005	.005	.005
sp. F	-	.022	-	-	-	-	-	-	-	-	-	-	-
Thalassiosira spp.	-	-	-	.010	.095	.072	.101	.101	.061	-	.095	.067	.052
Ceratium macroceros	-	-	-	.005	-	-	-	-	-	-	.002	.003	.002
Rhizosolenia delicatula	-	-	-	.186	.040	.061	.055	.005	.029	-	.007	-	-
Nitzschia closterium	-	-	-	.002	-	.002	.007	.003	.005	-	-	-	-

Table AII-3 (cont.)

Surface Net Phytoplankton

February 20, 1975
Station II

Time:	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
sp. G	-	-	-	.025	-	-	-	-	-	-	-	-	-
Skeletonema costatum	-	-	-	-	.012	.009	-	-	-	-	-	-	-
Peridinium depressum	-	-	-	-	-	-	.002	.003	-	-	-	-	-
Chaetoceros sp. A	-	-	-	-	-	-	-	-	-	-	-	-	.005
Gyrosigma spencerii	-	-	-	-	-	-	.002	-	-	-	-	-	-
sp. H	-	-	-	-	-	-	-	.088	-	-	-	-	-
sp. I	-	-	-	-	-	-	-	-	.005	-	-	-	-
Plagiogamma vanheurckii	-	-	-	-	-	-	-	-	-	-	.040	-	-
sp. J	-	-	-	-	-	-	-	-	-	-	.002	-	-

Table AII-3 (cont.)

Surface Net Phytoplankton

April 14, 1975
Station II

Time:	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
Species												
Biddulphia granulata	.010	.030	.002	.004	.002	.009	.002	.019	.009	.007	.005	.007
Rhizosolenia setigera	.004	.007	.007	.008	.013	.014	.018	.009	.005	-	.002	.019
Thalassiosira spp.	.015	.016	.016	-	.010	-	.081	-	.011	-	-	-
Biddulphia favus	.002	.016	.016	-	.010	-	-	.002	-	-	-	-
sp. M	.002	-	-	-	-	-	-	-	-	-	-	-
Guinardia flaccida	.839	.876	.932	.881	.008	.957	.881	.931	.954	.977	.942	.957
Skeletonema costatum	.125	.023	.030	.042	-	-	-	-	-	-	-	-
Planktoniella sol	.002	-	-	-	-	-	-	.002	-	-	-	-
Coscinodiscus sp.	-	.016	.002	.004	-	-	.002	.006	.009	.002	.002	.002
Asterionella japonica	-	-	-	.012	-	.011	.011	.017	.007	.009	-	-
Nitzschia seriata	-	-	-	-	.013	-	-	.009	-	-	.037	.005
Rhizosolenia alata	-	.009	.005	.006	-	-	-	-	.002	.002	-	-
Nitzschia closterium	-	-	-	-	.002	-	-	-	-	-	-	-
Plagiogamma vanheurckii	-	.021	-	-	-	-	-	-	-	-	-	-
sp. E	-	-	-	.036	.065	-	-	-	-	-	-	-
Ceratium tripos	-	-	-	-	-	.005	-	-	-	-	-	.002
Ceratium fusus	-	-	-	-	-	.002	-	-	-	-	.002	-
Rhizosolenia styliformis	-	-	-	-	-	.002	.004	.006	-	-	.012	.005

Table AIII-1

Zooplankton abundance per m^3

Date: June 20, 1974 Cruise No.: 5

Species	Station 1 T	Station 1 B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	17,272	12,950	391	2,037	558	6,107
Centropages hamatus	1,084	180	164	103	227	213
Centropages typicus	-	18	-	-	-	-
Oithona similis	-	-	2	-	22	-
Paracalanus sp.	-	-	-	-	7	-
Pseudocalanus minutus	77	506	25	62	337	19
Temora longicornis	310	127	7	-	205	-
Podon sp.	1,582	36	194	669	704	155
Balanus sp. (cyprid)	99	18	2	72	44	39
Fish eggs	111	54	289	62	183	-
Veliger	-	54	-	51	7	58
Polychaete larvae	22	54	2	-	22	19
Copepod nauplii	11	-	-	-	14	-
Copepodites	-	36	-	82	44	19
Limacina inflata	44	271	2	62	27	77
Fish larvae	-	-	-	10	7	-
Crangon septemspinosa	310	36	7	41	-	-
Upogebia affinis	77	-	5	-	-	-
Uca sp.	-	-	40	-	36	-
Centropages (copepodite)	-	54	50	10	-	-
Labidocera aestiva	44	18	17	10	-	19
Balanus sp. nauplii	11	36	-	10	-	-
Pagurus longicarpus	11	-	-	-	-	-
Neopanope texana	22	36	-	20	499	-
Pseudodiaptomus coronatus	-	271	-	154	-	562
Labidocera (copepodite)	-	-	-	20	-	-
Globigerina sp.	-	-	-	-	-	19
Eucalanus attenuatus	-	-	-	-	-	19
Pinnixa sayana	-	-	-	-	-	19
Ovalipes ocellatus	-	-	-	-	-	19
Total	21,092	14,755	1,197	3,475	2,953	7,363

Table AIII-1 (cont.)

Date: July 19, 1974 Cruise No.: 6

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	202	17,770	256	2,158	303	743
Pseudodiaptomus coronatus	9	2,521	34	532	117	2,060
Labidocera (copepodite)	7	40	7	-	8	26
Centropages typicus	3	-	-	-	-	-
Copepod nauplii	2	-	7	-	-	-
Fish eggs	56	-	23	-	40	-
Copepodites	-	-	2	7	-	-
Limacina inflata	-	20	9	-	12	18
Callianassa sp.	-	-	2	14	4	9
Neopanope texana	-	-	431	-	52	-
Uca sp.	-	-	36	14	1,293	9
Microcalanus sp.	-	-	-	-	4	-
Centropages (copepodite)	-	-	-	-	32	-
Eurytemora affinis	-	-	-	-	69	-
Oithona sp. ?	-	-	-	7	4	-
Centropages hamatus	-	20	-	-	4	-
Pseudocalanus minutus	-	-	-	-	8	-
Pinnixa sayana	-	-	-	78	73	53
Pagurus longicarpus	-	20	-	-	8	-
Crangon septemspinosa	-	40	-	-	-	-
Penilia avirostris	-	20	-	-	-	-
Oikopleura sp.	-	40	-	7	-	9
Mesuda	-	-	-	7	-	-
Eucalanus attenuatus	-	-	-	-	-	-
Hexapanopeus angustifrons	-	-	-	-	-	18
Libinia sp.	-	20	-	-	-	9
Total	279	20,511	807	2,824	2,031	2,954

Date: August 1, 1974 Cruise No.: 7

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	727	579	3,516	-	5,242	7,793
Centropages hamatus	3	-	-	-	-	-
Labidocera (copepodites)	38	-	-	-	-	77
Oithona similis	3	-	-	29	-	-
Copepod nauplii	55	12	26	-	16	-
Unidentified copepodites	100	-	26	-	62	51
Fish eggs	83	6	287	86	234	-
Oikopleura sp.	3	6	-	-	-	-

Table AIII-1 (cont.)

Date: August 1, 1974 (cont.) Cruise No.: 7

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Neopanope texana	14	-	-	72	94	77
Panopeus herbstii	14	-	-	72	-	-
Centropages (copepodite)	-	-	78	-	16	-
Polychaete larvae	-	-	13	-	-	26
Acartia clausi	-	-	-	-	16	-
Pseudodiaptomus coronatus	-	1,200	-	460	-	410
Limacina inflata	-	48	-	72	-	128
Medusa	-	66	-	-	-	-
Pagurus longicarpus	3	6	-	14	-	26
Paracalanus sp.	-	6	-	-	-	51
Cyphonautes larva	-	12	-	-	-	-
Acartia (copepodite)	-	-	-	-	-	102
Upogebia affinis	-	12	-	-	-	51
Callianassa sp.	3	-	-	-	-	102
Fish larvae	-	-	-	-	-	51
Pinnixa sayana	-	6	-	-	-	487
Mysid	-	12	-	-	-	-
Total	1,046	1,971	3,946	805	5,680	9,432

Date: August 21, 1974 Cruise No.: 8

	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B*
Acartia tonsa	74	1,575	27	148	22	
Centropages typicus	1	-	-	-	-	
Labidocera (copepodite)	4	-	-	-	-	
Microcalanus sp.	1	-	-	-	-	
Paracalanus sp.	1	5	-	-	-	
Unidentified copepodites	5	-	-	-	-	
Polychaete larvae	4	5	2	-	2	
Limacina inflata	24	31	16	37	7	
Balanus (nauplii)	1	-	-	-	-	
Neopanope texana	3	-	6	-	22	
Uca sp.	1	5	-	-	-	
Crangon septemspinosa (zoea)	-	5	-	-	-	
Centropages (copepodites)	-	-	2	-	-	
Balanus (cyprid)	-	-	1	-	-	
Pinnixa sayana	-	5	5	-	5	
Oithona similis	-	5	-	-		
Pseudodiaptomus coronatus	-	36	-	-	-	
Cyphonautes larva	-	31	-	-	-	
Medusa	-	5	-	37	-	
Globigerina sp.	-	21	-	-	-	

Table AIII-1 (cont.)

Date: August 21, 1974 (cont.) Cruise No.: 8

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B*
Upogebia affinis	2	5	-	-	-	
Unidentified zoeae	-	-	-	37	-	
Mysid	-	67	-	-	-	
Ovalipes ocellatus	-	5	-	-	-	
Total	121	1,806	59	259	58	

* Not preserved

Date: September 17, 1974 Cruise No.: 9

	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia clausi	-	-	1	-	-	-
Acartia tonsa	199	2,638	13	557	623	1,367
Pseudodiaptomus coronatus	65	516	4	354	41	175
Oithona sp. ?	80	59	12	33	66	14
Paracalanus sp.	24	206	5	22	25	-
Microcalanus sp.	18	-	2	-	43	-
Corycaeus sp.	26	192	1	22	13	52
Centropages hamatus	2	-	-	-	-	-
Centropages typicus	2	-	-	-	-	5
Euterpina acutifrons	2	15	-	4	-	9
Unidentified copepodites	37	44	3	29	43	19
Copepod nauplii	15	44	4	22	10	14
Oikopleura sp.	96	192	96	100	170	128
Limacina inflata	28	59	3	70	-	47
Penilia avirostris	65	59	8	26	58	38
Fish eggs	3	-	4	-	-	-
Polychaete larvae	3	15	1	-	3	5
Emerita talpoida	2	-	-	-	-	5
Ovalipes ocellatus	2	-	-	-	-	9
Crangon septemspinosa (zoea)	-	-	1	-	-	-
Hexapanopeus angustifrons	-	-	1	-	-	-
Balanus (nauplii)	-	15	1	-	-	-
Centropages (copepodites)	-	-	-	-	28	-
Pseudocalanus minutus	-	44	-	18	5	9
Eucalanus attenuatus	-	118	-	-	-	14
Temora (copepodite)	-	15	-	-	-	9
Copepod sp. A	-	59	-	15	-	19
Globigerina	-	177	-	-	-	-
Cyphonautes larva	-	118	-	41	-	261
Medusa	-	59	-	18	-	47
Veliger	-	103	-	11	-	-

Table AIII-1 (cont.)

Date: September 17, 1974 (cont.) Cruise No.: 9

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Balanus cyprid	-	15	-	4	-	-
Unidentified amphipod	-	15	-	-	-	-
Echinoderm larva	-	-	-	29	-	24
Acartia copepodite	-	-	-	148	-	57
Corophium sp.	-	-	-	-	-	19
Pagurus longicarpus	-	-	-	-	-	33
Pinnotheres maculatus	-	29	-	7	-	14
Neopanope texana	-	-	-	7	-	5
Pinnixa sayana	-	-	-	4	-	5
Total	669	4,806	160	1,541	1,128	2,403

Date: October 15, 1974 Cruise No.: 10

	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	96	100	60	136	125	740
Acartia (copepodite)	8	-	-	-	58	-
Centropages typicus	29	-	26	43	19	82
Centropages (copepodite)	38	-	8	-	19	33
Corycaeus	67	-	21	43	48	66
Euterpina acutifrons	25	-	8	68	58	378
Eucalanus attenuatus	4	-	-	26	-	33
Paracalanus sp.	197	100	68	238	182	691
Pseudocalanus minutus	54	-	10	247	77	625
Temora longicornis	8	-	5	-	10	-
Temora (copepodite)	46	-	16	9	86	66
Penilia avirostris	163	-	55	136	67	181
Cyphonautes larva	21	100	24	68	38	99
Oikopleura	670	897	550	1,250	1,371	1,316
Limacina inflata	122	-	29	60	38	99
Sagitta sp.	8	-	-	-	-	-
Polychaete larva	34	-	13	51	29	345
Veliger bivalve?	13	199	71	17	192	16
Amphipod	4	-	-	-	-	-
Unidentified copepod?	38	-	24	-	-	16
Unidentified copepodites	8	-	3	-	29	16
Medusa	17	299	13	111	10	99
Echinoderm larva	29	-	16	51	249	131
Copepod nauplius	13	-	18	-	77	-
Balanus (nauplius)	17	-	3	9	-	16
Globigerina	8	100	-	17	-	-
Evadne sp.	4	-	8	-	-	-
Pagurus longicarpus	4	-	-	-	-	-

Table AIII-1 (cont.)

Date: October 15, 1974 (cont.) Cruise No.: 10

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Pseudodiaptomus coronatus	-	-	-	-	38	395
Labidocera aestiva	-	-	-	9	10	-
Balanus (cyprid)	-	-	-	-	10	16
Natantia (larvae)	-	-	-	-	19	-
Oithona similis	-	-	-	9	-	-
Unidentified pteropod	-	-	-	9	-	-
Reptantia (zoeae)	-	-	-	9	-	-
Harpacticoid copepod	-	-	-	-	-	16
Total	1,745	1,795	1,049	2,616	2,859	5,475

Date: October 30, 1974 Cruise No.: 11

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	483	3,657	8,719	1,124	2,338	2,352
Centropages hamatus	284	57	386	-	156	-
Centropages typicus	85	1,600	129	34	57	52
Centropages (copepodite)	625	228	515	42	198	105
Paracalanus sp.	2,500	4,400	32	321	283	1,150
Euterpina acutifrons	511	3,142	354	194	283	627
Microcalanus sp.	1,080	-	804	-	269	-
Temora longicornis	142	1,886	418	8	57	-
Oithona similis	170	171	-	25	14	52
Pseudocalanus minutus	597	6,571	193	194	198	627
Corycaeus sp.	426	1,257	-	34	-	105
Eucalanus attenuatus	85	114	32	25	28	105
Unidentified copepodites	313	229	-	25	-	52
Acartia clausi	-	-	-	-	71	-
Copepod nauplii	-	114	-	-	28	52
Veligers	682	3,600	32	161	14	105
Polychaete larvae	142	457	869	279	439	1,620
Limacina inflata	284	457	-	17	14	-
Echinoderm larvae	57	-	-	-	-	-
Balanus nauplii	-	171	32	-	-	-
Penilia avirostris	114	286	32	59	57	52
Oikopleura sp.	369	114	-	85	85	-
Calanus sp.	-	-	-	-	85	314
Pinnotheres maculatus	28	-	-	-	-	-
Temora (copepodite)	-	686	-	51	-	-
Acartia (copepodite)	-	114	-	8	-	105
Pseudodiaptomus coronatus	-	571	-	110	-	261
Labidocera aestiva	-	228	-	-	-	523

Table AIII-1 (cont.)

Date: October 30, 1974 (cont.) Cruise No.: 11

Species	Station I T	Station I B	Station II T	Station II B	Station T	Station B
Medusa	-	171	-	8	-	-
Sagitta sp.	-	114	-	-	-	-
Noctiluca scintillans	-	-	-	-	-	-
Total	8,977	30,395	12,547	2,804	4,674	8,259

Date: November 14, 1974 Cruise No.: 12

	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	267	185	1,026	766	268	331
Acartia (copepodite)	57	-	28	11	34	-
Centropages hamatus	-	-	7	49	-	28
Centropages typicus	172	244	166	32	78	-
Corycaeus sp.	521	643	194	49	122	166
Euterpina acutifrons	534	448	208	103	214	110
Eucalanus attenuatus	13	10	-	-	-	-
Oithona similis	114	97	42	49	63	-
Paracalanus sp.	629	789	159	205	181	249
Pseudocalanus minutus	102	156	132	43	54	83
Temora longicornis	172	380	28	22	24	-
Temora (copepodite)	13	-	14	5	5	28
Eurytemora affinis	6	-	-	-	-	-
Unidentified copepod	76	-	7	5	-	-
Copepod species A	89	136	83	59	107	-
Veliger	350	555	374	281	371	470
Penilia avirostris	102	58	7	22	49	-
Limacina inflata	19	49	7	-	20	-
Globigerina sp.	13	29	-	-	5	-
Oikopleura sp.	32	78	14	27	68	28
Polychaete larvae	32	39	7	-	5	-
Balanus (nauplius)	6	-	-	-	5	-
Echinopleuteus larvae	6	-	7	-	5	-
Centropages (copepodite)	-	-	35	5	20	-
Pseudodiaptomus coronatus	-	19	63	32	-	-
Unidentified copepodites	-	-	21	5	-	-
Sagitta sp.	-	10	7	-	15	-
Unidentified amphipod	-	-	7	5	-	-
Echinoderm larvae	-	-	-	-	5	-
Medusa	-	-	-	-	5	-
Labidocera aestiva	-	10	-	5	-	-
Noctiluca	-	-	-	-	-	-
Total	3,325	3,935	2,643	1,780	1,723	1,493

Table AIII-1 (cont.)

Date: December 13, 1974 Cruise No.: 13

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	2,395	3,777	5,683	2,142	4,923	4,249
Acartia clausi	77	-	-	-	61	17
Acartia (copepodite)	510	363	311	89	1,029	231
Oithona similis	618	121	93	-	40	50
Centropages typicus	355	23	-	-	-	66
Centropages hamatus	15	291	155	30	-	116
Centropages (copepodite)	155	73	124	30	20	50
Paracalanus sp.	324	121	-	-	-	17
Corycaeus sp.	31	-	-	-	-	-
Oithona brevicornis	139	-	-	-	20	-
Unidentified copepodites	170	-	186	-	282	66
Unidentified copepod	108	-	-	-	40	-
Copepod nauplii	232	-	62	-	61	17
Microcalanus sp.	31	-	-	-	-	-
Polychaete larvae	510	242	31	60	-	50
Veliger	185	2,010	745	357	303	380
Balanus (nauplii)	62	-	-	-	-	17
Echinoderm larvae	108	-	-	-	-	-
Oikopleura sp.	15	-	-	-	-	-
Globigerina sp.	108	145	-	30	-	17
Foraminifera spp.	-	48	62	536	282	-
Euterpina acutifrons	-	73	31	30	-	50
Sagitta sp.	-	24	-	-	-	17
Temora longicornis	-	24	31	-	-	-
Pseudodiaptomus coronatus	-	-	-	-	-	-
Balanus (cyprid)	-	-	-	-	-	17
Harpacticoid copepod	-	-	31	-	-	17
Total	6,148	7,336	7,545	3,304	7,061	5,444

Table AIII-1 (cont.)

Date: January 16, 1975 Cruise No.: 14

Species	Station I		Station II		Station III	
	T	B	T	B	T	B
Acartia clausi	29	6	-	5	89	8
Acartia tonsa	14	194	147	208	263	236
Centropages hamatus	112	104	217	185	184	87
Centropages typicus	275	37	10	71	43	43
Centropages (copepodites)	604	174	178	275	171	152
Paracalanus sp.	36	-	10	5	11	-
Pseudocalanus minutus	43	115	17	9	59	16
Oithona similis	94	51	24	33	16	19
Temora longicornis	7	62	17	14	14	11
Veliger	14	169	395	753	79	385
Balanus (nauplii)	7	20	10	-	3	0
Fish eggs	43	-	3	-	3	0
Echinoderm larvae	14	-	-	-	3	3
Unidentified copepodites	11	8	17	5	11	-
Polychaete larvae	-	6	3	-	0	-
Mancocuma altera	-	-	7	-	5	-
Balanus (cyprid)	-	-	0	19	3	8
Temora (copepodites)	-	6	-	-	0	8
Medusa	-	20	-	-	-	30
Cyphonautes larva	-	6	-	5	-	5
? *Pseudocalanus* (copepodite)	-	17	-	-	-	16
Acartia (copepodite)	-	8	-	14	-	8
Copepod nauplius	-	3	-	-	-	-
Evadne sp.	-	3	-	-	-	-
Foraminifera spp.	-	-	-	33	-	-
Harpacticoid copepod	-	-	-	5	-	-
Corycaeus sp.	-	-	-	5	-	3
Globigerina sp.	-	-	-	-	-	3
Pseudodiaptomus coronatus	-	-	-	-	-	5
Total	1,303	1,009	1,052	1,644	957	1,046

Table AIII-1 (cont.)

Date: February 20, 1975 Cruise No.: 15

Species	0700 T	0700 B	0800 T	0800 B	1000 T	1000 B
Acartia clausi	3	4	8	18	18	-
Acartia tonsa	2	71	30	259	75	763
Centropages hamatus	6	7	5	-	86	21
Centropages typicus	48	54	39	46	48	50
Centropages copepodite	48	56	13	42	30	110
Oithona brevicornis	4	-	2	-	14	-
Oithona similis	3	30	-	42	7	28
Paracalanus sp.	18	2	3	14	16	46
Pseudocalanus minutus	142	364	22	371	145	156
Temora longicornis	20	180	12	224	52	67
Tortanus discaudatus	-	-	-	-	-	-
Unidentified copepodite	69	30	29	25	97	96
Balanus (nauplii)	4	-	3	4	2	11
Balanus (cyprid)	-	4	2	-	-	4
Sagitta sp.	-	-	-	-	-	-
Mysid	-	-	-	-	-	-
Veliger	-	11	-	4	-	7
Mancocuma altera	-	-	-	-	-	71
Acartia copepodite	-	4	-	-	-	-
Pseudocalanus copepodite	-	11	-	95	-	-
Temora copepodite	-	56	-	49	-	85
Fish eggs	-	13	-	-	-	7
Medusa	-	-	-	46	-	35
Foraminifera sp.	-	-	-	4	-	14
Cyphonaute larvae	-	-	-	11	-	-
Species A (copepod)	-	-	-	-	-	11
Copepod nauplii	-	-	-	-	-	4
Unidentified copepod	-	-	-	-	-	7
Total	367	897	168	1,254	590	1,593

Table AIII-1 (cont.)

Date: February 20, 1975 (cont.) Cruise No.: 15

Species	1100 T	1100 B	1200 T	1200 B
Acartia clausi	9	19	22	11
Acartia tonsa	24	351	9	322
Centropages hamatus	78	71	18	36
Centropages typicus	42	44	26	45
Centropages copepodite	18	88	9	66
Oithona brevicornis	3	-	6	-
Oithona similis	5	34	2	20
Paracalanus sp.	5	7	-	9
Pseudocalanus minutus	14	206	5	259
Temora longicornis	10	84	6	66
Tortanus discaudatus	-	-	-	-
Unidentified copepodite	22	37	10	20
Balanus (nauplii)	-	-	-	7
Balanus (cyprid)	-	-	-	-
Sagitta sp.	-	-	-	-
Mysid	-	-	-	-
Veliger	< 1	7	-	4
Mancocuma altera	-	-	-	-
Acartia copepodite	-	3	-	-
Pseudocalanus copepodite	-	37	-	-
Temora copepodite	-	67	-	-
Fish eggs	-	10	-	11
Medusa	-	10	-	7
Foraminifera sp.	-	7	-	14
Cyphonaute larvae	-	7	-	-
Species A (copepod)	-	-	-	-
Copepod nauplii	-	-	-	-
Unidentified copepod	-	-	-	-
Total	231	1,089	113	897

Table AIII-1 (cont.)

Date: February 20, 1975 (cont.) Cruise No.: 15

Species	1300 T	1300 B	1400 T	1400 B	1600 T	1600 B
Acartia clausi	13	21	27	14	46	5
Acartia tonsa	16	496	11	345	297	76
Centropages hamatus	18	43	5	28	112	91
Centropages typicus	41	43	5	101	97	35
Centropages copepodite	34	91	4	79	104	43
Oithona brevicornis	12	-	2	-	31	-
Oithona similis	7	38	< 1	31	-	23
Paracalanus sp.	8	5	< 1	6	39	2
Pseudocalanus minutus	45	255	2	280	815	163
Temora longicornis	13	126	1	107	35	13
Tortanus discaudatus	-	-	< 1	-	-	-
Unidentified copepodite	31	112	7	36	324	13
Balanus (nauplii)	1	5	-	-	8	-
Balanus (cyprid)	< 1	-	< 1	-	-	-
Sagitta sp.	-	-	-	-	-	-
Mysid	-	-	-	-	-	-
Veliger	-	-	-	-	-	3
Mancocuma altera	-	-	-	-	-	2
Fish eggs	-	11	-	14	-	5
Medusa	-	-	-	36	-	22
Foraminifera sp.	-	11	-	-	-	7
Species A (copepod)	-	3	-	-	-	-
Cyphonaute larvae	-	3	-	3	-	2
Acartia copepodite	-	11	-	14	-	-
Pseudocalanus copepodite	-	72	-	64	-	-
Temora copepodite	-	-	-	28	-	-
Copepod nauplii	-	-	-	3	-	-
Corycaeus sp.	-	-	-	-	-	-
Polychaete larvae	-	-	-	-	-	-
Unidentified copepod	-	-	-	-	-	-
Total	240	1,346	68	1,189	1,908	505

Table AIII-1 (cont.)

Date: February 20, 1975 (cont.) Cruise No.: 15

Species	1700 T	1700 B	1800 T	1800 B
Acartia clausi	18	4	44	102
Acartia tonsa	411	116	509	102
Centropages hamatus	223	321	126	158
Centropages typicus	65	54	69	20
Centropages copepodite	94	116	44	86
Oithona brevicornis	18	-	38	-
Oithona similis	-	31	-	36
Paracalanus sp.	88	-	107	7
Pseudocalanus minutus	1,220	433	1,387	362
Temora longicornis	6	71	44	115
Tortanus discaudatus	0	-	-	49
Unidentified copepodite	352	36	289	-
Balanus (nauplii)	6	4	13	3
Balanus (cyprid)	-	-	-	-
Sagitta sp.	6	-	-	-
Mysid	-	-	6	-
Veliger	-	4	-	3
Mancocuma altera	-	-	-	-
Fish eggs	-	9	-	3
Medusa	-	4	-	-
Foraminifera sp.	-	22	-	10
Species A (copepod)	-	-	-	3
Cyphonaute larvae	-	4	-	6
Acartia copepodite	-	18	-	-
Pseudocalanus copepodite	-	40	-	-
Temora copepodite	-	45	-	-
Copepod nauplii	-	4	-	3
Corycaeus sp.	-	0	-	3
Polychaete larvae	-	0	-	3
Unidentified copepod	-	-	-	7
Total	2,507	1,336	2,676	1,081

Table AIII-1 (cont.)

Date: February 20, 1975 (cont.)   Cruise No.: 15

Species	1900 T	1900 B
Acartia clausi	16	4
Acartia tonsa	91	110
Centropages hamatus	80	330
Centropages typicus	80	35
Centropages copepodite	59	62
Oithona brevicornis	16	-
Oithona similis	-	4
Paracalanus sp.	69	4
Pseudocalanus minutus	794	432
Temora longicornis	150	273
Unidentified copepodite	273	44
Balanus (nauplii)	5	-
Balanus (cyprid)	-	4
Sagitta sp.	-	-
Mysid	5	-
Veliger	-	-
Mancocuma altera	5	-
Acartia copepodite	-	-
Pseudocalanus copepodite	-	66
Temora copepodite	-	22
Fish eggs	-	33
Medusa	-	-
Foraminifera sp.	-	-
Cyphonaute larvae	-	-
Species A (copepod)	-	-
Copepod nauplii	-	-
Unidentified copepod	-	-
Total	1,643	1,423

Table AIII-1 (cont.)

Date: March 18, 1975 Cruise No.: 16

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia tonsa	28	126	103	32	834	284
Acartia clausi	74	21	114	64	124	42
Centropages typicus	483	-	228	149	247	84
Centropages hamatus	883	589	148	288	432	147
Oithona similis	102	211	262	75	556	189
Oithona brevicornis	139	569	285	256	710	241
Paracalanus sp.	112	84	274	299	1,205	410
Pseudocalanus minutus	1,088	842	2,555	1,142	5,745	1,956
Temora longicornis	492	2,992	183	266	803	273
Unidentified copepodites	698	632	958	993	2,625	315
Sagitta sp.	28	253	11	43	31	11
Balanus (nauplii)	9	42	46	11	-	-
Veliger	9	42	34	224	-	-
Limacina inflata	-	21	11	128	-	-
Fish eggs	-	-	11	-	-	-
Microcalanus sp.	-	-	11	-	-	-
Balanus (cyprid)	-	21	-	21	93	31
Crangon septemspinosa	-	-	-	53	31	11
Crab zoeae	-	21	-	-	-	-
Labidocera aestiva	-	105	-	-	-	-
Euterpina acutifrons	-	-	-	21	-	-
Centropages copepodite	-	-	-	310	-	536
Acartia copepodite	-	-	-	-	-	31
Total	4,145	6,571	5,234	4,375	13,436	4,561

Table AIII-1 (cont.)

