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PALEOECOLOGY OF THE MIOCENE CHOPTANK FORMATION OF MARYLAND AND VIRGINIA

by
Robert Everett Gernant

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of the requirements for the degree of
Doctor of Philosophy in
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Doctoral Committee:
Professor Robert V. Kesling, Chairman
Associate Professor Donald B. Macurda, Jr.
Assistant Professor Charles I. Smith
Professor Erwin C. Stumm
Professor Henry van der Schalie

A B S T R A C T

PALEOECOLOGY OF THE MIOCENE CHOPTANK FORMATION
OF MARYLAND AND VIRGINIA

by

Robert Everett Gernant

Chairman: Robert Kesling

During the Middle Miocene, fossils and sediments of the Choptank Formation accumulated in the Salisbury Embayment of the Middle Atlantic Coastal Plain. Previously, five subdivisions of the formation were numbered and given biostratigraphic designations. However, they are here considered rock-stratigraphic units and given the following names: Calvert Beach Member, Drumcliff Member, St. Leonard Member, Boston Cliffs Member, and Conoy Member. The "unconformity" with the underlying Calvert Formation, as described by Shattuck (1904), may exist but is visually much less impressive than he suggested.. Although he considered the Choptank conformable with the overlying St. Marys, the present evidence indicates that the contact between formations is an erosional-depositional unconformity. To supplement the unrepresentative type section, a principal reference section is designated in the Calvert Cliffs, 0.9 mile southeast of Western Shores, Maryland, and 1.0 mile northwest of Calvert Beach, Maryland. Hack (1955) proposed the name "North Keys sand" for a unit he considered to be distinct from but which present evidence clearly indicates is part of the Choptank.

The study's main purpose is to enlarge understanding of the paleoecology and depositional history of the Choptank Formation through an inter-disciplinary approach. Analysis

of microfaunal and macrofaunal assemblages is supplemented by study of biogenic and inorganic sedimentary structures, sedimentary textures, and stratigraphic relationships.

One of the more important results of this investigation is the hypothesis that the major Choptank shell beds were formed by passing marine swell possibly related to tropical storms. The effect on the substrate would have been the establishment of a pressure gradient causing flow into the bottom deposits and flow out accompanied by effusion of the sediments. This lifting action and vertical sorting would have created zones of traction and accumulation. This mechanism sufficiently explains the characteristics of the Choptank shell beds. In fact, this process of shell accumulation may be much more important in modern and ancient seas than the little attention given to it indicates.

In its area of present outcrop the Choptank was deposited primarily in inner shelf environments but in rare cases as deep as 60 meters. In addition, faunal evidence indicates that the formation occurred in central and southern regions of the cold temperate marine climate.

The lowest unit, the Calvert Beach Member, was deposited in the coldest water of any unit in the Choptank. Its environments were slightly inimical to many types of bottom communities as evidenced by the bivalve dominance of the Lucinacea. The Drumcliff Member represents a shallowing of environments on the inner shelf and possibly slight warming. According to the hypothesis previously discussed, marine swells passed through the area concentrating shells into great beds.

Maximum shallowing occurred during the St. Leonard Member. Marginal marine environments dominated this unit in the outcrop vicinity. The best delineated of these was the

lower bay environment, which occurred in the area of the modern Calvert Cliffs. The slight warming trend continued into the Boston Cliffs Member, but the shallowing trend of the lowest three members was reversed. This member represents a return to open inner shelf environments, where the bottom was again swept by marine swells concentrating great volumes of shells.

Sediments of the Conoy Member were deposited in distinctly deeper water but still were probably shallower than 50 meters. Like the previous Choptank Members, the Conoy was deposited in the cold temperate marine climate. However, by the time of the Conoy the warming trend placed the member in the southern end of the cold temperate region. The St. Marys Formation generally continues the deepening trend started in the Boston Cliffs Member.

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INTRODUCTION

With the publication of the monumental Miocene Volume in 1904 by the Maryland Geological Survey, the fossils and stratigraphy of the Chesapeake Group became well known. This thorough, systematic investigation and presentation of the Maryland Miocene, which includes the Choptank Formation, prepared the foundation for paleoecological and paleoenvironmental studies. Unfortunately over 60 years have passed and still very little is known of these aspects.

Many characteristics of the Maryland and Virginia Choptank Formation favor paleoecological studies: the famous Calvert Cliffs of the Western Shore of Maryland present a nearly continuous dip section, almost 15 miles long, resulting in excellent lateral correlation of units; the fauna is well preserved; the fossils are easily extracted from the unconsolidated sediment; the comparatively small stratigraphic thickness of the Choptank provides the opportunity for a bed-by-bed analysis and study of individual horizons; the taxonomy of the macrofauna and the Foraminifera has been well studied; and several species of this Miocene fauna are thought to be extant, so their ecology may be directly inferred from the living forms.

Fossils from two prolific shell beds of the Choptank have been extensively sought for private and public collections. Yet, attempts to explain the abnormal quantity of shells have used only speculative intuition. The approach

of this study offers new insights into their nature and origin.

The purpose of this investigation is to enlarge the understanding of the paleoecology and sequence of geological events recorded within the Choptank Formation. Firm basis for conclusions is provided by a rarely used interdisciplinary approach combining analysis of microfaunal and macrofaunal assemblages with study of biogenic and inorganic sedimentary structures, sedimentary textures, and stratigraphic relationships.

REGIONAL GEOLOGICAL SETTING

Around 15 to 20 million years ago the sediments of the Choptank Formation were deposited in the Atlantic Coastal Plain, but the regional geological setting was beginning to take form a few hundred million years prior to that. Structural lineaments, regional negative areas, local basins, sediment supply areas, river tributary systems, the strike of the Choptank, and other characteristics of the formation were probably established by the late Paleozoic Appalachian orogeny and possibly by early Paleozoic orogenies. Deeply buried Precambrian and Paleozoic crystalline rocks of the Piedmont underlie the wedges of Mesozoic and Cenozoic sediments. The boundary separating the Piedmont from the Coastal Plain is marked by the fall line (map 1) which passes through Philadelphia, Baltimore, Washington, Fredericksburg, and Richmond. The Choptank outcrops in a

belt from about 30 to 50 miles east of the Piedmont, which undoubtedly supplied most of the terrigenous detritus to the formation.

Geophysical work and well sections have revealed a deep basin in the basement rocks, its axis trending approximately through Berlin, Salisbury, and Cambridge, Maryland, and almost to Washington, D. C. Richards (1948) named this structure the Salisbury embayment. The deepest known part of the basin is at Berlin, Maryland, where the Coastal Plain sediments are 7,157 feet thick. Maher (1965, p. 6) said, "this embayment is fairly prominent in the basement rocks, but loses form in the younger beds, suggesting that it is a pre-Cretaceous feature filled by Cretaceous sedimentation." My field investigations indicate that this basin was indeed a locus of increased Tertiary deposition, particularly Miocene. The thickest surface and subsurface sections of the Choptank occur over the axis of the Salisbury embayment and thin away from the axis. The other formations of the Chesapeake Group have similar distributions. The Maryland Miocene sediments would seem to indicate that the basin was mobile and affected deposition at least for that part of the Tertiary.

The Appalachain Mountains went through episodes of uplift and dissection during the Tertiary. River systems, such as the ancient Susquehanna, Patuxent, Potomac, Rappahannock, York, and James, must have carried tremendous volumes of terrigenous detritus to the middle Atlantic

Coastal Plain. Another major regional influence on both the sediments and the biota was the configuration of ocean and longshore currents. The results of this study indicate that the animals and sediments of the Chesapeake Group were found in the temperate marine climate. This climate results from a very delicate balance of factors primarily relating to cold water currents flowing from the north and warm water currents flowing from the south. Longshore currents are sculpturing numerous barrier islands along the present Atlantic Coast and may well have done the same during the Miocene; there certainly would have been enough sand available.

Within this complex framework the sediments of the Maryland Miocene were deposited. The interplay of geological parameters produced units unique enough to receive different names. The major subdivisions have been called, from oldest to youngest, the Calvert, Choptank, and St. Marys Formations. These, in turn, were broken into "zones" and given numbers by Shattuck (1904) with "zone 16" through "zone 20" representing the Choptank. In the Chesapeake Group of Virginia the Yorktown Formation lies above the former three.

HISTORY OF PREVIOUS INVESTIGATIONS

Investigations of the Maryland Miocene prior to 1904 were summarized by Shattuck (1904, pp. xxxiii-lxiv) in the Miocene V@lume published by the Maryland Geological Survey.

The only paleoecological conclusions that were presented before 1904 were those of Lardner Vanuxem (1828, p. 67). In discussion of the Maryland Miocene, he said,

> This region is characterized by littoral shells, analogous to those of the Tertiary deposits of the Paris and English Basins: unlike the Secondary, this formation contains a vast number of genera, of which few or none are extinct; indeed very many of the species differ but little from the littoral shells now existing on various parts of the American coast.

Those statements mark Vanuxem as the senior paleoecologist of the Chesapeake Group.

Dall, in the Maryland Miocene Volume (1904, p. cxliii), felt the molluscan fauna of the Chesapeake Group was "derived from cool-temperate seas." He added (p. cxlv),

> In all cases and throughout its extent the fauna has the characteristics of a shallow-water assembly, without any marked littoral elements, but which might well have existed in the immediate vicinity of low, nearly level, muddy or sandy shores, and have extended off-shore to a distance more or less indefinite, but which did not include any area subject to the influences of an open and unsheltered ocean.

Either misprints were introduced or he presented contradictory statements, since on page cxlix he introduced evidence to suggest that the molluscan fauna was of warm temperate origin. On the same page he said, "Between the several horizons of the Maryland Chesapeake there is but very slight indication of any temperature difference; so far as there is any, it points toward a progressive but slight cooling of the water from the Calvert to the St. Marys. . ."

Schoonover (1941a) reported a nest of echinoids near the Calvert-Choptank unconformity. This would have obvious paleoecological significance for the Choptank if it occurred there, but from her description it must have occurred in the upper Calvert. In the same year (Schoonover, 1941b) she presented a very careful investigation of the Calvert and Choptank bivalves, which included a few statements of paleoecological interest.

Since Ulrich and Bassler (1904), Malkin (1953) was the first paleontologist to work on the Maryland Miocene ostracodes. Her analysis of that part of the microfauna in addition to the Foraminifera led to the conclusion that the Miocene sediments of New Jersey, Maryland, and Virginia were deposited in 10 to 150 meters of open ocean water "of average salinity (35°/oo) and average calcium carbonate content." She felt the Miocene assemblages were "similar to the Atlantic south of Cape Hatteras, and to the Caribbean Sea."

Mongin (1959) discussed both autecology and synecology of the Chesapeake Group molluscs, particularly the bivalves. She felt the fauna was more warm temperate or tropical than cold temperate. In her opinion the prolific shell beds of the Choptank represented transgressive beach accumulations.

The most intensive paleoecological investigation to date was that of Gibson (1962). He felt the Choptank was deposited in very shallow, cool to moderately warm waters with zone 17 (of Shattuck, which is equivalent to the Drumcliff Member to be named in this paper) representing

the shallowest water in the formation. His evidence suggested a general warming trend during the Miocene. In 1966 Gibson was more precise with his paleotemperature determinations by claiming the Calvert Foraminifera were cool temperate, while those of the Choptank, St. Marys, and lower Yorktown were slightly warmer. The upper Yorktown was thought to be warm temperate.

