A REVIEW OF THE BENTHIC FAUNA AT THE PROPOSED 60-MILE NORTHERN ALTERNATE SITE FOR WASTE DISPOSAL AND RISKS IF USED

by

Janice Caracciolo-Ward and Frank W. Steimle, Jr.

U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, New Jersey 07732

Report No. SHL 84-03

Introduction:

The northern alternate site (NAS), located 60 miles east-southeast of Sandy Hook, New Jersey (Fig. 1) has been proposed at various times as an alternate dumpsite for wastes currently being disposed of within 15 miles of Sandy Hook. To decide if the site should be used, environmental and resource managers require information on biological resources potentially at risk from this practice. This report has been prepared to summarize the available data and characterize the benthic fauna at or near this site and to evaluate the potential impacts of waste dumping on them.

Benthic macrofauna are useful monitoring tools because: 1) they are relatively immobile, living at or near the sediment surface and are thus unable to avoid exposure to contaminants in water or sediments; 2) they are important in food webs where many species are preyed upon by resource species; 3) they are possible direct sources of contaminant transfer to food species and ultimately to man; and 4) some species, such as ampeliscid amphipods, are extremely sensitive to low levels of contaminants and their rarity or absence may be used as an indicator of contaminated, stressed, or altered habitats.

Study Area:

The NAS lies northeast of the Hudson Shelf Valley, approximately 25 nautical miles (n mi) south of Long Island (Fig. 1). Water depths at this site range from 45 m in the northwest corner to almost 60 m in the eastern portion. Thus, it occupies, for the most part, the outer continental shelf (depth range 50-100 m). The sediment surface is flat to gently sloping with small ripples and mounds rather than the larger ridge and swale pattern found further offshore. Surficial sediments are primarily sand and gravel. Available data indicate that fine sand occurs in the northeastern portion of the dumpsite, and medium sand is present in western and southern areas.

Stations 96 and 98 (Fig. 2) contain 5-10% mud, all others consist of <5% mud. A gravel area (maximum 39% gravel) occurs in the southeastern part of the site (NOAA 1976; Fig. 3). Sediment heavy metals concentrations are low, when compared to samples from the New York Bight apex (Carmody et al. 1973; Graikoski et al. 1974; Greig et al. 1974). Concentrations of trace metals in the water column are close to average values for uncontaminated coastal surface waters (NOAA 1976). Values of heavy hydrocarbons are low as compared with the apex (Exxon Production Research Company 1976). Bottom currents at the site move to the southwest year-round at a mean speed of 5.1 cm s^{-1} (Charnell and Mayer 1975; Patchen et al. 1975). In winter, surface currents generally move in a northeasterly direction; during summer, surface currents frequently move toward the southwest (Hardy et al. 1975).

Methods:

Characterization of the benthic fauna will rely heavily upon previously reported, but not completely analyzed, benthic sample data collected by the National Marine Fisheries Service (NMFS) at a grid of 33 stations within the NAS. Thirty-one stations were sampled in June 1974 and six stations resampled in February 1975 (Fig. 2) using a 0.1 m^2 Smith-McIntyre grab sampler; samples were washed through a 1 mm mesh screen. See Pearce et al. (1976) for details of sampling procedures. Q-mode cluster analysis (Boesch 1977) was used to evaluate quantitative differences in species composition among stations sampled during both surveys. Supplementary information for this site consists of benthic data from eight stations resampled by the NMFS during August 1978, and from two stations at the site that are annually monitored by the Northeast Monitoring Program (NEMP) (Reid et al. 1982); to date, there are data for two NEMP surveys, July-August 1980 and August 1981. The NAS has also been studied by Raytheon, Inc. (Cox 1975) and the central and outer shelf benthos of the

New York Bight has been characterzed by Boesch et al. (1977) and Wigley and Theroux (1981). Their data will be used for comparisons.

Results:

1. Benthic Community Structure

During 1974 and 1975 NMFS surveys, a total of 153 different species was collected. The 1974 survey averaged 32 species per station with a high of 54 at station 86 (near the center of the site); the 1975 survey averaged 21 species with a high of 26, again at station 86. Numerically dominant species on both surveys were almost identical, with the polychaetes, Tharyx acutus, Spiophanes bombyx, Ampharete arctica, Euchone elegans, and Scalibregma inflatum, the most abundant. The five numerically most abundant species at all stations consisted primarily of polychaetes and gammarid amphipods; the echinoderm, Echinarachnius parma, and the archiannellid, Polygordius triestinus, were present in moderate numbers. The isopod, Cirolana polita, occurred among the top five species at one station, and molluscs did not appear among the top five (Table 1).

Figure 4 is the dendrogram generated through Q-mode cluster analysis of data from 1974 and 1975 NMFS surveys. A similarity level of 0.3 was used that yielded four station groups (see also Table 1). Group 1 consisted of 15 stations, six bordering the western edge of the site, seven in the southwestern section, and two in the southeastern part of the site. Sediments at all of these stations were medium grain sand. The mobile, tube or gallery dwelling polychaete, T. acutus, was clearly dominant, with tube dwelling polychaetes, S. bombyx and A. arctica, next in abundance. Few amphipods were present, as compared with other station groups, and no ampeliscids were collected. Dominant species were all surface deposit feeders.

Group 2 consisted of nine medium sand stations primarily in the north- and southeastern parts of the site. Spiophanes bombyx was numerically dominant with T. acutus and the tube dwelling polychaete, E. elegans, of secondary importance. The tube dwelling amphipod, Unciola irrorata, was present in moderate numbers. As previously mentioned, S. bombyx and T. acutus are surface deposit feeders, E. elegans is a suspension/surface deposit feeder, and U. irrorata is classified as an omnivore/scavenger/surface deposit feeder.

Three stations, two medium sand stations located in the northwestern part of the site and one fine sand station in the central part of the site, comprised Group 3. Tharyx acutus was again numerically dominant, but S. bombyx, E. elegans, and U. irrorata were all of equal secondary importance.

Group 4 consisted of 10 stations, five with medium sand sediments and five with fine sand, scattered throughout the site. This station group was by far numerically dominated by the tube dwelling amphipod, Ampelisca agassizi, a suspension/surface deposit feeder. Ampeliscids occurred among the top five species at six of the 10 stations and were the most abundant species collected at three stations, occurring in highest concentrations at station 98. Ampharete arctica, S. bombyx, and the tube dwelling, deposit feeding polychaete, Clymenella zonalis, were of about equal secondary numerical importance. This station group had the highest proportion of amphipods. Unciola irrorata, U. inermis, A. vadorum, and A. macrocephala were collected in addition to A. agassizi.

In all, 27 species constituted the top five (numerically) at all stations sampled; 24 of these use surface deposit or deposit feeding as all or part of their feeding strategy; at least 15 are important as prey in fish diets.