Date: April 14, 1975 Cruise No.: 17

Species	0800 T	0800 B	1100 T	1100 B	1200 T	1200 B
Acartia clausi	529	106	32	-	29	65
Acartia tonsa	7	24	-	-	13	19
Centropages hamatus	987	1,145	562	-	394	1,875
Centropages typicus	64	0	40	-	55	-
Centropages copepodite	493	791	190	-	357	1,026
Oithona brevicornis	43	-	44	-	117	-
Oithona similis	21	94	4	-	67	224
Paracalanus sp.	14	24	16	-	50	-
Pseudocalanus minutus	129	118	89	-	42	289
Temora longicornis	665	814	553	-	407	1,586
Tortanus discaudatus	7	24	-	-	-	-
Unidentified copepodite	300	24	69	-	76	-
Sagitta sp.	14	83	-	-	8	9
Copepod nauplii	-	12	-	-	-	-
Veligers	-	24	-	-	-	-
Balanus (cyprid)	21	-	8	-	-	-
Crangon septemspinosa (zoeae)	50	71	-	-	-	-
Fish eggs	-	83	-	-	-	47
Pseudodiaptomus coronatus	93	83	4	-	-	-
Polychaete larvae	7	-	-	-	-	-
Globergerina sp.	-	35	-	-	-	-
Medusa	-	-	-	-	-	-
Mysid	-	-	-	-	-	-
Acartia copepodite	-	83	-	-	-	47
Pinnixa sayana	-	-	-	-	-	-
Neopanope texana sayi	-	-	-	-	-	-
Temora copepodite	-	-	-	-	-	-
Cyphonaute larvae	-	-	-	-	-	-
Cancer irroratus (zoeae)	-	-	-	-	-	-
Limacina inflata	7	-	-	-	-	-
Euterpina acutifrons	-	24	-	-	-	-
Eurytemora sp.	-	12	-	-	-	-
Foraminifera sp.	-	12	-	-	-	-
Labidocera aestiva	-	-	-	-	-	-
Corycaeus sp.	-	-	-	-	-	-
Harpacticoid	-	-	-	-	-	-
Total	3,451	3,686	1,611	-	1,615	5,187

Table AIII-1 (cont.)

Date: April 14, 1975 (cont.) Cruise No.: 17

Species	1300 T	1300 B	1400 T	1400 B
Acartia clausi	6	98	29	106
Acartia tonsa	2	56	-	35
Centropages hamatus	300	1,427	565	1,833
Centropages typicus	29	-	21	9
Centropages copepodite	111	546	237	584
Oithona brevicornis	34	-	25	-
Oithona similis	27	308	8	27
Paracalanus sp.	-	56	29	9
Pseudocalanus minutus	36	518	216	558
Temora longicornis	52	1,623	42	1,275
Tortanus discaudatus	6	-	8	9
Unidentified copepodite	21	168	83	142
Sagitta sp.	-	56	29	133
Copepod nauplii	2	14	-	9
Veliger	-	-	17	35
Balanus (cyprid)	-	-	8	9
Crangon septemspinosa (zoeae)	-	-	8	18
Fish eggs	2	-	-	44
Pseudodiaptomus coronatus	4	-	21	-
Polychaete larvae	-	28	-	18
Globergerina sp.	-	-	-	-
Medusa	-	-	-	-
Mysid	-	-	-	-
Acartia copepodite	-	-	-	44
Pinnixa sayana	-	-	-	-
Neopanope texana sayi	-	-	-	-
Temora copepodite	-	-	-	-
Cyphonaute larvae	-	14	-	9
Cancer irroratus (zoeae)	-	-	-	-
Limacina inflata	-	-	-	-
Euterpina acutifrons	-	14	-	-
Eurytemora sp.	-	-	-	-
Foraminifera sp.	-	-	-	35
Labidocera aestiva	-	-	-	-
Corycaeus sp.	-	14	-	-
Harpacticoid	-	14	-	9
Total	632	4,954	1,346	4,950

Table AIII-1 (cont.)

Date: April 14, 1975 (cont.)   Cruise No.: 17

Species	1500 T	1500 B	1600 T	1600 B	1700 T	1700 B
Acartia clausi	122	-	561	167	418	64
Acartia tonsa	-	-	28	56	17	154
Centropages hamatus	784	-	1,151	1,214	2,089	2,023
Centropages typicus	45	-	66	-	200	-
Centropages copepodite	249	-	234	140	479	666
Oithona brevicornis	54	-	84	-	35	-
Oithona similis	23	-	37	98	9	77
Paracalanus sp.	27	-	28	-	52	26
Pseudocalanus minutus	249	-	374	600	200	371
Temora longicornis	140	-	590	1,647	1,880	3,009
Tortanus discaudatus	14	-	19	42	17	64
Unidentified copepodite	127	-	271	90	322	166
Sagitta sp.	36	-	9	42	17	-
Copepod nauplii	5	-	-	-	-	-
Veliger	14	-	-	14	-	-
Balanus (cyprid)	5	-	-	28	9	-
Crangon septemspinosa (zoeae)	9	-	-	98	69	51
Fish eggs	5	-	-	70	-	38
Pseudodiaptomus coronatus	14	-	28	14	-	77
Polychaete larvae	-	-	-	-	9	13
Globergerina sp.	-	-	-	56	-	26
Medusa	-	-	-	14	-	-
Mysid	-	-	-	14	-	-
Acartia copepodite	-	-	-	-	-	154
Pinnixa sayana	-	-	-	-	-	102
Neopanope texana sayi	-	-	-	-	-	13
Temora copepodite	-	-	-	-	-	-
Cyphonaute larvae	-	-	-	-	-	-
Cancer irroratus (zoeae)	-	-	-	-	-	-
Total	1,922	-	3,480	4,384	5,822	7,094

Table AIII-1 (cont.)

Date: April 14, 1975 (cont.) Cruise No.: 17

Species	1800 T	1800 B	1900 T	1900 B
Acartia clausi	939	174	561	131
Acartia tonsa	55	95	236	100
Centropages hamatus	2,415	876	2,274	664
Centropages typicus	207	-	266	39
Centropages copepodite	1,353	347	1,299	703
Oithona brevicornis	28	-	133	-
Oithona similis	28	63	15	70
Paracalanus sp.	69	-	-	8
Pseudocalanus minutus	594	276	960	688
Temora longicornis	2,526	2,478	1,048	487
Tortanus discaudatus	14	16	15	23
Unidentified copepodite	511	32	236	46
Sagitta sp.	69	71	74	8
Copepod nauplii	-	-	-	-
Veligers	-	16	-	-
Balanus (cyprid)	55	24	-	15
Crangon septemspinosa (zoeae)	566	166	-	46
Fish eggs	-	63	-	8
Pseudodiaptomus coronatus	-	8	576	-
Polychaete larvae	-	8	44	8
Globergerina sp.	-	-	-	8
Medusa	-	-	-	-
Mysid	-	-	-	-
Acartia copepodite	-	63	-	23
Pinnixa sayana	-	-	-	-
Neopanope texana sayi	-	-	-	-
Temora copepodite	-	-	-	8
Cyphonaute larvae	-	-	-	8
Cancer irroratus (zoeae)	-	-	-	8
Total	9,429	4,776	7,737	3,099

Table AIII-1 (cont.)

Date: May 9, 1975 Cruise No.: 18

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Acartia clausi	5	-	43	93	170	349
Acartia tonsa	5	-	-	-	28	-
Centropages hamatus	242	2,272	1,174	1,633	1,435	3,638
Centropages typicus	57	222	140	-	113	604
Centropages copepodite	196	291	183	139	500	2,034
Oithona brevicornis	206	485	11	301	264	418
Oithona similis	88	222	22	104	104	93
Paracalanus sp.	36	1,302	65	996	151	430
Pseudocalanus minutus	31	1,718	86	2,085	208	418
Temora longicornis	1,187	6,566	1,163	4,413	2,559	5,207
Tortanus discaudatus	46	14	-	81	38	453
Unidentified copepodite	93	762	248	614	283	511
Crangon septemspinosa	21	-	11	81	-	314
Balanus (nauplii)	5	14	-	12	19	-
Copepod nauplii	5	42	-	-	9	12
Sagitta sp.	-	55	-	46	19	12
Evadne sp.	-	28	-	12	19	-
Cancer irroratus	-	28	-	12	-	12
Calanus finmarchicus	-	14	-	12	-	-
"Arrow Worm"	-	-	-	12	-	12
Limacina inflata	-	-	-	35	-	-
Euterpina acutifrons	-	-	-	-	-	23
Shrimp-Species A	-	-	-	-	-	12
Total	2,223	14,035	3,146	10,681	5,919	14,587

Table AIII-1 (cont.)

Date: May 28, 1975 Cruise No.: 19

Species	Station I T	Station I B	Station II T	Station II B	Station III T	Station III B
Centropages hamatus	2,836	4,178	62	44	177	44
Centropages typicus	350	1,293	20	-	41	-
Centropages copepodite	600	1,012	56	165	227	658
Oithona similis	6	140	-	35	6	250
Oithona brevicornis	69	553	11	-	22	14
Temora longicornis	31	1,030	1	6	-	-
Fish eggs	350	262	123	82	136	61
Unidentified copepodite	87	384	27	-	10	14
Pseudocalanus minutus	12	66	-	-	-	-
Acartia clausi	56	721	24	-	16	17
Podon sp.	75	19	35	47	2	14
Labidocera aestiva	31	-	-	-	2	34
Balanus (nauplii)	19	1,208	-	-	-	78
Balanus (cyprid)	6	206	-	222	2	91
Crangon septemspinosa (zoeae)	6	112	-	1	2	51
Polychaete larvae	6	103	-	10	2	61
Copepod nauplii	19	9	22	-	2	3
Ovalipes ocellatus	6	-	-	-	-	3
Acartia tonsa	-	525	4	26	8	74
Veliger	-	19	2	-	-	-
Tortanus discaudatus	-	47	1	-	-	7
Insect larvae	-	-	1	-	-	-
Microcalanus sp.	-	112	1	-	-	-
Evadne sp.	-	-	1	-	2	-
Unidentified copepodite	-	384	-	-	10	14
Limacina inflata	-	66	-	3	-	7
Pagurus longicarpus	-	9	-	-	-	3
Sagitta sp.	-	37	-	-	-	24
Paracalanus sp.	-	9	-	1	-	27
Crab megalops	-	-	-	-	18	-
Crab zoeae (Portunnid)	-	-	-	-	20	-
Acartia copepodite	-	-	-	7	-	17
Pseudodiaptomus coronatus	-	-	-	1	-	-
Eucalanus attenuatus	-	-	-	1	-	-
Temora copepodite	-	-	-	-	-	71
Total	4,565	12,120	391	651	695	1,623

Table AV-1

Sediment characteristics for transect stations

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Water Content (%)	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1- 1	1.383	1.463	+0.236	2.390	0.380	28.6	1.12	1.0	92.3	3.4	3.3
1- 2	1.537	2.525	+0.189	2.283	0.360	24.7	1.06	10.2	76.2	7.5	6.1
1- 3	2.600	0.546	+0.167	1.768	0.166	29.1	0.76	-	94.6	2.8	2.6
1- 4	2.253	0.173	+0.054	1.239	0.208	24.2	0.48	-	95.5	2.5	2.0
1- 5	0.917	0.711	-0.295	1.792	0.510	20.0	0.12	5.4	93.7	0.9	-
1- 6	1.303	0.783	-0.398	2.049	0.380	20.4	1.98	5.6	93.7	0.7	-
1- 7	2.197	0.394	+0.093	0.969	0.222	23.4	0.14	-	99.0	1.0	-
1- 8	1.273	1.435	-0.060	1.003	0.404	18.8	0.55	7.1	89.1	3.8	-
1- 9	0.927	0.826	-0.144	1.148	0.500	21.4	0.13	1.5	97.5	1.0	-
2- 1	1.443	0.707	-0.110	1.111	0.348	24.1	0.53	0.1	97.0	1.3	1.6
2- 1B	1.490	1.073	+0.136	1.807	0.329	20.6	0.90	0.5	93.4	4.6	1.5
2- 2	1.543	1.051	+0.213	0.925	0.387	18.8	0.66	0.3	96.8	1.1	1.8
2- 3	1.753	1.207	-0.088	1.601	0.277	27.0	0.56	6.4	89.1	2.4	2.1
2- 3B	1.670	1.262	-0.078	1.182	0.298	23.3	0.39	1.1	95.0	2.6	1.3
2- 4	3.757	1.149	+0.426	2.879	0.078	36.0	1.77	-	70.3	24.3	5.4
2- 5	3.080	0.428	+0.080	1.287	0.119	28.9	0.62	-	95.0	4.0	1.0
2- 6	5.220	3.141	+0.750	1.105	0.073	71.2	3.26	-	53.2	26.2	20.6
3- 1	1.910	1.326	+0.196	1.613	0.263	10.8	0.71	-	92.4	4.0	3.6
3- 2	3.273	0.317	+0.048	1.386	0.104	11.9	0.43	-	97.2	2.8	-
3- 3	1.783	1.227	-0.060	1.608	0.278	13.1	1.24	2.3	92.6	2.4	2.7
3- 4	1.997	0.299	-0.028	1.025	0.251	19.0	0.30	-	99.2	0.8	-
3- 5	2.193	0.740	-0.168	1.071	0.205	11.3	0.29	-	96.8	3.2	-
3- 6	2.207	0.958	+0.428	0.809	0.265	17.7	1.36	-	94.9	3.3	1.8
3- 7	6.550	2.976	+0.536	0.847	0.023	76.2	6.46	-	19.1	51.2	29.7
3- 8	1.707	2.234	+0.281	2.101	0.342	10.5	0.67	4.4	82.6	7.3	5.7

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Water Content (%)	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
4- 1	3.783	1.166	+0.455	3.229	0.076	38.2	1.53	-	71.0	23.2	5.8
4- 2	3.053	0.342	+0.276	1.163	0.125	27.2	0.52	-	96.5	3.5	-
4- 3	2.393	0.858	+0.582	1.968	0.229	26.5	0.98	-	92.0	5.1	2.9
4- 4	1.220	0.851	+0.317	2.272	0.445	18.1	0.70	-	94.6	5.4	-
4- 5	2.040	0.324	+0.214	1.054	0.125	26.1	0.56	-	99.9	0.1	-
4- 6	1.610	0.998	+0.153	0.929	0.358	22.7	0.47	0.3	96.9	1.9	0.9
4- 7	2.873	0.354	+0.253	1.514	0.140	30.2	0.74	-	96.5	1.5	2.0
4- 8	2.790	0.623	+0.008	1.037	0.144	30.8	0.58	-	95.8	3.0	1.2
4- 9	3.287	0.425	+0.086	1.313	0.103	31.8	0.90	-	92.4	6.1	1.5
4-10	3.497	0.465	+0.208	1.187	0.092	29.4	0.75	-	86.7	11.3	2.0
4-11	3.610	1.214	+0.645	3.762	0.093	8.1	0.86	-	79.6	13.9	6.5
4-12	6.887	3.031	+0.324	0.876	0.012	117.8	8.92	-	16.2	49.5	34.3
5- 1	2.743	1.365	+0.238	1.645	0.159	30.4	0.81	-	86.0	9.8	4.2
5- 2	5.847	2.676	+0.633	1.341	0.035	93.7	4.69	-	21.0	60.0	19.0
5- 3	2.493	1.213	+0.563	2.629	0.200	29.9	1.10	-	90.0	5.9	4.1
5- 4	2.500	0.923	-0.173	0.992	0.160	24.1	0.77	-	94.4	5.6	-
5- 5	2.137	0.589	+0.089	1.329	0.231	31.1	0.57	-	97.5	2.5	-
5- 6	3.157	0.416	+0.248	1.332	0.113	32.3	0.33	-	93.6	4.4	2.0
5- 7	2.747	0.686	+0.455	1.280	0.167	30.5	1.07	-	91.5	4.0	4.5
5- 8	3.267	0.465	+0.275	1.203	0.108	29.0	0.50	-	91.9	4.3	3.8
5- 9	3.953	1.546	+0.758	3.637	0.086	44.4	1.72	-	74.0	17.3	8.7
5-10	5.090	2.580	+0.727	1.559	0.058	74.2	4.04	-	48.2	36.7	15.1
6- 1	4.937	2.209	+0.644	2.414	0.055	49.2	3.08	-	41.0	46.0	13.0
6- 2	3.163	0.610	+0.282	1.168	0.120	33.7	0.90	-	89.0	8.3	2.7
6- 3	2.467	0.317	+0.156	1.077	0.188	27.7	0.40	-	98.5	1.5	-
6- 4	2.840	0.784	+0.291	1.486	0.148	26.0	1.16	-	89.0	8.5	2.5
6- 5	2.830	0.534	+0.138	1.810	0.144	28.1	0.53	-	94.9	2.9	2.2

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Water Content (%)	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
6- 6	1.860	0.949	+0.304	0.828	0.327	31.3	0.44	-	96.1	3.0	0.9
6- 7	2.930	0.436	+0.225	1.369	0.136	32.2	0.60	-	95.5	3.0	1.5
6- 8	3.850	1.369	+0.555	3.078	0.078	44.3	1.86	-	69.5	22.8	7.7
6- 9	3.680	1.623	+0.711	3.383	0.103	43.5	1.62	-	76.6	15.0	8.4
7- 1	2.780	2.183	+0.454	1.318	0.189	38.1	2.21	-	69.0	24.5	6.5
7- 2	3.843	0.873	+0.361	2.545	0.070	37.3	1.65	-	65.4	30.1	4.5
7- 3	1.357	0.862	-0.317	1.444	0.344	22.2	0.69	1.7	96.7	1.6	-
7- 4	2.817	0.439	+0.121	1.305	0.144	31.3	0.61	-	97.2	2.8	-
7- 5	6.447	3.020	+0.529	0.891	0.023	120.1	7.76	-	22.8	48.9	28.3
7- 6	1.457	0.990	-0.012	1.351	0.360	21.8	0.34	1.5	94.8	3.7	
7- 7	1.700	0.841	+0.297	2.414	0.317	18.8	0.81	-	93.8	3.5	2.7
(7- 7)	1.653	0.764	+0.277	2.134	0.321	25.7	0.81	-	94.9	3.1	2.0
7- 8	3.280	1.215	+0.717	2.374	0.128	32.5	1.14	-	81.7	13.3	5.0
8- 1	3.590	0.555	+0.211	1.280	0.086	37.6	1.07	-	79.8	17.0	3.2
8- 2	3.663	1.435	+0.543	3.001	0.089	38.3	1.61	-	71.2	21.0	7.8
8- 3	2.820	0.468	+0.361	2.186	0.148	29.2	0.50	-	92.8	5.9	1.3
8- 4	5.570	2.585	+0.652	1.076	0.044	90.5	5.14	-	36.2	44.0	19.8
8- 5	5.730	2.749	+0.745	1.167	0.047	75.2	3.83	-	32.0	46.6	21.4
8- 6	2.303	1.240	+0.087	0.856	0.210	25.0	0.75	-	91.9	5.7	2.4
8- 7	3.307	0.410	+0.081	1.499	0.103	29.2	0.68	-	93.9	4.2	1.9
8- 8	1.583	0.469	-0.054	1.100	0.329	18.8	0.25	-	99.6	0.4	-
8- 9	1.053	1.150	+0.065	1.856	0.470	29.3	0.75	4.4	88.6	4.7	2.3
9- 1	4.693	1.749	+0.638	3.533	0.051	39.6	2.00	-	27.9	50.1	22.0
9- 2	5.917	2.646	+0.724	1.251	0.0395	82.8	4.68	-	22.9	56.2	20.9
9- 3	7.047	3.119	+0.487	0.853	0.0145	110.3	7.80	-	8.2	56.5	35.3
9- 4	3.247	0.350	+0.147	1.134	0.107	19.9	0.46	-	96.4	3.6	-

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Water Content (%)	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
9- 5	3.233	0.417	+0.107	1.088	0.108	28.6	0.63	-	95.2	3.6	1.2
9- 6	3.283	0.422	+0.211	1.308	0.105	23.1	0.40	-	93.1	4.6	2.3
9- 7	1.533	0.674	+0.090	1.104	0.355	23.7	0.25	-	97.5	2.5	-
10- 1	6.500	2.911	+0.681	1.590	0.0245	99.5	6.61	-	6.7	71.9	21.4
10- 2	5.490	2.313	+0.755	2.186	0.0454	64.5	3.01	-	21.0	62.6	16.4
10- 3	2.573	2.611	-0.206	1.717	0.091	31.0	1.34	11.2	66.1	17.2	5.5
10- 4	3.377	0.365	+0.200	1.230	0.099	32.1	0.46	-	92.7	7.0	0.3
10- 5	0.827	2.058	-0.412	1.337	0.358	17.5	0.35	20.0	76.4	2.6	1.0
10- 6	3.287	0.434	+0.067	1.280	0.104	31.9	0.71	-	94.2	4.3	1.5
10- 7	0.867	1.023	-0.270	1.253	0.493	23.3	0.27	6.8	90.7	1.5	1.0
11- 1	2.447	1.884	+0.492	1.233	0.278	28.6	1.21	-	76.5	19.1	4.4
11- 2	3.417	0.426	+0.175	1.288	0.097	31.9	0.80	-	90.7	7.1	2.2
11- 3	3.953	1.605	+0.546	3.109	0.077	38.7	1.38	-	66.2	25.0	8.8
11- 4	6.997	4.273	+0.421	1.393	0.018	99.8	5.24	-	12.0	54.8	33.2
11- 5	3.873	1.781	+0.338	3.544	0.075	47.6	1.76	0.8	64.4	26.4	8.4
11- 6	3.557	1.308	+0.141	3.733	0.087	39.8	1.22	0.4	79.3	15.7	4.6
11- 7	1.823	1.972	+0.307	1.685	0.322	32.6	1.01	4.1	84.7	7.0	4.2
12- 1	6.117	3.416	+0.444	1.195	0.0305	75.4	4.21	-	27.4	48.4	24.2
12- 2	1.770	2.837	+0.460	1.952	0.440	64.8	2.91	6.2	75.3	11.3	7.2
12- 3	-	-	-	-	-	-	-	-	-	-	-
12- 4	6.180	3.095	+0.740	0.826	0.041	92.0	4.37	-	31.2	39.1	29.7
12- 5	4.230	3.831	+0.683	0.856	0.189	71.1	4.35	1.0	60.3	17.6	21.1
13- 1	5.267	3.197	+0.380	1.100	0.045	74.4	3.16	-	42.2	37.9	19.9
13- 2	7.047	3.333	+0.470	0.991	0.015	107.4	6.80	-	10.9	55.7	33.4
13- 3	6.650	3.957	-0.032	0.862	0.0080	103.7	7.82	-	24.6	36.0	39.4
13- 4	4.247	2.439	+0.614	2.386	0.087	60.6	3.46	-	68.6	19.2	12.2
13- 5	6.287	3.459	-0.100	0.661	0.0092	119.2	9.43	-	32.1	36.8	31.1

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
14- 1	4.80	2.28	+.562	1.74	.0568	2.89	-	45.3	41.4	13.3
14- 2					NO SAMPLE					
14- 3	1.28	1.25	-.318	1.32	.360	0.57	7.3	91.4	1.3	-
14- 4	0.55	1.23	+.028	1.19	.720	0.45	9.3	86.4	2.3	-
14- 4*	0.56	1.08	+.084	1.07	.800	0.48	6.4	91.1	2.5	-
14- 5	2.94	0.38	+.178	1.33	.134	0.79	-	97.3	2.7	-
14- 6	3.13	0.86	+.525	2.71	.123	1.54	-	88.7	7.7	3.6
14- 7	0.50	0.52	+.244	1.49	.725	0.16	-	98.1	1.9	-
14- 8	2.91	0.31	+.075	0.99	.132	0.59	-	98.5	1.5	-
14- 8*	3.02	0.33	+.120	0.93	.137	0.41	-	98.6	1.4	-
14- 9	0.78	2.18	-.158	0.77	.490	0.66	21.2	76.1	2.7	-
15- 1	1.90	0.57	-.196	1.12	.256	0.39	-	98.5	1.5	-
15- 2	4.71	2.03	+.686	2.71	.0568	2.90	-	43.2	42.9	13.9
15- 3	0.72	2.19	-.371	1.85	.390	0.49	21.4	76.0	2.6	-
15- 3*	1.37	1.64	-.270	2.03	.322	0.61	10.7	87.3	2.0	-
15- 4	1.55	1.01	-.099	1.31	.321	0.78	1.3	95.8	2.9	-
15- 5	1.86	0.56	+.231	1.91	.281	0.63	4.3	93.6	2.1	-
15- 6	2.87	0.34	+.269	1.06	.141	0.68	-	98.6	1.4	-
15- 7	6.24	3.02	+.323	1.15	.0204	8.72	-	20.6	54.0	25.4
15- 8	3.14	0.77	+.168	2.45	.118	1.13	1.2	89.6	6.1	3.1
16- 1	3.79	1.41	+.557	3.89	.0820	2.07	-	75.6	17.6	6.8
16- 2	3.35	0.41	+.138	1.26	.100	0.80	-	93.2	5.4	1.4
16- 3	4.81	2.35	+.761	2.20	.0719	3.28	-	60.2	30.5	9.3
16- 4	2.46	0.82	+.602	0.75	.234	0.71	-	93.7	5.3	1.0
16- 5A	1.81	0.96	+.121	2.61	.300	0.68	0.6	95.8	3.6	-
16- 5B	2.22	0.36	+.020	1.27	.214	0.42	-	98.3	1.7	-
16- 6	2.02	0.98	+.081	1.10	.249	0.83	-	95.2	2.7	2.1
16- 7	2.75	0.54	-.273	1.58	.148	0.71	-	97.3	2.7	-

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
16- 8	3.80	1.90	+.273	2.80	.0841	2.17	-	70.7	21.3	8.0
16- 9	3.36	0.36	+.058	1.36	.0970	0.53	-	93.8	6.2	-
16-10	5.81	2.56	+.549	1.18	.0531	4.68	-	22.7	57.5	19.8
16-11	3.92	3.65	+.462	1.25	.145	2.96	1.5	61.8	20.8	15.9
17- 1	3.85	1.21	+.415	3.28	.0725	1.94	-	65.7	28.0	6.3
17- 2	3.48	0.92	+.525	2.61	.0980	1.77	-	82.1	13.5	4.4
17- 2*	3.45	0.83	+.522	2.58	.102	1.40	-	84.2	12.5	3.3
17- 3	2.30	1.16	+.570	1.60	.257	1.07	-	90.8	5.8	3.4
17- 4	2.07	0.42	+.274	0.98	.252	0.44	-	100.0	-	-
17- 5	1.82	0.88	+.059	1.21	.297	0.51	-	97.7	2.3	-
17- 6	2.98	0.56	-.217	1.38	.120	0.82	-	95.5	4.5	-
17- 7	3.40	1.32	+.379	3.86	.097	1.35	-	84.9	9.2	5.9
17- 8	3.13	0.34	+.030	0.83	.117	-	-	98.4	1.6	-
17- 9	3.21	0.45	+.078	1.17	.109	0.53	-	94.5	5.5	-
17-10	5.19	2.95	-.108	1.00	.0220	0.70	-	29.6	53.2	17.2
17-11	4.94	2.36	+.604	1.84	.058	2.75	-	45.7	40.5	13.8
18- 1	1.64	0.47	-.208	1.63	.307	0.31	-	97.2	2.8	-
18- 2	3.82	1.41	+.526	2.14	.085	2.26	-	65.7	27.1	7.2
18- 3	2.27	1.13	+.469	2.24	.240	1.04	-	91.6	5.2	3.2
18- 4	2.76	0.32	+.082	1.21	.150	0.41	-	100.0	-	-
18- 5	2.97	0.54	-.023	1.42	.131	0.60	-	96.4	3.6	-
18- 6	2.98	0.50	+.208	1.26	.132	0.34	-	95.6	4.4	-
18- 7	2.85	0.67	-.183	0.97	.131	0.79	-	96.8	3.2	-
18- 8	2.90	0.28	+.201	0.94	.138	0.51	-	99.8	0.2	-
18- 9	3.63	1.16	+.584	3.47	.089	1.67	-	78.5	16.0	5.5
18-10	5.39	2.82	+.767	1.02	.0665	3.67	-	54.1	25.0	20.9

