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The Biogenic Structure of Lower Chesapeake Bay Sediments

by

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CONTENTS

FIGURES

Number		Page

TABLES

I. EXECUTIVE SUMMARY

Sediment dynamics in estuarine areas are controlled by a complex interaction of physical and biological processes. When most toxic substances enter the estuary they become closely associated with the sediment, thus, the factors that influence the movement of sediments must be understood in order to predict the transport and fate of toxicants. This study characterizes the biological processes that effect sediment dynamics in the lower Chesapeake Bay.

Benthic organisms (a very diverse group of invertebrates that live on and in bottom sediments) have the potential to redistribute dissolved and particulate materials within the sediments, and between the sediment and water column. This activity of benthic organisms is generally referred to as bioturbation. Depending upon the life habits of the particular species involved their bioturbation activities may affect the distribution of toxic substances by:

- mixing - causing newly arrived surface material to be quickly buried or resurfacing older material
- ventilation - increasing the exchange between interstitial water and the water column
- increasing sediment stability - decreasing the probability that buried material will be resurfaced
- decreasing sediment stability - increasing the probability that buried material will be resurfaced
- causing rapid sedimentation - through pellitization of fine suspended particles
- causing erosion - by making sediment more easily transported

Analysis of our box core samples from around the lower Bay (Figure 1) brought us to the following set of basic conclusions:

- The majority of the stations with large percentages of silt and clay are found north of the Rappahannock River. Stations south of the Rappahannock are mostly muddy sands. Sand dominates the mouth of the Bay and along the Eastern Shore.

- Many of naturally occurring particles that compose the sediments are organic-mineral aggregates that are destroyed during classical grain size measurement techniques. These aggregates cannot be neglected in considering the dynamics of deposition and transport of toxic substances. Microscopic analysis showed an average of 69% of the particle species showed a positive reaction for the presence of organic matter. All stations exhibited great similarity in the percent abundance distribution of the different natural particles despite wide differences in grain size as derived from conventional analysis. The larger organic-mineral aggregates are certainly fecal pellets, created by the feeding activities of the benthos. Smaller amorphic aggregates are most likely formed in the decay of fecal pellets.

- Organisms capable of bioturbating sediments were found to occur over the entire lower Bay. Populations were numerically dominated by euryhaline opportunists. These species are extremely dynamic and occur over a wide range of salinities and sediments. Their populations tend to vary a great deal both spatially and temporally. A large number of equilibrium species were also found. While not numerically dominant they tended to be the biomass dominants. A pattern along the salinity gradient also exists, with the polyhaline zone having the greater number of individuals and species than the mesohaline zone.

- The majority of the benthic organisms in the lower Bay are found in the top 10 cm of sediment. Muds have the fewest deep dwelling organisms, muddy sands an intermediate number, and sands the highest number. While there are a greater number of individuals and species in the polyhaline zone compared to the mesohaline zone the proportion of deep dwelling organisms is similar in both salinity zones. Polychaetes were the most specious groups to live deep (>10 cm) in the sediment. All major taxonomic groups had deep dwelling representatives. Most of the deep dwelling species, were not numerically dominant, but due to their large size were capable of processing large volumes of sediment.

- None of our cores were without some evidence of bioturbation. The vast majority of the cores were 90 to 99% bioturbated. Those that had the least amount of bioturbation tended to be in the upper part of the study area, have fluid mud surfaces, or have high amounts of coarse sand and gravel. Physical structures, mostly mud or sand laminations, dominated the muds in deep channel areas and deep holes where perioidic summer anoxia allows only the temporary settling of opportunistic species which tend to be shallow bioturbators. Muds in shallower areas contain more species and more biological structures. Most of the muddy sands of the lower Bay are dominated by both living and abandoned biogenic structures. Sands are most uniformly mixed from bioturbation activities and show little biogenic structure other than tubes of living organisms. Muds tend to have a more tube or burrow oriented sedentary community while sands have a more mobile fauna causing a more uniform bioturbated sediment fabric.

° The density of biogenic structures of living organisms is highest in the top 2-3 cm of sediment, but structures are common to 15-20 cm and have been observed below 50 cm. This would indicate mixing to be most rapid near the surface and decrease with depth. Back filling of abandoned burrows and tubes is an important means of quick burial of surface material to depths of 5 to 40 cm or more.

These findings all have implications that must be considered for the management of toxic substances and for modeling their distribution and fate in estuaries. The benthos directly and/or indirectly influence the chemical gradients within the pore waters. They also figure very predominantly in mixing and turnover of the sediments. Our study indicates that bioturbation will be most intense in the top several centimeters, but that most areas of the lower Bay have large organisms penetrating to 30 cm or more. Most of the Bay bottom is bioturbated, with the least bioturbation occurring in deep holes where fluid mud and periodic anoxia limit the development of benthic populations. The mechanisms of toxic transport by the benthos can be summarized as follows:

- Feeding activities
  - subsurface to surface movement
  - sedimentation through pelletization
- Burrowing activities
  - subsurface to surface movement
  - lateral movement within sediments
- Tube building
  - stabilization of surface
  - increase in sedimentation
- Ventilation of burrows or tubes
  - alter pore water profiles
  - increases flux between sediment and water column

All these activities in some way affect the mass properties of sediments and the dynamics of estuarine sedimentation. Any model for predicting the movement of toxic substances within or between the sediment and water must include biological mixing coefficients. Models not considering the benthos may erroneously predict permanent burial of a toxicant within a short time when in fact the toxicant could be buried and resurfaced many times before sedimentation removes the toxicant from the biologically active zone.

II. INTRODUCTION

One of the prime objectives of the EPA Chesapeake Bay Program has been to obtain the information necessary to predict the distribution and ultimate fate of toxic materials entering the Chesapeake Bay system. Most toxicants entering the water column become closely associated with particulate materials which eventually settles to the bottom as sediment. Thus, a thorough understanding of sediment dynamics and chemistry is necessary to understand the movement of sediment-bound toxicants through the Bay system.

With the exceptions of azoic or rapidly accumulating environments, most sediments are inhabited by benthic organisms which have the potential to redistribute dissolved and particulate materials within the sediments. In the Chesapeake Bay faunal composition and abundance change with substrate type and salinity gradients (Boesch 1977, Roberts et al. 1975). These faunal changes are reflected in the type and degree of influence benthic organisms have on both sedimentological and geochemical profiles (Winston and Anderson 1971, Aller 1978).

Depending on their life histories and living positions, benthic organisms may increase sediment stability (Fager 1964, Mills 1967), decrease sediment stability (Rhoads and Young 1971, Thayer 1979), increase the sediment accumulation rate (Haven and Morales-Alamo 1966, Lynch and Harrison 1970) or increase erosion (Rowe 1974). All of these processes indirectly influence the fate of sediment-bound toxicants. Benthic organisms may also affect the distribution of toxicants through their burrowing and feeding activities which displace materials, both horizontally and vertically, or through burrow ventilation which effectively increases the exchange between interstitial waters and the overlying water column (Aller 1978).

This study was designed to obtain information on the animal-sediment relationships in the Chesapeake Bay as a means of assessing the relative importance of benthic macroinvertebrates in determining the distribution and fate of sediment-borne toxic substances. Large volume box cores for biological examination were collected simultaneously with cores taken by Maryland Geological Survey for interstitial water chemistry. Vertical distribution of organisms within the cores was utilized as a means of determining the depth of biological mixing. The vertical distribution of organisms has been found to be correlated to the depth of mixing by Krezoski et al. (1978). We also employed an x-ray technique established by Howard and Frey (1975) to determine the relative amounts of mixing in different areas of the estuary as well as the types of biogenic structure produced by resident organisms. Our last approach involved a microscopic study of the sediments to aid in the conceptualization of the effects animals have on altering grain size properties. This information was used to formulate hypotheses regarding the effect benthic organisms have on interstitial chemical profiles and sediment dynamics.

III. METHODS

A joint cruise with Maryland Geological Survey was made in September 1978. Twenty-five stations in the Virginia portion of the Chesapeake Bay were sampled with a box corer for biological studies and a gravity corer for chemical studies. An additional 3 stations were sampled by box corer on a separate cruise in late April 1979 in order to perfect newly developed core processing techniques. A second joint cruise with Maryland Geological Survey (sediment chemistry) and National Bureau of Standards (water column chemistry) in June 1979 visited a final 25 stations. The resulting data includes detailed biological and chemical profiles from 50 stations representing the various sedimentary and estuarine environments of the lower Bay (Fig. 1).

Biological sampling was accomplished using a U.S. Navy Electronics Laboratory spade box corer. The box corer takes an undisturbed sample encompassing a surface area of 0.062 m^2 with a maximum penetration of 60 cm.

Once the box core was retrieved any overlying water was carefully siphoned off and surface topography (ripple marks, fecal mounds, burrow openings, tube density, surface traces) was observed and recorded. One side of the box was removed and a 6 cm thick vertical slice was cut, placed in a water tight plexiglass container and refrigerated for later radiography. The remainder of the box corer was measured for depth of penetration and then a small sediment sample was taken at vertical intervals of 0, 2, 5, 10, 20 and, if possible, 40 cm and preserved in 70% ethyl alcohol for later staining and microscopic examination. The remainder of the core was placed intact in a water tight plexiglass container and stored in a freezer.

The 6 cm section was trimmed to a 2 cm thickness for radiographic examination. This is thought to be the ideal thickness for examining biological and sedimentological structures (Howard and Frey 1975). We used a Torr 120 kv. x-ray machine with 14 x 17 Kodak AA Industrial x-ray film. Voltage, amerage, exposure time and development time was recorded for each radiograph. Color and/or black and white photographs were taken of each core for further visual documentation and comparison. The degree of bioturbation at a station was visually estimated from x-radiographs of the vertical core sections using criteria outlined in Howard and Frey (1973, 1975). This technique involves estimating the amount of physical structure observable in radiographs versus the amount that has been altered by biological activities including tube building and mixing.

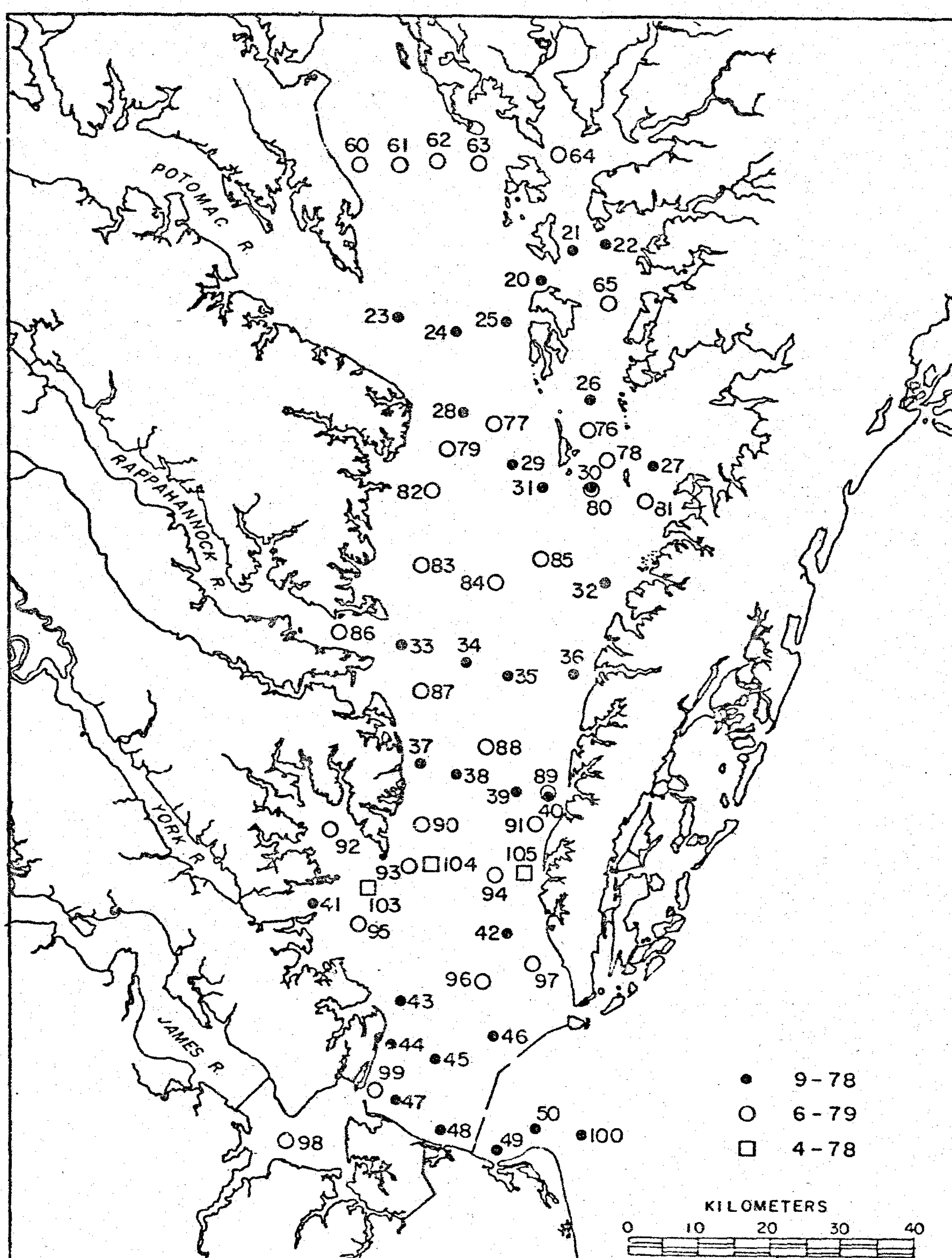

Fig. 1. Box core station locations.

The other frozen box core section was cut into 5 cm horizons. A sediment sample was saved for grain size analysis. Each horizon was dissected to uncover an organism's position and associated biogenic structures. The organisms were removed, identified and preserved in 70% ethanol. The disaggregated sediment was sieved through a 0.5 mm sieve to recover any small macrofaunal organisms missed in the dissections. Information derived from dissections, sieved samples and radiographs was used to construct a three dimensional distribution map of organisms for each core (See Appendix C).

The small sediment samples taken at vertical intervals along the core were microscopically examined in order to classify particle types. A periodic acid-Schiff reagent was used to stain particles for the presence of carbohydrates and carbohydrate-proteins (Humason 1967). Details of staining procedure is given by Whitlatch and Johnson (1974). Small amounts of stained sediments were mounted on microscope slides using a glycerol mounting medium. Fields were randomly chosen until the first 300 particles on each of 2 slides were measured and identified into the following categories at 400X:

Non-Encrusted Mineral Grains	Encrusted Mineral Grains	Mineral Aggregates
<25 μm	<25 μm	<25 μm
25-50 μm	25-50 μm	25-100 μm
50-100 μm	50-100 μm	100-300 μm
100-150 μm	100-150 μm	300-500 μm
⋮	⋮	>500 μm

A scan of the entire slide at 100X was made to count less frequently occurring particles (fecal pellets, plant tissue, diatoms, etc.).

Problems arose in attempts to perform all analyses on one box core. Also, freezing the core resulted in poor preservation of biological specimens, thus making identifications difficult. A separate cruise was made in April 1979 to perfect new sampling procedures. Two box cores rather than one were taken at each of three stations (103, 104 and 105). One box core was used for an x-ray sample (taken as before) and the remainder was dissected on board rather than frozen and transported to the laboratory. The other box core was divided on board at intervals of 0-2 cm, 2-5 cm, 5-10 cm, 10-15 cm, 20-30 cm, 30-40 cm and 40-50 cm. Sediment samples for grain size and microscope analysis were taken at each interval before sieving through a 0.5 mm sieve on board. All biological samples were preserved in 10% formalin. Biological samples were sorted, identified and transferred to 70% ethanol as before. These techniques proved more successful and were employed on the June 1979 cruise.

IV. RESULTS

A. Sediments

Table 1 lists the percent sand, silt, and clay for the vertical intervals taken down each core. The majority of the stations with large percentages of silt and clay are found north of the Rappahannock River. Stations south of the Rappahannock River are mostly muddy sands. Sand dominates the areas at the mouth of the Bay and along the Eastern Shore.

Most of the cores are fairly homogeneous, but a few show some large vertical variations. Sediments at Station 27 in Pocomoke Sound contains mostly fine sand (55%) with little gravel (.2%) in the top 5 cm. At the 20-25 cm layer the gravel content has increased to 20% and fine sand has decreased to 15%. Sediments at Stations 37 and 39 are mostly medium sand in the top 5 cm, but become coarser towards the deeper layers. Station 41 has alternate layers of low and high gravel content sediments.

Station 77 has high percent silt-clay sediments in the top 5 cm (45%) but this drops to 12.5% in the 10-15 cm layer before increasing to 30% in the 20-40 cm layer. Station 78 exhibits the most dramatic example of vertical sediment change. The top 10 cm contains 90% mud sediments, but the next layer (10-15 cm) only 28% mud.

Sediments at Station 80 fluctuate considerably in % sand with depth. Sediments at Stations 89 and 91 increase in their percent mud and coarse sand with depth. Stations 28 and 49 are the only two stations which have a consistent gradient of increasingly muddy sediments with depth.

The most common vertical variation found in cores is an increase of coarser material with depth, the next most frequent occurrence is random fluctuations, and the least common is an increase of finer materials with depth. Vertical variations represent changes in the energy environment or source of sedimentary materials.

Table 2 lists the sedimentation rates at the different sampling sites. Most stations have net deposition rates on the order of .5 to 1.5 cm/yr. Stations 26, 86, 94 and 96 have deposition rates greater than 1.5. Except for Station 96, all have high silt clay contents. Station 96 with the largest deposition rate (2.64 cm/yr) is located in a shoal area just east of the York Spit Channel and south of a large discontinued spoil dump area. Stations 44, 50, 90, 91, 97, and 100 have negative deposition rate indicating erosion in these areas. All these areas have clean sands and except for stations 90 and 91 occur at or very near the mouth of the Bay. Both stations 90 and 91 occur in shallow high energy environments.

Table 1 . Grain size distribution from vertical sectioning of box cores.

Section Depth	% gravel	% sand	% silt	% clay
Station 26				
0-5 cm	missing			
5-10	trace	11.6	50.9	37.5
10-15	0.1	6.0	53.0	40.9
15-20	0.1	6.3	50.8	42.8
20-25	missing			
25-30	0.1	10.6	47.2	42.0
30-35	trace	2.5	46.5	51.0
35-40	0	2.7	48.5	48.8
40-43	0	4.1	49.5	46.4
Station 27				
0-5 cm	0.2	85.8	8.6	5.4
5-10	0.1	92.8	3.9	3.2
10-15	0	92.7	3.9	3.4
15-20	6.0	83.2	5.4	5.4
20-25	19.9	73.9	2.9	3.3
25-30	16.8	71.2	5.1	6.9
Station 28				
0-5 cm	1.3	85.3	5.0	8.4
5-10	1.4	88.5	3.3	6.8
10-15	5.1	78.1	6.0	10.8
15-20	1.4	62.1	15.3	21.1
20-27	5.5	56.7	16.9	20.8
Station 29				
0-5 cm	trace	96.4	0.9	2.6
5-10	0.1	97.6	0.7	1.5
10-15	0.1	97.3	0.6	2.0
15-19	0.1	96.6	1.2	2.1
Station 30				
0-5 cm	0.2	19.6	41.8	38.4
5-10	0	15.9	56.3	27.8
10-15	0	35.3	30.6	34.1
15-20	0	16.8	41.3	41.9
20-25	0	31.3	35.2	33.5
Station 31				
0-5 cm	0.1	1.1	51.5	47.3
5-10	0	0.6	55.4	44.0
10-15	0	2.6	54.0	43.5

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 32				
0-5 cm	0.2	58.7	25.3	15.8
5-10	0.4	52.2	27.2	20.2
10-15	trace	52.4	27.9	19.6
15-25	0.1	54.4	25.9	19.5
Station 33				
0-5 cm	missing			
5-10	0.2	44.5	38.1	17.2
10-40	missing			
Station 34				
0-5 cm	0	21.6	52.0	26.4
5-10	0.1	18.6	53.7	27.6
10-15	0	21.4	53.5	25.0
15-21	0	13.0	53.6	33.4
Station 35				
0-5 cm	0.2	38.5	41.6	19.7
5-10	missing			
10-15	0	43.1	36.4	20.6
15-20	0	42.6	34.9	22.5
20-25	0	34.7	40.2	25.0
25-30	trace	44.1	24.9	31.0
30-38	0	39.6	36.1	24.3
Station 36	missing			
Station 37				
0-5 cm	10.8	84.4	1.7	3.2
5-10	18.3	72.8	3.6	5.2
10-18.5	25.5	64.4	4.5	5.5
Station 38				
0-5 cm	0.7	41.7	39.8	17.8
5-10	1.6	38.1	39.9	20.5
10-15	missing			
15-20	0.3	21.6	51.2	26.9
20-25	0.2	22.5	52.0	25.3
25-30	0.3	26.0	48.5	25.2
30-35	0.7	34.1	42.4	22.9
35-40	0.3	34.0	44.1	21.7
40-45	0.6	34.1	42.3	23.0
45-51	0	21.3	48.7	30.1

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 39				
0-5 cm	1.7	95.7	0.5	2.0
5-10	4.8	92.0	0.8	2.4
10-16	32.7	59.4	3.3	4.6
Station 40				
0-5 cm	0	90.4	4.1	5.5
5-10	0	88.6	5.5	5.8
10-15	trace	88.1	4.9	6.9
15-20	0.2	86.2	5.8	7.8
20-25	0.5	86.7	5.0	7.8
25-33	0.6	84.8	6.3	8.3
Station 41				
0-5 cm	5.8	78.8	5.8	9.5
5-10	14.7	63.0	8.7	13.6
10-15	11.8	61.1	13.1	14.0
15-20	7.4	56.2	13.5	22.9
20-24	27.4	46.4	9.9	16.4
Station 42				
0-5 cm	0.7	73.3	16.0	10.0
5-10	0.1	61.8	24.5	13.6
10-15	0	67.4	19.9	12.7
15-20	trace	67.7	19.8	12.5
20-25	missing			
25-30	0	66.4	18.6	14.9
30-36	trace	68.9	19.5	11.6
Station 43				
0-5 cm	1.4	69.4	20.0	9.2
5-10	missing			
10-15	1.8	73.9	14.9	9.3
15-20	1.0	80.0	12.2	6.8
20-24	0.1	79.9	13.5	6.5
Station 44				
0-5 cm	2.0	91.3	2.3	4.5
5-10	1.3	87.8	3.2	7.7
10-13	missing			
Station 45				
0-5 cm	0.6	95.1	1.4	2.9
5-10	0.7	95.8	0.9	2.6
10-15	3.7	90.9	1.8	3.6
15-20	0.9	85.9	5.0	8.1
20-27	3.9	83.1	5.7	7.2

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 46				
0-5 cm	0.1	82.0	8.8	9.2
5-10	0.1	82.4	10.4	7.0
10-18	0.5	73.9	14.5	11.1
Station 47				
0-5 cm	0.1	79.8	11.4	8.7
5-10	missing			
10-15	trace	56.6	26.9	16.5
15-20	0.5	62.5	22.3	14.6
20-25	trace	72.1	15.3	12.6
25-30	0.8	71.2	13.2	14.9
30-38	0.1	57.1	20.4	22.4
Station 48				
0-5	0.1	72.8	18.0	9.1
5-10	0.2	81.0	11.9	6.9
10-18	0.2	81.0	12.1	6.6
Station 49				
0-5	1.0	60.6	26.8	11.5
5-10	0.6	58.1	25.2	16.0
10-15	0.2	53.2	26.5	20.1
15-20	0.1	51.6	30.0	18.3
20-25	0	50.4	29.5	20.1
25-30	trace	47.3	29.6	23.1
30-35	trace	46.6	29.3	24.1
35-40	0.1	42.8	31.2	25.8
40-45	0	33.6	38.9	27.6
45-50	trace	40.0	34.1	25.9
50-55	trace	39.0	35.2	25.8
Station 50				
0-5 cm	missing			
5-10	0.2	90.6	4.7	4.6
10-15	0.1	88.8	5.4	5.7
15-22	0.1	90.1	4.9	4.9
Station 76				
0-2 cm	trace	4.0	47.5	48.5
2-5	0	6.7	49.8	43.5
5-10	0	3.8	56.0	40.2
10-15	0.1	4.3	53.6	41.9
15-20	0.1	3.8	54.6	41.5
20-30	0.1	5.6	56.7	37.7
30-40	0	5.6	51.8	42.7

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 77				
0-2	0.3	54.3	18.2	27.2
2-5	0	85.2	5.9	8.9
5-10	0.1	84.9	5.6	9.4
10-15	trace	87.5	4.0	8.5
15-20	1.1	68.5	8.4	13.0
20-30	0.7	65.6	13.1	20.7
30-40	0.3	69.5	12.2	17.9
Station 78				
0-2	0.2	9.8	48.8	41.1
2-5	0.2	10.7	46.2	42.9
5-10	0	11.9	53.6	34.5
10-15	0.7	71.6	12.4	15.3
15-20	0.1	72.7	13.7	13.5
20-30	0.6	77.3	10.9	11.1
30-40	0.4	80.4	9.5	9.7
Station 79				
0-2	1.3	2.9	41.2	54.6
2-5	0	0.3	50.4	49.2
5-10	0.1	3.7	45.9	50.3
10-15	0.2	3.9	46.9	49.1
15-20	trace	4.9	47.4	47.6
20-30	0	5.2	46.5	48.3
30-40	0	4.2	45.5	50.2
Station 80				
0-2	0.1	66.3	21.4	12.2
2-5	0	54.1	31.6	14.3
5-10	0.1	29.4	47.4	[illegible]
10-15	0	41.7	36.6	21.6
15-20	0	31.0	43.8	25.2
20-30	trace	56.3	27.1	16.5
30-40	0.4	59.3	26.5	13.8
40-50	0.3	48.1	31.8	19.8
Station 81				
0-2 cm	0.1	68.5	18.9	12.5
2-5	2.7	74.1	11.0	12.1
5-10	0.7	65.6	16.7	16.9
10-15	0	68.7	15.2	16.0
15-20	1.2	68.3	13.7	16.7
20-30	0.8	44.6	25.1	29.4
30-40	1.7	66.2	15.9	16.3
40-50	0.9	60.9	18.6	19.5

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 82				
0-2 cm	0	1.1	46.4	52.5
2-5	0	1.9	52.5	45.5
5-10	0	2.4	51.4	46.2
10-15	0.1	0.4	43.1	56.4
15-20	0	0.7	45.3	54.0
20-30	0	2.0	47.5	50.5
Station 83				
0-2 cm	0.6	3.2	49.5	46.6
2-5	0	1.8	47.3	50.8
5-10	0	1.7	51.7	46.6
10-15	0	1.9	48.2	50.0
15-20	trace	1.5	50.2	48.3
20-30	0	1.7	45.4	53.0
Station 84				
0-2 cm	0.3	9.9	62.8	26.9
2-5	0	8.9	60.1	31.0
5-10	0	5.8	55.7	38.5
10-15	0	9.0	56.7	34.3
15-20	0	11.3	59.8	28.9
20-30	0	14.3	56.3	29.4
30-40	0.1	5.0	55.2	39.7
Station 85				
0-2 cm	0.4	6.2	53.8	39.5
2-5	trace	5.5	57.6	36.9
5-10	0.3	8.0	55.2	36.5
10-15	0	11.7	53.7	34.6
15-20	0.1	14.4	53.8	31.7
20-30	missing			
30-40	0	10.0	52.7	37.3
40-50	0	11.0	49.2	39.8
Station 86				
0-2 cm	0.2	2.7	49.8	47.3
2-5	0	1.1	45.7	53.2
5-10	0.1	2.2	52.5	45.2
10-15	0.2	1.8	51.8	46.1
15-20	1.0	1.6	48.6	48.8
20-30	0	1.4	50.2	48.3

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 87				
0-2 cm	trace	6.0	73.6	20.4
2-5	0	8.6	67.2	24.2
5-10	0	10.1	63.2	26.7
10-15	0.1	10.9	62.4	26.6
15-20	0	10.0	62.7	27.4
20-30	0	7.4	58.4	34.2
30-45	0	9.0	56.8	34.2
Station 88				
0-2 cm	0.4	35.1	46.0	18.5
2-5	0.1	42.5	35.9	21.5
5-10	0	29.5	48.5	22.1
10-15	0	26.9	47.6	25.4
15-20	0.1	27.1	50.3	22.5
20-30	0	27.9	49.5	22.6
30-40	0	25.4	49.1	25.4
40-50	0.2	24.7	48.4	26.8
Station 89				
0-2 cm	0.1	82.3	8.4	9.2
2-5	0.1	87.7	5.5	6.8
5-10	trace	92.5	3.0	4.5
10-15	0.3	89.9	4.3	5.5
15-20	0	84.1	5.8	10.1
20-30	1.2	87.8	4.5	6.5
Station 90				
0-5 cm	0.2	96.6	0.6	2.6
5-10	0.3	97.2	0.4	2.0
10-18	0.7	97.7	0.3	1.4
Station 91				
0-2 cm	0.2	96.8	0.8	2.2
2-5	0	96.6	0.5	2.8
5-10	0.1	97.7	0.3	1.8
10-15	0.1	96.1	1.5	2.3
15-20	1.3	95.0	1.2	2.5
Station 92				
0-2	0	0.3	49.5	50.2
2-5	0	0.5	54.6	44.9
5-10	missing			
10-15	0	0.3	49.2	50.4
15-20	0	1.1	49.2	49.6
20-30	0	0.4	48.6	51.0
30-40	0	0.3	49.7	50.0
40-50	0	0.4	47.8	51.7

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 93				
0-2 cm	0.1	5.5	59.9	34.5
2-5	0.2	9.4	62.0	28.3
5-10	0.6	11.7	58.7	28.9
10-15	0	8.9	58.3	32.8
15-20	0	14.3	56.3	29.4
20-30	0.1	15.3	52.4	32.2
30-40	0	12.9	55.9	31.2
40-50	0.5	8.7	57.0	33.7
Station 94				
0-2 cm	0.1	56.8	30.2	12.9
2-5	0.1	67.9	21.4	10.6
5-10	0	62.0	26.0	11.9
10-15	0	54.9	29.9	15.2
15-20	0	54.8	31.4	13.8
20-30	0	49.5	34.9	15.6
30-42	0	58.2	25.6	16.2
Station 95				
0-2 cm	0	8.8	53.2	38.0
2-5	trace	10.0	50.0	40.0
5-10	0	5.4	53.4	41.2
10-15	0	7.2	53.2	39.6
15-20	0	6.4	52.6	41.0
20-30	0	7.2	50.3	42.5
30-40	trace	7.8	51.1	41.0
40-50	0	12.7	50.3	37.0
Station 96				
0-2	0.1	92.9	2.8	4.2
2-8	0.1	93.6	2.7	3.6
Station 97				
0-2 cm	1.8	65.8	*32.3 silt & clay	
2-5	trace	67.0	20.6	12.3
5-10	trace	76.9	13.3	9.8
10-15	trace	79.9	11.3	8.8
15-20	0	63.0	24.9	12.1
Station 98				
0-2 cm	12.7	68.1	8.4	10.8
2-5	4.4	77.1	6.8	11.8
5-10	5.7	80.4	5.5	8.3

Table 1 (continued)

Section Depth	% gravel	% sand	% silt	% clay
Station 99				
0-5 cm	0.2	73.0	16.2	10.6
5-10	trace	62.0	20.4	17.6
10-15	0.3	65.1	18.0	16.6
15-20	0.5	64.0	17.0	18.5
20-30	0.7	57.1	20.6	21.6
30-40	0.5	63.4	19.9	16.2
Station 100	missing			
Station 103				
0-2 cm	missing			
2-5	0.3	70.9	14.2	14.6
5-10	0.3	78.8	11.9	8.9
10-20	0.2	66.4	18.7	14.7
20-37	0.1	66.1	19.0	14.8
Station 104				
0-2 cm	0.6	30.8	43.6	25.0
2-5	missing			
5-10	0.2	49.0	31.0	19.8
10-15	missing			
15-20	0	61.3	19.5	19.2
20-30	trace	50.3	29.7	20.0
30-40	0.1	61.5	18.7	19.8
Station 105				
0-2 cm	0.1	68.1	19.1	12.8
2-5	0	61.7	23.5	14.8
5-10	0.1	58.9	23.9	17.1
10-15	0	49.3	32.0	18.7
15-20	trace	53.4	28.0	18.5
20-30	0	63.0	19.6	17.5
30-40	0	68.3	15.3	16.4

Table 2. Net sedimentation rates predicted for box core station locations*.

Station	Sedimentation rate cm/yr	depth (ft)
26	1.80	98
27	.76	12
28	.82	82
29	.40	33
30	.58	88
31	1.05	44
32	.97	46
33	.74	35
34	.75	39
35	.56	39
36	.64	37
37	.96	22
38	.82	37
39	.57	43
40	.57	42
41	.33	46
42	.04	38
43	0	38
44	-.22	24
45	.81	29
46	.42	24
47	.11	44
48	1.46	28
49	missing	38
50	-.08	58
76	.59	98
77	1.05	65
78	1.47	78
79	.55	60
80	.58	58
81	.86	51
82	1.46	80
83	.83	40
84	.85	42
85	.83	39
86	1.59	61
87	.62	33
88	missing	38
89	.89	40
90	-.65	26
91	-.44	30
92	.70	20

Table 2 (continued)

Station	Sedimentation rate cm/yr	depth (ft)
93	1.01	43
94	2.20	55
95	1.22	35
96	2.64	27
97	-1.02	110
98	missing	61
99	.11	55
100	-1.08	62

* Information taken from Annual report of EPA grant R806001010 Baseline sediment studies to determine distribution, physical properties, and sedimentation budgets and rates by Robert J. Byrne, Carl H. Hobbs III, and Michael J. Carron. 1979.

B. Faunal Composition and Abundance

A total of 34,811 individuals representing 173 taxa were collected. Polychaetes were by far the most numerous (21,592 individuals) and diverse (84 species) benthic invertebrates, with crustaceans second (8,491 individuals, 39 species), and molluscs third (4,499 individuals, 35 species). Miscellaneous groups were represented by 229 individuals and 15 species (see Appendix A for species list).

A great disparity existed between the number of individuals collected on the September 1978 cruise and the number collected on the June 1979 cruise. In September, 1978 4,197 individuals were collected. Polychaetes represented 10% of the total, crustaceans 82%, molluscs 7% and miscellaneous taxa 1%.

On the June 1979 cruise 27,326 individuals were collected, almost a 7 fold increase. Polychaetes had the greatest relative increase with 69% of the total. Relative to the total, crustaceans decreased to 17%, molluscs to 13% and miscellaneous groups to less than 1%.

Aside from the numerical disparity between the two seasons, a shift in dominance from one set of species to another occurred. Using McCloskey's Biological Index (McCloseky 1970) a ranking dominance can be given that is representative of each species abundance and frequency. The five dominant species in the fall collections were: 1) Pseudeurythoe ambigua (polychaete), 2) Paraprionospio pinnata (polychaete), 3) Retusa canaliculata (gastropod), 4) Ampelisca abdita (amphipod), and 5) Nereis succinea (polychaete). In the early summer collections the five dominant species were: 1) Streblospio benedicti (polychaete), 2) Pectinaria gouldii (polychaete), 3) Pseudeurythoe ambigua (polychaete), 4) Paraprionospio pinnata (polychaete), and 5) Mulinia lateralis (bivalve). Streblospio benedicti was not among the top 20 in the fall, while Pectinaria gouldii was ninth and Mulinia lateralis was seventh.

Some of this disparity can be explained by the sampling of different stations as well as a change in techniques (see Methods section). Most of the numerical disparity and species dominance shift from fall to spring can be explained by spring juvenile recruitment, especially by fecund surface dwellers such as Streblospio benedicti, Polydora ligni, Mediomastus ambiseta, Mulinia lateralis and Pectinaria gouldii. Boesch et al. (1976), in discussing the seasonality of benthic communities in Chesapeake Bay, notes that although recruitment takes place all summer long, only spring and fall recruitment contribute significantly to the adult population. Predation by epibenthic predators such as the blue crab and fish can reduce the populations of these prolific surface dwellers during the summer (Virnstein 1977). By September, the benthos is probably at its lowest population levels, as reflected by the samples taken at this time.

Table 3 lists the common species found in the study with information on occurrence, feeding type, biogenic activity and habitat preferences.

Table 3. Summary information on the biology of some common Chesapeake Bay benthic invertebrates.

Species	Stations Occurred	Depth Distribution	Feeding Type	Biogenic Activity or Structure	Habitat	References
Nemertea *Cerebratulus lacteus*	29, 46, 76, 80, 83, 84, 90, 96, 97, 104, 105	0-50 cm	predator	random burrowing	wide range prefers mud mesohaline to polyhaline	Howard & Frey 1975 Boesch 1973
Tubulanus pellucidus	88, 89, 91, 93, 94, 97, 99, 100, 103, 104	0-10 cm	predator	random burrowing	wide range of sediments polyhaline	
Phoronida *Phoronis* sp.	27, 28, 29, 37, 40, 46, 47, 49, 84, 89, 90, 91, 94, 96, 97, 99, 103	0-20 cm	suspension feeder	sand encrusted tube	sand polyhaline	
Mollusca Gastropoda *Odostomia* sp.	34, 41, 46, 48, 76, 77, 78, 87, 94, 95, 103, 104, 105	0-2 cm	deposit feeder, facultative ectoparasite of molluscs and marine worms	crawling trails on surface	wide range of sediments mesohaline to polyhaline	Abbott 1974
Retusa canaliculata	26, 27, 29, 32, 34, 35, 36, 40, 43, 44, 46, 47, 48, 49, 78, 79, 81, 84, 85, 87, 88, 89, 91, 94, 95, 97, 104, 105	0-2 cm	carnivore	crawling trails on surface	wide range more abundant on mud mesohaline to polyhaline	Sanders 1960 Boesch 1973 McCall 1977
Bivalvia *Anadara transversa*	28, 32, 35, 36, 40, 41, 42, 77, 89, 91, 103, 104, 105	surface	suspension feeder	binds sediment by byssus threads, pelletization	muddy sands mesohaline to polyhaline	Maurer et al. 1974
Ensis directus	29, 40, 82, 84, 87, 88, 89, 90, 91, 93, 94, 95, 96, 97, 98, 99, 100	0-20 cm	suspension feeder	vertical burrows	fine-medium sand polyhaline	Mayou and Howard 1975 Boesch 1973 Maurer et al. 1974

Table 3 (continued)

Species	Stations Occurred	Depth Distribution	Feeding Type	Biogenic Activity or Structure	Habitat	References
Bivalvia (continued)						
Lyonsia hyalina	77, 81, 84, 87, 88, 89, 90, 91, 93, 94, 95, 96, 97, 99	0-5 cm	suspension feeder	pelletization	wide range of sediments polyhaline	
Mulinia lateralis	26, 29, 37, 38, 42, 44, 48, 49, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 93, 94, 95, 96, 97, 98, 99, 104	0-5 cm	suspension feeder	burrowing produces funnel shaped depressions	wide range of sediments mesohaline to polyhaline	Frey & Howard 1972 Stanley 1970 Boesch 1973
Mya arenaria	76, 77, 78, 81, 83, 84, 87, 88, 89, 90, 95, 97, 98	0-10 cm	suspension feeder	long vertical burrow for their siphons	wide range of sediments mesohaline to polyhaline	Maurer et al. 1974
Tellina agilis	44, 46, 47, 48, 50, 88, 89, 90, 91, 92, 94, 96, 97, 99, 100, 105	0-10 cm	suspension feeder	pelletization	muddy sand - sand polyhaline	Maurer et al. 1974
Yoldia limatula	42, 43, 46, 49, 88, 89, 94, 95, 97, 104, 105	0-5 cm	shallow subsurface deposit feeder	pelletization 6-12 $g/m^2/yr$ random burrowing	silt clay to fine sediment polyhaline	Rhoads 1974
Crustacea						
Ostracod sp.	29, 30, 32, 35, 36, 38, 44, 47, 48, 89, 94, 103, 104, 105	0-5 cm	filter feeder	unknown	wide range of sediments & salinity	Barnes 1968

Table 3 (continued)

Species	Stations Occurred	Depth Distribution	Feeding Type	Biogenic Activity or Structure	Habitat	References
Cumacea						
Leucon americanus	26, 30, 32, 76, 78, 81, 84, 86, 87, 88, 93, 95, 98, 104	0-2 cm	selective deposit feeder	unknown	mud to muddy sands mesohaline to polyhaline	Maurer 1977
Isopoda						
Edotea triloba	26, 30, 36, 76, 78, 81, 89, 93, 94, 96, 97, 98, 103, 104, 105	0-2 cm	epistrate feeder - scavenger	rapid burrowing	wide range of sediments mesohaline to polyhaline	Myers 1977 Sanders 1960
Amphipoda						
Ampelisca abdita	26, 27, 29, 30, 32, 35, 36, 46, 47, 49, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91, 93, 94, 96, 97	0-5 cm	selective deposit feeder	dense tube formation stabilizes sediment surface	mud to muddy sands	Rhoads 1974 Boesch 1973 Maurer 1977
Corophium tuberculatum	36, 84, 88, 89, 91, 93, 94, 96, 97, 103, 104	0-2 cm	suspension feeder, selective deposit feeder	tubes cause shift toward finer sediment	wide range of sediments polyhaline	Myers 1977 Wolff 1973 Watling 1975
Listriella clymenellae	32, 35, 40, 49, 84, 88, 89, 91, 98, 103, 105	0-30 cm	selective deposit feeder	unknown	lives in the tubes of Clymenella torquata	Maurer 1977

Table 3 (continued)

Species	Stations Occurred	Depth Distribution	Feeding Type	Biogenic Activity or Structure	Habitat	References
Amphipoda (continued)						
Paracaprella tenuis	35, 84, 88, 91, 93, 94, 96, 97, 103, 104, 105	surface	ambush predator, filter feeder	uncertain	erect bryozoan or hydroids	Caine 1978 Caine 1977
Annelida						
Polychaeta						
Asabellides oculata	78, 79, 82, 84, 87, 88, 89, 90, 91, 93, 94, 95, 96, 97, 98, 99, 104, 105	0-5 cm	tentaculate surface deposit feeder	forms tubes of surface debris horizontally along the sediment surface	wide range of sediments polyhaline	Fauchald & Jumars 1979
Clymenella torquata	27, 28, 35, 77, 84, 88, 89, 91, 95, 96, 97, 98, 103, 105	0-30 cm	subsurface selective deposit feeder	long sand encrusted tube "conveyor belt species" ventilates tube	muddy sand to sand, most abundant in higher energey regimes	Howard & Frey 1975 Mayou & Howard 1975 Rhoads 1974 Rhoads 1967
Eteone heteropoda	76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 91, 93, 95, 96, 97, 98	0-5 cm	long eversible unarmed pharynx feeds on Nereis succinea, canabilistic and detritus	burrowing	wide range of sediments & salinity	Fauchald & Jumars 1979
Glycera americana	35, 38, 40, 42, 45, 46, 76, 77, 85, 87, 88, 89, 90, 91, 94, 95, 96, 98, 99, 100, 104, 105	0-40 cm	carnivore, non-selective deposit feeder	maintains deep gallery of burrows, ventilates	wide range prefers mud mesohaline to polyhaline	Hertweck 1972 Howard & Frey 1975 Boesch 1973
Glycera dibranchiata	27, 28, 29, 32, 37, 39, 44, 50, 76, 80, 96	0-40 cm	carnivore, non-selective deposit feeder	maintains deep gallery of burrows, ventilates	wide range of sediments mesohaline to polyhaline	

Table 3 (continued)

Species	Stations Occurred	Depth Distribution	Feeding Type	Biogenic Activity or Structure	Habitat	References
Polychaeta (continued)						
Heteromastus filiformis	41, 46, 76, 78, 80, 81, 82, 83, 88, 89, 90, 91, 92, 93, 94, 95, 98, 99, 103, 104, 105	0-20 cm	non-selective deposit feeder	network of capiliary like burrows	mud to muddy sand mesohaline to polyhaline	Myers 1977 Howard & Frey 1975 Fauchald & Jumars 1979
Mediomastus ambiseta	76, 78, 83, 84, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 100	0-10 cm	non-selective deposit feeder	feeds head down, defeacts on surface so can be considered "conveyor-belt species"	wide range of sediments polyhaline	Fauchald & Jumars 1979
Nereis succinea	26, 28, 30, 33, 34, 36, 40, 41, 76, 77, 78, 79, 80, 81, 82, 83, 84, 87, 88, 89, 91, 93, 94, 95, 96, 97, 98, 103, 104	0-40 cm	omnivore, non-selective deposit feeder	forms branching burrows ventilates	wide range of sediment and salinity	Fauchald & Jumars 1979 Howard & Frey 1975 Wolff 1973
Paraprionospio pinnata	26, 27, 28, 30, 31, 34, 35, 36, 37, 38, 41, 43, 47, 48, 49, 76, 78, 79, 80, 81, 82, 83, 84, 85, 87, 88, 89, 92, 93, 94, 95, 96, 103, 104, 105	0-15 cm	tentaculate deposit feeder	forms temporary burrows	wide range of sediments prefers mud mesohaline to polyhaline	Boesch 1973 Fauchald & Jumars 1979
Pectinaria gouldii	32, 35, 36, 38, 41, 46, 76, 77, 78, 79, 80, 81, 82, 83, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 103, 104, 105	0-7 cm	tentaculate selective sub-surface deposit feeder	cone shaped sand tube, "mud ball" feeding trace random burrowing "conveyor belt species"	wide range of sediments mesohaline to polyhaline	Hertweck 1972 Whitlatch 1974 Rhoads 1974 Gordon 1966

Table 3 (continued)

Species	Stations Occurred	Depth Distribution	Feeding Type	Biogenic Activity or Structure	Habitat	References
Polychaeta (continued)						
Polydora ligni	76, 77, 78, 81, 82, 83, 84, 87, 88, 89, 90, 91, 93, 94, 96, 97, 98, 100	0-5 cm	suspension feeder, surface deposit feeder	builds mucous tube in great densities, have been known to bury oyster reefs	wide range of sediments mesohaline to polyhaline	Wolff 1973 Grassle & Grassle 1974 Pettibone 1963 Fauchald & Jumars 1979
Pseudeurythoe ambigua	27, 28, 29, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 48, 50, 77, 79, 80, 81, 83, 84, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 103, 104	0-40 cm	eversible lower lip for rasping carrion feeder	random burrowing	wide range of sediments mesohaline to polyhaline	Fauchald & Jumars 1979
Scoloplos fragilis	76, 78, 80, 81, 84, 85, 87, 88, 90, 93, 95	0-15 cm	non-selective deposit feeder	burrower, semi-permanent burrows it irrigates	mostly mud mesohaline to polyhaline	Myers 1977 Howard & Frey 1975 Fauchald & Jumars
Sigambra tentaculata	32, 43, 77, 79, 84, 85, 87, 88, 89, 91, 92, 93, 94, 95, 97, 99	0-30 cm	eversible pharynx	random burrowing	muddy sands mesohaline to polyhaline	Gardiner 1975
Streblospio benedicti	76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 103, 104	0-5 cm	selected surface deposit feeder	tube builder	wide range of sediments mesohaline to polyhaline	Fauchald & Jumars 1979

Table 3 (continued)

Species	Stations Occurred	Depth Distribution	Feeding Type	Biogenic Activity or Structure	Habitat	References
Polychaeta (continued)						
<u>Tharyx</u> sp.	29, 36, 45, 47, 49, 84, 88, 89, 90, 91, 93, 94, 95, 96, 97, 98, 99, 100	0-15	grooved tentaculate selective surface deposit feeder	sub-surface defecation produces clay balls	wide range of sediments polyhaline	Myers 1977 Young & Young 1978
Oligochaete	76, 77, 78, 79, 80, 81, 85, 89, 90, 91, 93, 94, 96, 98, 99, 100	0-10	sub-surface deposit feeder	"conveyor belt species"	wide range of sediments salinity	Fisher et al. 1980

C. Spatial Patterns in Distribution

To facilitate the discussion of species distribution patterns, stations have been categorized into major salinity and substrate habitats (Table 4). We have adopted the Venice classification of salinity zones for estuaries (Symposium on the Classification of Brackish Waters 1958). Stations were differentiated between the meso-polyhaline transition zone and the polyhaline zone by the occurrence of species restricted to higher salinities (i.e. Micropholis atra, Nucula proxima, Yoldia limatula). Station differentiation between the polyhaline and the poly-euhaline transition zones was based on the occurrence of stenohaline continental shelf species (i.e. Goniades carolinae, Glycera robusta, Spiophanes wigleyi, and various syllid species). Some of the stations in the meso-polyhaline transition zone included stations sampled by Maryland Geological Survey.