During the 1978 NAS resurvey, when eight stations were resampled, 19 of the 27 dominants from the 1974-1975 surveys were again among the five top numerical dominants.

Similar species again appeared among the numerical dominants in samples collected from two NEMP stations located within the NAS on surveys in 1980 and 1981.

A 1975 study done by Raytheon at the NAS (Cox 1975) also yielded very similar results to our studies. For all three of their surveys, they found _T. acutus_ to be the dominant polychaete with _S. bombyx_ and _A. arctica_ also important. Similarly, _Ampelisca_ and _Unciola_ spp. were the most important amphipods present.

Boesch et al. (1977) found the outer contintental shelf to be characterzed by tube dwellers and burrowers which are surface or subsurface deposit feeders. They believed that this reflected the reduced frequency of bottom sediment disturbance in deeper water that is characteristic of the inner shelf. In our studies we found the same to be true. Twenty-four of our 27 dominant species were tube or gallery dwellers or burrowers and, as previously mentioned, 24 of the 27 dominants fed entirely or partially on surface or subsurface deposits. Boesch's outer shelf dominants were _U. irrorata_, _S. bombyx_, _E. elegans_, and _A. agassizi_; again, all of these species were among our numerical dominants.

Many of the species found at the NAS are also common to other areas of the New York Bight and adjacent waters (O'Connor 1972; Pearce et al. 1976, 1977; Caracciolo and Steimle 1983). There is also a high degree of similarity with assemblages found at a cluster of stations 16 n mi south of the Hudson Shelf Valley in 1974 (Radosh et al. 1978).

2. Biomass

A summary of the biomass data of the benthic macrofauna collected within the NAS from 1974-1975 surveys is presented in Table 2 and Figure 5. Figure 5 indicates that the benthic biomass at the site varies by two orders of magnitude (4-3658 g/m^2) and illustrates a patchy distribution. Some generalizations are evident, however, e.g., biomass is lowest in the southwest quadrant of the site. The variation caused by the presence or absence of larger bodied species in samples from a station makes even replicate samples (e.g., station 92) highly variable. These taxa, such as bivalve molluscs (primarily the ocean quahog, Arctica islandica) dominated the biomass at 55% of the stations with echinoderms (mainly the sand dollar, Echinarachnius parma) dominating another 26% of the stations.

The species that dominate the biomass at the site are also primarily suspension or surface deposit feeders (Arctica, Echinarchnius, Astarte spp., Cyclocardia borealis, Ensis directus, Ampelisca spp., and Aphrodita hastata) or carnivores (Asterias vulgaris, Sthenelais limicola, Colus spp., and possibly Aglaophamus circinata).

The average biomass level (336 g/m^2 at the site from the 1974-1975 surveys) is similar to mean values and ranges found by Wigley and Theroux (1981) in their 1962 survey of the area, i.e. biomass levels between 100-499 g/m^2 for inner to mid-shelf areas off eastern Long Island and 25-99 g/m^2 for deeper waters (Fig. 6). Their dominant biomass taxa were also the same: bivalve molluscs and echinoderms. Their survey included nine stations that were in or just outside the currently defined site. Total biomass at these stations ranged from 126-2108 g/m^2 ($\bar{x}$ = 784 g/m^2), dominated by Arctica at five stations or by other bivalves or Echinarachnius at three other stations. The remaining station biomass was dominated by the polychaete, Aphrodita and Arctica.

3. Community Function

The diets of seven common fish species in the southern New England area (Table 3) suggest that much of this wet weight biomass is not utilized as food by these fish species. Bivalve molluscs only comprised a maximum of 4.8% of the diet of any of these species, that species being the little skate, Raja erinacea. Only one fish species, the eel pout, Macrozoarces americanus, consumed the sand dollar, Echinarachnius, to any degree. On the other hand, the minor biomass contributors, polychaetes and crustaceans were important to the diets of three food fish: red hake, Urophycis chuss; scup, Stenotomus chrysops; and yellowtail flounder, Limanda ferruginea and one non-food fish, the little skate. The species eaten by the butterfish, Peprilus triacanthus, were non-benthic. The probable reasons for this paradox (the largest biomass contributors are relatively unimportant in the diets of fish) are certain to involve such factors as the size range of the prey preferred by these fish, the availability of prey species (deeply burrowing species are less available than those species that spend at least part of the time at the sediment surface), and possibly the greater food value and productivity of polychaetes and crustaceans compared to other taxa. The average food energy (calories) of polychaetes and most crustaceans on a total weight-to-weight basis is two to three times that of shelled molluscs and echinoderms and the productivity is about triple (Steimle, in review).

Discussion and Conclusions:

Results of our studies and those of others (Cox 1975; Boesch et al. 1977) indicate that benthic species composition within the NAS is relatively uniform and stable when compared with fauna found in samples from the New York Bight apex (Pearce et al. 1976, 1977; Caracciolo and Steimle 1983), even though both areas have many species in common.

If the dumping of sewage sludge is initiated at the NAS, the Environmental Protection Agency assumes that the quantity of sewage sludge dumped will be greater than or equal to that dumped at the existing site and the methods used will be the same. The best predictions about the impact of sewage sludge on sediments and benthic communities at this site must be based on known effects in the Bight apex. As far as sediments are concerned, one could expect an increase in heavy metals, increased organic matter content, and buildup of long-chain hydrocarbons. When this happens, there should also be a change in the benthic community structure. Amphipods, particularly ampeliscids, which are among the numerically dominant species at the site, are also among the most sensitive to certain environmental contaminants (Blumer et al. 1970; Sanders et al. 1972) and will probably be reduced or disappear entirely to be replaced by more tolerant species, e.g., polychaetes. This could be detrimental because Ampelisca agassizi is among the most preferred foods of a number of important fishery resource species, notably the yellowtail flounder (Langton and Bowman 1981). The NAS is known to be in the migratory path of both coastal (north-south) and inshore-offshore migrant fishes (NOAA 1976). Yellowtail and fourspot (Paralichthys oblongus) flounders and ocean pout reside in the area all year. Cod (Gadus morhua) and summer flounder (Paralichthys dentatus) are absent during summer but migrate through, with a portion overwintering in the area. The northern site and its environs are also inhabited by commercially valuable shellfish: surf clam (Spisula solidissima), sea scallop (Placopecten magellanicus), ocean quahog (Arctica islandica), and lobster (Homarus americanus).

Because many valuable resource species inhabit or migrate through the NAS, one must also consider the problem of transfer of contaminants through the food web. The dominant benthic invertebrates at the NAS are almost all deposit or surface deposit feeders and thus are highly likely to ingest contaminants from dumped sewage sludge. These contaminants could be transferred from the invertebrates to resource species that use them as food and eventually possibly to man.