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
19- 1	4.19	1.95	+.255	1.63	.0695	3.33	-	55.0	39.6	5.4
19- 2	3.69	0.83	+.373	2.03	.080	0.89	-	70.1	24.9	5.0
19- 2*	3.73	0.88	+.353	2.19	.078	1.43	-	69.7	25.6	4.7
19- 3	3.07	1.38	-.228	1.43	.0975	1.53	-	80.8	15.9	3.3
19- 4	1.96	1.10	+.217	0.96	.294	0.60	-	96.0	4.0	-
19- 5	2.26	0.95	+.362	0.83	.258	0.42	-	96.4	3.6	-
19- 6	1.02	0.45	+.097	1.04	.505	0.16	-	100.0	-	-
19- 7					NO SAMPLE					
19- 8	6.51	3.47	+.210	1.04	.0118	3.07	-	24.9	42.1	33.0
20- 1	4.49	1.74	+.641	3.26	.057	2.59	-	42.7	47.5	9.8
20- 2					NO SAMPLE					
20- 3	2.38	0.34	+.027	1.26	.291	0.83	-	98.8	1.2	-
20- 4	2.73	1.14	-.068	0.80	.168	0.79	-	90.7	9.3	-
20- 5	0.36	2.00	-.266	0.86	.560	0.42	26.1	70.5	3.4	-
20- 6					NO SAMPLE					
20- 7	1.54	0.49	-.072	1.04	.338	0.18	-	100.0	-	-
20- 8	2.29	0.98	-.104	2.35	.196	0.82	-	94.1	4.1	1.8
20- 9					NO SAMPLE					
21- 1	6.41	2.70	+.642	1.05	.0270	3.59	-	9.0	57.2	33.8
21- 2	4.09	1.19	+.399	2.73	.0615	1.60	-	50.0	44.5	5.5
21- 3	5.46	3.30	+.282	1.60	.0478	4.85	-	38.2	42.3	19.5
21- 4	3.04	0.36	+.054	1.02	.122	0.35	-	98.3	1.7	-
21- 5	1.88	1.97	+.157	1.52	.323	0.62	2.0	93.2	4.8	-
21- 6	1.82	0.84	+.070	1.62	.283	0.29	-	97.9	2.1	-
21- 7	1.27	0.61	+.112	1.22	.415	0.26	-	98.8	1.2	-
21- 8	1.37	0.61	+.025	1.06	.387	0.29	1.0	97.3	1.7	-

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
22- 1	7.29	2.74	+.389	1.03	.0097	8.48	-	3.3	62.6	34.1
22- 2	4.24	1.57	+.331	2.99	.0596	1.48	-	45.6	46.0	8.4
22- 3	2.83	0.87	-.560	0.92	.112	1.45	0.4	96.8	2.8	-
22- 3*	3.28	1.72	+.253	3.47	.101	2.30	-	79.3	14.6	6.1
22- 4	2.81	0.80	-.301	0.92	.125	0.70	-	95.8	4.2	-
22- 5	3.47	0.43	+.138	1.32	.0923	0.85	-	89.7	10.3	-
22- 5*	3.47	0.40	-.080	1.64	.0915	1.28	-	90.7	9.3	-
22- 6	7.84	3.71	-.001	0.77	.0041	5.04	-	19.4	31.5	49.1
22- 7	0.46	1.46	-.384	1.06	.590	0.31	17.4	81.6	1.0	-
23- 1	7.72	2.53	+.209	0.98	.0058	9.95	-	3.5	54.3	42.2
23- 2	4.02	1.58	+.668	2.90	.083	2.06	-	69.2	22.2	8.6
23- 3	1.65	0.54	-.221	1.57	.304	0.46	0.6	98.6	0.8	-
23- 4	1.37	0.74	-.455	1.54	.329	0.43	0.2	98.8	1.0	-
23- 5	2.00	0.45	+.021	1.35	.253	0.44	0.2	98.6	1.2	-
24- 1	2.11	0.71	+.074	0.71	.265	0.69	-	98.8	1.2	-
24- 2	6.03	3.22	+.486	1.33	.0303	4.14	-	25.4	41.2	33.4
24- 3	6.27	4.05	+.036	1.11	.0124	4.42	2.6	20.4	43.0	34.0
24- 4	3.77	2.10	+.290	2.19	.0815	1.80	2.2	62.6	25.0	10.2
24- 5	1.21	0.69	-.001	1.05	.430	0.31	-	99.1	0.9	-
25- 1					N O S A M P L E					
25- 2	0.96	1.34	-.176	0.87	.450	1.84	7.8	91.0	1.2	-
25- 3	9.03	4.04	-.065	1.02	.0018	3.04	2.2	6.4	31.4	60.0
25- 4	3.18	2.25	+.141	2.08	.108	1.15	1.9	75.3	14.0	8.8
25- 5	2.38	2.64	+.222	2.19	.230	2.22	7.8	73.9	10.9	7.4

Table AV-1 (cont.)

Station	M_z (ϕ)	σ_i (ϕ)	Sk_i	K_g	50% mm	Volatiles (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
26- 1	4.93	2.48	+.617	1.35	.0645	4.06	0.5	50.2	34.8	14.5
26- 2	4.25	2.19	+.673	2.82	.090	1.15	-	70.6	27.5	11.9
26- 3	6.64	2.93	+.361	1.01	.0149	7.90	-	13.5	56.1	30.4
26- 4	2.48	1.21	-.023	1.61	.157	0.93	-	91.8	5.1	3.1
26- 5	5.68	3.35	+.372	0.86	.0341	5.93	0.3	35.1	39.9	24.7

* Replicate

Table AV-2

Water quality data for transect stations

Date	Station	Salinity	Dissolved Oxygen (mg/l)	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1972								
7/24	1- 1	31.354	5.51	20	18	-100	67'	Medium coarse sand, shell fragments
7/24	1- 2	31.365	5.27	20.5	17.5	+ 50	67'	Medium coarse sand, shell fragments
7/24	1- 3	30.806	5.74	21.5	18.8	+150	56'	Fine-medium sand with trace silt
7/24	1- 4	30.180	6.25	21.5	22	+100	45'	Fine clean sand
7/24	1- 5	29.146	6.28	22	22.2	+150	33'	Clean coarse sand with pebbles
7/24	1- 6	28.475	-	22.5	21.5	+ 90	20'	Medium coarse sand with pebbles
7/24	1- 7	28.051	3.43	22	22.5	+170	12'	Fine clean sand
7/24	1- 8	25.054	7.90	25	23.7	- 60	38'	Coarse sand, pebbles, shell fragments
7/24	1- 9	24.956	6.85	24.5	23.7	+ 90	10'	Coarse clean sand, trace shell fragments
7/24	2- 1	23.360	11.46	27	36.8	+ 60	11'	Fine to medium sand, shell fragments
7/24	2- 1B	23.168	7.93	25.5	23	+ 50	23'	Medium sand, some shell fragments, clay
7/24	2- 2	30.261	4.91	22.5	18.7	- 90	76'	H_2S, medium to coarse sand, reducing zone
7/24	2- 3	30.394	5.35	21	21	+120	58'	Coarse sand with shell fragments and pebbles
7/24	2- 3B	30.133	5.44	21.5	22	- 20	30'	Medium sand, shell fragments
7/24	2- 4	27.500	6.64	23.5	24	- 90	33'	Fine silty sand with clay
7/24	2- 5	25.782	7.31	24.5	25.3	+100	10'	Fine sand, shell fragments
7/24	2- 6	23.399	6.45	26.5	25	-100	23'	Fine silty sand (organic), clay
7/25	3- 1	24.307	7.03	24.5	24.7	+130	18'	Medium sand trace organic, shell fragments
7/25	3- 2	22.688	8.70	25	25.2	+ 10	14'	Fine clean sand, few Tellina
7/25	3- 3	30.068	5.13	20	21	- 20	120'	Medium coarse sand, shell fragments, Solen fragments
7/25	3- 4	23.595	8.49	24.5	21.6	+250	12'	Clean fine sand, Haustorids, Anthropods
7/25	3- 5	29.890	5.57	20.5	19.8	+190	50'	Medium clean sand, shell fragments
7/25	3- 6	28.216	5.96	22.5	23.4	-150	50'	Fine sand, trace organic, shell fragments
7/25	3- 7	22.261	6.77	26	26	-190	24'	Muddy bottom
7/25	3- 8	19.975	5.14	28	27	-230	18'	Coarse sand, large shell fragments

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1972								
7/26	4- 1	23.347	7.50	25	23.8	-200	12'	Fine organic sand, small shell fragments
7/26	4- 2	25.196	8.45	25.5	22	-100	10'	Fine clean sand, small shell fragments
7/26	4- 3	24.874	7.20	22.5	22.3	- 80	21'	Fine sand with small shell fragments
7/26	4- 4	29.187	5.07	20.5	19.5	+200	75'	Medium to coarse sand, small shell fragments
7/26	4- 5	26.407	5.98	21.5	22	+110	20'	Fine clean sand with shell fragments
7/26	4- 6	29.067	5.78	20.5	20	- 20	45'	Medium sand, shell fragments
7/26	4- 7	24.306	9.40	23.5	21.5	+ 40	15'	Fine sand
7/26	4- 8	25.234	6.76	23	23.2	- 20	22'	Fine sand with fine shell fragments
7/26	4- 9	23.285	7.73	24	23.7	-110	15'	Fine sand, *Tellina*
7/26	4-10	23.250	7.20	24	23	- 30	20'	Fine sand, many shell fragments
7/25	4-11	19.189	6.88	28	27.6	-200	16'	Fine silty sand, clay, trace organic
7/25	4-12	15.157	7.07	29.5	27.7	-250	11'	Organic mud, H_2S
7/27	5- 1	23.331	8.06	23.5	23.7	- 90	12'	Fine medium sand, shell fragments
7/27	5- 2	24.360	8.35	22	21	-140	23'	Mud, H_2S, slight oxidized, shell fragments
7/26	5- 3	28.603	4.43	21	20	-180	68'	Fine to medium organic sand, shell fragments
7/26	5- 4	24.309	6.92	23	23	- 20	24'	Fine, clean sand, shell fragments-*Ensis*
7/26	5- 5	26.607	5.85	22	22.2	+ 90	27'	Medium sand with small pebbles, clean
7/26	5- 6	25.961	6.65	23.5	23	-100	28'	Fine sand with shell fragments
7/26	5- 7	24.246	6.76	24	23	- 40	27'	Fine to medium sand, trace organic matter
7/27	5- 8	21.608	7.18	23	23	- 80	12'	Fine hard sand
7/27	5- 9	19.165	-	25	25	-150	12'	H_2S smell, oxidized layer on top, silt
7/27	5-10	17.202	5.92	25.5	25.5	-150	12'	H_2S smell, oxidized layer on top, mud
7/27	6- 1	23.995	6.93	22	21	- 80	29'	H_2S smell, silty mud, clay, shell fragments
7/27	6- 2	24.240	7.41	22.5	21.5	+ 60	15'	Fine sand, small shell fragments

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
<u>1972</u>								
7/27	6- 3	25.244	6.57	22	22	+130	9'	Fine clean sand
7/27	6- 4	26.461	5.35	21.5	22	- 30	45'	Fine, medium sand, shell fragments
7/27	6- 5	25.785	6.07	22	22	- 20	45'	Fine sand, small shell fragments
7/27	6- 6	25.781	4.50	22	22.3	-130	18'	Fine sand, shell fragments
7/27	6- 7	25.597	6.72	22	22	- 50	24'	Fine sand, dead <u>Ensis</u>
7/27	6- 8	22.208	7.10	24	24	- 80	19'	Fine silty sand, <u>Tellina</u>, small shell fragments
7/27	6- 9	17.654	6.70	25	25	- 60	12'	H_2S odor, oxidized, silty mud, shell fragments
7/28	7- 1	24.027	6.83	23	22.5	-220	32'	Fine mud, oxidized layer on top, organic
7/28	7- 2	26.166	5.56	21.5	22.2	- 60	19'	Fine sand, organic
7/28	7- 3	27.220	5.20	21	12	+ 60	43'	Coarse, clean sand
7/28	7- 4	25.956	6.74	21.5	22	+ 50	17'	Fine, clean sand, shell fragments
7/28	7- 5	25.346	6.89	22	21.5	-130	53'	Smooth mud, H_2S odor
7/28	7- 6	25.194	6.74	22.5	22	+100	51'	Medium coarse sand with pebbles
7/28	7- 7	24.671	6.70	-	23	-130	23'	Fine to medium sand, organic
7/27	7- 8	22.063	6.95	24	23.7	-100	17'	Fine silty sand, organic, small shell fragments, shell fragments with clay sand
7/27	7- 9	18.614	6.66	24.5	-	-	13'	No sediment sample, oyster shell bottom
7/28	8- 1	21.971	9.23	24	23.5	-120	12'	Fine sand, organic
7/28	8- 2	25.743	6.17	22	21	-150	48'	Fine silt, shell fragments, oxidized layer
7/28	8- 3	22.648	9.75	23	23	+ 50	9'	Clean fine sand, small shell fragments
7/28	8- 4	24.032	6.74	22	22	-240	17'	H_2S, mud, bottom-reducing, top-oxidized
7/28	8- 5	24.354	6.80	22	21.4	-220	32'	H_2S, mud, oxidized, silt
7/28	8- 6	24.277	6.76	23.5	23.3	-100	48'	Fine and medium sand, shell fragments
7/28	8- 7	23.587	6.76	23.5	23	- 50	34'	Fine sand, shell fragments
7/28	8- 8	23.318	6.74	24	23	+110	14'	Fine clean sand, small shell fragments
7/28	8- 9	20.931	7.09	24	24.5	- 80	17'	Coarse sand with pebbles, shell fragments
8/ 7	9- 1	22.845	8.07	24.5	24	- 80	15'	Large and small shell fragments, mud
8/ 7	9- 2	22.570	6.57	24.5	23	-380	18'	Oxidized layer, mud
8/ 7	9- 3	-	6.97	24	23	-150	21'	Oxidized layer, mud

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1972								
8/ 7	9- 4	20.952	6.80	24.5	25	+ 50	14'	Very fine sand, trace organic
8/ 7	9- 5	21.949	5.53	23.5	25	+100	48'	Medium sand, fine shell fragments
8/ 7	9- 6	19.281	7.98	24.5	25	+160	18'6"	Fine sand, small shell fragments
8/ 7	9- 7	17.799	7.92	25	25	+ 70	17'	Coarse sand, shell fragments, organic
8/ 7	10- 1	19.287	6.73	24.8	25	-200	9'	Oxidized layer, fine mud and sand
8/ 7	10- 2	18.773	8.39	25.5	25	+ 20	14'	Oxidized layer, mud, shell fragments
8/ 7	10- 3	17.926	7.60	24.3	24.5	-150	23'	Medium sand, silt, shell fragments
8/ 7	10- 3	-	-	-	24	+ 50	6'	Two grabs, very fine sand
8/ 7	10- 5	19.175	6.93	25	25	- 40	47'	Medium coarse sand, pebbles
8/ 7	10- 6	17.637	7.54	25	25	- 50	19'	Organic matter, fine sand, shell fragments, plant
8/ 7	10- 7	16.503	7.79	24.8	25	+120	12'	Two grabs, oyster shell, slight organic, sand
8/ 9	11- 1	20.678	-	20.7	26	-140	17'	Silty sand, oxidized, shell fragments
8/ 9	11- 2	19.397	6.74	24.2	25	+ 90	24'	Fine sand, organic, small shell fragments
8/ 9	11- 3	18.598	7.01	24.2	25	-	27'	Medium sand, oxidized, silt, shell fragments
8/ 9	11- 4	19.822	6.59	24.1	24.7	-110	57'	Mud, thin layer sand in oxidized zone shell fragments
8/ 9	11- 5	-	6.92	24.5	25	-130	21'	Fine sand, oxidized layer, silt clay
8/ 9	11- 6	17.858	6.74	25	25	-100	28'	Silty sand, oxidized layer, plant, shell
8/ 9	11- 7	16.962	7.68	24.7	26	-110	23'	Medium to coarse sand, shell fragments, silt
8/ 8	12- 1	13.168	7.28	24.5	24	-	13'	Fine sand, silty clay, <u>Gemma gemma</u>
8/ 8	12- 2	13.533	7.12	25	24	-100	24'	Oxidized 1/2" coarse sand, shell
8/ 8	12- 3	15.351	6.78	24.5	-	- 30	49'	Two grabs, midsand, oyster shell fragments
8/ 8	12- 4	13.007	7.85	24.5	24	-130	15'	Silt, oxidize, shell fragments
8/ 8	12- 5	13.008	7.49	23.5	24	-240	10'	Two grabs, H_2S, oyster shell fragments, silt
8/ 8	13- 1	10.140	6.92	24.6	24.5	-250	16'	Oxidized
8/ 8	13- 2	11.611	6.67	24	24	-280	22'	Mud oxidized
8/ 8	13- 3	12.036	6.91	24.6	24	- 50	47'	Two grabs, mud bottom, sand top, oxidized
8/ 8	13- 4	10.987	7.12	24.6	25	+ 60	76'	Very fine sand, oxidized, shell fragments
8/ 8	13- 5	11.205	6.93	24.6	25.5	+100	18'	H_2S, fine sand, plant matter, silt

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen (ppm)	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1973								
6/19	14- 1	26.629	11.56	18.7	-	-160	15'	Dark mud, H_2S oxidized layer on top
6/19	14- 2	27.242	15.78	17.8	18	-180	22'	H_2S, oxidized layer on top, dark mud
7/ 2	14- 3	28.261	5.35	19.8	19.5	- 80?	55'	one hermit crab
7/ 2	14- 4	29.440	-	18.8	19.5	+ 65	125'	-
7/ 2	14- 5	29.314	11.86	19.6	19.5	+ 40	45'	-
7/ 2	14- 6	28.931	15.54	20.4	20.0	- 80	36'	-
7/ 2	14- 7	29.970	17.33	19.8	20.0	+ 50	30'	Coarse-medium sand
7/ 2	14- 8	29.643	15.10	20.1	20.0	- 30	17'	-
7/ 2	14- 9	30.564	13.67	19.3	19.5	+ 10	38'	Fine-medium wet sand
6/19	15- 1	26.276	14.69	18.9	19	+ 20	10'	Fine sand
7/ 2	15- 2	28.505	15.06	19.8	20.0	oxid. +110, -250	32'	slight oxidized layer, H_2S
7/ 2	15- 3	29.099	14.17	19.0	19.5	+105	70	Pebbles, medium sand
7/ 2	15- 4	-	16.11	19.5	21.0	+140	50	-
7/ 2	15- 5	28.707	15.54	20.1	20.0	+ 60	40	Clay, shells, fine-medium sand
7/ 2	15- 6	28.067	17.02	21.3	21.5	+ 20	12	-
7/ 2	15- 7	28.680	2.98	21.1	21.0	Top-10 Bot-280	28	Thin oxidized layer, H_2S
7/ 2	15- 8	28.585	17.50	21.2	21.0	Top+20 Bot-130	22	-
6/19	16- 1	25.775	15.93	19.2	19.5	-140	8	Very fine sand, slight oxidized layer
6/26	16- 2	23.573	15.69	23.5	22.5	- 60	12	-
6/26	16- 3	23.573	23.16	21.9	-	+ 70	24	Young oyster cracker
6/25	16- 4	24.875	15.93	20.5	20.0	-100	20	Fine sand
6/26	16- 5A	28.801	16.00	17.2	17.5	- 80	98	Fine-medium sand, some shell
6/26	16- 5B	26.576	25.01	19.2	19.0	-100	30	Fine sand, shell fragments
6/26	16- 6	27.850	17.98	18.0	18.5	-145	52	Fine sand, shell

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1973								
6/26	16- 7	27.114	17.06	19.0	21	Top+25 Bot+65	30	Fine sand, some silt, shell fragments
6/26	16- 8	27.261	19.22	18.9	19	Top -140 Bot -290	50	H_2S odor, silt and clay, fine sand, light oxidized layer, shell, <u>Busycon canaliculatum</u>
6/26	16- 9	23.468	32.19	21.5	21	- 70	18	Very fine sand with shell fragments
6/26	16-10	22.067	17.30	22	22	Top -100 Bot -245	23	Mud, silt and clay, thin oxidized layer
6/26	16-11	19.854	11.01	23	22	Top - 90 Bot -210	11	Silt, clay, shell
6/19	17- 1	23.911	14.38	20.2	20	+ 20	10	Many shells, H_2S
6/26	17- 2	-	24.53	20.6	20	-170	15	Fine sand with oxidized layer on top
6/26	17- 3	25.737	15.43	18.5	18.0	Top -100 Bot -225	65	Fine sand with silt, definite oxidized layer
6/26	17- 4	22.393	24.62	20.6	20.5	+ 50	10	Fine sand, silt, organic matter
6/26	17- 5	25.039	22.20	19.8	19.5	+ 55	40	Fine sand with silt
6/26	17- 6	24.524	26.47	20.3	20	+ 65	35	-
6/26	17- 7	22.404	28.34	21.4	21	Top -150 Bot -290	27	Silt, sand, shells, small oxidized

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
<u>1973</u>								
6/26	17- 8	20.718	38.05	22.5	22.5	+ 80	15	-
6/25	17- 9	-	47.88	22.9	23	- 20	10	Very fine sand with oxidized layer
6/25	17-10	17.824	32.47	23.4	22	Top -130 Bot -300	7	-
6/25	17-11	16.481	22.57	24.1	23	Top -260 Bot -330	7	Thin oxidized layer, H_2S odor
6/19	18- 1	24.124	14.20	20.2	20	+ 20	10	Fine sand
6/25	18- 2	23.435	22.85	20.120	Top	23 -180 Bot -280	-	
6/25	18- 3	28.128	12.03	17.0	18	Top + 10 Bot -140	68	Fine sand, silt, shell
6/25	18- 4	22.907	30.36	20.8	21	+ 15	12	-
6/25	18- 5	25.738	24.01	19.5	20	- 5	42	Fine sand, organics, hard packed
6/25	18- 6	25.575	24.86	19.6	21.5	- 90	26	-
6/25	18- 7	23.647	33.74	21.0	22	-190	20	Fine hard packed sand of organics
6/25	18- 8	23.717	32.13	21.3	22.5	- 45	15	Fine hard packed sand
6/25	18- 9	20.164	37.11	22.9	22.5	Top -210 Bot -280	8	-
6/25	18-10	16.481	33.47	23.9	23.5	Surf. -320	8	Thin oxidized layer, clay

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1973								
6/19	19- 1	22.331	14.34	22.5	19	-130	18	Oxidized layer, H_2S odor
6/22	19- 2	19.812	15.39	22	22	+ 20	8	Fine sand
6/25	19- 3	22.714	12.40*	19.6	20	Top - 10 Bot - 40	45	Fine sand and silt, lots of shell
6/25	19- 4	23.198	13.12*	19.7	19.5	- 40	45	-
6/25	19- 5	20.139	15.69*	21.6	20	- 50	30	-
6/25	19- 6	19.121	18.72	22.6	21.5	+ 25	8	Clean sand, oyster shells
6/22	19- 7	19.239	18.04	22	-	-	12	Live oysters, oyster shell
6/22	19- 8	15.297	5.53	23.1	22	- 50	10	Mud with thin oxidized layer, H_2S odor
6/22	20- 1	21.571	11.76	22.9	22.5	+100	12	Silty mud with oxidized layer on top
6/22	20- 2	20.145	13.38	21.9	21.5	- 70	30	Fine sand with shell fragments
6/22	20- 3	21.402	9.74	21.6	21.5	+ 60	12	Fine sand with organics
6/22	20- 4	24.311	10.53	19.4	21	-100	42	Fine to medium sand, shell fragments
6/22	20- 5	22.210	5.52	20.1	21	+120	48	Sand with silt and pebbles (Bottle broke)
6/25	20- 5	17.720	15.54*	21.4	No Sed.	+ 40	42	Two grabs: coarse sand, pebbles, large rock
6/22	20- 6	20.396	16.20	21.2	No Sed.	-	15	Three grabs: oyster bed, oyster shells, *Mercenaria* shells, no sediment.
6/22	20- 7	21.049	16.68	21.8	22	+ 60	12	Fine sand, *Gemma gemma*, oyster shell
6/22	20- 8	16.684	7.89	22.6	22	+150	10	Mud, oyster shells
6/22	20- 9	W A T E R	T O O	S H A L L O W		T O	T A K E	S A M P L E
6/21	21- 1	20.588	12.12	22.4	21.0	Top + 20 Bot -120	10	-
6/21	21- 2	20.925	15.93	22.3	22.0	-130	10	Two juvenile *Limulus*, fine sand and silt

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1973								
6/21	21- 3	18.998	22.57	21.9	22	-180	22	Large shells, fine sand and silt
6/21	21- 4	15.193	15.13	21.8	22	+ 40	8	Fine sand
6/21	21- 5	22.686	12.69	19.8	21	-110	48	Fine-medium sand, pebbles
6/21	21- 6	18.833	13.76	21.2	21.5	+ 40	26	Fine sand, many *Gemma gemma*
6/21	21- 7	18.457	15.24	21.8	23	+ 50	19	-
6/21	21- 8	17.086	16.50	22.5	22	+ 80	12	Clean, clear fine sand, few shell
6/21	22- 1	19.674	14.06	23.8	22	-300	8	-
6/21	22- 2	20.474	17.67	23.2	22	Top + 10 Bot -130	12	-
6/21	22- 3	18.410	16.59	21.2	22	-110	25	One juvenile *Mercenaria* and one large *Mercenaria* (on grab that didn't take)
6/21	22- 4	21.799	17.33	20.4	21	- 25	45	-
6/21	22- 5	16.302	17.50	22.2	22	- 50	22	One *Mercenaria*
6/21	22- 6	18.086	13.33	22.0	22.5	-181	14	-
6/21	22- 7	-	13.94	22.4	23	+ 10	12	Medium-coarse sand
6/20	23- 1	15.687	12.45	22.9	22	-190	8	Light oxidized layer, black mud
6/20	23- 2	14.857	12.36	21.5	22.5	Top + 9 Bot -140	22	Silty mud with oxidized layer on top
6/20	23- 3	17.895	9.44	21.1	21.5	+ 20	50	Fine to medium sand, few clay particles
6/20	23- 4	13.028	13.90	22	22	+ 90	18	Fine to medium sand
6/20	23- 5	12.461	12.32	22.2	22	+ 40	8	Fine sand, *Gemma gemma*
6/20	24- 1	14.113	14.23	21.8	22	+ 60	8	One stone, fine stone, one large pebble
6/20	24- 2	12.707	12.49	22.2	22.5	0	22	Mud

Table AV-2 (cont.)

Date	Station	Salinity	Dissolved Oxygen	Water Temp.	Sed. Temp.	Eh	Depth	General Comments
1973								
6/20	24- 3	15.553	10.27	21.4	22	+ 60	50	Sandy layer on top of muddy clay
6/20	24- 4	13.507	13.30	22.0	22	-120	20	Silty clay with sand layer on top, shell fragments
6/20	24- 5	11.175	14.20	22.4	23	+ 60	8	Fine to medium sand, no organic matter, few shells
6/20	25- 1	NO SAMPLE TAKEN - ONLY 1 FOOT OF WATER						
6/20	25- 2	8.457	15.03	22.5	23	+ 35	10	Clean medium sand
6/20	25- 3	11.566	9.70	21.9	23	-250	55	Clay, fine sand
6/20	25- 4	10.733	13.69	22.1	22	- 25	20	Fine sand, mud with excessive shell
6/20	25- 5	8.925	-	22.1	23	-190	12	Mud and shell
6/19	26- 1	6.302	12.94	22.2	21	-190	10	Fine sand with oxidized layer
6/20	26- 2	8.269	11.88	22.2	21	-150	35	Fine sand with oxidized layer, plant debris, marsh grass
6/20	26- 3	9.020	11.52	22.2	20.5	- 20	50	Fine sand with oxidized layer, plant debris
6/20	26- 4	7.846	11.67	22.1	21	- 50	20	Fine sand, silt and organic debris
6/20	26- 5	8.544	11.98	22	22	+ 30	10	Fine sand with oxidized layer, oyster shell, plant debris

* clear bottle

Table AV-3

Number of individuals/0.1 m^2 at transect stations

		Stations								
	Species	101	102	103	104	105	106	107	108	109
4006	*Driloneris longa*		1							
4025	*Glycera americana*	1	1						3	
4027	*Glycera dibranchiata*	2								
4028	*Glycinde solitaria*					2				
4038	*Lumbrineris tenuis*		2							
4053	*Nephtys picta*	2				1				
4080	*Eumida sanguinea*								4	
4088	*Harmothoe (Lagisca) extenuata*								1	
4092	*Lepidonotus sublevis*	1								
4093	*Sabellaria vulgaris*								1	
4118	*Spiophanes bombyx*	1								
4143	*Glycera robusta*		1							
4144	*Sthenelais (denticulatum)*		1							
4145	*Sigalion* sp.					2				
5047	*Nucula proxima*	16	4						8	
5070	*Tellina agilis*	4		5	41	2	3		2	
5080	*Ensis directus*			56					3	
5081	*Spisula solidissima*			1	19	4				
7051	*Corophium insidiosum*								1	
7055	*Unciola irrorata*	1								
7057	*Unciola dissimilis*								9	1
7076	*Protohaustorius deichmannae*							12	1	
7086	*Lysianopsis alba*		6						1	
7111	*Crangon septemspinosa*								1	
7115	*Pagurus longicarpus*	1								
7121	*Cancer irroratus*	1	1						1	
7124	*Neopanope texana sayi*		2							
7130	*Pinnixa sayana*	2								
7148	*Callianassa* sp. cf. *C. atlantica*	1	1							

Table AV-3 (cont.)