A similar strategy was employed in differentiating sediment type. Ignoring eurytopic species, we used less frequent, but common species to determine biologically meaningful sediment differences. Species which occur at either end of the mud-sand spectrum tend to be more restricted to their habitat than species occurring in mixed sediments (Purdy 1964). Mud stations usually had less than 10% sand and contained species which do not occur normally in sand (i.e. Asychis elongata, Ogyrides limicola, Macoma balthica). Sand stations had less than 15% sand and were characterized by sand specific species (i.e. Sabellaria vulgaris, Trichophoxus epistomus, Owenia fusiformis, and Monoculodes edwardsi). Sediments with a more even mixture of mud and sand were considered as mixed sediments.

The dominant species in each of the 8 habitats sampled in the lower Bay are listed in Table 5. Eight species occur among the 10 dominant organisms in more than half of the habitat types. This reflects the relatively opportunistic tendencies exhibited by these species. The ubiquity, dominance, and irruptive population dynamics of these organisms make it difficult to understand patterns in distribution. Rhoads et al. (1978) have pointed out the importance of sea-floor disturbance in determining the distribution of most opportunistic species, yet disturbance is a difficult parameter to quantify particularly when it is not of a catastrophic nature.

Tests of significance (t-test, Sokal and Rholf 1969) were used to compare numbers of species between various sediment types, salinity zones, and seasons. There was a highly significant ($p=0.01$) increase in the number of species from the 9/78 sampling to the 6/79 sampling. There were no significant differences between substrates within any one salinity zone for the fall sampling. There was a significant ($p=0.05$) substrate difference in the polyhaline zone for the June 1979 sampling, with mud having fewer species than either mixed or sand substrates. Haven et al. (1967) sampling the polyhaline zone of the York River also found fewer species in the mud than in sand.

Significant differences also existed in the comparisons between salinity zones. The meso-polyhaline transition zone had fewer species than the polyhaline zone in both seasons. Boesch (1972) found a similar gradient in species diversity from areas of higher salinity to areas of lower salinities.

Table 4. Major salinity and substrate habitats sampled.

	Station Numbers*		
September-October 1978			
Salinity	Mud	Substrate	Sand
Meso-Polyhaline transition	23, 24, 26, 30, 31	22, 32, 34	20, 21, 25, 27 28, 29
Polyhaline	none	35, 38, 41, 42, 43	36, 37, 39, 40
Poly-Euhaline transition	none	46, 47, 48, 49	44, 50
June 1979			
Salinity	Mud	Substrate	Sand
Meso-Polyhaline transition	23, 24, 76, 78, 79, 82, 83, 84, 85, 86	21, 77, 80, 81	25, 65
Polyhaline	87, 92, 93, 95	88, 94, 98, 99, 103, 104	89, 90, 96
Poly-Euhaline transition	none	97, 105	91, 100

* Stations 33 and 45 not included in the analysis due to inadequate sampling.

Table 5. Dominant species and their depth distribution in each major habitat based on the biological index of McCloseky (1970).

Meso-polyhaline mud

1. Streblospio benedicti
2. Ampelisca abdita
3. Nereis succinea
4. Mulinia lateralis
5. Paraprionospio pinnata
6. Pectinaria gouldii
7. Eteone heteropoda
8. Leucon americanus
9. Pseudoeurythoe ambigua
10. Glycinde solitaria

Meso-polyhaline mud-sand

1. Pectinaria gouldii
2. Mulinia lateralis
3. Streblospio benedicti
4. Paraprionospio pinnata
5. Ampelisca abdita
6. Pseudoeurythoe ambigua
7. Nereis succinea
8. Eteone heteropoda
9. Glycinde solitaria
10. Macoma balthica
    Retusa canaliculata

Meso-polyhaline sand

1. Paraprionospio pinnata
2. Pseudoeurythoe ambigua
3. Glycera dibranchiata
4. Ampelisca abdita
5. Phoronis sp.
6. Retusa canaliculata
7. Glycinde solitaria
8. Nereis succinea
9. Ampelisca vadorum
10. Streblospio benedicti

Table 5 (continued)

Polyhaline mud

1. *Pectinaria gouldii*
2. *Streblospio benedicti*
3. *Mediomastus ambiseta*
4. *Mulinia lateralis*
5. *Paraprionospio pinnata*
6. *Sigambra tentaculata*
7. *Asabellides oculata*
8. *Glycinde solitaria*
9. *Pseudoeurythoe ambigua*
10. *Lyonsia hyalina*

Polyhaline mud-sand

1. *Pectinaria gouldii*
2. *Pseudoeurythoe ambigua*
3. *Paraprionospio pinnata*
4. *Streblospio benedicti*
5. *Anadara transversa*
6. *Nereis succinea*
7. *Clymenella torquata*
8. *Mediomastus ambiseta*
9. *Mulinia lateralis*
10. Oligochaete

Polyhaline sand

1. *Pseudoeurythoe ambigua*
2. *Streblospio benedicti*
3. *Mulinia lateralis*
4. *Spiophanes bombyx*
5. *Mediomastus ambiseta*
6. *Ensis directus*
7. *Sabellaria vulgaris*
8. *Pectinaria gouldii*
9. *Ampelisca verrilli*
10. *Anadara transversa*

Table 5 (continued)

Poly-euhaline mud-sand

1. *Retusa canaliculata*
2. *Paraprionospio pinnata*
3. Maldanidae
4. *Tellina agilis*
5. *Mediomastus ambiseta*
6. *Pectinaria gouldii*
7. *Pseudeurythoe ambigua*
8. *Turbonilla interrupta*
9. *Ampelisca abdita*
10. Glycinde solitaria

Poly-euhaline sand

1. *Tellina agilis*
2. *Spiophanes bombyx*
3. *Streblospio benedicti*
4. *Glycera* sp.
5. *Mediomastus ambiseta*
6. Arabellidae
7. *Glycera dibranchiata*
8. Capitellidae sp. A
9. *Retusa canaliculata*
10. *Pectinaria gouldii*

D. Vertical Distribution Patterns

The vertical distribution patterns of individuals and species in the major habitats for each cruise are graphically depicted in Figures 2-16. Histograms represent the number of individuals or species while the line represents the cumulative % with depth. All areas had the greatest species abundances in the top 10 cm. Based on the percentages, only the fall sampling in the meso-polyhaline transition zone showed any differences in species numbers and abundances. Mud had 100% of its macrobenthic organisms contained in the top 10 cm, while mixed had 91% and sand the least with 54%.

If one looks at the actual numbers of organisms living below 10 cm a pattern emerges. Muds generally had the shallowest faunal penetration, with mixed sediments intermediate. Sand usually had the largest number of deep dwelling organisms. A pattern along the salinity gradient also existed, with the polyhaline zone having greater number of individuals and species than the meso-polyhaline transition zone. With one exception the poly-euhaline transition zone had the least number of deep dwelling organisms. That one exception was station 91, which had a large number of animals penetrating beyond 10 cm.

Individual species distribution

Polychaetes were the most successful group living in the deeper sediment layers. Most of these polychaetes built long tubes (e.g. Clymenella and Asychis) or deep burrows (e.g. Glycera and Nereis). A few polychaetes burrowed freely without any permanent structure to the surface (i.e. Pseudeurythoe ambigua, Sigambra). Molluscs and crustaceans were equal in their ability to penetrate the deeper layers. Bivalves with long siphons, such as Mya, Macoma and Tellina, were able to bury deep and still maintain connections to the surface. Ensis directus, another deep burrowing bivalve, maintains a burrow as its connection to the surface. Crustaceans which could build tubes or burrows (e.g. the anthurid isopod Cyanthura, amphipod Leptocheirus and the decapods Upogebia and Callianassa) were able to penetrate into the anaerobic zone. Aligenea elevata (a bivalve) and Listriella clymenellae (an amphipod) were able to live deep in the sediments due to their association with the deep tube dwelling polychaete Clymenella torquata.

Table 6 lists the twenty dominant species found in this study with their maximum sediment penetrations. Most of the abundant species are restricted to the top layers.

Table 7 lists those species whose populations living below 10 cm exceed 10% of the total population. A total of 34 species would be significantly undersampled if a sampler was to penetrate only 10 cm. Pseudeurythoe ambigua, the third most dominant species of the study, had more than one half of its population living deeper than 10 cm. Fig. 17 describes its vertical distribution along a sand gradient. Increasing the mud content decreases the penetration of this annelid. Other numerically dominant species with significant deep populations include the mobile glycerid

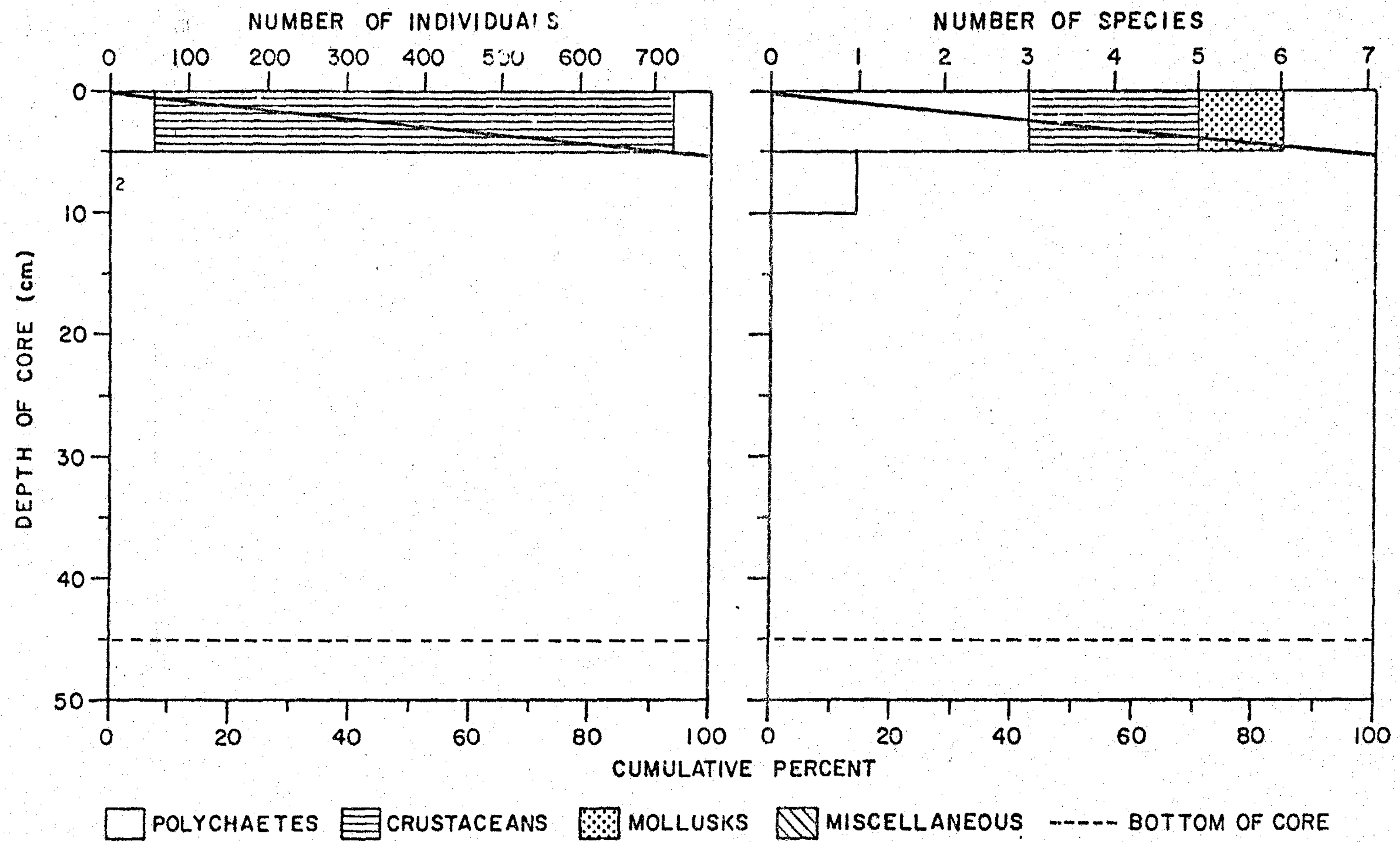

Fig. 2. Vertical distribution of the meso-polyhaline mud habitat 9-78.

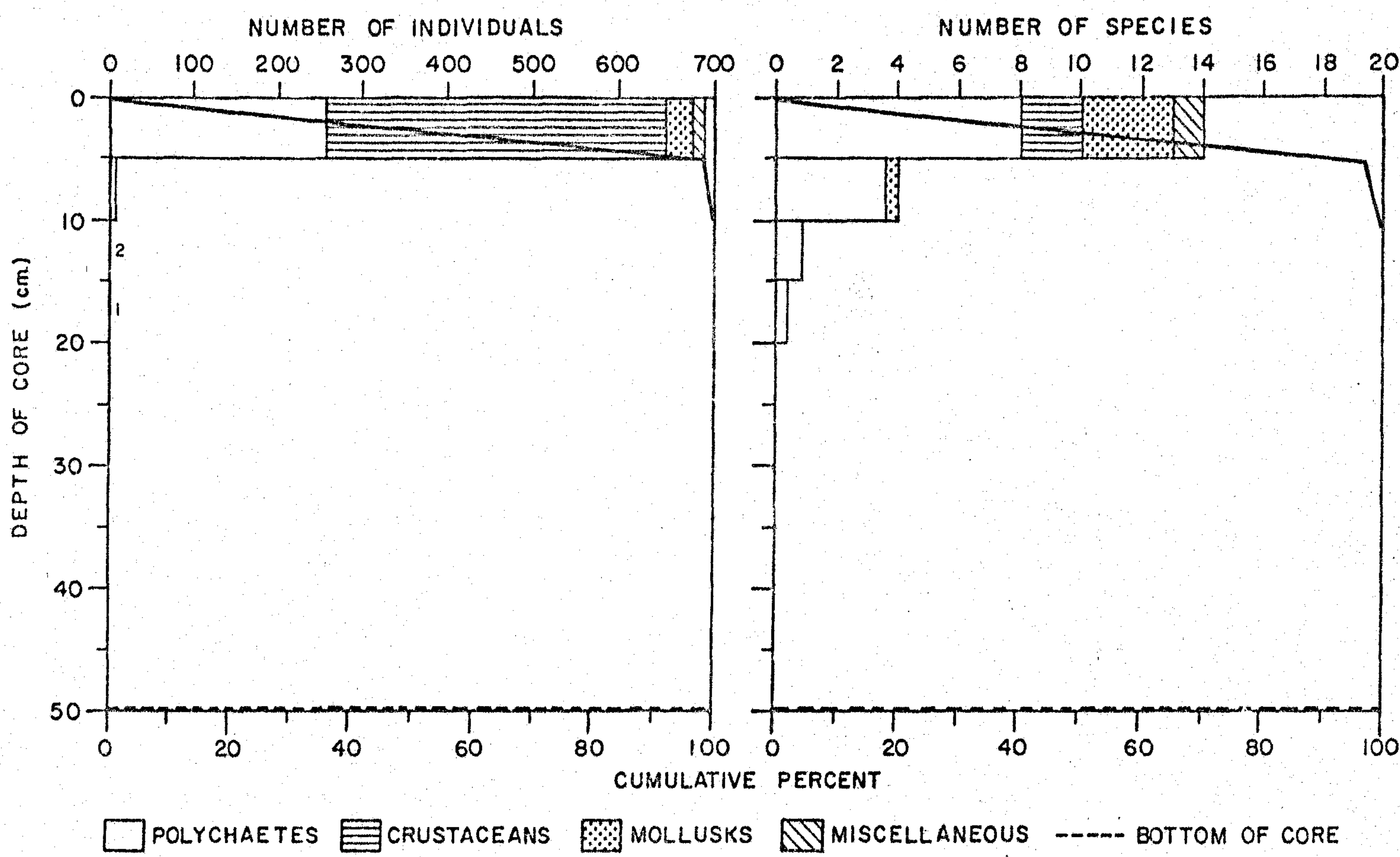

Fig. 3. Vertical distribution of the meso-polyhaline mud habitat 6-79.

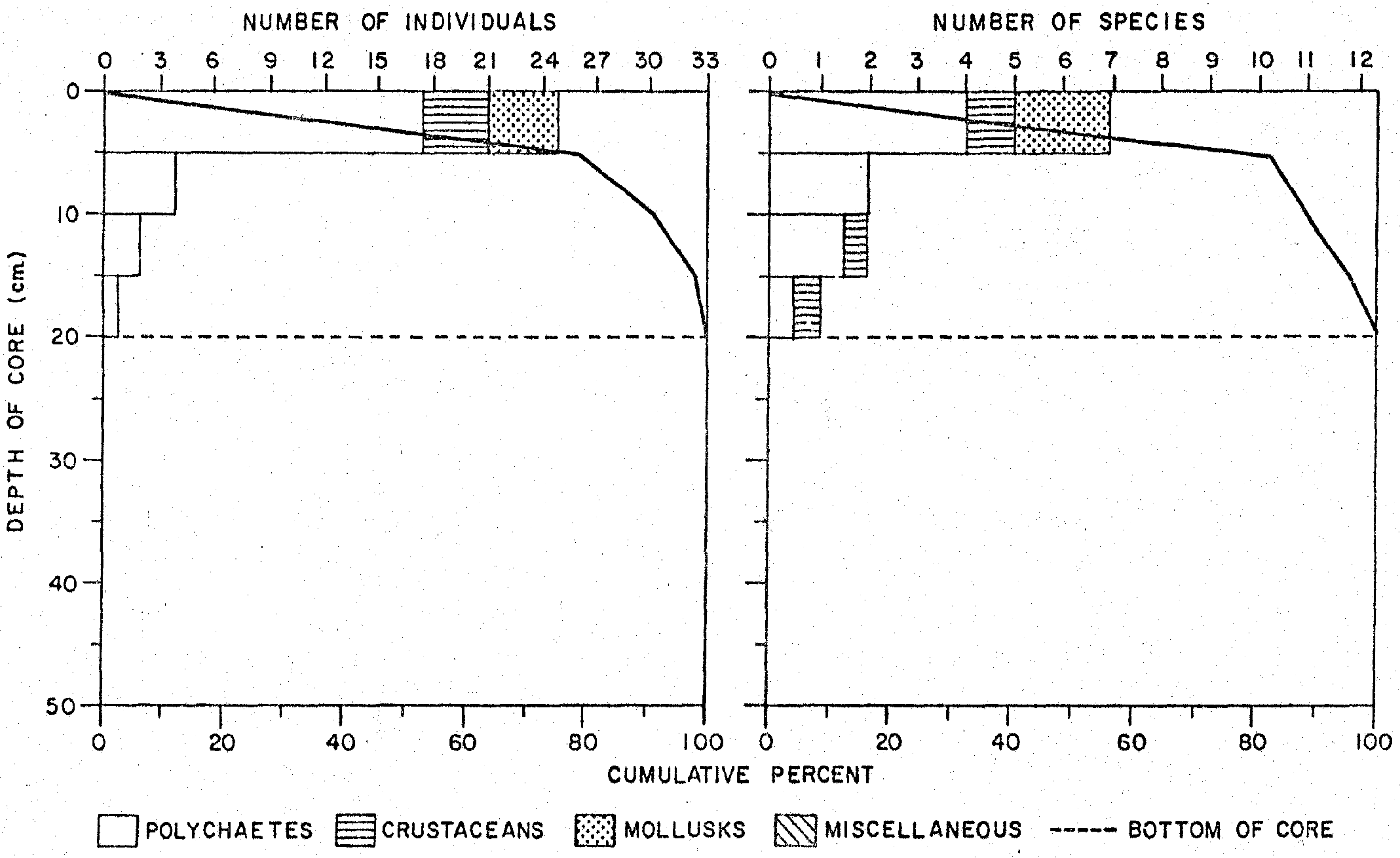

Fig. 4. Vertical distribution of the meso-polyhaline mixed habitat 9-78.

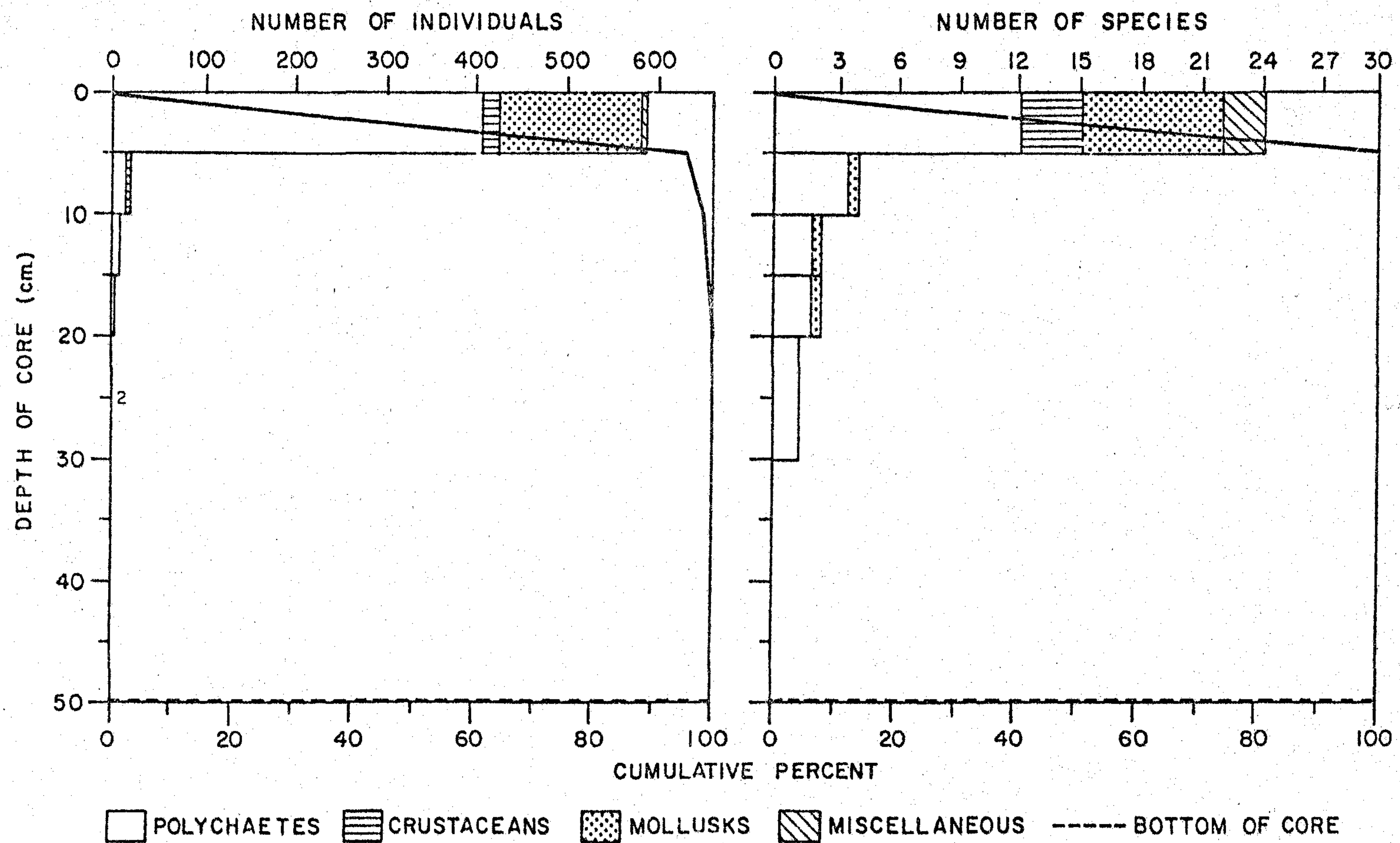

Fig. 5. Vertical distribution of the meso-polyhaline mixed habitat 6-79.

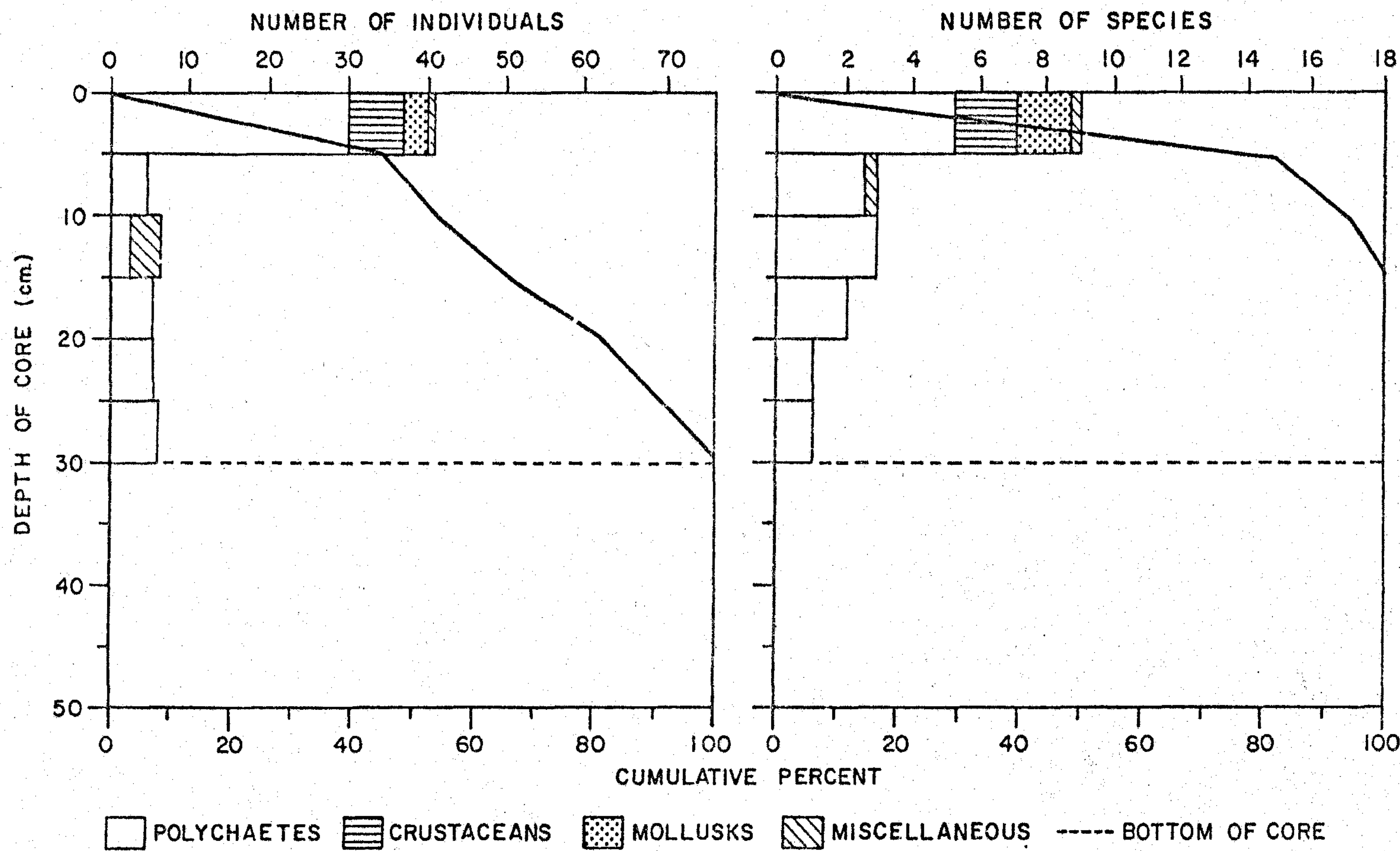

Fig. 6. Vertical distribution of the meso-polyhaline sand habitat 9-78.

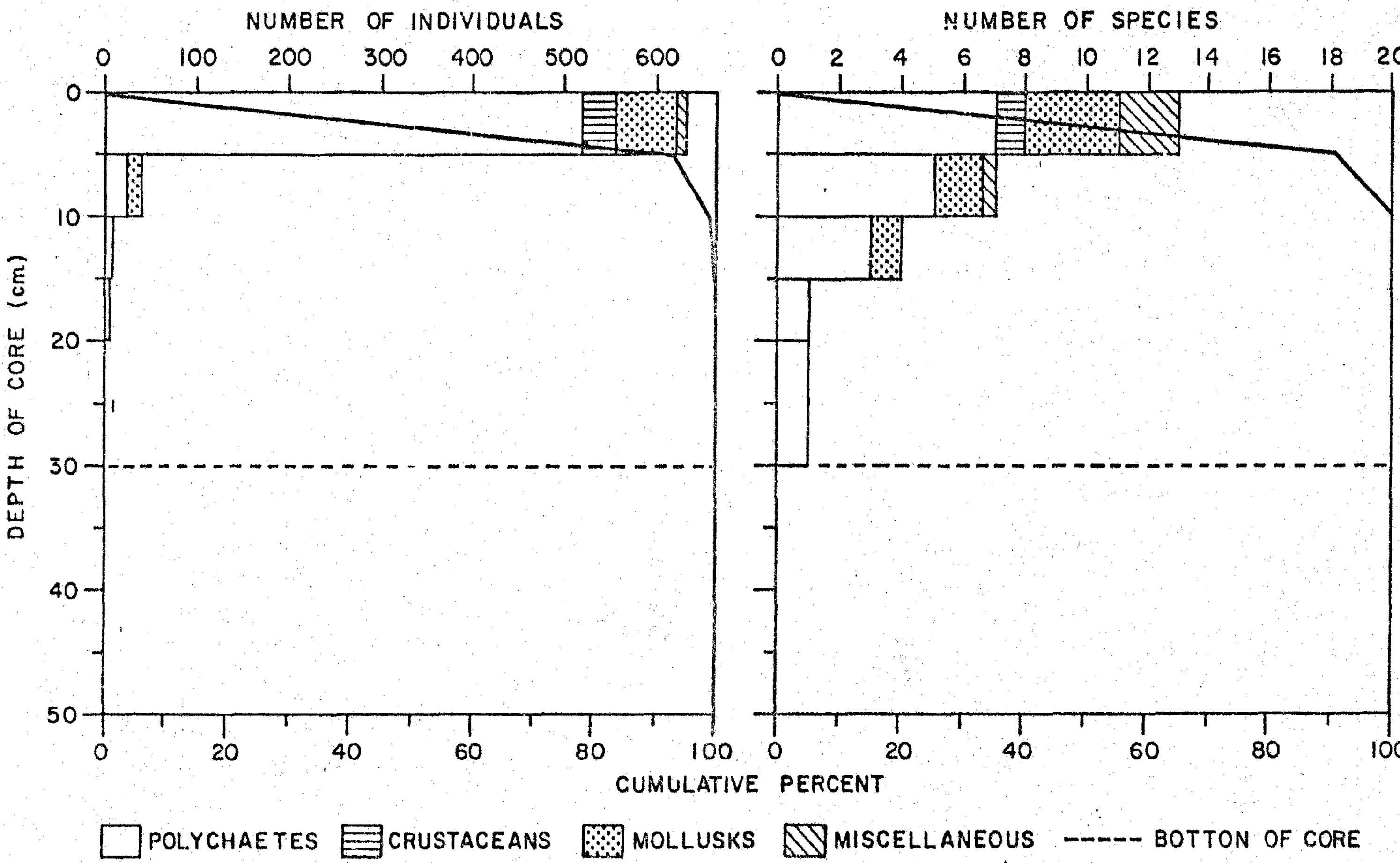

Fig. 7. Vertical distribution of the meso-polyhaline sand habitat 6-79.

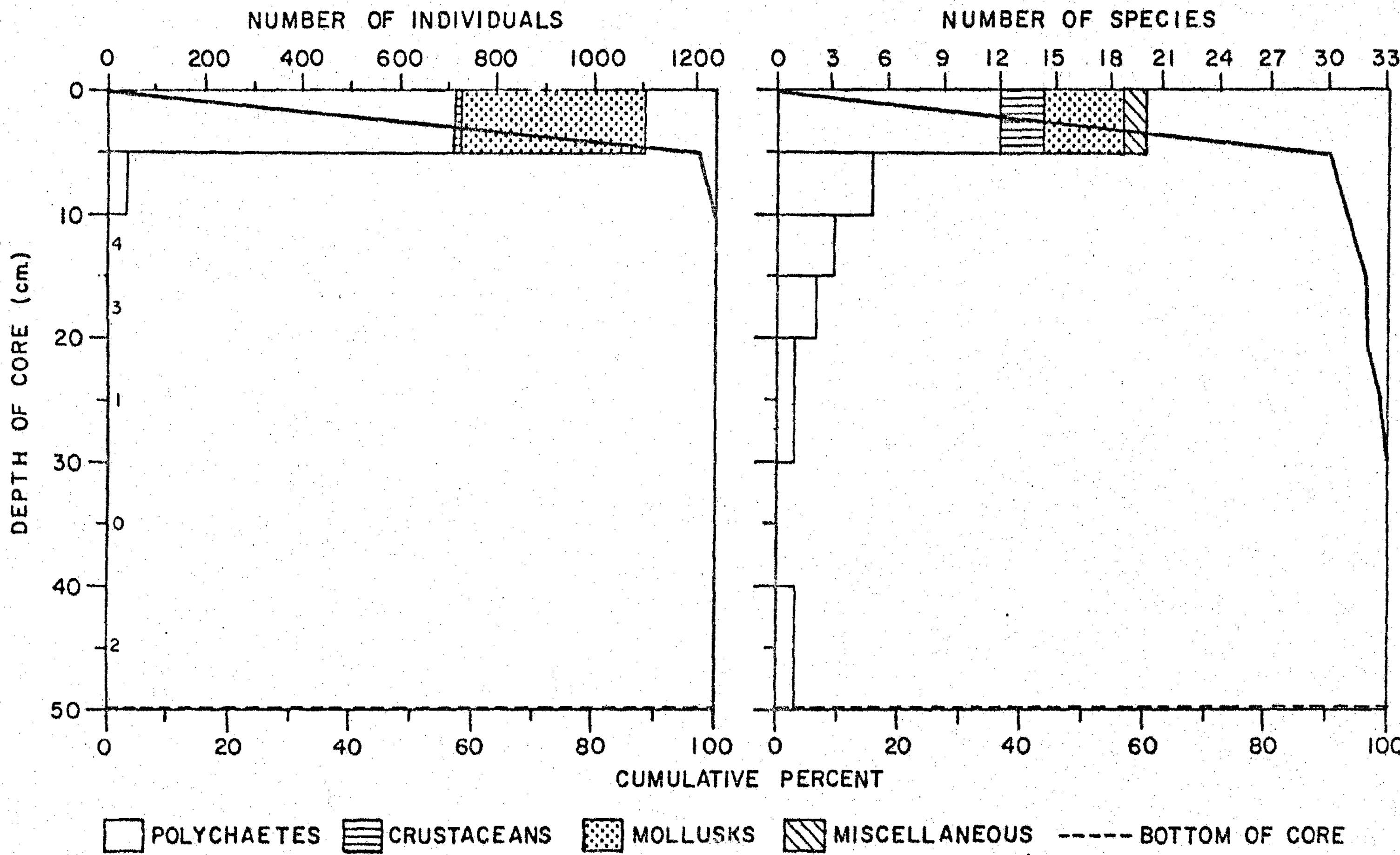

Fig. 8. Vertical distribution of the polyhaline mud habitat 6-79.

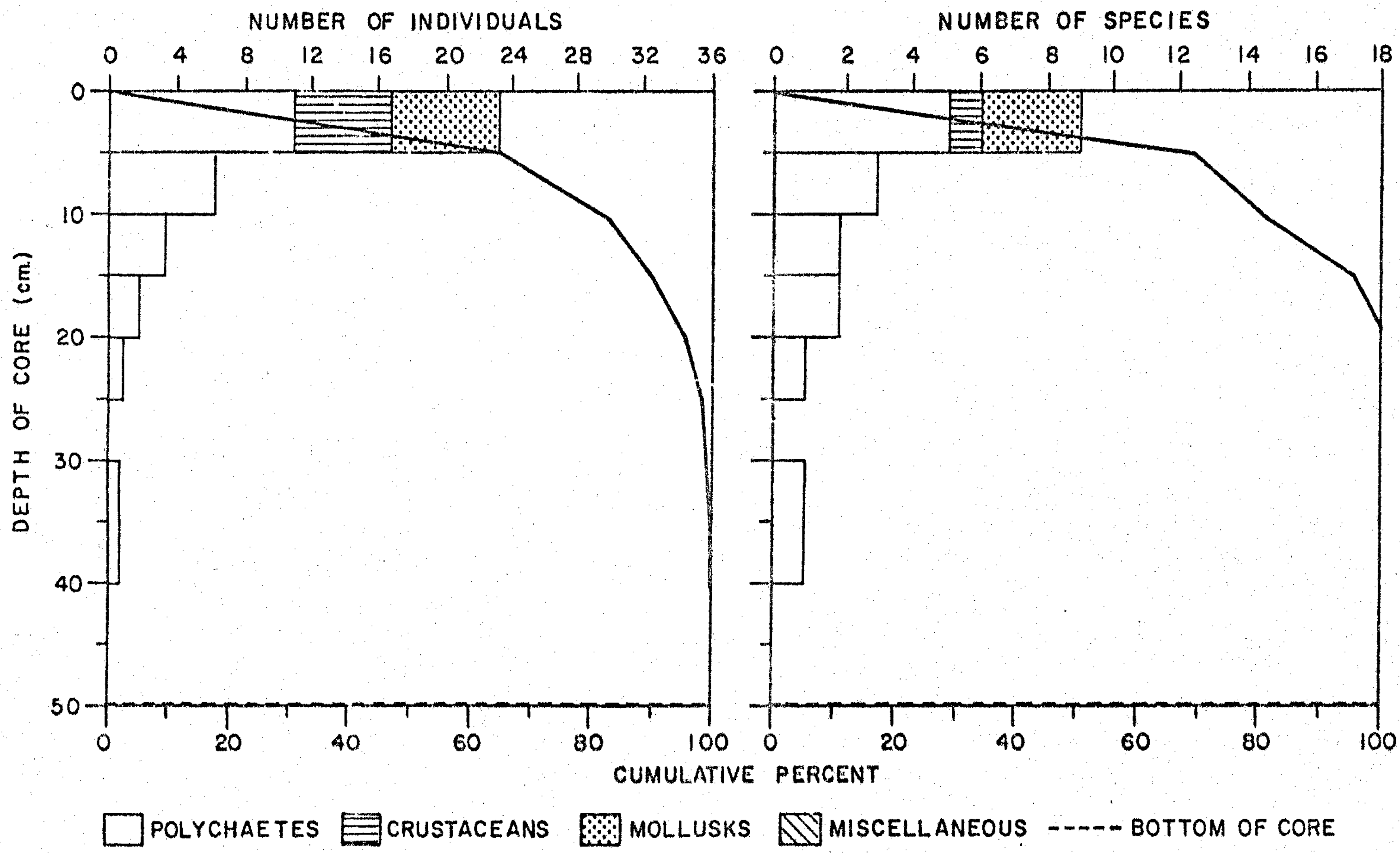

Fig. 9. Vertical distribution of the polyhaline mixed habitat 9-78.