From bathymetric and hydrographic contrasts between the apex and the open shelf, it is thought that sewage sludge dumped on the shelf would be dispersed even more widely than in the apex (NOAA 1976). Because the prevailing shelf bottom drift is to the southwest, it is believed that dumping in the NAS would likely result in further contamination of the depositional Hudson Shelf Valley which is already receiving inputs at the New York Bight apex dumpsite at its head (Caracciolo and Steimle 1983).

Acknowledgments:

We thank Dorothy Jeffress for determining the biomass of the benthic macrofauna and Robert Reid for providing us with unpublished NEMP benthic grab sample data. We also thank Daniel Ralph and Suellen Craig for their assistance with statistical analysis of the data, and Maureen Montone for typing the manuscript.

Literature Cited

Blumer, M., J. Sass, G. Souza, H. Sanders, F. Grassle, and G. Hampson. 1970. The West Falmouth oil spill, persistence of the pollution eight months after the accident. Woods Hole Oceanogr. Inst. Ref. 70-44. 32 p.

Boesch, D. F. 1977. Application of numerical classification to ecological investigation of water pollution. EPA Ecological Research Series 600/3-77-033. 113 p.

Boesch, D. F., J. N. Kraeutner, and D. K. Serafy. 1977. Benthic ecological studies: megabenthos and macrobenthos. In Chemical and biological benchmark studies on the middle Atlantic outer continental shelf. Draft final report from Virginia Institute of Marine Science to Bureau of Land Management. Unpublished.

Bowman, R. E., and W. L. Michaels. 1982. Food of seventeen species of Northwest Atlantic fish: Part I, Examination by predator length and geographic area. NOAA, NMFS, NEFC, Woods Hole Laboratory, Reference Document No. 82-16. 88 p.

Caracciolo, J. V., and F. W. Steimle, Jr. 1983. An atlas of the distribution and abundance of dominant benthic invertebrates in the New York Bight apex with reviews of their life histories. NOAA Tech. Rep. NMFS SSRF-766. 58 p.

Carmody, D. T., J. B. Pearce, and W. E. Yasso. 1973. Trace metals in sediments of the New York Bight. Mar. Poll. Bull. 4(9): 132-135.

Charnell, R. L., and D. A. Mayer. 1975. Water movement within the apex of the New York Bight during summer and fall of 1973. NOAA Tech. Rep. ERL-AOML, U. S. Dept. Comm., April 1975. 29 p.

Cox, G. V. (editor). 1975. Environmental survey of a proposed alternate dumpsite in the outer New York Bight. Unpublished manuscript prepared for the U.S. Environmental Protection Agency by Raytheon Company, Portsmouth, RI.

Exxon Production Research Company. 1976. Table 9 and Figures 63 and 64. pp. 111-114. In NOAA Tech. Mem. ERL MESA-11, Boulder, CO.

Graikoski, J., R. A. Greig, and J. A. Babinchak. 1974. Coliform and metal concentrations in sediments from the Atlantic and Long Beach area - New York Bight, January 15-17, 1974. MACFC Informal Rep. No. 22. NOAA/NMFS, U. S. Dept. Comm., Highlands, NJ 07732. 13 p.

Greig, R., D. Wenzloff, B. Nelson, A. Adams, and J. Graikoski. 1974. Distribution of five metals in sediments from the New York Bight. MACFC Informal Rep. No. 36. NOAA/NMFS, U. S. Dept. Comm., Highlands, NJ 07732. 33 p.

Hardy, C. D., E. R. Baylor, and P. Moskowitz. 1975. Sea surface circulation in the Northport apex of the New York Bight. State University of New York, Stony Brook. June 15, 1975.

National Oceanic and Atmospheric Administration. 1976. Evaluation of proposed sewage sludge dumpsite areas in the New York Bight. NOAA Tech. Mem. ERL MESA-11. 212 p. Boulder, CO.

O'Connor, J. 1972. The benthic fauna of Moriches Bay, New York. Biol. Bull. 142(1): 84-102.

Patchen, R. C., E. E. Long, and B. B. Parker. 1975. Analysis of current meter observations in the New York Bight apex, August 1973-June 1984. NOAA/ERL MESA Tech. Rep. 5. 24 p.

Pearce, J. B., J. V. Caracciolo, M. Halsey, and L. Rogers. 1976. Temporal and spatial distribution of benthic macroinvertebrates in the New York Bight. Am. Soc. Limnol. Oceanogr. Spec. Symp. 2: 394-403.

Pearce, J. B., L. Rogers, J. V. Caracciolo, and M. Halsey. 1977. Distribution and abundance of benthic organisms in the New York Bight apex, five seasonal cruises, August 1973 through September 1974. NOAA Environ. Res. Lab., NOAA Data Rep. ERL MESA-32. Boulder, CO. 803 p.

Pearce, J. B., L. Rogers, J. Thomas, J. Caracciolo, M. Halsey, and K. McNulty. 1976. Distribution and abundance of benthic organisms in the outer New York Bight and proposed alternate disposal sites, June 1974 and February 1975. NOAA Environ. Res. Lab., NOAA Data Rep. ERL MESA-10. Boulder, CO. 68 p.

Radosh, D., A. Frame, T. Wilhelm, and R. Reid. 1978. Benthic survey of the Baltimore Canyon Trough, May 1974. Draft final report to Bureau of Land Management. Sandy Hook Laboratory Rep. No. SHL 78-8. 133 p.

Reid, R. N., J. E. O'Reilly, and V. Zdanowicz (editors). 1982. Contaminants in New York Bight and Long Island Sound sediments and demersal species, and contaminant effects on benthos, summer 1980. NOAA Tech. Mem. NMFS-F/NEC-16. 96 p.

Sanders, H., F. Grassle, and G. Hampson. 1972. The West Falmouth oil spill. I. Biology. Woods Hole Oceanogr. Inst. Tech. Rep. 72-20. 23 p.

Steimle, F. W., Jr. In review. Biomass and estimated productivity of the benthic macrofauna in the New York Bight: A stressed area. Estuar. Coast. Shelf Sci.

Wigley, R. L., and R. B. Theroux. 1981. Atlantic continental shelf and slope of the U.S. -- Macrobenthic invertebrate fauna of the Middle Atlantic Bight Region -- Faunal composition and quantitative distribution. Geol. Surv. Prof. Paper 529-N. 198 p.