	Species	Stations							
		201	201B	202	203	203B	204	205	206
3008	*Cerebratulus lacteus*								1
3014	*Nemertea* sp.				1		1		
4025	*Glycera americana*			1	1		1		
4027	*Glycera dibranchiata*				1				1
4039	*Magelona* sp. 1				1				
4053	*Nephtys picta*				1				
4115	*Scolecolepides viridis*				1				
5027	*Nassarius trivittatus*					2			1
5068	*Gemma gemma*	24							
5070	*Tellina agilis*	8	11	4	3	10	2	4	
5080	*Ensis directus*		1	2	21	27	1		
5082	*Mulinia lateralis*							1	
5087	*Corbula contracta*			2					
7002	*Neomysis americana*	1							
7075	*Protohaustorius wigleyi*	1							
7093	*Trichophoxus epistomus*	2							
7111	*Crangon septemspinosa*					1			
7115	*Pagurus longicarpus*					2		1	

		301	302	303	304	305	306	307	308
4010	*Heteromastus filiformis*								1
4025	*Glycera americana*	1							
4027	*Glycera dibranchiata*		1				1		
4028	*Glycinde solitaria*						1		
4033	*Lumbrineris acuta*			1					
4042	*Magelona* sp. 4				1				
4053	*Nephtys picta*	1		4					
4076	*Pectinaria gouldii*			1					
4150	*Lumbrineris* sp. cf. *L. tenuis*					5			
4151	*Clymenella* sp. cf. *C. torquata*								6
4152	*Harmothoe* sp. cf. *H. extenuata*								1
5013	*Crepidula convexa*								1

Table AV-3 (cont.)

	Species	Stations 301	302	303	304	305	306	307	308
5027	*Nassarius trivittatus*		1				1		
5044	*Dorodella obscura*								1
5047	*Nucula proxima*						1		
5066	*Mercenaria mercenaria*								2
5070	*Tellina agilis*	12	3	17		13	13	1	1
5080	*Ensis directus*			2		5	2		1
5081	*Spisula solidissima*		3						
5060	*Cyclocardia borealis*	19							
7002	*Neomysis americana*	15	1						
7035	*Ampelisca abdita*								2
7047	*Batea catharinensis*	2							
7053	*Corophium tuberculatum*	22							5
7054	*Erichthonius brasiliensis*	1							
7056	*Unciola serrata*								1
7070	*Melita nitida*	1							2
7072	*Parahaustorius attenuatus*				1				
7075	*Protohaustorius wigleyi*		3	1					
7076	*Protohaustorius deichmannae*				5				
7093	*Trichophoxus epistomus*		1			4			
7106	*Paracaprella tenuis*	1		1					
7111	*Crangon septemspinosa*	1							1
7121	*Cancer irroratus*						13		
6003	*Tanystylum orbiculare*	2					1		

		401	402	403	404	405	406	407	408	409	410	411
3014	*Nemertea* sp.		1		1			3				
4006	*Driloneris longa*	4										
4027	*Glycera dibranchiata*							1			3	
4028	*Glycinde solitaria*										4	
4053	*Nephtys picta*			2		2	1		2			
4064	*Haploscoloplos fragilis*								1			
4075	*Paraonis (Paraonides) lyra*					1						

Table AV-3 (cont.)

	Species	Stations 401	402	403	404	405	406	407	408	409	410	411
4118	Spiophanes bombyx								1			
4119	Streblospio benedicti										1	
4400	Oligochaete				1							
5027	Nassarius trivittatus				1							
5047	Nucula proxima										5	
5070	Tellina agilis	4	3	19	7		30	10	7	22	8	5
5080	Ensis directus						4	78	49	1		
5081	Spisula solidissima						1		2			
5082	Mulinia lateralis							5				2
7002	Neomysis americana		2	4							1	
7035	Ampelisca abdita		2									
7037	Ampelisca verrilli	4										
7053	Corophium tuberculatum	1										
7070	Melita nitida										1	
7075	Protohaustorius wigleyi		30	1		1		17				
7076	Protohaustorius deichmannae						2					
7093	Trichophoxus epistomus							2				
7115	Pagurus longicarpus										1	
7121	Cancer irroratus										2	
7130	Pinnixa sayana			1								

		501	502	503	504	505	506	507	508	509	510
3014	Nemertea sp.	1									
4002	Asabellides oculatus	1									
4010	Heteromastus filiformis	1	2							2	
4027	Glycera dibranchiata	1				1		1			
4028	Glycinde solitaria								3		
4053	Nephtys picta			3			1				
4110	Polydora ligni	1									
4119	Streblospio benedicti	1								2	1
5047	Nucula proxima	3	13					6			4
5056	Crassostrea virginica							1			

Table AV-3 (cont.)

Stations

	Species	501	502	503	504	505	506	507	508	509	510
5070	*Tellina agilis*	20	1	14	9	1	2	11	16	1	
5080	*Ensis directus*			2		4	4	24	3		
5081	*Spisula solidissima*					3					
5082	*Mulinia lateralis*		1								
5091	*Lyonsia hyalina*					1					
7002	*Neomysis americana*			4		2	5			1	
7035	*Ampelisca abdita*									1	
7037	*Ampelisca verrilli*	1									
7047	*Batea catharinensis*						1				
7075	*Protohaustorius wigleyi*			1							
7093	*Trichophoxus epistomus*			1	2	1					
7111	*Crangon septemspinosa*						1				
7115	*Pagurus longicarpus*	1					1				
7121	*Cancer irroratus*						1				

		601	602	603	604	605	606	607	608	609
3014	*Nemertea* sp.					1	1			
3015	*Micrura leidyi*						3			
4010	*Heteromastus filiformis*	2						1	1	
4027	*Glycera dibranchiata*		2		1		1	3	3	
4028	*Glycinde solitaria*				1					
4053	*Nephtys picta*			1				1		
4065	*Haploscoloplos robustus*	1							3	
4066	*Orbinia ornatus*							1		
4119	*Streblospio benedicti*	1								2
4154	*Protodorvillea gaspeensis*	1								
5029	*Marginella roscida*				1					
5047	*Nucula proxima*	25								
5048	*Yoldia limatula*	1								
5066	*Mercenaria mercenaria*						1			
5070	*Tellina agilis*		2			2	4			

Table AV-3 (cont.)

Stations

	Species	601	602	603	604	605	606	607	608	609
5080	Ensis directus		1			1	1			
5082	Mulinia lateralis								1	2
7002	Neomysis americana	1				1				1
7035	Ampelisca abdita	2								13
7037	Ampelisca verrilli								2	
7075	Protohaustorius wigleyi			5						
7124	Neopanope texana sayi				2					
7150	Ampithoidae sp.				1					

	Species	701	702	703	704	705	706	707	708	709
3014	Nemertea sp.									6
4006	Driloneris longa		1							
4010	Heteromastus filiformis	3	3							6
4027	Glycera dibranchiata	1					3	4	3	
4053	Nephtys picta						1			
4055	Nereis (Neanthes) succinea									2
4064	Haploscoloplos fragilis		1						3	
4093	Sabellaria vulgaris							2		
4110	Polydora ligni									1
4118	Spiophanes bombyx							1		
4119	Streblospio benedicti								1	
4155	Melinna sp. cf. M. maculata							4		
5027	Nassarius trivittatus		1							
5047	Nucula proxima	1								
5070	Tellina agilis		2	2	4	2	7		4	
5080	Ensis directus							620	1	
5082	Mulinia lateralis								5	
7002	Neomysis americana							2		
7075	Protohaustorius wigleyi				1					
7093	Trichophoxus epistomus				1					
7115	Pagurus longicarpus				1					

Table AV-3 (cont.)

	Species	801	802	803	805	806	807	808	809
3014	*Nemertea* sp.				1				
4009	*Capitella capitata*	1				2	1		
4010	*Heteromastus filiformis*		3		7				13
4025	*Glycera americana*								4
4027	*Glycera dibranchiata*						2		2
4053	*Nephtys picta*							1	
4055	*Nereis (Neanthes) succinea*								1
4064	*Haploscoloplos fragilis*	1							
4077	*Eteone heteropoda*								1
4093	*Sabellaria vulgaris*					1			2
4115	*Scolecolepides viridis*							1	
4119	*Streblospio benedicti*								4
4122	*Exogone verugera*								2
4018	*Tharyx* sp. 2				1				
4157	*Cirratulus* sp. cf. *C. grandis*							1	
4158	*Asabellides* sp. cf. *A. oculatus*								1
5027	*Nassarius trivittatus*								
5047	*Nucula proxima*				1				
5048	*Yoldia limatula*		1						
5066	*Mercenaria mercenaria*						1		1
5068	*Gemma gemma*							13	17
5070	*Tellina agilis*	4	2	3	1	7	2		6
5080	*Ensis directus*					8	1		1
5082	*Mulinia lateralis*				1		3		2
5084	*Mya arenaria*								1
7002	*Neomysis americana*	2							
7011	*Cyathura polita*	8							
7056	*Unciola serrata*								1
7058	*Corophium simile*								5
7065	*Gammarus mucronatus*								1
7070	*Melita nitida*								5
7074	*Parahaustorius longimerus*							2	

Table AV-3 (cont.)

	Species	Stations							
		801	802	803	805	806	807	808	809
7075	Protohaustorius wigleyi			1					
7078	Acanthohaustorius millsi							5	
7093	Trichophoxus epistomus			1					

		901	903	904	906	907
4009	Capitella capitata	2				
4010	Heteromastus filiformis		8		1	
4027	Glycera dibranchiata				1	1
4053	Nephtys picta				1	1
4077	Eteone heteropoda	1				
4110	Polydora ligni	2				
5070	Tellina agilis				2	2
5080	Ensis directus				1	1
7053	Corophium tuberculatum	18				
7058	Corophium simile	3				
7075	Protohaustorius wigleyi	2		2		
7115	Pagurus longicarpus	1				
7124	Neopanope texana sayi	1				
7146	Xanthid sp.	1				

		1001	1002	1003	1004	1005	1006	1007
4010	Heteromastus filiformis	18	28	4				1
4027	Glycera dibranchiata					1	4	1
4053	Nephtys picta				1			
4055	Nereis (Neanthes) succinea			1				
4119	Streblospio benedicti							1
5028	Ilyanassa obsoletus		1					
5070	Tellina agilis		2		1	8		
5080	Ensis directus		1					
5082	Mulinia lateralis		3		1			
5091	Lyonsia hyalina						1	

Table AV-3 (cont.)

	Species	1001	1002	1003	1004	1005	1006	1007
7052	*Corophium lacustre*	2	1					
7053	*Corophium tuberculatum*		1					
7058	*Corophium simile*			1				
7070	*Melita nitida*		1	12				1
7075	*Protohaustorius wigleyi*				5			
7095	*Parapleustes aestuarius*						1	
7111	*Crangon septemspinosa*	2						
7115	*Pagurus longicarpus*					1		
7121	*Cancer irroratus*					1		
7123	*Eurypanopeus depressus*			2				
		1101	**1102**	**1103**	**1104**	**1105**	**1106**	**1107**
3014	*Nemertea* sp.		4				1	
4010	*Heteromastus filiformis*	7				5	6	2
4027	*Glycera dibranchiata*							1
4055	*Nereis (Neanthes) succinea*							13
5010	*Epitonium rupicola*					3		
5068	*Gemma gemma*		4	1				
5080	*Ensis directus*	2				6	1	
5082	*Mulinia lateralis*				1	45	102	
7002	*Neomysis americana*		4					
7070	*Melita nitida*	2				1		
7123	*Eurypanopeus depressus*			1				
7130	*Pinnixa sayana*	1						
		1201	**1202**	**1203**	**1204**	**1205**		
4010	*Heteromastus filiformis*			3				
4027	*Glycera dibranchiata*					1		
4055	*Nereis (Neanthes) succinea*					3		

Stations

Table AV-3 (cont.)

	Species	Stations 1201	1202	1203	1204	1205
4115	Scolecolepides viridis				1	
5068	Ensis directus	354				
5070	Tellina agilis				4	
5072	Macoma tenta	1	1			
5082	Mulinia lateralis		2			
7011	Cyathura polita					2

		1301	1303
4027	Glycera dibranchiata		1
4115	Scolecolepides viridis	1	

		1401	1402	1403	1404	1405	1406	1407	1408	1409
3014	Nemertea sp.				5				1	2
4002	Asabellides oculatus									1
4010	Heteromastus filiformis		1			1				1
4025	Glycera americana				1					
4026	Glycera capitata									1
4028	Glycinde solitaria							1		
4040	Magelona sp. 2								1	
4051	Nephtys bucera				1				1	1
4053	Nephtys picta			6					1	
4071	Aricidea cerruti			1						
4084	Phyllodoce arenae			1						
4112	Polydora websteri			2						
4115	Scolecolepides viridis			1						4
4116	Scolelepis squamata				1					
4118	Spiophanes bombyx			1						4
4124	Parapionosyllis longicirrata									1
4146	Aricidea sp.				3					
4165	? Chaetozone									1

Table AV-3 (cont.)

	Species	1401	1402	1403	1404	1405	1406	1407	1408	1409
5027	*Nassarius trivittatus*					2				
5047	*Nucula proxima*	13	5							
5053	*Mytilus edulis*	3		1	1					1
5064	*Mysella planulata*			1						
5070	*Tellina agilis*	2		15	5	3			3	18
5081	*Spisula solidissima*			1		4	1		1	
5082	*Mulinia lateralis*	1	3							
5087	*Corbula contracta*			1						
7027	*Chiridotea nigrescens*						1			
7037	*Ampelisca verrilli*		2							
7075	*Protohaustorius wigleyi*								31	2
7078	*Acanthohaustorius millsi*								1	
7111	*Crangon septemspinosa*		1							
7121	*Cancer irroratus*			1						

	Species	1501	1502	1503	1504	1505	1506	1507	1508
3014	Nemertea sp.		1		1				
4002	*Asabellides oculatus*			2					6
4006	*Driloneris longa*			1					
4015	*Caulleriella* sp. 2								56
4025	*Glycera americana*			1					
4027	*Glycera dibranchiata*			5	1	2			1
4051	*Nephtys bucera*						1		
4053	*Nephtys picta*			2	2	1			
4071	*Aricidea cerruti*		1						
4092	*Lepidonotus sublevis*			1					
4093	*Sabellaria vulgaris*			1					
4110	*Polydora ligni*								11
4115	*Scolecolepides viridis*							1	
4118	*Spiophanes bombyx*			7					1
4119	*Streblospio benedicti*								1
4142	*Scoloplos* sp.						1		

Table AV-3 (cont.)

	Species	1501	1502	1503	1504	1505	1506	1507	1508
		Stations							
4146	*Aricidea* sp.		5						
4166	? *Asabellides*			3					
4167	Ampharetidae sp. 1				1				
5012	*Crepidula fornicata*			1					
5027	*Nassarius trivittatus*								8
5037	*Sayella fusca*		1						
5047	*Nucula proxima*		63	1					8
5048	*Yoldia limatula*		1					1	
5050	*Anadara ovalis*								4
5053	*Mytilus edulis*		1						
5066	*Mercenaria mercenaria*								4
5068	*Gemma gemma*			1				1	456
5070	*Tellina agilis*	24	1	13	4	10	2	1	80
5080	*Ensis directus*			1					
5081	*Spisula solidissima*						1		
5082	*Mulinia lateralis*		3		1			1	8
6001	*Limulus polyphemus*			1					1
7002	*Neomysis americana*						1	1	
7012	*Ptilanthura tenuis*	1							
7075	*Protohaustorius wigleyi*				1	1	5		
7092	*Paraphoxus spinosus*	23							
7106	*Paracaprella tenuis*								1
7111	*Crangon septemspinosa*		1						
7115	*Pagurus longicarpus*					1			1
7121	*Cancer irroratus*			2		1			2
7130	*Pinnixa sayana*	7							
7068	*Elasmopus laevis*								1
9005	*Echinarachnius parma*					1			

Table AV-3 (cont.)

	Species	1601	1602	1603	1604	1605	1605B	1606	1607	1608	1610	1611
		Stations										
4002	Asabellides oculatus			8								
4010	Heteromastus filiformis	6								2		12
4018	Tharyx sp. 2											18
4023	Marphysa sanguinea			23								
4025	Glycera americana			1								
4026	Glycera capitata				1			3	2			
4027	Glycera dibranchiata					1		2	1			
4053	Nephtys picta					2	1		1			
4055	Nereis (Neanthes) succinea			3								5
4061	Travisia carnea						3					
4063	Haploscoloplos acutus				3							
4064	Haploscoloplos fragilis		3		1							
4065	Haploscoloplos robustus								1		4	
4078	Eteone lactea			1								3
4079	Eteone longa			6								
4088	Harmothoe (Lagisca) extenuata			24								
4091	Lepidonotus squamatus			2								
4092	Lepidonotus sublevis			1								
4093	Sabellaria vulgaris				4							6
4101	Hydroides dianthus			193								
4110	Polydora ligni				105			1				44
4111	Polydora socialis			1								
4119	Streblospio benedicti			6							4	5
4125	Proceraea cornuta			1								
4137	Polycirrus eximius			2								
5014	Crepidula plana			13								
5027	Nassarius trivittatus					2	1			4		
5028	Ilyanassa obsoletus											16
5044	Dorodella obscura			2								
5047	Nucula proxima			6		9				24		
5053	Mytilus edulis			5				1				4
5070	Tellina agilis		9		28	19	8		2	4	4	

Table AV-3 (cont.)

	Species	1601	1602	1603	1604	1605	1605B	1606	1607	1608	1610	1611
		Stations										
5081	Spisula solidissima						9		1			
5082	Mulinia lateralis		1			4					24	
5093	Pandora gouldiana				1							
7002	Neomysis americana			15								
7028	Edotea triloba	3										
7042	Lembos smithi			3								
7054	Erichthonius brasiliensis			195								
7056	Unciola serrata			1164								
7058	Corophium simile			1076								
7068	Elasmopus laevis			14								
7070	Melita nitida			20								2
7075	Protohaustorius wigleyi						10					
7092	Paraphoxus spinosus		16	2	1							
7095	Parapleustes aestuarius			20								
7097	Parametopella cypris											9
7106	Paracaprella tenuis			162								4
7111	Crangon septemspinosa					1		2				
7115	Pagurus longicarpus				1	1						
7123	Eurypanopeus depressus			24								
7124	Neopanope texana sayi			45								1
7130	Pinnixa sayana				4							
6003	Tanystylum orbiculare			6								

		1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711
4007	Driloneris longa						1					
4010	Heteromastus filiformis								1	1		
4026	Glycera capitata						1	1		1		
4027	Glycera dibranchiata						6	4		1		
4053	Nephtys picta			2	1							
4064	Haploscoloplos fragilis									1		
4118	Spiophanes bombyx									1		

Table AV-3 (cont.)

Stations

	Species	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711
4146	Aricidea sp.					11						
5027	Nassarius trivittatus			2								
5028	Ilyanassa obsoletus											5
5047	Nucula proxima	2						4				
5053	Mytilus edulis			1								
5068	Gemma gemma										4	
5070	Tellina agilis	6	3	12	2	9	15	18	6	7		
5081	Spisula solidissima				10	10						
5082	Mulinia lateralis	2		7					1			
7002	Neomysis americana		1									
7009	Oxyurostylis smithi								1			
7037	Ampelisca verrilli	1										
7075	Protohaustorius wigleyi			2								
7092	Paraphoxus spinosus					1						
7115	Pagurus longicarpus				1							
7124	Neopanope texana sayi					1						

		1801	1802	1803	1804	1805	1806	1807	1808	1809	1810
3008	Cerebratulus lacteus	1									
3014	Nemertea sp.		1				2				
4010	Heteromastus filiformis							1	1	49	8
4026	Glycera capitata									1	
4027	Glycera dibranchiata						8	2			
4038	Lumbrineris tenuis		1								
4053	Nephtys picta			1							
4064	Haploscoloplos fragilis		1							4	
4071	Aricidea cerruti		1								
4125	Proceraea cornuta			1						22	
5027	Nassarius trivittatus			1							
5028	Ilyanassa obsoletus										4
5047	Nucula proxima	1	1				1			1	

Table AV-3 (cont.)

Stations

	Species	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810
5053	Mytilus edulis		1								
5068	Gemma gemma	900								1	3760
5070	Tellina agilis	19	2	6	1		10	3		7	4
5080	Ensis directus		2								
5082	Mulinia lateralis			1	2	4		1			
5091	Lyonsia hyalina	1									
7002	Neomysis americana	1									
7035	Ampelisca abdita										3
7065	Gammarus mucronatus					1					
7075	Protohaustorius wigleyi	3		1	16				5		
7079	Acanthohaustorius millsi	8									
7092	Paraphoxus spinosus	1									
7111	Crangon septemspinosa			2		1					
7121	Cancer irroratus					1					

	Species	1901	1902	1903	1904	1905	1906	1907	1908
3014	Nemertea sp.		5		2				
4010	Heteromastus filiformis	19	1						
4025	Glycera americana			1					
4026	Glycera capitata				2		1		
4027	Glycera dibranchiata					8	1		
4028	Glycinde solitaria			1					
4038	Lumbrineris tenuis	1							
4055	Nereis (Neanthes) succinea							1	
4059	Ophelia bicornis						1		
4064	Haploscoloplos fragilis		1	2					
4065	Haploscoloplos robustus					1			
4110	Polydora ligni							27	
5025	Busycon carica	1							
5027	Nassarius trivittatus			1					
5047	Nucula proxima	10	1	2					
5056	Crassostrea virginica							4	

Table AV-3 (cont.)

	Species	Stations							
		1901	1902	1903	1904	1905	1906	1907	1908
5068	*Gemma gemma*	32							3
5070	*Tellina agilis*	3	2	7	11	8	2		
5082	*Mulinia lateralis*		1						
7002	*Neomysis americana*			3					
7028	*Edotea triloba*								1
7051	*Corophium insidiosum*						1		
7053	*Corophium tuberculatum*							11	
7058	*Corophium simile*							11	
7070	*Melita nitida*							2	
7095	*Parapleustes aestuarius*							2	
7106	*Paracaprella tenuis*							14	
		2001	2002	2003	2005	2006	2007	2008	2009
4002	*Asabellides oculatus*							1	
4005	*Arabella iricolor*						2		
4010	*Heteromastus filiformis*	31	4			3		8	
4025	*Glycera americana*		4						
4026	*Glycera capitata*						3		
4027	*Glycera dibranchiata*				2		3	2	
4038	*Lumbrineris tenuis*	5					1		
4053	*Nephtys picta*			1	1				
4055	*Nereis (Neanthes) succinea*						1	1	
4064	*Haploscoloplos fragilis*	6							
4065	*Haploscoloplos robustus*							1	
4071	*Aricidea cerruti*		4						
4077	*Eteone heteropoda*					1			
4079	*Eteone longa*							3	
4082	*Paranaitis kosteriensis*					1			
4088	*Harmothoe (Lagisca) extenuata*				2				
4093	*Sabellaria vulgaris*						3	7	
4110	*Polydora ligni*		12		18	5		18	

Table AV-3 (cont.)

	Species	Stations 2001	2002	2003	2005	2006	2007	2008	2009
4118	*Spiophanes bombyx*			1					
4119	*Streblospio benedicti*		4			1			
4137	*Polycirrus eximius*					5	19		
4142	*Scoloplos* sp.		4						
4147	*Microphthalmus aberrans*							1	
5013	*Crepidula convexa*					1			
5014	*Crepidula plana*				2	1			
5027	*Nassarius trivittatus*		4		2				
5047	*Nucula proxima*		16						
5053	*Mytilus edulis*				49				
5056	*Crassostrea virginica*					2			
5068	*Gemma gemma*			5			416	6	
5070	*Tellina agilis*	11	24				7		
5091	*Lyonsia hyalina*						9	1	
6010	*Balanus (Semibalanus) balanoides*					15			
7002	*Neomysis americana*			1					
7028	*Edotea triloba*			1				1	
7051	*Corophium insidiosum*				1				
7056	*Unciola serrata*		1					12	
7058	*Corophium simile*							1	
7070	*Melita nitida*				7	5			1
7075	*Protohaustorius wigleyi*			20					
7092	*Paraphoxus spinosus*								6
7095	*Parapleustes aestuarius*				1			2	
7106	*Paracaprella tenuis*								1
7115	*Pagurus longicarpus*		1						1
7121	*Cancer irroratus*		1						
7124	*Neopanope texana sayi*				1	1		1	1
7144	*Pinnotheres maculatus*				1				

Table AV-3 (cont.)

	Species	Stations 2101	2102	2103	2104	2105	2106	2107	2108
4002	*Asabellides oculatus*			1					
4007	*Driloneris* sp. cf. *D. magna*					1			
4010	*Heteromastus filiformis*	4		14		1	1		
4026	*Glycera capitata*						1	2	
4027	*Glycera dibranchiata*		1	1				1	
4028	*Glycinde solitaria*		1						
4053	*Nephtys picta*						1		
4061	*Travisia carnea*								3
4093	*Sabellaria vulgaris*					1			
4101	*Hydroides dianthus*							2	
4110	*Polydora ligni*			17		1	2		
4115	*Scolecolepides viridis*								1
4118	*Spiophanes bombyx*				1				
4137	*Polycirrus eximius*					1	2		
5047	*Nucula proxima*	1				2			
5053	*Mytilus edulis*		1						
5068	*Gemma gemma*		2				200	11	6
5070	*Tellina agilis*	2	12		1	12	20		
5080	*Ensis directus*							1	
5082	*Mulinia lateralis*	9							
5084	*Mya arenaria*						2		9
5091	*Lyonsia hyalina*						2		
7028	*Edotea triloba*							14	
7035	*Ampelisca abdita*	2	1						
7053	*Corophium tuberculatum*							2	
7058	*Corophium simile*							2	
7070	*Melita nitida*			11					
7075	*Protohaustorius wigleyi*				7	5			
7092	*Paraphoxus spinosus*						3		
7111	*Crangon septemspinosa*			1		2			
7123	*Eurypanopeus depressus*			1					
7124	*Neopanope texana sayi*			3					

Table AV-3 (cont.)

	Species	2201	2202	2203	2204	2205	2206	2207
3014	*Nemertea* sp.				1			
4002	*Asabellides oculatus*			8				
4010	*Heteromastus filiformis*		46				3	
4026	*Glycera capitata*					5		
4027	*Glycera dibranchiata*		1	1	1			
4028	*Glycinde solitaria*		2			1		
4053	*Nephtys picta*				1			
4064	*Haploscoloplos fragilis*						4	
4093	*Sabellaria vulgaris*			7				
4101	*Hydroides dianthus*			1				
4110	*Polydora ligni*			4				
5016	*Lunatia heros*	1						
5028	*Ilyanassa obsoletus*	1						
5047	*Nucula proxima*				1			
5066	*Mercenaria mercenaria*					1		
5068	*Gemma gemma*	32			3	1		2
5070	*Tellina agilis*	1	1		7	4		
5082	*Mulinia lateralis*	6	2					
5084	*Mya arenaria*							23
7070	*Melita nitida*			1				
7123	*Eurypanopeus depressus*			1				
7126	*Rhithropanopeus harrisi*						1	

	Species	2301	2302	2303	2304	2305
3014	*Nemertea* sp.			1		
4027	*Glycera dibranchiata*		1			
4059	*Ophelia bicornis*				1	
5068	*Gemma gemma*		10		101	4
5072	*Macoma balthica*	6				
7011	*Cyathura polita*				1	
7013	*Cyathura burbancki*				1	

Table AV-3 (cont.)