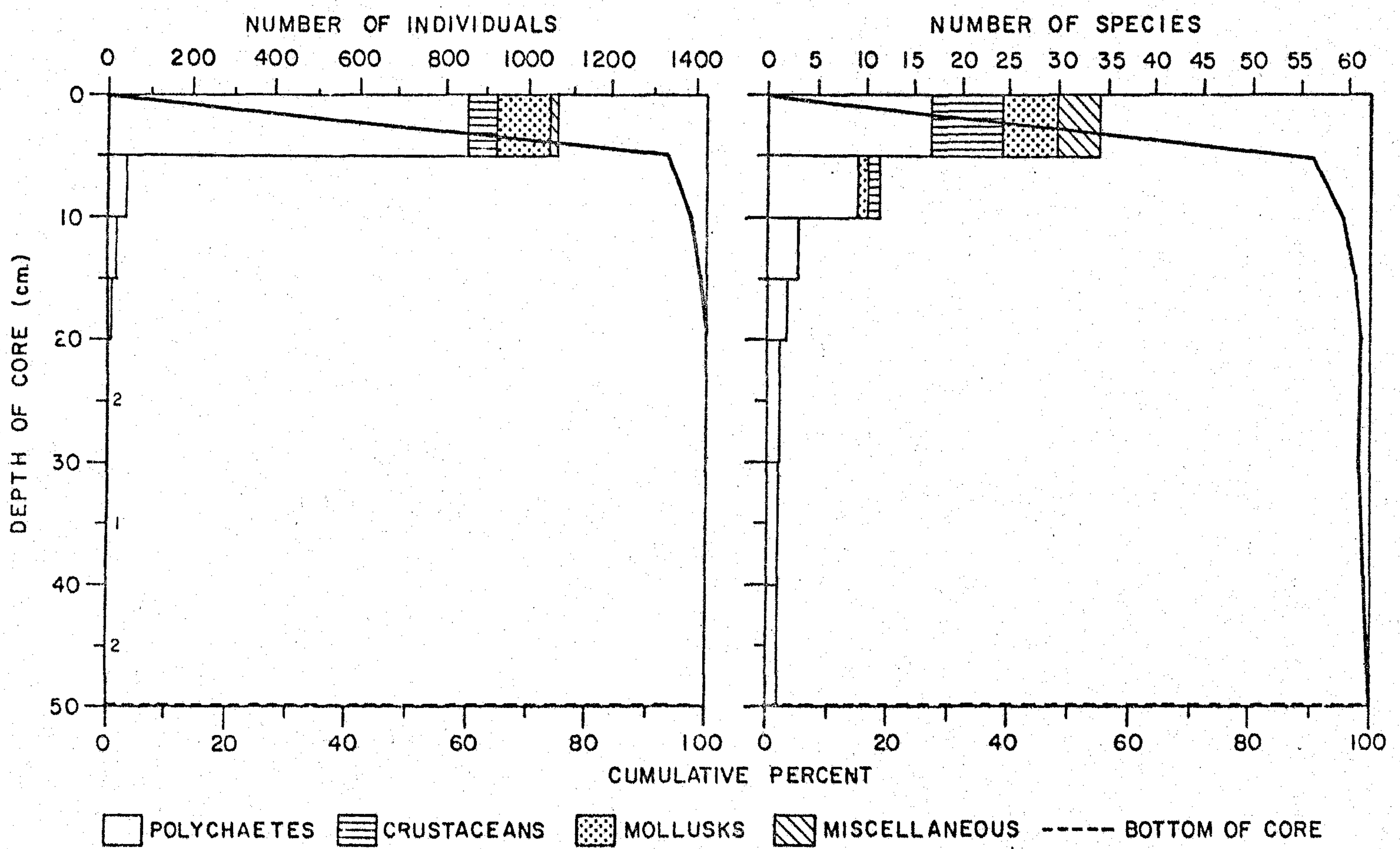

Fig. 10. Vertical distribution of the polyhaline mixed habitat 6-79.

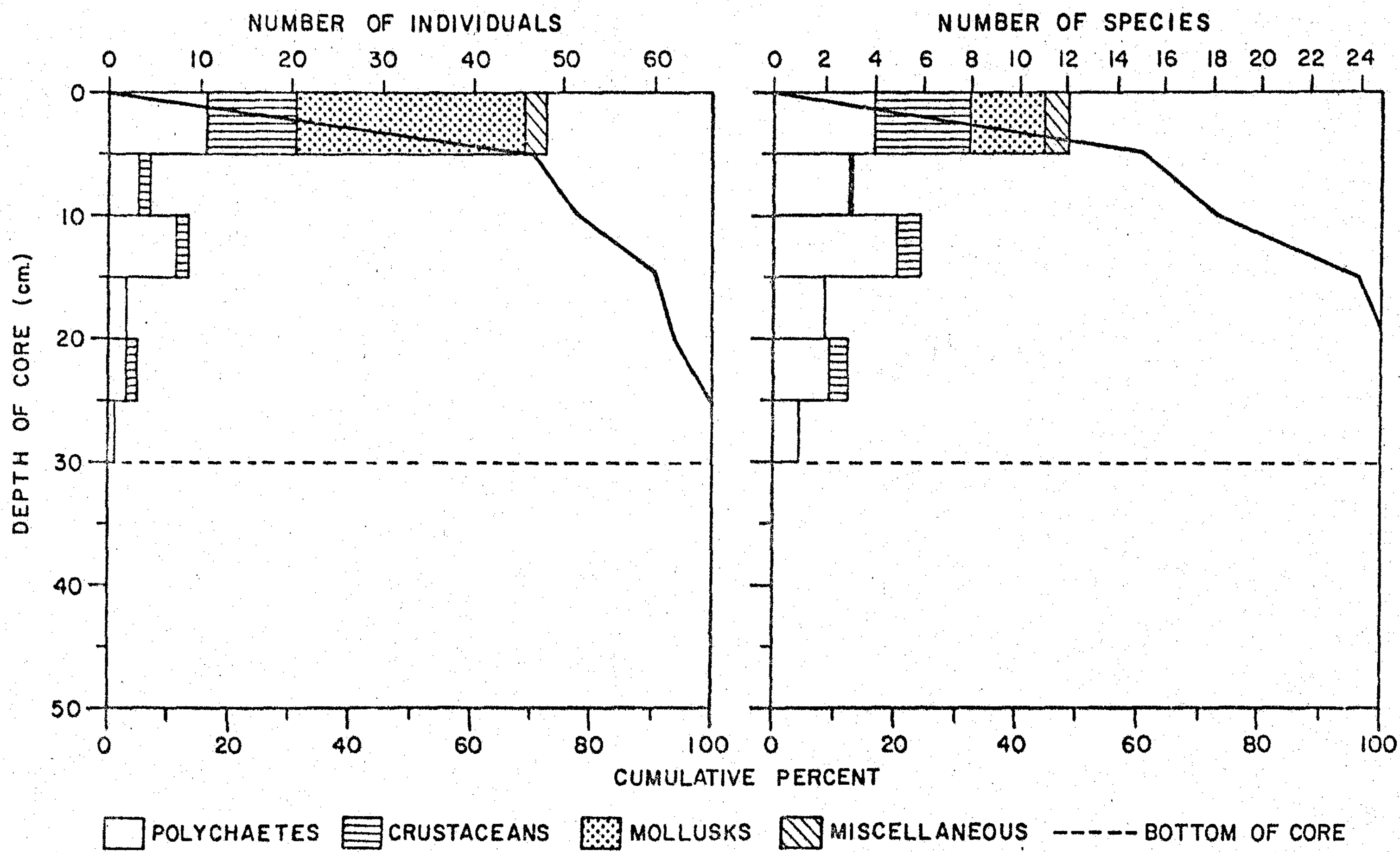

Fig. 11. Vertical distribution of the polyhaline sand habitat 9-78.

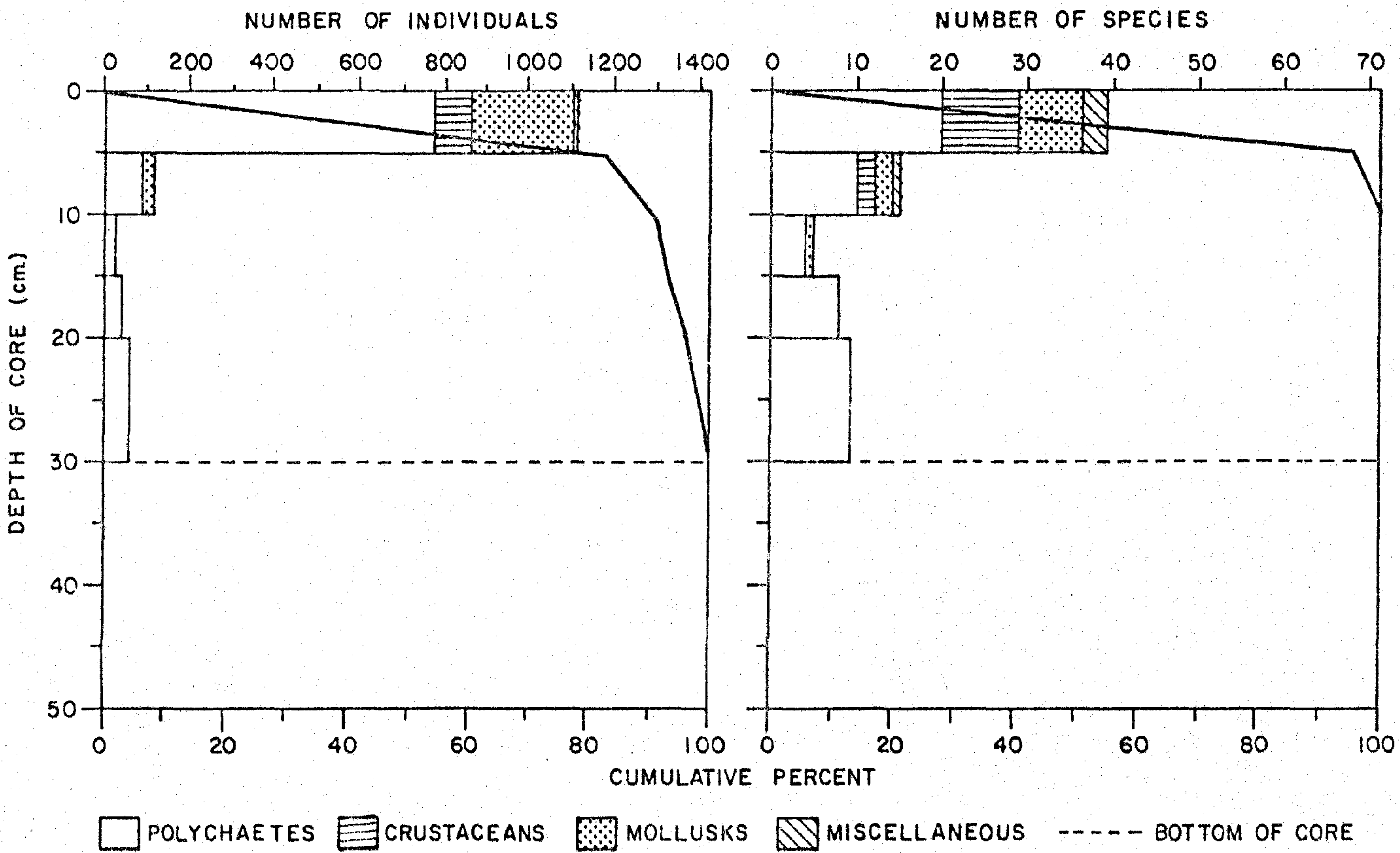

Fig. 12. Vertical distribution of the polyhaline sand habitat 6-79.

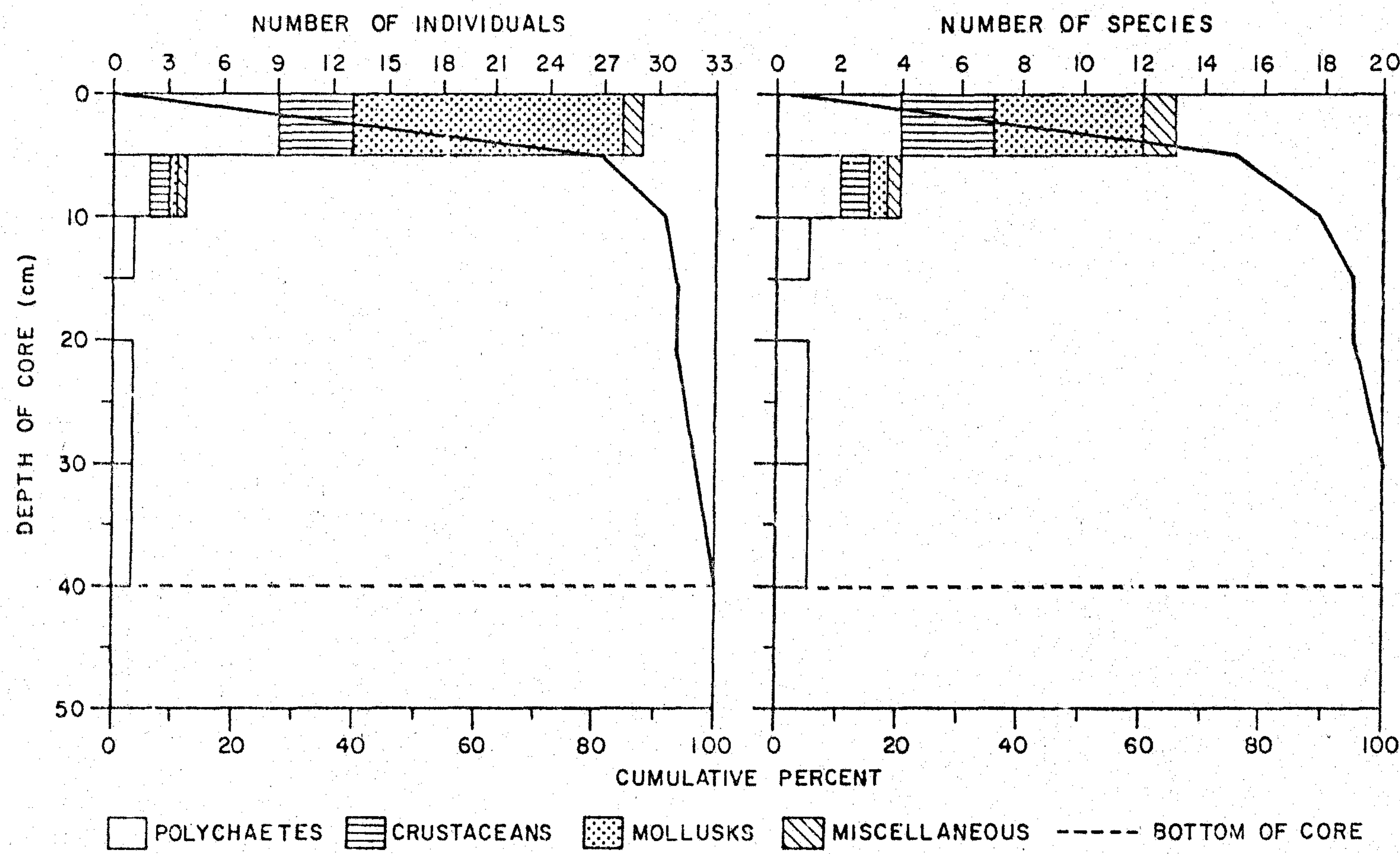

Fig. 13. Vertical distribution of the poly-euhaline mixed habitat 9-78.

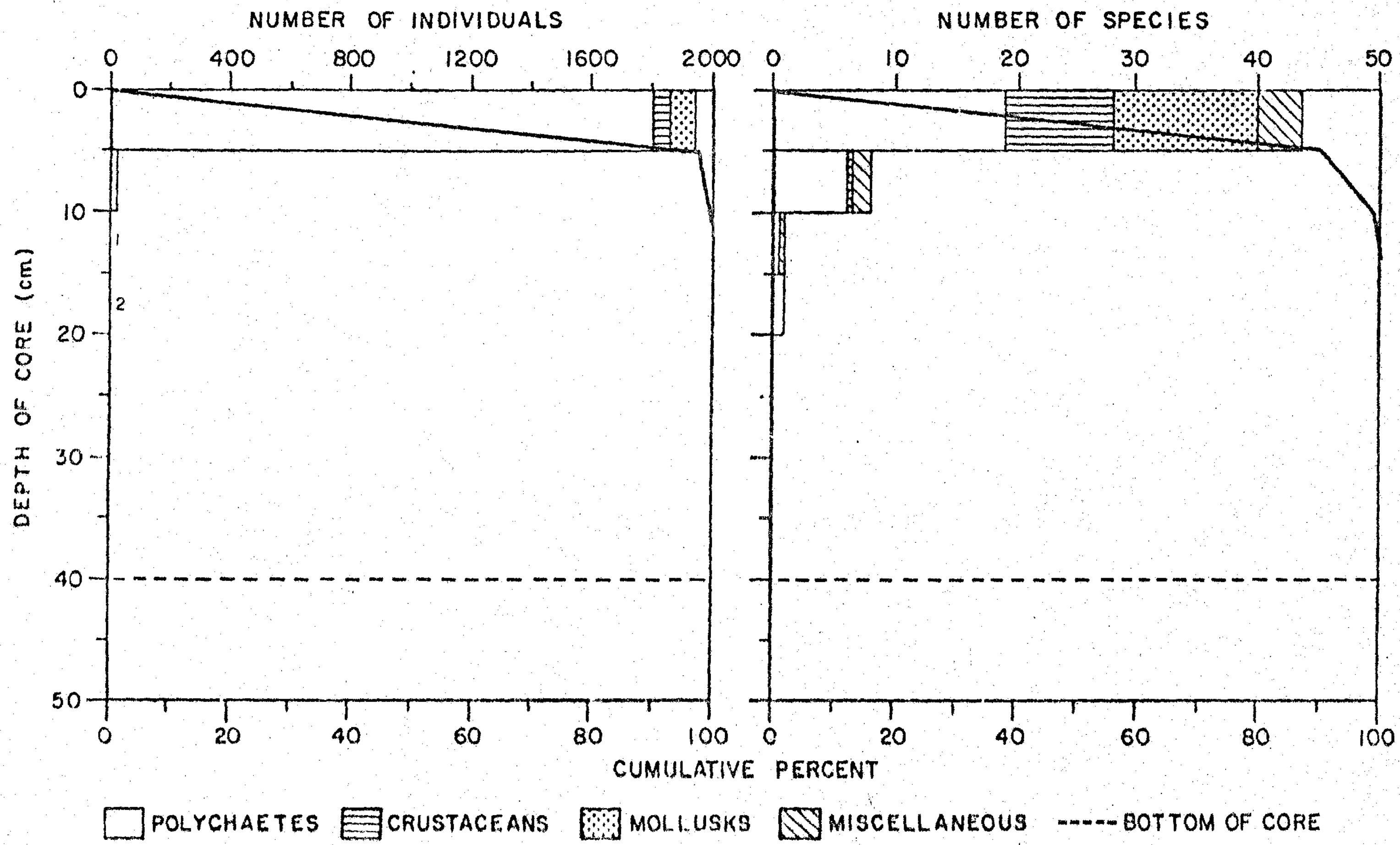

Fig. 14. Vertical distribution of the poly-euhaline mixed habitat 6-79.

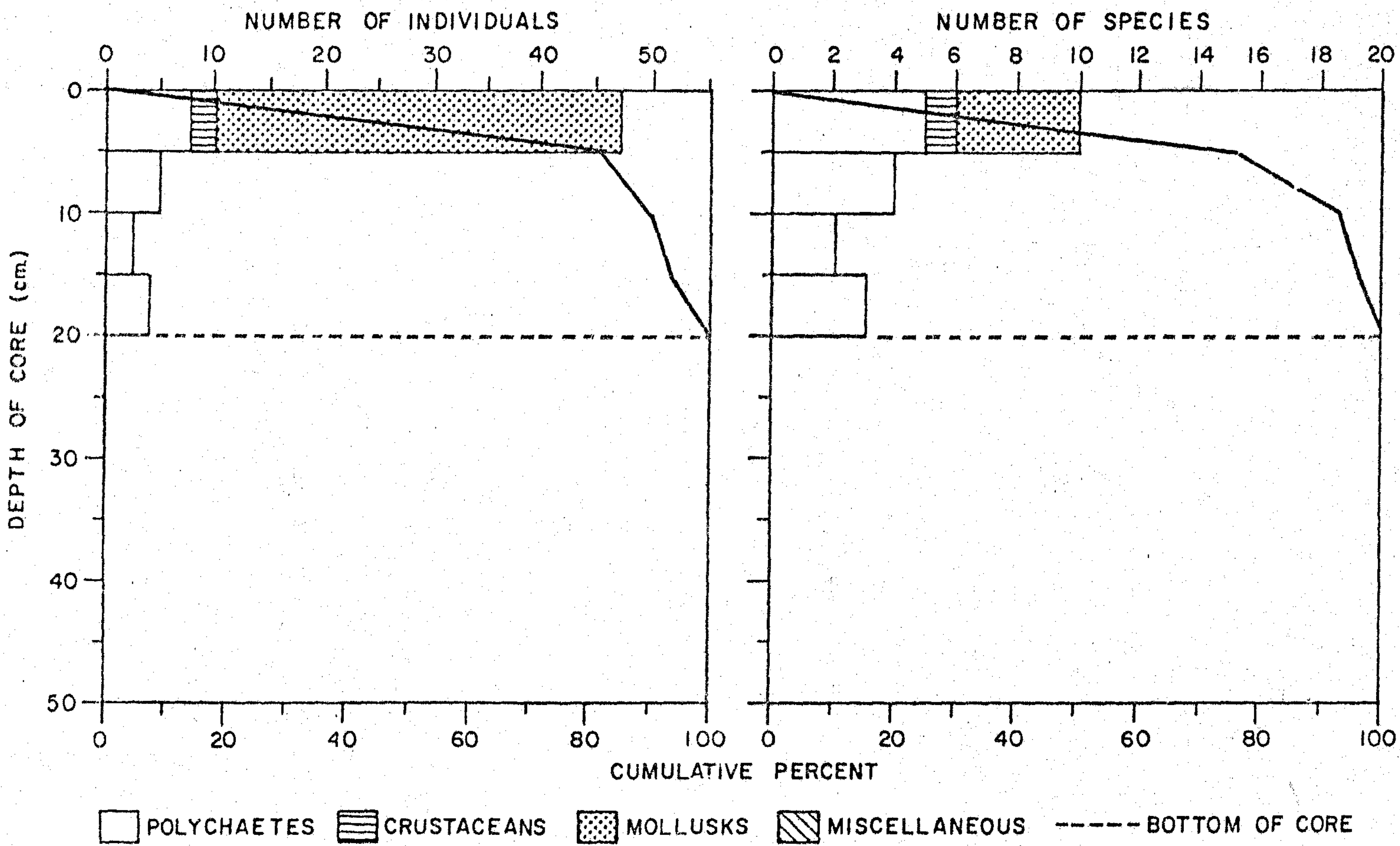

Fig. 15. Vertical distribution of the poly-euhaline sand habitat 9-78.

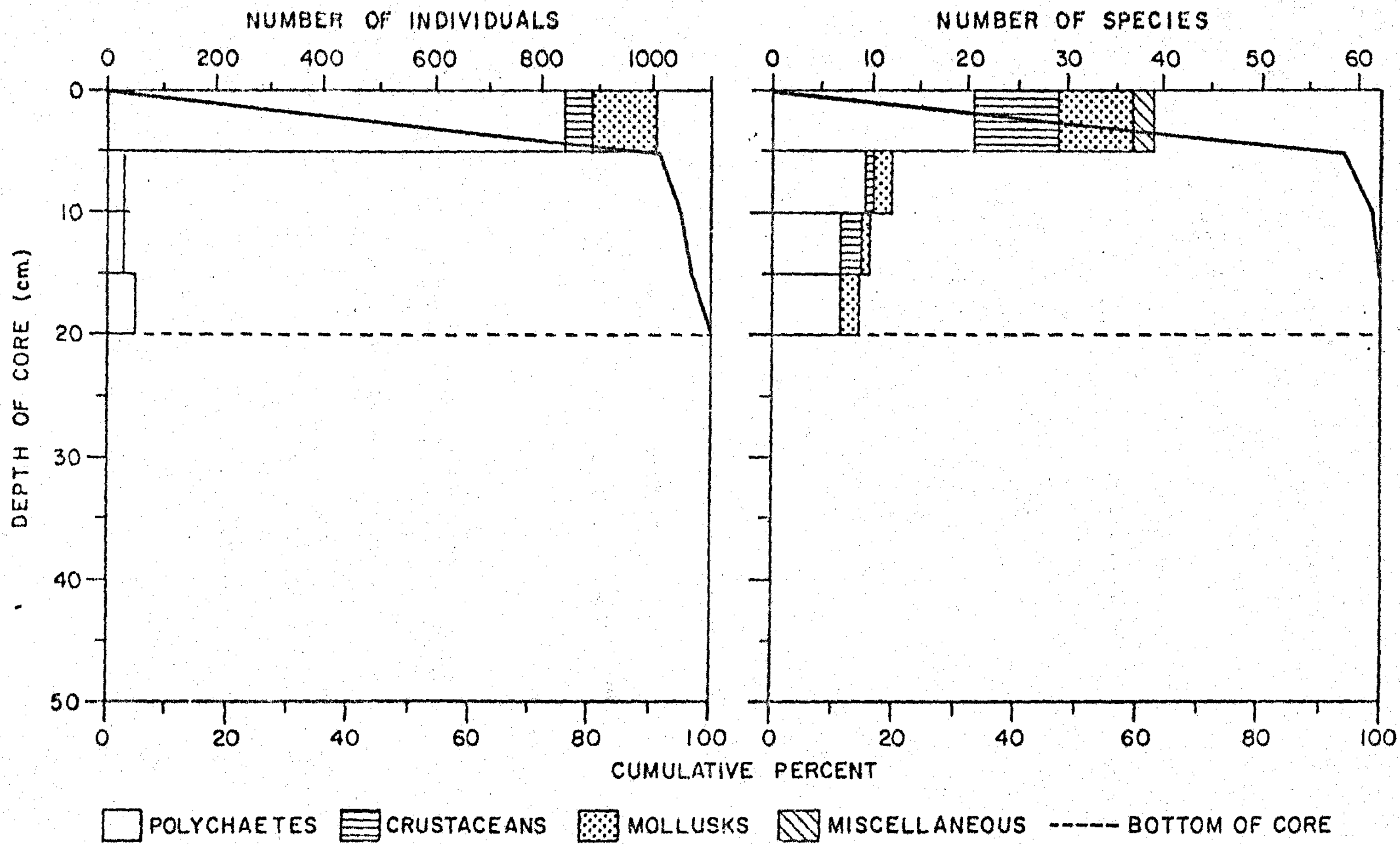

Fig. 16. Vertical distribution of the poly-euhaline sand habitat 6-79.

polychaetes, which build temporary burrows extending 40 cm or more, and the maldanid polychaete *Clymenella torquata*, which builds a vertical sand tube of 15-20 cm in length. In the cases of *Callianassa atlantica*, *Scoloplos robustus*, *Pilargis* sp. A, *Asychis elongata*, and *Dilonereis magna* all individuals were found below 10 cm.

Seasonal effects

Of the 53 stations sampled, 42 stations had 80% or more of the total number of organisms contained in the top 10 cm. Of the remaining 11 stations, 10 were from the September 1978 cruise. This is a result of both technique differences which allowed better recovery of small soft bodied animals and the spring bloom of surface dwellers such as *Streblospio benedicti*, *Mulinia lateralis*, *Pectinaria gouldii*, *Mediomastus ambiseta*, and *Polydora ligni*. Populations of deep dwelling organisms remained relatively constant increasing slightly in the spring collection.

E. Sediment Structure and Levels of Bioturbation

X-ray techniques, developed by Howard and Frey (1973, 1975), were used to determine the effects organisms have on mixing sediment. Radiographs have enabled us to determine the degree of bioturbation, what organisms dominate the sediment structures, and depths to which biogenic structures extend. Since we used methods outlined by Howard and Frey (1975) we felt it appropriate to use their bioturbation classification. By estimating the percentage of the area in a radiograph disturbed by organisms, a station could be placed in one of the following bioturbation percentage groups: 0, <30, 30-60, 60-90, 90-99, 100% (see Table 8). None of our samples were without some evidence of bioturbation and the vast majority fell in the group 90-99% bioturbated. Those that had the least amount of bioturbation tended to be either in the upper part of the study area, have fluid mud surfaces, or have high amounts of coarse sand and gravel (Stations 41, 49, 78, 79, 80, 82, 86, and 98).

Since x-rays are expensive to reproduce we have chosen to reproduce for the final report radiographs which are representative of most major habitats in the lower Chesapeake Bay (see Appendix D). For a description of radiographs plus other visual observations for each core see Appendix E. A description of structures produced, as well as size and orientation is given for each major species in Appendix F.

Physical Structures

Most of the physical structuring in the lower Chesapeake Bay consists of mud-sand laminations (in the radiographs sand appears black; mud appears white). Laminations are of small scale ripple in Station 82 (Plate 1) to planar in Station 80 (Plate 2). Sand lamination occurs in Station 100 (Plate 3) trough cross bedding.

Table 6. The twenty dominant species with their depth distribution (determined by BioIndex of McCloskey 1971).

	Species	depth distribution (cm)
1.	*Streblospio benedicti*	0-5
2.	*Pectinaria gouldii*	0-5
3.	*Pseudoeurythoe ambigua*	0-50
4.	*Paraprionospio pinnata*	0-15
5.	*Mulinia lateralis*	0-3
6.	*Ampelisca abdita*	0-3
7.	*Mediomastus ambiseta*	0-5
8.	*Nereis succinea*	0-40
9.	*Retusa canaliculata*	0-2
10.	*Glycera* spp. (*dibranchiata*, *americana*)	0-40
11.	Maldanidae sp.	0-50
12.	*Glycinde solitaria*	0-10
13.	*Anadara transversa*	0-2
14.	*Polydora ligni*	0-5
15.	*Eteone heteropoda*	0-5
16.	*Tellina agilis*	0-10
17.	*Leucon americanus*	0-2
18.	*Sabellaria vulgaris*	0-2
19.	*Tharyx* sp.	0-10
20.	*Ensis directus*	0-20

Table 7. List of species living having 10% or more of their populations below 10 cm.

	#	%
Mollusca		
Aligena elevata	11	33
Crustacea		
Listriella clymenellae	2	29
Pinnixa retinens	2	33
P. chaetopterana	2	40
Callianassa atlantica	2	100
Upogebia affinis	1	33
Annelids		
Ancistrosyllis hartmanae	5	83
Glycera dibranchiata	4	21
Pseudoeurythoe ambigua	383	56
Clymenella torquata	39	15
Scoloplos rubra	5	38
Praxillela gracilis	1	50
Maldanaidae sp.	9	13
Cirratulidae sp.	3	75
Ampharetidae sp.	1	25
Bhawania goodei	6	32
Glycera americana	11	14
Harmothoe sp. A	1	25
Paleonotus heteroseta	2	17
Ancistrosyllis jonesi	1	33
Pilargis sp. A	1	100
Sigambra tentaculata	42	32
Scoloplos robustus	1	100
Gyptis brevipalpa	3	33
Arabella iricolor	1	50
Cabira incerta	10	48
Harmothoe extenuata	2	29
Magelona rosea	1	50
Asychis elongata	6	100
Drilonereis longa	2	40
Arabellidae sp.	4	44
Drilonereis magna	1	100
Brania wellfleetensis	5	71
Echinodermata		
Micropholis atra	3	60

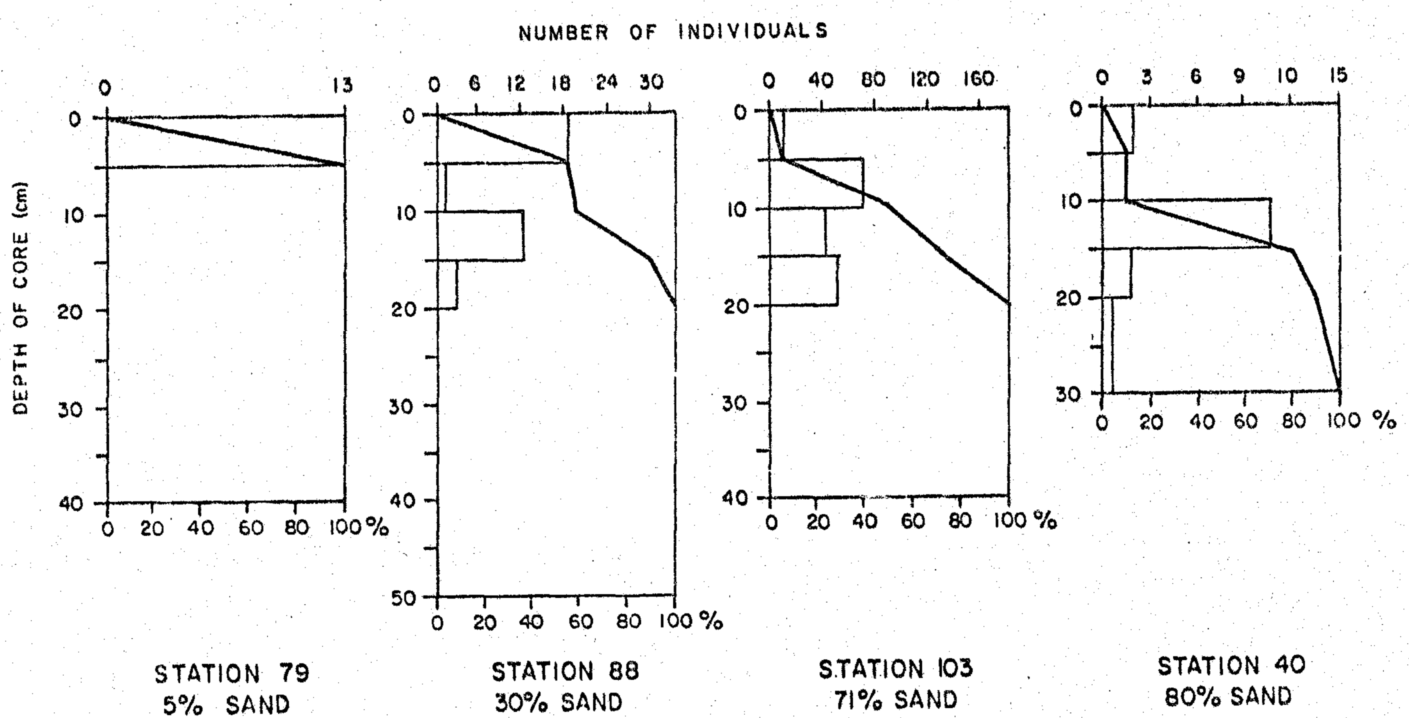

Fig. 17. Vertical distribution of Pseudeurythoe ambigua along a sand gradient.

Table 8. Sediment type based on visual observations and extent of bioturbation based on radiographs for each station sample.

Station	Sediment Type	Percent Bioturbation
26	mud	no radiograph
27	sand	90-99
28	sand	90-99
29	sand	100
30	mud	no radiograph
31	mud	no radiograph
32	muddy sand	no radiograph
33	mud	no radiograph
34	muddy sand	100
35	muddy sand	90-99
36	muddy sand	100
37	sand	90-99
38	muddy sand	90-99
39	sand	90-99
40	sand	90-99
41	muddy sand	90-99
42	muddy sand	90-99
43	muddy sand	90-99
44	sand	90-99
45	sand	no radiograph
46	muddy sand	90-99
47	muddy sand	90-99
48	muddy sand	90-99
49	muddy sand	60-90
50	sand	90-99
76	mud	90-99
77	muddy sand	90-99
78	mud	60-90
79	mud	60-90
80	muddy sand	30-60
81	muddy sand	90-99
82	mud	30-60
83	mud	90-99
84	mud	90-99
85	mud	90-99
86	mud	<30
87	mud	90-99
88	muddy sand	90-99
89	muddy sand	100
90	sand	90-99
91	sand	no radiograph
92	mud	90-99

Table 8 (continued)

Station	Sediment Type	Percent Bioturbation
93	mud	90-99
94	muddy sand	90-99
95	mud	90-99
96	sand	90-99
97	muddy sand	90-99
98	muddy sand	60-90
99	muddy sand	90-99
100	sand	90-99
103	muddy sand	90-99
104	muddy sand	90-99
105	muddy sand	90-99

Other physical structures consist of methane pocketing as seen in the lower half of Station 82 (Plate 1). Methane is produced in areas of high organic input and absence of oxygen. Methane production in these areas may be so high, particularly during the summer, that bubbles form which escape to the surface, thus forming bubbletubes (Martens and Klump 1980). Macrofauna may, by pumping oxygen into the sediment, prevent methane saturation (Martens 1976).

Other physical features of special interest are substrate changes. Station 78 (Plate 4) has a fluid mud surface stabilized by a dense mat of Ampelisca abdita (an amphipod) tubes. Below the tubes the sediment changes abruptly to coarse sand and gravel. The top 12-15 cm of Station 27 (Plate 5) is fine sand below which is a storm erosion layer of hard clay, rocks and shells. At Station 103 (Plate 6) there was formerly an oyster reef which is now covered by fine sand and populated by the maldanid polychaete Clymenella torquata.

Biological Structures

Biological structures can be classified into three types. Living maintained structures are usually found in the top 10 cm, but have been found as deep as 50 cm. Most of these are tubes or burrows of polychaetes, many having a halo of lighter colored sediment due to ventilation by the occupants. The most frequent tubes or burrows seen are those of Pectinaria gouldii, Paraprionospio pinnata, Loimia medusa, Asychis elongata, Clymenella torquata, Glycera sp. and Heteromastus filiformis. Details of their burrow or tube morphology can be found in Appendix F. Except for Ensis, no other molluscs made permanent burrows, their effects being restricted to bioturbation. Crustaceans, except for thallasian shrimps, produced burrows too small to be easily recognized or preserved. Although biogenic structures attributable to fish were not observed, other studies have noted the effects of fish on bottom sediments (Cook 1971, Risk and Craig 1976, Howard et al. 1977). The abundance of rays, flat fish and blue crabs in Chesapeake Bay make them good candidates for a lot of the bioturbation seen in our cores.

Tubes or burrows which are abandoned and subsequently filled in with surface sediment represent the second major class of biogenic structures. The filling consists of surface sediment which has not undergone compaction and is therefore very fluid as well as black due to the higher oxygen demand of a higher organic content surface fill. These cylinders of fluid black mud generally occur below 5 cm to depths greater than 60 cm. Most of these structures are large; apparently the small burrows are destroyed by bioturbation (Cullen 1973). These structures are seen in radiographs of Stations 84 (Plate 7-E) 95 (Plate 8-6), and 78 (Plate 4-F).

The third major class of biogenic structures is the bioturbation structure. The random feeding and burrowing of polychaetes, molluscs, and crustaceans mix the sediment layers. At low levels this feeding produces a mottled appearance with faint bands of former laminae (see radiographs of Stations 84 - Plate 7 and 95 - Plate 8). At higher levels of bioturbation the substrate is completely mixed, leaving living maintained structures as the only sediment structures (see radiographs of Stations 27 - Plate 5, 42 - Plate 9 and 96 - Plate 10).

Trends

Physical structures dominate the muds in deep channel areas extending into deep holes at the mouths of major rivers. Stressful conditions of a fluid mud surface and periodic summer anoxic conditions allow only the temporary settling of oportunistic species such as the clam Mulinia lateralis, and the polychaete Streblospio benedicti (see Radiograph of Station 82 - Plate 1).

Sometimes Ampelisca abdita, a tube dwelling amphipod, can colonize these fluid surfaces and reach densities high enough to literally carpet the surface. This has a stabilizing effect allowing deeper tube dwellers like Loimia to become established. These tube mats are ephemeral (Mills 1967) and are destroyed by major physical disruptions (i.e. storm, anoxia, or high deposition of sediment). Radiograph 80 (Plate 2) had such a Ampelisca community and demonstrates the alternate horizons of physical and biological dominances.

Muds in shallower regions are less likely to suffer anoxic conditions, contain more animals, and hence are more biologically structured. Faint physical layering is evident, but backfilled burrows dominate the sediment fabric (see radiographs of Stations 84 - Plate 7 and 95 - Plate 8).

Most of the mixed sediments of the bay are dominated by biogenic structures. Tubes of the maldanid polychaete Clymenella torquata are very common in these areas (see radiographs of Stations 42 - Plate 9 and 103 - Plate 6). Sands appear to be the most uniform, usually lacking back-filled burrows which are probably destroyed by the bioturbation of the mobile fauna characteristic of the sand. Only the tubes and burrows of living animals remain (see radiographs of Stations 27 - Plate 5 and 96 - Plate 10). Wave action is probably the dominant influence on the sediment fabric in the sand areas just outside the bay (see radiograph of Station 100 - Plate 3).

F. Microscopic examination of sediments

Biologists involved in animal-sediment relationship studies are disgruntled over the information derived from traditional dry sieving grain size analysis. Larger biogenic structures such as fecal pellets, organic aggregates, tube fragments and plant fragments are often destroyed or broken down to their smaller mineral components. Young (1971) found dry sieving yielded 78-91% silt-clay while gentler wet sieving gave values of 33-50%.

Very often the distribution of organisms does not correlate with median grain size, % silt, clay or other parameters derived from dry sieving. Whitlatch (1976) in a study of food resource partitioning in deposit feeding annelids, noted that the sorting coefficient based on only three points was a poor measure of sediment complexity, but diversity of particle species based on a microscopic study was more indicative of what an organism is likely to encounter while feeding.

Since a toxin's fate and transport is ultimately tied in with where a particle settles we thought it useful to obtain information on the abundance and size of particles before they are destroyed, by using microscopic and staining techniques recently developed (see Methods).

Table 9 lists the types of particles and whether they are abundant, common or rare in lower Chesapeake Bay sediments. Organic-mineral aggregates refer to small mineral grains embedded in a matrix of organic material. Most workers (Rhoads 1974, Johnson 1974, Ronan 1978) agree that the organic-mineral aggregates represent fecal pellets in various states of decay.

Mineral particles consist of solitary grains usually of quartz which may or may not have an organic encrustation. Anderson and Meadows (1969) have found these encrustations to be bacterial films and colonies. Almost all mineral grains larger than 25 μ were encrusted while less than 20% of the mineral grains less than 25 μ were encrusted.