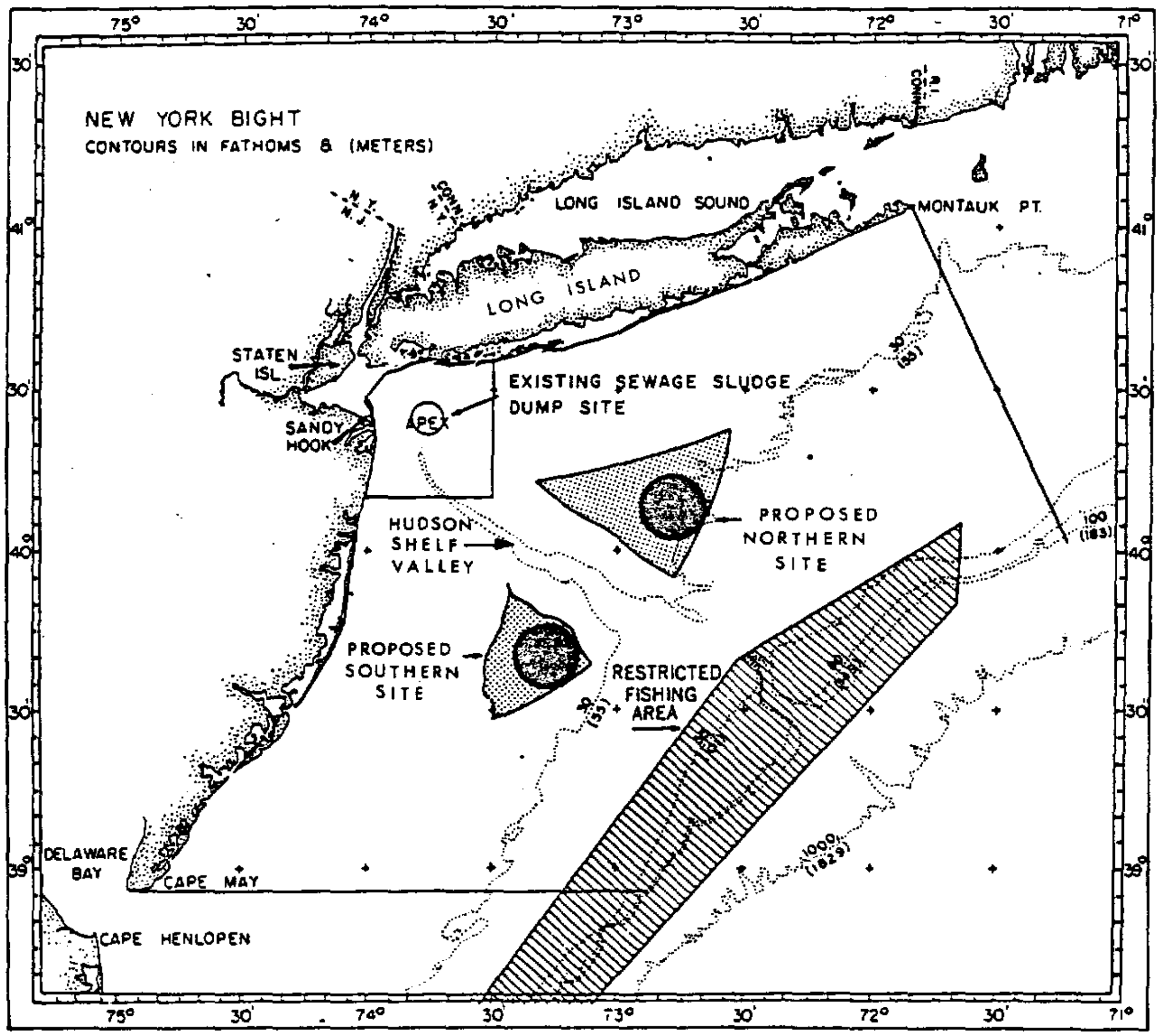


Figure 1. Existing and proposed alternative sewage dump site areas (Northern and Southern). The shaded area along the continental shelf is a no-fishing area established by international bilateral agreements. (From NOAA 1976).

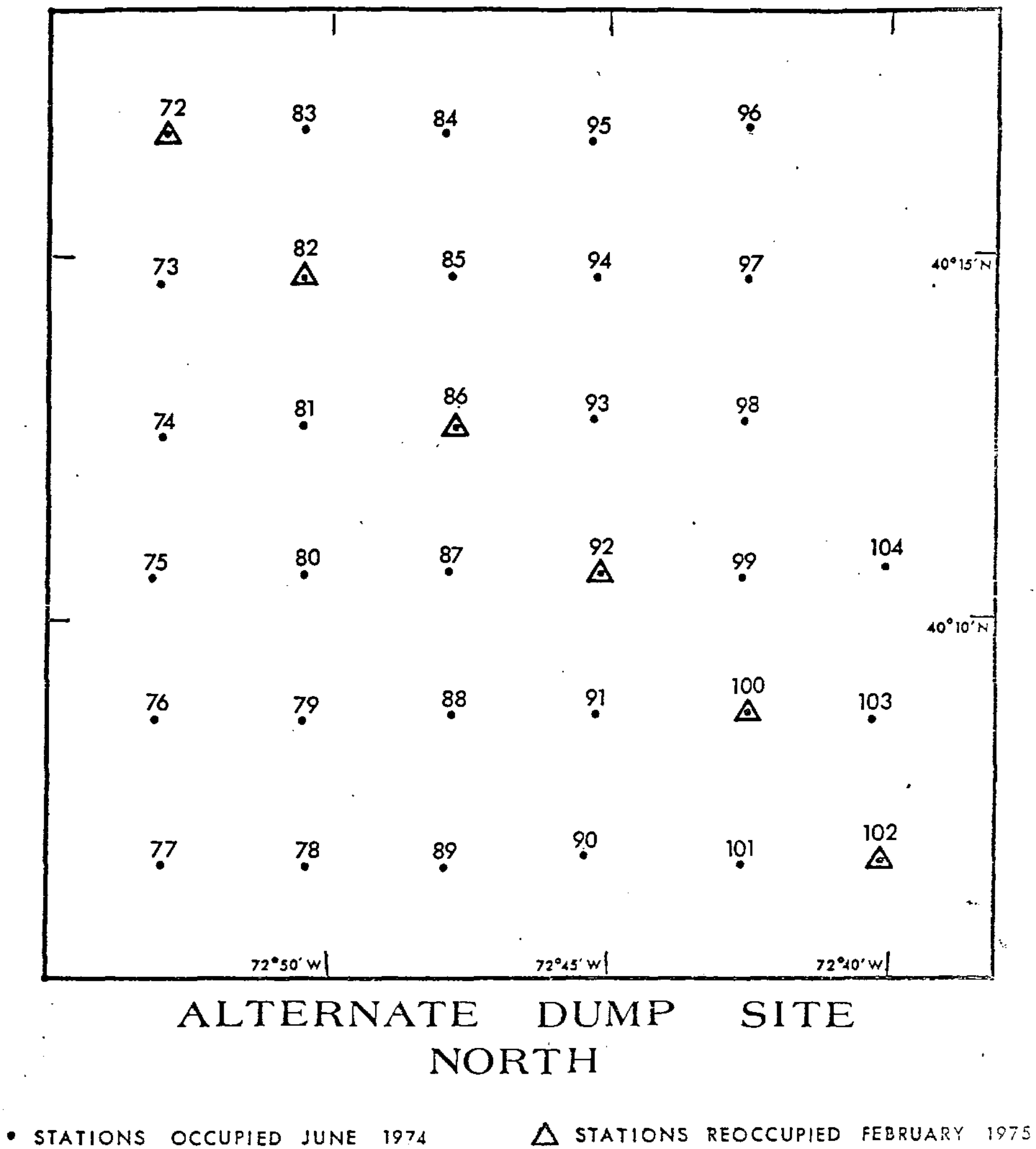


Figure 2. Station locations within the north alternate dump site. (From Pearce et al. 1976).