	Species	Stations 2401	2402	2403	2404	2405
3014	*Nemertea* sp.				1	
4010	*Heteromastus filiformis*				3	1
4053	*Nephtys picta*			1		
4115	*Scolecolepides viridis*	1				
5068	*Gemma gemma*		3		229	
5082	*Mulinia lateralis*				276	
5084	*Mya arenaria*				124	1

		2502	2503	2504	2505
4010	*Heteromastus filiformis*			1	
4055	*Nereis (Neanthes) succinea*		2	2	
4110	*Polydora ligni*		2		
4115	*Scolecolepides viridis*	1			
5052	*Geukensia demissa*			2	
6009	*Balanus (Balanus) improvisus*			32	
7011	*Cyathura polita*				1

		2601	2602	2604	2605
3014	*Nemertea* sp.			2	
4010	*Heteromastus filiformis*	1			
5052	*Geukensia demissa*				1
5056	*Crassostrea virginica*				4
5072	*Macoma balthica*	12	1		
5084	*Mya arenaria*				1
6009	*Balanus (Balanus) improvisus*			5	5
7051	*Corophium insidiosum*				1
7123	*Eurypanopeus depressus*				1
7126	*Rhithropanopeus harrisi*				3

Table AVI-1

Sediment characteristics for quarterly samples

May 1974

Station	50% mm	$\phi 50$	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
1-1	.233	2.10ϕ	2.10ϕ	0.31ϕ	+.024	1.10		99.0	1.0		0.61
1-2	.263	1.92ϕ	1.93ϕ	0.35ϕ	+.066	1.14		98.9	1.1		0.61
1-3	.254	1.98ϕ	1.99ϕ	0.33ϕ	-.006	1.11		99.2	0.8		0.50
2-1	.296	1.76ϕ	1.66ϕ	1.15ϕ	-.163	1.10	2.5	94.9	1.3	1.3	0.42
2-2	.286	1.81ϕ	1.63ϕ	1.25ϕ	-.219	1.15	3.5	93.0	2.9	1.6	0.66
2-3	.274	1.87ϕ	1.78ϕ	1.06ϕ	-.179	1.27	2.2	94.9	0.9	2.0	0.45
3-1	.305	1.71ϕ	1.51ϕ	1.49ϕ	-.342	1.87	8.8	87.8	2.7	1.7	0.55
3-2	.325	1.62ϕ	1.40ϕ	1.65ϕ	-.374	2.01	8.2	88.3	2.0	1.5	0.85
3-3*	.432	1.21ϕ	-0.16ϕ	2.71ϕ	-.537	0.93	25.8	71.4	1.7	1.1	0.08
4-1	.138	2.86ϕ	2.89ϕ	0.38ϕ	+.140	1.22		98.3	1.7		0.66
4-2	.136	2.87ϕ	2.95ϕ	0.41ϕ	+.264	1.20		98.0	2.0		0.76
4-3	.139	2.85ϕ	2.88ϕ	0.40ϕ	+.163	1.22		97.7	2.3		0.92
5-1	.081	3.62ϕ	3.75ϕ	1.32ϕ	+.568	3.82		73.6	18.7	7.7	1.72
5-2	.080	3.65ϕ	3.84ϕ	1.33ϕ	+.585	3.40		69.9	22.3	7.8	1.80
5-3	.080	3.64ϕ	3.97ϕ	1.58ϕ	+.668	3.13		66.7	23.4	9.9	2.93
6-1	.246	2.02ϕ	2.07ϕ	0.36ϕ	+.377	1.42		98.4	1.6		0.37
6-2	.245	2.02ϕ	2.05ϕ	0.32ϕ	+.309	1.58		98.8	1.2		0.39
6-3	.242	2.05ϕ	2.08ϕ	0.33ϕ	+.318	1.62		98.9	1.1		0.39
7-1	.072	3.79ϕ	4.42ϕ	1.99ϕ	+.532	2.07		56.6	32.3	11.1	1.54
7-2	.067	3.91ϕ	4.45ϕ	1.70ϕ	+.525	1.78		53.5	39.4	7.1	0.64
7-3	.066	3.91ϕ	4.66ϕ	2.07ϕ	+.611	1.95		53.0	34.2	12.8	1.48

Table AVI-1 (cont.)

May 1974 (cont.)

Station	50% mm	ϕ50	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
8-1	N O S A M P L E										
8-2	.072	3.81φ	4.55φ	1.69φ	+.708	1.80		56.9	33.3	9.8	2.12
8-3	.067	3.91φ	4.73φ	2.01φ	+.728	2.30		53.7	33.4	12.9	2.20
9-1	N O S A M P L E										
9-2	N O S A M P L E										
9-3	.0381	4.71φ	5.58φ	2.26φ	+.547	0.89		29.2	51.4	19.4	3.06
10-1	.0670	3.90φ	4.12φ	1.31φ	+.614	3.18		56.0	35.7	8.3	2.14
10-2	.0607	4.04φ	4.89φ	1.97φ	+.737	2.18		48.2	38.3	13.5	2.92
10-3	.0598	4.06φ	4.37φ	0.97φ	+.484	0.84		48.0	48.8	3.2	2.24

* 3-3 (1) One 16 mm stone accounted for 16% of the sample.

August 1974

Station	50% mm	ϕ50	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
1-1	.231	2.13φ	2.08φ	0.33φ	-.125	1.11		99.5	0.5		0.53
1-2	.227	2.13φ	2.13φ	0.33φ	+.034	1.13		99.1	0.9		0.48
1-3	.219	2.19φ	2.17φ	0.37φ	-.052	1.21		98.2	1.8		0.51
2-1	.261	1.94φ	1.83φ	1.25φ	-.108	3.37	1.8	93.9	2.4	1.9	0.73
2-2	.580	0.79φ	0.18φ	2.33φ	-.305	0.96	23.9	74.5	1.6		0.29
2-3	.418	1.25φ	0.70φ	2.97φ	-.316	0.96	18.9	78.2	2.9		2.36
3-1	.565	0.82φ	0.28φ	2.42φ	-.236	0.93	23.8	72.5	3.7		0.90
3-2	.270	1.88φ	1.83φ	1.94φ	+.146	2.33	4.7	84.2	6.8	4.3	1.27
3-3	.309	1.71φ	1.00φ	2.97φ	-.224	1.49	20.4	71.7	4.0	3.9	1.25

Table AVI-1 (cont.)

August 1974 (cont.)

Station	50% mm	$\phi 50$	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
4-1	.084	3.56ϕ	3.57ϕ	0.51ϕ	+.132	1.51		84.8	12.0	3.2	1.09
4-2	.088	3.50ϕ	3.52ϕ	0.43ϕ	+.091	0.99		87.5	11.2	1.3	0.69
4-3	.089	3.46ϕ	3.63ϕ	0.56ϕ	+.238	1.09		86.3	13.7		1.01
5-1	.085	3.58ϕ	3.61ϕ	1.35ϕ	+.370	3.20		77.1	16.1	6.8	0.40
5-2	.092	3.48ϕ	3.60ϕ	1.29ϕ	+.480	3.07		77.4	16.0	6.6	1.63
5-3	.101	3.22ϕ	3.27ϕ	0.70ϕ	+.010	1.51		89.2	8.7	2.1	1.31
6-1	.230	2.11ϕ	2.15ϕ	0.35ϕ	+.338	1.33		99.0	1.0		0.45
6-2	.225	2.16ϕ	2.15ϕ	0.43ϕ	+.211	1.43		98.9	1.1		0.43
6-3	.221	2.17ϕ	2.23ϕ	0.38ϕ	+.293	1.27		99.2	0.8		0.44
7-1	.066	3.91ϕ	4.07ϕ	1.19ϕ	+.420	1.76		57.1	38.7	4.2	1.63
7-2	.063	3.97ϕ	4.41ϕ	1.65ϕ	+.559	2.54		51.3	40.7	8.0	3.84
7-3	.060	4.08ϕ	4.63ϕ	1.76ϕ	+.653	2.34		47.2	42.4	10.4	2.49
8-1	.080	3.62ϕ	3.72ϕ	1.48ϕ	+.057	2.34	0.7	68.0	30.3	1.0	2.36
8-2	.082	3.62ϕ	3.94ϕ	1.47ϕ	+.613	3.74		74.9	18.5	7.6	1.65
8-3	.084	3.56ϕ	3.70ϕ	1.36ϕ	+.373	2.77		72.3	21.4	6.3	1.71
9-1	.083	3.60ϕ	3.21ϕ	2.43ϕ	-.070	2.43	1.8	66.4	24.2	7.6	3.18
9-2	.095	3.39ϕ	2.98ϕ	2.33ϕ	-.067	1.97		77.6	17.3	5.1	2.81
9-3	.072	3.80ϕ	4.15ϕ	2.44ϕ	+.299	2.34		55.0	33.7	11.3	4.01
10-1	.056	4.15ϕ	4.70ϕ	1.65ϕ	+.608	2.19		42.1	46.3	11.6	2.83
10-2	.062	4.00ϕ	4.31ϕ	1.52ϕ	+.602	2.94		49.1	40.9	10.0	2.17
10-3	.061	4.00ϕ	4.25ϕ	1.32ϕ	+.530	2.86		49.7	41.2	9.1	2.65

Table AVI-1 (cont.)

November 1974

Station	50% mm	ϕ50	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
1-1	.2292	2.13ϕ	2.12ϕ	0.32ϕ	-.028	1.09		99.2	0.8		0.63
1-2	.2240	2.16ϕ	2.18ϕ	0.29ϕ	+.108	1.27		99.5	0.5		0.49
1-3	.2068	2.27ϕ	2.29ϕ	0.33ϕ	+.079	1.14		99.4	0.6		0.65
2-1	.1047	3.26ϕ	3.26ϕ	0.99ϕ	+.369	3.72		89.5	5.9	4.6	1.18
2-2	.1128	3.15ϕ	3.19ϕ	0.52ϕ	+.207	1.08		92.9	5.4	1.7	0.61
2-3	.1248	3.00ϕ	3.04ϕ	0.48ϕ	+.106	1.03		95.9	2.3	1.8	0.77
3-1	.2597	1.95ϕ	1.83ϕ	1.11ϕ	-.149	1.38	1.3	95.6	1.2	1.9	1.02
3-2	.3351	1.58ϕ	1.19ϕ	1.70ϕ	-.348	1.06	11.9	86.7	1.4		0.74
3-3	.3424	1.55ϕ	1.23ϕ	1.74ϕ	-.283	1.03	11.6	86.0	2.4		0.62
4-1	.0914	3.45ϕ	3.46ϕ	0.33ϕ	+.206	1.24		90.3	7.8	1.9	0.62
4-2	.0886	3.50ϕ	3.48ϕ	0.38ϕ	+.092	1.34		89.1	8.5	2.4	0.76
4-3	.0958	3.38ϕ	3.40ϕ	0.35ϕ	+.165	1.40		92.0	6.0	2.0	0.74
5-1	.0706	3.82ϕ	4.27ϕ	1.07ϕ	+.520	0.64		53.9	43.6	2.5	2.71
5-2	.0609	4.04ϕ	4.38ϕ	1.19ϕ	+.486	0.82		49.3	46.5	4.2	3.23
5-3	.0764	3.71ϕ	4.16ϕ	1.64ϕ	+.717	2.96		62.6	27.6	9.8	1.99
6-1	.1457	2.78ϕ	2.77ϕ	0.45ϕ	-.001	1.06		98.9	1.1		0.63
6-2	.1383	2.85ϕ	2.86ϕ	0.43ϕ	-.020	1.07		98.7	1.3		1.54
6-2	.1360	2.88ϕ	2.88ϕ	0.42ϕ	+.016	1.16		99.3	0.7		0.62
6-3	.1345	2.89ϕ	2.90ϕ	0.41ϕ	+.025	1.20		99.0	1.0		0.53
7-1	.0707	3.82ϕ	3.95ϕ	1.98ϕ	+.313	1.96		55.2	35.8	9.0	2.45
7-2	.0747	3.74ϕ	3.72ϕ	1.80ϕ	+.222	2.11		57.7	35.3	7.0	2.07
7-3	.0709	3.82ϕ	3.75ϕ	1.44ϕ	-.039	0.79		56.9	41.4	1.7	2.12

Table AVI-1 (cont.)

November 1974 (cont.)

Station	50% mm	ϕ50	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
8-1	.0683	3.87φ	4.02φ	1.18φ	+.419	2.04		53.3	42.4	4.3	2.75
8-2	.0585	4.10φ	4.28φ	1.83φ	+.435	2.17		45.6	41.9	12.5	1.99
8-3	.0767	3.70φ	3.97φ	1.37φ	+.651	2.77		63.0	29.5	7.5	2.19
9-1	.0815	3.62φ	3.78φ	1.30φ	+.526	2.76		67.5	26.8	5.7	2.11
9-2	.0770	3.70φ	3.92φ	1.34φ	+.452	1.88		59.5	35.5	5.0	1.31
9-3	.0746	3.75φ	4.33φ	1.93φ	+.687	2.64		57.5	31.2	11.3	2.51
10-1	.0724	3.79φ	4.12φ	1.13φ	+.614	1.89		56.4	39.0	4.6	1.36
10-2	N O S A M P L E										
10-3	.0737	3.76φ	4.14φ	1.40φ	+.720	2.97		60.9	31.2	7.9	2.09

February 1975

Station	50% mm	ϕ50	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
1-1	.2395	2.06φ	2.05φ	0.30φ	-.040	1.20		99.2	0.8		0.26
1-2	.2455	2.03φ	2.06φ	0.30φ	+.167	1.06		99.4	0.6		0.49
1-3	.2661	1.91φ	1.94φ	0.32φ	+.069	1.29		99.2	0.8		0.44
2-1	.3444	1.54φ	1.30φ	1.07φ	-.295	1.18	3.1	93.7	1.2	2.0	0.38
2-2	.3613	1.47φ	1.25φ	1.01φ	-.333	0.98	2.8	96.2	1.0		0.42
2-3	.3498	1.52φ	1.27φ	1.28φ	-.521	1.93	6.4	92.6	1.0		0.54
3-1	.3172	1.66φ	1.56φ	1.06φ	-.107	1.15	2.2	96.3	0.4	1.1	0.22
3-2	.2747	1.86φ	1.81φ	1.06φ	-.155	1.28	2.4	95.1	1.4	1.1	0.42
3-3	.2955	1.76φ	1.57φ	1.47φ	-.355	1.63	7.4	90.1	0.8	1.7	0.31

Table AVI-1 (cont.)

February 1975 (cont.)

Station	50% mm	$\phi 50$	M_z	σ_i	Sk_i	K_g	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Volatiles
4-1	.0940	3.41ϕ	3.38ϕ	0.46ϕ	-.096	1.53		90.1	8.9	1.0	0.54
4-2	.0907	3.46ϕ	3.55ϕ	1.05ϕ	+.437	4.05		80.2	15.4	4.4	1.08
4-3	.0930	3.43ϕ	3.43ϕ	0.49ϕ	+.005	1.64		87.4	11.2	1.4	0.53
5-1	.0823	3.60ϕ	3.77ϕ	1.35ϕ	+.546	2.79		69.4	23.0	7.6	1.82
5-2	.0806	3.63ϕ	4.03ϕ	1.58ϕ	+.666	2.78		65.0	26.3	8.7	1.04
5-3	.0752	3.73ϕ	4.36ϕ	1.73ϕ	+.720	2.03		58.2	32.8	9.0	2.08
6-1	.1606	2.64ϕ	2.61ϕ	0.44ϕ	-.072	0.99		99.1	0.9		0.31
6-2	.0882	3.50ϕ	3.43ϕ	0.70ϕ	-.220	1.33		83.1	16.9		0.39
6-3	.1585	2.66ϕ	2.64ϕ	0.45ϕ	-.044	0.98		99.1	0.9		0.42
7-1	.0808	3.63ϕ	4.18ϕ	1.57ϕ	+.775	3.73		73.3	19.2	7.5	1.39
7-2	.0762	3.71ϕ	4.10ϕ	1.42ϕ	+.666	2.60		61.3	31.0	7.7	2.42
7-3	.0813	3.62ϕ	3.80ϕ	1.21ϕ	+.629	3.43		71.9	21.4	6.7	1.08
8-1	.0873	3.52ϕ	3.53ϕ	0.52ϕ	+.119	2.09		87.0	11.9	1.1	0.49
8-2	.0588	4.09ϕ	4.71ϕ	2.13ϕ	+.648	2.06		46.0	43.6	10.4	3.41
8-3	.0802	3.64ϕ	3.73ϕ	1.16ϕ	+.452	3.01		69.1	25.6	5.3	1.79
9-1	.0836	3.58ϕ	3.82ϕ	1.37ϕ	+.599	3.45		72.9	19.7	7.4	2.70
9-2	.0596	4.07ϕ	4.55ϕ	1.77ϕ	+.637	2.48		46.5	42.2	11.3	2.47
9-3	.0680	3.88ϕ	4.30ϕ	1.73ϕ	+.573	2.25		53.9	36.2	9.9	1.77
10-1	.1275	2.97ϕ	3.43ϕ	1.89ϕ	+.658	1.94		64.1	26.8	9.1	1.31
10-2	.0492	4.34ϕ	5.48ϕ	2.64ϕ	+.709	1.96		28.2	53.1	18.7	1.10
10-3	.0817	3.61ϕ	3.63ϕ	1.17ϕ	+.307	2.38		71.9	23.2	4.9	1.14

Table AVI-2

Total number of individuls, percent occurrence, and percent of total fauna for species collected in quarterly samples

Station 1 Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Nephtys picta	8	20.0	2.4
Nephtys bucera	4	26.7	1.2
Magelona sp. 2	8	13.3	2.4
Spiophanes bombyx	3	6.7	0.9
Dispio uncinata	1	6.7	0.3
Nucula proxima	21	33.3	6.4
Nassarius trivittatus	1	6.7	0.3
Tellina agilis	2	6.7	0.6
Mulinia lateralis	21	26.7	6.4
Spisula solidissima	1	6.7	0.3
Mytilus edulis	1	6.7	0.3
Donax variabilis	1	6.7	0.3
Parahaustorius attenuatus	4	26.7	1.2
Parahaustorius longimerus	216	100.0	65.8
Bathyporeia parkeri	1	6.7	0.3
Neomysis americana	1	6.7	0.3
Paracaprella tenuis	1	6.7	0.3
Ampelisca abdita	8	13.3	2.4
Edotea triloba	2	13.3	0.6
Corophium insidiosum	2	13.3	0.6
Bathyporeia quoddyensis	2	13.3	0.6
Chiridotea tuftsi	3	13.3	0.9
Elasmopus laevis	6	6.7	1.8
Xanthid sp.	2	6.7	0.6
Protohaustorius wigleyi	5	13.3	1.5
Orchestia grillus	1	6.7	0.3
Sesarma reticulatum	1	6.7	0.3
Ampelisca verrilli	1	6.7	0.3
Station 2			
Nemertea sp.	12	26.7	0.43
Spio setosa	1462	60.0	53.18
Spiophanes bombyx	30	46.7	1.09
Glycera dibranchiata	11	40.0	0.40
Phyllodoce arenae	3	13.3	0.10
Magelona sp. 2	2	13.3	0.07
Heteromastus filiformis	7	20.0	0.25
Polydora socialis	5	20.0	0.18
Aricidea sp.	1	6.7	0.03
Asabellides oculatus	9	33.3	0.32

Table AVI-2 (cont.)

Station 2 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Nephtys picta	35	60.0	1.27
Aricidea cerruti	10	13.3	0.36
Lumbrineris acuta	1	6.7	0.03
Scoloplos sp.	3	13.3	0.10
Streblospio benedicti	14	26.7	0.50
Mediomastus ambiseta	62	26.7	2.25
Glycera americana	7	33.3	0.25
Oligochaeta A	5	13.3	0.18
Clymenella torquata	1	6.7	0.03
Sabellaria vulgaris	9	26.7	0.32
Polydora ligni	1	6.7	0.03
Eteone heteropoda	1	6.7	0.03
Drilonereis magna	3	6.7	0.10
Scoloplos acutus	1	6.7	0.03
Paranaitis speciosa	2	6.7	0.07
Scoloplos robustus	4	13.3	0.14
Harmothoe extenuata	23	26.7	0.83
Scoloplos fragilis	3	20.0	0.10
Goniadella gracilis	1	6.7	0.03
Glycera capitata	2	13.3	0.07
Eumida sanguinea	22	20.0	0.80
Polydora concharum	1	6.7	0.03
Capitella capitata	31	20.0	1.12
Ampharete acutifrons	2	6.7	0.07
Nereis succinea	1	6.7	0.03
Lepidonotus sublevis	1	6.7	0.03
Amphitrite ornata	5	13.3	0.18
Nephtys incisa	2	6.7	0.07
Tellina agilis	242	100.0	8.80
Lyonsia hyalina	1	6.7	0.03
Ensis directus	8	33.3	0.29
Crepidula fornicata	5	20.0	0.18
Mytilus edulis	604	33.3	21.97
Marginella roscida	1	6.7	0.03
Nucula proxima	20	33.3	0.72
Mulinia lateralis	5	20.0	0.18
Acteocina canaliculata	2	13.3	0.07
Petricola pholadiformis	1	6.7	0.03
Crepidula plana	3	6.7	0.10
Parahaustorius attenuatus	1	6.7	0.03
Parahaustorius longimerus	10	40.0	0.36
Oxyurostylis smithi	2	13.3	0.07
Bathyporeia parkeri	1	6.7	0.03
Corophium tuberculatum	2	6.7	0.07

Table AVI-2 (cont.)

Station 2 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Unciola serrata	12	40.0	0.43
Unciola irrorata	4	6.7	0.14
Crangon septemspinosa	5	13.3	0.18
Xanthid sp.	5	20.0	0.18
Neomysis americana	2	13.3	0.07
Lysianopsis alba	6	26.7	0.21
Elasmopus laevis	2	6.7	0.07
Pinnixa sp.	1	6.7	0.03
Neopanope texana sayi	1	6.7	0.03
Protohaustorius wigleyi	2	6.7	0.07
Synchelidium americanum	1	6.7	0.03
Siphonoecetes smithianus	1	6.7	0.03
Edotea triloba	1	6.7	0.03
Leptocuma minor	1	6.7	0.03
Paraphoxus spinosus	1	6.7	0.03
Pinnotheres maculata	1	6.7	0.03

Station 3

Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Spio setosa	535	66.7	26.65
Asabellides oculatus	14	33.3	0.69
Glycera dibranchiata	8	33.3	0.39
Harmothoe extenuata	41	46.7	2.04
Spiophanes bombyx	9	46.7	0.44
Aricidea cerruti	14	40.0	0.69
Sabellaria vulgaris	12	33.3	0.59
Driloneris magna	2	13.3	0.09
Caulleriella sp. 2	1	6.7	0.04
Nereis succinea	9	26.7	0.44
Lepidonotus squamatus	2	6.7	0.09
Pherusa affinis	2	13.3	0.09
Polydora ligni	4	13.3	0.19
Mediomastus ambiseta	72	26.7	3.58
Oligochaeta A	5	13.3	0.24
Heteromastus filiformis	4	6.7	0.19
Streblospio benedicti	9	26.7	0.44
Polycirrus eximius	9	20.0	0.44
Ampharete acutifrons	2	13.3	0.09
Nemertea sp.	6	33.3	0.29
Eumida sanguinea	17	46.7	0.84
Schistomeringos rudolphi	1	6.7	0.04
Scoloplos robustus	7	26.7	0.34

Table AVI-2 (cont.)

Station 3 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Lepidonotus sublevis	4	6.7	0.19
Amphitrite ornata	1	6.7	0.04
Phyllodoce maculata	2	13.3	0.09
Tharyx sp. 2	1	6.7	0.04
Podarke obscura	1	6.7	0.04
Glycinde solitaria	1	6.7	0.04
Nephtys picta	20	53.3	0.99
Glycera americana	5	20.0	0.24
Scoloplos fragilis	3	13.3	0.14
Phyllodoce arenae	3	20.0	0.14
Schistomeringos caecus	1	6.7	0.04
Chaetozone sp.	4	6.7	0.19
Driloneris longa	1	6.7	0.04
Polydora socialis	4	6.7	0.19
Glycera capitata	6	13.3	0.29
Lepidametria commensalis	1	6.7	0.04
Capitella capitata	1	6.7	0.04
Tellina agilis	153	86.7	7.62
Mytilus edulis	879	53.3	43.79
Marginella roscidium	7	20.0	0.34
Doridella obscura	1	6.7	0.04
Nassarius trivittatus	1	6.7	0.04
Nucula proxima	6	26.7	0.29
Spisula solidissima	1	6.7	0.04
Crepidula plana	11	20.0	0.54
Crepidula convexa	1	6.7	0.04
Crepidula fornicata	2	6.7	0.09
Ensis directus	3	13.3	0.14
Lyonsia hyalina	1	6.7	0.04
Mulinia lateralis	1	6.7	0.04
Pagurus longicarpus	12	26.7	0.59
Unciola serrata	23	60.0	1.14
Pinnixa sayana	1	6.7	0.04
Unciola irrorata	4	26.7	0.19
Xanthid sp.	15	26.7	0.74
Hexapanopeus angustifrons	1	6.7	0.04
Pinnixa sp.	3	20.0	0.14
Pinnixa retinens	1	6.7	0.04
Upogebia affinis	1	6.7	0.04
Lysianopsis alba	23	20.0	1.14
Cancer irroratus	1	6.7	0.04
Panopeus herbsti	1	6.7	0.04
Euceramus praelongus	1	6.7	0.04

Table AVI-2 (cont.)

Station 3 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Parahaustorius longimerus	1	6.7	0.04
Callianassa sp. cf. C. atlantica	2	13.3	0.09
Unciola dissimilis	1	6.7	0.04
Oxyurostylis smithi	5	6.7	0.24
Station 4			
Nephtys bucera	5	26.7	0.77
Spiophanes bombyx	13	40.0	2.00
Spio setosa	4	20.0	0.61
Dispio uncinata	1	6.7	0.15
Glycera dibranchiata	18	53.3	2.77
Nephtys picta	5	33.3	0.77
Nemertea sp.	18	40.0	2.77
Glycinde solitaria	4	20.0	0.61
Scoloplos robustus	14	40.0	2.16
Glycera capitata	31	66.67	4.78
Scoloplos acutus	2	13.3	0.30
Asabellides oculatus	3	13.3	0.46
Scoloplos fragilis	2	13.3	0.30
Sthenelais limicola	1	6.7	0.15
Mytilus edulis	1	6.7	0.15
Tellina agilis	131	93.33	20.21
Mulinia lateralis	11	26.7	1.69
Nucula proxima	119	40.0	18.36
Acteon punctostriatus	7	13.3	1.08
Acteocina canaliculata	8	26.7	1.23
Ensis directus	1	6.7	0.15
Protohaustorius wigleyi	148	26.7	22.83
Synchelidium americana	1	6.7	0.15
Ampelisca verrilli	9	26.7	1.38
Ampelisca vadorum	1	6.7	0.15
Oxyurostylis smithi	6	13.3	0.92
Pinnixa sayana	4	20.0	0.61
Trichophoxus epistomus	71	46.7	10.95
Pinnixa retinens	1	6.7	0.15
Pinnixa sp.	2	6.7	0.30
Pagurus longicarpus	1	6.7	0.15
Alcyonidium polyoum	1	6.7	0.15

Table AVI-2 (cont.)

Station 5

Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Capitella capitata	19	26.7	0.08
Spio setosa	3	13.3	0.01
Asabellides oculatus	19	13.3	0.08
Scoloplos robustus	2	13.3	0.00
Lumbrineris acuta	1	6.7	0.00
Sthenelais limicola	2	13.3	0.00
Glycera americana	4	26.7	0.01
Glycera dibranchiata	1	6.7	0.00
Pectinaria gouldii	1	6.7	0.00
Nephtys incisa	1	6.7	0.00
Heteromastus filiformis	2	13.3	0.00
Tellina agilis	389	93.3	1.73
Yoldia limatula	15	40.0	0.06
Siliqua costata	1	6.7	0.00
Nucula proxima	21,393	93.3	95.45
Mulinia lateralis	18	26.7	0.08
Ensis directus	101	60.0	0.45
Mytilus edulis	3	20.0	0.01
Nassarius trivittatus	2	13.3	0.00
Haminoea solitaria	3	13.3	0.01
Acteon punctostriatus	14	13.3	0.06
Acteocina canaliculata	2	13.3	0.00
Protohaustorius wigleyi	2	6.7	0.00
Ampelisca verrilli	9	33.3	0.04
Neomysis americana	1	6.7	0.00
Ampelisca vadorum	2	13.3	0.00
Lysianopsis alba	1	6.7	0.00
Oxyurostylis smithi	1	6.7	0.00
Parahaustorius longimerus	1	6.7	0.00
Upogebia affinis	1	6.7	0.00
Pinnixa retinens	1	6.7	0.00
Ampelisca abdita	8	13.3	0.03

Station 6

Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Nephtys bucera	11	40.0	2.50
Scoloplos sp.	2	13.3	0.45
Nephtys picta	4	6.7	0.90
Nemertea sp.	1	6.7	0.22
Spio setosa	2	6.7	0.45
Magelona sp. 2	1	6.7	0.22
Nucula proxima	11	33.3	2.50

Table AVI-2 (cont.)