PROCEDURES IN FIELD AND LABORATORY

Because outcrops of the Choptank are typically unconsolidated and fresh, as a result of nearly continual mass wasting, study and procurement of samples are relatively easy. Each bed or unit that was visually distinct from units above and below in faunal or lithologic content was measured, described, and sampled in nearly 80 sections. Most all units were less than two or three feet thick and many were less than one foot. For each of the thinner units only one sample was taken, but for units over two feet thick multiple samples were taken. Not all samples collected were analyzed in the laboratory, however.

Sediment colors were compared in fresh exposures against the color scheme of the Geological Society of America Rock-Color Chart. Sediment sizes were determined in the field with the aid of a ten-power hand lens and a pocket guide to grain size. All macrofossils were identified in the field and their relative abundances were determined according to a scale of logarithmic progression with

the following classes: rare (approximately 1 to 30 specimens per square meter), few (approximately 3 to 6 specimens), numerous (approximately 6 to 15 specimens), common (approximately 15 to 30 specimens), very common (approximately 30 to 60 specimens), abundant (approximately 60 to 150 specimens), and flood (more than approximately 150 specimens). Other distributional and orientation characteristics including size of specimens, measured to the nearest hundredth of a centimeter, and orientation and inclination measurements were determined from particular beds in the field.

Samples for microfauna analysis were dried at room temperature and then placed in a solution of sodium bicarbonate and warmed. After washing, Ostracoda and Foraminifera were separated from the residue using a variation of the soap flotation method suggested by Howe (1941, p. 691). Previously, this technique had been used only to concentrate ostracodes, but it was found completely satisfactory for Choptank foraminifers, as well. Microscopic examination of washed residues indicated that the procedure worked equally well with the two kinds of microfossils.

A sample splitter was used to reduce accurately excessively large microfaunal assemblages. Phleger (1960, pp. 33-35) presented data leading to the conclusion, "that little if anything is to be gained by counting samples much larger than approximately 300 specimens and that the illusion of accuracy tends to be misleading". Consequently, the goal in

splitting samples was between 300 and 500 specimens of ostracodes and of foraminifers.

Counting Foraminifera is relatively straightforward, but making a meaningful count of Ostracoda is no easy matter. In order to grow, ostracodes molt their former valves and secrete new ones. Thus one living individual could be represented by as many as eighteen isolated fossil valves in one sample. However, these molts are often difficult to correlate with the proper adults, and indeed many juvenile fossil valves have been described as separate species. Ulrich and Bassler (1904) committed this error in the Maryland Miocene. The strong sexual dimorphism in some species introduces problems of assigning the proper forms to the same species in addition to knowing whether to count males and females separately or together. A precedent can be found for practically any method of counting ostracodes. Considering the widespread lack of agreement, I devised what seemed the most meaningful system to me. Separate counts were made for right and left valves of juvenile valves where they could be correlated with adults, of male valves, and of female valves where sexual dimorphs could be recognized. The supposed number of individuals was computed by adding the greater of either left or right male valves, left or right female valves, and left or right juvenile valves. Statistical studies of living populations and their relationship to fossil populations could greatly improve the accuracy of counting fossil assemblages.

FOSSIL CLASSIFICATIONS

Identifications of the Choptank Foraminifera followed Gibson (1962) quite closely. The Ostracoda were more of a problem. The first work was that of Ulrich and Bassler (1904), which was extremely important since it described many of the Miocene to modern ostracodes of the northwestern Atlantic area. All of the Ulrich and Bassler type specimens at the U. S. National Museum were compared with specimens of the present study. Unfortunately, there are several taxonomic problems in their analysis. They described juveniles and adults, males and females as separate species. Various later workers used Ulrich and Bassler's names for different ostracodes, and ignored some of their other species. Their Choptank specimens came from two of the formational members (named in the section on stratigraphy), the Drumcliff at Pawpaw Point in St. Marys County and the Boston Cliffs on the Eastern Shore. The only other worker who has published on Choptank ostracodes was Malkin (1953). She studied two samples, both from the same members that Ulrich and Bassler sampled. Her samples came from Governor Run, however. Although Malkin corrected several taxonomic problems of the Ulrich and Bassler study, she also perpetuated a few and started others. Between the Ulrich and Bassler paper and the Malkin paper, there was a significant study by Edwards (1944) on the Ostracoda of the Duplin Marl of North Carolina. He described many species currently recognized in Miocene

through modern sediments. All of his type specimens were examined at the U. S. National Museum. Swain (1951) described species from the Miocene of North Carolina, some of which are also in the Choptank. His types at the U. S. National Museum were also studied. Specific solutions to nomenclatural problems are discussed in the section on paleoautecology. Generic classification largely follows that of van Morkhoven (1963) and Hazel (1967).

The classification of molluscs follows the specific determinations of Martin and Glenn (1904) and Schoonover (1941b). Since their report on the molluscs only a very few subspecies have been added.

STRATIGRAPHY

The Choptank Formation is part of the Middle and Late Miocene sediments of Maryland and Virginia that Darton (1891) called the Chesapeake Group. In Maryland this sequence consists of the Calvert, Choptank, and St. Marys Formations, in ascending order. The Yorktown Formation is found above these three in Virginia.

The Choptank was named in 1902 by G. B. Shattuck for its exposure in the western bank of the Choptank River on the Eastern Shore of Maryland. It is better known from its exposures in the Calvert Cliffs along the Western Shore of the Chesapeake Bay. Stratigraphic relationships are much more easily studied in the exposures along the Chesapeake Bay, and the Patuxent and Potomac Rivers.

The present consensus among stratigraphers is that the age of the Choptank is Middle Miocene, correlating with the Helvetian of Europe. To date, correlation with other exposed units remains uncertain.

The only possible correlation of the Choptank with other Atlantic Coastal Plain marine or marginal marine units would be with the Kirkwood or Cohansey formations of New Jersey. Malkin (1953, p. 771) correlated the Kirkwood with the Calvert on the basis of their ostracode assemblages and the nonmarine Cohansey with the Choptank, St. Marys, and Yorktown on the basis of subsurface evidence. Her correlations seem a bit speculative considering she examined only two samples from the Choptank, only one from the Kirkwood, and, of course, she had no marine fauna from the Cohansey. By her own criteria, the Kirkwood correlates equally well with either the Calvert or Choptank. The ostracodes she used to correlate the Kirkwood and Calvert were: Trachyleberis exanthemata (=Actinocythereis exanthemata of this study), Cytheropteron sp. (?=Cytheropteron sp. of this study), Trachyleberis evax (=Henryhowella evax), Trachyleberis dorsicornis (=juvenile Murrayina martini), Cytheretta burnsi, Cytherideis ashermani (=Hulingsina ashermani), and Trachyleberis radiata (=Murrayina martini). Her faunal list indicates that Cytheretta plebia also is exclusive to the Kirkwood and Calvert. These occurrences show a perfect, positive correlation with the Calvert and a negative correlation with the Choptank. Unfortunately,

this analysis was based on only two samples from the Choptank, both of which came from similar facies at the same locality. Further investigations of ostracodes has shown that every Calvert species of Malkin's list above also occurs in the Choptank, and in some beds, in great abundance. At this point correlation between the Maryland and New Jersey Miocene seems uncertain. It does appear, however, that there are no outcrop equivalents to the south in the Atlantic Coastal Plain.

Exposures of the Choptank Formation are found in Caroline, Talbot, and Dorchester Counties on the Eastern Shore of Maryland, Calvert and St. Marys Counties on the Western Shore of Maryland, and Westmoreland County in northeastern Virginia (map 1). On the Eastern Shore the unconsolidated, non-resistant beds are so well buried by Pleistocene deposits that their distribution and character are very imperfectly known. Nearly all of the known outcrops are in the banks of the Choptank River, but even there they are sparse and widely separated.

The Choptank Formation is best known from its exposures along the Western Shore of the Chesapeake Bay from Parker Creek in the north to a short distance north of Cove Point in the south (map 1). This nearly continuous line of outcrops makes up part of the Calvert Cliffs, first mapped by Captain John Smith in 1608. Many excellent exposures may be found along the Patuxent River and its tributaries in Calvert and St. Marys Counties. A few, small, good sections

are in the bluffs along Breton Bay off the Potomac River in St. Marys County. The Nomini, Stratford, and Horsehead Cliffs of Westmoreland County, Virginia, form a nearly continuous section for about 6 miles along the Potomac River. Inland outcrops are very rare primarily as a result of the non-resistant beds within the formation. The major rivers of the Western Shore of Maryland and Virginia are approximately perpendicular to the regional strike of the formation, exposing a few major dip sections for study. Unfortunately, some facies changes between dip sections are not easy to understand. This is one of the major obstacles to study of the depositional history and paleoecology of Atlantic Coastal Plain. The lateral control of the Choptank Formation, however, is better than for most formations in this region.

In the area of surface exposure the formational strike is approximately northeast-southwest. The dip is approxi-10 feet per mile to the southeast. Hence, the Choptank crops out on the hilltops to the north and gradually occupies lower levels until, as can be seen a short distance north of Cover Point, it dips under beach or sea level.

The outcrop thins from approximately 75 feet thick along the Calvert Cliffs to approximately 55 feet in the Nomini Cliffs of Virginia and to 29 feet 4 inches in the Horsehead Cliffs of Virginia. There is pronounced thickening in the subsurface. Several examples have been reported of the entire Miocene continuously increasing in thickness

down dip. However, there are only two records of actual thickness of the Choptank in the subsurface. Anderson (1948, p. 19) reported that in the Ohio Oil Company's Larry G. Hammond Well No. 1 near Salisbury, Maryland "the thickness of Choptank is 125 feet, and it extends from 515 feet to 640 feet." Another report from the southern portion of the Eastern Shore was made by Shattuck (1904, p. lxxx): "The Choptank Formation attains a thickness of about 175 feet" in a well section at Crisfield, Maryland in Somerset County. McLean (1956 and 1966) presented information on the Miocene and Pleistocene from well cores and records of eastern Virginia. At the Camp Manufacturing Company well 4 at Franklin, Nansemond County, Virginia, he reported the Choptank to occur from 90 to 110 feet for a total of 20 feet. It is difficult to understand from the remainder of his information how thick the Choptank is in the other test borings. His drawn sections of test wells on the Norfolk side of the Chesapeake Bay Bridge and Tunnel from the southern tip of the Delmarva Peninsula to Norfolk, Virginia, seem to indicate that he interprets the Choptank thickness to average about 30 feet. If I interpret McLean's data correctly, it illustrates the fundamental significance of the Salisbury Embayment on the development of the Choptank deposition. Thickest accumulation occurs near the center of this structure, and thinner sequences occur on the flanks of the embayment. At this time lateral boundaries of the formation have not been located.

Shattuck (1904, p. lxxx) said,

> the Choptank Formation lies unconformably on the Calvert Formation. This unconformity is in the nature of an over-lap but is not easily discernible even where the contact is visible. The best place to observe the unconformity is in that portion of the Calvert Cliffs just below the mouth of Parker Creek. Even here, the unconformity cannot be seen while standing on the beach but may be observed from a boat a short distance from the shore.