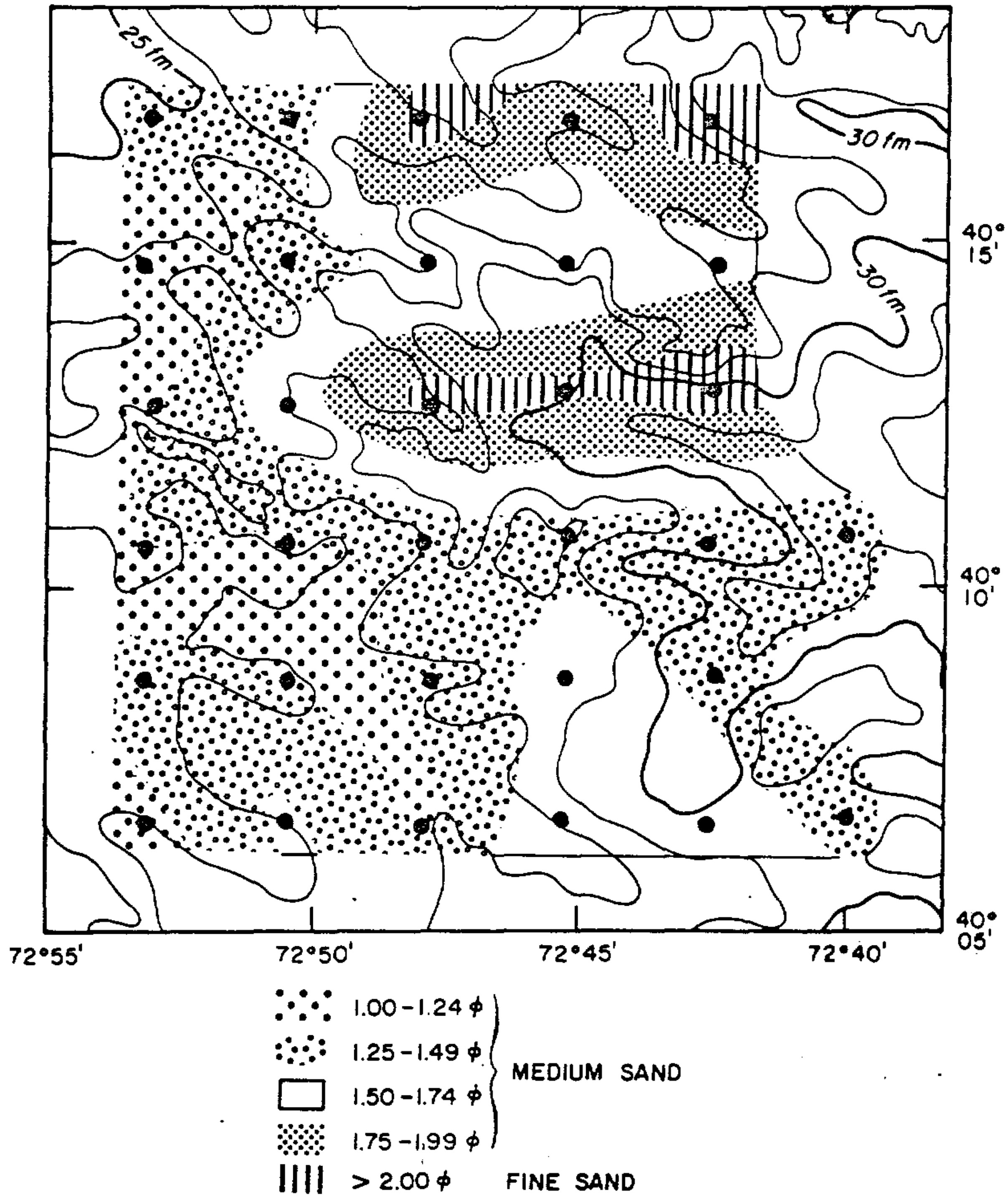


Figure 3. Mean grain-size distribution of the sand-sized fraction of sediments of the north alternate dump site. (From NOAA 1976).