Station 6 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Ensis directus	4	6.7	0.90
Spisula solidissima	19	20.0	4.31
Mulinia lateralis	2	13.3	0.45
Tellina agilis	3	13.3	0.68
Turbonilla interrupta	1	6.7	0.22
Parahaustorius longimerus	168	73.3	38.18
Acanthohaustorius millsi	104	80.0	23.63
Bathyporeia parkeri	16	20.0	3.63
Acanthohaustorius shoemakeri	5	6.7	1.13
Parahaustorius holmesi	1	6.7	0.22
Protohaustorius wigleyi	83	73.3	18.86
Trichophoxus epistomus	1	6.7	0.22
Mancocuma altera	1	6.7	0.22
Station 7			
Asabellides oculatus	6	20.0	1.27
Scoloplos robustus	9	46.7	1.91
Spio setosa	13	26.7	2.76
Heteromastus filiformis	4	13.3	0.85
Glycera capitata	5	13.3	1.06
Capitella capitata	1	6.7	0.21
Glycera dibranchiata	3	20.0	0.63
Streblospio benedicti	1	6.7	0.21
Nephtys incisa	15	60.0	3.19
Scoloplos fragilis	1	6.7	0.21
Nephtys bucera	3	6.7	0.63
Paraprionospio pinnata	1	6.7	0.21
Glycera americana	2	13.3	0.42
Sipunculidae sp.	2	6.7	0.42
Pectinaria gouldii	2	6.7	0.42
Glycinde solitaria	1	6.7	0.21
Spiophanes bombyx	2	6.7	0.42
Nemertea sp.	1	6.7	0.21
Nephtys picta	1	6.7	0.21
Yoldia limatula	19	33.3	4.04
Tellina agilis	61	66.7	12.97
Mulinia lateralis	68	60.0	14.46
Crepidula fornicata	1	6.7	0.21
Ensis directus	6	33.3	1.27
Nucula proxima	107	46.7	22.76
Turbonilla interrupta	1	6.7	0.21
Mytilus edulis	3	6.7	0.63

Table AVI-2 (cont.)

Station 7 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Siliqua costata	1	6.7	0.21
Acanthohaustorius millsi	6	26.7	1.27
Bathyporeia quoddyensis	1	6.7	0.21
Bathyporeia parkeri	1	6.7	0.21
Ampelisca vadorum	2	13.3	0.42
Parahaustorius longimerus	8	20.0	1.70
Ampelisca verrilli	89	73.3	18.93
Pinnixa retinens	1	6.7	0.21
Edotea triloba	2	6.7	0.42
Trichophoxus epistomus	1	6.7	0.21
Ampelisca abdita	14	20.0	2.97
Oxyurostylis smithi	1	6.7	0.21
Cancer irroratus	1	6.7	0.21
Protohaustorius wigleyi	3	13.3	0.63
Station 8			
Hydroides dianthus	2601	93.3	9.57
Polydora ligni	309	60.0	1.13
Marphysa sanguinea	109	86.7	0.40
Sabellaria vulgaris	852	93.3	3.13
Polydora socialis	104	60.0	0.38
Nereis succinea	109	93.3	0.40
Polycirrus eximius	310	80.0	1.14
Syllis gracilis	14	33.3	0.05
Spio setosa	38	46.7	0.13
Heteromastus filiformis	111	80.0	0.40
Proceraea cornutus	2	6.7	0.00
Asabellides oculatus	305	93.3	1.12
Capitella capitata	27	46.7	0.09
Harmothoe extenuata	165	60.0	0.60
Lepidonotus squamatus	125	86.7	0.45
Streblospio benedicti	14	40.0	0.05
Lepidonotus sublevis	13	20.0	0.04
Pectinaria gouldii	6	20.0	0.02
Phyllodoce arenae	9	33.3	0.03
Glycinde solitaria	65	60.0	0.23
Tharyx sp. 2	5	20.0	0.01
Maldanidae sp. 1	2	6.7	0.00
Oligochaeta B	15	26.7	0.05
Glycera americana	4	26.7	0.01
Diopatra cuprea	1	6.7	0.00
Eteone heteropoda	1	6.7	0.00
Eteone longa	3	6.7	0.01

Table AVI-2 (cont.)

Station 8 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Sthenelais boa	13	40.0	0.04
Mediomastus ambiseta	288	66.7	1.05
Phyllodoce maculata	5	6.7	0.01
Amphitrite ornata	1	6.7	0.00
Oligochaeta A	27	40.0	0.09
Zygeupolia rubens	1	6.7	0.00
Pherusa affinis	6	6.7	0.02
Nemertea sp.	17	46.7	0.06
Scoloplos robustus	1	6.7	0.00
Eumida sanguinea	804	66.7	2.95
Goniadella gracilis	4	6.7	0.01
Podarke obscura	21	53.3	0.07
Schistomeringos rudolphi	4	13.3	0.01
Flatworm A	4	13.3	0.01
Glycera capitata	2	13.3	0.01
Polydora concharum	2	13.3	0.01
Spiophanes bombyx	1	6.7	0.00
Nephtys incisa	2	6.7	0.01
Cirratulidae sp.	5	20.0	0.01
Polydora caulleryi	1	6.7	0.00
Mytilus edulis	13,904	60.0	51.15
Tellina agilis	29	86.7	0.10
Mulinia lateralis	2	13.3	0.01
Nucula proxima	483	86.7	1.77
Crepidula plana	166	53.3	0.61
Crepidula convexa	1	6.7	0.00
Mercenaria mercenaria	86	80.0	0.31
Petricola pholadiformis	1	6.7	0.00
Lyonsia hyalina	1	6.7	0.00
Hydrobia totteni	1	6.7	0.00
Acteocina canaliculata	1	6.7	0.00
Doradella obscura	1	6.7	0.00
Cuthona concinna	1	6.7	0.00
Doto coronata	1	6.7	0.00
Neopanope texana sayi	95	86.7	0.34
Panopeus herbsti	3	13.3	0.01
Xanthid sp.	714	100.0	2.62
Unciola serrata	2,827	100.0	10.40
Corophium simile	1,596	100.0	5.87
Lembos smithi	348	86.7	1.28
Paracaprella tenuis	4	6.7	0.01
Paraphoxus spinosus	28	46.7	0.10
Elasmopus laevis	17	46.7	0.06
Erichthonius brasiliensis	26	40.0	0.09

Table AVI-2 (cont.)

Station 8 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Microdeutopus gryllotalpa	3	6.7	0.01
Pagurus longicarpus	9	40.0	0.03
Oxyurostylis smithi	53	46.7	0.19
Melita nitida	41	66.7	0.15
Parahaustorius longimerus	4	13.3	0.01
Heteromysis formosa	3	6.7	0.01
Ampelisca abdita	24	53.3	0.08
Protohaustorius wigleyi	1	6.7	0.00
Corophium tuberculatum	3	6.7	0.01
Acanthohaustorius millsi	2	6.7	0.01
Ampelisca verrilli	9	6.7	0.03
Crangon septemspinosa	2	6.7	0.01
Caprella equilibra	99	40.0	0.36
Ampelisca verrilli	4	13.3	0.01
Phoxocephalus holbolli	7	6.7	0.02
Tanystylum orbiculare	10	13.3	0.03
Pinnixa sp.	3	6.7	0.01
Neomysis americana	7	6.7	0.02
Cancer irroratus	1	6.7	0.00
Paracaprella tenuis	3	6.7	0.01
Parapleustes aestuarius	8	20.0	0.02
Edotea triloba	8	20.0	0.02
Batea cathariensis	9	6.7	0.03
Corophium tuberculatum	1	6.7	0.00
Station 9			
Cirratulidae sp.	2	6.7	0.01
Syllis gracilis	3	6.7	0.02
Lumbrineris acutus	1	6.7	0.00
Nucula proxima	370	93.3	3.26
Mercenaria mercenaria	78	73.3	0.68
Tellina agilis	27	66.7	0.23
Mytilus edulis	3,322	66.7	29.27
Lyonsia hyalina	5	20.0	0.04
Crepidula convexa	3	6.7	0.02
Crepidula plana	17	33.3	0.14
Anomia simplex	2	13.3	0.01
Ensis directus	1	6.7	0.00
Petricola pholadiformis	1	6.7	0.00
Anachis avara	5	13.3	0.04
Doradella obscura	1	6.7	0.00
Mitrella lunata	2	6.7	0.01

Table AVI-2 (cont.)

Station 9 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Hydrobia totteni	1	6.7	0.00
Mulinia lateralis	1	6.7	0.00
Anadara ovalis	3	13.3	0.02
Xanthid sp.	340	80.0	2.99
Oxyurostylis smithi	35	53.3	0.30
Corophium simile	645	66.7	5.68
Pagurus longicarpus	11	33.3	0.09
Neopanope texana sayi	82	46.7	0.72
Ampelisca verrilli	6	40.0	0.05
Edotea triloba	22	46.7	0.19
Elasmopus laevis	17	46.7	0.14
Batea catharinensis	2	13.3	0.01
Paracaprella tenuis	7	20.0	0.06
Melita nitida	56	46.7	0.49
Unciola serrata	955	75.3	8.41
Lembos smithi	111	53.3	0.97
Erichthonius brasiliensis	63	40.0	0.55
Paraphoxus spinosus	27	20.0	0.23
Corophium tuberculatum	11	6.7	0.09
Phoxocephalus holbolli	4	6.7	0.03
Panopeus herbsti	4	6.7	0.03
Hydroides dianthus	2,603	80.0	22.93
Nereis succinea	131	66.7	1.15
Marphysa sanguinea	64	73.3	0.56
Harmothoe extenuata	35	60.0	0.30
Glycinde solitaria	96	93.3	0.84
Spio setosa	14	20.0	0.12
Driloneris longa	8	13.3	0.07
Glycera americana	13	46.7	0.11
Capitella capitata	10	13.3	0.08
Polydora ligni	53	40.0	0.46
Sabellaria vulgaris	288	73.3	2.53
Polydora socialis	17	33.3	0.14
Asabellides oculatus	194	93.3	1.70
Polycirrus eximius	269	80.0	2.37
Nemertea sp.	24	40.0	0.21
Oligochaeta A	79	26.7	0.69
Heteromastus filiformis	245	93.3	2.15
Scoloplos robustus	3	20.0	0.02
Streblospio benedicti	50	46.7	0.44
Pherusa affinis	1	6.7	0.00
Lepidonotus sublevis	42	13.3	0.37
Mediomastus ambiseta	394	80.0	3.47
Sthenelais boa	15	40.0	0.13

Table AVI-2 (cont.)

Station 9 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Lepidonotus squamatus	42	53.3	0.37
Eumida sanguinea	321	66.7	2.82
Amphitrite ornata	3	6.7	0.02
Tharyx sp. 2	6	13.3	0.05
Eteone heteropoda	3	6.7	0.02
Phyllodoce arenae	14	33.3	0.12
Pectinaria gouldii	20	46.7	0.17
Glycera dibranchiata	2	6.7	0.01
Goniadella gracilis	4	6.7	0.03
Podarke obscura	17	26.7	0.14
Flatworm A	4	6.7	0.03
Polydora concharum	2	13.3	0.01
Proceraea cornuta	4	26.7	0.03
Lepidometria commensalis	1	6.7	0.00
Chaetozone sp. 1	5	13.3	0.04
Glycera capitata	1	6.7	0.00
Lysianopsis alba	1	6.7	0.00
Ampelisca abdita	3	20.0	0.02
Caprella equilibra	2	13.3	0.01
Thyone briareus	1	6.7	0.00
Balanus improvisus	1	6.7	0.00
Station 10			
Spio setosa	1	6.7	0.11
Glycera americana	4	20.0	0.47
Asabellides oculatus	27	20.0	3.21
Scoloplos robustus	7	20.0	0.83
Streblospio benedicti	1	6.7	0.11
Sthenelais limicola	1	6.7	0.11
Heteromastus filiformis	1	6.7	0.11
Glycinde solitaria	9	13.3	1.07
Pherusa affinis	1	6.7	0.11
Harmothoe extenuata	1	6.7	0.11
Diopatra cuprea	1	6.7	0.11
Nephtys incisa	7	26.7	0.83
Pectinaria gouldii	1	6.7	0.11
Scoloplos fragilis	11	33.3	1.31
Paraprionospio pinnata	1	6.7	0.11
Nephtys picta	3	13.3	0.35
Glycera dibranchiata	2	13.3	0.23
Yoldia limatula	15	66.7	1.78
Tellina agilis	52	86.7	6.19

Table AVI-2 (cont.)

Station 10 (cont.) Species	Total Number Individuals	Percent Occurrence	Percent of Fauna by Number
Ensis directus	21	40.0	2.50
Nucula proxima	435	100.0	51.84
Mulinia lateralis	56	73.3	6.67
Mytilus edulis	47	40.0	5.60
Pandora gouldiana	1	6.7	0.11
Acteocina canaliculata	8	20.0	0.95
Acteon punctostriatus	2	13.3	0.23
Polinices duplicatus	1	6.7	0.11
Nassarius trivittatus	1	6.7	0.11
Thyone briareus	2	6.7	0.23
Ampelisca abdita	34	33.3	4.05
Ampelisca verrilli	75	86.7	8.93
Bathyporeia parkeri	1	6.7	0.11
Oxyurostylis smithi	2	13.3	0.23
Edotea triloba	3	20.0	0.35
Corophium tuberculatum	1	6.7	0.11
Xanthid sp.	1	6.7	0.11
Erichthonius brasiliensis	1	6.7	0.11
Neopanope texana sayi	1	6.7	0.11

Table AVI-3

Number of individuals of each species collected in all samples

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3
Nephtys picta	1								6		1				
Nephtys bucera				1		1								1	1
Magelona sp. 2							1		7						
Spiophanes bombyx									3						
Dispio uncinata									1						
Nucula proxima						5		10		1			2	3	
Nassarius trivittatus															1
Tellina agilis									2						
Mulinia lateralis		1		9	9	2									
Spisula solidissima	1														
Mytilus edulis		1													
Donax variabilis		1													
Parahaustorius attenuatus	1	1					1				1				
Parahaustorius longimerus	4	4	6	36	45	33	28	7	4	17	12	11	2	3	4
Bathyporeia parkeri		1													
Neomysis americana		1													
Paracaprella tenuis				1											
Ampelisca abdita				7	1										
Edotea triloba				1	1										
Corophium insidiosum					1	1									
Bathyporeia quoddyensis					1						1				
Chiridotea tuftsi					2			1							
Elasmopus laevis						6									
Xanthid sp.						2									
Protohaustorius wigleyi								1	4						
Orchestia grillus								1							
Sesarma reticulatum								1							
Ampelisca verrilli											1				
Sertularia argentea	x														
Campanularia sp.	x														
Hydractinia echinata				x											

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3
Nemertea sp.				6									3	2	1
Spio setosa	4	14	10	85	3	10							345	446	545
Spiophanes bombyx	10		11							3	1		3	1	2
Glycera dibranchiata	2		1						1			4	2	1	
Phyllodoce arenae	2								1						
Magelona sp. 2	1			1											
Heteromastus filiformis	2		1		4										
Polydora socialis	1											1		3	
Aricidea sp.	1														
Asabellides oculatus		1	2	1										3	2
Nephtys picta		1	2				1	15	7	2		1	3	3	
Aricidea cerruti		1		9											
Lumbrineris acuta		1													
Scoloplos sp.		1		2											
Streblospio benedicti				10	2	1									1
Mediomastus ambiseta				53		7						1			1
Glycera americana				1						1			3	1	1
Oligochaeta A				2	3										
Clymenella torquata				1											
Sabellaria vulgaris				1									4	3	1
Polydora ligni				1											
Eteone heteropoda				1											
Driloneris magna				3											
Scoloplos acutus				1											
Paranaitis speciosa					2										
Scoloplos robustus					2		2								
Harmothoe extenuata						5							1	16	1
Scoloplos fragilis							1							1	1
Goniadella gracilis							1								
Glycera capitata											1			1	
Eumida sanguinea													4	17	1
Polydora concharum													1		

Table AVI-3 (cont.)

Species	May 1974 2-1	May 1974 2-2	May 1974 2-3	August 1974 2-1	August 1974 2-2	August 1974 2-3	November 1974 2-1	November 1974 2-2	November 1974 2-3	February 1975 2-1	February 1975 2-2	February 1975 2-3	May 1975 2-1	May 1975 2-2	May 1975 2-3
Capitella capitata													6	10	15
Ampharete acutifrons													2		
Nereis succinea														1	
Lepidonotus sublevis														1	
Amphitrite ornata														1	4
Nephtys incisa															2
Tellina agilis	9	8	13	9	5	3	51	33	51	15	5	1	14	13	12
Lyonsia hyalina	1														
Ensis directus	1	1		3	2			1							
Crepidula fornicata				1										2	2
Mytilus edulis					4	6							55	429	110
Marginella roscida						1									
Nucula proxima							2	5	8	2	3				
Mulinia lateralis							2	1	2						
Acteocina canaliculata								1	1						
Petricola pholadiformis										1					
Crepidula plana														3	
Parahaustorius attenuatus	1														
Parahaustorius longimerus	2			1			2	1			2			1	
Oxyurostylis smithi	1		1												
Bathyporeia parkeri	1														
Corophium tuberculatum		2													
Unciola serrata		1	1	2		2								3	3
Unciola irrorata			4												
Crangon septemspinosa				1		4									
Xanthid sp.				1		1								3	
Neomysis americana				1				1							
Lysianopsis alba				2		2								1	1
Elasmopus laevis					2										
Pinnixa sp.						1									

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3
Protohaustorius wigleyi								2							
Synchelidium americanum									1						
Siphonoecetes smithianus									1						
Edotea triloba											1				
Leptocuma minor												1			
Paraphoxus spinosa														1	
Pinnotheres maculata															1
Hydractinia echinata	x														
Electra monostachys	x	x	x	x	x	x									
Conopeum truitti					x										
Conopeum tenuissimum	x		x	x	x	x									
Membranipora tuberculatum		x													
Alcyonidium polyoum		x			x										
Amphioplus abditus				1											
	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3
Spio setosa	20	9	1	1	2	2	3								
Asabellides oculatus	4	5		3	1									1	
Glycera dibranchiata	1				1		2					3	1		
Harmothoe extenuata	3	3	1	18	9	6									1
Spiophanes bombyx	1	1	3									1	1	1	1
Aricidea cerruti	1	3		2	2	3	3								
Sabellaria vulgaris		2	1		1				7					1	
Driloneris magna			1	1											
Caulleriella sp. 2			1												
Nereis succinea				3	2	3	1								
Lepidonotus squamatus				2											
Pherusa affinis				1	1										
Polydora ligni				1		3									

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3
Mediomastus ambiseta				34	10	5	13								
Oligochaeta A				4					1						
Heteromastus filiformis					4										
Streblospio benedicti					1	2	5	1							
Polycirrus eximius					2	3	4								
Ampharete acutifrons					1										1
Nemertea sp.					2	1	1		1	1					
Eumida sanguinea					3			3	6		1	1	1	2	
Schistomeringos rudolphi					1										
Scoloplos robustus					3			1	2	1					
Lepidonotus sublevis						4									
Amphitrite ornata						1									
Phyllodoce maculata						1	1								
Tharyx sp. 2						1									
Podarke obscura						1									
Glycinde solitaria							1								
Nephtys picta							1		1	2	7	1	3	1	4
Glycera americana							1	1	3						
Scoloplos fragilis							2							1	
Phyllodoce arenae							1			1				1	
Schistomeringos caecus							1								
Chaetozone sp.							4								
Driloneris longa								1							
Polydora socialis								4							
Glycera capitata										3		1	2		
Lepidametria commensalis														1	
Capitella capitata														1	
Tellina agilis	8	1	8		2	1	1		5	31	33	34	9	13	7
Mytilus edulis	3	1		357	36	255							78	129	20

Table AVI-3 (cont.)

Species	May 1974 3-1	May 1974 3-2	May 1974 3-3	August 1974 3-1	August 1974 3-2	August 1974 3-3	November 1974 3-1	November 1974 3-2	November 1974 3-3	February 1975 3-1	February 1975 3-2	February 1975 3-3	May 1975 3-1	May 1975 3-2	May 1975 3-3
Marginella roscidium	1					5		1							
Doridella obscura	1														
Nassarius trivittatus		1													
Nucula proxima			1		2	2						1			
Spisula solidissima			1												
Crepidula plana				7	3								1		
Crepidula convexa				1											
Crepidula fornicata					2										
Ensis directus											1			2	
Lyonsia hyalina														1	
Mulinia lateralis															1
Pagurus longicarpus	4	5						2						1	
Unciola serrata	1	1	3			1	4	3	5				1	4	
Pinnixa sayana		1													
Unciola irrorata			1								1	1			1
Xanthid sp.						10	1	3	1						
Hexapanopeus angustifrons						1									
Pinnixa sp.						1	1	1							
Pinnixa retinens						1									
Upogebia affinis						1									
Lysianopsis alba						6	14	3							
Cancer irroratus							1								
Panopeus herbsti							1								
Euceramus praelongus							1								
Parahaustorius longimerus								1							
Callianassa sp. cf. *C. atlantica*									1				1		
Unciola dissimilis												1			
Oxyurostylis smithi													5		
Electra monostachys	x	x		x		x	x	x	x						
Alcyonidium polyoum	x	x	x	x	x	x									

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3
<u>Membranipora tuberculatum</u>							x								
<u>Membranipora tenuis</u>					x		x								
<u>Schizoporella errata</u>						x									
<u>Cryptosula pallasiana</u>						x	x		x						
<u>Hydractinia echinata</u>				x										x	
<u>Astrangia danae</u>					x										
<u>Cliona celata</u>					x										
<u>Conopeum truitti</u>									x	x					
<u>Conopeum tenuissimum</u>								x	x		x				
	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3
<u>Nephtys bucera</u>	1	1	1				2								
<u>Spiophanes bombyx</u>		2			1	2	1						4		3
<u>Spio setosa</u>		2											1	1	
<u>Dispio uncinata</u>			1												
<u>Glycera dibranchiata</u>				3	3	2			1		3	2	3	1	
<u>Nephtys picta</u>				1		1		1	1		1				
<u>Nemertea</u> sp.				1	6		3	5	1						2
<u>Glycinde solitaria</u>				1	2	1									
<u>Scoloplos robustus</u>				1	4	1	1		4				3		
<u>Glycera capitata</u>					6	10	1	2	1	2	2	2		1	4
<u>Scoloplos acutus</u>					1									1	
<u>Asabellides oculatus</u>						2							1		
<u>Scoloplos fragilis</u>						1					1				
<u>Sthenelais limicola</u>								1							
<u>Mytilus edulis</u>	1														
<u>Tellina agilis</u>		4	2	6	14	17	56	5	3	1	2	6	7	2	6
<u>Spisula solidissima</u>		4													
<u>Mulinia lateralis</u>				1	6		2			2					
<u>Nucula proxima</u>					10		44	14	2				37	11	

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3
Acteon punctostriatus							3	4							
Acteocina canaliculata									2	1	2	3			
Ensis directus															1
Protohaustorius wigleyi	10	86	51				1								
Synchelidium americana			1												
Ampelisca verrilli				1		5				1			2		
Ampelisca vadorum					1										
Oxyurostylis smithi					4										2
Pinnixa sayana						2					1		1		
Trichophoxus epistomus							17	34	8	7		2	1		2
Pinnixa retinens								1							
Pinnixa sp.								2							
Pagurus longicarpus											1				
Parahaustorius longimerus											1				
Alcyonidium polyoum			x												
	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3
Capitella capitata	10												1	6	2
Spio setosa		2											1		
Asabellides oculatus		6	13												
Scoloplos robustus		1	1												
Lumbrineris acuta		1													
Sthenelais limicola		1												1	
Glycera americana			1							1		1		1	
Glycera dibranchiata										1					
Pectinaria gouldii										1					
Nephtys incisa												1			
Heteromastus filiformis												1			1
Tellina agilis	11	13	19	14	50	55	6	11	16	4	1		110	29	50
Yoldia limatula	1	4	6							2		1		1	

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3
Siliqua costata		1													
Nucula proxima		9	18	1299	5653	3489	1857	2315	1405	3	2	2	4787	184	370
Mulinia lateralis		5	11								1	1			
Ensis directus		23	61	5	1	5		1				3		1	1
Mytilus edulis			1										1	1	
Nassarius trivittatus								1		1					
Haminoea solitaria								1	2						
Acteon punctostriatus								6	8						
Acteocina canaliculata										1		1			
Protohaustorius wigleyi		2													
Ampelisca verrilli		1	3							1	3	1			
Neomysis americana				1											
Ampelisca vadorum				1							1				
Lysianopsis alba					1										
Oxyurostylis smithi										1					
Parahaustorius longimerus												1			
Upogebia affinis												1			
Pinnixa retinens														1	
Ampelisca abdita														4	4
	6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3
Nephtys bucera	1			3	1		3	2	1						
Scoloplos sp.					1	1									
Nephtys picta						4									
Nemertea sp.								1							
Spio setosa													2		
Magelona sp. 2													1		
Nucula proxima	1			3			4	2					1		
Ensis directus			4												
Spisula solidissima				2	5	12									

Table AVI-3 (cont.)

Species	May 1974 6-1	May 1974 6-2	May 1974 6-3	August 1974 6-1	August 1974 6-2	August 1974 6-3	November 1974 6-1	November 1974 6-2	November 1974 6-3	February 1975 6-1	February 1975 6-2	February 1975 6-3	May 1975 6-1	May 1975 6-2	May 1975 6-3
Mulinia lateralis				1									1		
Tellina agilis								2			1				
Turbonilla interrupta									1						
Parahaustorius longimerus	24	4	20	23	22	53	3	4	3				7		5
Acanthohaustorius millsi	30	4	24	1	3	25	4		1		1		6	4	1
Bathyporeia parkeri	8	1	7												
Acanthohaustorius shoemakeri				5											
Parahaustorius holmesi				1											
Protohaustorius wigleyi					1	9	13	3	6	20	11	5	2	3	10
Trichophoxus epistomus							1								
Mancocuma altera															1
	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3
Asabellides oculatus	4		1												1
Scoloplos robustus	1	1	3	1	1	2									2
Spio setosa	1												5	2	5
Heteromastus filiformis	1						3								
Glycera capitata		1												4	
Capitella capitata		1													
Glycera dibranchiata			1										1	1	
Streblospio benedicti			1												
Nephtys incisa				2	3		3	2	1	1	1			1	1
Scoloplos fragilis					1										
Nephtys bucera						3									
Paraprionospio pinnata							1								
Glycera americana								1		1					
Sipunculidae sp.								2							
Pectinaria gouldii									2						
Glycinde solitaria											1				

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3
Spiophanes bombyx													2		
Nemertea sp.													1		
Nephtys picta														1	
Yoldia limatula	1			3		1							8	6	
Tellina agilis		1	2	2	1	3					1	3	12	17	19
Mulinia lateralis		1		20	28	13		1		2	1	1	1		
Crepidula fornicata			1												
Ensis directus				1			2						1	1	1
Nucula proxima				27	32	33		1		8		4	2		
Turbonilla interrupta							1								
Mytilus edulis													3		
Siliqua costata														1	
Acanthohaustorius millsi	3							1					1	1	
Bathyporeia quoddyensis													1		
Bathyporeia parkeri	1														
Ampelisca vadorum	1	1													
Parahaustorius longimerus	2												2	4	
Ampelisca verrilli				2	3	3	7	15	6	8	25	16	2		2
Pinnixa retinens						1									
Edotea triloba							2								
Trichophoxus epistomus								1							
Ampelisca abdita									1		12			1	
Oxyurostylis smithi												1			
Cancer irroratus											1				
Protohaustorius wigleyi											1		2		
Alcyonidium polyoum			x												
	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3
Hydroides dianthus	111	18	3	106	30	159	202	494	24	609	584	160	79		22
Polydora ligni	229	17	14				2	10	2		15	18	2		
Marphysa sanguinea	22	8	4	4	6	3	8	14		9		9	6	12	4

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3
Sabellaria vulgaris	15	1		23	3	30	35	79	231	225	114	51	11	21	13
Polydora socialis	44	8	3					7	1	3		5	3	30	
Nereis succinea	16	10	5	2	3	3	9	14	3	1		1	14	21	7
Polycirrus eximius	10	5	3				7	14	4	114	18	45	4	66	20
Syllis gracilis	3						5	2					1	3	
Spio setosa	1	11	7				1						1	3	14
Heteromastus filiformis	8	12	28	1	6		7	9	13		3		1	18	5
Proceraea cornutus	1							1							
Asabellides oculatus	1	5	4	11	177	12	34	3	3		6	10	16	18	5
Capitella capitata	1	3	9	1		3							6		4
Harmothoe extenuata	79	22	6	2		3						7	24	12	10
Lepidonotus squamatus	14	1		2		3	14	27	11	6	6	17	14	9	1
Streblospio benedicti		2	4	1		3				3					1
Lepidonotus sublevis		2		6				5							
Pectinaria gouldii		1					2							3	
Phyllodoce arenae		1					1	1	3					3	
Glycinde solitaria		1		3	9	3	2	9	23					12	3
Tharyx sp. 2		3	1						1						
Maldanidae sp. 1		2													
Oligochaeta B		1						1					5		8
Glycera americana		1						1	1						1
Diopatra cuprea		1													
Eteone heteropoda			1												
Eteone longa			3												
Sthenelais boa				2				2	2				1	3	3
Mediomastus ambiseta				14	9		10	37	61		9	19	2	99	28
Phyllodoce maculata				5											
Amphitrite ornata				1											
Oligochaeta A				4				4	3			1		12	3
Zygeupolia rubens				1											

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3
Pherusa affinis					6										
Nemertea sp.					3		1			2		6	1	3	1
Scoloplos robustus					3										
Eumida sanguinea						12	9	54	48	18	60	124	44	309	126
Goniadella gracilis							4								
Podarke obscura							4	5	3		3	1	1	3	1
Schistomeringos rudolphi							1							3	
Flatworm A								3	1						
Glycera capitata									1				1		
Polydora concharum												1	1		
Spiophanes bombyx													1		
Nephtys incisa													2		
Cirratulidae sp.													1	3	1
Polydora caulleryi															1
Mytilus edulis	887	24	24	17	2					2			6029	5427	1492
Tellina agilis	2		1	1	5	8	1	1	1	2	1		2	2	2
Mulinia lateralis	1			1											
Nucula proxima		23	13		15	17	31	26	30	35	10	9	10	84	180
Crepidula plana			56				5		7	2	82		2	1	11
Crepidula convexa			1												
Mercenaria mercenaria				2	1	3	12	18	19	7	7	5	3	6	3
Petricola pholadiformis					1										
Lyonsia hyalina						1									
Hydrobia totteni							1								
Acteocina canaliculata										1					
Doradella obscura												1			
Cuthona concinna													1		
Doto coronata													1		
Neopanope texana sayi	16			33	8	8	3	2	1	3	3	1	7	3	7
Panopeus herbsti	2											1			

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3
Xanthid sp.	132	16	18	108	26	21	40	93	11	79	44	30	49	40	7
Unciola serrata	177	47	32	264	6	108	38	279	82	600	429	477	25	154	109
Corophium simile	516	42	8	162	6	123	81	242	73	72	117	30	48	73	9
Lembos smithi	55	6		21		9	18	130	9	41	30	15	2	11	1
Paracaprella tenuis	4														
Paraphoxus spinosus	12	1		3				1	4		6		1		
Elasmopus laevis	2		1		2			4	1		6		1		
Erichthonius brasiliensis	6			6	2	6		3					3		
Microdeutopus gryllotalpa	3														
Pagurus longicarpus		1	1		1				2		3			1	
Oxyurostylis smithi		2	11						1	12		18		8	1
Melita nitida		5	1	3	1	6	5	3	2		3	12			
Parahaustorius longimerus				3				1							
Heteromysis formosa				3											
Ampelisca abdita				3	2				1	3	3	9	1	2	
Protohaustorius wigleyi					1										
Corophium tuberculatum					3										
Acanthohaustorius millsi					2										
Ampelisca verrilli						9									
Crangon septemspinosa							1						1		
Caprella equilibra							4	31	2		33		22	7	
Ampelisca verrilli							1					3			
Phoxocephalus holbolli							7								
Tanystylum orbiculare								4			6				
Pinnixa sp.									3						
Neomysis americana									7						
Cancer irroratus										1					
Paracaprella tenuis										3					
Parapleustes aestuarius										3	3		2		

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3
Edotea triloba											3	3		2	
Batea cathariensis											9				
Corophium tuberculatum													1		
Sertularia argentea	x		x												
Tubularia crocea	x														
Electra monostachys	x						x						x		
Conopeum tenuissimum		x	x						x						
Alcyonidium polyoum	x	x						x		x	x				
Schizoporella errata	x	x	x				x	x	x	x	x				
Microciona prolifera	x			x	x						x				
Membranipora tenuis					x										
Cliona celata					x										
Thyone briareus												1			
Starfish (juv.)													1		
Triticella elongata														x	
	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3
Cirratulidae sp.													2		
Syllis gracilis													3		
Lumbrineris acutus															1
Nucula proxima	2		9	5	36	6	57	33	25	41	38	37	58	1	23
Mercenaria mercenaria	2				8		16	11	7	11	2	7	6	4	4
Tellina agilis	8	2	2	3	2	3	4						1	1	1
Mytilus edulis	2	1008	7	54	14	56				10			1553	417	201
Lyonsia hyalina				2	2		1								
Crepidula convexa				3											
Crepidula plana					3			2	2	9		1			
Anomia simplex					1		1								

Table AVI-3 (cont.)