Whole fecal pellets, although abundant in the scanning, represent a small fraction of the abundance as compared to organic-mineral aggregates, encrusted mineral grains and mineral grains. This may be caused by their rapid degradation and as mentioned before degradated fecal pellets are probably represented as organic-mineral aggregates. McCall (1979) took fecal pellets and disaggregated them by stirring and then more vigorous blending. His results as documented in sequential light micrographs, show that whole fecal pellets disaggregate into large organic-mineral aggregates followed by small aggregates, and finally solitary mineral grains.

Macrophyte fragments were common in all sediments sampled. The identity of the plants could not be ascertained, but most likely represented remains of the marsh grass Spartina alterniflora and eelgrass Zostera marina. Because most stations sampled were in water depth in excess of 20 feet, live diatoms were rare, but their frustules were common.

All other particles, although common, were represented by such low numbers as to be considered unimportant to this study.

Table 10 gives the per cent abundance distribution among the four major particle classes. Organic-mineral aggregates less than 25 μ were the most abundant particles, except at six stations where non-encrusted mineral grains less than 25 μ were. Of these six stations, four stations (44, 90, 91, 100) are undergoing erosion (see Table 2). The absence of low density organic-mineral aggregates, which are more easily transported than mineral grains of comparable size might be expected in this type of environment. Johnson (1974) experimented with settling velocities found organic-mineral aggregates stayed in suspension longer than their mineral components lending support to the buoyancy effect of the organic matter.

Table 9. List of Particle species found in lower Chesapeake Bay sediments.

Mineral grains	(a)	Various unknowns	(c)
Organic-mineral aggregates	(a)		
Encrusted mineral grains	(a)		
Fecal pellets	(a)		
Macrophyte fragments	(c)		
live diatoms	(r)		
diatom frustules	(c)		
tube fragments	(c)		
spines, rods or spicules	(c)		
filamentous algae	(r)		
Unknown cells	(c)		
Polychaete setae	(r)		
Plant seeds	(r)		
Metazoans	(r)		
Pine pollen	(c)		
egg cells	(c)		
Foramanifera test	(c)		
Oak trichome	(c)		
Dinoflagellate	(r)		
Crustacean exoskeleton	(r)		
Plant pollen	(r)		
Protozoan	(r)		
flagellates	(r)		
Tittinid test	(r)		
Hydroid fragment	(r)		
Veliger	(r)		
fish scale	(r)		

a - abundant
c - common
r - rare

Table 10. Mean % abundance distribution among the four major particle types.

Station	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Mineral grains <25 μ	44	35	31	32	18	25	33	31	36	30	28	23	34	26	24	24	26	28	30	32	27	25	21	23	25
Encrusted Mineral grain <25 μ	4	7	6	4	6	9	6	8	8	5	4	5	10	5	6	5	7	5	5	5	5	5	8	7	5
Organic-mineral aggregate <25 μ	41	35	41	35	59	41	39	43	41	43	44	51	41	51	43	49	43	50	21	48	42	53	52	45	41
Organic-mineral aggregate 25-100 μ	6	13	15	11	8	16	11	11	8	11	14	15	10	11	17	17	12	8	7	8	14	9	8	14	10

Station	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	103	104	105
Mineral grains <25 μ	31	31	33	32	29	33	31	31	27	31	25	28	31	28	48	44	30	31	36	32	37	28	26	33	36	30	27	32
Encrusted Mineral grain <25 μ	5	5	4	5	6	6	5	6	6	5	7	6	6	4	6	5	8	5	5	6	6	4	5	6	5	5	4	3
Organic-mineral aggregate <25 μ	43	46	43	42	40	42	49	45	49	46	44	47	45	44	24	23	45	47	43	47	28	43	44	42	19	43	46	40
Organic-mineral aggregate 25-100 μ	17	14	15	17	18	14	12	14	13	13	19	14	12	16	6	6	13	11	10	11	7	17	18	10	8	13	16	13

Except for the erosional stations it is remarkable how similar the other stations are in their % abundance distributions of particle types. This is very different from grain size data obtained by conventional grain size analyses based on weight (see Table 1).

Fig. 18 is a graph of the mean number of fecal pellets at each depth sampled for all stations sampled in each cruise. The highest number of fecal pellets lie on the surface and quickly decline at 2 cm and more slowly decline until 10 cm where there is a slight increase. From 10-40 cm there is a gradual decline. This distribution is expected because most benthic organisms deposit their fecal pellets on the surface. A slight increase from 5-10 cm probably represents a secondary input from subsurface defecation. The fact that whole fecal pellets are found at 40 cm is consistent with the experiments by Cadee (1979) on the resistance of *Heteromastus filiformis* fecal pellets. He found the pellets to be highly resistant to bacterial breakdown or moderate stirring as compared to experiments with *Macoma balthica* fecal pellets, which were very easily disaggregated (Risk and Moffat 1977).

Sediments collected during the early summer cruise (6-79) had about twice the number of fecal pellets as did those collected during the fall cruise (9-78). This is consistent with the overall increase in numbers of animals for the 6-79 cruise.

Sediments at all stations showed an abundance of stained particles. Differences between stations in the number of stained versus non-stained particles were insignificant, but some differences existed in the size or form. For example fine grained sediments lacked the larger encrusted mineral grains, but had a correspondingly higher concentration of organic-mineral aggregates. Vertical differences at any one station were insignificant, with the exception of larger numbers of fecal pellets and live diatoms near the surface.

G. Pore Water Chemistry

At the time of this writing the only complete set of chemical analysis of the pore water is on the major cations and anions (information provided by Dr. S. Tyree, Department of Chemistry, College of William and Mary). Most of these (Na, K, Mg, Ca, F, Cl) ions are conservative and constant with depth. The rest (NH_4^+, NO_3^{-2}, PO_4^{-3}, SO_4^{-2}, HCO_3^-) are controlled by decomposition of organic matter mediated by various microorganisms. Sulphate reduction is probably the controlling decomposition pathway and has been frequently studied. In two studies of the sulphur cycle in the marine environment Jörgensen (1977) and Goldhaber et al. (1977) attributed the constant sulphate value in the upper 10 cm of the sediment to the irrigation activity of the macrofauna.

In examining our data for this relationship several difficulties arose. The need for a certain volume of water to be able to run all the analyses allowed the chemists to sample only mud, which has a high water content. Such environments are limited in the lower Bay and have sparse benthic

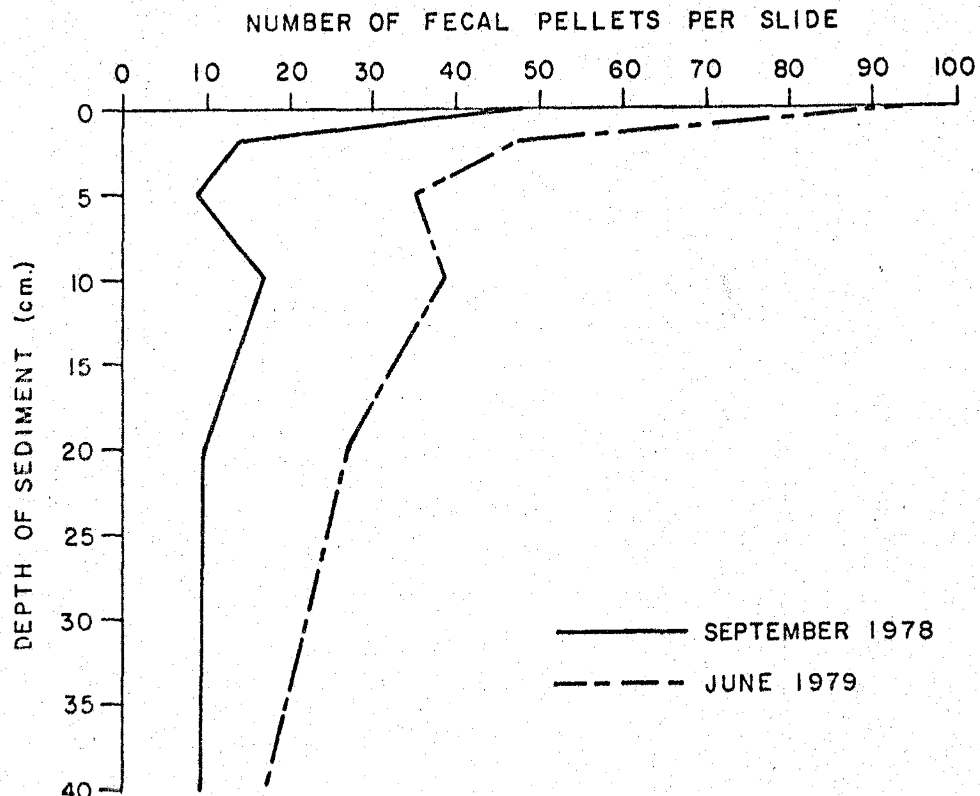

Fig. 18. Vertical distribution of fecal pellets at depth for all stations sampled each cruise.

populations. Nevertheless there seems to be good agreement between the abundance, composition and vertical distribution of benthic invertebrates and the sulphate profile. In cores from stations 26, 30, 32, 33, 76, 80, 82, 86 and 92, sulphate decreases sharply after the first several centimeters. All these cores either had low populations of macrofauna or animals were restricted to the upper 5 cm. Cores of stations 28, 34, 35, 38, 77, 79, 83, 84, 85, 87 and 88 had either erratic sulphate changes or increasing sulphate with depth. These cores had larger populations of benthic animals, whose activity could be responsible for the observed sulphate distribution.

V. DISCUSSION

A. Population Distribution

Macrobenthic communities in the lower Bay are numerically dominated by euryhaline opportunists (sensu Boesch 1977). These species are extremely dynamic, and occur over a wide range of salinities and sediment types. Their populations vary both spatially and temporally. Equilibrium species, while not numerically dominant, tend to dominate biomass.

The majority of macrobenthic organisms in the lower Chesapeake Bay are found in the top 10 cm of the sediment column. Such a vertical distribution agrees with vertical studies elsewhere (Molander 1928, Holme 1953, Lie and Pamatmat 1965, Keith and Hulings 1965, Johnson 1967, Smith and Howard 1971, Beukema 1974 and Rosenberg 1974). Most ecologists agree that the surface sediment contains the largest reservoir of easily assimilated organic matter. Microbial distributions have been directly linked to the abundant supply of organic material on and near the surface (Aller and Yingst 1980).

Even if food supply is adequate at depth within the sediment, oxygen may not be. Substrate plays a large role in determining oxygen penetration. A larger grain size of sand sediments facilitates pore water exchanges, allowing oxygenation to deeper depths. This enables a deep mobile fauna to exist without connections to the surface.

Deep dwelling organisms in the stable mud habitat where the RPD (Redox Potential Discontinuity) layer lies almost on the surface tend to have a direct connection to the surface via a tube or permanent burrow. Organisms irrigate these structures, thus bringing oxygen down into the sediments. The few organisms that live at depth in the muddy sediments, such as the polychaete Pseudeurythoe ambigua, must have a tolerance of sulphides with some capacity to respire anaerobically. Unstable mud habitats probably lack deep dwelling organisms because of the organism's inability to maintain permanent connections with the unstable surface.

All salinity habitats sampled in this study have a similar proportion of deep dwelling organisms, but differences exist in actual numbers of individuals and species. The increase in deep dwelling organisms from the meso-polyhaline transition zone to the polyhaline zone may be just a reflection of the overall increase in numbers and species of the polyhaline zone. Numbers of deep dwellers decreased from polyhaline to poly-euhaline transition zone. Rhoads (1967) states that organisms respond to the fluctuating environment of the nearshore by building deep burrows while offshore benthos restrict themselves to the upper layers.

Individual species distribution

As was true in most studies of macrobenthic vertical distribution most of the organisms found below 10 cm in the study were polychaetes (Smith and Howard 1971 and Beukema 1974). Their respiratory physiology is well adapted to infaunal life (Mangum 1970). Many of the deep dwelling species are not numerically dominant, but the large size of many of these animals (i.e. Asychis, Callianassa, Cerebratulus, Ceriantheopsis, Upogebia and Thyone) would dominate standing crop biomass. Because of their large size they process large volumes of sediment, thus altering the geological properties and indirectly affecting community development (Myers 1977).

Seasonal effects

Juvenile settling in spring by Streblospio benedicti, Mulinia lateralis, Mediomastus ambiseta, and Polydora ligni caused large increases in the number of organisms inhabiting the 0-2 cm horizon. These opportunistic species are well known for their quick population eruptions (Boesch et al. 1976). Virnstein (1977, 1979) examined the role of predation in structuring Chesapeake Bay bottom communities. His conclusion was that summer predation by fish and crabs lowered populations of surface dwellers, while organisms living deeper in the sediment escaped and were abundant year around. In addition, deeper dwelling organisms have temporally more stable populations because they are buffered from the variability of the sediment-water interface (Sanders et al. 1965).

B. Biogenic Structure and Bioturbation

Information from our radiographs and dissections indicates that the sediments of the lower Chesapeake Bay are highly bioturbated. The prevalence of bioturbated sediments have been found in other areas (Moore and Scrutton 1957, Rhoads 1967, Robbins et al. 1979, Howard and Frey 1973). The density of biogenic structures of living animals is highest in the top 2-3 cm but structures are common to 15-20 cm and have been observed beyond 50 cm. This would indicate mixing to be extremely rapid near the surface and to be considerably slower deeper down. This is precisely what Aller and Cochran (1976) found when measuring biological mixing rates of Long Island Sound sediments using $^{234}Th/^{238}U$ ratios.

Back-filled burrows occur below 5 cm down to depths of 40 cm or more. These structures have several implications for the geochemistry of pore waters. First, they represent an avenue for rapid subduction of high water content, high organic content, surface material without the usual slow compaction and decay process normally associated with slow burial. Secondly, these back-filled burrows represent areas of high bacterial activity which may strongly influence the chemistry of pore water. The geochemist must compensate for this type of heterogeneity by either taking larger samples or more replicates. For instance, a small diameter core taken in the middle of a back-filled burrow would yield different results from one taken to either side of the burrow.

An important trend evident in the radiographs, that has geochemical implications, is that muds tend to have a more tube or burrow orientated community while sands have a more mobile fauna, thus causing a more uniform bioturbated sediment fabric. Howard and Frey (1975) noted the same thing for Georgia estuaries. Aller (1978) hypothesized that a sedentary fauna would develop horizontal gradients as well as vertical gradients in sediment chemistry while with mobile fauna only a vertical gradient would be present.

Howard and Frey (1973), in studying nine Georgia estuaries, concluded that biogenic influences decreased with salinity and deep channel areas. Many of the least bioturbated areas were in deep channels (Station 82 and 86). Periodic summer anoxia prevents the establishment of a permanent benthic population. This study only examined the lower Bay (south of the Potomac River) but comparison with the concurrent study of biogenic structures in the upper Bay by Maryland Geological Survey (EPA contract R805964) shows a lowering of bioturbation levels in the lower salinities. This is not surprising since number of individuals and species collected differed by an order of magnitude. Winston and Anderson (1971) in a study of bioturbation of a New Hampshire estuary concluded that the lower rate of biological mixing in the lower salinities was due to lower numbers of the polychaete Nereis. Depth of mixing may be different for the two areas based on Pb 210 analysis by Goldberg et al. (1978). They concluded that mixing by invertebrates occurred in the top 5 cm in the upper Bay while it occurred to 30 cm or more in the lower Bay.

Seasonal differences are not possible to differentiate in our x-rays. At sedimentation rates on the order of 0.5 to 1 cm per year benthic populations mix sediments in terms of years, not months. Seasonal differences in bioturbation levels have been noted by Cadee (1979), Myers (1977), and Driscoll (1975). The higher water temperatures of late summer stimulate the benthos to their highest activity levels. Longer term differences in bioturbation levels, substrate type and community composition have been mentioned for Stations 80, 78, and 103.

C. Sediment Composition

In this study, sediments examined microscopically exhibited a high degree of similarity in the percent abundance distributions of particles despite wide differences in grain size information derived from conventional methods. Many of the differences between this microscopic study and conventional grain size analyses can be attributed to the destruction of larger organic-mineral aggregates into smaller mineral components by the latter method and the fact that convention sanalyses are based on weight of particles. The microscopic method is somewhat arbitrary and subject to unavoidable variability in technique. It needs refinement to be more quantitative and to detect differences one feels must exist. This criticism is also raised by other workers (Johnson 1974, Hughes 1979). Despite its shortcomings, the microscopic method may more realistically characterize sediment structure and complexity as it exists in the field, than do standard grain size analyses.

All of the particle types found in this study have been found in similar studies by Johnson (1974, 1977), Whitlatch (1974, 1976), Ronan (1978) and Hughes (1979). As with the other studies mineral grains and organic-mineral aggregates dominate over all other particles. An average of 69% of the particle species showed a positive reaction for the presence of organic material. In a similar environment Johnson (1977) found stained particles made up 61% of the total, and in a study of sediments in St. Margaret's Bay, Nova Scotia Hughes (1979) found stained particles comprised 66% of the total.

A significant finding in our study was the large numbers of fecal pellets found in all sediments. Risk and Moffat (1977) found that high populations of Macoma balthica could incorporate up to 28 $cc/m^3/yr$ of sediment into fecal pellets and pseudofeces. The binding of fine mineral grains into larger fecal pellets (pelletization) has profound effects on the geophysical properties of sediments. Pelletization causes water content to increase and compaction to decrease, resulting in a more easily resuspended sediment (Rhoads & Young 1971, Driscoll 1975). This results not only in transport, but increased surface area for exchange between sediment and the water column, an important feature in nutrient and geochemical cycling (Rhoads 1973).

A second effect of pelletization is increased sedimentation. Suspension feeders remove very fine particles which would not ordinarily settle out due to the hydrodynamic regime and bind them into larger, more easily deposited fecal pellets (Haven and Morales-Alamo 1966, Risk and Moffat 1977). Finally, pelletization may stimulate bacterial growth (Hargrave 1976, Newell 1965). This is important because the metabolic process of bacterial decomposition of organic material governs most of the important geochemical reactions in sediments (Berner 1976). Gordon et al. (1978) found that oil levels in sediments decreased by the increased bacterial degradation stimulated by the activities of the polychaete Arenicola.

Insignificant vertical differences in sediment composition have been attributed to homogenization thru bioturbation (Johnson 1977). Several of our stations reveal the lack of bioturbation and so it seems impossible the lack of vertical sediment changes are due to this process. Forces which coagulate mineral grains and organic debris, as well as encrustation processes are widespread within the sediment. Surface material incorporated at depth does not change significantly, at least within the sensitivity of our methods.

D. The Relationship Between Pore Water Chemistry and Macrobenthos

Jørgensen (1977), in a study of sulphate reduction in Limfjorden, found constant sulphate values in the pore water in the upper ten centimeters of the sediment. This was attributed to the macrofauna, which would pump overlying waters into the sediments and thus decrease the concentration gradient existing between the water and pore water. He also discovered a great deal of difference between replicate cores. This may have been due to macrofauna density differences. In this study, the types of sulphate profiles measured in cores were generally related to faunal depth distribution profiles. Cores with fauna limited to the upper 5 cm generally had decreasing sulphate profiles, while increasing or erratic profiles were observed in cores with larger populations and a greater proportion of deep-dwelling fauna.

Fenchel (1969) attributed heterogeneity of Eh measurements to worm burrows. Goldhaber et al. (1977) stated the necessity of taking large samples to integrate all the heterogeneity caused by macrofauna burrows. Aller and Yingst (1978) detailed this heterogeneity in their chemical study of the burrow of the polychaete *Amphitrite ornata*. Burrows are lined with rich organic material that enhances bacterial decomposition. Extremely high rates of sulphate reduction take place along the outer wall while aerobic conditions prevail along the inner wall, setting up strong concentration gradients. Sulphate is continuously supplied by irrigation as well as by the flushing out of decomposition products. We have seen evidence of these microenvironments in our samples. A thin black lining surrounds the light colored halo of oxygenated sediment of many tube and burrow dwellers.

VI. MECHANISMS OF TOXIC TRANSPORT BY MACROBENTHOS

Macrobenthic organisms can affect the distribution of toxic materials by solid phase mixing (toxic materials adhering to sediment particles) or liquid phase mixing (toxic materials dissolved in pore waters).

Mobile deposit feeders mix and transport particles during their feeding and burrowing activities. Sheldon and Warren (1966) note that sand may be physically transported in the stomachs of fish and crustaceans. Several workers (Rhoads 1963, 1967, Gordon 1966, Mangum 1964) have measured rates of particle mixing of common marine invertebrates of the Atlantic and found their mixing rates to exceed annual sedimentation rates several times. One animal in particular, Clymenella torquata, studied by both Mangum (1964) and Rhoads (1967) is particularly important because of its feeding style and depth of influence. Clymenella is a maldanid polychaete which builds a sand tube extending down 15-20 cm. It feeds at the bottom of its tube and defecates on the surface; hence the term "conveyor belt species" (Rhoads 1974). This animal is quite abundant in the lower Bay and it can resurface material 25-100 years old depending on local sedimentation rates. Robbins et al. (1979) detailed the effects of a "conveyor belt species" (an oligochaete found in the Great Lakes) by sprinkling radioactive ^{137}Cs on the surface sediments in an aquarium filled with oligochaetes. Initially the layer of ^{137}Cs was buried until it reached the feeding level where it was resurfaced again. Some escaped feeding, but overall the effect was continuing process of burial and resurfacing.

Animals may also indirectly alter the probability of particle movement. Large tube dwelling polychaetes mound sediments, exposing them to higher current velocities (Newman et al. 1970). Tubes of benthic animals have been known to bind and stabilize bottom sediments (Fager 1964, Mills 1967, Featherstone and Risk 1977). Tubes can trap fine materials, increasing the sedimentation rate (Lynch and Harrison 1971).

Mobile deposit feeding bivalves, by pelletizing the surface sediments, produce a porous surface allowing for greater water content (Rhoads and Young 1971). This decreases critical threshold velocity for resuspension and increases the opportunity for sediment-water exchange so important in nutrient cycling (Rhoads 1973).

Pellet production affects grain size distribution and settling velocities. Pelletization increases sedimentation rates (Risk and Moffat 1977, Verwey 1952) and in some cases biodeposits exceed other sedimentary pathways (Prokopovich 1969). Populations of suspension feeders trap fine materials from the water column and process them into larger fecal pellets. McCall (1979) measured settling velocities of fecal pellets and their constituent particles and found an increase of two orders of magnitude in settling when the particles are pelletized.

Pellet production indirectly affects the chemistry of interstial waters. Fecal pellets provide an excellent substrate for enhanced bacterial growth (Newell 1965). Other studies have linked macrofauna activity and bacterial activity (Briggs et al. 1979, Tunnicliffe and Risk 1977). Since bacterial metabolism is the controlling action for many chemical species (Berner 1976), this enhancement by macrofauna on bacteria indirectly influences the chemistry of pore waters. Two studies have found that the activities of deposit feeding polychaetes increased bacterial degradation by stimulating microbial metabolism (Gordon et al. 1978, Gardner et al. 1979).

Benthic animals significantly affect pore water profiles by irrigation of their dwelling structure. Rhoads et al. (1978) found irrigation rates were an order of magnitude greater than particle reworking rates. Jørgensen (1977) and Goldhaber et al. (1978) both note that macrofauna irrigation may be responsible for the homogeneous distribution of sulphate in the upper 10 cm. Irrigation increases oxygen penetration (Jørgensen 1977, Rhoads et al. 1978). Increasing oxygen has the effect of lowering pH, increasing Eh and decreasing phosphorus and ammonia (Khalid et al. 1978).

Studies documenting the effects animals have on chemical profiles are increasing. Bowen et al. (1976) and Livingston and Bowen (1979) cite bioturbation as controlling transuranium nuclide distribution. Even redistribution of ^{137}Cs at a 2800 m radioactive disposal site by macrofauna is reported (Dayal et al. 1979). These activities have lead scientists to construct bioturbation mixing models (Goldberg and Koide 1962, Berger and Heath 1968, Guinasso and Schinck 1975, Aller and Yingst 1978, Aller 1980, Hutson 1980) necessary for a complete model of transport of toxics within and out of the sediments.

VII. MANAGEMENT CONSIDERATIONS AND FUTURE RESEARCH NEEDED

The crux of this report to managers is that macrofaunal animals are abundant in the lower Chesapeake Bay sediments and play a major role in the movement of sediment, which in turn influences the distribution and fate of toxic materials. The magnitude of animal activities may change from mud to sand and from oligohaline to polyhaline habitats. Effects also differ for different communities of animals (sedentary vs. mobile, shallow infauna vs. deep infauna). In considering the sediment fluxes in the lower Bay it is then essential to factor in the effects of the dynamic macrofauna.

Animals mixing sediments and altering sediment movements have several implications to management decisions. Pollution or other disturbances usually induce the development of benthic communities which differ from those inhabiting undisturbed bottoms. According to Rhoads et al. (1978) quick colonizing surface dwellers are favored under disturbed conditions. Deeper dwelling species are usually not colonizers and may require years to reestablish populations. The loss of deep living benthic animals decreases the depth of bioturbated sediments and may mean the loss of nutrients for recycling. Hale (1975) indicated the benthos to be the most important source of nutrient regeneration to Narragansett Bay, contributing to the Bay's high productivity. Our large seafood industry depends on the high productivity of our Bay and any activity that would cause a change in regeneration of nutrients should be carefully evaluated.

Another consideration is that any model predicting the movement of toxic material within the sediment or between sediment and water must have a biological mixing coefficient. Models without such a coefficient may erroneously predict permanent burial of a harmful toxin within a short time. Dayal et al. (1979) found ^{137}Cs redistributed primarily by bioturbation at a 2800 m nuclear waste disposal site. Managers should realize that benthic animals, unlike man, do not allow things to be buried and forgotten.

Benthic animals may affect dredge material movements. Engineers may predict, based on hydrodynamic regime and conventional grain size distribution analysis, where dredged material may eventually settle. Unfortunately, spoil sediments passing over an oyster reef might be deposited as larger fecal pellets which would accumulate instead of being transported. If this was polluted dredged material, an oyster reef could be contaminated.

Macrobenthic organisms are important in understanding the distribution and fate of toxins, and in forming hypotheses on the possible effects and transformation of toxicants. Work is now needed to establish biological mixing rates for the incorporation of animal effects into models predicting the movement of toxic substances. These rates should be measured using different communities, varying temperatures, and under different stress levels. Sampling for chemical profiles should be scaled to reflect burrow sizes and densities, both of which impart a small scale heterogeneity to the chemical environment.

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Appendices for The Biogenic Structure of Lower Chesapeake Bay Sediments

Appendix A
Species List

Phylum Cnidaria
    Class Hydrozoa
            Sertularia argentea Linnaeus, 1758
    Class Anthozoa
            Anthozoa sp.
        Family Edwardsiidae
            Edwardsia elegans Verrill, 1869
        Family Cerianthidae
            Ceriantheopsis americanus (Verrill, 1864)
Phylum Platyhelminthes
    Class Turbellaria
            Turbellarians
Phylum Rhynchocoela
    Class Anopla
        Family Tubulanidae
            Tubulanus pellucidus (Coe, 1895)
        Family Lineidae
            Cerebratulus lacteus (Leidy, 1851)
            Nemertea sp.
    Class Enopla
        Family Amphiporidae
            Amphiporus bioculatus (McIntosh, 1873)
            Amphiporus sp.
Phylum Ectoprocta
    Class Gymnolaemata
        Family Walkeriidae
            Aeverrillia armata (Verrill, 1874)
        Family Membraniporidae
            Membranipora sp.
        Family Electridae
            Electra crustulenta (Pallas, 1766)
Phylum Phoronida
            Phoronis sp.
Phylum Mollusca
    Class Pelecypoda
        Family Nuculidae
            Nucula proxima Say, 1822
        Family Nuculanidae
            Yoldia limatula (Say, 1831)
        Family Arcidae
            Anadara ovalis (Bruguiere, 1792)
            Anadara transversa (Say, 1822)
        Family Mytidae
            Mytilus edulis Linnaeus, 1785
        Family Leptonidae
            Leptonid

Appendix A Species List (continued)

Phylum Mollusca (continued)
- Family Montacutidae
  - *Aligena elevata* (Stimpson, 1851)
- Family Lucinidae
  - *Lucina multilineata* Tuomey and Holmes, 1857
- Family Veneridae
  - *Gemma gemma* (Totten, 1834)
  - *Mercenaria mercenaria* (Linnaeus, 1758)
  - *Pitar morrhuana* (Linsley, 1848)
- Family Mactridae
  - *Mulinia lateralis* (Say, 1822)
- Family Tellinidae
  - *Macoma mitchilli* Dall, 1895
  - *Macoma balthica* (L., 1758)
  - *Tellina agilis* Stimpson, 1858
- Family Solenidae
  - *Ensis directus* Conrad, 1843
- Family Myacidae
  - *Mya arenaria* (Linnaeus, 1758)
- Family Lyonsiidae
  - *Lyonsia hyalina* Conrad, 1831
- Family Pandoridae
  - *Pandora trilineata* Say, 1822

Class Gastropoda
- Family Caecidae
  - *Caecum pulchelum* Stimpson, 1851
- Family Calyptraeidae
  - *Crepidula plana* Say, 1822
- Family Naticidae
  - *Natica pusilla* Say, 1822
- Family Columbellidae
  - *Anachis translirata* Ravenel, 1861
  - *Mitrella lunata* (Say, 1826)
- Family Melongenidae
  - *Busycon carica* (Gmelin, 1790)
- Family Nassaridae
  - *Nassarius trivittatus* (Say, 1822)
- Family Turridae
  - *Mangelia cerina* Kurtz and Stimpson, 1851
- Family Pyramidellidae
  - *Odostomia impressa* Say, 1822
  - *Odostomia* sp.
  - *Turbonilla interrupta* Totten, 1835
  - *Turbonilla stricta* Verrill, 1874
- Family Acteonidae
  - *Acteon punctostriatus* C. B. Adams, 1840
- Family Retusidae
  - *Retusa canaliculata* (Say, 1822)

Appendix A Species List (continued)

- Phylum Mollusca (continued)
    - Family Scaphandridae
        - *Cylichna alba* Brown, 1827
    - Family Corambidae
        - *Doridella obscura* Verrill, 1870
    - Family Cratenidae
        - *Cratena kaoruae* Marcus, 1957
- Phylum Annelida
    - Class Polychaeta
        - Family Polygordiidae
            - *Polygordius* sp.
        - Family Phyllodocidae
            - *Phyllodoce arenae* Webster, 1879
            - *Phyllodoce mucosa* Oersted, 1843
            - *Paranaitis speciosa* (Webster, 1870)
            - *Eteone heteropoda* Hartman, 1951
        - Family Polynoidae
            - *Lepidametria commensalis* Webster, 1879
            - *Lepidonotus sublevis* Verrill, 1973
            - *Harmothoe extenuata* (Grube, 1840)
            - *Harmothoe* sp. A
        - Family Chrysopetalidae
            - *Bhawania goodei* Webster, 1884
            - *Paleanotus heteroseta* Hartman, 1945
        - Family Glyceridae
            - *Glycera americana* Leidy, 1855
            - *Glycera dibranchiata* Ehlers, 1868
            - *Glycera robusta* Ehlers, 1868
        - Family Goniadidae
            - *Goniadella gracilis* (Verrill, 1873)
            - *Glycinde solitaria* (Webster, 1879)
        - Family Nephtyidae
            - *Nephtys incisa* (Malmgren, 1865)
            - *Nephtys picta* (Ehlers, 1868)
            - *Aglaophamus circinata* (Verrill, 1874)
        - Family Syllidae
            - *Brania wellfleetensis* Pettibone, 1956
            - *Syllis cornuta* Rathke, 1843
            - *Proceraea cornuta* (Agassiz, 1863)
        - Family Hesionidae
            - *Gyptis brevipalpa* (Hartmann-Schröder, 1959)
            - *Podarke obscura* Verrill, 1873
        - Family Pilargidae
            - *Ancistrosyllis hartmanae* Pettibone, 1966
            - *A. jonesi* Pettibone, 1966
            - *Sigambra tentaculata* (Treadwell, 1941)
            - *Sigambra* sp.
            - *Cabira incerta* Webster, 1879
            - *Pilargis* sp. A

Appendix A Species List (continued)

Phylum Annelida (continued)

Family Nereidae
- *Nereis succinea* (Frey and Leuckart, 1847)
- *Websterinereis tridentata* (Webster, 1880)

Family Capitellidae
- Capitellidae sp. A
- Capitellidae sp. B
- *Heteromastus filiformis* (Claparede, 1864)
- *Mediomastus ambiseta* Hartman, 1947
- *Notomastus* sp.

Family Maldanidae sp.
- *Asychis elongata* (Verrill, 1873)
- *Praxillela gracilis* (Sars, 1861)
- *Clymenella torquata* (Leidy, 1855)
- *Clymenella zonalis* (Verrill, 1874)

Family Ophelidae
- *Travisia carnea* (Verrill, 1873)

Family Spionidae
- *Spio filicornis* (O. F. Muller, 1766)
- *Spio setosa* (Verrill, 1873)
- *Scolecolepides viridis* (Verrill, 1873)
- *Prionospio cirrifera* Wirén, 1883
- *Prionospio pygmaea* Hartman, 1961
- *Prionospio cirrobranchiata* Day, 1961
- *Paraprionospio pinnata* (Ehlers, 1901)
- *Polydora ligni* Webster, 1879
- *Polydora socialis* (Schmarda, 1861)
- *Streblospio benedicti* Webster, 1879
- *Spiophanes bombyx* (Claparede, 1870)
- *Spiophanes wigelyi* Pettibone, 1962

Family Paraonidae
- *Aricidea fragilis* McIntosh, 1885
- *Aricidea wassi* Pettibone, 1965
- *Aricidea catherinae* Laubier, 1967
- *Aricidea suecica* Eliason, 1920

Family Chaetopteridae
- *Chaetopterus variopedatus* (Renier, 1804)
- *Spiochaetopterus oculatus* (Gitay, 1969)

Family Sabellaridae
- *Sabellaria vulgaris* Verrill, 1873

Family Onuphidae
- *Onuphis eremita* Audouin and Milne-Edwards, 1833
- *Diopatra cuprea* (Bosc, 1802)

Family Eunicidae
- *Marphysa sanguinea* (Montagu, 1815)

Family Arabellidae
- *Arabella iricolor* (Montagu, 1804)
- *Drilonereis longa* Webster, 1879
- *Drilonereis magna* Webster and Benedict, 1887

Appendix A Species List (continued)

- Phylum Annelida (continued)
  - Family Amphinomidae
    - *Pseudeurythoe ambigua* (Monro, 1933)
  - Family Magelonidae
    - *Magelona* sp.
    - *Magelona rosea* Moore, 1907
  - Family Orbiniidae
    - *Scoloplos rubra* (Webster, 1879)
    - *Scoloplos robustus* Verrill, 1873
    - *Scoloplos foliosus* Hartman, 1951
    - *Scoloplos acutus* (Verrill, 1873)
    - *Scoloplos fragilis* (Verrill, 1873)
  - Family Cirraculidae
    - *Cirratulus grandis* Verrill, 1873
    - *Tharyx* sp.
  - Family Oweniidae
    - *Owenia fusiformis* (Delle Chiaje, 1844)
  - Family Pectinariidae
    - *Pectinaria gouldii* (Verrill, 1873)
  - Family Ampharetidae
    - *Asabellides oculata* (Webster, 1879)
  - Family Terebellidae
    - *Amphitrite ornata* (Leidy, 1855)
    - *Loimia medusa* (Savigny, 1818)
    - *Polycirrus eximius* (Leidy, 1855)
  - Family Sabellidae
    - *Sabella microphthalma* Verrill, 1873
  - Class Oligochaete
    - Oligochaete sp.
- Phylum Arthropoda
  - Subclass Ostracoda
    - Ostracod sp.
  - Subclass Malacastraca
    - Order Cumacea
      - Family Leuconidae
        - *Leucon americanus* Zimmer, 1943
      - Family Diastylidae
        - *Oxyurostylis smithi* Calman, 1912
    - Order Isopoda
      - Family Anthuridae
        - *Cyathura polita* (Stimpson, 1855)
        - *Ptilanthura tenuis* (Harger, 1880)
      - Family Idoteidae
        - *Chiridotea caeca* (Say, 1818)
        - *Edotea triloba* (Say, 1818)
        - *Erichsonella filiformis* (Say, 1818)
    - Order Amphipoda
      - Family Ampeliscidae
        - *Ampelisca abdita* Mills, 1964
        - *Ampelisca vadorum* Mills, 1963
        - *Ampelisca verrilli* Mills, 1967

Appendix A Species List (continued)

Phylum Arthropoda (continued)

- Family Corophiidae
  - *Corophium tuberculatum* Shoemaker, 1934
  - *Erichthonius brasiliensis* Dana, 1855
  - *Unciola irrorata* Say, 1818
  - *Unciola serrata* Shoemaker, 1945
  - *Unciola dissimilis* Shoemaker, 1942
- Family Gammaridae
  - *Gammarus mucronatus* Say, 1818
  - *Elasmopus laevis* Smith, 1873
  - *Melita nitida* Smith, 1873
- Family Lilljeborgiidae
  - *Idunella* sp.
  - *Listriella clymenellae* Mills, 1962
- Family Oediarotidae
  - *Monoculodes edwardsi* Holmes, 1903
- Family Photidae
  - *Photis dentata* Shoemaker, 1945
  - *Leptocheirus plumulosus* Shoemaker, 1932
- Family Phoxocephalidae
  - *Trichophoxus epistomus* Bousfield, 1973
- Family Pleustidae
  - *Pleusymtes glaber* (Boeck, 1861)
- Family Stenothoidae
  - *Parametopella cypris* (Holmes, 1903)
- Family Caprellidae
  - *Caprella penantis* Leach, 1814
  - *Paracaprella tenuis* Mayer, 1903

Order Mysidacea

- Family Mysidae
  - *Neomysis americana* (S. I. Smith, 1873)

Order Decapoda

- Family Ogyrides
  - *Ogyrides limicola* Williams, 1955
- Family Crangonidae
  - *Crangon septemspinosa* (Say, 1818)
- Family Upogebiidae
  - *Upogebia affinis* (Say, 1818)
- Family Callianassidae
  - *Callianassa atlantica* Rathbun, 1926
- Family Paguridae
  - *Pagurus longicarpus* Say, 1817
- Family Majidae
  - *Libinia dubia* H. Milne-Edwards, 1834
- Family Xanthidae
  - *Neopanope texana sayi* (Smith, 1869)
- Family Pinnotheridae
  - *Pinnixa retinens* Rathbun, 1918
  - *Pinnixa chaetopterana* Stimpson, 1860

Appendix A Species List (concluded)

Phylum Echinodermata
Class Ophiuroidea
Family Ophiodermatidae
Micropholis atra (Stimpson, 1852)
Class Holothuroidea
Family Cucumariidae
Thyone briareus (LeSueur, 1824)
Phylum Chordata
Class Ascidiacea
Family Botryllidae
Botryllus schlosseri (Pallas, 1766)
Family Molgulidae
Molgula manhattensis (DeKay, 1843)

Appendix B

Species and Abundance data for each station collected during the 9/78, 4/79, and 6/79 sampling cruises

Station 26 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
	Box core section (cm)								
Mollusca									
Mulinia lateralis	8								
Retusa canaliculata	1								
Crustacea									
Ampelisca abdita	86	1*							
Edotea triloba	2								
Leucon americanus	86	1*							
Polychaeta									
Glycinde solitaria	2								
Loimia medusa	1								
Nereis succinea	3								
Paranaitis speciosa	1								
Paraprionospio pinnata	7								

* contamination from surface

Station 27 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30
Mollusca						
Retusa canaliculata	6					
Crustacea						
Ampelisca abdita	2				1*	
Listriella clymenellae		1		1		
Polychaeta						
Ancistrosyllis hartmanae				1		
Clymenella torquata			2			
Glycera dibranchiata		1		1		
Glycinde solitaria	1					
Paraprionospio pinnata	5					
Pseudoeurythoe ambigua	1		4	6		
Spiophanes sp.	1					
Spionidae		1				
Phoronida						
Phoronis sp.		1				

* contamination from surface

Station 28 9-78

Taxon	0-5	5-10	10-15	15-20	20-28
Mollusca					
Anadara transversa	2				
Crustacea					
Pinnixa retinens	1				
Polychaeta					
Chaetopterus variopedatus	1				
Clymenella torquata		1			
Glycera dibranchiata					1
Glycinde solitaria	1	1			
Maldanidae sp.					1
Nereis succinea	3				
Paraprionospio pinnata		6			
Pseudoeurythoe ambigua		1	1	9	19
Phoronida					
Phoronis sp.	2				

Station 29 9-78

Taxon	0-5	5-10	10-15	15-20
Nemertea				
Cerebratulus lacteus	1		1	
Mollusca				
Ensis directus	1			
Mulinia lateralis	2			
Odostomia impressa	1			
Retusa canaliculata	4			
Crustacea				
Ampelisca abdita	5	2*		
Ampelisca verrilli	6	3*		
Cyanthura polita	1			
Ostracod	2			
Polychaeta				
Ancistrosyllis hartmanae			1	
Drilonereis longa		1		
Glycera dibranchiata	5		1	
Loimia medusa	1			
Orbiniidae sp.		2		
Pseudoeurythoe ambigua			2	1
Scoloplos rubra			2	
Terebellidae sp.	1			
Tharyx sp.	1			
Phoronida				
Phoronis sp.			5	

* contamination from surface

Station 30 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30
Mollusca						
Acteon punctostriatus	1					
Bivalve sp.	1					
Crustacea						
Ampelisca abdita	3,080	6*	6*	3*		
Edotea triloba	19					
Leucon americanus	5					
Melita nitida	1					
Neomysis americana	1					
Ostracod	3					
Polychaeta						
Glycinde solitaria	2					
Loimia medusa	2	1				
Nereis succinea	25	1				
Paraprionospio pinnata	1					

* contamination from surface

Station 31

Taxon	0-5	5-10	10-15
Polychaeta			
Prionospio sp.			1*
Pseudoeurythoe ambigua			1*

* contamination from surface

Station 32 9-78

Taxon	0-5	5-10	10-15	15-20
Mollusca				
Anadara transversa	2		1*	
Retusa canaliculata	1			
Crustacea				
Ampelisca abdita	7			
Leucon americanus	1			
Listriella clymenellae	1		1	
Ostracod	1			
Polychaeta				
Clymenella sp.		1		
Glycera dibranchiata	1			
Orbiniidae sp.	1			
Paraprionospio pinnata	3			
Pectinaria gouldii	2	1	1*	
Praxillela gracilis			1	
Pseudoeurythoe ambigua		1		
Sigambra tentaculata				1

* contamination from surface

Station 33 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Crustacea								
Unciola irrorata							3*	
Polychaeta								
Nereis succinea	2							
Pseudoeurythoe ambigua		1						

* contamination from surface.