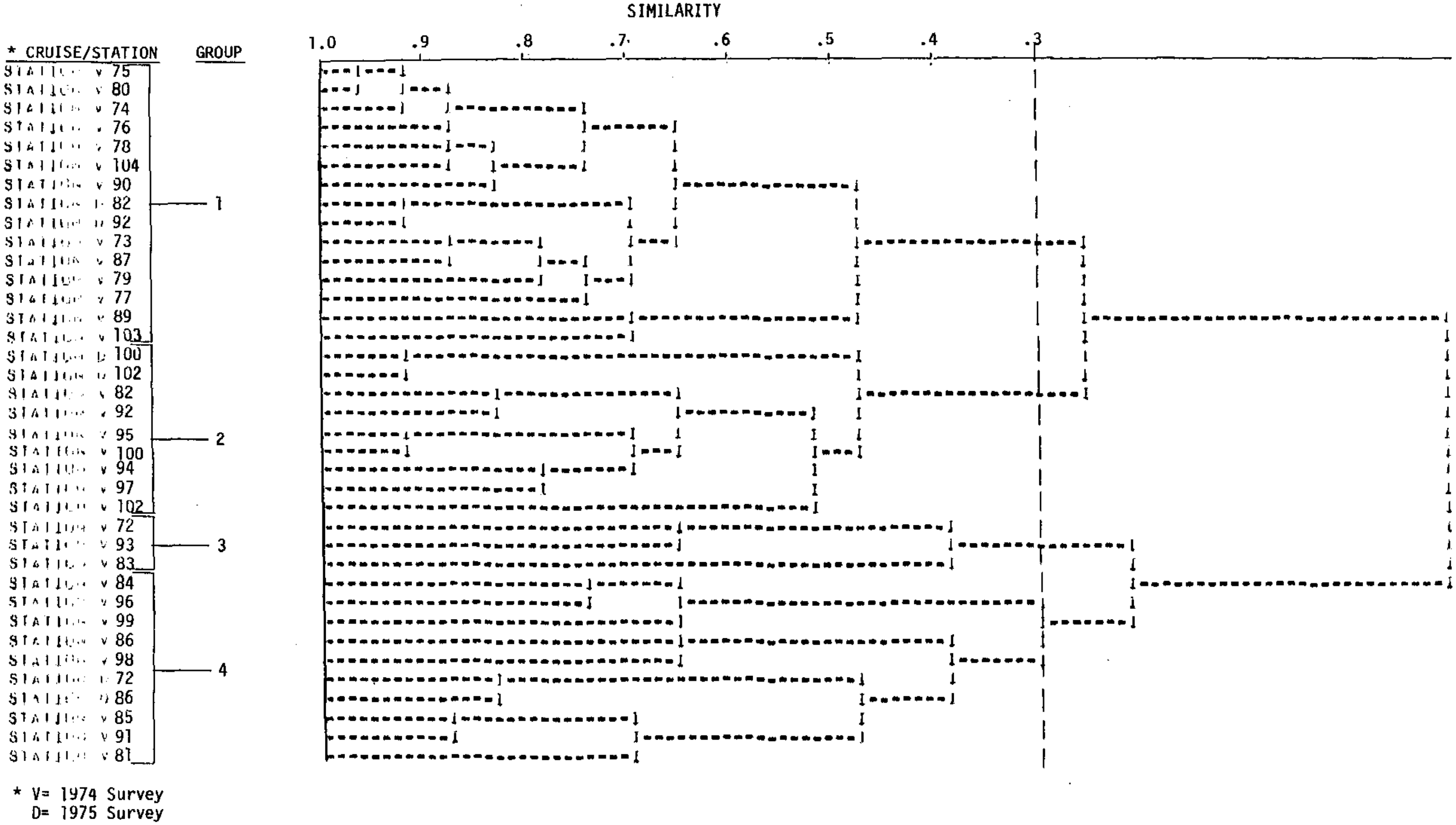
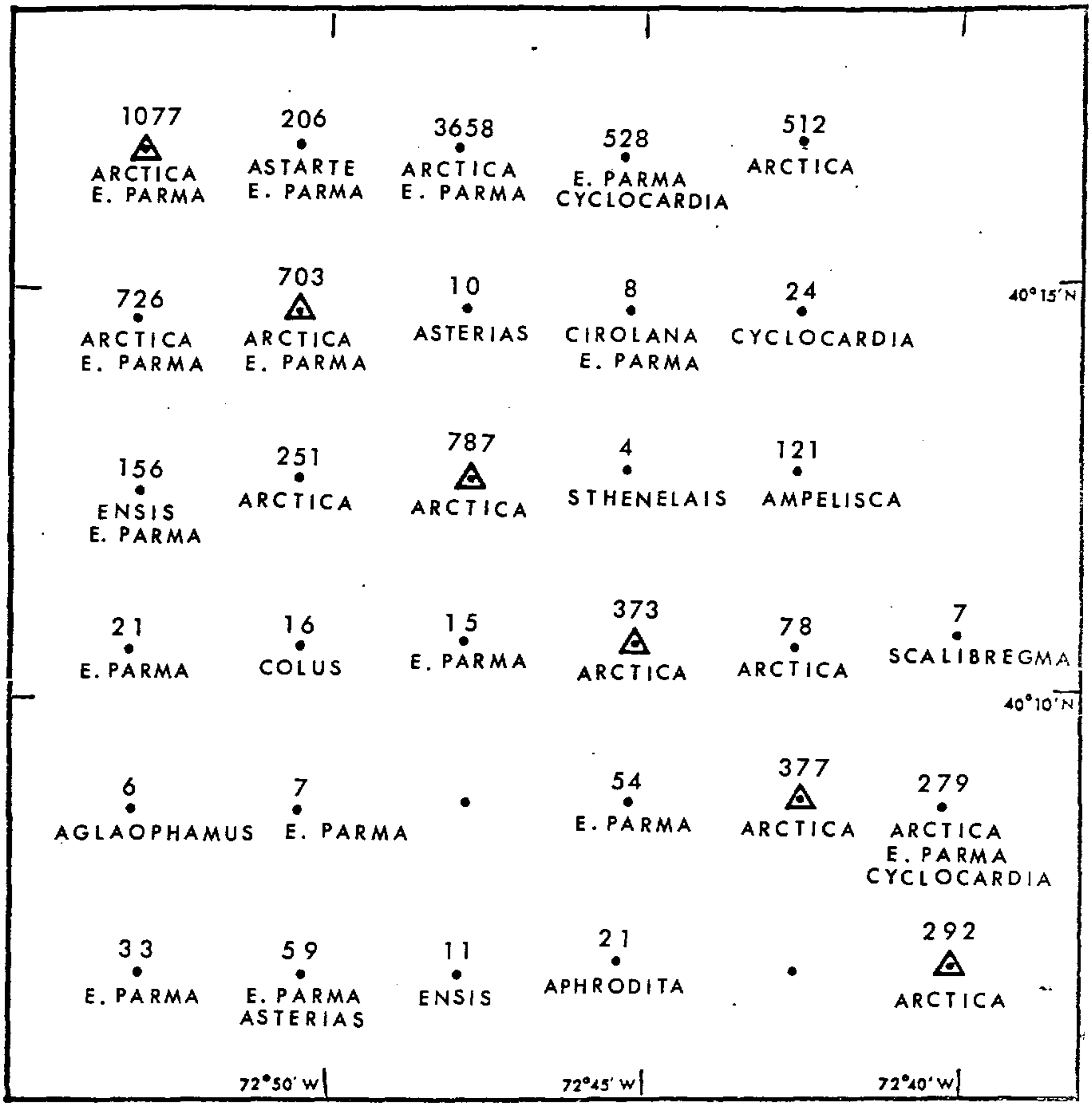


Figure 4. Dendrogram showing similarities in species composition among northern alternate dump site stations.



ALTERNATE DUMP SITE
NORTH

• STATIONS OCCUPIED JUNE 1974 △ STATIONS REOCCUPIED FEBRUARY 1975

Figure 5. Total benthic macrofauna biomass (g/m^2 wet weight) per station within the north alternate dump site and dominant contributor species.