Investigators of the Maryland Miocene who have followed Shattuck have had difficulties in trying to relocate the unconformity. Unfortunately, the character of the sediments and fossils on both sides of the formation boundary is very similar, and Shattuck did not clearly differentiate the units on either side of the formational boundary. Fortunately he did publish (1904, pp. lxxxix-xc) three measured sections that pertain to this problem. In the highest unit of the Calvert (his "zone 15" of the Maryland Miocene) he measured 9, 5, and 4 feet, respectively, at 1/2 mile south of Parker Creek, 1 mile south of Parker Creek, and Governor Run. In the lowest unit of the Choptank (his "zone 16") he measure 0, 10, and 13 feet, respectively, at the same localities. The absence of "zone 15" at Parker Creek and the thickening toward Governor Run constitute the visual evidence of an overlapping unconformity.

Having walked out this area several times and observed it from a boat, the present author looked in vain for an overlapping unconformity. One feature of the outcrop, however, might be confused with an unconformity. Plate 4 shows what appears to be a prominent stratigraphic break

in the "zone 15"--"zone 16" interval in the first cliffs south of Parker Creek. Upon examination of the outcrop, it is clear that this feature is not a depositional break. The only change across this boundary is a color change which probably resulted from leaching above. Very close study reveals no bedding plane or textural change at this structure. In fact, the color range cuts through sedimentary structures and fossils. Also if this peculiarity is traced far enough to the south, it is seen to cut all the way down to "zone 14".

Since Shattuck's conception of the formational contact at Parker Creek is controversial, the author studied the sections of this interval in the Governor Run--Kenwood Beach area and to the north. In this area there is a subtle lithologic and paleontologic break where Shattuck placed the boundary (pl. 5 and 6, also see locality 67-75, Kenwood Beach, in Appendix 1). This subtle change can be traced as far south as Calvert Beach and as far north as Parker Creek (see localities 67-65 and 67-74 in Appendix 1). If this stratigraphic break is accepted as the formational boundary, "zone 15" is 3 feet 6 inches thick and "zone 16" is 15 feet 3 inches thick at Kenwood Beach; and "zone 15" is 3 feet 9 inches thick and "zone 16" is 13 feet thick in the first cliffs south of Parker Creek. If there is, in fact, an overlapping unconformity, it is visually much less impressive than Shattuck stated.

Subsequent investigation by Gibson (1962, p. 13) lends

credence to Shattuck's insight as to where to place a significant formational boundary in the sequence in areas other than Parker Creek. In analysis of the contact at his locality 5 (Kenwood Beach), Gibson said,

> Samples taken both two feet above and below the supposed unconformity show that the lowest bed of the Choptank formation is of considerably warmer water origin than the highest bed of the Calvert. The temperature change may have been gradual with the minimum temperature reached for the existence of these species at this time, or a hiatus may exist between the formations with an unconformity possibly present.

Shattuck cited additional evidence (1904, p. lxxx) for an overlapping unconformity:

> The unconformity of the Choptank on the Calvert formation is also proved from the fact that at the above-mentioned locality [Parker Creek] the fossil bed which lies lowest in the Choptank formation rests on the Calvert, while at Mt. Harmony and northward the upper fossil bed of the Choptank rests on the Calvert Formation.

This may well be the best structural evidence of an unconformity. Study of this relationship near Paris (see locality 67-58, Appendix 1) shows it to be something less than straightforward. Locality 67-58 is a hill between state highways 260 and 613 between Paris and West Beach. The Calvert Formation can be found low on the north side of the hill, but the upper part of the north side is covered. At the top of the south side, there is an unmistakable exposure of the upper fossil bed of the Choptank (later in this paper to be defined as the Boston Cliffs Member). This would be what Shattuck said, "rests on the Calvert". However, there are two units totaling 5 feet 9 inches of

pale reddish-orange, slightly muddy, fine sand below the bed and grading into it. Analysis of a sample from the lowest foot of the sand produced an ostracode and foraminiferal assemblage very typical of shallow-water Choptank assemblages. In fact, without exception every specimen was typical of the Choptank. Additional evidence that the sand belongs to the Choptank is the presence of the ostracodes Campylocythere laevissima, Pokornyella punctistriata, and Bensonocythere whitei, which Malkin (1953, p. 769) found in the Choptank but not the Calvert, and the presence of Nonion marylandicum, which Gibson (1962, p. 46) reported as occurring only in the Choptank Formation of Maryland and Virginia. Establishing this sand as Choptank, certainly does not disprove Shattuck's contention that this section showed the unconformity. An unconformity may exist at the base of the sand, rather than at the top as he envisioned. From topographic and stratigraphic considerations, it appears that the only beds above the Calvert at this locality are those exposed on the south side of the hill. Possibly, this could be regarded as evidence for an overlapping unconformity.

The problem of the Choptank-Calvert boundary is far from settled. Away from the area of the Calvert Cliffs, where the boundary is defined, the contact becomes more difficult to locate. A few exposures on the Patuxent River contain the interval under consideration. One of the best of these is at Sandgates (see locality 67-59,

in Appendix 1), where the supposed unconformity is nearly impossible to locate by correlating the sequence of lithologic characteristics from the reference area. The formational contact needs more study. Subsurface investigations combined with micopaleontological analyses hold promise for a more satisfactory solution.

In spite of the uncertainties of boundary definition based on physical criteria, the formational boundary certainly appears justified. The general fauna and sediment types of the Choptank are sufficiently different from the Calvert to warrant two distinct formational designations. In addition, Gibson's analysis indicates a significant change in the paleotemperature across the subtle physical boundary.

All accounts to date of the Miocene stratigraphy assert that the Choptank is conformably overlain by the St. Marys Formation. The present author's analysis of the contact is that in places it represents a surface of either erosion or nondeposition and thereby qualifies as an unconformity. Unfortunately, the exposures of the contact are not readily accessible, and this greatly complicates study of the relationships.

Plate 49 shows two views of the Calvert Cliffs at Camp Conoy. Structure around the formational contact is rather dramatic. In figure 2 the double-headed arrow on the right points out the section in the base of the St. Marys Formation which is not present at the left end of the

cliffs. The arrow on the left points to the contact and to the beds of locality 66-21 shown in plate 50. The upper unit in the Choptank corresponds to Shattuck's "zone 20" and later in this paper will be defined as the Conoy Member. The Conoy Member here is dusky greenish-blue, very muddy, very fine sand, and the main sediment in the base of the St. Marys is dark chocolate-brown, muddy, fine sand. The arrows and mechanical pencil point to a few of the abundant bivalve borings which extend down into the uppermost sediments of the Conoy Member. The borings have all been filled by chocolate-brown, fine sand from the overlying St. Marys. Also note immediately above the contact the stringy, discontinuous, very well sorted, "basal sand".

This unconformity is not without complexities, however. The structural discordance can be seen only in this outcrop. To the south, all the way to Cove Point, the units of the Choptank and St. Marys are parallel, but the sequence of beds indicated on the right in plate 49 is absent. To the north, at least to Flag Ponds, the Choptank and St. Marys units appear conformable, including the additional units at the base of the St. Marys.

Samples were taken at Flag Ponds, locality 66-25, to compare the Conoy Member with units in the local sequence of the St. Marys Formation. Sample 66-25-21 came from 2 feet 1 inch to 3 feet 1 inch below the top of the Choptank; sample 66-25-23 came from the lower 7 inches of the St.

Marys; sample 66-25-27 came from 9 feet 5 inches to 10 feet 5 inches above the base of the St. Marys. The last two samples occurred stratigraphically lower than the indurated ledge which intersects the label "St. Marys Fmn." in plate 49, figure 2. Analysis of faunal assemblages indicates that the advent of the St. Marys brought distinctly shallower and warmer waters to this area. Of course, the warmer temperature could in part be a function of the shallower water. In any case, a distinct environmental change marked the lowest St. Marys.

The evidence seems to suggest that after the deposition of the Conoy Member a local shallow basin was created, possibly by slight uplift to the south, in which the sequence of sediments in question was deposited. The normal regional dip is to the southeast. On the contrary, it is clear even in plate 49 that here the beds below the unconformity dip slightly to the north and that the beds above are nearly horizontal. This reversal of dip may well have formed the local basin.

At locality 67-71 the Conoy Member (between arrowheads on plate 47, figure 2) is abnormally thin, being only a little over 4 feet thick. Within 500 feet southeast the Conoy is 8 to 9 feet thick, as can be seen in plate 1. Close examination of the formational contact reveals this to be a surface of erosion, accounting for the meager thickness. The two arrowheads in plate 47, figure 2, mark the location of plates 48 and 74, in addition to indicating

the thickness of the Conoy Member. These illustrations show the broadly but deeply undulating formation boundary. They also show the "basal sand" of the St. Marys filling this undulating surface. This site offers additional evidence for an unconformity between the Choptank and St. Marys Formations.

Within the Chesapeake Group of Maryland, Shattuck (1904, pp. lxix-lxxxvi) recognized and delineated 24 subdivisions. He called the subdivisions "zones" and gave each one a number, starting with number one at the base of the Calvert and continued through number 24 at the top of the St. Marys. The Choptank consisted of "zone 16" through "zone 20". Each of his "zones" was defined on the basis of the lithologic characteristics and the relative quantity of fossil shells, not by the occurrence of particular species.

Article 4 of the Code of Stratigraphic Nomenclature states (Krumbein & Sloss, 1963, p. 625), "A rock-stratigraphic unit is a subdivision of the rocks in the earth's crust distinguished and delimited on the basis of lithologic characteristics." Shattuck's 24 subdivisions qualify as rock-stratigraphic units. Since the rank of formation is occupied, the next designation available is that of member. The five subdivisions of the Choptank as recognized by Shattuck will be redefined, named, and given type sections in the discussion below.

Subdivisions of the Choptank Formation

Calvert Beach Member. -- This member corresponds to "zone 16" of Shattuck and lies at the base of the Choptank (pls. 1 and 2). The type section, here designated, is the low bluffs in the Calvert Cliffs at Calvert Beach, Maryland (pls. 7-10, and 54. Also see locality 67-65 in Appendix 1 for detailed description of the type section). The sediments vary from dusky green to dusky blue, rarely yellowish-brown to dark brown, very muddy to slightly muddy, fine sand to very fine sand. The nature of the lower contact is not clear (see previous discussion) but can be described as subtle (pls. 5-7). Due to the gradational nature of the upper contact, it is often difficult to know exactly where it should be placed. Inasmuch as the overlying bed is defined in part as a major shell bed, the contact should be placed at the base of the first major influx of shells (plates 11 and 13). Sedimentary structures included in this member are small scour and fill structures (pls. 6, 8), burrows (pls. 9, 10, and 54), sand stringers and lenses (plate 5), localized low-angle, planar, cross laminations, and irregular bedding laminations. In general, macrofossils are scarce, but in a few localities they are somewhat more abundant. The fossils at Calvert Beach superbly show what appear to be life assemblages (pls. 7-10). Some of the more common macrofossils in the Calvert Beach Member are Turritella plebeia, Lucinoma contracta, Diplodonta subvexa, Glossus fraternus marylandicus, Anomia aculeata, Yoldia

laevis, Ensis ensiformis, Hiatella arctica, Ecphora quadricostata umbilicata, Dosinia acetabula, and cheilostome bryozoans.