Station 34 9-78

Taxon	0-5	5-10	10-15	15-21
Mollusca				
Odostomia sp.	1			
Retusa canaliculata	5			
Crustacea				
Neomysis americana	1			
Pinixa retinens				1
Polychaeta				
Ancistrosyllis sp.			1	
Glycinde solitaria	5			
Maldanidae sp.	1			
Nereis succinea	1	1		
Orbiniidae sp.	1			
Paraprionospio pinnata	12	5	1	
Pseudoeurythoe ambigua	1			

Station 35 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30	30-38
Mollusca							
Anachis translirata	1						
Anadara transversa	2						
Retusa canaliculata	6	1*					
Turbonilla interrupta	1						
Crustacea							
Ampelisca abdita	20	1*					
Corophium sp.	1						
Listriella clymenellae	1						
Neomysis americana		1*					
Ostracod	2						
Pinnixa chaetopterana			1				
P. retinens				1			
Polychaeta							
Clymenella torquata		3		1			
Glycera americana		1					
Goniadidae sp.	1						
Harmothoe sp. A		1					
Nephtyidae sp.	1						
Notomastus sp.	1						
Paleanotus heteroseta		1					
Paraprionospio pinnata	2						
Pectinaria gouldii	5	1					
Pseudoeurythoe ambigua		1			2		1
Echinodermata							
Microphiolis atra			1				

* contamination from surface

Station 36 9-78

Taxon	0-5	5-10	10-15	15-20
Mollusca				
Anadara transversa	76			
Retusa canaliculata	3			1*
Turbonilla interrupta	1			
Crustacea				
Ampelisca abdita	5			
Ampelisca vadorum	3			
Ampelisca verrilli	5	4		
Corophium tuberculatum	3			
Edotea triloba	1			
Ostracod	3			
Polychaeta				
Ampharetidae		1		
Cirratulidae sp.			2	
Nephtyidae sp.			1	
Nereis succinea	8			
Paraprionospio pinnata	1			
Pectinaria gouldii	1			
Polygordius sp.		1		
Pseudoeurythoe ambigua		1	1	1
Sabellaria vulgaris	16			
Tharyx sp.		3		
Ascidacea				
Molgula manhattensis	9			

* contamination from surface

Station 37 9-78

Taxon	0-5	5-10	10-18.5
Mollusca			
Mulinia lateralis	2		
Crustacea			
Neomysis americana	6	1*	
Polychaeta			
Ampharetidae sp.		1	1
Ancistrosyllis hartmanae			1
A. jonesi			1
Bhawansa goodesi			1
Drilonereis longa			1
Glycera dibranchiata	1	1	
Paraprionospio pinnata	3		
Pseudoeurythoe ambigua		4	2
Phoronida			
Phoronis sp.	1		

* contamination from surface

Station 38 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-51
Mollusca									
Mulinia lateralis	2								
Crustacea									
Ostracod sp.		1*							
Polychaeta									
Glycera americana			1						
Glycinde solitaria	1								
Loimia medusa	1	1							
Paleonotus heteroseta	1								
Paraprionospio pinnata	1	8	3						
Pectinaria gouldii	5	3							
Pseudoeurythoe ambigua				1					

Station 39 9-78

Taxon	0-5	5-10	10-15	15-20
Mollusca				
Turbonilla interrupta	1			
Crustacea				
Ampelisca verrilli	2			
Callianassa atlantica				1
Pinnixa chaetopterana	1		1	
Pinnotheridae sp.			1	
Ptilanthura tenuis	3			
Trichophoxus epistomus	2	1*	1*	
Polychaeta				
Arabellidae sp.			1	
Cirratulidae sp.			1	
Glycera dibranchiata		1		
Glycera sp.	1	1	1	
Nephtys sp.	2			
Orbiniidae sp.	1			
Paleanotus heteroseta		1		
Paraonidae			1	
Phyllodocidae	1			
Pseudoeurythoe ambigua		1		
Echinodermata				
Micropholis atra				1

* contamination from surface

Station 40 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-33
Mollusca						
Acteon punctostriatus	1					
Anadara transversa	1		1*			
Busycon carica	1					
Ensis directus		1				
Odostomia impressa	1					
Retusa canaliculata	6					
Crustacea						
Ampelisca verrilli	1					
Anthuridae sp.					1*	
Listriella clymenellae			1		1	
Pinnotheridae sp.	1					
Unciola irrorata	1					
Polychaeta						
Amphinomidae sp.	1					
Capitellidae			1			
Glycera americana	1		1			
Harmothoe sp. A			1			
Maldanidae sp.	1		1	2	1	1
Nereis succinea	1					
Paleanotus heteroseta			1			
Phyllodocidae			1			
Pseudeurythoe ambigua	2		11	2	1	
Sabellaria vulgaris	5					
Echinodermata						
Micropholis atra			1			
Phoronida						
Phoronis sp.		1				
Ascidacea						
Molgula manhattensis	1					

* contamination from surface

Station 41   9-78

Taxon	0-5	5-10	10-15	15-20	20-24
Mollusca					
Anadara transversa	11			2*	
Odostomia sp.	1				
Crustacea					
Ampeliscidae sp.	1				
Polychaeta					
Ancistrosyllis sp.			1		
Heteromastus filiformis			1		
Maldanidae sp.				1	
Nereis succinea	6				
Paleanotus heteroseta	1				
Paraprionospio pinnata	1				
Pectinaria gouldii	4				
Pseudoeurythoe ambigua	2	1	1	1	1
Sabellaria vulgaris	4				
Spionidae sp.	1				

* contamination from surface

Station 42 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30	30-36
Mollusca							
Anadara transversa	1						
Mulinia lateralis	1						
Yoldia limatula	1						
Polychaeta							
Glycera americana					1		
Maldanidae	3	1	1	1			
Nephtys picta	4						
Nereidae			1				
Paleanotus heteroseta		2		1			
Phyllodocidae	1						
Pilargidae				1			
Pilargis sp. A			1				
Pseudoeurythoe ambigua			1	1			
Sigambra sp.	1						

Station 43   9-78

Taxon	0-5	5-10	10-15	15-20	20-24
Mollusca					
Aligena elevata	1				
Nucula proxima	1				
Retusa canaliculata	1				
Yoldia limatula	1				
Polychaeta					
Capitellidae sp.	1				
Harmothoe sp. A		1			
Maldanidae sp.		1			
Nephtys sp.	2	1			
Orbiniidae sp.			1		
Paleanotus heteroseta		1			
Paraprionospio pinnata	3				
Pilargidae sp.			1		
Praxillella gracilis	1				
Pseudoeurythoe ambigua		1	1		1
Sigambra tentaculata				1	
Echinodermata					
Micropholis atra		1			

Station 44 9-78

Taxon	0-5	5-10	10-13
Mollusca			
Acteon punctostriatus	2		
Mangelia cerina	1		
Mulinia lateralis	6		
Natica pusilla	1		
Retusa canaliculata	57		
Tellina agilis	2		
Turbonilla interrupta	1		
Crustacea			
Neomysis americana	1		
Ostracod	1		
Oxyurostylis smithi	2		
Polychaeta			
Arabellidae		1	
Glycera dibranchiata	1	2	
Glycera sp.	7		1
Glycinde solitaria	1		
Maldanidae	1		

Station 45 9-78

Taxon	0-5	5-10	10-15	15-20	20-27
Mollusca					
Busycon carica	1				
Polychaeta					
Ampharetidae sp.	1				
Glycera americana		1			
Pseudoeurythoe ambigua	4	3	1		2
Scoloplos robustus			1		
Tharyx sp.			1		
Phoronida					
Phoronis sp.	1				

Station 46 9-78

Taxon	0-5	5-10	10-18
Mollusca			
Odostomia sp.	1		
Pitar morrhuana	1		
Retusa canaliculata	1		
Tellina agilis	1		
Turbonilla interrupta	6		1*
Yoldia limatula	1		
Crustacea			
Ampelisca abdita	7		
Libinia dubia	1		
Paguridae sp.	1		
Unciola serrata			1*
Upogebia affinis	1		
Polychaeta			
Glycera americana			1
Glycinde solitaria	1		
Glycinde sp.	2		
Heteromastus filiformis		1	
Asychis elongata	1		
Paleanotus heteroseta	2		
Pectinaria gouldii	1	1	
Pseudoeurythoe ambigua	1	1	1
Nemertea			
Cerebratulus lacteus		1	
Phoronida			
Phoronis sp.	1		
Echinodermata			
Micropholis atra	1		

* Contamination from surface

Station 47 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30	30-38
Mollusca							
Retusa canaliculata	11						
Tellina agilis	1						
Turbonilla stricta	1						
Crustacea							
Ampelisca abdita	1						
Ostracod sp.	1						
Oxyurostylis smithi	1						
Pinnixa chaetopterana	1	1					
Polychaeta							
Aglaophamus circinata	2						
Glycinde solitaria	1						
Goniadidae sp.			1				
Maldanidae sp.		1					2
Orbiniidae sp.	1						
Paraprionospio pinnata	2	1					
Spionidae sp.	1						
Tharyx sp.	1						
Terebellidae sp.					1		
Phoronida							
Phoronis	1						

Station 48 9-78

Taxon	0-5	5-10	10-18
Mollusca			
Mulinia lateralis	2		
Odostomia sp.	1		
Retusa canaliculata	20		
Tellina agilis	1		
Crustacea			
Ostracod sp.	1		
Polychaeta			
Glycinde solitaria	3	1	
Loimia medusa	3		
Paraprionospio pinnata	7	1	
Pseudoeurythoe ambigua			2

Station 49 9-78

Taxon	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-5
Mollusca											
Acteon punctostriatus									1*		
Cylichna alba	3										
Macoma balthica	1	1									
Mulinia lateralis	1										
Retusa canaliculata	5										
Yoldia limatula	1										
Crustacea											
Ampelisca abdita	1										
Listriella clymenellae		1									
Upogebia affinis		1						1			
Polychaeta											
Aricidea fragilis					1	1					
Glycinde solitaria		1									
Maldanidae sp.			1								
Paleanotus heteroseta	1										
Paraprionospio pinnata	3	1									
Tharyx sp.	1										
Phoronida											
Phoronis sp.		1					1*				

* contamination from surface

Station 50 9-78

Taxon	0-5	5-10	10-15	15-22
Mollusca				
Tellina agilis	3			
Polychaeta				
Arabellidae sp.	1	1	1	2
Cirratulidae sp.	1			
Drilonereis longa		2		1
Glycera dibranchiata	1			
G. robusta	2			
G. sp.		1		
Magelona sp.		1		
Orbiniidae sp.	1			
Pseudoeurythoe ambigua				1
Scoloplos rubra			1	
Spionidae sp.		1		

Station 76 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40
Platyhelminthes								
Turbellaria sp.	(a)**	5		1				
Nemertea								
Amphiporus bioocculatus		41		1				
Amphiporus sp.		3						
Cerebratulus lacteus	(b)			1				
Mollusca								
Macoma balthica	(c)	20		4				
Mulinia lateralis	(d)	15						
Mya arenaria	(e)	24						
Odostomia sp.	(f)	6						
Tellinidae sp.		2						
Crustacea								
Ampelisca abdita	(g)	1106	15	15*	21*	9*	1*	3*
Edotea triloba	(h)	3						
Gammarus mucronatus	(i)	130	1	3*	4*	1*		
Leucon americanus	(j)	4						
Melita nitida	(k)	103	5	3*	2*			
Polychaeta								
Eteone heteropoda	(l)			3				
Glycera americana		1						
Glycera dibranchiata	(m)					1		
Glycinde solitaria	(n)	84						
Heteromastus filiformis	(o)	13		3				
Mediomastus ambiseta	(v)	2		2				
Nereis succinea	(p)	270	3	3	1	2		
Paraprionospio pinnata	(q)	5						
Pectinaria gouldii	(r)	58	1	1*		1*		
Polydora ligni	(s)	141						
Scolecolepides viridis	(t)	2						
Scoloplos fragilis		2	1					
Streblospio benedicti	(u)	305	1	10*	6*			
Oligochaeta sp.		5	1					
dead Hydroid mat (m)				p				

* contamination from surface

**letters refer to drawings in Appendix C

Station 77 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30
Ectoprocta							
Membranipora sp.		P					
Mollusca							
Anadara transversa	(a)	1					
Lyonsia hyalina	(b)	1					
Macoma balthica	(c)		1				
Mulinia lateralis	(d)	16					
Mya arenaria	(e)					1*	1*
Odostomia sp.	(f)	1					
Crustacea							
Ampelisca abdita	(g)	3		1*			
Crangon septemspinosa	(h)	1					
Polychaeta							
Ancistrosyllis jonesi	(i)		1				
Clymenella torquata	(j)				1		
Eteone heteropoda	(k)		1		1*		
Glycera americana	(l)		1			1	
Harmothoe extenuata							1*
Hesionidae sp.							1*
Nereis succinea	(m)	14	2				1
Pectinaria gouldii	(n)	14	1				1*
Polydora ligni		2	1	1*			
Pseudeurythoe ambigua	(p)	2	1	3	6	14	6
Sigambra tentaculata	(q)						1
Streblospio benedicti	(r)	17	7	1			
Oligochaeta sp.			1				

* contamination from surface

Station 78   6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40
Nemertea								
Amphiporus bioculatus	(a)	6						
Amphiporus sp.		2						
Mollusca								
Macoma balthica	(b)	8	7					
Mulinia lateralis	(c)	10						
Mya arenaria	(d)	6						
Odostomia sp.	(e)	2						
Retusa canaliculata	(f)	1						
Crustacea								
Ampelisca abdita	(g)	1837	62	30*	17*	6*	2*	3*
Edotea triloba	(h)	12	1		1*			
Gammarus mucronatus	(i)	28	1	2*				
Leucon americanus	(j)	345	3	3*	1*			
Melita nitida	(k)	73	2					
Polychaeta								
Asabellides oculata	(l)	1						
Capitellidae sp.		5	2	1				
Eteone heteropoda	(m)	42	1					
Heteromastus filiformis	(n)	7	2				1	
Mediomastus ambiseta	(o)	4		1				
Nereis succinea	(p)	55	5					
Paraprionospio pinnata	(q)	10	2					
Pectinaria gouldii	(r)	21	1				1*	
Polydora ligni	(s)	8		1				
Scoloplos fragilis	(t)	1						
Streblospio benedicti	(u)	425	9	13*	3*			1*
Oligochaeta sp.		1						

* contamination from surface

Station 79 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40
Mollusca								
Macoma balthica	(a)	1	1					
M. mitchilli	(b)	1						
Mulinia lateralis	(c)	6	1					
Retusa canaliculata	(d)	1						
Crustacea								
Ampelisca abdita	(e)	2						
Polychaeta								
Ancistrosyllis jonesi	(f)		1					
Asabellides oculata	(g)	2						
Eteone heteropoda	(h)	12		1*				
Glycinde solitaria	(i)	10	1					
Nereis succinea	(j)	4		1				
Paraprionospio pinnata	(k)	11	14	5	1			
Pectinaria gouldii	(l)				1*			
Pseudeurythoe ambigua	(m)	3	10					
Scoloplos acutus	(n)	2						
Sigambra tentaculata	(o)				1			
Streblospio benedicti	(p)	55		1				
Oligochaeta sp.		2						

* contamination from surface

Station 80 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Platyhelminthes									
Turbellaria sp.	(a)	1							
Nemertea									
<u>Cerebratulus lacteus</u>	(b)	1	2						
Mollusca									
<u>Macoma balthica</u>	(c)	7	9						
<u>Mulinia lateralis</u>	(d)	27	2		1*				
Crustacea									
<u>Ampelisca abdita</u>	(e)	80	2	8*	4*				
Polychaeta									
<u>Eteone heteropoda</u>	(f)	7							
<u>Glycera dibranchiata</u>	(g)		1						
Glyceridae sp.		1							
<u>Glycinde solitaria</u>	(h)	1							
<u>Heteromastus filiformis</u>	(i)	9	26	7					
<u>Nereis succinea</u>	(k)	14							
<u>Paraprionospio pinnata</u>	(l)	15							
<u>Pectinaria gouldii</u>	(m)	64	1		3*				
<u>Pseudeurythoe ambigua</u>	(n)		1						
<u>Scolecolepides viridis</u>	(o)	1							
<u>Scoloplos fragilis</u>	(p)	2	2						
<u>Streblospio benedicti</u>	(q)	198	1	2*	2*				
Oligochaeta sp.		4	3						

r - dead hydroid mat

Station 81 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Platyhelminthes									
Turbellaria sp.	(a)	2	9	1	1*				
Nemertea									
Amphiporus bioculatus	(b)	1							
Nemertea sp.						1			
Mollusca									
Lyonsia hyalina	(c)	1							
Mulinia lateralis	(d)	19							
Mya arenaria	(e)	1							
Retusa canaliculata	(f)	2							
Crustacea									
Ampelisca abdita	(g)	1							
Edotea triloba		1				1*			
Leucon americanus	(h)	6		1*					
Polychaeta									
Eteone heteropoda	(i)	41		2*					
Glycinde solitaria	(j)	1		1					
Gyptis brevipalpa			1						
Heteromastus filiformis	(k)		2						
Loimia medusa	(l)		1	3		1			
Nereis succinea	(m)	3							
Paraprionospio pinnata	(n)	2					1*		
Pectinaria gouldii	(o)	665	12	15	9*	1*	1*		
Polydora ligni	(p)	1	2						
Pseudeurythoe ambigua	(q)		7	10					
Scoloplos fragilis	(r)		5						
Streblospio benedicti	(s)	8							
Oligochaeta sp.	(t)	5	6						

* contamination from surface

Station 82 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30
Mollusca							
Ensis directus	(a)	1					
Macoma balthica	(b)	1					
Mulinia lateralis	(c)	3					
Mytilus edulis	(d)	2					
Crustacea							
Ampelisca abdita	(e)	9					
Gammarus mucronatus	(f)	3					
Polychaeta							
Asabellides oculata	(g)	2					
Eteone heteropoda	(h)	3					
Heteromastus filiformis	(i)	3					
Nereis succinea	(j)	2	1				
Paraprionospio pinnata	(k)	1		1			
Pectinaria gouldii	(l)	18					
Polydora ligni	(m)	1					
Streblospio benedicti	(n)	152	1				

Station 83 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30
Nemertea							
Cerebratulus lacteus	(a)			1			
Mollusca							
Macoma balthica	(b)		2	2			
M. mitchelli	(c)	1		2			
Mulinia lateralis	(d)	24	1				
Mya arenaria	(e)						
Crustacea							
Ampelisca abdita	(f)	12					
Leptocheirus plumulosus	(g)	1					
Polychaeta							
Eteone heteropoda	(h)	2					
Glycinde solitaria	(i)	2	3	3			
Heteromastus filiformis	(j)				1		1
Loimia medusa	(k)		1	1			
Mediomastus ambiseta	(l)	23					
Nereis succinea	(m)	2	1	1	1	1	
Paraprionospio pinnata	(n)	1	9	13	2		
Pectinaria gouldii	(o)	33					
Polydora ligni		2					
Pseudeurythoe ambigua	(p)			1			
Streblospio benedicti	(q)	120	7	1			

Station 84 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40
Nemertea								
Cerebratulus lacteus	(a)	1						
Nemertea frag.		2						
Mollusca								
Acteon punctostriatus		1						
Cratena kaoruae	(c)	3						
Ensis directus	(d)	1	1					
Lyonsia hyalina	(e)	53	7					
Mulinia lateralis	(f)	421	14	8*	1*	1*	3*	
Mya arenaria	(g)	4						
Retusa canaliculata	(h)	5	2*	1*				
Crustacea								
Ampelisca abdita	(i)	53	2					
Corophium tuberculatum	(j)	5						
Leucon americanus	(k)	1	1					
Listriella clymenellae	(l)		1					
Oxyurostylis smithi	(m)	1						
Paracaprella tenuis	(n)	2						
Polychaeta								
Asabellides oculata	(o)	30						
Clymenella torquata	(p)	1	1					
Eteone heteropoda	(q)	36					1*	
Glycinde solitaria	(r)	13						
Mediomastus ambiseta	(s)	140		1				
Nereis succinea	(t)	26	5					
Paraprionospio pinnata	(u)	8	19	4		1*		
Pectinaria gouldii	(v)	163	15	4	3*	2*		
Polydora ligni	(w)	3						
Pseudeurythoe ambigua	(x)		3	4	1	3		
Scoloplos fragilis	(y)	1	1	2				
Sigambra tentaculata	(z)	1	1		2	2	1	
Streblospio benedicti	(aa)	229	5	3*			1*	
Tharyx sp.	(bb)		1					
Phoronida								
Phoronis sp.	(cc)	1						

* contamination from surface

(b) *Cerianthus americanus* in dissecting core

Station 85 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Nemertea									
Amphiporus bioculatus	(a)		1						
Mollusca									
Mulinia lateralis	(b)	69		1*					
Retusa canaliculata	(c)	9							
Crustacea									
Ampelisca abdita	(d)	22							
Crangon septemspinosa	(e)	1							
Polychaeta									
Eteone heteropoda	(f)	26	3						
Glycera americana	(g)						1		
Glycinde solitaria	(h)	2							
Paraprionospio pinnata	(i)	1	1						
Pectinaria gouldii	(j)	45	2						
Polydora ligni	(k)						1*		
Pseudeurythoe ambigua	(l)		1	1					
Scoloplos fragilis	(m)	1	3	3					
Sigambra tentaculata	(n)			4					
Streblospio benedicti	(o)	11	1	1					
Oligochaeta sp.	(p)	2	2						

* contamination from surface

Station 86 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30
Mollusca							
Mulinia lateralis	(a)	8	2				
Crustacea							
Leucon americanus	(b)	2					
Polychaeta							
Eteone heteropoda	(c)	10					
Pectinaria gouldii	(d)	3	1				
Streblospio benedicti	(e)	22	2				

Station 87 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-45
Platyhelminthes								
Turbellaria sp.	(a)	2		1				
Mollusca								
Acteon punctostriatus		1						
Ensis directus	(b)	6	1					
Lyonsia hyalina	(c)	18	4					
Mya arenaria	(d)	4						
Mulinia lateralis	(e)	1107	44	19*				
Odostomia sp.	(f)	11	1					
Retusa canaliculata	(g)	7	1					
Crustacea								
Ampelisca abdita	(h)	1						
Leucon americanus	(i)	4						
Polychaeta								
Asabellides oculata	(j)	3						
Cabira incerta	(k)			1				
Eteone heteropoda	(l)	10	1					
Glycera americana	(m)		1					
Glycinde solitaria	(n)	7	1					
Lepidametria commensalis	(o)		1					
Loimia medusa	(p)		2					
Mediomastus ambiseta	(q)	50						
Nereis succinea	(r)	1						
Paraprionospio pinnata	(s)	17	39	9	1			
Pectinaria gouldii	(t)	628	39	12	1*	3*		
Polydora ligni	(u)	1						
Scoloplos fragilis	(v)	1	1	3	1			
Sigambra tentaculata	(w)		9	6	3			
Streblospio benedicti	(x)	84	4	1*				

* contamination from surface

Station 88 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Nemertea									
Tubulanus pellucidus	(a)	1	1						
Mollusca									
Aligena elevata	(b)					1			
Ensis directus	(d)	3	2						
Lyonsia hyalina	(e)	11							
Mulinia lateralis	(f)	161	4	1*					
Mya arenaria	(g)	1							
Retusa canaliculata	(h)	2							
Tellina agilis	(i)	1							
Turbonilla interrupta	(j)	2							
Yoldia limatula	(k)	1							
Crustacea									
Ampelisca abdita	(l)	10							
Corophium tuberculatum	(m)	9	3	1*				2*	
Crangon septemspinosa	(n)	3							
Erichthonius brasiliensis	(o)	10					1*	1*	
Leucon americanus	(p)	11							
Listriella clymenellae	(q)	4	1		2				
Ogyrides limicola	(r)	1							
Paracaprella tenuis	(s)	4	1					1*	
Photis dentata	(t)		1						
Polychaeta									
Asabellides oculata	(u)	5							
Asychis elongata	(v)								1
Clymenella torquata	(w)	4	2			2	1		
Eteone heteropoda	(x)	3							
Glycera americana	(y)					1			
Glyceridae sp.									1
Glycinde solitaria	(z)	7		1					
Gyptis brevipalpa	(aa)			1		1			
Heteromastus filiformis	(bb)			1					
Mediomastus ambiseta	(cc)	42	2						
Nereis succinea	(dd)	2							
Paraprionospio pinnata	(ee)	28	37	7	2				
Pectinaria gouldii	(ff)	142	2						
Polydora ligni	(gg)	8							
Prionospio cirrifera	(hh)		1						
Pseudeurythoe ambigua	(ii)	17	1	1	12	3			
Scoloplos fragilis	(jj)	2							
Sigambra tentaculata	(kk)	2			4	1			
Streblospio benedicti	(ll)	132							
Tharyx sp.	(mm)		1	1					

Station 88 6-79 (continued)

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Ascidiacea									
Molgula manhattensis	(nn)	1							

* contamination from surface

Station 89 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30
Nemertea							
Tubulanus pellucidus	(a)	1	1	1			
Ectoprocta							
Membranipora sp.		P					
Mollusca							
Aligena elevata	(b)	5	5	1			2
Anadara transversa	(c)	16		1*	2*		3*
Ensis directus	(d)	1					
Lyonsia hyalina	(e)	9					2*
Mitrella lunata		1					
Mulinia lateralis	(f)	5					
Mya arenaria	(g)	1					
Nucula proxima		1					
Retusa canaliculata	(h)	16	1				
Tellina agilis	(i)	3	1				
Turbonilla interrupta	(j)	9					
Yoldia limatula	(k)	6					
Crustacea							
Ampelisca abdita	(l)	26	2	2*		6*	2*
Ampelisca vadorum		1					
Ampelisca verrilli	(m)	1					
Caprella penantis	(n)	63	25*	11*	15*	10*	33*
Corophium tuberculatum	(o)						2*
Edotea triloba	(p)	5	1*	1*			
Erichthonius brasiliensis	(q)	2	6	1*		1*	1*
Erichsonella filiformis			1			1*	
Gammarus mucronatus	(r)			1*			1*
Listriella clymenellae	(s)	7	7	3	4		
Ostracod sp.		1					
Polychaeta							
Arabella iricolor	(t)						1
Arabellidae sp.						1	
Asabellides oculata	(u)	3					
Bhawania goodei	(v)		3	2		1	
Cabira incerta	(w)		1		1		
Capitellidae sp.							1
Clymenella torquata	(x)	80	51	11	5	4	5
Clymenella zonalis	(y)	19	8	3	3	1	
Glycera americana	(z)	1	5		1		
Glycinde solitaria	(aa)	1	1				1*

Station 89 6-79 (continued)

Taxon		0-2	2-5	5-10	10-15	15-20	20-30
Polychaeta (continued)							
Gyptis brevipalpa	(bb)	1	2				
Harmothoe extenuata	(cc)				1		
Heteromastus filiformis	(dd)	62	39	7	1	2	1
Maldanidae sp.			3	5		1	1
Mediomastus ambiseta	(ee)	34	24	1			
Nereis succinea	(ff)	3			1		2
Owenia fusiformis	(gg)	1					
Paranaitis speciosa	(hh)	2					
Paraprionospio pinnata	(ii)	8	2				2*
Pectinaria gouldi		287	15	10	6*	2*	2*
Phyllodoce mucosa	(jj)	1					
Polydora ligni	(kk)	37	1		1*	1*	8*
Prionospio cirrifera			1				
Pseudeurythoe ambigua	(mm)	37	128	30	33	34	38
Sabellaria vulgaris	(nn)	6	7*	1*	7*	7*	13*
Sigambra tentaculata	(oo)	1	5	2		1	2
Streblospio benedicti		233	33	4*			
Tharyx sp.				3			
Oligochaete sp.		6	5				
Phoronida							
Phoronis sp.			4				
Ascidiacea							
Molgula manhattensis		2					

* contamination from surface

Station 90 6-79

Taxon		0-5	5-10	10-18
Nemertea				
Cerebratulus lacteus	(a)		1	
Phoronida				
Phoronis sp.	(b)	1		
Mollusca				
Aligena elevata	(c)	4		1
Ensis directus	(d)	19	9	2
Lyonsia hyalina	(e)	9		
Mulinia lateralis	(f)	27	4	
Mya arenaria	(g)	2		
Tellina agilis	(h)	3	1	1
Crustacea				
Ampelisca abdita	(i)	1		
Chiridotea caeca	(j)	1		
Erichthonius brasiliensis	(k)	1		
Monoculodes edwardsi	(l)	5	1	
Oxyurostylis smithi	(m)	5		1*
Trichophoxus epistomus	(n)	1		
Polychaeta				
Asabellides oculata	(o)	1		
Glycera americana	(p)	22	3	
Heteromastus filiformis	(q)	2	2	1
Mediomastus ambiseta	(r)	9	3	
Nephtyidae sp.	(s)	1		
Pectinaria gouldii	(t)	1		
Polydora ligni	(u)	1		
Pseudeurythoe ambigua	(v)	2	1	7
Scolecolepides viridis	(w)		2	
Scolelepis squamata	(x)	1		
Scoloplos fragilis	(y)		1	
Scoloplos rubra	(z)	3	1	2
Spiophanes bombyx	(aa)	194	77	35*
Streblospio benedicti	(bb)	22	4	
Tharyx sp.	(cc)	21	12	2
Travisia carnea	(dd)	1		
Oligochaete sp.	(ee)	87	3	

* contamination from surface

Station 91   6-79

Taxon		0-2	2-5	5-10	10-15	15-20
Nemertea						
Tubulanus pellucidus	(a)	2				
Mollusca						
Acteon punctostriatus	(b)	4				
Aligena elevata	(c)	1		1	1	7
Anadara transversa	(d)	2				
Caecum pulchellum			1			
Ensis directus	(e)	19	5	1		2
Lucina multilineata	(f)		5			
Lyonsia hyalina	(g)	44				2*
Mercenaria mercenaria	(h)	1				
Mulinia lateralis	(i)	37				
Nucula proxima	(j)	3				
Retusa canaliculata	(l)	12	1*			
Tellina agilis	(m)	20				
Turbonilia interrupta	(n)	3				
Crustacea						
Ampelisca abdita	(p)	4				
Ampelisca verrilli	(q)	15				
Callianassa atlantica	(r)				1	
Caprella penantis	(s)	29	1*			
Corophium tuberculatum	(t)	6			1*	
Erichthonius brasiliensis	(u)	7				
Gammarus mucronatus	(v)	4				
Listriella clymenellae	(w)	3	2	4	2	
Monoculodes edwardsi	(x)	1				
Oxyurostylis smithi	(y)	7				
Paracaprella tenuis	(z)					1*
Parametopella cypris		1				
Unciola serrata	(aa)	3				
Polychaeta						
Aricidea catherinae	(bb)		1			
Aricidea wassi	(cc)	1		1		
Asabellides oculata	(dd)	1	1			
Asychis sp.	(ee)					1
Bhawania goodei	(ff)					2
Brania wellfleetensis		3	1	1	2	
Cabira incerta	(gg)	2	2	3	5	4
Capitellidae sp.					1	
Clymenella torquata	(ii)	9	6	2	4	5
Drilonereis magna	(jj)					1

Station 91   6-79 (continued)

Taxon		0-2	2-5	5-10	10-15	15-20
Polychaeta (continued)						
Eteone heteropoda	(kk)	2				
Glycera americana	(ll)	21	2			1
Glycinde solitaria	(mm)	2				
Goniadides carolinae	(nn)	1				
Heteromastus filiformis	(oo)	12				
Magelona rosea					1	
Mediomastus ambiseta	(pp)	37	2	2		
Nephtys incisa	(qq)	2	1			
Nereis succinea	(rr)	4				
Pectinaria gouldii	(ss)	48				
Polydora ligni	(tt)	45				
Pseudeurythoe ambigua	(uu)	4	5	4	9	22
Sabellaria vulgaris	(vv)	2				
Scoloplos rubra	(ww)			1		
Sigambra tentaculata	(xx)				1	
Spio filicornis	(yy)	1				
Spiophanes bombyx	(zz)	131	42	8		4*
Streblospio benedicti	(ab)	710	18	11*	1*	10*
Tharyx sp.	(ac)	16	1			
Oligochaete		20	1	1	1*	5*
Phoronida						
Phoronis sp.	(ad)	1				

* contamination from surface

Station 92 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Mollusca									
<u>Tellina agilis</u>	(a)		1						
Polychaeta									
<u>Asychis elongata</u>	(b)				1				
<u>Glycinde solitaria</u>	(c)	2		1					
<u>Gyptis brevipalpa</u>	(d)					1			
<u>Heteromastus filiformis</u>	(e)						1		
<u>Mediomastus ambiseta</u>	(f)	13	8						
<u>Paraprionospio pinnata</u>	(g)	3	4	4	1		1*		
<u>Pectinaria gouldii</u>	(h)		1	1					
<u>Pseudeurythoe ambigua</u>	(i)								2
<u>Sigambra tentaculata</u>	(j)		1	1		1			
<u>Streblospio benedicti</u>	(k)	11	7						

* contamination from surface

Station 93 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Platyhelminthes									
Turbellaria sp.	(a)	3							
Nemertea									
Tubulanus pellucidus	(c)	1							
Mollusca									
Ensis directus	(d)	1	1						
Lyonsia hyalina	(e)	2							
Mulinia lateralis	(f)	73	10						
Crustacea									
Ampelisca abdita	(g)	11	3	1*	1*				
Corophium tuberculatum	(h)	6							
Edotea triloba	(i)		1						
Leucon americanus	(j)	25	2						
Ogyrides limicola	(k)	1							
Paracaprella tenuis	(l)		1						
Polychaeta									
Asychis sp.	(m)					1			
Asabellides oculata	(n)	102	23	1					
Eteone heteropoda	(o)	7	2						
Glycinde solitaria	(p)	2	2						
Heteromastus filiformis	(q)						1		
Mediomastus ambiseta	(r)	55	9						
Nereis succinea	(s)	3							
Paraprionospio pinnata	(t)	9	34	13	3				
Pectinaria gouldii	(u)	234	27	4					
Polydora ligni	(v)	3							
Prionospio cirrifera	(w)		1						
Pseudeurythoe ambigua	(x)	3	3	2	1				
Scoloplos fragilis	(y)		1	1					
Sigambra tentaculata	(z)		6	6	1				
Streblospio benedicti	(aa)	176	20	3					
Tharyx sp.	(bb)		1						
Oligochaeta sp.		1							

* contamination from surface

(b) *Cerebratulus lacteus* found in the dissecting core

Station 94 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40
Nemertea								
Tubulanus pellucidus	(a)		3	2				
Phoronida								
Phoronis sp.	(b)	1		1				
Mollusca								
Ensis directus	(c)	3	4	1				
Lyonsia hyalina	(d)	6						
Mitrella lunata	(e)	3						
Mulinia lateralis	(f)	21	2					
Odostomia sp.	(g)				1*			
Retusa canaliculata	(h)	8						
Tellina agilis	(i)	18						
Yoldia limatula	(j)	6	1					
Crustacea								
Ampelisca abdita	(k)	25						
Corophium tuberculatum	(l)	17						
Crangon septemspinosa	(m)	1	1					
Edotea triloba	(n)	5						
Erichthonius brasiliensis	(o)	9						
Ostracoda sp.		1						
Paracaprella tenuis	(p)	12	1					
Polychaeta								
Asabellides oculata	(q)	75						
Asychis elongata	(r)						1	
Bhawania goodei	(s)	1	1	6	2			
Cabira incerta	(t)		1	1				
Clymenella zonalis	(u)	4	1	2				
Glycera americana	(v)	2			1			
Glycera sp.			1					
Glycinde solitaria	(w)	5						
Gyptis brevipalpa	(x)			1				
Harmothoe extenuata	(y)	1						
Mediomastus ambiseta	(z)	358	26	3				
Nephtys incisa	(aa)	2						
Nereis succinea	(bb)	6						
Paraprionospio pinnata	(cc)	2						
Pectinaria gouldii	(dd)	2036	42	8	3*	8*	1*	
Polydora ligni	(ee)	36						
Prionospio cirrifera	(ff)	3		5				
Pseudeurythoe ambigua	(gg)	1				1		

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40
Polychaeta (continued)								
Scoloplos sp.	(hh)	1						
Sigambra tentaculata	(ii)	3	4	4	6			
Spio sp.	(jj)	1						
Streblospio benedicti	(kk)	234	10					
Tharyx sp.	(ll)	7	4	6	3*	2*		
Oligochaeta sp.		34	12					
Ascidiacea								
Botryllus schlosseri	(mm)				P*			

* contamination from surface

(nn) *Thyone briareus* found in the dissecting core

(oo) *Cerianthus americanus* - found in the dissecting core

Station 95 6-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-40	40-50
Mollusca									
Ensis directus	(a)	1							
Lyonsia hyalina	(b)	1		1*					
Mulinia lateralis	(c)	155	19	2*		1*			
Mya arenaria	(d)	3	1						
Odostomia sp.	(e)	9	2						
Retusa canaliculata	(f)	1							
Yoldia limatula	(g)	1							
Crustacea									
Leucon americanus	(i)	1	1*						
Polychaeta									
Asabellides oculata	(j)	19	1						
Clymenella torquata	(k)	1							
Eteone heteropoda	(l)	8	1						
Glycera americana	(m)	1				1			
Glycinde solitaria	(n)	5							
Mediomastus ambiseta	(o)	100	1						
Nereis succinea	(p)	1				1			
Paraprionospio pinnata	(q)	14	19	3					
Pectinaria gouldii	(r)	787	88	34	1*	5*	2		
Pseudeurythoe ambigua	(s)	1	1						
Scoloplos fragilis	(t)		1						
Sigambra tentaculata	(u)	1	14	1	1	1			
Streblospio benedicti	(v)	93	1						
Tharyx sp.	(w)	1							

* contamination from surface

Station 96 6-79

Taxon		0-2	2-8
Colenterata			
Edwardsia elegans	(a)	1	
Nemertea			
Cerebratulus lacteus	(b)	3	
Phoronida			
Phoronis sp.	(c)	2	
Mollusca			
Ensis directus		267	25
Lyonsia hyalina	(e)	29	
Mulinia lateralis	(g)	183	4
Tellina agilis	(h)	26	1
Crustacea			
Ampelisca abdita	(i)	1	
Ampelisca verrilli	(j)	1	
Corophium tuberculatum	(k)	2	
Edotea triloba	(l)	3	
Erichthonius brasiliensis	(m)	1	
Gammarus mucronatus	(n)	1	
Monoculodes edwardsi	(o)	1	
Oxyurostylis smithi	(p)	1	
Paracaprella tenuis	(q)	2	1
Pinnotheres sp.	(r)		1
Polychaeta			
Asabellides oculata	(s)	9	
Clymenella torquata	(t)	14	1
Eteone heteropoda		7	
Glycera americana	(v)	28	1
Glycera dibranchiata	(w)		4
Gyptis brevipalpa	(x)		1
Harmothoe extenuata	(y)		1
Mageiona rosea	(z)	1	1
Mediomastus ambiseta	(aa)	87	17
Nephtys incisa	(bb)	2	2
Nereis succinea	(cc)	2	
Owenia fusiformis	(dd)	1	
Paraprionospio pinnata	(ee)	3	
Pectinaria gouldii	(ff)	79	3
Polydora ligni	(gg)	11	1
Prionospio pygmae	(hh)	8	2

Station 96   6-79 (continued)

Taxon		0-2	2-8
Polychaeta (continued)			
Pseudeurythoe ambigua	(ii)	1	2
Sabellaria vulgaris	(jj)	2	
Spio setosa	(kk)	1	
Spiophanes bombyx	(ll)	131	15
Streblospio benedicti	(mm)	250	14
Tharyx sp.	(nn)	6	1
Oligochaetes		1	1

(d) *Busycon carica* found in dissection core

(f) *Mitrella lunata* found in dissection core

(u) *Diopatra cuprea* found in dissection core

Station 97 6-79

Taxon		0-2	2-5	5-10	10-15	15-21
Hydrozoa						
Hydractinia echinata	(a)	P				
Sertularia argentea	(b)	P	P	P	P	P
Nemertea						
Cerebratulus lacteus	(c)	5	1			
Tubulanus pellucidus	(d)	9				
Phoronida						
Phoronis sp.		1				
Mollusca						
Acteon punctostriatus	(e)	1				
Crepidula plana	(f)	2				
Doridella obscura	(g)	1				
Ensis directus	(h)	1				
Lyonsia hyalina	(i)	2				
Mitrella lunata	(j)	3				
Mulinia lateralis	(k)	1				
Mya arenaria	(l)	2				
Mytilus edulis	(m)	5				
Nucula proxima	(n)	1				
Retusa canaliculata	(o)	3				
Tellina agilis	(p)	37				
Yoldia limatula	(q)	1				
Crustacea						
Ampelisca abdita	(r)	2				
Corophium tuberculatum	(s)	16	1			
Crangon septemspinosa	(t)	1				
Edotea triloba	(u)	1				
Erichthonius brasiliensis	(v)	1				
Libinia dubia	(w)	1				
Neomysis americana	(x)	1				
Oxyurostylis smithi	(y)	1				
Paracaprella tenuis	(z)	23	2*	4*	3*	
Parametopella cypris	(aa)	14				
Pleusymtes glaber	(bb)	4				
Unciola serrata	(cc)	8				
Polychaeta						
Asabellides oculata	(dd)	12		1*		
Clymenella torquata	(ee)	2				
Eteone heteropoda	(ff)	3				

Taxon		0-2	2-5	5-10	10-15	15-21
Polychaeta (continued)						
Lepidonotus sublevis	(gg)	3				
Mediomastus ambiseta	(hh)	185				
Nephtys incisa	(ii)	4		1		
Nereis succinea	(jj)	7				
Paranaitis speciosa	(kk)	3				
Pectinaria gouldii	(ll)	1951	7	8	1*	
Polydora ligni	(mm)	76				
Proceraea cornuta	(nn)	1				
Pseudeurythoe ambigua	(oo)			3		
Sabellaria vulgaris	(pp)	523	2	9*	1*	
Sigambra tentaculata	(qq)	2	1	2		2
Streblospio benedicti	(rr)	220	1	1*		
Tharyx sp.	(ss)	7	2			

* contamination from surface

Station 98 6-79

Taxon		0-2	2-5	5-13
Nemertea				
Amphiporus bioculatus	(a)	1		
Mollusca				
Ensis directus	(b)	4	3	
Mercenaria mercenaria	(c)	1		1
Mulinia lateralis	(d)	3	3	
Mya arenaria	(e)	6		1
Crustacea				
Edotea triloba	(g)	2		
Idunella sp.	(h)			1
Leucon americanus	(i)	13	4	
Listriella clymenellae	(j)	2	1	1
Neomysis americana	(k)	1		
Pleusymtes glaber	(m)	1		
Unciola serrata	(n)	4	1	
Polychaeta				
Arabella iricolor	(o)		2	1
Aricidea suecica	(p)		1	
Asabellides oculata	(q)	7	6	2
Clymenella torquata	(r)	16	3	8
Eteone heteropoda	(s)	9	4	1
Glycera americana	(t)	3	1	
Glycinde solitaria	(u)	2	1	1
Gyptis brevipalpa	(v)	2	2	
Heteromastus filiformis	(w)	18	11	2
Marphysa sanguinea	(y)			1
Mediomastus ambiseta	(z)	2		
Nereis succinea	(aa)	3	3	1
Pectinaria gouldii	(bb)	40	35	5
Polycirrus eximius	(cc)	37	3	1
Polydora ligni	(dd)	2	1	
Pseudeurythoe ambigua	(ee)	5		2
Scoloplos rubra	(ff)	1	2	
Spio setosa	(gg)	2		
Streblospio benedicti	(hh)	178	80	13
Syllis cornuta	(ii)	1	1	
Tharyx sp.	(jj)	3	1	1
Oligochaeta sp.	(kk)	22	26	2