Species	May 1974 9-1	May 1974 9-2	May 1974 9-3	August 1974 9-1	August 1974 9-2	August 1974 9-3	November 1974 9-1	November 1974 9-2	November 1974 9-3	February 1975 9-1	February 1975 9-2	February 1975 9-3	May 1975 9-1	May 1975 9-2	May 1975 9-3
Ensis directus						1									
Petricola pholadiformis						1									
Anachis avara							2			3					
Doradella obscura							1								
Mitrella lunata							2								
Hydrobia totteni							1								
Mulinia lateralis								1							
Anadara ovalis										1			2		
Xanthid sp.	1			63	50	81	21	4	8	45	2		37	22	6
Oxyurostylis smithi	2						3	10	1	12	2		3		2
Corophium simile		4		141	49	294	96		8	22			17	13	1
Pagurus longicarpus		1			4		1		3			2			
Neopanope texana sayi		1		21	14	30	1						6	9	
Ampelisca verrilli		4					1	1							
Edotea triloba		1	1					1	2	10		6			1
Elasmopus laevis		1		3		9	1		1	1			1		
Batea catharinensis		1											1		
Paracaprella tenuis		2											3	2	
Melita nitida				6	2	39	2		1	5			1		
Unciola serrata				159	61	342	86	14	40	129	15		88	13	8
Lembos smithi				6	9	21	47	3	6	18	1				
Erichthonius brasiliensis				6	11	42	1	1						2	
Paraphoxus spinosus					3	21				3					
Corophium tuberculatum					11										
Phoxocephalus holbolli							4								
Panopeus herbsti										1			3		
Hydroides dianthus	440			633	219	816	175	28	10	99	13	1	117	52	
Nereis succinea	11			27	9	45	6			12	3		9	7	2
Marphysa sanguinea	2			15	6	18	2	2	6	6	1		3	3	

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3
Harmothoe extenuata	1	1		9	6	3				3			6	5	1
Glycinde solitaria	2		4	15	9	9	9	3	13	12	3	5	6	1	5
Spio setosa	5	5													4
Driloneris longa	2												6		
Glycera americana	2	1		3				3	2		1	1			
Capitella capitata	2													8	
Polydora ligni	33	4					5		1	9	1				
Sabellaria vulgaris	8			66	24	84	20	2	14	36	3		30	1	
Polydora socialis	4							1	5				3		4
Asabellides oculatus	1	16	10	39	30	39	5		1	21	2	1	6	19	4
Polycirrus eximius	1			75	24	18	8		9	33	14	4	39	34	10
Nemertea sp.	2				3			1	1				15		2
Oligochaeta A	1			33		27			18						
Heteromastus filiformis	5	3		18	18	75	2	1	14	45	13	18	9	3	21
Scoloplos robustus		1						1	1						
Streblospio benedicti		2		9	6	15					3		12		3
Pherusa affinis			1												
Lepidonotus sublevis				27		15									
Mediomastus ambiseta				36	30	51	18	7	31	120	4	18	60	5	14
Sthenelais boa				6	3		1		3		1				1
Lepidonotus squamatus				3			17	1	2	3	2		12	2	
Eumida sanguinea				52		45	27	1	25	54	9		84	12	12
Amphitrite ornata					3										
Tharyx sp. 2					3	3									
Eteone heteropoda						3									
Phyllodoce arenae							3			6	1	1			3
Pectinaria gouldii							3	3	4	3		3	3		1
Glycera dibranchiata							2								
Goniadella gracilis							4								
Podarke obscura							10		3			1	3		
Flatworm A							4								

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3
Polydora concharum									1					1	
Proceraea cornuta									1	3					
Lepidometria commensalis									1						
Chaetozone sp. 1										3					2
Glycera capitata												1			
Lysianopsis alba										1					
Ampelisca abdita										1	1	1			
Caprella equilibra										1			1		
Sertularia argentea		x													
Electra monostachys		x												x	
Conopeum tenuissimum	x			x						x	x				
Membranipora tenuis	x	x			x										
Alcyonidium polyoum					x					x					
Schizoporella errata				x		x			x						
Triticella elongata					x		x			x					
Cliona celata					x										
Halichondria cf. H. bowerbanki						x									
Conopeum truitti														x	
Thyone briareus														1	
Balanus improvisus														1	
	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3
Spio setosa	1														
Glycera americana	1					1				2					
Asabellides oculatus	12	14	1												
Scoloplos robustus	4	2								1					
Streblospio benedicti	1														
Sthenelais limicola	1														

Table AVI-3 (cont.)

Species	May 1974 10-1	May 1974 10-2	May 1974 10-3	August 1974 10-1	August 1974 10-2	August 1974 10-3	November 1974 10-1	November 1974 10-2	November 1974 10-3	February 1975 10-1	February 1975 10-2	February 1975 10-3	May 1975 10-1	May 1975 10-2	May 1975 10-3
Heteromastus filiformis	1														
Glycinde solitaria	5	4													
Pherusa affinis	1														
Harmothoe extenuata		1													
Diopatra cuprea			1												
Nephtys incisa				1		1			1						4
Pectinaria gouldii				1											
Scoloplos fragilis				1	2	3					3	2			
Paraprionospio pinnata							1								
Nephtys picta										1	2				
Glycera dibranchiata												1			1
Yoldia limatula	4	2		1	2	1	1		1				1	1	1
Tellina agilis	6	4	1		4	8	4	4	4	1	3	10	2		1
Ensis directus	5	11	1	1	2					1					
Nucula proxima	3	11	2	32	37	64	74	74	56	2	4		27	19	30
Mulinia lateralis	6	9	6	7	14	4	1	5	1		2	1			
Mytilus edulis		3	28			1							9	3	3
Pandora gouldiana						1									
Acteocina canaliculata							5	1	2						
Acteon punctostriatus								1	1						
Polinices duplicatus											1				
Nassarius trivittatus											1				
Thyone briareus														2	
Ampelisca abdita	7	3	1										22	1	
Ampelisca verrilli	7	7		2	2	2	1	1	4	15	7	13	9	5	
Bathyporeia parkeri		1													
Oxyurostylis smithi		1								1					
Edotea triloba		1								1		1			

Table AVI-3 (cont.)

Species	May 1974			August 1974			November 1974			February 1975			May 1975		
	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3
Corophium tuberculatum			1												
Xanthid sp.				1											
Erichthonius brasiliensis					1										
Neopanope texana sayi									1						

Table AVII-1

Benthic invertebrates in grab samples
Station 3

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3006	<u>Zygeupolia rubens</u>													1							
3014	<u>Nemertea</u> sp.			2			2			1		4			1			1	1		
4011	<u>Mediomastus ambiseta</u>	1	2	21	10	59	11	4	18	7	16	10	3	25	26	1		1	41	8	6
4018	<u>Tharyx</u> sp. 2	1																			
4171	Chaetozone sp. 3	1																			
4071	<u>Aricidea cerruti</u>	2		4				2	4	3	3	3	1	5	1		2	2	19		2
4077	<u>Eteone heteropoda</u>	1		2			2			1		1		1					1		
4105	<u>Sthenelais boa</u>	1				1															
4110	<u>Polydora ligni</u>	1		3		1	6		1		3	2		1	3		1		1	1	
4117	<u>Spio setosa</u>	4		1	6	1	1		6	1	1	2	9		1	1	1	5	7		1
4119	<u>Streblospio benedicti</u>	1		1	1	1	1		1	1	2			2	2			1	2		
4061	<u>Travisia carnea</u>	1																			
4101	<u>Hydroides dianthus</u>		4												1		1		1		
4088	<u>Harmothoe extenuata</u>		13	40	12	15	19	26	23	7	9		5	6	9	8	3		8	11	7
4055	<u>Nereis succinea</u>		2	11	5		3	5	12	5	2	8	2	2	1		3	1	1	11	6
4002	<u>Asabellides oculatus</u>		1	2	1	2	2	3	1	4	2	9	2	4	8	1			3		3
4137	<u>Polycirrus eximius</u>		1	11	4	3	6	1	5	4	5	24	3	3	4	2	2		3	1	4
4091	<u>Lepidonotus squamatus</u>		1		1			1	1					2							
4111	<u>Polydora socialis</u>				5			1	5		1				3	1					4
4080	<u>Eumida sanguinea</u>				1				6	1			1						1		
4066	<u>Orbinia ornata</u>				1																
4134	<u>Amphitrite ornata</u>				1										1						
4010	<u>Heteromastus filiformis</u>			2					1		1	1		2	1				3	2	
4021	<u>Schistomeringos rudolphi</u>			2			1		1	1							1		1		
4023	<u>Marphysa sanguinea</u>			2		1						2			1						
4140	Cirratulidae sp.			1						2				1							
4025	<u>Glycera americana</u>					1	2	1	1		2	1		1				1		1	

Table AVII-1 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4092	Lepidonotus sublevis					3	2		1	3	4		3		3	1	1		2		2
4172	Chaetozone sp. 1					1								1						1	
4076	Pectinaria gouldii					1													1		
4084	Phyllodoce arenae					1															
4125	Procerae cornuta					1															
4016	Chaetozone setosa						4		1												
4024	Pherusa affinis							1	1	1			1				1				1
4001	Ampharete acutifrons								1			2		1							
4173	Chaetozone sp. 4								2			1									
4006	Driloneris longa										2	1	1	1							
4064	Scoloplos fragilis											2									
4026	Glycera capitata										1								1		
4174	Pionosyllis sp.										1										
4175	Nereis arenaceodonta															1	1		2		2
4109	Polydora concharum																1				
4065	Scoloplos robustus																1				
4030	Podarke obscura																			2	
4171	Chaetozone sp. 2																			1	1
4083	Paranaitis speciosa																		1		
4153	Schistomeringos caecus																		1		
4400	Oligochaeta A					6					6	1	4	5	2					3	
4401	Oligochaeta B													1							
5027	Nassarius trivittatus	2		1					1				3								2
5013	Crepidula convexa	4		3	3	6	2		1	2		5	1		5		1	1		1	
5087	Corbula contracta	1																			
5014	Crepidula plana		1	1			1							2						5	
5053	Mytilus edulis		167	894	221	99	271	529	433	235	153	706	194	211	130	15	100	4	69	289	191
5047	Nucula proxima			3	3		1		1			1	2		1		1		2		
5080	Ensis directus			1								1		1				1	1		1
5029	Marginella roscida			3	1	2			2			5	2	1	1						
5070	Tellina agilis			2	1		1		2		1	4	2				3	7	1		1

Table AVII-1 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5012	Crepidula fornicata																			1	
7115	Pagurus longicarpus	1														1					
7086	Lysianopsis alba	1	1	11	2	23	18	28	21	14	11	18	3	11	10	1	22		12		10
7145	Heteromysis formosa	2							3					2		1	1				
7146	Xanthidae sp.	6		26	11	23	16	12	5	7	4	38	5	18	11	5	18		12		14
7130	Pinnixa sayana	1		3			1					2	1	2			1		1		
7125	Panopeus herbsti			2	1		1					2	1		3				1		
7056	Unciola serrata			2	11	1			1	2	2	4	3		2		2		4		
7068	Elasmopus laevis				1																
7147	Pinnixa sp.			1		1						2	1		1	1	1	3			
7148	Callianassa sp. cf. C. atlantica						1				1				1				1		
7054	Erichthonius brasiliensis						1														
7121	Cancer irroratus								1			1	1	1							
7013	Cyathura burbancki								1	1											1
7149	Euceramus praelongus											1									
7111	Crangon septemspinosa																				
7116	Pagurus pollicaris																				
7127	Hexapanopeus angustifrons						1	1	1												
7144	Pinnotheres maculatus							1	1	1											
9003	Amphioplus abditus						1												1		
8012	Membranipora tenuis	x		x			x			x									x		x
	Hydractinia echinata	x				x			x			x				x		x			
8023	Schizoporella errata		x													x	x				
8002	Alcyonidium polyoum				x	x		x	x		x		x			x			x	x	
8013	Membranipora tuberculatum			x			x			x			x						x		x
	Electra monostachys			x		x	x			x	x	x	x			x		x	x		x
8014	Conopeum tenuissimum			x		x		x	x					x							
8028	Cribulina punctata															x			x		
8015	Conopeum truitti															x					

Table AVII- 2

Benthic invertebrates in dredge samples
Station 3

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2002	Tubularia crocea				1	1					1										
2007	Hydractinia echinata		1	1	1				1			2	1	1		1	1	0	1		1
2008	Podocoryne carnea			1																	
3006	Zygeupolia rubens							1				1			1		1		1		
3008	Cerebratulus lacteus														1		1				
3014	Nemertea sp.	1	1		1	1	3								1	1	1	1		1	
4001	Ampharete acutifrons	1					1														
4002	Asabellides oculatus	3		1	1	1	1	1	1				1	1	1		1	1	2		
4006	Driloneris longa																	1			
4011	Mediomastus ambiseta	7	5	3	5	4	5	5	5	5	3	2	5	5	5	7	5	7	7	5	5
4015	Caulleriella sp. 2												1								
4018	Tharyx sp. 2				1																
4021	Schistomeringos rudolphi		1	1													1				
4023	Marphysa sanguinea																		1		
4024	Pherusa affinis	1									1								1		
4027	Glycera dibranchiata																		1		
4030	Podarke obscura						1														
4055	Nereis succinea	5	5	4	3	3	5	3	5	5	3	3	5	5	5	5	4	5	7	3	3
4071	Aricidea cerruti	1					1	1				1	1	1		1		1			
4076	Pectinaria gouldii	1																			
4077	Eteone heteropoda	1	1	1	1	1	5	3	2	3		1	7	2	1	1	3	1	5	1	1
4080	Eumida sanguinea	1	1	2	4		5	3	3		1	1	3	1	1	5	5	1	5	3	1
4083	Paranaitis speciosa																1				
4085	Phyllodoce maculata																			1	
4088	Harmothoe extenuata	7	5	7	7	5	7	7	7	7	5	7		7	6	7	7	7	7	7	7
4091	Lepidonotus squamatus		1	1	1	1		1			1	1	1	1	1	1		1		1	1
4092	Lepidonotus sublevis	3	1	1	1	3					1		1								
4093	Sabellaria vulgaris	1		1	1	1	1	1	1						1	1			1	1	
4101	Hydroides dianthus			1	1	1							1			1			1		

Table AVII-2 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4109	Polydora concharum	1														1	1	1			
4110	Polydora ligni	7		6	7	7	7	7	7	7	5	7	7	5	5	7	7	7	7	7	5
4111	Polydora socialis	1														1	1	1			
4117	Spio setosa	1					1	3	3			1	1			1	1	1	4		
4119	Streblospio benedicti	1	1				1		1				1	1		1	1		1		1
4124	Parapionosyllis longicirrata		1	1									1								
4137	Polycirrus eximius	5	1	3	5	3	4	3	4	4	3	5	4	3	3	3	4	5	5	3	3
4140	Cirratulidae sp.													1				1		1	
4146	Aricidea sp.	3																	1	5	
4171	Chaetozone sp. 3				1			1	1			1	1				1	1	1		
4172	Chaetozone sp. 1	1																			
4176	Chaetozone sp. 2	1															1	1			
4177	Lepidonotus (juv.)			1	5			3	3	3		1				1	1	1	1		
4400	Oligochaeta	3				1			3					3		7			1		
5012	Crepidula fornicata				1																
5013	Crepidula convexa	1	1		1	1					1	1			1	1	2	1			
5014	Crepidula plana	3	5	5	5	5	5	3	3		1	3	3	3	5	3	7	6			3
5023	Mitrella lunata				1	1	1	1							1	1					1
5027	Nassarius obsoletus				1				1										1		
5029	Marginella roscida	3	1			3			1			1	1	1		1	1	1		1	1
5042	Chaetopleura apiculata																1				
5047	Nucula proxima	1		1	1	1	1	1	1	1	1	5	1	1	3	3	3	3	3	3	1
5053	Mytilus edulis	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
5064	Mysella planulata												1								
5070	Tellina agilis	1								1					1				1	1	
5097	Nudibranchia sp.							1													
6009	Balanus (Balanus) improvisus			1																	
7002	Neomysis americana	3		3	5	6	3	5	7	5		1		3	1	3	1			1	
7011	Cyathura polita																1				
7013	Cyathura burbancki												1								
7035	Ampelisca abdita		1																		
7049	Corophium acherusicum							1	1												

Table AVII- 2 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7056	Unciola serrata			1	1	3	1	5	5				1		1				1	1	
7058	Corophium simile			1																	
7086	Lysianopsis alba	5	3	3	3	4	1	2		3	5		3	4	4	5	3	5	4	5	5
7111	Crangon septemspinosa	3	1		1	1	1	3	3	1	3		1		1	1		1	1		1
7115	Pagarus longicarpus	1	1	1	1				1			1	3			1	1				1
7116	Pagarus pollicaris		1						1		1	1			1						
7121	Cancer irroratus		1		1					1		1	1	1	1		1		1	1	1
7124	Neopanope texana sayi		1	1									1								
7125	Panopeus herbsti													1							
7138	Libinia emarginata							1		1											
7146	Xanthid sp.		1	1	3	3	3	3	1	3	1	1	3	1	1	2	3	4	5		1
7147	Pinnixa sp.															1					
7152	Libinia sp. (juv.)															1					
8002	Alcyonidium polyoum	4	5	5	2	1	1	3	7	3	3	3	1	3	5	3	3	3		3	5
8012	Membranipora tenuis	3		4	1	3	1		3	1	3	3	3	3				1	1		1
8013	Membranipora tuberculata	1	3				5	5			3	3			1	2	1	1	1		
8014	Conopeum tenuissimum		1		1	5		5	1		1	3			3	4	4		3	1	
8015	Conopeum truitti					1	1		1		1	1	1	1				1	3		
8018	Electra hastingsae	3	3	4	5	5	4	3	3	4	4	3	3	5	4	3	4	5		3	5
8022	Cryptosula pallasiana					1	1	1	1			1	3		5	3	3	1	3		
8023	Schizoporella errata	1	1	3	1	1	1	1	4	2		1	1	1	1	1	1		1	3	1
8024	Schizoporella biaperta														5	4	4		3	1	
8025	Microporella ciliata	1		3					1			1	1	1	1	1		1		1	1
9001	Asterias forbesi										1	3									
9003	Amphioplus abditus																1				
9004	Arbacia punctulata								1												
9005	Echinarachnius parma						1														
9008	Starfish (juv.)													1	1	1	5	3	1	3	1

Table AVII-3

Benthic invertebrates in grab samples
Station 4

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3014	Nemertea sp.	1	3		2	1	1	1		1		1	2			1		5	1	1	
4034	Amphitrite ornata										1										
4002	Asabellides oculatus							2		1	4							1		1	
4026	Glycera capitata	4	8	2	4	7	5	4	3	2	1	3	5	3	4	3	7	5	9	1	1
4027	Glycera dibranchiata	1	1	1	1		5	4	3	1	2	3	1	3			2		1	2	4
4028	Glycinde solitaria						1	1		2			2	1	1		1	3	1		
4010	Heteromastus filiformis							1													
4011	Mediomastus ambiseta				2																
4053	Nephtys picta				2		1					1		1							1
4084	Phyllodoce arenae											1									
4085	Phyllodoce maculata								1												
4116	Scolelepis squamata					2														1	
4063	Scoloplos acutus												2					2			
4064	Scoloplos fragilis	1	2	4	3	5	13	8	3	5	3	1	5	2	3	4		2		3	
4065	Scoloplos robustus																4				
4117	Spio setosa							1													
4118	Spiophanes bombyx	1			1	1	2	1	2	4		1	1	1	1	1	1		4	2	
4105	Sthenelais limicola			1													1				
4025	Glycera americana														1						
5080	Ensis directus					1		2			1	1	2	2	1	3	1		3	1	1
5082	Mulinia lateralis		3	1	1	1	2	4	2	3		4	3					2	1	4	
5070	Tellina agilis	8	5	8	6	10	5	13	10	12	17	10	12	14	16	21	2	9	17	12	6
7037	Ampelisca verrilli	1	5		1	4	2		2	3	1	3	1	2	3	8	4	3	1	8	1
7029	Erichsonella filiformis																		1		
6001	Limulus polyphemus														1		1				
7086	Lysianopsis alba		1																		
7009	Oxyurostylis smithi		1		3		1	7	2	4		3	4		3			1			1
7147	Pinnixa sp.						1														
7130	Pinnixa sayana								1	2						3	1	1			

Table AVII-3 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7091	Synchelidium americanum											1									2
7093	Trichophoxus epistomus			1						2		1		1			2	1			1
7146	Xanthid sp.					1															
8018	Electra hastingsae												x								
8009	Triticella elongata															x					
8002	Alcyonidium polyoum								x												

Table AVII-4

Benthic invertebrates in dredge samples
Station 4

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2032	Metridium senile				1									1							
3014	Nemertea sp.	1		1	1		1	1													1
4118	Spiophanes bombyx															1					
4002	Asabellides oculatus	5	5	5	3	1	6	3	5	5	5	3	5	5	5	5	5		1		1
4010	Heteromastus filiformis						1														
4026	Glycera capitata	3	3	5	3	3	3	1			3	3		3	1	5		1	3	2	1
4027	Glycera dibranchiata	1	1					1		1							1				
4028	Glycinde solitaria			3	1			1	1	1		1	1			1					1
4055	Nereis succinea										1										
4064	Haploscoloplos fragilis		1	1	3	5	1	1	1	3		1		1	1	1			1	1	1
4084	Phyllodoce arenae																	1			
4092	Lepidonotus sublevis																	1			
4110	Polydora ligni									1	1										
4116	Scolelepis squamata									1											
4117	Spio setosa	3	1	1	1		1	1			3	1		1	1						1
4119	Streblospio benedicti									1											
4142	Scoloplos sp.												1								
4176	Chaetozone sp. 2						1														
5013	Crepidula convexa		1								1	1			3						
5014	Crepidula plana		1															1			
5023	Mitrella lunata								1	1											
5027	Nassarius obsoletus		1						1	1	1					1	1				
5047	Nucula proxima	1	3				1				1	1		1	1				1		
5066	Mercenaria mercenaria						1														
5070	Tellina agilis	5	5	5	5	3	5	5	3	5	5	5	5	5	5	5	3	3	5	3	5
5080	Ensis directus	3	3	1			1	1	1		3	1	1	1	1	1	1			1	1
5081	Spisula solidissima															1					
5082	Mulinia lateralis	5	7	5	5	5	5			7	5	5	5	5	5	5	5	5	5	5	5
5091	Lyonsia hyalina		1	1		1	2	1	1		3	1	1			1	1				1

Table AVII- 4 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7002	Neomysis americana	1	3	5	5	5	7	7	7	7	7	7	5		5	7	5	5	5	3	3
7009	Oxyurostylis smithi			1	1			3			1		1			1	1	1			1
7028	Edotea triloba				1							1									
7029	Erichsonella filiformis									1	1										
7037	Ampelisca verrilli	5	3	5	3	1	4	1	1	5	3	3	3	1	1	1	1	3	1		3
7048	Cerapus tubularis									1	1	1			1						
7049	Corophium acherusicum							5		5					1	1					
7053	Corophium tuberculatum		1					5	1	5	5			1		1					
7054	Erichthonius brasiliensis									1	1	1									
7080	Neohaustorius biarticulatus					1	1														
7082	Microprotopus raneyi							5	5												
7091	Synchelidium americanum	1			1	1	3		1				1		1		1	3	1	2	
7093	Trichophoxus epistomus						1	3				1					1				1
7111	Crangon septemspinosa	1	3	1				3	1	1	3	1				1	1		1		
7115	Pagarus longicarpus		1			1		1	1	1	1	1			3	1	1				
7119	Ovalipes ocellatus									1		1									
7121	Cancer irroratus															1					
7137	Libinia dubia								1												
7147	Pinnixa sp.		1			1	1			1						1				1	
8002	Alcyonidium polyoum		3	1				3	1	1	1	1			3	1		1		1	
8003	Alcyonidium verrilli									3											
8009	Triticella elongata													1						1	
8014	Conopeum truitti				1																
7130	Pinnixa sayana				1						1			1							

Table AVII-5

Benthic invertebrates in grab samples
Station 5

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3014	Nemertea sp.	2		2		2				2											
4053	Nephtys picta	2	1	2	3	2		1	1	1											
4116	Scolelepis squamata	1																			
4061	Travisia carnea		1																		
4025	Glycera americana				1	1															
4064	Scoloplos fragilis				1																
4063	Scoloplos acutus									1											
4105	Sthenelais limicola										1										
4117	Spio setosa													1			1				
4010	Heteromastus filiformis													1							
4140	Cirratulidae sp.														2			1			
4052	Nephtys incisa																			1	
5070	Tellina agilis	46	39	39	35	35	65	43	54	45	60	55	47	38	52	57	37	13	38	19	26
5080	Ensis directus	4	1	3	5	2	5	4	2	2		4	8	1	6	4	1	1	2	2	1
5048	Yoldia limatula	1		2		2		2	1				1							3	
5047	Nucula proxima	926	1993	991	437	445	2683	1572	1722	1689	2602	4713	1294	7581	5941	6907	11937	14233	2272	322	2681
5027	Nassarius trivittatus	1				1															
5082	Mulinia lateralis		1		1	7		2		1			1				1				
5040	Turbonilla interrupta									1											