Shattuck (1904, p. lxxxi) stated that at Parker Creek this member is absent and that "zone 17" overlaps it in this area. According to my interpretation, however, a section of the Calvert Beach Member totaling 13 feet occurs in the first cliffs south of Parker Creek. With this analysis the member is present in the Calvert Cliffs from Parker Creek to the vicinity of Long Beach and varies from about 12 to 16 feet in thickness. The best reference localities are those at Calvert Beach, Kenwood Beach, and Governor Run.

There are no proven exposures on the Eastern Shore, nor, for that matter, have any ever been suggested. Localities 67-80, 67-81, and 67-82 on the Choptank River south of Greensboro could possibly contain the Calvert Beach Member.

At locality 67-82, a thinly interbedded dark brown, very muddy, silt and light gray, well-sorted, fine sand occurs below a bed of molds and casts which is probably equivalent to the member which overlies the Calvert Beach. By stratigraphic sequence this interbedded lithology could be the Calvert Beach Member. However, since the sediments in these three Eastern Shore localities do not at all look like exposures on the Western Shore, they must represent an entirely different depositional environment, e.g.,

marginal marine. Shallow subsurface studies are needed on the Eastern Shore.

There are several exposures on the Patuxent River, particularly on the western side. Probably the best along the Patuxent is the section at Sandgates. Here "zone 14" of the Calvert and the Drumcliff Member of the Choptank are clearly discernible, but the intervening sequence is homogeneous. Lithologic and faunal evidence apparently provides no basis for dividing this sequence into "zone 15" and the Calvert Beach Member.

The upper part of the member is present in Pawpaw Hollow (see locality 66-35 in Appendix 1, also plate 11) along Breton Bay. The Horsehead, Stratford, and Nomini Cliffs of Virginia all expose this unit, but in many places there is a slight problem of differentiating the three lowest members of the Choptank as seen in Maryland. Perhaps this interval should not be divided in the exposures south of the Potomac River.

Drumcliff Member.--This member corresponds to "zone 17" of Shattuck and is the lower shell bed of the Choptank (pls. 1 and 2). The type section is here designated at Drumcliff (called Jones Wharf in the 1904 Maryland Geological Survey Miocene Volume) along the southwestern shore of the Patuxent River (pls. 12, 14-19, 21, 56-59, and 61; also see locality 66-14 in Appendix for detailed description of the type section). The dominant sediment type varies from pale yellowish-brown to very pale orange, slightly

muddy to very well sorted, fine sand. At the base, particularly in the sections in St. Marys County, the sediment is usually dusky blue to dusky green, very fine sand to fine sand. A few other colors occur rarely. The most distinguishing characteristic of this member is its prolific accumulation of shells, in some places so densely packed that there is scarcely any sediment. At some localities, certain beds are indurated (pls. 21; 26, fig. 1; 58; 60). The induration of these layers appears to be post-depositional, created by the calcite of shells being dissolved and later precipitated as calcareous cement binding the fine sand grains. The lower contact is nearly always gradational and marked by the first major influx of shells (pls. 11, 12, 13). The upper contact is usually sharp and distinct, marked by the upper limit of abundant shells (pls. 19, 21, 27, 57, 61, 62). The upper contact along Drumcliff appears to represent a channeled surface (pls. 19, 57). Biogenic and inorganic sedimentary structures are extremely rare. In St. Marys and Calvert Counties the base of the member contains a prolific concentration of the epifaunal bivalve Isognomon maxillata (pls. 11; 12; 26, fig. 1), occasionally accompanied by abundant pieces of the ahermatypic coral Astrhelia palmata. This lower accumulation of Isognomon maxillata is abnormally thick around the mouth of St. Leonard Creek. At Mackall's Landing, locality 66-43, this bed is 14 feet 9 inches thick (pl. 26, fig. 1). The Isognomon units are conspicuously absent north of

Calvert Beach in the Calvert Cliffs (pls. 5, 13) and in the exposures in Virginia. Above the Isognomon units there are alternating beds of abundant, densely packed, large shells and beds of less abundant, less densely packed, smaller shells. On the plates these beds are labeled "increased" and "reduced" macrofossil beds, respectively (pls. 12, 14-19, 56-59, 61, 62). North of Calvert Beach in the Calvert Cliffs the upper part of the member contains beds with low faunal diversity and great lateral variability.

Macrofaunas of the Drumcliff Member generally have much greater faunal diversity, more numerous epifauna, and many more species of snails than the upper shell bed of the Choptank. Life assemblages of the epifaunal bivalve Atrina harrisii on the eastern side of Breton Bay (see locality 66-36 in Appendix 1) deserve special mention. Species of the deep-burrowing, bivalve genus Panope are nearly unique in that they are always found double-valved and in living position (pl. 19; 20, fig. 1; 57). Nearly all other bivalves are flat lying and the shells are usually disarticulated (pls. 15, 16, 18, 19, 25). Specimens of Turritella plebeia, the most abundant mollusc of the member, normally appear randomly distributed, but in some places they are clumped in lenses or pockets (pls. 22-24). Some of the more common macrofossils are:

gastropods--
Busycon coronatum rugosum
Calliostoma aphelia
Calliostoma philanthropa
Cancellaria alternata
Crepidula fornicata
Crepidula plana

bivalves--
Aligena aequata
Anadara staminea
Anodontia anodonta
Anomia aculeata
Apolymetis biplicata
Asaphis centenaria

gastropods (continued)--
Crucibulum costatum
Crucibulum multilineatum
Drillia limatula
Ecphora quadricostata umbilicata
Epitonium marylandicum
Epitonium sayanum
Fissuridea griscomi
Hastula inornata
Lunatia heros
Mangelia parva
Nassarius peraltoides
Pleurotoma (Hemipleurotoma) choptankensis
Polynices duplicatus
Rhizorus iotus marylandicus
Scaphella typa
Siphonalia devexa
Turricula rugata
Turritella plebeia
Turritella variabilis cumberlandia
Urolsalpinx cinerea

coral--
Astrhelia palmata

echinoderm--
Abertella aberti

brachiopod--
Discinisca lugubris

bivalves (continued)--
Astarte thisphila
Atrina harrisii
Callocardia subnasuta
Cardita protracta
Cerastoderma lagueata
Corbula cuneata
Corbula idonea
Corbula inaequalis
Crassatella turgidula
Diplodonta acclinis
Dosinea acetabula
Ensis ensiformis
Glossus fraternus marylandicus
Isognomon maxillata
Lucina crenulata
Lucinoma contracta
Lyropecten madisonius
Macrocallista marylandica
Martesia ovalis
Mercenaria campechiensis cuneata
Mercenaria mercenaria
Mytilus conradinus
Panope americana
Placopecten marylandica
Semele subovata
Spisula marylandica
Spisula subparilis
Venericardia granulata

The thickest exposure of the Drumcliff Member is at Drumcliff, where it measures about 30 feet. Outcrops can be found downstream along the Patuxent, where slight reversal of regional dip has brought up the Calvert Beach-Drumcliff contact in low bluffs north of Sotterly. This reversal of dip can also be seen in exposures along St. Thomas Creek. Numerous outcrops contain the member in the Cuckold Creek--Hickory Landing Creek--Mill Creek--Mill Cove complex off the Patuxent River to the southwest. There are many exposures along the St. Leonard Creek with the thickest sections around

the mouth. At Mackall's Landing there is a particularly good section (pl. 26, fig. 1) nearly overgrown by poison ivy. One of the better exposures in the creek at Breedens Point (pl. 27 and 62).

Along the Calvert Cliffs the member is much thinner, averaging 6 to 8 feet. It may be found from Parker Creek in the north to 0.3 mile north of Point of Rocks in the south. South of Long Beach the unit contains much more mud than to the north and is commonly locally indurated.

There are no proven exposures of Drumcliff on the Eastern Shore, only an uncertain one. Shattuck (1904, pp. xxxii-cxxxvii) reported a Choptank outcrop at "Greensboro." His faunal list from there was unmistakably Drumcliff. An extensive search was made in the vicinity of Greensboro but unfortunately the only finding was a 1-1/2 foot bed of molds and casts at the top of a section of 6-1/2 feet of sediments which may be part of the Drumcliff (see locality 67-82, Choptank River south of Greensboro). This is another problem on the Eastern Shore that might be solved by subsurface studies.

The only exposures southwest of Drumcliff in Maryland are those along Breton Bay. However, farther southwest from there, the member is difficult to identify. In the Horsehead, Stratford, and Nomini Cliffs of Virginia some thin layers of shells look like Drumcliff assemblages and occur approximately in the same stratigraphic position. Even though these layers lack the characteristic, concentration of

shells, I believe they resulted from the episode that produced the densely packed macrofossil beds at Drumcliff.

St. Leonard Member.--This member corresponds to "zone 18" of Shattuck and is the bed between the two major shell beds of the Choptank (pls. 1, 2). The type section is here designated as the exposure in the Calvert Cliffs 1-1/4 mile east of St. Leonard, Maryland and 0.3 mile north of Calvert Beach, Maryland (pl. 3; also see locality 66-6 in Appendix 1 for detailed description of the type section). The sediments vary considerably. Along the Calvert Cliffs and at a questionable St. Leonard exposure on the Choptank River they are predominantly dusky blue to dusky greenish-blue, muddy to very muddy, fine sand to nearly silt. Exposures along the Patuxent appear oxidized and with heterogeneous sediments varying from light olive-green to pale yellowish-brown, muddy, fairly well sorted to poorly sorted, fine sand. The St. Leonard in Virginia varies from dusky olive to dark brown, slightly muddy to very muddy, fine sand to very fine sand.

Along the Calvert Cliffs and the Patuxent River there is typically a thin basal unit (pls. 1, 21, 61) of darker color, occasionally poorer sorting, and coarser sand than the remainder of the member above. Biogenic and inorganic sedimentary structures are fairly common. Biogenic activity is undoubtedly the cause of much of the sediment mottling. Plates 28, 29, 63, 64, and 65 illustrate some of the many types of traces left by biogenic activity in the St. Leonard

Member. Inorganic structures consist of irregular, discontinuous bedding and some local, subtle, bedding laminations which appear to be either wave ripple marks or distorted laminations (pl. 41, fig. 2). The lower contact is nearly always sharp and distinct, marked at the base of the near disappearance of shells and occasionally, as at Drumcliff, is a surface of deep channeling (pl. 19, 57). The upper contact is nearly always gradational and should be placed at the base of the first major influx of shells.

Macrofaunas of the St. Leonard Member are generally sparse. Some of the more common fossils are: Yoldia laevis, Ensis ensiformis, Discinisca lugubris, Mytilus conradinus, Cerastoderma laqueata, Balanus concavus, Anadara staminea, and Crucibulum multilineatum. The St. Leonard can be found in the Calvert Cliffs from Parker Creek to between Point of Rocks and Camp Baybreeze (Girl Scout camp). The most extensive exposures lie north of Calvert Beach where the thickness varies from about 18 to 22 feet. From Flag Ponds to its southern extent the member averages about 12 feet. The last downdip exposure of the entire member along the Calvert Cliffs is a short distance north of Point of Rocks, where it measures 11 feet 11 inches.