(f) *Callianassa atlantica* found in the dissection core

(i) *Pinnixa* sp. found in dissection core

Station 99 6-79

Taxon		0-5	5-10	10-15	15-20	20-30	30-39
Nemertea							
Tubulanus pellucidus	(a)	1					
Phoronida							
Phoronis sp.	(b)	3					
Mollusca							
Ensis directus	(c)	3	3				
Lyonsia hyalina	(d)		1				
Mulinia lateralis	(e)	2					
Tellina agilis	(g)	2					
Polychaeta							
Asabellides oculata	(h)	2					
Asychis elongata	(i)				1		
Glycera americana					1		
Glycera sp.	(j)	1					
Glycinde solitaria	(k)	1					
Pectinaria gouldii	(l)	70	39	25*	8*	4*	
Pseudeurythoe ambigua	(m)		2	2			
Sigambra tentaculata	(n)					1	
Streblospio benedicti	(o)	12					
Tharyx sp.	(p)	3					
Oligochaeta sp.	(q)	9					

* contamination from surface

Station 100 6-79

Taxon		0-8
Nemertea		
Tubulanus pellucidus	(a)	1
Phoronida		
Phoronis sp.	(b)	3
Mollusca		
Ensis directus	(c)	23
Nassarius trivittatus	(d)	3
Tellina agilis	(e)	34
Crustacea		
Pagurus longicarpus	(f)	1
Parametopella cypris		4
Unciola irrorata	(g)	3
Polychaeta		
Capitellidae sp. A	(h)	346
Capitellidae sp. B		1
Drilonereis longa	(i)	3
Glycera americana	(j)	3
Glycera sp.		4
Magelona rosea	(k)	1
Mediomastus ambiseta	(l)	86
Nephtys incisa	(m)	1
Pectinaria gouldii	(o)	4
Polydora ligni	(p)	1
Polydora socialis	(q)	1
Polygordius sp.	(r)	4
Prionospio pygmaea	(s)	15
Scoloplos acutus	(t)	1
Spio setosa	(u)	1
Spiophanes bombyx	(v)	7
Streblospio benedicti	(w)	8
Tharyx sp.	(x)	25
Oligochaeta sp.		4

(h) *Onuphis eremita* found in dissection core

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-45
Colenterata								
Anthozoa sp.	(a)		1					
Sertularia argentea	(b)	P	P	P*		P*	P*	P*
Nemertea								
Tubulanus pellucidus	(c)	2						
Ectoprocta								
Aeverillia armata	(d)	P	P*	P*		P*		P
Electra crustulenta	(e)	P	P*	P*		P*		
Phoronida								
Phoronis sp.	(f)	1						
Mollusca								
Aligena elevata	(g)	3		1	1			
Anadara transversa	(h)	68	34*	28*	2*	2*	11*	11*
Doridella obscura	(i)	6						
Lyonsia hyalina	(j)	1						
Mitrella lunata	(k)	69	5*	4*	2*		1*	2*
Mulinia lateralis	(l)				1*			
Crustacea								
Ampelisca vadorum	(m)	7		2*				1*
Corophium sp.	(n)						1*	
Edotea triloba	(o)	1				1*		
Elasmopus levis	(p)	9	4	1*				
Erichthonius brasiliensis	(q)	1						
Gammarus mucronatus	(r)	8	2				1*	
Listriella clymenellae	(s)			3		1		
Neopanope texana sayi	(t)	3						
Ostracoda sp.		1		1*				
Paracaprella tenuis	(u)	63	6*	14*	1*	8*	38*	68*
Parametopella cypris	(v)	2						
Polychaeta								
Amphitrite ornata	(w)	1	5	2				
Capitellidae sp.				1				
Chrysopetalidae sp.					1			
Clymenella torquata	(x)		3	9	6	5	3	1*
Eteone heteropoda	(y)	20	2	4*		2*	1*	
Glyceridae sp.				3				
Glycinde solitaria	(z)	1	3	1	1			
Gyptis brevipalpa	(aa)				1			

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-45
Polychaeta (continued)								
Hesionidae					3*	1*		
Heteromastus filiformis	(bb)				1	2		
Maldanidae sp.		31	4	2				
Mediomastus ambiseta	(cc)	52	7	6*				
Nereis succinea	(dd)	302	53	23	5		5	10
Paraprionospio pinnata	(ee)	3	6	7	3			
Pectinaria gouldii	(ff)				1*			
Podarke obscura	(gg)	1		1				
Polydora ligni		342	56	8*	6*			
Polynoidae sp.	(hh)	1						
Pseudeurythoe ambigua	(ii)	1	11	71	44	50	1	2
Sabella microphthalma	(jj)	32	22	16*	1*	1*	1*	
Sabellaria vulgaris	(kk)	10	4	8*		1*		
Scolecolepidis viridis	(ll)	3						
Sigambra tentaculata	(mm)				1			
Streblospio benedicti	(nn)	1						
Syllidae sp.	(oo)	1						
Syllidae sp. A		1						
Ascidiacea								
Botryllus schlosseri	(pp)	P	P*	P*	P*	P*	P*	P*
Molgula manhattensis	(qq)	2	14	2*	1*		1*	

* contamination from surface

Station 104 4-79

Taxon		0-2	2-5	5-10	10-15	15-20	20-30	30-37
Colenterata								
Anthozoa sp.		2			1			
Sertularia argentea		P	P*	P*		P*	P*	P*
Nemertea								
Cerebratulus lacteus			1					
Tubulanus pellucidus			1					
Ectoprocta								
Aeverrillia armata				P*				
Electra crustulenta		P*	P*		P*			
Mollusca								
Anadara ovalis		2						
Anadara transversa	(a)	99	32*	19*	14*	4*	1*	46*
Lynosia hyalina		1						
Mulinia lateralis		6						
Odostomia sp.		1						
Retusa canaliculata		5	1*	1*				
Turbonilla interrupta		1						
Yoldia limatula	(b)	1						
Crustacea								
Ampelisca vadorum		1						
Corophium tuberculatum		2	1	1*	1*	1*		1*
Edotea triloba		2						
Elasmopus levis		1						
Erichthonius brasiliensis					1*			
Gammarus mucronatus				1				
Leucon americanus		1						
Ostracoda sp.		1	1*	1*				1*
Paracaprella tenuis		2	1*		4*			
Pinnixia retinens			2	1				
Polychaeta								
Asabellides oculata		1						
Eteone heteropoda		2		1*				
Glycera americana	(c)		1					
Glycinde solitaria		8	2	1*				
Lepidametria commensalis		1						
Lepidonotus sublevis				1				
Maldanidae sp.		1						
Mediomastus ambiseta		24	6	5*				
Nereis succinea		18	4	2		1	1	3

Station 104 4-79 (continued)

Taxon	0-2	2-5	5-10	10-15	15-20	20-30	30-37
Polychaeta (continued)							
Orbiniidae sp.	1						
Paraprionospio pinnata (d)	6	20					
Pectinaria gouldii (e)	19	1					
Polydora ligni	14	3	4*		1*		1*
Pseudeurythoe ambigua		1	1		1		
Sabellaria vulgaris	2						
Scolecolepides viridis	1	1					
Scoloplos foliosus	1						
Scoloplos sp.			1				
Sigambra tentaculata	1	12	1		1		15
Streblospio benedicti	2						
Ascidiacea							
Botryllus schlosseri	P		P*		P*	P*	P*
Molgula manhattensis	5						

* contamination from surface

Station 105 4-79

Taxon	0-2	2-5	5-10	10-15	15-20	20-30	30-40
Colenterata							
Ceriantheopsis americanus			1				
Nemertea							
Cerebratulus lacteus				1			
Tubulanus pellucidus	2		1				
Mollusca							
Acteon punctostriatus	1						
Anadara transversa	1						
Bivalve sp.	1						
Cylichna alba	1						
Gemma gemma	1						
Nassarius trivittatus	1						
Odostomia sp.	5						
Retusa canaliculata	4						
Tellina agilis	13	1					
Turbonilla interrupta	7						
Yoldia limatula	7						
Crustacea							
Ampelisca vadorum	2	1					
Edotea triloba	2						
Listriella clymenellae	1		2				
Ostracoda sp.	9						
Paracaprella tenuis	1						
Photis dentata	2						
Polychaeta							
Asabellides oculata	3						
Cabira incerta	1	1	2		1		
Clymenella torquata	1						
C. zonalis	5	7	5				
Glycera americana		4					
Glycinde solitaria	12						
Harmothoe extenuata	2						
H. sp. A		2					
Heteromastus filiformis	4						
Loimia medusa			1				
Maldanidae sp.			5				
Mediomastus ambiseta	509	15					
Nephtys incisa	4						
Paleanotus heteroseta			1				
Paraprionospio pinnata	1						

Taxon	0-2	2-5	5-10	10-15	15-20	20-30	30-40
Polychaeta (continued)							
Pectinaria gouldii		1					
Phyllodoce arenae		1					
Polydora ligni	9						
Prionospio cirrobranchiata	1						
Prionospio sp.				1			
Sigambra tentaculata	1		4	1			
Spiochaetopterus oculatus	1	1					
Spionidae sp.		1					
Spiophanes wigleyi		1					
Tharyx sp.		3	2				
Westerinereis tridentata			1				

Appendix C

Selected three-dimensional drawings representing distribution and life styles of organisms in a box core at each station*

* letters refers to species listed in Appendix B for Stations 76-105.

Station 28

MOLLUSCA

a. *Anadara transversa*

CRUSTACEA

b. *Pinnixa retinens*

POLYCHAETA

c. *Glycinde solitaria*

d. *Nereis succinea*

e. *Chaetopterus variopedatus*

f. *Paraprionospio pinnata*

g. *Pseudoeurythoe ambigua*

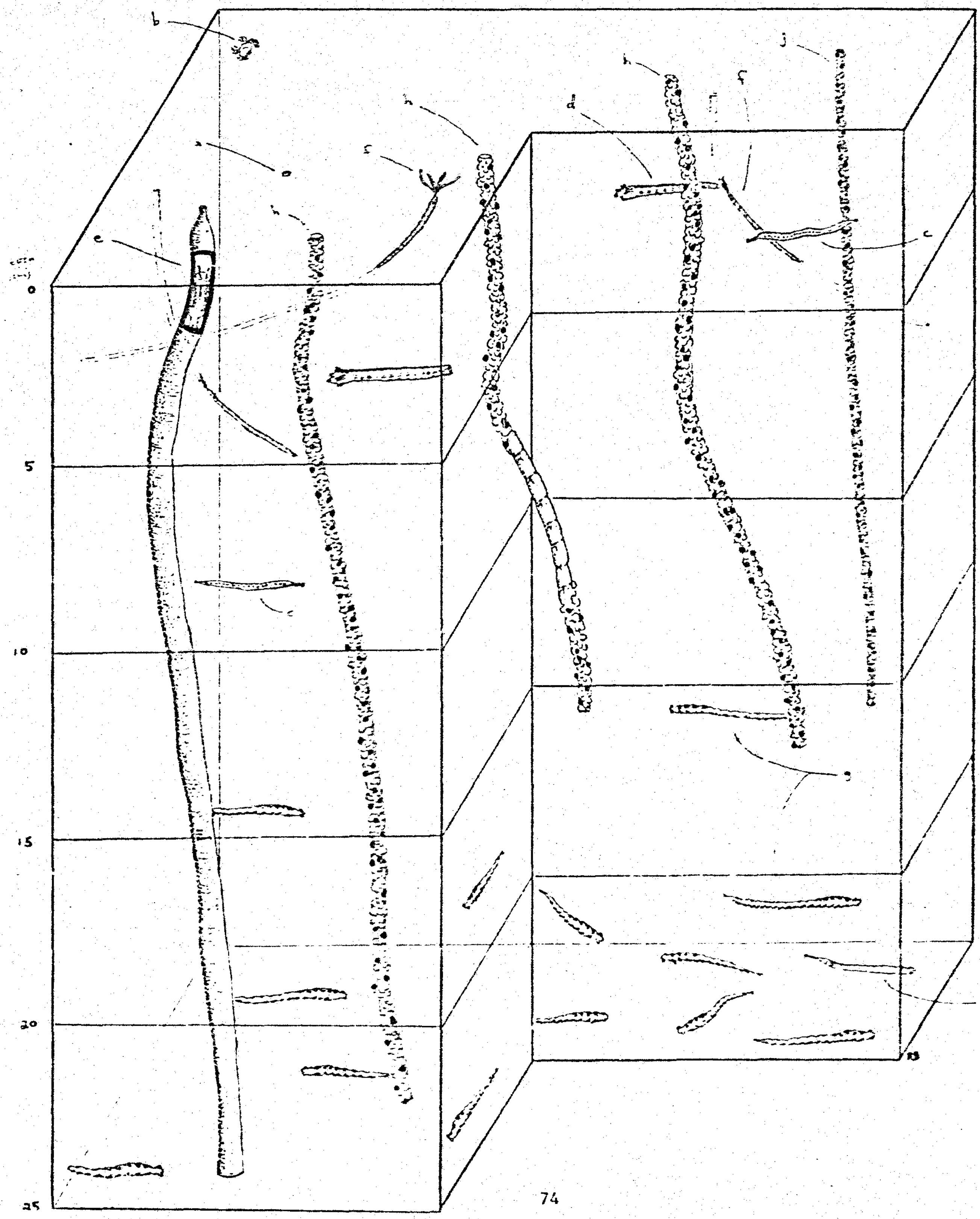
h. *Clymenella torquata*

i. *Glycera dibranchiata*

PHORONIDA

j. *Phoronis* sp.

STATION 28



Station 35

MOLLUSCA

a. Retusa canaliculata

b. Anadara transversa

c. Turbonilla interrupta

d. Anachis translirata

CRUSTACEA

e. Pinnixa retinens

f. Pinnixa chaetopterana

g. Ostracod

h. Ampelisca abdita

i. Listriella clymenellae

j. Paracaprella tenuis

k. Corophium sp. (juv)

ECHINODERMATA

l. Micropholis atra

POLYCHAETA

m. Paraprionospio pinnata

n. Pectinaria gouldii

o. Clymenella torquata

p. Glycinde solitaria

q. Nephtyidae

r. Notomastus sp.

s. Glycera americana

Station 35 (continued)

POLYCHAETA (cont.)

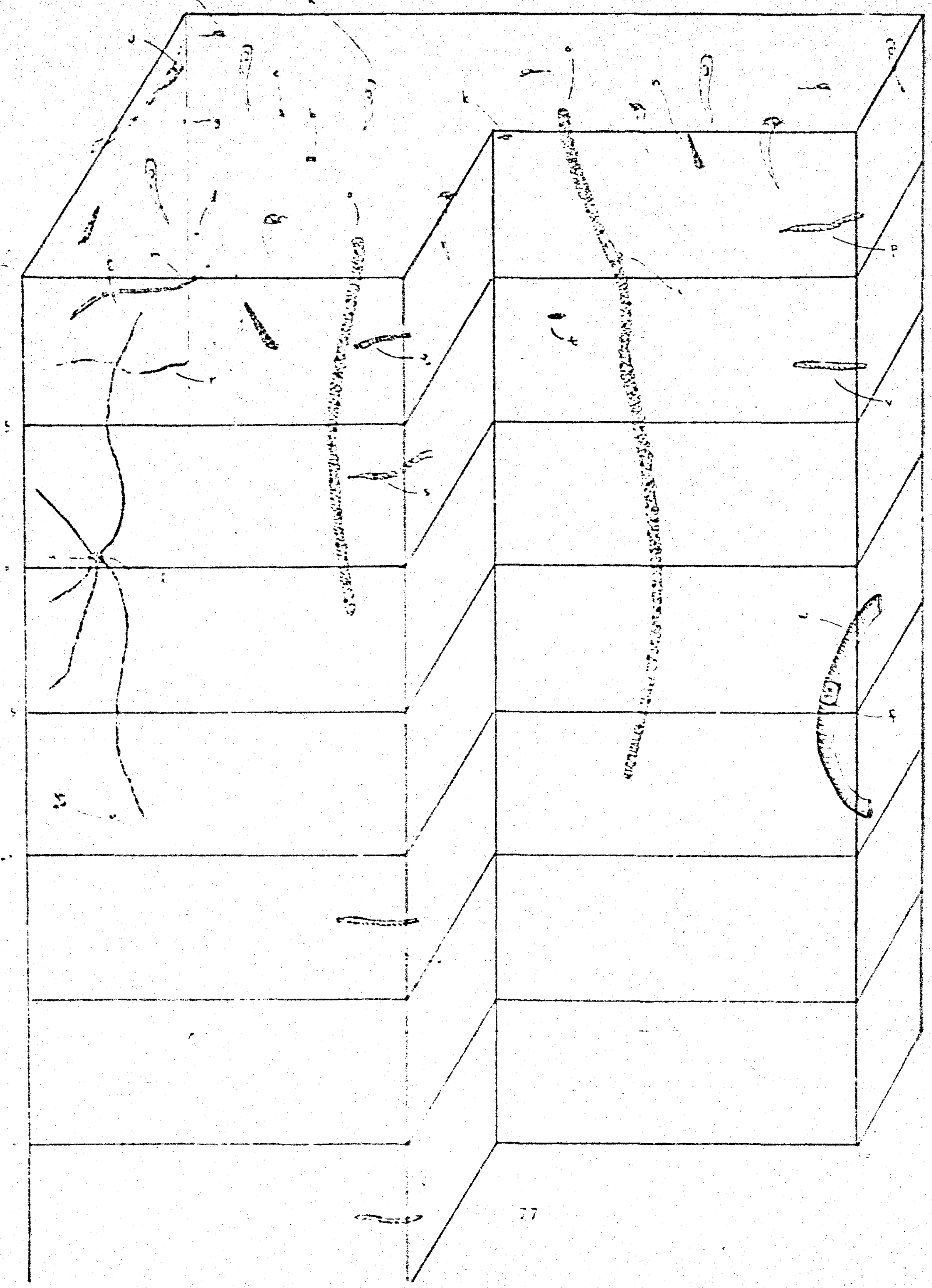
t. *Paleanotus heteroseta*

u. *Harmothoe* sp. A (located on the disk of *Microphholis atra*)

v. *Pseudoeurythoe ambigua*

w. empty Chaetopterid tube

STATION 35



Station 43

MOLLUSCA

a. *Nucula proxima*

b. *Retusa canaliculata*

c. Leptonidae

d. *Yoldia limatula*

POLYCHAETA

e. *Nephtys* sp.

f. *Paraprionospio pinnata*

g. Capitellidae

h. *Praxillella gracilis*

i. *Paleanotus heteroseta*

j. *Harmothoe* sp. A

k. *Pseudoeurythoe ambigua*

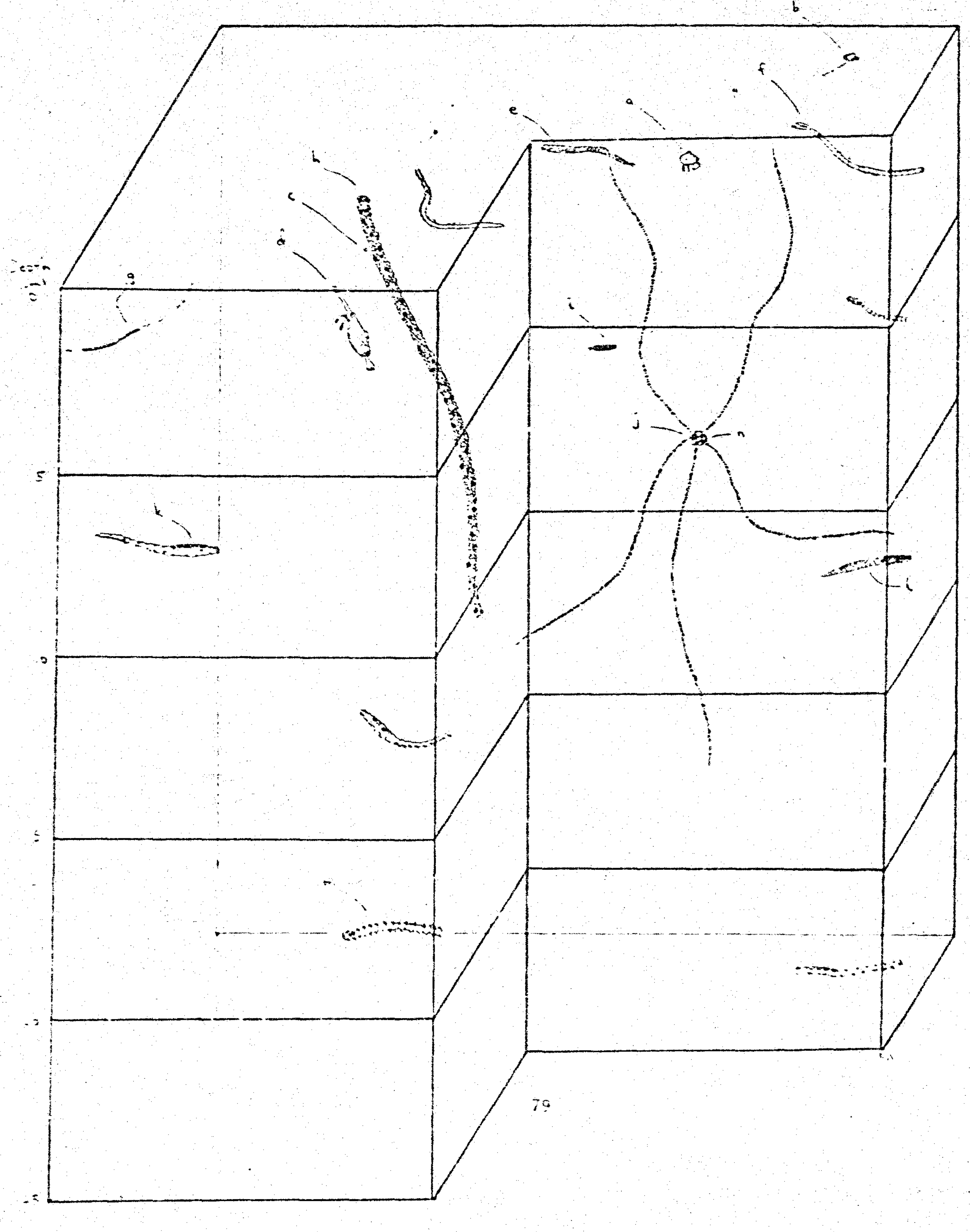
l. Orbiniidae

m. *Sigambra tentaculata*

ECHINODERMATA

n. *Micropholis atra*

STATION 43



Station 46

MOLLUSCA

a. *Turbonilla interrupta*

b. *Odostomia* sp. (juv)

c. *Retusa canaliculata*

d. *Tellina agilis*

e. *Yoldia limatula*

f. *Pitar morrhuana*

CRUSTACEA

g. *Ampelisca abdita*

h. *Upogebia affinis* (juv)

i. *Libinia dubia*

j. Paguridae

k. *Unciola serrata*

POLYCHAETA

l. *Glycinde solitaria*

m. *Glycera americana*

n. *Paleanotus heteroseta*

o. *Maldanopsis elongata*

p. *Pectinaria gouldii*

q. *Pseudoeurythoe ambigua*

r. *Heteromastus filiformis*

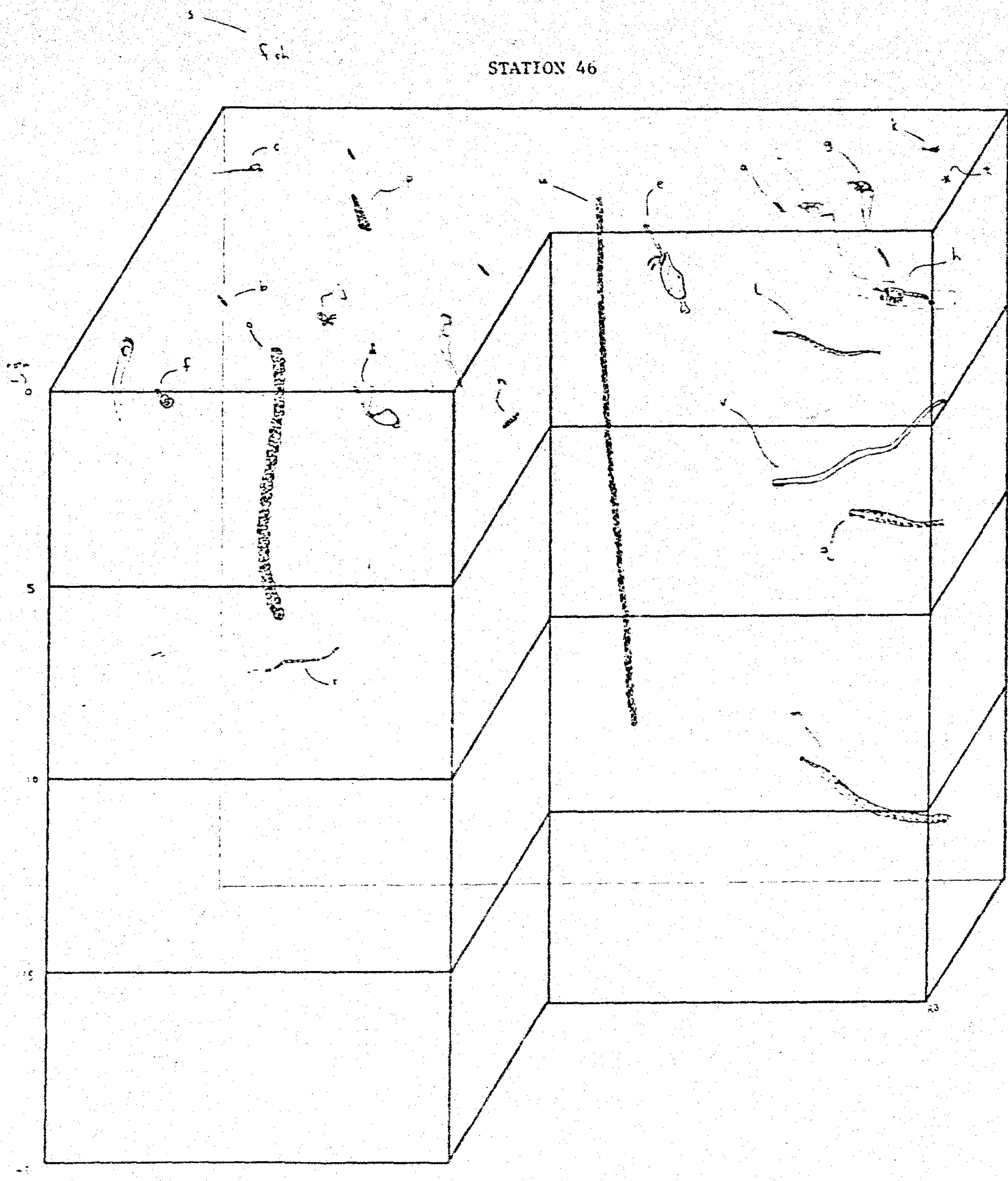
ECHINODERMATA

t Ophuroidea (juv)

PHORONIDA

u Phoronid

STATION 46



Station 50

MOLLUSCA

a. *Tellina agilis*

POLYCHAETA

b. Cirratulidae

c. *Glycera dibranchiata*

d. *Glycera robusta*

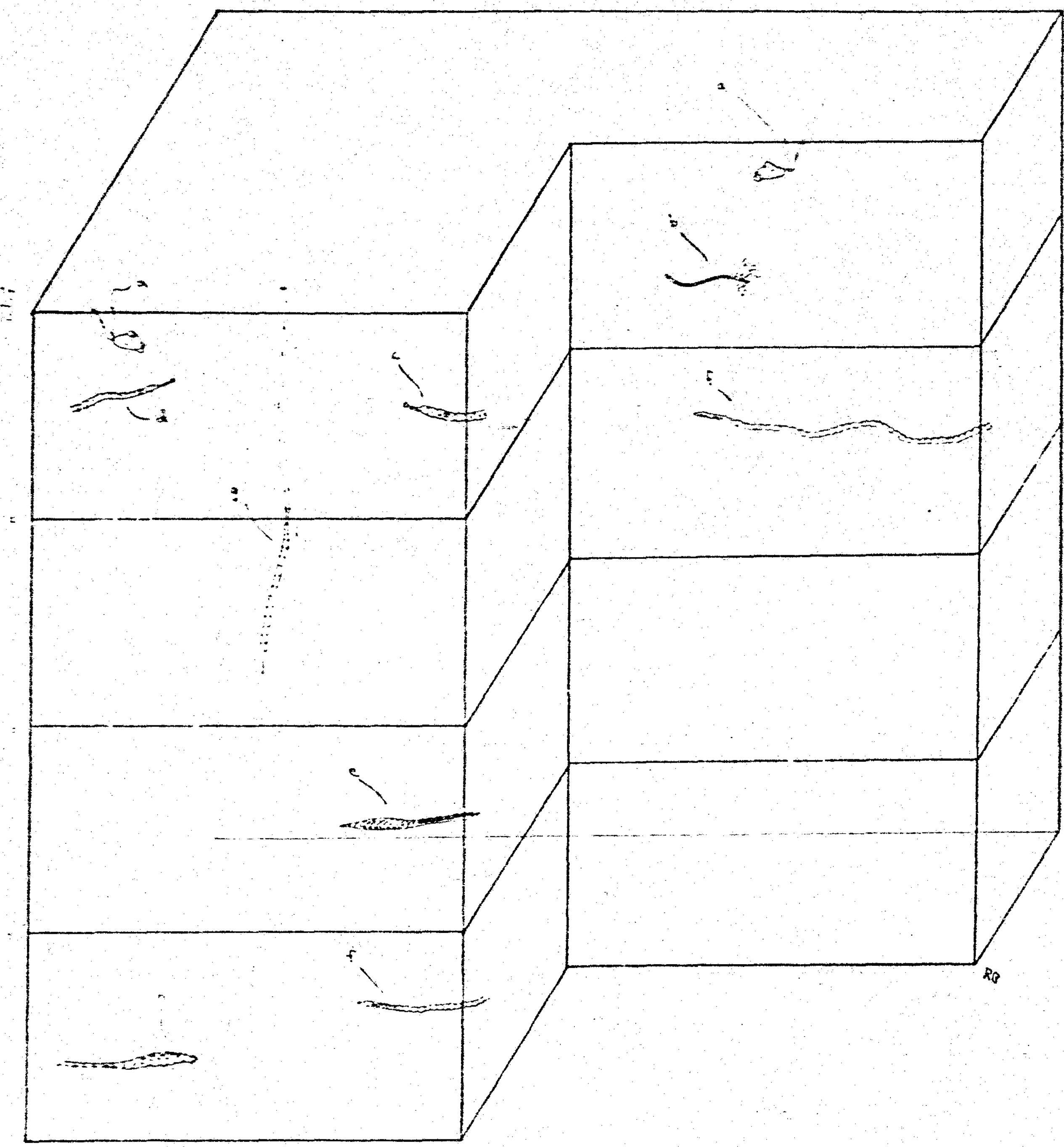
e. *Scoloplos rubra*

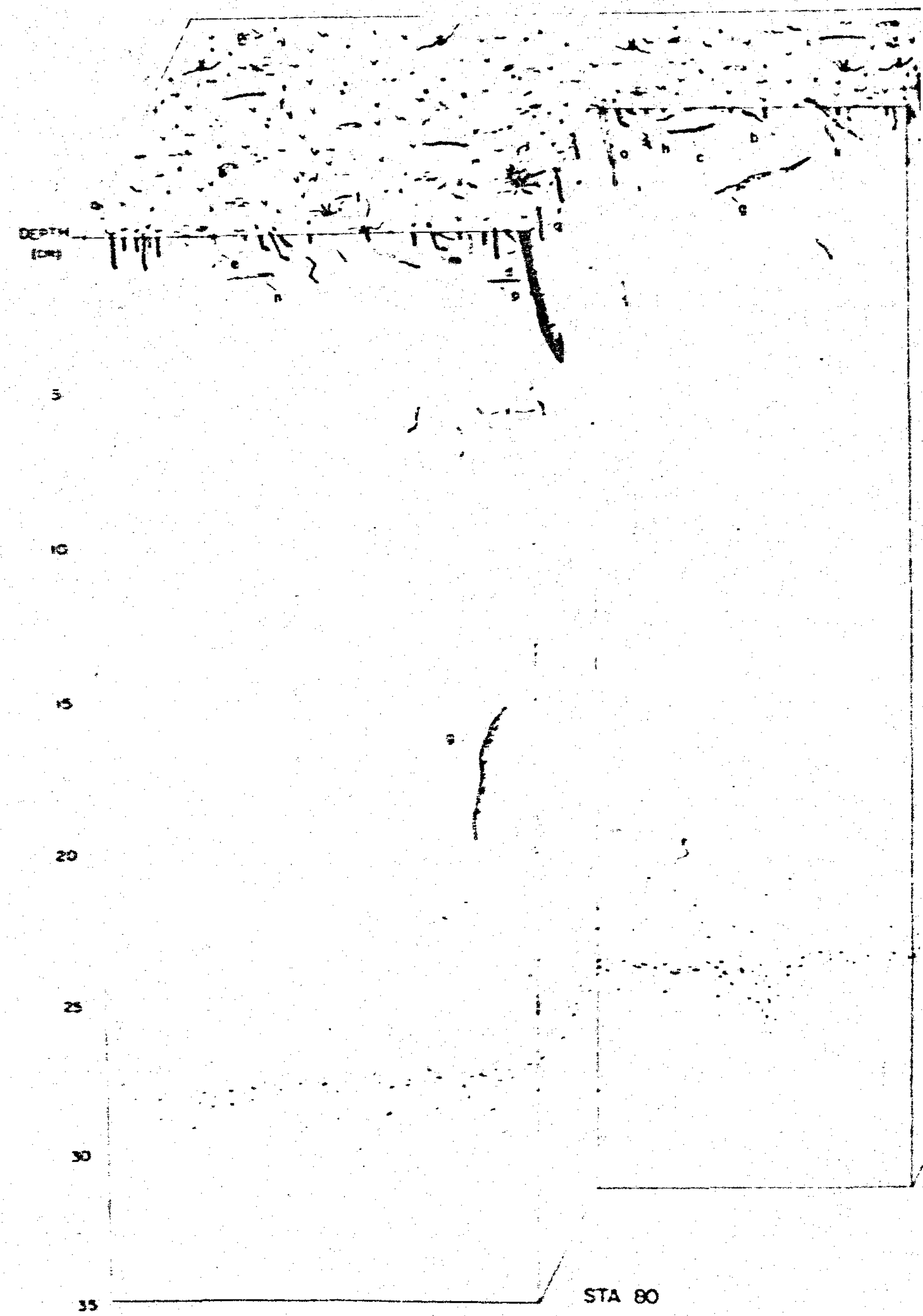
f. *Drilonereis longa*

g. *Magelona* sp.

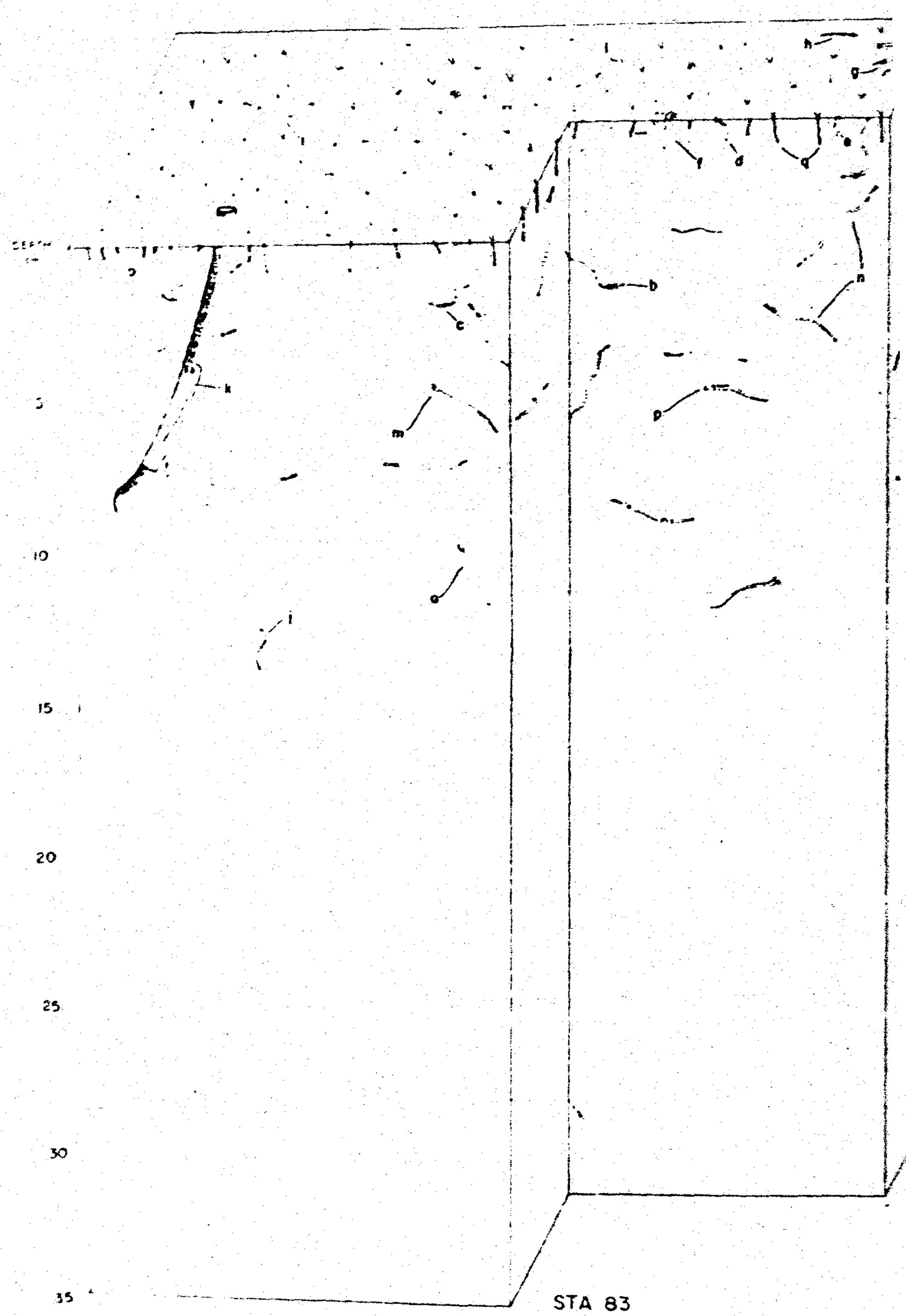
h. *Pseudoeurythoe ambigua*

STATION 50

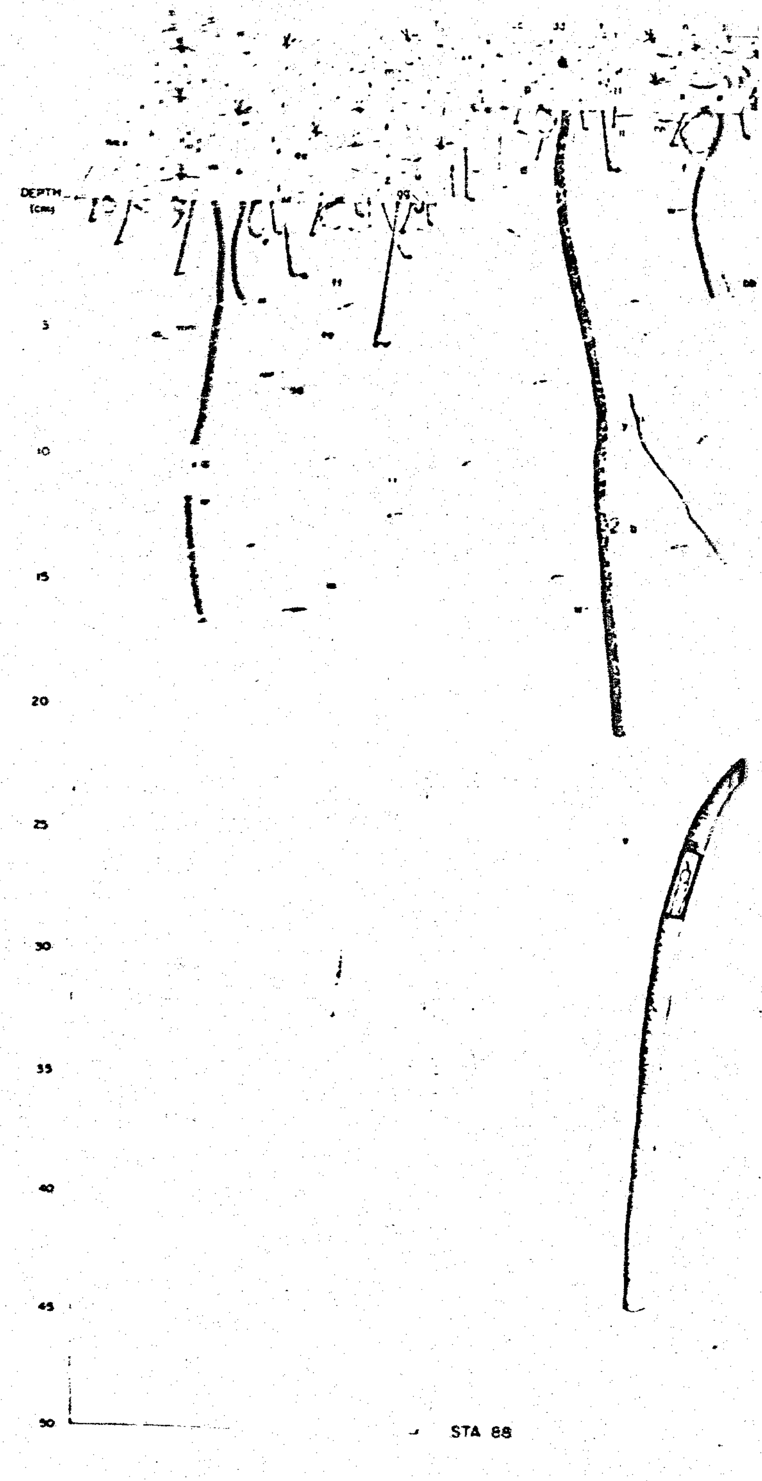




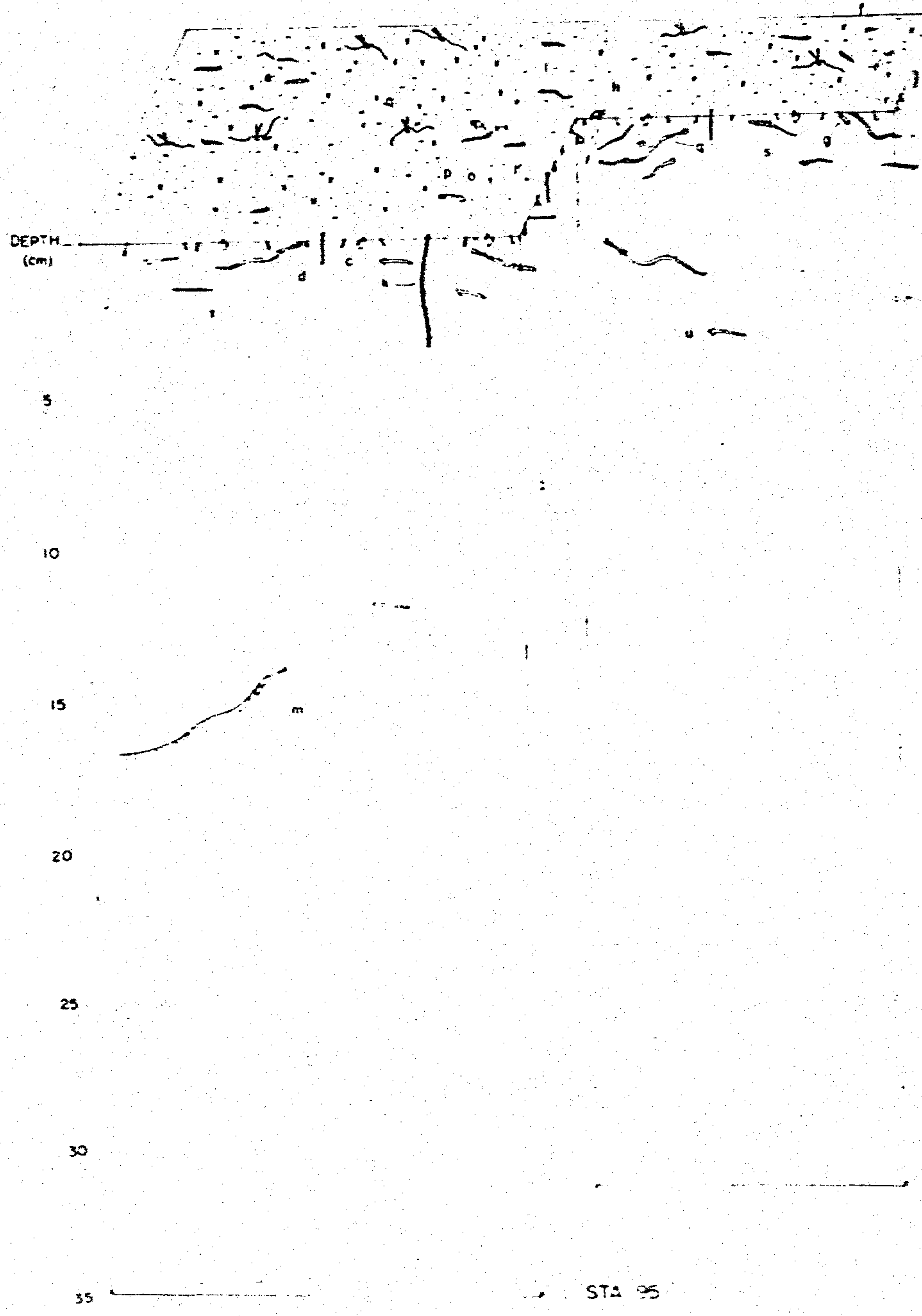
STA 80



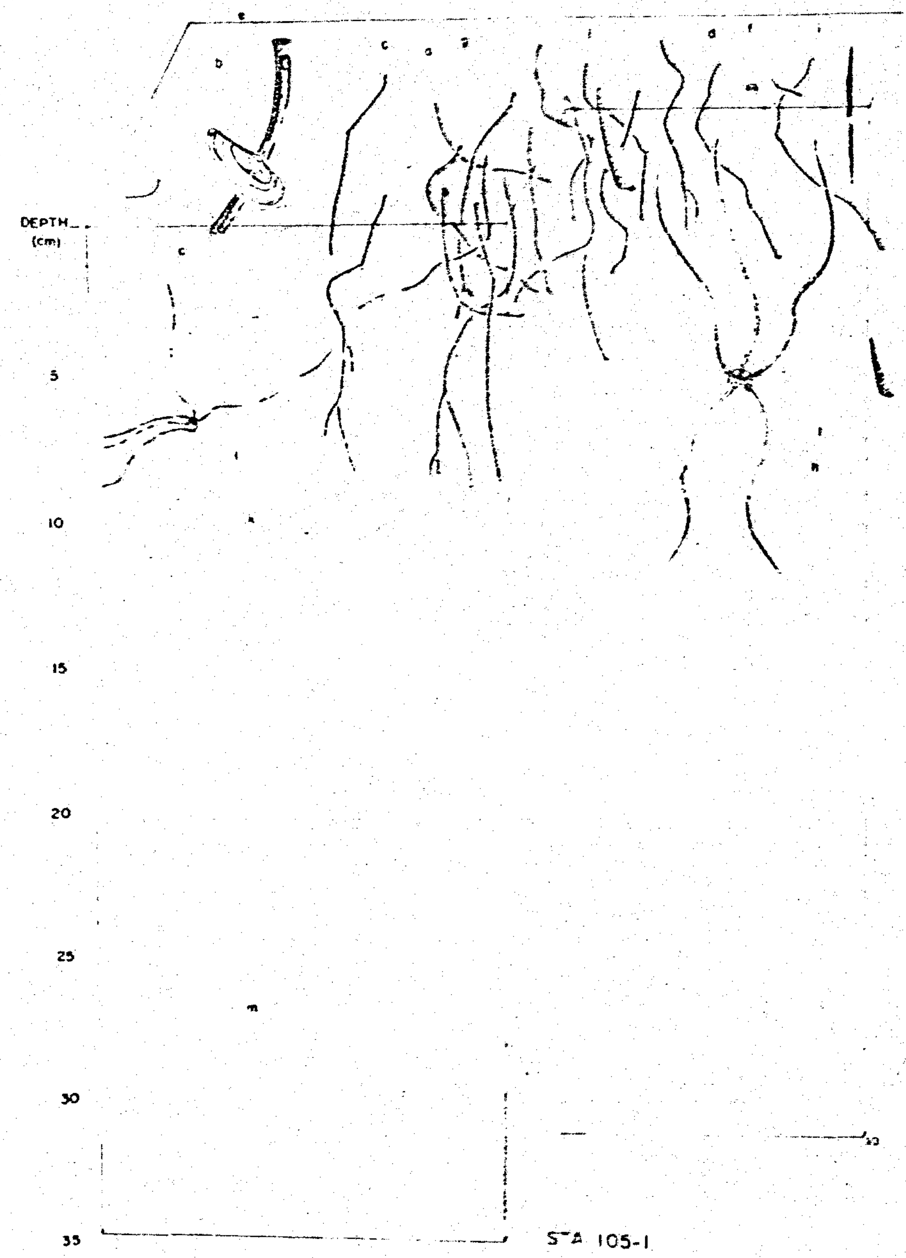
STA 83



STA 88



STA 95


DEPTH
(cm)
5
10
15
20
25
30
35
STA 105-1

Appendix D

Selected Radiographs

Plate 1. Station 82, Mud environment.