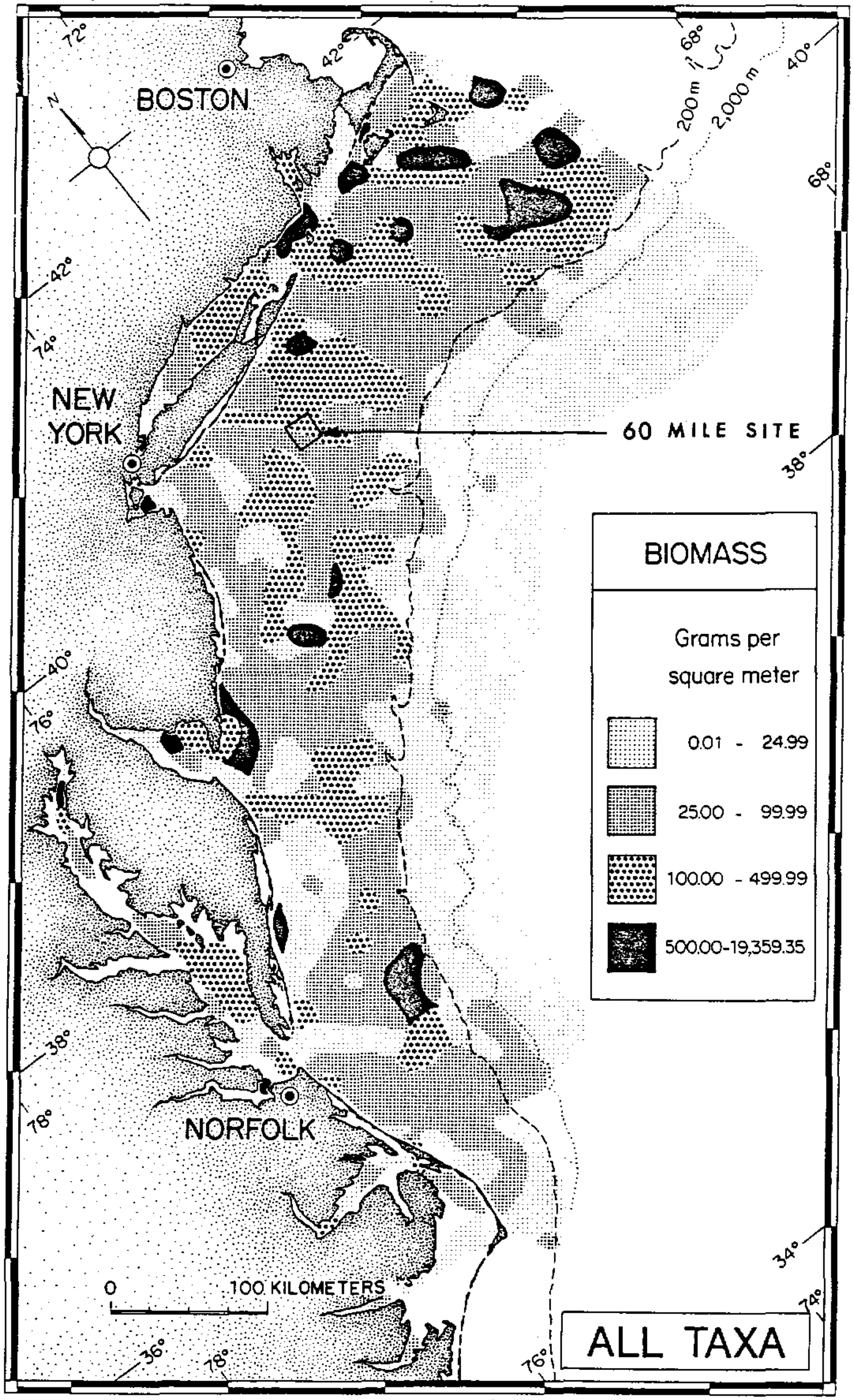


Figure 6. Geographic distribution of the biomass of all taxonomic groups combined and expressed as damp weight per square meter of bottom area. (From Wigley and Theroux 1981).

Table 1. Top five numerically dominant species for station groups generated by Q-mode cluster analysis. Numbers 1 through 5 represent the rank of each species among the top five.

	Station Group 1															Station Group 2									Station Group 3			Station Group 4									
									D				D			V	V				V	D	V	D	V			D				V	D				
Station No.	73	74	75	76	77	78	79	80	82	87	89	90	92	103	104	82	92	94	95	97	100	100	102	102	72	83	93	72	81	84	85	86	86	91	96	98	99
Species																																					
Polygordius triestinus				4			3		5	3	3		5				4								4		5										
Tharyx acutus	1	1	1	1	2	2	1	1	1	1	1	2	1	5	2	2	2			3		3	2	3	1	1	3	3	2					4			
Euchone elegans	2		2		4	5		3				4			5	1		3	2	1	2				3	5	2	5	4	2	3			5	3		2
Ampharete arctica	3	4	3			4		2	2	4			2	1		3			5		3	4		4		2		2	1	4	4	2	1	3	1		4
Lumbrinerides acuta	4		4		3		2				4																										
Exogone hebes		2			5	3	5	5			2																										
Exogone verugera																4																					
Clymenella zonalis		3		3								5			1														3	1	2	3	3	2		3	3
Clymenella torquata																								5													
Goniadella gracilis		5	5							2																											
Spiophanes bombyx				2	1	1		4	4			1	3	4	4	5	1	1	1		1	1	1	1	2		1	1			1		5	1	2	5	
Scalibregma inflatum									3	5		3	4	2	3					2		2		2				4					2		4		
Aglaophamus circinata																				5																	
Haploscoloplos robustus																							3														
Prionospio steenstrupi																																4					
Polydora socialis																																5				4	
Laonice cirrata																																				2	
Cirolana polita																		2																			
Unciola inermis																										3				3							
Unciola irrorata	5			5													5	5		4	4				5	4	4		5		5						5
Byblis serrata																			4		5		5														
Pseudunciola obliquua														3									4														
Phoxocephalus holbolli							4																														
Ampelisca macrocephala																														5							
Ampelisca vadorum																																	4		5		
Ampelisca agassizi																																1				1	1
Echinarachnius parma											5						3	4	3																		

Table 2. Total biomass (g m^2 wet weight) and contribution by major taxa of benthic macrofauna in the 60-mile site, 1974-1975.