The Eastern Shore has no certain exposures of the St. Leonard Member, but an outcrop (locality 67-83 in Appendix I) along the Choptank River near Lyford Landing may contain part of the unit. The sediments are nearly identical to those of the member in the Calvert Cliffs, and the only fossil

found is Yoldia laevis which is found frequently in the St. Leonard but certainly not confined to it. The Boston Cliffs Member is exposed downstream from Lyford Landing, while a probable outcrop of the Drumcliff occurs upstream. The preceding evidence is definitely not conclusive but nevertheless suggests that the St. Leonard Member is exposed at Lyford Landing.

Southwest of the Calvert Cliffs the St. Leonard thins considerably and becomes a light brown sand. At Breedens Point on St. Leonard Creek, only about 3 miles from the Calvert Cliffs, the thickness is only 4 feet (pl. 27, 62). At the mouth of the St. Leonard Creek the unit measures 5 feet (pl. 26, fig. 1; also see locality 66-43 in Appendix 1). Incomplete sections are exposed along Hellen Creek off the Patuxent (see locality 66-46 and locality 67-68 in Appendix 1). Near Drumcliff the St. Leonard varies from 6 to 8 feet (pls. 21, 61). In the Cuckold Creek vicinity it is 6 feet 6 inches and 5 feet 2 inches at locality 66-29 and locality 66-41, respectively. Variable thicknesses from 5 feet to 13 feet can be found on the Virginia side of the Potomac River. The base of the member is difficult to locate in the Nomini Cliffs, as a result of the slightly atypical expression of the Drumcliff Member (see Drumcliff discussion).

Boston Cliffs Member.--This member corresponds to "zone 19" of Shattuck and is the upper shell bed of the Choptank (pl. 1, 2). The type section is here designated

at Boston Cliffs on the Choptank River, 4 miles southeast of Easton, Maryland and 1.8 mile south of Dover Bridge (pls. 32, 33, 34, 35, 36, 66, 67; also see locality 66-12 in Appendix 1). The dominant sediment type varies from reddish-brown to moderate brown, muddy to slightly muddy, fine sand. The top of the member is very distinctively marked by a resistant, oxidized, indurated series of varicolored units. In some places (e.g., between Flag Ponds and Cove Point) exceedingly hard slabs of this upper series are piled up in front of the cliffs making walking along the beach very exhausting but serving as effective deterrents of wave erosion (pl. 51). The most distinguishing characteristic of the Boston Cliffs Member as a whole is its prolific accumulation of shells. The lower contact is gradational and usually somewhat arbitrary (pls. 30, 31). The upper contact is sharp and distinct with the oxidized, indurated sequence below and the nonresistant, dusky blue, fine sand of the Conoy Member above. Biogenic and inorganic sedimentary structures are nearly nonexistent. Typically, there is a gradational increase in number and size of fragments at the base of the member to a lower bed of abundant, large, flat-lying, bivalves (pls. 21, 32, 34, 35, 38, 39, 40, 41 fig. 1, 61, 66, 68-72). Commonly this lower increased macrofossil bed has distinct smaller units with low faunal diversity. For example, near the top of this unit there is a thin bed of valves of Anadara staminea that is amazingly continuous and can be traced

for miles (pls. 37-41; 69, fig. 3; 70-72). Next in succession is a reduced macrofossil bed, followed by another increased macrofossil bed, which are characterized by reduced size and number of shells and increased size and number of shells, respectively (pls. 32; 35-40; 42; 43; 66; 68; 69, fig. 1). The more common fossils of all the above-described beds are: bivalves--Macrocallista marylandica, Lyropecten madisonius, Anadara staminea, Dosinia acetabula, Cerastoderma laqueata, Corbula idonea, Astarte obruta, Crassatella marylandica, Mercenaria spp., Anodontia anodonta, Corbula inaequalis, and the snail -- Ecphora quadricostata umbilicata. Typically, another sequence of reduced and increased macrofossil beds follows, but the faunal composition is somewhat different and usually shell fragments are much more abundant (pls. 36-39, 43, 68, 69). Normally, the fauna is strongly dominated by oysters and scallops, with barnacles of somewhat lesser significance. Locally, however, cockles may be dominant. The more common fossils in this sequence, then, are: Crassostrea carolinensis, Lyropecten madisonius, Cerastoderma laqueata, and Balanus concavus. In some outcrops this oyster-scallop-barnacle assemblage is significant in other portions of, and in some exposures throughout, the Boston Cliffs Member. Faunal accumulations above the last described sequence are somewhat obscured by heavy oxidation and induration. Where the relationships were relatively clear, the alternation of increased and reduced macrofossil beds continued.

Macrofaunal assemblages of the Boston Cliffs Member generally have a lower faunal diversity, fewer epifaunal individuals, and considerably fewer snails than the Drumcliff Member. An exceptionally well-preserved assemblage of bivalves occurs in the lower increased macrofossil bed of the southern Calvert Cliffs, particularly between Flag Ponds and Camp Conoy. Some of these bivalves still retain remnants of the hinge ligament, and some still show shell coloration, which is uniformly dark yellowish-brown. In the same area, between Flag Ponds and Camp Conoy, individual shells of Anondontia anondonta are much fatter than elsewhere in the Choptank. Unusually large specimens of Lyropecten madisonius occur from Point of Rocks to Cove Point. At Boston Cliffs infaunal bivalves are unusually large (text fig. 1 A-D, 7B-D, 8A-C, 13A-C).

The best of the Eastern Shore exposures is at Boston Cliffs. Shattuck (1904, pp. xxxiii-cxxxvii) reported outcrops and fossils at Peach Blossum Creek and Trappe Landing, which were not found during the course of this investigation. A previously unreported section was located on the south bank of Island Creek (locality 66-B in Appendix 1). On the Eastern Shore and along the Calvert Cliffs, where the Boston Cliffs is exposed from Parker Creek to a little north of Cove Point, the thickness seems to average 14 to 15 feet. A very thin, inland exposure can be found at locality 67-58, near Paris, Maryland. Locality 66-46, Hellen Creek, is very similar to sections to the northeast,

except for some large crab burrows partially obscuring relationships (pl. 44). Exposures at the mouth of St. Leonard Creek and on the southwestern side of the Patuxent are only 9 to 11 feet thick, and the oyster-scallop-barnacle assemblage dominates the fauna throughout. The member at the western end of Nomini Cliffs (locality 67-72 in Appendix 1) is very much like the section along Chesapeake Bay. To the east the section thins to 3 feet (locality 67-70 in Appendix 1), and to the west at Horsehead Cliffs (locality 67-73 in Appendix 1) a rather uncharacteristic section measures 5 feet 2 inches.

Conoy Member.--This corresponds to "zone 20" of Shattuck and is the upper member of the Choptank (pl. 1, 2). The type section is here designated as the first major cliff northwest of Camp Conoy (Y.M.C.A.) along the Chesapeake Bay (see locality 66-21 in Appendix 1, also pl. 49, 50). Although somewhat unorthodox to name a rock-stratigraphic unit after a Y.M.C.A. Camp, there is a general scarcity of named geographic features in the vicinity. Since the United States Geological Survey 7.5 minute topographic map officially includes "Camp Conoy", it seems perfectly within the limits of the Code of Stratigraphic Nomenclature. The Calvert Cliffs at Flag Ponds would serve better for a type section, but unfortunately there already is a "Flag Pond Granite Group" in North Carolina and Tennessee. An excellent reference area for this member is the section of the Calvert Cliffs from Camp Conoy to

Flag Ponds (see localities 66-21, 66-44, 67-50, 66-25, and 66-15 in Appendix 1). The dominant sediment type is dusky grayish-green to dusky greenish-blue to dusky blue, very muddy, very fine sand to silt. Thickly-spaced, continuous, parallel, thin, bedding laminations are common (pl. 45; 47, fig. 1). The lower contact of the Conoy is sharp and distinct with the oxidized, indurated sequence of the Boston Cliffs below. The unconformable relationship with the overlying St. Marys Formation has been discussed above.

The general sparsity of macrofauna is interrupted in a few outcrops by a thin, concentrated accumulation of Turritella plebeia (pl. 46). The more common fossils of the Conoy are: the gastropod--Turritella plebeia and bivalves--Cerastoderma laqueata, Yoldia laevis, Mytilus conradinus, Atrina harrisii, Lyropecten madisonius, Balanus concavus, and Dosinia acetabula.

There are a few partial exposures of the Conoy Member along the shores of the Choptank River in the vicinity of Cambridge. This unit is in the Calvert Cliffs from Parker Creek to Cove Point. Along the Patuxent River the only outcrops are in the vicinity of Hellen and Hungerford Creeks. There are no known exposures in St. Marys County, but in Westmoreland County, Virginia the member is present all along the Horsehead, Stratford, and Nomini Cliffs. The thickness of the Conoy seems fairly constant throughout the outcrop belt, varying from over 9 feet to 15 feet.

In general, the five members of the Choptank are quite persistent and constant in thickness. Unfortunately, nothing is known of them in the subsurface. Knowledge of what and where the significant changes are will greatly increase understanding of the Choptank.

As mentioned at the beginning of the section on stratigraphy, Shattuck designated the Choptank River exposures below the Dover Bridge as the type locality. This was unfortunate since the type locality included only one of the five members, the Boston Cliffs Member. Thus, the other four members are totally unrepresented. Under article 13 of the Code of Stratigraphic Nomenclature (Krumbein & Sloss, 1963, p. 629) provision has been made for supplementing a type section with reference sections. In an effort to correct problems raised by the type section, the Calvert Cliffs from Calvert Beach to Governor Run, Maryland is here designated as the reference area for the Choptank Formation. Locality 66-5, 0.9 mile southeast of Western Shores, Maryland and 1.0 mile northwest of Calvert Beach, Maryland in the Calvert Cliffs, is here designated as the principal reference section (pl. 2, also see locality 66-5 in Appendix 1 for a detailed description of the principal reference section).

The name "North Keys Sand" was proposed by Hack (1955, p. 8) for "a bed of fine yellowish-orange sand which rests conformably on the top clay bed of the Calvert formation, and in the Brandywine (Maryland) area, underlies the

gravel of the Brandywine formation (Pliocene?)." He added

> The sand is at least in part Miocene in age, and in this area is equivalent to zone 19 in the Choptank . . . The North Keys sand is traceable on the basis of lithology over a wide area in southern Maryland and may not be equivalent everywhere to zone 19. The Miocene formations becoming younger to the south where it is equivalent to higher zones. For this reason, a new name defined on the basis of stratigraphic position and lithology is proposed even though in the Brandywine area fossil evidence nearly appears to identify the North Keys and with the Choptank.

In view of the available stratigraphic evidence Hack (1955, p. 10) considered two interpretations as possible: "Either the North Keys sand represents an overlap of sandy beds of the Choptank, on the eroded Calvert formation, or the North Keys sand becomes younger to the south and overlaps the Choptank as well as the Calvert." His paper makes it quite clear that of the two he favored the regressive-overlap interpretation.