Station 82: Channel regime just south of the Potomac River
Latitude: 37 45 8.315
Longitude: 76 11 28.303
Sampling Date: 6/22/79
Water Depth: 24.39 m
Radiographic positive print

MUD ENVIRONMENT:

Thinly laminated and homogeneous mud units evident are typical of the channels.

Methane bubbles are produced in great quantity in these regions.

Degree of bioturbation: trace

SPECIAL FEATURES:

A. Thin, parallel mud laminae

B. Homogenous silty clay texture

C. Methane bubbles

D. *Mulina lateralis* shells (disarticulated)


A
D
D
B
A
B
C
C

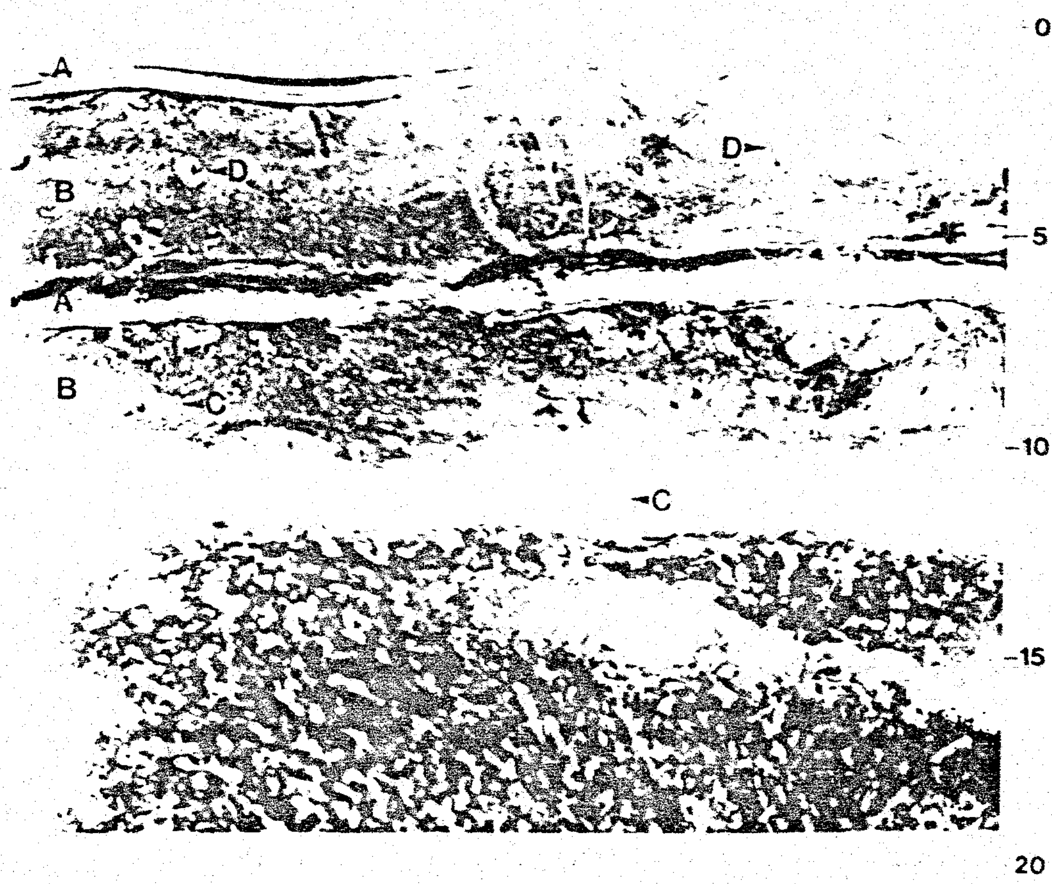

0
A
D
D
B
5
A
B
C
10
C
15
20

Plate 2. Station 80, Mixed-sediment environment.

Station 80: Southeast of Tangier Island
Latitude: 37 46 52.637
Longitude: 75 58 5.191
Sampling Date: 6/23/79
Water Depth: 17.68 m
Radiographic positive print

MIXED-SEDIMENT ENVIRONMENT:

Physical laminae alternate with biologically mixed zones. The distinct interbedded mud-sand laminations result from variable current energies. The bioturbated surface mud layer probably resulted from the entrapment of fine-grain sediments by dense populations of tube builders, namely _Ampelisca abdita_. Substrate stabilization has allowed other species (e.g. - _Loimia medusa_) to establish themselves at depth. Destruction of laminae is probably the result of general bioturbators.

Degree of bioturbation: <30%

SPECIAL FEATURES:

A. Bioturbated muddy sand zone

B. & C. Thick, parallel, interbedded mud and sand layers

D. Biologically reworked muddy sand layer containing _Mulina lateralis_ shells

E. _Pectinaria gouldii_ tube

E°. _Pectinaria gouldii_ tube with feeding trace

F. _Loimia medusa_ tube

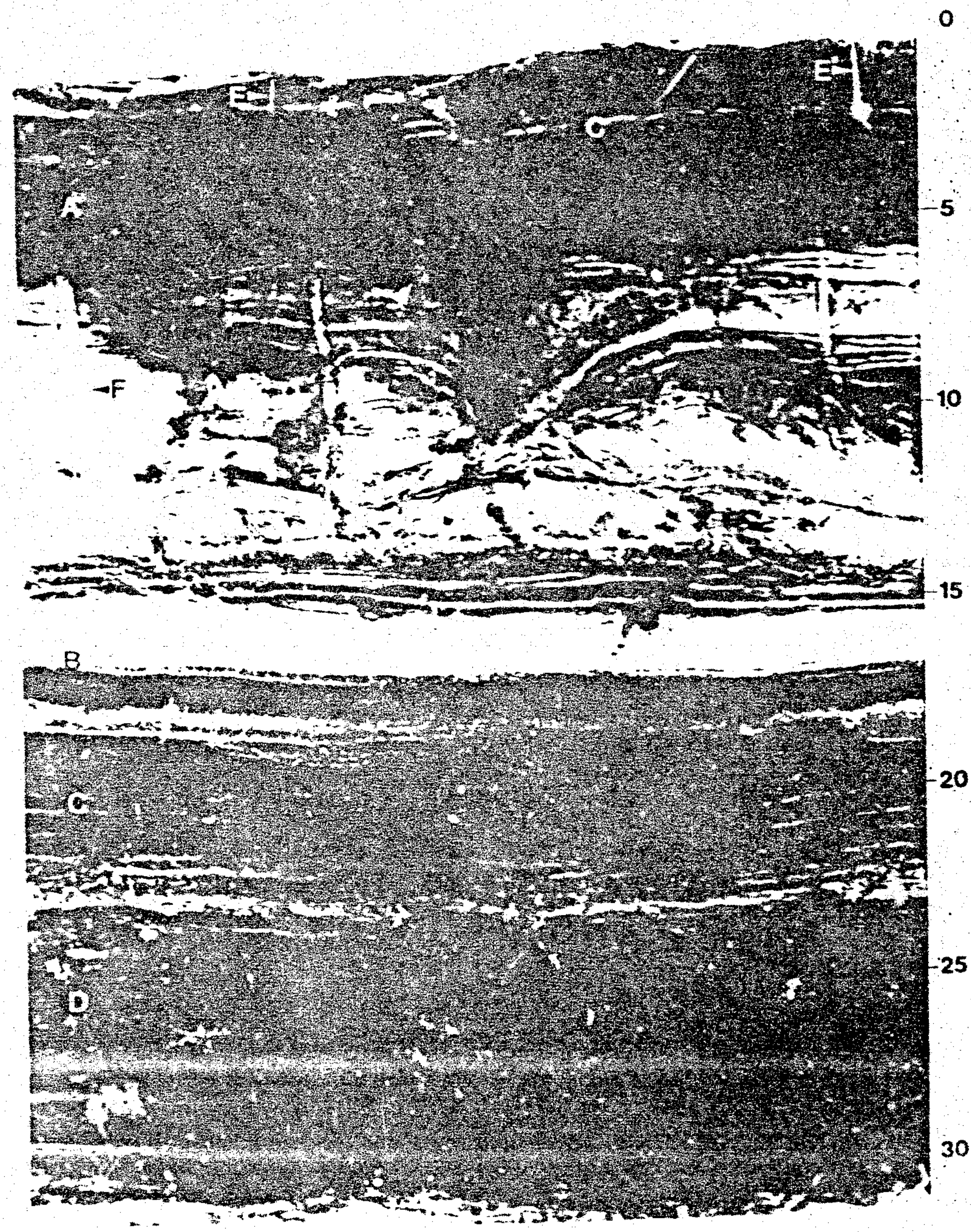

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Plate 3. Station 100, Coarse-medium sand environment

Station 100: Outside the mouth of the Chesapeake Bay just off Cape Charles
Latitude: 36 55 45.512
Longitude: 75 54 53.444
Sampling Date: 6/13/79
Water Depth: 18.90 m
Radiographic positive print

COARSE-MEDIUM SAND ENVIRONMENT:

The sediment environment within this region is heavily influenced by wave action. This high energy regime produces distinctive homogenous and cross-bedded units, although some biogenic activity is evident.

Degree of bioturbation: < 30 %

SPECIAL FEATURES:

A. Heavy mineral, planar cross-bedding unit

B. Homogenous sand bed

C. Undescribed capitellid burrows

D. *Onuphis eremita* tube


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Plate 4. Station 78, Mixed-sediment environment.

Station 78: East of Tangier Island
Latitude: 37 50 54.944
Longitude: 75 55 32.880
Sampling Date: 6/24/79
Water Depth: 23.78 m
Radiographic positive print

MIXED-SEDIMENT ENVIRONMENT:

This region is characterized by strong tidal currents. The surface mud lamina of this core is covered with tubes of the amphipod, Ampelisca abdita. High densities of these tubes act as a sediment trap for fine-grain materials. The sedimentary sequence changes abruptly into a sandy substrate with little bioturbation. A storm erosion layer is present at depth.

Degree of bioturbation: 60-90% (above 5 cm)
30-60% (below 5 cm)

SPECIAL FEATURES:

A. Clayey silt layer with some interbedded sand

B. Muddy coarse sand with gravel

C. Storm erosion layer with compacted clay pockets

D. Mulinia lateralis shells (boxed)

E. Ilyanassa vibex shell (remnant)

F. Unidentified polychaete burrow (inactive)

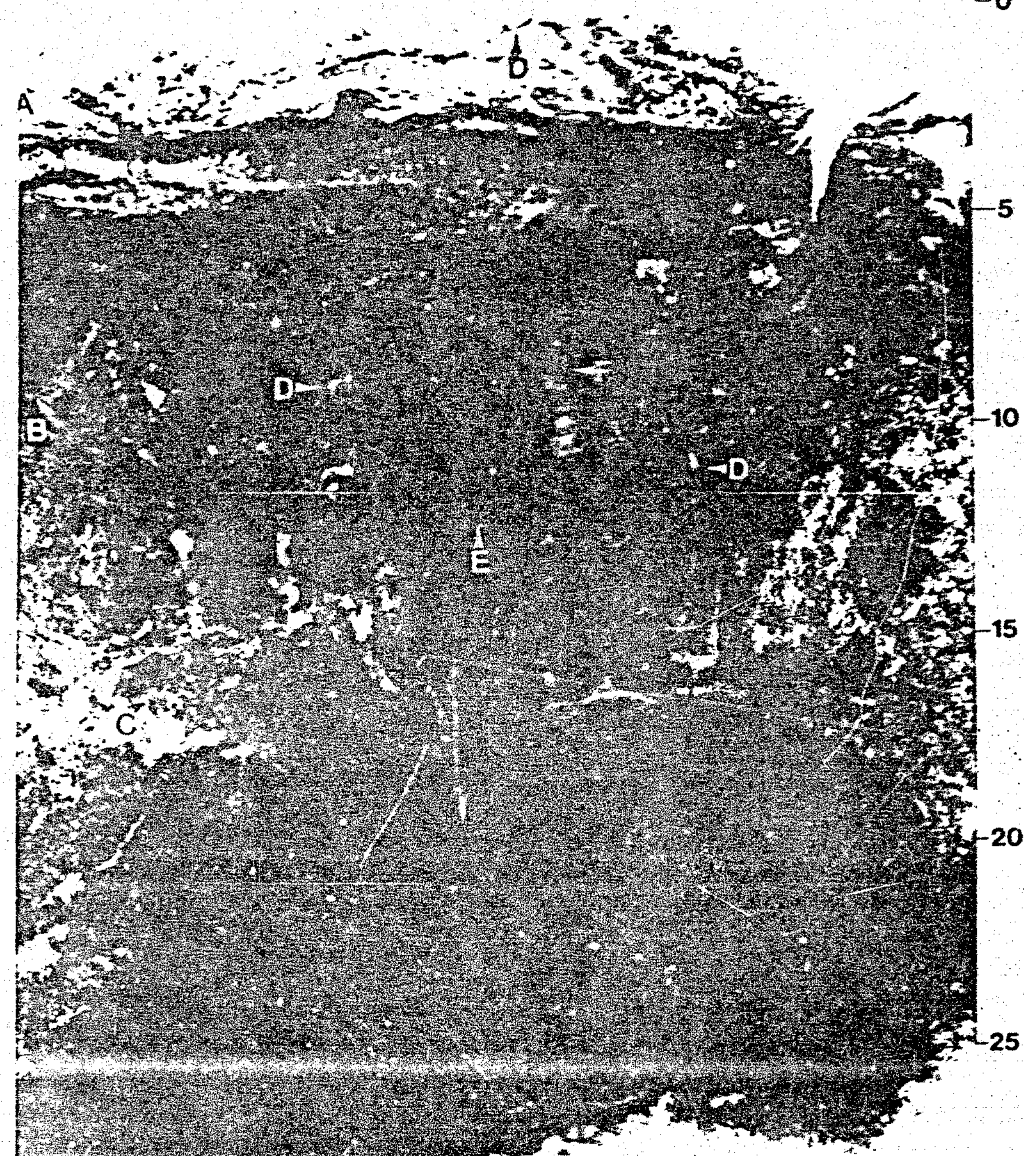
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Plate 5. Station 27, Fine sand environment.

Station 27: Pocomoke Sound
Latitude: 37 49 54.106
Longitude: 75 50 7.436
Sampling Date: 9/20/78
Water Depth: 4.88 m
Radiographic positive print

FINE SAND ENVIRONMENT:

General bioturbation activities in this core have disrupted the ripple laminae, and homogenized the heavy minerals. The underlying hard clay is characteristic along the nearshore margin.

Degree of bioturbation: 60-90% (above 15 cm)
0% (below 15 cm)

SPECIAL FEATURES:

A. Homogenous fine sand with scattered heavy minerals (dark granules)

B. Mud lamina

C. Consolidated clay substratum

D. Heavy mineral ripple lamina

E. Unidentified polychaete burrow

F. Ilyanassa vibex shell (remnant)

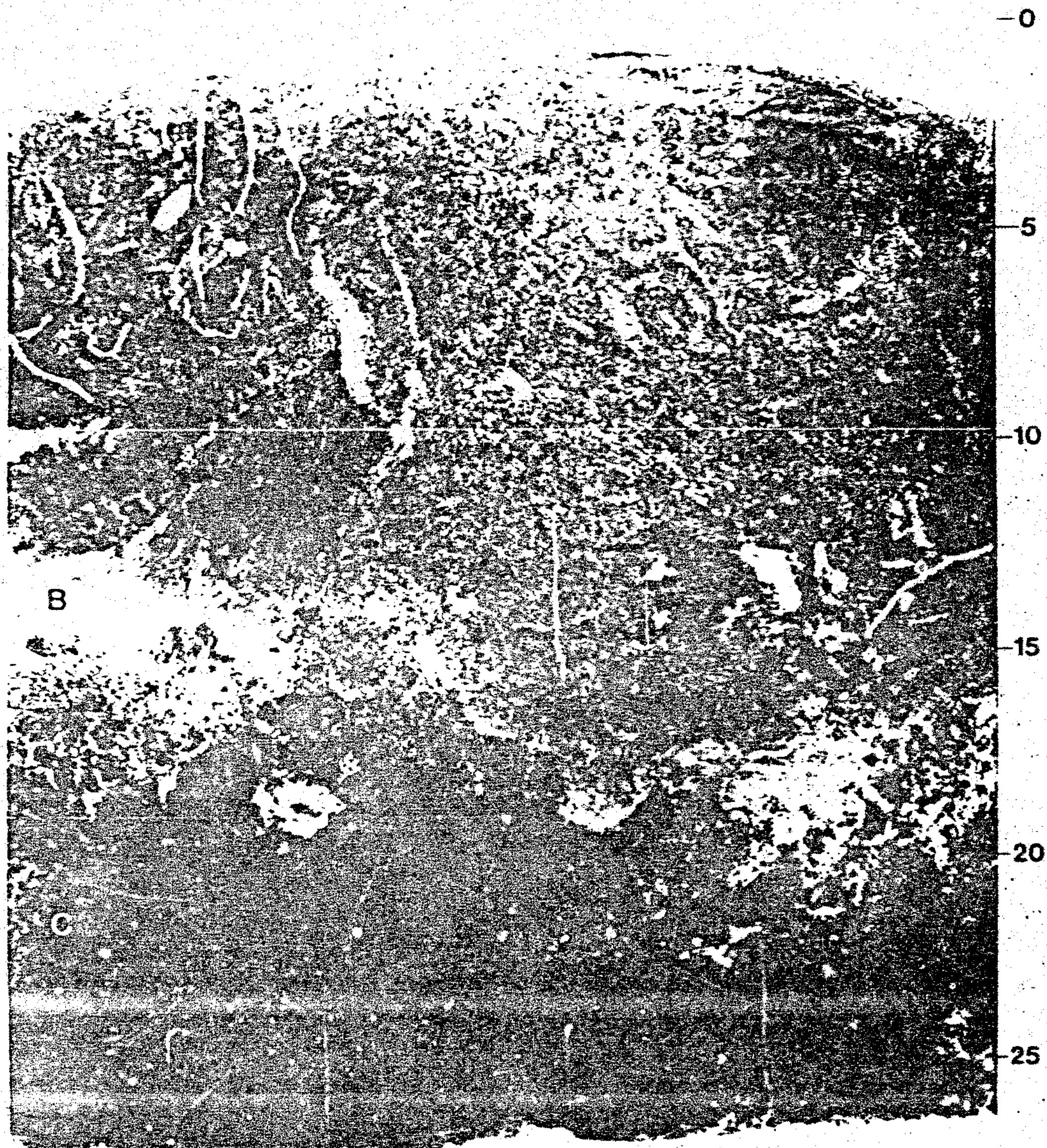

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Plate 6. Station 103, Mixed-sediment environment.

Station 103: Western Shore just south of Wolf Trap Light
Latitude:
Longitude:
Sampling Date: 4/25/79
Water Depth: 7.32 m
Radiographic positive print

MIXED-SEDIMENT ENVIRONMENT:

Muddy sand core and oyster reef. This reef was probably devastated by MSX disease in the 1950's. Clymenella torquata apparently is responsible for extensive sediment sorting. Laminar disruption and sediment mottling are evident. Degree of bioturbation: 90-99%

SPECIAL FEATURES:

A. Mud laminae

B. Crassostrea virginica shells (remnant)

C. Clymenella torquata tube

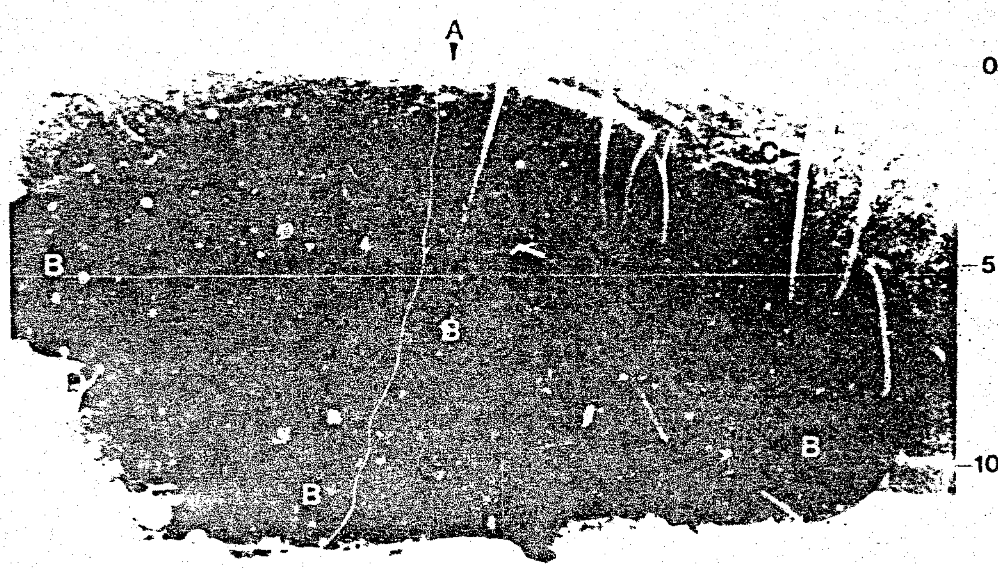
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Plate 7. Station 84, Mud environment.

Station 84: Middle of the Bay just north of the Rappahannock River
Latitude: 37 40 20.223
Longitude: 76 7 55.784
Sampling Date: 6/22/79
Water Depth: 12.80 m
Radiograph positive print

MUD ENVIRONMENT:

Bioturbated clayey silt core, illustrating massive destruction at depth by the cerianthid anemone, *Ceriantheopsis americanus*. Some physical lamination is still apparent.

Degree of bioturbation: 60-90%

SPECIAL FEATURES:

A. Faint mud laminae

B. *Paraprionspio pinnata* traces

C. *Mulinia lateralis* shell (live)

D. *Asychis elongata* tube

E. *Ceriantheopsis americanus* burrow (inactive)

F. *Macoma balthica* shell (disarticulated)

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Plate 8. Station 95, Mud environment.

Station 95: Mouth of the York River
Latitude: 37 12 45.712
Longitude: 76 16 38.419
Sampling Date: 6/12/79
Water Depth: 10.67 m
Radiographic positive print

MUD ENVIRONMENT:

Moderately bioturbated clayey silt with thin mud laminae; usually found in deep-water muddy environments.

Degree of bioturbation: 30-60%

SPECIAL FEATURES:

A. Homogenous clayey-silt texture

B. Horizontal planar mud lamination

C. Inclined planar mud laminae

D. *Paraprionspio pinnata* traces

E. *Pectinaria gouldii* tube

F. *Mulinia lateralis* shell (boxed)

G. Unidentified polychaete burrow with Fe^{+++} prec. halo (inactive)

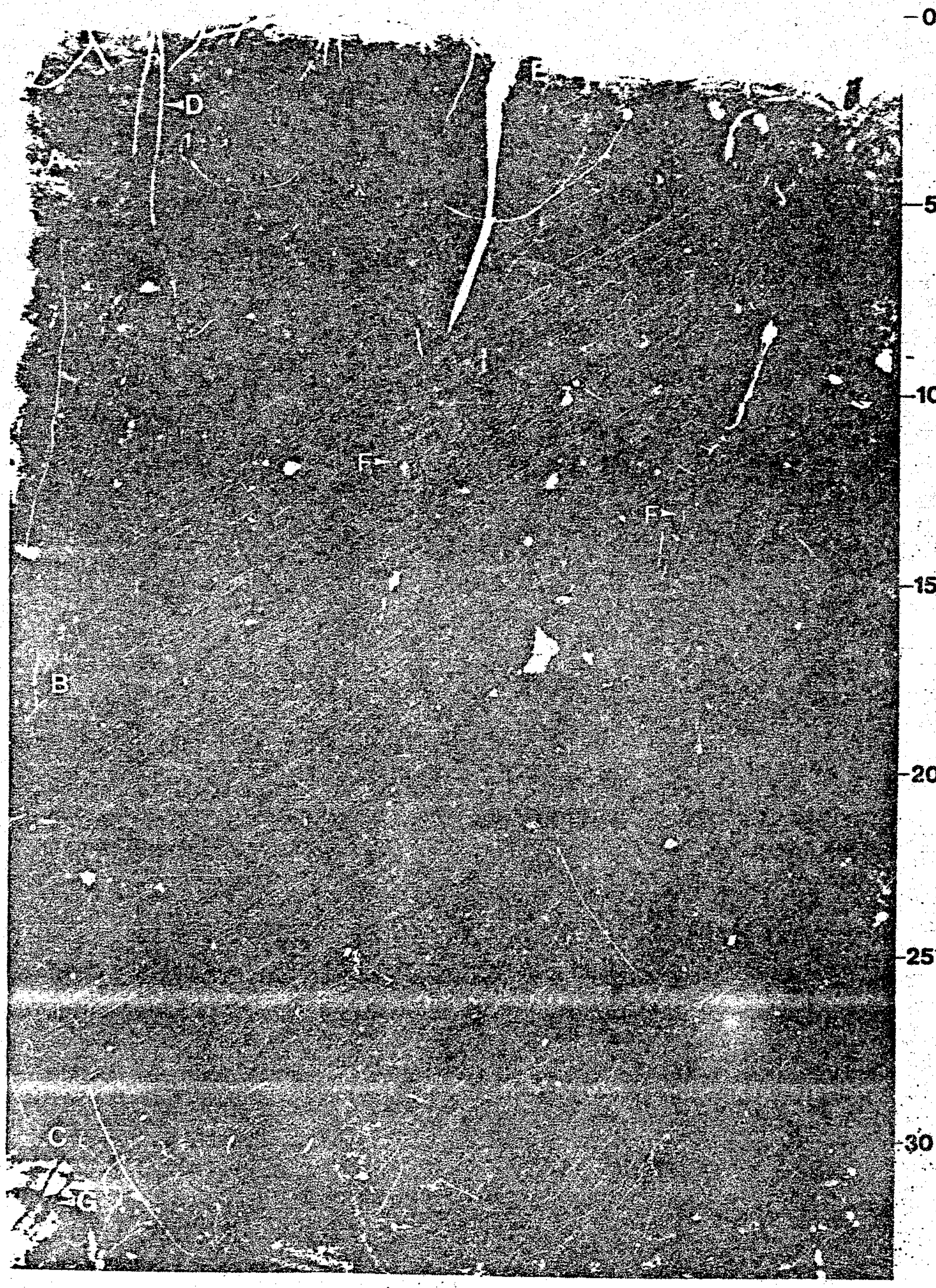
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Plate !. Station 42, Mixed-sediment environment.

Station 42: Eastern Shore opposite the mouth of the York River
Latitude: 37 12 48.174
Longitude: 76 4 6.364
Sampling Date: 9/15/78
Water Depth: 11.59 m
Radiographic positive print

MIXED-SEDIMENT ENVIRONMENT:

High densities of Clymenella torquata can potentially stabilize the sediments. Their reworking activities can greatly modify the sediment fabric, resulting in laminar disruption and sediment mottling.

Degree of bioturbation: 90-99%

SPECIAL FEATURES:

A. Mud lamina that has been disrupted resulting in mud pockets

B. Mulinia lateralis shell layer

C. Clymenella torquata tubes (active)

D. Clymenella torquata tube (inactive)

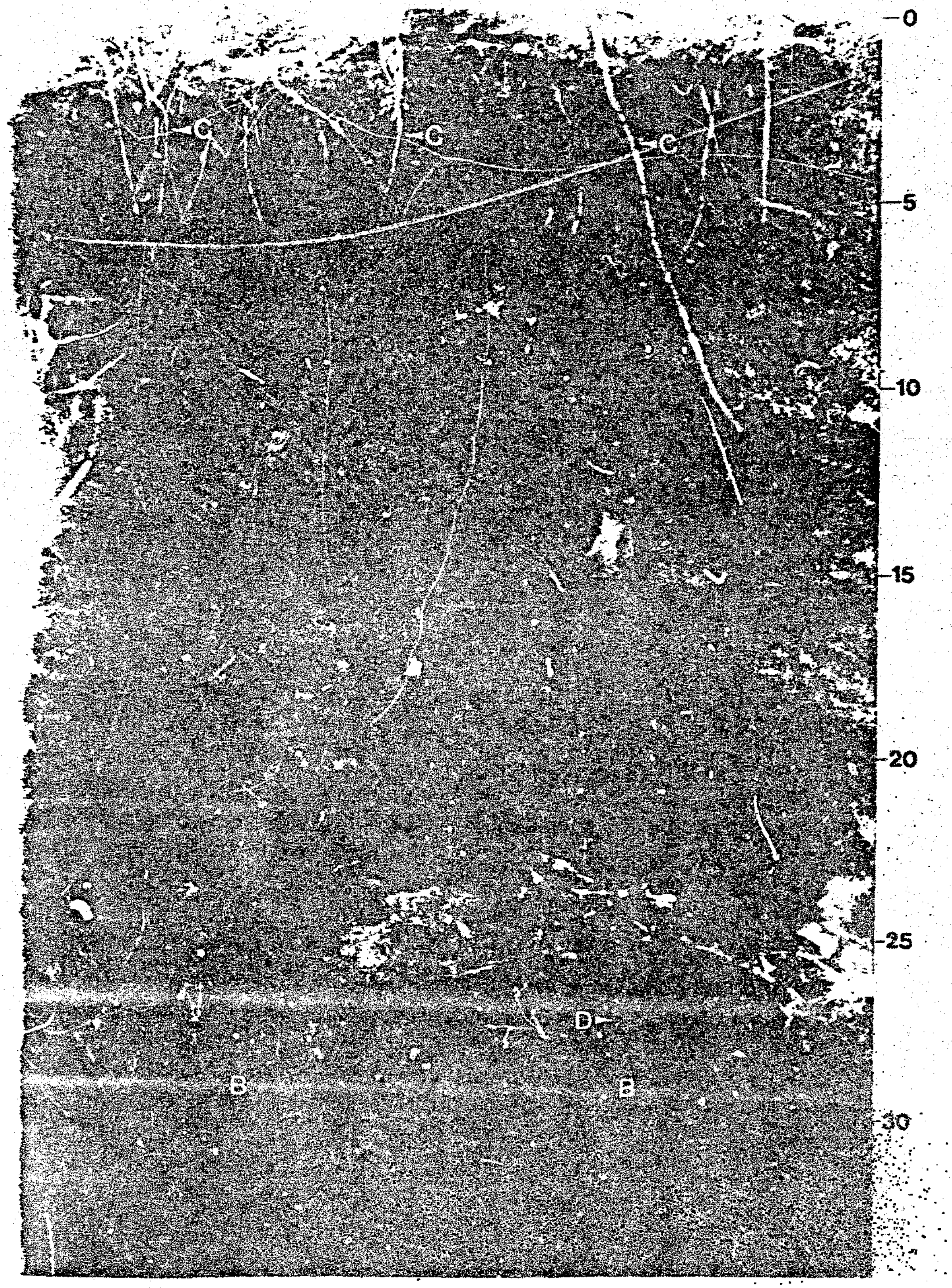
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Plate 10. Station 96, Coarse-medium sand environment.

Station 96: North of Chesapeake Bay Bridge Tunnel
Latitude: 37 10 49.356
Longitude: 76 7 9.316
Sampling Date: 6/14/79
Water Depth: 8.23 m
Radiographic positive print

COARSE-MEDIUM SAND ENVIRONMENT:

The oceanic-derived sands of this core contain a surface layer of Pectinaria gouldii tubes. Biological reworking processes have homogenized the sediments. The surface excavation is the result of unknown physical or biogenic action.

Degree of bioturbation: 90-99%

SPECIAL FEATURES:

A. Surface excavation of unknown origin

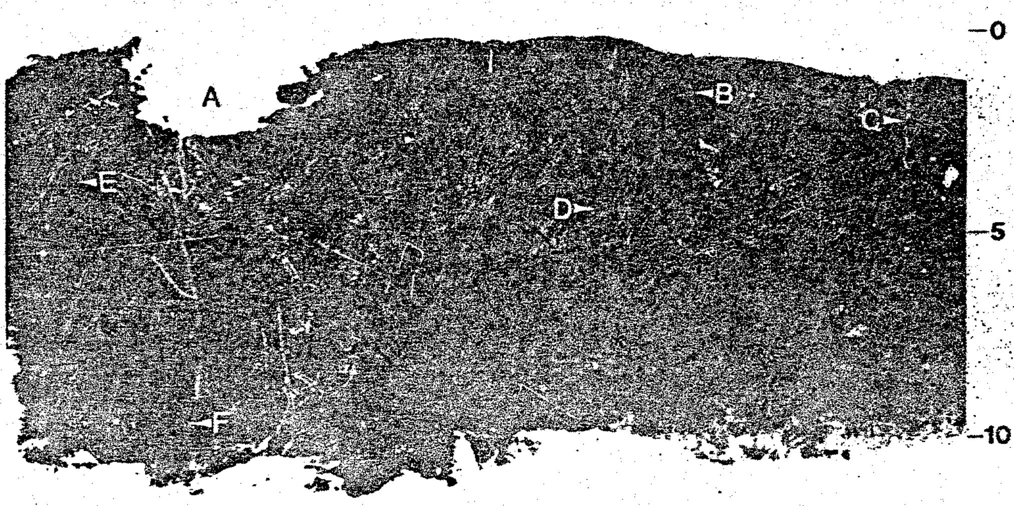
B. Pectinaria gouldii tube

C. Juvenile Ensis-directus burrow

D. Paraprionspio pinnata trace

E. Diopatra cuprea tube

F. Ensis directus shell



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Appendix E

Station description with visual observations, x-ray description and important biogenic species

Station: 26 9-78

Area: Tangier Sound (98 ft) Depth penetration: 43 cm

Sediment: mud (top 12 cm fluid mud than cohesive black nud to 40 cm than grey mud)

Visual Structures:

Physical: methane gas pocketing

Biological: few amphipod tubes brown against black background on surface than nothing until 35-43 mat of old ampeliscid tubes.

Important Biogenic Agents:

Ampelisca abdita - stabilizes sediment surface
Nereis succinea - ventilates burrows
Paraprionospio pinnata - small burrows (<1 mm. wide)
Loimia medusa - large tube dweller (4 mm wide)

X-ray structures: no x-ray, sample destroyed by on-board handling

Station: 27 9-78

Area: Pocomoke Sound (16 ft) Depth penetration: 30 cm

Sediment: medium-fine sand with increasing coarse sand & gravel with depth

Visual Structures:

Physical: many mineral colors, surface mottled with mud clasts, deeper get streaks of clay, thin layer mud under stones.

Biological: few Clymenella tubes on surface, 15-20 mud filled burrow (7 mm)

Imp. Biogenic Agents:

C. torquata - "conveyor belt" which mixes top 15-20 cm
P. ambigua - deep random burrowing polychaete
P. pinnata - thin burrow in the top 5 cm

X-ray structures:

Physical - between 13-16 cm. See transition of medium and fine sand to coarse sand and gravel. This represents a storm erosion layer, few mud clasts in upper 10 cm, mud lining underneath stones

Biological - few Clymenella tubes; most abundant are Paraprionospio pinnata burrows.

Station: 28 9-78

Area: just south of Potomac River mouth (82 ft)
Depth penetration: 28 cm

Sediment: fine-medium sand

Visual Structures:

Physical: few pebbles and clay veins toward bottom

Biological: on surface lots of *Pectinaria* tubes, few *Clymenella* tubes, 7 mm wide chaetopterid tube, glycerid polychaete trace to 28 cm. *Clymenella* tubes and a chaetopterid tube extend all the way to the bottom of the core

Important Biogenic Agents:

Chaetopterus variopedatus - large tube dweller
Paraprionospio pinnata - thin burrows
Pseudeurythoe ambigua - deep burrowing polychaete
Clymenella torquata - "conveyor belt" species
Glycera dibranchiata - large burrow dwelling polychaete capable of ventilating its burrow

X-ray Structures:

Physical - large lump of iron at 12-17 cm, more pebbles >15 cm down, one mud clast at 10 cm, lg irregular dark area 20-25 cm?

Biological: few *pectinaria* tubes on top. Several glycerid burrows, couple of *Clymenella* tubes.

Station: 29 9-78

Area: just west of Tangier Island (33 ft)
Depth penetration: 21 cm

Sediment: fine-medium sand

Visual Structures:

Physical: streaks of darker sediment (mottled R.P D.)

Biological: few Clymenella & ampeliscid tubes on surface
large terebellid tube 0-10 cm, phoronid tube 5-20 cm.
13 mm hole going out of core 10-15 (Callianassid shrimp?)

Important Biogenic Agents;

Terebellidae - large tube dweller
Deep errant polychaetes - Pseudoeurythoe ambigua, Ancistrosyllis, Orbinids, Driloneris
Phoronid - thin vertical sand tubes

X-ray structures

Physical: uniform bioturated sand

Biological: very little - few phoronid tubes, mostly a mobile fauna

Station 30 9-78

Area: off southern tip of Tangier Island (88 ft.)
Depth penetration: 38 cm

Sediment: mud - (fluid on top 5-6 cm)

Visual Structures:

Physical: none

Biological: surface matted with *Ampelisca*. Several unoccupied Terebellid tubes 5-15 cm. Hydroid strands 25-30 cm

Important Biogenic Agents:

Ampelisca abdita - tubes stabilize surface sediment
Nereis succinea - ventilates burrows
Terebellids - large ventilating tube dweller

X-ray: no good because sample was frozen

Station: 31 9-78

Area: west shore between Potomac River & Rappahannock River (44 ft)
Depth penetration: 19 cm

Sediment: mud (fluid)

Visual Structures:

Physical: none

Biological: none

Important Biogenic Agents: none

X-ray: sample frozen so no x-ray

Station: 32 9-78

Area: toward eastern shore between Rappahannock & Potomac Rivers (46 f.)