Table AVII-5 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5014	*Crepidula plana*														32						
5012	*Crepidula fornicata*														1						
5053	*Mytilus edulis*														5						
7147	*Pinnixa* sp.	2					1	1	1		2					2					
7115	*Pagurus longicarpus*		2			2									1	1					
7037	*Ampelisca verrilli*			1																	
7009	*Oxyurostylis smithi*				1	1															
7001	*Squilla empusa*				1																
7111	*Crangon septem-spinosa*					1				2	1					3					
7142	Mysid sp.										1			1							
7028	*Edotea triloba*												1							1	
7093	*Trichophoxus epistomus*												1								
7053	*Corophium tuberculatum*														2						
7065	*Gammarus mucronatus*														1						
7002	*Neomysis americana*																1				
7121	*Cancer irroratus*																1				
7138	*Libinia emarginata*																1				
8012	*Membranipora tenuis*			x																	
8018	*Electra monostachys*			x																	
8002	*Alcyonidium polyoum*					x															
8029	*Alcyonidium* sp.							x													

Table AVII- 6

Benthic invertebrates in dredge samples
Station 5

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2007	*Hydractinia echinata*		2		3				3	3				1							
4010	*Heteromastus filiformis*					1													1		
4024	*Pherusa affinis*																1				
4025	*Glycera americana*																	1			
4027	*Glycera dibranchiata*							1													
4028	*Glycinde solitaria*										1										
4052	*Nephtys incisa*	3		1	1		3	3	2	3	1	1		1	1	1	3		3		1
4055	*Nereis (Neanthes) succinea*							1													
4064	*Haploscoloplos fragilis*						3	1											1		
4065	*Haploscoloplos robustus*					1															
4091	*Lepidonotus squamatus*				1																
4092	*Lepidonotus sublevis*				1	1															
4093	*Sabellaria vulgaris*		1						1												
4107	*Paraprionospio pinnata*					1															
4110	*Polydora ligni*		2																		
4117	*Spio setosa*				1	3			1											1	
4137	*Polycirrus eximius*		1																		
5012	*Crepidula fornicata*				1																
5014	*Crepidula plana*	1	5	0	5	3		4	3	5				1	3	1					
5025	*Busycon carica*		1							1	1										
5027	*Nassarius trivittatus*	1	2			1				1	1										
5047	*Nucula proxima*	7	7	7	7	7	7	7	7	7	7	7	5	7	7	7	7	7	7	7	7
5048	*Yoldia limatula*	1	6	1			1		1	3	1	1			1	3	2	1		3	
5053	*Mytilus edulis*	1	3		3	1	1		1	5					1						
5070	*Tellina agilis*	3	5	5	5	5	5	5	5	5	5	4		5	5	5	5	1	5	5	5
5079	*Siliqua costata*				1																
5080	*Ensis directus*	5	2		1	3	3	3	3	1		1	1	3	1	1	3	3	3		1
5082	*Mulinia lateralis*	4	4			1		1	1	3		1	3			3	2	1	3	3	
6009	*Balanus (Balanus) improvisus*		3																		

Table AVII-6 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7002	Neomysis americana	4	6	3	5		3	5	3	7	6	3		5	5	3	3	1	1	3	1
7037	Ampelisca verrilli					1													1		
7055	Unciola irrorata						1														
7056	Unciola serrata				1																
7080	Neohaustorius biarticulatus			3																	
7082	Microprotopus raneyi														4						
7111	Crangon septemspinosa	5	5	5	5	5	5	7	5	7	7	5	1	3	5	1	1	1		1	1
7115	Pagurus longicarpus			1	3		1		1	1	1			1				1		1	
7116	Pagurus pollicaris	1	4		1	1			1	1					1					1	
7121	Cancer irroratus	1	1	1	1			1				1			1						
7138	Libinia emarginata							1													
8002	Alcyonidium polyoum		3		7	3		3	1	3				1	4					3	
8014	Conopeum tenuissimum		1																		
8018	Electra hastingsae		3																		

Table AVII- 7

Benthic invertebrates in grab samples
Station 9

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3006	Zygeupolia rubens				3		1				2									
3008	Cerebratulus lacteus			2									3							
3014	Nemertea sp.			18					2	3		12				4			1	
3016	Flatworm A														1					
4002	Asabellides oculatus	57	9	15	48	30	18	22	24	34	26	30	15	36	6	17	48	18	17	16
4006	Driloneris longa																		1	
4009	Capitella capitata	3																		
4010	Heteromastus filiformis	6	1	27	15	30	6	9	12	20	14	27	21	24	3	12	11	15	8	2
4011	Mediomastus ambiseta	12	4	3	21	12	36	62	10	109	88	114	16	36	9	150	78	53	29	2
4016	Chaetozone setosa		1			3		1		3		3				2				
4018	Tharyx sp. 2	3																		
4023	Marphysa sanguinea	6	1	6	9	9	12	10	7	2	2	3	9	12	15	1	6	6		3
4024	Pherusa affinis															1				
4025	Glycera americana		1		3	3	3	1		1							1			
4026	Glycera capitata		1																	
4028	Glycinde solitaria		2	9	27		3	12	5	18	20	27	3	12	18	24	24	8	9	8
4044	Clymenella spp.			3																
4055	Nereis succinea	9	1	9		12	21	7	10	12	7	15	3	23	16	15	10	9		2
4065	Haploscoloplos robustus		2							1										
4079	Eteone longa						6		1	1						4		6		
4080	Eumida sanguinea			12		9	12	7	6	8	5	15	10	52	49	5	17	12	1	
4088	Harmothoe extenuata					3				1		6			3					
4084	Phyllodoce arenae	1			3			2	1	2	1	3				3			1	1
4064	Haploscoloplos fragilis			3						1			3			1		3		1
4091	Lepidonotus squamatus	6	1	6	3	6		3	6	9			9	9	9	2	12	9		
4092	Lepidonotus sublevis						15			5										
4093	Sabellaria vulgaris	6	11	6		3	27		24	10		12	15	12	21	5	3	6		
4076	Pectinaria gouldii	15	1		3		3	1			1			12		3	2	6		1
4077	Eteone heteropoda	3	2			3		3			1			3			4			

Table AVII- 7 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4101	Hydroides dianthus	171	5	15	9	144	2	24	36	22		57	62	204	303	10	17	81		
4105	Sthenelais boa	6		3	3	3		2	1	2		6		3		1	1	3		
4109	Polydora concharum																1			
4110	Polydora ligni		3	3						1							1			1
4117	Spio setosa			9			3			1	3								1	
4119	Streblospio benedicti	6	24	6		6	21	34	6	28	33	24	5	16	6	59	35	38	20	8
4134	Amphitrite ornata				3	3				1		3								
4131	Syllis gracilis								3											
4137	Polycirrus eximius	24		54	15	27	24	16	10	32	9	30	6	27	9	6	5	15	4	
4140	Cirratulidae sp.								1											
4401	Oligochaeta B					3		16			4		3				2			
4400	Oligochaeta A		1		9			4												
5008	Triphora nigrocincta			1																
5013	Crepidula convexa								1			1	1							
5014	Crepidula plana			5					3	1		6					3	1		
5022	Anachis avara	3				7	2		6	3		5	2		1					
5023	Mitrella lunata			5			2	1	1	2		1								
5026	Busycon canaliculatum					1														
5027	Nassarius trivittatus										1									
5047	Nucula proxima	17	16	28	13	12	8	55	31	16	19	22	14	12	11	9	38	10	23	2
5053	Mytilus edulis	13		5	1	10	20	4	51	4		38		6	22		12	3	1	1
5056	Crassostrea virginica									1										
5066	Mercenaria mercenaria			5	1	1	6	2	14	4	1	2	5	3	1	14	9	2	2	1
5069	Petricola pholadiformis		1		1	3	1		2	2	3	1	1	2	1	3		2		1
5070	Tellina agilis	7	7	2	4		12	3	1	2	2	1		2	2	9	4	4		3
5080	Ensis directus			1									2				3		1	
5082	Mulinia lateralis						1									1				
5091	Lyonsia hyalina	1	1	3	5		11		3		6			1		8		2	3	1
5096	Odostomia dianthophilia												3	2						
6001	Limulus polyphemus										1									
6013	Parasterope pollex					1														

Table AVII-7 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7002	*Neomysis americana*		1																	
7005	*Bowmaniella dissimilis*															1				
7035	*Ampelisca abdita*			1			3		1	1					1	1				3
7037	*Ampelisca verrilli*				3														2	
7042	*Lembos smithi*	2		2				1	111	5		3	9	22	13	4			1	
7043	*Microdeutopus gryllotalpa*					17	1	1											2	
7047	*Batea catharinensis*					1														
7053	*Corophium tuberculatum*						5						1	1	1			4		
7054	*Erichthonius brasiliensis*	2			4	3	2	2	9	4		5	1	24	13	1	16	9		
7056	*Unciola serrata*	34	151	12	12	48	409	37	118	74	6	47	86	94	185	37	127	7	8	
7058	*Corophium simile*	11	71	2	1	28	73	5	208	40	1	57	47	83	212	42	51	7		
7068	*Elasmopus laevis*				1	3	2	1	3			2		4	5	1	1			
7070	*Melita nitida*		9	1		4	2	6	7	1		4		5	3		2			
7092	*Paraphoxus spinosus*				1	6	2	1	9	2		1		11	2	1	3			
7106	*Paracaprella tenuis*					2														
7111	*Crangon septemspinosa*																		1	
7114	*Callianassa atlantica*			1																
7115	*Pagarus longicarpus*			3				1		2	1			1		3		2	1	
7124	*Neopanope texana sayi*	7	1	2	1	25	18	11	8	2		4	13	3	5	8	7	9	2	
7145	*Heteromysis formosa*								4			2		1						
7146	Xanthid sp.	35	5		20	57	41	8	100	34	17	34	51	76	90	19	37	23	9	
7147	*Pinnixa* sp.		1						2			4								
7148	*Callianassa* sp. cf. *C. atlantica*																1			
7149	*Euceramus praelongus*				1															
7177	*Corophium bonelli*																23			
9007	*Thyone briareus*			1		1				1				1	1					
	Schizoporella errata	x			x			x	x	x	x		x				x			
	Alcyonidium polyoum	x			x	x	x		x	x		x	x				x	x		
	Ampelisca verrilli				x				x											
	Membranipora tenuis		x									x	x		x					x

Table AVII-7 (cont.)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Conopeum truitti		x																	
Microciona prolifera							x	x		x	x	x	x				x	x	
Conopeum tenuissimum							x		x			x		x		x		x	x
Bowerbankia gracilis								x											
Triticella elongata														x					
Porifera sp. A														x		x			
Electra monostachys																x			
Halichondria bowerbanki																	x		

Table AVII-8

Benthic invertebrates in dredge samples
Station 9

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1003	Microciona prolifera	6			5	6		1	1	1	3	3	3	3	4			5	6	7	
1006	Cliona celata		4	5	5	5	7	7	5			3	5	5	5	5	5	7		7	7
1008	cf. Halichondria bowerbanki																5	5			
2002	Tubularia crocea																		1		
3006	Zygeupolia rubens	1										1							1		
3014	Nemertea sp.		1	1		1		1		1	1				1			1		1	1
3016	Flatworm A		1	1		1					1	1	1					3	1		1
4010	Heteromastus filiformis	1	1	1					1				5					1			
4011	Mediomastus ambiseta	5	3	5	5	1	1	1	3	6	0	5	5	0	4	5	5	5	5	5	5
4019	Tharyx sp. 1					3															
4021	Schistomeringos rudolphi					1							1								
4023	Marphysa sanguinea	5	6	5	1	5	3	0	5	0	1	0	4	3	1	3	0	3	0	0	1
4025	Glycera americana																3				
4028	Glycinde solitaria								1											1	
4055	Nereis succinea	5	7	7	5	7	5	5	7	7	5	5	7	6	5	7	7	7	7	7	7
4064	Haploscoloplos fragilis																			1	
4077	Eteone heteropoda	3		1	1	0	0	1	0	0	0	1	0	0	1	1					
4080	Eumida sanguinea	5	7	7	5	7	7	7	7	7	5	7	7	7	7	7	7	7	7	7	7
4088	Harmothoe extenuata	7		5	5	5	5	3	5	5	5	3	5	5	5	3	5	3	5	5	5
4090	Lepidametria commensalis											1									
4091	Lepidonotus squamatus	3	3	0	3	0	3	1	0	3	1	5	3	5	1	5	4	3	3	5	3
4092	Lepidonotus sublevis	1							1	3	3				2	0	1	1	1	0	0
4093	Sabellaria vulgaris	5	7	7	7	7	5	7	7	7	6	7	7	7	7	7	7	7	7	7	5
4101	Hydroides dianthus	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
4105	Sthenelais boa	2		1	1	1	0	1	0	1	0	1	1	0	1	1	0	1	0	1	1
4117	Spio setosa									1					1						
4119	Streblospio benedicti	1	2	2	1	1	1	1	1	1	0	1	3	1	0	3	5	1	3	5	4
4131	Syllis gracilis	1		1															1	1	
4137	Polycirrus eximius	1	1	0	0	1								1	0	0	1	1	0	1	1

Table AVII-8 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4002	Asabellides oculatus	3	0	1	0	3	1	1	0	3	0	3	2	0	2	3	3	1	1	3	3
4400	Oligochaeta A				1							5	0	0	1						
4401	Oligochaeta B	3	1	4	0	2	3	1	1	0	0	5	7	0	5	7	5	1	5	7	7
5013	Crepidula convexa							1	0	1	0	0	0	0	0	1	1	0	0	0	0
5014	Crepidula plana	7	5	3	4	3	0	5	1	3	0	3	0	3	1	1	1	5	0	0	1
5020	Urosalpinx cinerea																	1			
5022	Anachis avara	1	0	0	0	1	0	1									1	0	1	1	0
5023	Mitrella lunata	3	1	1	1	0	1	1	0	1	3	1	0	1	1	1	1	1	1	0	0
5026	Busycon canaliculatum										1									1	
5027	Nassarius obsoletus													1							
5037	Sayella fusca	1																			
5040	Turbonilla interrupta											1									
5047	Nucula proxima	3	0	1	0	0	1	1	0	3	0	1	1	1	0	3	1	0	1	0	3
5053	Mytilus edulis	7	5	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
5050	Anadara ovalis																1				
5069	Petricola pholadiformis	1				1	0	1	0	0	0	6	0	0	1	2	1	0	0	0	1
5070	Tellina agilis					1	0	0	1	3	0	0	0	1	0	1	1	0	1	0	0
5082	Mulinia lateralis	1									1	1									
5091	Lyonsia hyalina															1					
5096	Odostomia dianthophilia	7	5	7	3	5	5	5	7	7	7	0	7	0	5	7	7	7	7	7	7
5097	Nudibranchia sp.	1																			
5098	Acteocina canaliculata		1																		
5099	Hydrobia totteni								1	1	0	0	1	0	0	1	0	0	1	0	0
7002	Neomysis americana							1	1	0	1	0	0	0	0	0	1	1	0	0	0
7035	Ampelisca abdita																		1	0	1
7037	Ampelisca verrilli	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0
7042	Lembos smithi	3	5	5	5	1	1	3	5	3	5	5	5	5	5	5	5	5	7	3	5
7053	Corophium tuberculatum								1	0	0	1									
7054	Erichthonius brasiliensis	3	5	1	5	5	5	5	5	3	5	5	0	5	3	5	5	3	5	5	0
7056	Unciola serrata	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
7058	Corophium simile	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
7068	Elasmopus laevis	3	3	3	5	5	5	5	5	3	5	5	1	0	5	1	5	5	3	5	0

Table AVII- 8 (cont.)

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7070	Melita nitida	3	0	0	0	1	1	0	1	0	0	0	1								
7086	Lysianopsis alba												3								
7092	Paraphoxus spinosus	6	5	7	7	5	5	1	5	5	5	5	5	0	5	5	5	5	5	3	0
7097	Parametopella cypris													1							
7105	Caprella equilibra															1	1	1	1	0	0
7111	Crangon septemspinosa	0	0	1	1	0	0	1	0	1	1	0	0	0	1	1	0	1	0	1	0
7115	Pagurus longicarpus	1	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0	1
7124	Neopanope texana sayi	1	0	0	0	0	0	0	0	1	0	1	0	0	3	0	0	0	0	0	0
7125	Panopeus herbsti													1							
7131	Sesarma cinereum																				1
7137	Libinia dubia									1											
7146	Xanthid sp.	5	5	5	5	5	3	4	4	5	5	5	5	7	5	4	5	5	5	7	5
7150	Ampithoidae sp.								1												
7177	Corophium bonelli	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7153	Ampelisca macrocephala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
8002	Alcyonidium polyoum	5	0	5	3	1	1	1	0	3	0	3	0	3	3	0	1	0	5	7	1
8003	Alcyonidium verrilli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
8004	Alcyonidium mammillatum	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0
8008	Bowerbankia gracilis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
8009	Triticella elongata	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0
8012	Membranipora tenuis	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
8014	Conopeum tenuissimum	0	5	5	1	5	5	1	0	3	3	3	5	3	3	3	3	3	0	0	1
8018	Electra hastingsae	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8022	Cryptosula pallasiana	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8025	Microporella ciliata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8023	Schizoporella errata	0	0	0	1	0	3	0	0	0	5	0	0	0	0	0	0	0	0	0	0
9008	Starfish (juv.)	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
4110	Polydora ligni	3	1	5	3	5	5	3	3	1	5	5	2	5	4	5	3	5	5	3	4
4084	Phyllodoce arenae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
7082	Microprotopus raneyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table AVII-9

	50% mm	$\phi 50$	M_z	σ_I	SK_I	K_G	% Gravel	% Sand	% Silt	% Clay	% Volatiles
3- 1	0.2896	1.79ϕ	1.23ϕ	2.38ϕ	-.236	1.23	18.3	71.5	8.5	1.8	3.81
3- 2	1.8269	-0.87ϕ	-0.39ϕ	3.21ϕ	+.334	0.74	49.0	41.2	6.5	3.3	0.66
3- 3	0.2772	1.85ϕ	1.73ϕ	1.19ϕ	-.108	1.31	0.9	94.3	2.0	2.8	1.14
3- 4	0.3507	1.51ϕ	0.91ϕ	2.28ϕ	-.286	1.09	20.5	73.3	4.8	1.4	1.06
3- 5	0.2256	2.15ϕ	1.40ϕ	2.07ϕ	-.164	1.20	16.6	73.7	8.4	1.3	0.92
3- 6	0.1968	2.35ϕ	1.84ϕ	3.21ϕ	-.135	1.82	16.9	65.0	12.9	5.2	1.24
3- 7	0.2615	1.90ϕ	1.35ϕ	3.26ϕ	-.208	0.86	24.1	56.2	17.1	2.6	2.23
3- 8	0.1775	2.49ϕ	2.80ϕ	2.75ϕ	+.140	1.28	8.1	64.8	22.5	4.6	1.21
3- 9	0.2548	1.97ϕ	1.13ϕ	3.10ϕ	-.218	1.17	21.3	62.8	12.7	3.2	1.15
3-10	0.3393	1.56ϕ	0.92ϕ	2.95ϕ	-.118	1.24	24.2	65.4	6.3	4.1	1.32
3-11	0.4536	1.14ϕ	0.79ϕ	2.02ϕ	-.235	1.09	18.1	77.1	2.7	2.1	0.75
3-12	0.3203	1.64ϕ	1.12ϕ	2.04ϕ	-.398	1.26	16.1	79.3	2.4	2.2	0.95
3-13	0.2131	2.23ϕ	2.20ϕ	3.06ϕ	+.095	2.02	11.7	69.7	9.6	9.0	1.28
3-14	0.2067	2.27ϕ	1.93ϕ	2.76ϕ	-.165	1.29	14.7	60.9	21.0	3.4	1.05
3-15	0.3329	1.59ϕ	0.73ϕ	2.49ϕ	-.358	0.73	29.0	65.0	3.3	2.7	1.17
3-16	0.3102	1.69ϕ	1.15ϕ	2.10ϕ	-.320	1.22	17.0	77.3	2.6	3.1	0.31
3-17	0.3520	1.51ϕ	1.48ϕ	1.94ϕ	-.033	0.99	9.5	78.2	9.5	2.8	2.16
3-18	0.2860	1.81ϕ	1.62ϕ	2.13ϕ	-.126	1.29	10.0	76.9	11.6	1.5	1.40
3-19	0.2426	2.04ϕ	1.30ϕ	3.55ϕ	-.198	0.66	29.8	49.7	16.3	4.2	2.78
3-20	0.2961	1.76ϕ	0.82ϕ	2.93ϕ	-.234	1.19	23.4	66.4	6.9	3.3	0.97

Table AVII-10

	50% mm	$\phi 50$	M_z	σ_I	SK_I	K_G	% Gravel	% Sand	% Silt	% Clay	% Volatiles
4- 1	.0922	3.44ϕ	3.44ϕ	0.38ϕ	+.078	1.38		90.1	8.0	1.9	0.87
4- 2	.0914	3.45ϕ	3.45ϕ	0.39ϕ	+.101	1.41		88.5	9.8	1.7	0.74
4- 3	.0942	3.41ϕ	3.42ϕ	0.39ϕ	+.130	1.40		90.5	8.0	1.5	1.67
4- 4	.0915	3.45ϕ	3.49ϕ	0.41ϕ	+.180	1.48		86.9	11.6	1.5	0.91
4- 5	.0916	3.45ϕ	3.53ϕ	0.44ϕ	+.300	1.45		84.6	13.4	2.0	0.53
4- 6	.0889	3.49ϕ	3.51ϕ	1.92ϕ	+.489	10.35		86.3	7.2	6.5	0.93
4- 7	.0903	3.47ϕ	3.54ϕ	0.88ϕ	+.493	3.83		83.8	11.9	4.3	1.64
4- 8	.0893	3.49ϕ	3.53ϕ	0.71ϕ	+.342	2.99		84.7	12.3	3.0	1.09
4- 9	.0894	3.48ϕ	3.47ϕ	0.44ϕ	+.004	1.53		87.6	10.3	2.1	0.80
4-10	.0920	3.44ϕ	3.50ϕ	0.55ϕ	+.342	1.89		85.4	12.0	2.6	0.94
4-11	.0908	3.46ϕ	3.45ϕ	0.38ϕ	+.072	1.29		89.4	9.1	1.5	1.47
4-12	.0897	3.48ϕ	3.50ϕ	0.50ϕ	+.269	1.93		87.3	9.7	3.0	1.30
4-13	.0926	3.43ϕ	3.44ϕ	0.37ϕ	+.132	1.33		89.6	8.9	1.5	0.74
4-14	.0918	3.45ϕ	3.44ϕ	0.38ϕ	+.025	1.40		90.7	7.8	1.5	0.84
4-15	.0909	3.46ϕ	3.53ϕ	0.81ϕ	+.450	3.44		84.3	12.2	3.5	1.71
4-16	.0888	3.49ϕ	3.51ϕ	0.46ϕ	+.160	1.68		87.1	9.7	3.2	0.72
4-17	.0897	3.48ϕ	3.50ϕ	0.82ϕ	+.391	3.95		87.8	8.2	4.0	0.42
4-18	.0941	3.41ϕ	3.42ϕ	0.49ϕ	+.271	2.03		90.4	6.4	3.2	0.90
4-19	.0884	3.50ϕ	3.64ϕ	0.97ϕ	+.545	3.56		80.1	15.6	4.3	1.65
4-20	.0927	3.43ϕ	3.44ϕ	0.38ϕ	+.150	1.46		89.7	8.4	1.9	0.99

Table AVII-11

	50% mm	$\phi 50$	M_z	σ_I	SK_I	K_G	% Gravel	% Sand	% Silt	% Clay	% Volatiles
9- 1	.0607	4.04ϕ	4.49ϕ	1.86ϕ	+.557	2.03		13.1	76.5	10.4	2.85
9- 2	.0936	3.42ϕ	3.55ϕ	1.32ϕ	+.502	3.63		78.6	15.1	6.3	1.88
9- 3				N O	S A M	P L E					
9- 4	.0782	3.68ϕ	3.94ϕ	1.41ϕ	+.564	2.44		62.7	30.1	7.2	1.89
9- 5	.0695	3.85ϕ	4.17ϕ	1.59ϕ	+.588	2.46		54.3	36.8	8.9	1.94
9- 6	.0595	4.07ϕ	5.03ϕ	2.46ϕ	+.683	1.90		47.5	37.5	15.0	2.85
9- 7	.0769	3.70ϕ	5.03ϕ	2.47ϕ	+.784	2.17		61.4	21.9	16.7	2.70
9- 8	.0537	4.22ϕ	5.35ϕ	2.47ϕ	+.705	1.51		41.1	41.4	17.5	2.64
9- 9	.0562	4.15ϕ	5.02ϕ	2.39ϕ	+.643	1.86		44.7	40.7	14.6	2.90
9-10	.0695	3.85ϕ	4.55ϕ	2.03ϕ	+.715	2.20		54.5	33.6	11.9	1.71
9-11	.0745	3.75ϕ	4.18ϕ	1.56ϕ	+.692	2.56		58.8	32.3	8.9	2.27
9-12	.0746	3.74ϕ	4.42ϕ	1.59ϕ	+.852	2.22		56.1	33.3	10.6	2.74
9-13	.0680	3.88ϕ	4.50ϕ	1.81ϕ	+.689	2.07		53.4	35.5	11.1	3.40
9-14	.0763	3.71ϕ	4.13ϕ	1.43ϕ	+.710	2.74		61.2	30.9	7.9	3.20
9-15	.0508	4.30ϕ	5.30ϕ	2.40ϕ	+.663	1.39		40.3	42.7	17.0	3.77
9-16	.0757	3.72ϕ	4.05ϕ	1.46ϕ	+.658	2.74		59.9	31.9	8.2	1.65
9-17	.0708	3.82ϕ	4.16ϕ	1.58ϕ	+.568	2.69		55.0	37.0	8.0	2.89
9-18	.0595	4.07ϕ	4.52ϕ	1.52ϕ	+.580	1.75		46.9	45.0	8.1	2.47
9-19	.0753	3.73ϕ	4.00ϕ	1.14ϕ	+.590	2.08		58.1	37.8	4.1	2.10
9-20	.0731	3.77ϕ	4.23ϕ	1.64ϕ	+.694	2.81		56.8	32.4	10.8	2.09

Table AVII-12

	50% mm	$\phi 50$	M_z	σ_I	SK_I	K_G	% Gravel	% Sand	% Silt	% Clay	% Volatiles
5- 1	.0861	3.54φ	3.83φ	1.60φ	+.630	3.27		73.0	18.1	8.9	2.11
5- 2	.0896	3.48φ	3.60φ	1.33φ	+.520	3.68		77.7	16.1	6.2	2.06
5- 3	.0842	3.57φ	3.91φ	1.47φ	+.614	2.53		69.6	23.0	7.4	1.67
5- 4	.0795	3.65φ	3.84φ	1.32φ	+.574	2.86		64.8	27.7	7.5	1.68
5- 5	.0835	3.58φ	3.77φ	0.78φ	+.380	1.21		71.4	25.7	2.9	1.95
5- 6	.0811	3.62φ	4.56φ	2.22φ	+.774	2.38		63.1	24.1	12.8	2.23
5- 7	.0842	3.57φ	3.91φ	1.52φ	+.628	2.65		68.2	23.9	7.9	1.53
5- 8	.0930	3.43φ	3.53φ	0.97φ	+.490	3.49		81.6	13.9	4.5	0.96
5- 9	.0865	3.53φ	3.67φ	0.97φ	+.461	1.93		73.7	22.4	3.9	2.30
5-10	.0907	3.46φ	3.58φ	1.43φ	+.547	4.57		79.9	12.9	7.2	1.20
5-11	.0831	3.59φ	4.30φ	1.77φ	+.729	1.65		65.5	26.4	8.1	1.66
5-12	.0915	3.45φ	3.59φ	1.21φ	+.552	3.52		78.0	16.1	5.9	1.10
5-13	.0849	3.56φ	4.12φ	1.87φ	+.705	2.84		69.2	19.8	11.0	2.04
5-14	.1008	3.31φ	3.32φ	0.48φ	+.168	1.40		90.6	6.9	2.5	1.78
5-15	.0959	3.38φ	3.45φ	1.12φ	+.463	3.59		83.3	11.3	5.4	1.43
5-16	.0912	3.45φ	3.58φ	1.01φ	+.476	2.67		79.2	16.7	4.1	1.48
5-17	.0863	3.53φ	3.77φ	0.95φ	+.486	1.63		73.7	22.7	3.6	2.05
5-18	.0751	3.73φ	4.13φ	1.30φ	+.608	1.23		56.7	38.4	4.9	2.12
5-19	.0833	3.59φ	3.78φ	1.15φ	+.565	2.74		72.7	22.1	5.2	1.70
5-20	.0994	3.33φ	3.40φ	0.74φ	+.409	2.15		84.8	13.1	2.1	1.60