I disagree. The evidence presented in Hack's own paper makes a regressive-overlap relationship stratigraphically and geometrically impossible. In his text and in the diagrammatic columnar sections (1955, p. 7, fig. 4) Hack stressed that the North Keys Sand is equivalent to Choptank in age because "zone 19" (=Boston Cliffs Member) is superjacent in an exposure near Paris (1955, p. 9). The writer examined the same key outcrops (locality 67-58 in Appendix 1) and agrees that the prolific shell bed near the top of the section is unmistakably Boston Cliffs. The conflict within Hack's reasoning arises from his claim that at Paris

the North Keys Sand occurs stratigraphically below the Boston Cliffs, but downdip their relative positions are reversed with the North Keys above the Boston Cliffs. Somewhere between Paris and the Calvert Cliffs these two sedimentary facies must intersect and cross according to his hypothesis. Even though Hack could find no fossils in the North Keys itself, he did try to understand something of its origin through size analysis of the sediment. Cumulative frequency curves "indicate that the North Keys Sand probably is a marine sand deposited in shallow water, on the shore, or as dunes behind the beach. Possibly it was deposited in all three environments and those parts of the formation which are free of clay or silt, and are devoid of fossils may represent a shore or shore-dune facies" (1955, p. 9). My sample, 67-58-1, from 4 feet 9 inches to 5 feet 9 inches below the "North Keys"--Boston Cliffs contact contained an assemblage of Ostracoda and Foraminifera that are very typical of the shallow, open marine Choptank. As mentioned in the discussion on the Choptank-Calvert contact, this fauna is indicative of only the Choptank, in light of our present knowledge. The stratigraphic probability of a shallow, open marine "North Keys sand" overlapping the Choptank, St. Marys, and Yorktown Formations, all predominantly shallow marine in their outcrops, is highly unlikely. Even more unlikely would be the intersection and reversal of the Boston Cliffs and "North Keys", both shallow, open-marine deposits in the

outcrop area.

In comparing this problem unit with other Miocene deposits Hack said (1955, p. 10) "The North Keys sand is lithologically unlike the Choptank formation as it is exposed in the Calvert Cliffs. . ." I agree for the most part with that statement. Since the "North Keys" grades into the Boston Cliffs at the Paris section, the counterpart in the Calvert Cliffs would be the St. Leonard Member which grades into the Boston Cliffs Member there. Admittedly the St. Leonard is typically dusky blue, fine sand where the "North Keys" is yellowish-orange, oxidized, fine sand. On the other hand, the only real difference is in the color--one is oxidized, and the other is not. In fact, some exposures of the St. Leonard along the Calvert Cliffs northwest of Point of Rocks are oxidized and appear very similar to the so-called "North Keys sand". The best correlation of the Paris section, however, is with the Choptank along the Patuxent River. Outcrops at Drumcliff, the mouth of St. Leonard Creek, and in the Cuckold Creek--Hickory Landing Creek--Mill Creek--Mill Cove complex expose a St. Leonard--Boston Cliffs sequence similar to the "North Keys"--Boston Cliffs sequence at Paris. It is the contention of this writer that the "North Keys" sand of Hack is nothing more than oxidized sediments of the Choptank Formation.

PALEOAUTECOLOGY

Analysis of Miocene paleoautecology certainly has

distinct advantages over Mesozoic, Paleozoic, or Precambrian biotic investigations. With older fossils the study must necessarily be much more empirical. For the most part, my approach utilizes direct extrapolation of ecological information from the present to the past.

The first statements concerning the paleoecology of the Choptank foraminifers were made by Malkin (1953, pp. 773-775) and were actually made about the Chesapeake Group as a whole. Because her paper primarily concerned Ostracoda, her treatment of the foraminifers was extremely sketchy.

The really important study on the foraminiferal paleoecology was that of Gibson (1962). Basically, he extrapolated directly the known ecology of the extant species to the Miocene. In addition, he relied upon these factors in planktonic Foraminifera. This method was greatly facilitated by the fact that 68 percent of the Choptank benthonic foraminifers were considered to belong to extant species.

One weakness of the approach used by Gibson is that only the extant species are considered while the extinct ones are disregarded. The extreme possibility could arise that the neglected part of an assemblage might contain several key organisms which would indicate a depositional environment other than that indicated by the extant species. This problems is somewhat amplified by the fact that Gibson's approach largely was to contrast the number of key living species representing different environments. Then

applied to fossil occurrences, the paleoenvironment was considered to be whatever the majority of species indicated. With this system it requires only a very few species indicating one environment or the other to completely change the outcome.

It should be made clear there that this criticism is really aimed at the approach and not Gibson's study. Within his study the foraminifers were between 60 to 80 percent extant, so the probability of accuracy was in his favor.

Gibson was pessimistic about including generic distributions as a basis for interpretation of paleoenvironments and said (1962, p. 52), "Using only genera and not species may give either an incorrect interpretation of the environment or be so widely tolerant as to give only a very broad interpretation." I agree in part, for using only genera or only extant species, as Gibson did, may introduce shortcomings into the final analysis. If, however, these two criteria in addition to various general characteristics of foraminiferal distribution, as reviewed by Gernant and Kesling (1966, pp. 135-136), are considered in the interpretation, the deficiencies of the various approaches may be dampened. Yet direct extrapolation from extant species should have the highest resolving power of any single foraminiferal criterion.

Summary of Known and Inferred Ecological Information

Foraminifera

(For a more detailed discussion see Gibson, 1962,

pp. 82-193.)

Bolivina paula Cushman & Ponton.--Although there are only a few reports of this species from modern seas, they indicate a warm temperate distribution from 9 to over 183 meters. The apparent scarcity of the species may be a result of its small size.

Bolivina plicatella Cushman.--This species occurs in boreal, temperate, and tropical regions and is most common in waters less than 50 meters but is found to 100 meters. Gibson (1962) and the present investigator found it in the Choptank but only in the Calvert Beach Member.

Buccella depressa Anderson.--Investigations have found this in boreal, temperate, and tropical regions from 7 to 223 meters deep water.

Buccella mansfieldi(Cushman).--This is a warm temperate species. Although occurrences have been found to depths of 92 meters, this foraminifer is predominantly found in very shallow water. In fact, Bandy (1961) considered it one of the dominant species in his 0 to 18 meter inner shelf fauna from the Gulf of California. This is one of the most abundant foraminifers in the Choptank, particularly in the St. Leonard, Boston Cliffs, and Conoy Members.

Bulimina elongota d'Orbigny.--This species has a world-wide distribution but seems to have a slight preference for cold temperate, boreal, and arctic regions. Depth information is scarce but it was found at 9 meters

in the Red Sea.

Buliminella elegantissima (d'Orbigny).--Numerous occurrences have been reported from subpolar to tropical seas. The species is predominantly indicative of less than 40 meters but is fairly common to 80 meters. Phleger (1952) reported this species was most common on sandy bottoms. In this study it was primarily found in the Drumcliff and Boston Cliffs Members, which are generally the sandier members.

Buliminella subfusiformis (Cushman).--One occurrence of living specimens was in 732 meters of water near the boreal--cold temperate boundary along California, and the other was in 4 meters of water in the tropics of eastern South America. From these records, it appears that this species currently is of little paleoecological importance.

Cancris sagra (d'Orbigny).--This species is found from boreal to tropical environments but seems to prefer warm temperate and tropical regions. The depth range is intertidal to 1200 meters but is most abundant from 20 to 120 meters.

Cibicides floridanus (Cushman).--The tropics and warm temperate areas are the clear choices of this foraminifer. It is most abundant in from 55 to 146 meters of marine water but is found intertidally to 339 meters.

Cibicides lobatulus (Walker & Jacob).--This species is widespread and very temperate tolerant. Grossman (1967) regarded it as being particularly indicative of boreal and

arctic regions. It has an exceptionally great range of depth but is usually in less than 73 meters of water. This foraminifer is known to live attached to objects, and most Choptank specimens appear to have had this mode of life. During this investigation many were seen fixed on mollusc shells, particularly bivalves which do not live in the bottom, such as the scallops. The shape of the dorsal side of many fossils found unattached suggests the animals lived attached. This species ranks as the most abundant foraminifer in the Choptank. In fact in two samples from the lower Drumcliff Member along the Patuxent River it constituted over 90 percent of the foraminiferal assemblages. Phleger (1952) reported occurrences of Cibicides lobatulus of this magnitude from the Atlantic coast of New Hampshire in sandy environments. Most of these encounters were in less than 50 meters of water. The only Choptank foraminiferal assemblages composed of less than 5 percent of this species are from the St. Leonard and Conoy Members.

Dentalina communis d'Orbigny.--Polar to tropical findings of this organism make it useless as an indicator of biogeographic regions. On the other hand, it is a good indicator of deep water, being found from 46 to 4790 meters. Only two specimens of this species were found in this study. Gibson (1962) found none.

Dentalina sp.--There is no known living representative of this form; however, the genus is now generally confined to deep water. Only one specimen was found in the Choptank.

That one came from the Drumcliff Member along Mill Creek in St. Marys County. Dorsey (1948) reported what appears to be the same from the Drumcliff Member north of Calvert Beach.

Discorbis floridana Cushman.--This species occurs in temperate and tropical seas but is more typical of the tropics. It is encountered intertidally to depths of 522 meters but generally in less than 30 meters of water.

Elphidium advenum (Cushman).--Modern occurrences are from temperate and tropical water but rarely from warm temperate areas. The species is characteristic of water shallower than 70 meters but is found to 117 meters. It is very rare in the Choptank and was found only in the vicinity of Pawpaw Point in the Calvert Beach and Drumcliff Members.

Elphidium poeyanum (d'Orbigny).--This species has been found in temperate and tropical modern oceans. The depth range is intertidal to 250 meters with the most abundant occurrences at less than 18 meters.

Entosolenia lucida Williamson.--The modern distribution is in cold temperate, boreal, and arctic waters. Although the species occurs intertidally to 201 meters of marine water, most encounters are in less than 55 meters of water. The Choptank occurrences of this species are mostly in the Calvert Beach and Drumcliff Members.

Epistominella pontoni (Cushman).--The only known modern occurrences are from deep water in the Gulf of

Mexico. The species was found in only one sample in this study, a trace occurrence from the Drumcliff Member at Pawpaw Point.

Globulina inaequalis Reuss.--The species is found predominantly in cold temperate water but also in warm temperate. Most encounters are in less than 68 meters of water but occurs to 193 meters. It was found only in the three lowest members of the Choptank.

Hanzawaia concentrica (Cushman).--Modern occurrences are from temperate and tropical seas. The depth range is intertidal to 200 meters, but it is most characteristic of water shallower than 80 meters.

Lagena acuticosta Reuss.--Both Atlantic and Pacific Ocean records have been from only boreal waters. The depth range is from 18 to 1281 meters. The foraminifer is rare in the Choptank and was found only in the three lowest members.

Lagena clavata (d'Orbigny).--This species has a "split personality"--it is found in 6 to 92 meters of boreal water in the Atlantic and in 70 to 104 meters of tropical water in the Pacific. In the Choptank it occurs most frequently in the Drumcliff Member but is found in all members except the Conoy.