Depth Penetration: 20 cm

Sediment: muddy sand, poorly sorted

Visual Structures:

Physical: none

Biological: ampeliscid tubes, few *Pectinaria* & *Clymenella* tubes, hydroids at 0-5 cm at 5-10. Terebellid tube, at 10-15 *Clymenella* tubes, Terebellid tube and hydroids, at 15-20 old ampeliscid tubes, 4 mm burrow with gold brown long, and still have Terebellid tube.

Important Biogenic Agents:

Pectinaria - mobile tube dweller & "conveyor belt" species
Clymenella - "conveyor belt" species
Deep burrowing polychaetes - Orbinids, *Pseudeurythoe ambigua*, Pilargids

X-ray Structures: lost due to refrigeration failure (dried out)

Station: 33 9-78

Area: near the mouth of the Rappahannock River (35 ft)
Depth penetration: 40 cm

Sediment: fine sandy mud

Visual Structure:

Physical : fluid top 3 cm

Biological: few stringy tubes on surface, 0-5 cm short piece of parchment-like tube, 5-20 cm Glycerid traces, 20-25 cm capitellid traces

Important Biogenic Agents:

Nereis succinea: ventilates burrow

X-ray Structure: none due to refrigeration failure

Station: 34 9-78

Area: middle of Bay off the Rappahannock River (39 ft)
Depth penetration: 21 cm

Sediment: very fine sandy mud

Visual Structures:

Physical: fluid surface

Biological: 1 mm dia tubes of Clymenella torquata and stringy tubes on top (Paraprionospio pinnata?), few Pectinaria tubes on surface. 5-10 cm. 1 mm diameter burrow trace vertical, large 6 mm in diameter tube, 10-15 cm part of U shaped tube. (Loimia medusa), continuation of the 6 mm tube, 15-21 cm continuation of 6 mm tube

Important Biogenic Agents:

Paraprionospio pinnata - small burrows
Clymenella torquata - "conveyor belt species"

X-ray Structures:

Physical: none

Biological: many in back-filled burrows of various sizes. Nereis burrow 0-4 cm, few vertical maldanid tubes, many small burrows of P. pinnata at 0-8 cm patch of small capitellid like traces at 17-21 cm (probably Heteromastus filiformis). Some Mulinia shell hash on surface

Station: 35 9-78

Area: toward Eastern Shore of Rappahannock River (39 ft)
Depth penetration: 38 cm

Sediment: very fine sandy mud

Visual Structures:

Physical: none

Biological: 0-5 cm *P. pinnata* mucoid tubes, ampeliscid tubes, many *Pectinaria* tubes, lg Chaetopterid tube, many *Clymenella* tubes, couple of terebellid tubes, 5-10 cm continuation of *Clymenella* and terebellid tubes, ophiuroid in life position. 10-15 cm piece of cerianthid tube, continuation of *Clymenella* tubes. 20-25 cm continuation of *Clymenella* and terebellid tubes. 25-30 cm capitellid traces. 30-38 cm nothing.

Important Biogenic Agents:

Clymenella torquata - "conveyor belt species"

X-ray Structures:

Physical: slight trough cross bed sand in the upper 2 cm

Biological: couple of *Clymenella* tubes, many back-filled burrows of Glycerids, Terebellid and Cerianthid anemones. *P. pinnata* traces in the top 8 cm. Few capitellid traces ation: 36 9-78

ea: Eastern Shore opposite Rappahannock River (37 ft)
Depth penetration: 21 cm

diment: muddy sand mixed with gravel

sual Structure:

Physical: mottled R.P.D., 0-5 cm, increasing amount of pebbles with increasing depth

Biological: surface has *Sabellaria vulgaris* tubes. few ampeliscid tubes, one *Pectinaria*, one Ampharetid tube, section of Cirratulid burrow with reddish-brown lining. 5-10 cm continuation of burrows and ampharetid tube. 10-15 cm continuation of cirratulid burrow. 15-20 cm nothing

mportant Biogenic Agents:

Nereis succinea - ventilates its burrow
Ampharetid - tentaculate polychaete which mound sediment around
Cirratulidae - large burrowing polychaete with lined burrow

X-ray Structure:

Physical: scattered pebbles, mottled with mud

Biological: many shell 1mm in diameter burrow (either *P. pinnata* or juvenile *Nereis*), 0-5 cm, couple of large back-filled burrows and cirratulid burrow (probably *Cirriformia grandis*)

Station: 37 9-78

Area: west shore of transect between York & Rappahannock Rivers (22 ft)

Depth penetration: 18.5 cm

Sediment: poorly sorted sand - lots of shell & gravel

Visual Structure:

Physical: lots of gravel on bottom

Biological: Clymenella tubes seen from surface. Ampharetid tube 0-15 cm, 5-10 cm 11 mm in dia. mud filled burrow, Glycerid traces

Important Biogenic Agents:

Mobile polychaetes - Glycera, Drilonereis, Pilargids, Pseudeurythoe

X-ray Structures:

Physical: lots of pebbles & shell hash, large oyster shell at 13 cm, grey uniform sediment, a mud layer .5 cm

Biological: Clymenella tube to 10 cm, mobile fauna responsible for uniform sediment

Station: 38 9-78

Area: middle of the Bay between York & Rappahannock Rivers (37 ft)
Depth penetration: 51 cm.

Sediment: poorly sorted sandy mud

Visual Structure:

Physical: none

Biological: Terebellid tube 0-51 cm, few *Pectinaria* tubes on surface, mucus tubes of *P. pinnata*

Important Biogenic Agents:

Pectinaria gouldii - mobile tube dweller, "conveyor belt species"
Loimia medusa - large tube dweller
Glycera americana - large polychaete which ventilates its burrow

X-ray Structure:

Physical: sand patch on surface to 2 cm

Biological: many various back-filled burrows, glycerid traces, capitellid burrows at 25 cm

Station: 39 9-78

Area: toward Eastern Shore between York & Rappahannock River (43 ft)
Depth penetration: 17 cm

Sediment: poorly sorted sand

Visual Structure:

Physical: gravel on bottom, black mottling, lots of *Mytilus edulis* shells

Biological: at 5-10 cm, a 2.4 cm diameter burrow (*Callianassa atlantica*) at 10-15 cm ophiuroid arm, *Callianasa atlantica*, many reddish-brown burrows with cirratulid tentacles (*Cirriform grandis*)

Important Biogenic Agents:

Callianassa atlantica - large burrow, process large amounts of sediment
Mobile polychaetes - *Glycera*, *Pseudoeurythoe*, Cirratulids, Arabellids
Micropholis atra - ventilates its burrow

X-ray Structure:

Physical: wavy sand layering in the top 4 cm, large pebbles & gravel, mud clasts

Biological: lots of small indistinguishing worms traces, general uniform sediment brought on by bioturbation of a mobile fauna

Station: 40 9-78

Area: Eastern Shore between York & Rappahannock Rivers
Depth Penetration: 33 cm

Sediment: medium fine sand

Visual Structure:

Physical: mottled RPD

Biological: Maldanid tube 0 to 25 cm, Whelk on surface, *Ensis directus* at 5-10 cm, fragment of cerianthid anemone tube, 10-15 cm goldish-brown burrows

Important Biogenic Agents:

Busycon carica - plower of the top several cm
Ensis directus - large burrowing bivalve
Clymenella torquata - "conveyor belt" species
Glycera americana - large burrow which it ventilates
Pseudoeurythoe ambigua - deep burrower
Micropholis atra - ventilates its burrow

X-ray Structure:

Physical: 16-22 cm patch of shell fragments

Biological: thin burrows along surface, couple of deep back-filled burrows. Mostly bioturbated uniform sands *Clymenella* tubes 0-15 cm

Station: 41 9-78

Area: between York River and Mobjack Bay (46 ft)
Depth Penetration: 24 cm

Sediment: muddy sand, poorly sorted

Visual Structure:

Physical: gravel throughout increasing with depth (15-20) along with patches of compact orange and grey clays, strands hydroid throughout

Biological: 0-5 thin mucoid tubes (*P. pinnata*), *Sabellaria* reefs, *Pectinaria* tubes, 10-15 cm capitellid worm traces

Important Biogenic Agents

Nereis succinea - ventilates its burrow
Clymenella torquata - "conveyor belt" species

X-ray Structure:

Physical: lots of *Anadara* shell hash near surface, very mottled looking, more stones at bottom with "islands of clay" mud living around stones

Biological: couple back-filled burrow, *Pectinaria* tubes

Station: 42 9-78

Area: Eastern Shore opposite York River (38 ft)
Depth penetration: 36 cm

Sediment: muddy fine sand

Visual Structure:

Physical: none

Biological: lots of *Clymenella* tubes, Cerianthid anemone tube at 15-20 cm, at 25-30 cm mud cylinder

Important Biogenic Agents:

Clymenella torquata - "conveyor belt species"
Various mobile polychaetes

X-ray Structures:

Physical: shell hash30-35 cm, mud streak 25 cm

Biological: many *Clymenella* tubes to 18 cm, few orbinid polychaete traces, few back-filled burrows in the deeper layers, streak of mud 30-35 cm tation: 43 9-73

rea: mid Bay off York River (38 ft) Depth Penetration: 25 cm

ediment: muddy sand, poorly sorted

isual Structure

Physical: gravel further down

Biological: Yoldia limatula at 3 cm. Pb_{210} core at this station resulted in a large cerianthid anemone. P. pinnata at 0-5 cm, 0-10 Praxiella gracilis tube, several misc. burrows, capitellid traces 10-13 cm, large burrow at 15-20 cm

Important Biogenic Agents:

Yoldia limatula - large deposit feeding bivalve, bioturbator
Maldanidae - "conveyor belt" species
Mobile polychaetes - general bioturbators
Micopholis atra - ventilates its burrow

X-ray Structure:

Physical: lg patch of sand without mud on left side 16-25 cm deep. lots of shell hash on surface

Biological: few maldanid tubes, some back-filled burrows, cerianthid trace or streaks at 19-28 cm, few mobile polychaete traces

Station: 44 9-78

Area: just north of Buckroe Beach (24 ft)
Depth Penetration: 13 cm

Sediment: well sorted fine sand with lots of shell hash

Visual Structure:

Physical: surface rippled with wave height of 2 cm. Wave length 1/2 width of box. lots of shells.

Biological: *Mulinia lateralis* on surface, Glycerid polychaetes 5-10 cm.

Important Biogenic Agents:

Mulinia lateralis - produces "sitz" marks
Glycera dibranchiata - ventilates its burrow

X-ray Structure:

Physical: lots of shell hash, ripple at right end surface, mud chart under crest. Very dynamic

Biological: one back-filled burrow

Station: 45 9-78

Area: western side near the James River (29 ft)
Depth Penetration: 27 cm

Sediment: medium fine sand

Visual Structures:

Physical - few pebbles

Biological - *Busycon* on surface, maldanid tubes, phoronid tubes

Important Biogenic Structures:

Busycon carica - "plower"
Mobile polychaetes - *Pseudoeurythoe*, *Glycera*, *Scoloplos*

X-ray Structures: no x-ray

Station: 46 9-78

Area: mid Bay off Fishermen's Island (49 ft)
Depth Penetration: 18 cm

Sediment: muddy sand, poorly sorted

Visual Structures:

Physical - none

Biological - *Pectinaria* tubes on surface, terebellid tubes beyond 17 cm, *Yoldia* & *Tellina* in 0-5 cm layer, *Cerebratulus* in 5-10 cm layer

Important Biogenic Agents:

Pectinaria gouldii - mobile tube dweller, "conveyor belt species"
Asychis elongata - large tube dwelling polychaete
Mobile fauna - *Glycera*, *Pseudeurythoe*, *Cerebratulus*

X-ray Structures:

Physical - shell fragments 0-5 cm

Biological - *L. medusae* tubes, grey bioturbate texture due to mobile fauna

Station: 47 9-78

Area: Hampton Roads (44 ft) Depth Penetration: 38 cm

Sediment: muddy fine sand

Visual Structure:

Physical: none

Biological: Terebellid & Maldanid tubes all the way down

Important Biogenic Structures:

Upogebia affinis - decapod burrower
Terebellidae - large tube dwelling polychaete
Maldanidae - "conveyor belt" species

X-ray Structures:

Physical - patch of layered mud-sand (laminated) at 7-8 cm. Shell hash patchy at 20-26 cm

Biological - few *P. pinnata* burrows, a *Pectinaria* tube, maldanid tube, several glycerid burrows deeper down & capitellid traces deep

48 9-78

off Little Creek (28 ft) Depth Penetration: 18 cm

: a fine sand with lots of shell hash

ructures:

sical - none

logical - Mulinia lateralis on top, Loimia medusa tube, mobile polychaetes

t Biogenic Structures:

mia medusa - large tube dwelling polychaete
aprionospio pinnata - small burrows
udoeurythoe ambigua - deep burrowing polychaete

ructures:

sical - shell lag area 10-15 cm

logical: numerous P. pinnata burrows at 0-7 cm, lots of glycerid traces, grey bioturbate texture from mobile fauna

Station: 49 9-78

Area: off Lynnhaven (38 ft) Depth Penetration: 55 cm

Sediment: muddy sand top 20 cm than sandy mud 20-55 cm

Visual Structures:

Physical - more clay 40-50 cm

Biological - surface mucoid tubes of P. pinnata and Ampelisca, Yoldia at 0-5 cm. Maldanid tubes to 20 cm, glycerid burrow 25-30 cm, Mulinia shells below 20 cm, lots of mud filled burrows 35-40 cm, capitellid burrows, more glycerid burrows to 50 cm

Important Biogenic Agents:

Yoldia limatula - deposit feeding mollusc bioturbator
Upogebia affinis - large deep burrowing decapod
Maldanids - "conveyor belt" species

X-ray Structures:

Physical - top 8 cm sandier, patches of mud with thin sand layer at 1-5 cm and 30 cm

Biological - lots shell hash top 8 cm lot of mottling of back-filled burrows in last 30 cm (probably Asychis and Glycerids)

Station: 50 9-78

Area: off Cape Henry (58') Depth Penetration: 22 cm

Sediment: medium-fine sand

Visual Structures:

Physical: none

Biological: *Nassarius* crawling on top, mobile polychaetes

Important Biogenic Agents:

Mobile polychaetes - *Glycera*, Orbinids, Arabellids

X-ray Structures:

Physical - large *Ensis* shell, slight layering on top 1 cm

Biological - small worm traces, general grey bioturbate texture

Station: 76 6-79

Area: Tangier Sound (98 ft) Depth Penetration: 30 cm

Sediment: mud

Visual Structures:

Physical - black fluid mud, methane gas holes, dead hydroids throughout

Biological - lots of ampeliscid tubes on top, few *Pectinaria* on surface

Important Biogenic Agents:

Macoma balthica - deposit feeding bivalve
Ampelisca abdita - stabilizing tubes
Nereis succinea - ventilates its burrow
Pectinaria gouldii - mobile tube dweller, "conveyor belt" species
Capitellids - "conveyor belt" species

X-ray Structures:

Physical: darker mud band 2-4 cm
hydroid mat produces mottling, methane bubbles 10-15 cm

Biological: numerous sinuous worm burrows (*P. pinnata*, *Mediomastus*, small *Nereis*)

Station: 77 6-79

Area: south of the Potomac River mouth (65 ft)
Depth Penetration: 47 cm

Sediment: muddy medium-fine sand

Visual Structures:

Physical - top sandy mud (0-2 cm) than slightly muddy sand

Biological - lots *Pseudeurythoe ambigua*, few ampeliscid tubes, *Pectinaria* tubes & *Clymenella* tubes. An abandoned ceriantbid anemone tube

Important Biogenic Agents:

Nereis succinea - ventilates its burrow
Pseudeurythoe ambigua - deep mobile burrower
Glycera dibranchiata - ventilates its burrow

X-ray Structures:

Physical - mottling

Biological - many small worm traces (probably juvenile *Nereis*) 5-30 cm lots of back-filled burrows producing the mottling

Station: 78 9-78

Area: Tangier Sound (78 ft) Depth of penetration: 35 cm

Sediment: mud - first 10 cm, 10-40 cm medium coarse sand

Visual Structures:

Physical - first 10 cm mud than coarse sand

Biological - Nereis & P. pinnata near surface, no back-filled burrow noted, deep down some old amphipod tubes

Important Biogenic Agents:

Macoma balthica - deposit feeding bivalve
Ampelisca abdita - its tubes stabilizes surface, increases sedimentation
P. pinnata - small burrowing polychaete
Nereis succinea - medium burrowing polychaete, ventilates its burrow

X-ray Structures:

Physical: good demarcation between mud and sand at 5-10 cm, shell lag upper 10 cm, wavy sand laminae in upper 5 cm of mud

Biological: Mulinia at surface, Nereis succinea burrows, Pectinaria tubes, few back-filled burrows

Station: 79 9-78

Area: south of Potomac River Mouth (60')
Depth of Penetration: 30 cm

Sediment: mud (black, fluid)

Visual Structures:

Physical: fluid mud

Biological: few *Mulinia* on surface

Important Biogenic Agents:

P. pinnata - small burrowing polychaete

X-ray Structures:

Physical - density change with higher mud content 0-8 cm than sandier further down - not supported by grain size data maybe just more cohesive

Biological - thin burrows 0-5 cm (probably *P. pinnata*) larger *Nereis succinea* branched burrow at 9-14 cm. *Mulinia* on surface, 3-6 cm lots of capitellid traces

Station: 80 6-79

Area: south Tangier Island (58 ft)
Depth of Penetration: 50 cm

Sediment: alternating muddy sand to fine sandy mud

Visual Structures:

Physical - none

Biological - scattered ampeliscid tubes, *Loimia* tube & *Pectinaria* tubes

Important Biogenic Structures:

Ampelisca abdita - stabilizes sediment surface
Pectinaria gouldii - "conveyor belt" species
Heteromastus filiformis - "conveyor belt" species

X-ray Structures:

Physical - laminated mud and sand layers

Biological - *Pectinaria* tubes, large abandoned *Loimia medusa* tubes pierce laminae, capitellid traces

Station: 81 6-79

Area: Pocomoke Sound (51 ft) Depth of Penetration: 50 cm

Sediment: muddy sand

Visual Structures:

Physical - sand gets coarser with depth

Biological - mucoid tubes of *P. pinnata* on surface, old *Loimia medusae* tubes, few back-filled burrows. Some *Pectinaria* tubes

Important Biogenic Agents:

Pectinaria gouldii - "conveyor belt" species
Loimia medusa - large tube dwelling polychaete
Pseudoeurythoe ambigua - mobile polychaete

X-ray Structures:

Physical - lots of shell hash, surface muddier with thin sand layering. Few pebbles & wood

Biological - mottled with back-fill burrows below 8 cm. Lots of *Pectinaria* on surface *Asychis elongata* tube 4-11 cm.

Station: 82 6-79

Area: western shore between the Potomac and Rappahannock Rivers (80 ft)

Depth of Penetration: 30 cm

Sediment: mud (black, fluid)

Visual Structures:

Physical: fluid mud

Biological: none

Important Biogenic Agents:

Pectinaria gouldii - "conveyor belt" species

X-ray Structures:

Physical: methane gas holes, wavy layering top 2 cm and 5-7 cm, mud layer at 10-11 cm and 15-17 cm

Biological: few *Mulinia* shells, general bioturbate texture at 2-4 cm and 6-12 cm

Station: 83 6-79

Area: north Rappahannock River (40 ft)
Depth of Penetration: 50 cm

Sediment: mud

Visual Structures:

Physical - methane gas holes

Biological - large cerianthid back-filled burrow, lots of *P. pinnata*, *Macoma* at 10 cm.

Important Biogenic Agents:

Cerebratulus lacteus - general bioturbator
P. pinnata - small burrowing polychaete
N. succinea - medium burrowing polychaete, ventilates its burrow
Capitellids - "conveyor belt" species
Macoma balthica - deposit feeding bivalve

X-ray Structures:

Physical - nothing

Biological - many long thin burrows of *P. pinnata* from 0-12 cm, 6-40 cm back-filled burrows, *Macoma* at 6 cm, 4 mm burrow of *Nereis succinea* at 3-7 cm. Another at 27-34 cm

Station: 84 6-79

Area: mid Bay, north of the Rappahannock River (42 ft.)
Depth of Penetration: 50 cm

Sediment - mud

Visual Structures:

Physical - none

Biological - large cerianthid back-filled burrow, lots of back-filled burrows

Important Biogenic Agents:

Ceriantheopsis americanus - large tube dwelling anemone
Asychis elongata - large tube dwelling polychaete
Nereis succinea - medium burrowing polychaete, ventilates its burrow

X-ray Structures:

Physical - none

Biological - lots of *P. pinnata* burrows upper 12 cm, 3.5 cm wide back-filled cerianthid tube, 5 mm *Asychis* tube 9-15 cm. few *Pectinaria* on surface, few *Mulinia* on surface

Station: 85 6-79

Area: mid Bay between the Potomac and Rappahannock River (39 ft.)
Depth of Penetration: 50 cm

Sediment: mud

Visual Structures:

Physical: none

Biological: few *Pectinaria* on surface, few back-filled burrows

Important Biogenic Agents:

Pectinaria gouldii - "conveyor belt" species

X-ray Structures:

Physical - *Mulinia* shell hash layer 0-10 cm

Biological - few *Mulinia* near surface, few thin burrows 0-2 cm, few juvenile *Pectinaria* tubes near surface, few vertical burrows 0-8 cm, lots of back-filled burrows 8-37 cm

Station: 86 6-79

Area: in the mouth of the Rappahannock River (61 ft)
Depth of Penetration: 30 cm

Sediment: mud (black, fluid)

Visual Structures:

Physical - fluid, gas bubbles

Biological - none

Important Biogenic Agents: none

X-ray Structure:

Physical - thin sand laying top 2 cm than gas bubbles. Some sand layering 6-7 cm. lots of shell hash 1-5 cm

Biological - nothing significant

Station: 87 6-79

Area: off Piankatank River (33 ft)
Depth of Penetration: 50 cm

Sediment: mud

Visual Structures:

Physical - none

Biological - few maldanid tubes, back-filled burrows, few *Pectinaria* tubes

Important Biogenic Agents:

Chaetopterus variopedatus - large tube dwelling polychaete
Pectinaria gouldii - "conveyor belt" species
Capitellids - "conveyor belt" species
Glycera americana - large burrowing polychaete, ventilates its burrow
Loimia medusa - large tube dwelling polychaete

X-ray Structures:

Physical - none

Biological - lots of juvenile *Pectinaria* on surface, lots of *P. pinnata* burrows in the 0-7 cm, lots of small scattered capitellid burrows, back-filled burrows 5-40 cm

Station: 88 6-79

Area: mid bay between Rappahannock River and Mobjack Bay (38 ft)
Depth of Penetration: 45 cm

Sediment: fine sandy mud

Visual Structures:

Physical - none

Biological - U shaped Loimia medusa tube, Pectinaria on surface, lots of Mulinia, small Busycon on surface

Important Biogenic Agents:

Mulinia lateralis - small burrowing bivalve
Clymenella torquata - "conveyor belt species", ventilates
P. pinnata - small burrowing polychaete
Capitellid - "conveyor belt" species
Glycerids - large burrowing polychaete, ventilates
Asychis - large tube dwelling polychaete

X-ray Structures

Physical - few pebbles

Biological - Pectinaria & Mulinia on surface. P. pinnata 0-11 cm, capitellid burrows 0-10 cm, few back-filled burrows

Station: 89 9-78

Area: Eastern Shore between Rappahannock and York Rivers (40 ft)
Depth of Penetration: 30 cm

Sediment: muddy sand

Visual Structures:

Physical: none

Biological: few hydroids on top, lots of maldanid and *Pectinaria* tubes, *Sabellaria* reef, *Loimia medusa* tube, lots of mobile polychaetes, *Molgula* on top

Important Biogenic Agents:

Clymenella sp. - "conveyor belt" species, ventilates
Mobile polychaetes - *Glycera*, *P. ambigua*, capitellids - bioturbators
Pectinaria gouldii - "conveyor belt" species
Molgula manhattensis - prolific biodepositor

X-ray Structure:

Physical: none

Biological: lots of juvenile *Clymenella* 0-7 cm, lots of *P. pinnata* burrows, grey bioturbate texture from mobile fauna

Station: 90 6-79

Area: Wolf Trap (26 ft) Depth of Penetration: 20 cm

Sediment: fine-medium sand

Visual Structures:

Physical: few mud layers below 10 cm

Biological: lots of maldanid tubes and *Spiophanes bombyx* tubes, mobile polychaetes

Important Biogenic Agents:

Ensis directus - burrowing bivalve
Oligochaete - "conveyor belt" species
Spiophanes bombyx - tube dwelling polychaete, stabilizes
Mobile polychaetes - *Glycera*, *Pseudeurythoe*, *Scoloplos* bioturbation

X-ray Structures:

Physical - thin mud layers at 12, 16, 20, 21 and 25 cm. few mud layers below 20 cm

Biological - lots of *Ensis* traces, 0-7 cm. long thin burrows. *Mulinia* shell hash layers at 12, 16, 20, 21 and 25 cm. (seems to be associated with thin mud layers)

Station: 91 6-79

Area: Eastern Shore between Rappahannock and York Rivers (30 ft)
Depth of Penetration: 20 cm

Sediment: medium-fine sand

Visual Structures:

Physical - none

Biological - numerous *Mulinia*, *Ensis* and *Tellina* bivalves, lots of *Clymenella* tubes, mobile polychaetes and phoronid tubes

Important Biological Agents:

Ensis directus - burrowing bivalve
Tellina agilis - burrowing bivalve
Callianassa atlantica - large burrowing decapod
Clymenella torquata - "conveyor belt" species, ventilates
Pectinaria gouldii - "conveyor belt" species
Spiophanes bombyx - tube dwelling polychaete, stabilizes
Mobile polychaete - *Glycera*, *Pseudoeurythoe*, *Scoloplos* - bioturbators

X-ray Structure: none, dropped

Station: 92 6-79

Area: in Mobjack Bay (20 ft) Depth of Penetration: 50 cm

Sediment: mud (fluid)

Visual Structures:

Physical - fluid mud

Biological - watery tubes, lots of *P. pinnata*

Important Biogenic Agents: none

X-ray Structure:

Physical: frozen so partially destroyed

Biological: deep worm traces

Station: 93   6-79

Area: off the mouth of Mobjack Bay (43 ft)
Depth of Penetration: 50 cm

Sediment: mud to sandy mud

Visual Structures:

Physical: none

Biological: small maldanid and ampeliscid tubes, dead hydroid fragments throughout, large *Cerebratulus* found just outside the box. lots of *P. pinnata*

Important Biogenic Agents:

Cerebratulus lacteus - bioturbator
Pectinaria gouldii - "conveyor belt" species
P. pinnata - small burrowing polychaete
Asychis elongata - tube dwelling polychaete

X-ray Structure: frozen

Physical: mud layer at 20 cm

Biological: few back-filled burrows. Grey bioturbate texture

Station: 94 6-79

Area: mid Bay off Mobjack Bay (55 ft)
Depth of Penetration: 40 cm

Sediment: sandy mud

Visual Structures:

Physical - none

Biological - large ampeliscid tubes, lots of *Asabellides* and *Pectinaria* tubes, old cerianthid tube, glycerid burrow, *Thyone briareus*

Important Biological Agents:

Glycera americana - large burrowing polychaete, ventilates
Thyone briareus - large deposit feeding holothurian
Ceriantheopsis americanus - large tube dwelling anemone
Cerebratulus lacteus - bioturbator
Pectinaria gouldii - "conveyor belt" species
Clymenella torquata - "conveyor belt" species, ventilates

X-ray Structures:

Physical: *Mytilus edulis* shells at 30 cm

Biological: lots of juvenile *Pectinaria* on surface, some *Clymenella* tubes, large mud traces of back-filled burrows *Asychis* tube 15-20 cm

Station: 95 6-79

Area: mouth of the York River (35 ft)
Depth of Penetration: 50 cm

Sediment: mud

Visual Structures:

Physical: none

Biological: *P. pinnata* tubes on surface, few maldanid and Ampeliscid tubes, glycerid traces, old Cerianthid tubes. Many back-filled burrows

Important Biogenic Agents:

Glycera sp. - large burrowing polychaete
Pectinaria gouldii - "conveyor belt" species
P. pinnata - small burrowing polychaete
Clymenella torquata - "conveyor belt" species, ventilates
Capitellids and oligochaetes - "conveyor belt" species

X-ray Structures:

Physical: some sand layering at 15-35 cm

Biological: many *Pectinaria* juveniles on surface, long *P. pinnata* burrows 0-10 cm, few small *Mediomastus* burrows at surface many back-filled burrow 7-35 cm. *Macoma* shell layer 12-14 cm 7-20 cm many capitellid burrows

Station: 96 6-79

Area: mid Bay near York Spit Channel (27')
Depth of Penetration: 13 cm

Sediment: all fine sand

Visual Structure:

Physical: none

Biological - large *Diopatra* tube, few maldanid tubes, lots of *Ensis*, *Busycon* on surface

Important Biogenic Agents:

Glycera americana - large burrowing polychaete, ventilates
Ensis directus - burrowing bivalve, bioturbator
Clymenella torquata - "conveyor belt" species, ventilates
Spiophanes bombyx - tube dwelling polychaete, stabilizes
Pectinaria gouldii - "conveyor belt" species
Capitellids - "conveyor belt" species

X-ray Structures:

Physical: some sand layering top 0-4 cm, shallow cavity on surface

Biological: *Ensis* tubes, *Diopatra* tube, *Pectinaria* on surface, *Clymenella* tubes, lots of small thin branched burrows 0-1 cm

Station: 97 6-79

Area: north of Cape Charles (110 ft)
Depth of Penetration: 20 cm

Sediment: muddy fine sand

Visual Structures:

Physical:

Biological - lots *Pectinaria* on surface, some glycerid traces

Important Biogenic Agents:

Tellina agilis - burrowing bivalve, bioturbator
Nereis succinea - medium burrow dwelling polychaete, ventilates
Oligochaete - "conveyor belt" species
Sabellaria vulgaris - builds "reefs" of sand
Pectinaria gouldii - "conveyor belt" species
Glycera americana - burrowing polychaete

X-ray Structure:

Physical - top 4 cm darker (muddier), lots of shell hash

Biological - lots of *Pectinaria*, few mud burrows, mostly grey bioturbate texture

Station: 98 6-79

Area: off Newport News (61 ft) Depth of Penetration: 13 cm

Sediment: muddy gravely coarse sand, poorly sorted

Visual Structures:

Physical: very heterogeneous sediment-mud gravel, hydroids, shells, junk and large rock on top

Biological: three large Callianassid burrows, mobile polychaetes

Important Biogenic Agents:

Callianassa atlantica - large burrowing decapod
Nereis succinea - medium burrow dwelling polychaete, ventilates
Oligochaetes - "conveyor belt" species
Pectinaria gouldii - "conveyor belt" species
Mobile polychaetes - *Glycera*, Orbinids, *Arabella*, *Marphysa*

X-ray Structures:

Physical: mud clasts, lots of shells hash, gravel and stones

Biological: few *Nereis* burrows

Station: 99 6-79

Area: Hampton Roads (55 ft) Depth of Penetration: 39 cm

Sediment: muddy fine sand

Visual Structures:

Physical: shell layer at 10 cm

Biological: maldanid tubes, Ensis directus burrows, long Glycerid burrow to 20 cm. Pockets of fluid mud, cerianthid tube

Important Biogenic Agents:

Ensis directus - burrowing bivalve, bioturbator
Pectinaria gouldii - "conveyor belt" species
Glycera americana - large burrowing polychaete, ventilates

X-ray Structures:

Physical: lot of shell hash 5-15 cm. Darker mud band at 15-20 cm, large rock on surface

Biological: few Pectinaria on surface, three Asychis burrows 14-30 cm, back-filled burrows 15-35 cm

Station: 100 6-79

Area: off Cape Henry (62 ft) Depth of Penetration: 11 cm

Sediment: fine-medium sand

Visual Structures:

Physical: none

Biological: *Ensis* burrows. Mobile polychaetes

Important Biogenic Agents:

Capitellids - "conveyor belt" species
Mobile polychaete: *Glycera*, *Magelona*, *Drilonereis*

X-ray Structures:

Physical: iron oxide traces, sand layering in cross trough bedding

Biological - large *Loimia medusae* tube, small worm traces (Capitellids), *Ensis directus* traces, few thin Y branched burrows (probably juvenile glycerid)

Station: 103 4-79

Area: mouth of the York River (25 ft)
Depth of Penetration: 17 cm

Sediment: muddy fine sand, lots of oyster shells

Visual Structures:

Physical - oyster shell layer at 5-12 cm

Biological - lots of *Clymenella* tubes

Important Biogenic Agents:

Clymenella torquata - "conveyor belt" species, ventilates
Paraprionospio pinnata - small burrowing polychaete
Glycera sp. - large burrowing polychaete, ventilates

X-ray Structures:

Physical - slight mud layering on top

Biological - oyster shells 5-12 cm, with tubes

Station: 104 4-79

Area: near Wolf Trap Depth of Penetration: 57 cm

Sediment: muddy fine sand

Visual Structures:

Physical: none

Biological: hydroid community on top, lots of back-filled burrows, cerianthid tube, lots of *Pectinaria* on surface, large *Cerebratulus* leaving traces

Important Biogenic Agents:

Sertularia - hydroid, changes surface topography
Cerebratulus lacteus - bioturbator
Molgula manhattensis - biodepositor
Paraprionospio pinnata - small burrowing worm
Nereis succinea - medium burrowing worm, ventilates
Pectinaria gouldii - "conveyor belt" species
Mobile polychaetes - *Glycera*, orbinids, etc.

X-ray Structures:

Physical: large mud patches

Biological: back-filled burrow of *Glycera* or cerianthids, small worms traces 0-5 cm (probably *P. pinnata*) few *Pectinaria* on surface

Station: 105 4-79

Area: Eastern Shore off Cape Charles City
Depth of Penetration: 40 cm

Sediment: muddy fine sand

Visual Structures:

Physical: none

Biological: lots of *Clymenella* tubes, large *Cerebratulus* burrowing leaving a smooth oval burrow. Glycerid type back-filled burrows and traces. Ophiuroid with commensal polynoid at 7 cm, terebellid tubes, large *Yoldia limatula*, *Asychis* tube.

Important Biogenic Agents:

Yoldia limatula - deposit feeding bivalve
Cerebratulus lacteus - bioturbator
Ceriantheopsis americanus - large tube dwelling anemone
Micropholis atra - ventilates
Clymenella torquata - "conveyor belt" species
Capitellidae - "conveyor belt" species
Oligochaetes - "conveyor belt" species
Glycera sp. - large burrowing polychaete, ventilator
Loimia medusa - large tube dwelling polychaete

X-ray Structures:

Physical: none

Biological: *Clymenella* tubes, large *Pectinaria*, small worm traces, general grey bioturbate structure from mobile fauna

Appendix F

Description of the biogenic structures of some of the common and important macrobenthic organisms found in the lower Chesapeake Bay

Hydrozoa

Sertularia argentea - dead forms of this species break off during storms and are transported to certain areas where they are buried. They appear as black streaks and dots in our radiographs (ex. Sta. 76).

Anthozoa

Ceriantheopsis americanus - a large tube dwelling anemone which may be up to 2 cm in diameter and may go beyond 60 cm in depth. The tube is made of tough cnidae and persists long after the animal dies allowing for surface material to fill in (ex. Sta. 84). For more details on this organism and its structure see Frey (1970).

Nemertea

Cerebratulus lacteus - large predator (2 cm in diameter and 120 cm long) randomly burrowing as it searches for food. We have found specimens hanging from the bottom of 55 cm cores. As it burrows it leaves a oval opening matching its body. Howard and Frey (1975) found that its foraging traces do not remain open long and its effect is that of general bioturbation. Like other nemerteans, Cerebratulus produces copious amounts of mucous which may have a binding effect on sediment grains (see Station Drawing 93b).

Phoronida

Phoronis sp. - a tentaculate suspension feeder which builds a long thin straight tube of sand from 0-15 cm in length and <1 mm in diameter. May serve to stabilize the sediments at high densities (Ronan 1978).

Mollusca

Busycon carica - large carnivorous gastropod (up to 20 cm) which plows the top several centimeters of sediment leaving furrows behind it. Results of this action is the destruction of physical layering leaving a more homogeneous bioturbated texture. (See Station Drawing 40a).

Mollusca (continued)

Ensis directus - deep infaunal suspension feeding bivalve. It forms a slightly inclined burrow, which we have found as deep as 20 cm, but is known to occur as deep as 50 cm. (Allen 1954). We have found it to have a halo of lighter colored (oxygenated) sediment around the burrow. It is an extremely fast burrower and probably contributes to the highly bioturbated sands that it is commonly found in. (See Station Drawing 100c).

Mulinia lateralis - shallow infaunal suspension feeding bivalve. We found size ranges <.5 mm to 20 mm. It can occur in large densities (approximately 30,000 per m^2 at station 87). It is this bivalve which contributes most heavily to the shell hash over most of the bay. Their colonization and die off sequences can be seen as distinct shell layers in several of our cores (see radiograph of Sta. 82).

Polychaeta

Asabellides oculata - a tentaculate deposit feeding ampharetid polychaete which is unusual because it builds a tube horizontally along the sediment surface. Tube has a thin membrane lining with coarse debris. (See Station Drawing 84o).

Asychis elongata - a deep deposit feeding maldanid polychaete which produces a mud reinforced tube. Unlike other members of the maldanid family, Asychis feeds on the surface. Its tube is usually 4-6 mm wide and up to 50 cm long. It often becomes back-filled when abandoned. (See Station Drawing 88v).

Clymenella torquata - a deep deposit feeding maldanid polychaete which builds a thin (2-3 mm) sand tube to depths of 15-20 cm. Because of its foraging habit of feeding at the bottom of its tube (20 cm) and defecating on the surface, Rhoads (1974) called it a "conveyor belt" species. This species is very common in muddy sands and sand of the bay and is responsible for recycling old buried materials. It also irrigates its tube often causing metals to form insoluble oxides around it. In some of our radiographs faint white lines can be seen around its burrows due to these metal oxides. In our visual observation the loadings appear as an orange rust appearance. (See Radiographs 89 and 103).

Polychaeta (continued)

Diopatra cuprea - tubiculous carnivore which decorates the top third of its tube with bits of shell, hydroids, pebbles and other coarse material. Not significant in our study but may be locally abundant (Wass 1972). (See Sta. drawing 96 and radiograph 96).

Glycera dibranchiata and G. americana - infauna omnivores which produce inclining vertical burrows of 4-6 mm and up to 50 cm in depth. These commonly become backfilled. A halo of oxidized sediment surrounds these burrow. See Howard and Frey 1975 for more details on burrow morphology. (See Sta. drawing 85g).

Heteromastus filiformis - sma'l infaunal subsurface deposit feeding capitellid polychaete. It builds small (<.5 mm diameter 30 cm deep) multibranched feeding burrows with a vertical defecation tube so it is another "conveyor belt" species. A more complete description of its sediment reworking can be found in Cadee (1979). (See Station Drawing 80i).

Loimia medusa - tentaculate deposit feeding terebellid polychaete. It builds a mud reinforced I shaped tube. They are often back-filled. It produce fecal mounds producing a micro-topography. (See Sta. drawing 87p).

Mediomastus ambiseta - small infaunal subsurface deposit feeding capitellid polychaete. Like Heteromastus it is a "conveyor belt" species but is confined to the top 5 cm. (See Sta. drawing 95o).

Nereis succinea - infaunal omnivore. It builds a complex burrow (up to 6 mm in diameter) with several openings to the surface as well as blind feeding branches. Fairly common to 15 cm in depth occasionally large adults to 50 cm. By ventilating its burrow it produces a halo of oxidized sediment in the anaerobic zone. This organism was designated to the most important species in the bioturbation of a New Hampshire estuary (Winston and Anderson 1971).

Paraprionospio pinnata - infaunal surface deposit feeding spionid polychaete. It forms a temporary burrow of .5 mm in diameter and down to 15 cm in depth although usually does not exceed 7 cm in depth. The burrow is very meandering with a mostly vertical component. This is our most common small burrow. (See Radiograph 84).

Appendix F (continued)

Polychaeta (continued)

Pectinaria gouldii - shallow infaunal deposit feeding polychaete (size range 2-68 mm). It produces a well constructed tube of sand grains, resembling an ice cream cone. It buries until the tip of its tube is at the sediment-water interface, feeding at the bottom and defecating on the surface ("conveyor belt" species). A lot of work on the biology and sediment reworking by this animal has been done (Gordon 1966, Rhoads 1967, Whitlatch 1974). Juveniles were extremely abundant in almost all of our cores in the spring of 1979. (See Sta. drawing 81o).

Polydora ligni - a small suspension feeding spionid polychaete which builds silty U-shaped tubes. Galstoff (1964) reports its presence in Delaware Bay was responsible for the burial of oyster beds due to increase sedimentation rate caused by the suspension feeding biodeposition activities of this spionid polychaete.

Pseudoeurythoe ambigua - deep infaunal sub-surface deposit feeding polychaete. No burrow associated with this organism, a random burrower. It is one of the few organisms which occurs below 10 cm in muddy sediments without a direct connection to the surface. Its' respiratory physiology would be an interesting study.

Sabellaria vulgaris - suspension feeding polychaete which builds a very hard sand tube often interwining with other Sabellaria vulgaris tubes to form "mini reefs". Assorted epifauna which could not survive the soft bottom are associated with the Sabellaria structures (hydroids, Anadara, Molgula caprellids, etc.).

Scoloplos sp. - a sub-surface deposit feeding orbinid which has no permanent structures associated to it. Its' random burrowing in search for food produces the homogeneous bioturbate texture seen in many of our muddy sand and sand cores.

Spiochaetopterus occulatus - a suspension feeding polychaete which builds long, thin, straight tubes of clear chitin. Only abandoned tubes transported from other areas (Zostera beds) were found.

Spiophanes bombyx - tentaculate surface deposit feeding polychaete which builds a loosely constructed sand tube approximately 4 cm long and 2-3 mm wide. (See Sta. Drawing 90aa)

Polychaeta (continued)

Streblospio benedicti - small surface deposit feeding spionid which produces flimsy mucous tubes which project a few mm. from the surface. Frey (1970) tells how these organisms may be used as current vanes. (See Sta. drawing 86e).

Oligochaeta

Oligochaete sp. - small subsurface deposit feeding annelid. Another "conveyor belt" species.

Amphipoda

Ampelisca abdita - tube dwelling surface deposit feeder. It has been found to form tense tube mats ($\sim$ 68,000/m^2) which stabilizes surface and may increase the sedimentation of fine material (Harrison and Lynch 1970). (See radiograph of Sta. 78 and station drawings of 30, 76 and 78).

Decapoda

Callianassa atlantica - a deposit feeding shrimp. It builds large (2 cm diameter) burrows with complex brancing and several openings to the surface. Both Shinn (1968) and Howard & Frey (1975) describe the burrows in greater detail. (See Sta. drawing 98).

Echinodermata

Micropholis atra - a deposit feeding ophiuroid found 5-12 cm deep. Usually 2 to 3 arms extend down anchoring the animal while the remaining arms reach the surface for feeding. A cavity surrounds the animal which it ventilates causing a halo of oxygenated sediments around it. (See Sta. drawing 105).

Thyone briareus - large deposit feeding holothurians. Moyers (1977) discusses the effect on sediment properties produced by the bioturbation of a deposit feeding sea cucumber. (See Sta. drawing 94).