Cruise Station # Grab #	Coelenterata	Rhynchocoela	Polychaeta	Crustacea	Mollusca	Echinodermata	Phoronida	Miscellaneous	Total	Dominant Species
VE 7401										
73-1			8.7	0.2	599.0	117.7			725.7	Arctica; Echinarachnius
74-1	3.6		23.8	0.1	64.8	64.0			156.3	Ensis; Echinarachnius; Myxicola
75-1			4.4	0.3	0.04	9.2			21.2	Echinarachnius
76-1			4.9	0.9					5.8	Aglaophamus
77-1			6.6	0.05	1.4	25.0			33.1	Echinarachnius
78-1			5.6	1.2	0.1	52.2			59.1	Echinarachnius; Asterias
79-1			2.3	1.1		4.1			7.4	Echinarachnius
80-1			5.7	3.0	5.9	1.6			16.3	Colus
81-1			18.9	4.5	219.7	7.3		0.5	250.9	Arctica
83-1			4.7	0.5	115.0	85.4			205.6	Astarte; Echinarachnius
84-1			3.9	1.1	1836.0	1817.0		0.2	3658.3	Arctica; Echinarachnius
85-1			3.6	3.1	0.2	10.5			17.4	Asterias
87-1			4.9	0.3		10.1			15.2	Echinarachnius
89-1			4.5	0.4	5.9	0.1			11.0	Ensis
90-1			17.2	0.5	3.7	0.04			21.4	Aphrodita
91-1			15.9	4.9	0.2	32.8			53.8	Echinarachnius
93-1			3.6	0.5				0.01	4.1	Sthenelais
94-1			1.8	3.7	0.05	2.5			8.1	Cirolana; Echinarachnius
95-1			8.9	2.0	116.9	400.0			527.8	Echinarachnius; Cyclocardia
96-1	1.4		13.8	2.7	494.0				511.9	Arctica
97-1			5.8	1.0	16.1	1.0			23.8	Cyclocardia
98-1		0.03	9.4	109.8	1.6	0.01	0.01	0.5	121.3	Ampelisca agassizi
99-1		0.01	9.5	2.5	66.2				78.2	Arctica
103-1			2.2	0.7	189.4	87.0	0.01		279.3	Arctica; Echinarachnius; Cyclocardia
104-1			6.0	0.5	0.7	0.01			7.3	Scalibregma
DE 7502										
72-1			7.9	0.2	1018.4	50.0		0.01	1076.6	Arctica; Echinarachnius
82-1			5.5	0.9	0.1				6.5	None
82-2			5.5	0.4	1269.0	124.6			1399.6	Arctica; Echinarachnius
86-1			2.9	0.2	148.7				151.8	Astarte
86-2		0.01	8.2	2.4	1410.0	1.7		0.3	1422.5	Arctica
92-1			4.2	0.7					4.9	Scalibregma
92-2			2.6	0.1	499.0	32.8			534.4	Arctica; Thyone
92-3			3.0	0.4	980.0				983.4	Arctica
92-4			6.4	3.4		324.8			334.6	Strongylocentrotus
92-5			4.8	0.4	0.4				5.6	Scalibregma
100-1			24.6	1.0	175.0	5.2			205.8	Arctica; Nephtys
100-2			3.9	0.3	543.1	0.1			547.4	Placopecten; Arctica
102-1			144.7	0.6	399.7	5.3		5.2	555.5	Arctica; Aphrodita
102-2			8.0	2.2	3.4	15.1			28.7	Echinarachnius

Last table was cut off from original scan

Table 3. Food of fishes representing generalized dietary categories in Southern New-England. Data are expressed as a percentage of the total stomach contents weight (From Bowman and Michaels 1982).

Stomach contents	Southern New England Fishes						
	Silver hake	Red hake	Little skate	Butterfish	Scup	Yellowtail flounder	Ocean pout
POLYCHAETA	0.1	3.9	13.5	20.3	32.4	47.7	2.7
Aphrodita sp.	-	1.4	2.4	-	-	-	1.9
Other Polychaeta	0.1	2.5	13.1	20.3	32.4	47.7	0.8
CRUSTACEA	7.3	34.0	61.4	12.0	22.2	24.9	6.1
Amphipoda	0.2	5.1	22.9	0.9	12.9	19.0	3.5
Unciola irrorata	-	0.6	2.4	-	2.9	5.9	-
Leptocheirus pinguis	-	0.9	7.9	-	3.6	3.3	-
Gammarus annulatus	-	-	4.1	-	-	-	-
Other Amphipoda	0.2	3.6	8.5	0.9	6.4	8.8	3.5
Decapoda	2.6	25.0	30.5	3.4	3.8	4.7	2.6
Axius serratus	-	0.6	4.3	3.3	-	-	-
Cancer sp.	-	4.3	11.4	-	-	-	1.0
Geryon quinquedens	-	-	-	-	-	-	-
Pagurus sp.	-	0.9	2.5	-	-	-	-
Crangon septemspinosa	1.0	3.0	5.9	-	-	2.2	-
Dichelopandalus leptocerus	1.2	7.8	2.7	-	-	1.9	-
Pandalus borealis	-	-	-	-	-	-	-
Pasiphaea multidentata	-	-	-	-	-	-	-
Other Decapoda	0.4	8.4	3.7	0.1	3.8	0.6	1.5
Euphausiacea	3.4	-	-	-	-	-	-
Meganyctiphanes norvegica	3.4	-	-	-	-	-	-
Thysanoessa inermis	-	-	-	-	-	-	-
Other Euphausiacea	-	-	-	-	-	-	-
Mysidacea	0.7	-	-	-	1.3	-	-
Neomysis americana	0.7	-	-	-	-	-	-
Other Mysidacea	-	-	-	-	1.3	-	-
Other Crustacea	0.4	3.9	8.0	7.7	4.2	1.2	0.1
MOLLUSCA	13.7	13.9	4.8	<0.1	10.5	0.6	0.8
Loligo pealei	13.0	-	-	-	-	-	-
Other Cephalopoda	0.7	10.6	-	-	8.4	-	-
Scallop viscera	-	-	-	-	-	-	-
Other Mollusca	-	3.3	4.8	<0.1	2.1	0.6	0.3
THALIACEA	-	-	-	8.5	-	-	-
ECHINODERMATA	-	3.0	-	-	0.4	-	88.3
Echinoidea	-	-	-	-	-	-	88.2
Ophiuroidea	-	-	-	-	-	-	-
Holothuroidea	-	3.0	-	-	-	-	-
Other Echinodermata	-	<0.1	-	-	0.4	-	0.1
PISCES	78.4	37.7	4.8	-	5.3	-	-
Merluccius bilinearis	7.9	-	-	-	-	-	-
Clupeidae	1.3	2.7	-	-	-	-	-
Scomber scombrus	6.0	-	-	-	-	-	-
Ammodytes americanus	0.4	-	-	-	-	-	-
Stenotomus chrysops	4.1	-	-	-	-	-	-
Peprilus triacanthus	2.2	-	-	-	-	-	-
Sebastes marinus	-	-	-	-	-	-	-
Hippoglossoides platessoides	-	-	-	-	-	-	-
Gadus morhua	-	-	-	-	-	-	-
Melanogrammus aeglefinus	-	-	-	-	-	-	-
Pollachius virens	-	-	-	-	-	-	-
Urophycis tenuis	-	-	-	-	-	-	-
Other Pisces	56.5	35.0	4.8	-	5.3	-	-
MISCELLANEOUS	0.5	7.5	13.5	59.2	29.2	26.8	1.9
Number of fish examined	918	481	486	394	262	502	239
Number of empty stomachs	357	97	35	108	76	163	73
Mean stomach content weight (g)	1.915	1.532	0.810	0.087	0.219	0.323	3.959