Lagena laevis (Montagu).--It would appear that this species is dependent on cold water. Modern occurrences are from Arctic waters from 15 to 401 meters but with most less than 92 meters. The species also is found in tropical

regions of the Pacific but there is found only in bathyal and abyssal environments where the water is quite cold. Its most significant record in the Choptank is in the Conoy Member at Flag Ponds where it is 10 percent of the foraminiferal assemblage.

Lagena substriata Williamson.--This widespread species is found in all oceans except the polar and is rare in warm temperate and tropical seas. It ranges in depth from 11 to 2798 meters but is most characteristic of water deeper than 55 feet. Probably the most interesting aspect of its distribution in the Choptank is the infrequent encounter in the Boston Cliffs Member.

Lagena tenuis (Bornemann).--This species is found throughout modern oceans except the polar. It occurs from 2 to 142 meters but most records are shallower than 50 meters.

Lagena sp. A.--This form may be the same as Lagena sp. A. of Dorsey (1948, p. 290). There are no known modern occurrences.

Lagena sp. B.--This foraminifer has not been found living. It is known only from the Conoy Member.

Lagena sp. C.--No modern occurrences are known. The species is found only in the Calvert Beach Member.

Marginulina sp. A.--This form may be the same as Marginulina sp. C of Dorsey (1948, p. 285). It is not known to be extant. In this study it was found only in the Drumcliff Member.

Marginulina sp. B.--There are no known modern occurrences. In this study the species was found only in the Calvert Beach Member.

Massilina glutinosa Cushman & Cahill.--There are no known modern occurrences of this agglutinated foraminifer, but probably it was a very shallow water organism. This species is known only from the Choptank Formation of Maryland and Virginia and is present throughout the formation in minor abundances.

Massilina mansfieldi Cushman & Cahill, M. quadrans Cushman & Ponton, and M. sp.--Although these species are known only in fossil records, the genus is generally typical of shallow water. In the Choptank they are all found only in the Drumcliff Member north of Calvert Beach, Maryland.

Miliammina fusca (H. B. Brady).--This species is found in all marine climates. It occurs in very shallow marine water but is particularly characteristic of brackish water. In the Choptank it is absent in the Calvert Beach Member and rare in other members.

Nodosaria catesbyi d'Orbigny.--Modern occurrences are restricted to warm temperate and tropical seas. The depth range is from 4 to 433 meters, but the species is most common in less than 60 meters of water. In the Choptank it was found only at the Horsehead Cliffs of Virginia.

Nonion marylandicum Dorsey.--This species is known only from the Choptank Formation of Maryland and Virginia and is generally a minor constituent of foraminiferal

assemblages throughout the formation. The greatest abundance occurs in the Boston Cliffs Member along the Calvert Cliffs.

Nonion medio-costatum (Cushman).--There are no known modern occurrences of this species. Modern foraminiferal distributions seem to indicate that this genus is more common on the middle and outer shelf than on the inner. Empirical evidence in this study would seem to indicate this species as characteristic of deeper shelf environments. The greatest abundance of this species is in the Conoy Member. In a sample from this member near Flag Ponds this fossil constituted 40 percent of the foraminiferal assemblage.

Nonion pizarrense Berry.--Modern occurrences are scarce but are in boreal and cold temperate seas. The known modern depth range is from 15 to 18 meters. Empirical evidence in this investigation would seem to indicate that the species may be indicative of somewhat greater depths. This foraminifer is present throughout the Choptank but is most abundant in the Conoy and Calvert Beach Members and least important in the St. Leonard Member.

Nonionella auris (d'Orbigny).--The species is distributed in shallow, boreal and cold temperate waters and more rarely in warm temperate seas.

Nonionella sp.--This foraminifer is known only from the lower Calvert Beach Member at the type section.

Pseudopolymorphina dumblei (Cushman & Applin).--

There are no known modern occurrences. This species is not very abundant in the Choptank, but well over 90 percent of its occurrences are in either the Drumcliff or Boston Cliffs Members. This suggests the possible association with sandier bottoms.

Pseudopolymorphina striata (Bagg).--This species occurs in warm temperate water of southeastern United States at depths of 27 to 120 meters. It is widespread in the Drumcliff Member but rare in the remainder of the Choptank.

Pyrgo subsphaerica (d'Orbigny).--Today, this species occurs in temperate and tropical oceans. It is found only in very shallow water in the northern portions of its geographic range but has a depth range of intertidal to 300 meters in the tropics. In the Choptank the only known occurrence was in the Drumcliff Member at Horsehead Cliffs, Virginia.

Quinqueloculina contorta d'Orbigny.--Modern occurrences are predominantly in boreal and cold temperate seas. Choptank occurrences are very rare and only in the Drumcliff Member north of Calvert Beach.

Quinqueloculina seminula (Linnaeus).--This species is widespread and is found in all marine climates but more frequently in cool temperate, boreal, and arctic seas. Primarily it occurs in shallow water, from beach to 50 to 90 meters. It was encountered in all Choptank members except the Conoy and was most frequent in the Drumcliff.

Robulus americanus (Cushman).--This species is unknown in modern oceans.

Rotalia bassleri (Cushman & Cahill).--There are no known modern occurrences of this species, but the genus is characteristic of very shallow marine and marginal marine environments. It occurs throughout the Choptank but is most frequently encountered in the Drumcliff Member.

Sigmomorphina concava (Williamson).--Modern occurrences are all in temperate seas. This species is most characteristic of marine environments shallower than 40 meters deep. It is found throughout the Choptank except for the Conoy Member and where present constitutes one percent or less of the foraminiferal assemblages.

Sigmomorphina williamsoni (Terguem).--This species has been found in cold temperate areas of the Atlantic Ocean in shallow water. It occurs rarely in the Calvert Beach and Drumcliff Members of the Choptank.

Spiroplectammina exilis Dorsey.--There are no known modern occurrences of this species. In fact, Gibson (1962) considered it endemic to the Choptank, whereas Dorsey (1948) considered it confined to the Choptank and St. Marys. The Choptank distribution is quite peculiar. All samples from the Drumcliff Member, except for one which contains only five benthonic Foraminifera, includes this species. In addition, it is found in all samples of the Virginia Choptank. Other occurrences are very rare. The greatest abundance of specimens is in the Virginia

samples.

Spiroplectammina of. S. exilis Dorsey.--This form differs distinctly from the typical S. exilis and is found only in the St. Leonard Member.

Spiroplectammina mississippiensis (Cushman).--There are no known living occurrences of this species. This has been reported previously as abundant in the Calvert but absent in the Choptank. In this study there was a single occurrence in the Calvert Beach Member.

Textularia candeiana d'Orbigny.--The modern distribution is from boreal to tropical seas. The depth range is from 18 to 300 meters. Off the Atlantic coast of New Hampshire, Phleger (1952) found this species confined to a depth zone bounded by 90 and 300 meters. In the Choptank it occurs rather infrequently in the St. Leonard and Boston Cliffs Members.

Textularia consecta d'Orbigny.--There are no known living occurrences. In the Choptank this species was found in all members except the St. Leonard. Samples containing the greatest abundance were from the Drumcliff.

Textularia gramen d'Orbigny.--This species is found in temperate and tropical marine environments. The depth range is intertidal to 110 meters. The species occurs throughout the Choptank but with significantly reduced abundance in the Conoy. Two of the foraminiferal assemblages studied were made up of over 20 percent of this species. Both of those samples came from the Boston Cliffs

Member in the vicinity of the type section where this member may indicate slightly brackish conditions. In fact, the microfauna in sample 67-79-2 has the strongest brackish water appearance of any seen in the Choptank, and Textularia gramen is the most abundant foraminifer in the assemblage. Thus, this species appears to favor brackish water.

Textularia ultima-inflata Dorsey.--There are no known living occurrences.

Textularia sp. There are no known living occurrences. In the Choptank there was a single specimen in the Conoy Member.

Uvigerina subperegrina Cushman & Kleinpell.--The known modern distribution is in cold temperate and boreal seas. The depth range is from 26 to 386 meters deep but particularly deeper than 100 meters. Choptank occurrences are frequent only in the Calvert Beach and Drumcliff Members. The most abundant occurrence, by far, was found in the Calvert Beach Member at the Parker Creek locality.

Valvulineria floridana Cushman.--There are no known living occurrences. This species shares the foraminiferal limelight with Cibicides lobatulus as the two most important species in the Calvert Beach and Drumcliff Members. It occurs with less abundance in the other members of the Choptank.

Virgunina miocenica Cushman & Ponton.--Living specimens have not been reported. In the Choptank this species occurs most consistently in the Drumcliff Member and is

absent from the St. Leonard.

Virgulina punctata d'Orbigny.--The modern distribution is in boreal through tropical seas but this foraminifer seems to show a preference for the warm temperate and tropical waters. This species is strongly indicative of water shallower than 40 meters.

Ostracoda

The two basic pioneering studies on Miocene to modern ostracodes of the Western Atlantic were by Ulrich and Bassler (1904) and Edwards (1944). Most subsequent investigations involved identifying or misidentifying their species. Some valid species have been added to the confusion. Fortunately, many of the Miocene to modern ostracodes of this area are based on Calvert and Choptank specimens as a result of Ulrich and Bassler's work. Considering the various problems it was most instructive to study the type specimens designated by Ulrich and Bassler, Edwards, and others that are on deposit at the U. S. National Museum, Washington, D. C.

To date only four Choptank samples have been examined for ostracodes, two by Ulrich and Bassler (1904) and two by Malkin (1953). Since many taxonomic problems exist in the Miocene to modern Ostracoda of the Western Atlantic, in some cases brief remarks are included with the paleoecological information to clarify my concept of the various species.

Actinocythereis exanthemata Ulrich & Bassler.--While this species has been frequently recorded from modern seas, all accounts I saw are of some other species of the genus. The species is considered here as being extinct. Other problems concern its identification in ancient sediments. Howe and Ellis (1935) and Puri (1953) described Actinocythereis exanthemata var. marylandica, which may be simply a female of the species described by Ulrich and Bassler. The only investigator to identify this species correctly after Ulrich and Bassler was Malkin (1953). Choptank occurrences are throughout the formation but always in minor percentages of the ostracode assemblages. Slightly higher percentages are found in the Drumcliff Member.

Actinocythereis aff. A. gomillionensis (Howe & Ellis).--The Choptank specimens look very similar except that they are much larger than the type specimens. The small size is supposed to be one of the distinguishing characteristics. Williams (1966) reports this species from 2 to 31 meters in Narragansett Bay of Rhode Island. In the Choptank it is quite rare and has not been found in the St. Leonard Member.

Actinocythereis aff. A. mundorffi (Swain).--Reported by Swain (1951) from the subsurface middle Miocene of North Carolina, this species has no known modern occurrence. The Choptank distribution is peculiar in that the species is found only in the St. Leonard Member between Calvert

Beach and Parker Creek along the Chesapeake Bay, but there it is the most abundant ostracode. In fact, near Parker Creek it constitutes over half of the ostracode assemblage. As will be explained more fully below, this organism is characteristic of a lower bay environment.

Actinocythereis sp.--This species may be similar to some modern ones reported from the western Atlantic and Gulf of Mexico. In the Choptank it makes up 2 percent of the ostracode assemblage in the Conoy Member at Horsehead Cliffs, Virginia and is not seen elsewhere.

Aurila laevicula (Edwards).--The Choptank specimens compare well with Edward's types in the U. S. National Museum. This is the first report from the Chesapeake Group. The only certain modern occurrence is in the Pamlico Sound of North Carolina, where this ostracode is not really common. Hazel (1967) reported two juveniles at 23 meters off Martha's Vineyard that appear to be this species. The Choptank specimens are from the Calvert Beach, Drumcliff, and Boston Cliffs members. The greatest abundance located is from an oyster bed in the lower Boston Cliffs Member near the type section. As mentioned, the microfauna there is the most brackish appearing of any in the Choptank. This species may have an affinity for brackish water.

Basslerites tenmilecreekensis Puri.--The only known modern occurrences are from the Pamlico Sound and the Atlantic deltas of the Sound (Grossman, 1967), where the

salinity range was 25 to 35°/oo and the depth range was 3 to more than 9 meters. The substate preference was sand or silty sand. The only occurrence in the Choptank is in the Boston Cliffs Member in the Nomini Cliffs of Virginia.

Bensonocythere whitei (Swain).--The Choptank material compares well with Swain's type speciments, which are from the Miocene of North Carolina. The modern distribution is in the temperate waters of the western Atlantic. The depth range is 3 to 201 meters with most occurrences in less than 61 meters of water. Specimens are distributed throughout the Choptank but are most consistent and slightly more abundant in the Drumcliff Member.

Bythocythere bifurcata (Puri).--The only occurrence of live specimens is between Cape Hatteras and Cape Kennedy at 29 and 60 meters. The only occurrence in the Choptank is in the lowermost Drumcliff Member along the Patuxent River.

Campylocythere laevissima (Edwards).--The Choptank specimens compare well with Edward's type specimen. Modern occurrences are in temperate and tropical waters of normal marine salinity. This species is encountered intertidally to 375 meters but is characteristic of less than 29 meters of water. The modern ostracode prefers sandy-bottom environments, and this seems to be carried over from the Miocene as the Choptank specimens are associated with the cleaner sands of the Drumcliff and Boston Cliffs Members.

Campylocythere sp.--This species has no known modern

occurrences. In the Choptank it was found only in the Conoy Member in the Horsehead Cliffs of Virginia.

Cushmanidea agricola (Howe & Hadley).--The modern distribution of this species is in the temperate areas of the Atlantic. The known depth range is 12 to 332 meters with most organisms shallower than 40 meters. This species occurs throughout the Choptank in minor abundance but is most common in the Calvert Beach and Conoy Members.

Cushmanidea seminuda (Cushman).--This species prefers substrates in boreal and cold temperate water from marginal marine environments to 35 meters of open ocean water. It has been reported in brackish estuaries of Maryland and Virginia. Throughout the Choptank it occurs with low abundance.

Cushmanidea ulrichi (Howe & Johnson).--In modern seas this species is found in cold temperate and possibly warm temperate water. The depth range is intertidal to 160 meters with most shallower than 25 meters. This is the most consistently abundant ostracode in the Choptank, and within the formation it is most consistently abundant in the Boston Cliffs Member, where it typically makes up 25 to 60 percent of the ostracodes.

Cyprideis floridana (Howe & Hough).--This species is found in warm temperate and tropical water in very shallow environments. In fact, it commonly occurs in marginal-marine, brackish environments. In the Choptank it is restricted to the lower part of the Boston Cliffs Member in

the vicinity of its type section. It is considered indicative of brackish water.

Cytherella sp.--This undescribed species is very rare in the Choptank. Two valves were found in the Conoy Member in the Horsehead Cliffs of Virginia. Generally, the genus is characteristic of warm-water and moderately deep shelf environments.

Cytheretta burnsi (Ulrich & Bassler).--There are no known living occurrences but the genus is prominent in shallow marine environments. This is one of the most abundant ostracodes in the Choptank, more numerous in the Drumcliff, Boston Cliffs and Conoy than in the other members.

Cytheretta ulrichi Puri.--Ulrich and Bassler (1904, p. 102) named this form Cythere plebeia, but that name was preoccupied. There are no known living occurrences, but the genus is one of the more prominent ones in shallow marine environments. It occurs throughout the Choptank but is more frequently encountered in the Calvert Beach and Drumcliff Members. Generally, it is found to have only minor abundance, but in the Drumcliff Member at Nomini Cliffs, Virginia, it is the most abundant ostracode.

Cytheridea subovalis (Ulrich & Bassler).--This species was erected on the "strength" of one broken valve collected from the Drumcliff Member at Pawpaw Point. The form is actually quite common at that locality, however, and the present material compares well with the type specimen. Malkin (1953) overlooked the description by Ulrich and

Bassler and renamed it Clithrocytheridea diagonalis on the basis of specimens which she found in the Calvert and Choptank formation of Maryland and the Kirkwood of New Jersey. The present writer examined the microfauna of two samples from the St. Marys and found this species in both of them.

There are no known modern occurrences. This ostracode is found throughout the Choptank.

Cytherois fischeri (Sars).--The modern distribution is in boreal and temperate water of the North Atlantic. The species is found on plants at less than 34 meters and is considered euryhaline. Choptank occurrences are sparse and only in the Drumcliff and Boston Cliffs Members.

Cytheromorpha warneri Howe & Spurgeon.--This species has been reported in temperate and tropical waters. It is euryhaline and is found shallower than 55 meters. In the Choptank it occurs generally in low abundance but is more common in samples indicating marginal marine environments.

Cytheropteron sp.--This Choptank form looks very similar to Cytheropteron talquinensis Puri from the Miocene of Florida. The most significant difference is in the ventral ala. In describing that structure, Puri said (1953, p. 243), "It is very sharp, pointed and well-developed . . . ." This writer has examined several hundred specimens from the Choptank, and they all have very blunt ventral alae. Possibly, the Choptank form is a geographical subspecies of C. talguinensis. In any event it appears

to be a new taxonomic entity.

The genus Cytheropteron is generally found in deeper water. Empirical evidence in the present study would seem to indicate that the Choptank form is a deeper shelf ostracode. This species is found throughout the Choptank in minor occurrence. It was found most abundant in the Conoy and lower Calvert Beach Members.

Echinocythereis clarkana (Ulrich & Bassler).--There are no known modern occurrences of this species, but the genus is found in deeper shelf environments. In the Choptank this species occurs with minor abundance and is nearly absent from the St. Leonard Member. It is most numerous in the Calvert Beach and Conoy Members, but nowhere in the Choptank does it constitute over 8 percent of the ostracode assemblage. Its most significant occurrence was in sample 67-65-2, from the lowest 4 inches of the formation at Calvert Beach, in which it is the fourth most abundant ostracode.

Eucythere declivis (Norman).--This boreal and temperate animal occurs in 7 to 230 meters of water but generally is considered a near-shore ostracode. In the Choptank it has been found only in the Calvert Beach and Drumcliff Members, and even there it never makes up more than one percent of the ostracode assemblage.

Eucythere gibba Edwards.--Benson (1967) questionably identified specimens from 130, 160, and 200 meters on the Atlantic shelf off North Carolina. In the Choptank it

occurs infrequently with minor abundance in all members except the Conoy.

Haplocytheridea bassleri Stephenson.--This species was originally described by Ulrich and Bassler (1904, p. 124) as Cytheridea subovata, but that name was preoccupied. It has been reported frequently in the Gulf of Mexico as a euryhaline ostracode. Some specimens have been found as deep as 26 meters in the open Gulf, but most are found in marginal marine environments, e.g., lagoonal, upper bay, lower bay, estuarine, and mangrove island. In the Choptank it is most abundant in the St. Leonard and Boston Cliffs Members and is absent in the Conoy.

?Haplocytheridea sp.--This ostracode is known only from three valves collected from the Drumcliff Member at Nomini Cliffs, Virginia.

Henryhowella evax (Ulrich & Bassler).--The modern distribution of this species is in temperate and tropical seas from depths of 155 to 677 meters. In the Choptank its abundance is generally very low. In fact, it is nearly absent from the St. Leonard and Boston Cliffs Members. The greatest abundance found was in sample 67-65-2, from the lowest 4 inches of the formation at Calvert Beach, Maryland, where this species is the second most abundant ostracode.

Hermanites sp.--This species is known only from the Boston Cliffs Member of the Maryland Choptank.

Hulingsina ashermani (Ulrich & Bassler).--This species is quite common in shallow, temperate seas. The depth range

is 2 to 200 meters with most occurrences shallower than 40 meters. The lowest reported salinity is 25°/oo but most reported specimens are from normal marine water. In the Choptank they are most abundant in the Drumcliff, St. Leonard, and Boston Cliffs Members. Generally speaking, it is one of the most consistent and abundant ostracode in the formation. It seems to show a preference for clean sand substrates.

Loxoconcha granulata Sars.--This is a frequently misidentified species. Malkin (1953) labeled five figures on plate 80 as Loxoconcha reticularis, of which only figures 15 and 16 are actually L. reticularis while figures 13 and 14 are adults of L. granulata and figure 17 appears to be a juvenile of the latter. Hall (1965, pp. 50-51) recognized Malkin's inclusion of two species under one name, but he called figures 13 and 14 L. purisubrhomboidea Edwards. I compared the Choptank species with Edward's type from the Miocene Duplin Marl of North Carolina. The two are very different. For that matter, neither are Hall's specimens L. purisubrhomboidea.

L. granulata has been reported from boreal and cold temperate seas of the Atlantic at depths of 2 to 38 meters. In the Choptank it is one of the most consistently occurring ostracodes but is most abundant in the middle and upper portions of the Drumcliff Member.

Loxoconcha reticularis Edwards.--The present material compares well with the type specimen. (See discussion of

Loxoconcha granulata.) This species is widespread in the warm temperate marine climate of the shelf from Cape Hatteras to Cape Kennedy. The depth range is 12 to 238 meters with most less than 50 meters.

An interesting relationship exists between L. granulata and L. reticularis. Hulings (1966 and 1967) reported the distribution of ostracodes of the cold temperate water off the Virginia coast north of Cape Hatteras and the warm temperate water from Cape Hatteras to Cape Kennedy. In the cold temperate water he found L. granulata and no L. reticularis, but in the warm temperate water he found L. reticularis and no L. granulata. It would seem that a comparison of the abundance and presence or absence of these two species in the Miocene would establish the boundary of the two marine climates.

L. reticularis occurs somewhat infrequently and in very low percentages in the lowest three members, but in the Boston Cliffs it occurs in nearly all samples and with increased abundance.

Machaerina? sp.--There are no known modern occurrences of this species, but the genus is made up of plant-dwelling, open-shelf ostracodes. Encounters in the Choptank are very rare and only in the Boston Cliffs Member.

Muellerina lienenklausi (Ulrich & Bassler).--This is a very overlooked species. It occurs commonly in Atlantic Miocene to modern assemblages but has only been identified correctly by Hazel (1967, pp. 21-22), who discussed the

problems associated with this species. Several authors have misidentified it as Trachyleberis or Murrayina martini. Hulings (1966 and 1967) called it Murrayina canadensis.

This is a boreal and temperate species ranging in depth from 7 to 201 meters. It occurs throughout the Choptank.

Murrayina howei Puri.--This species contains complex problems of identification and nomenclature. It was originally described by Ulrich and Bassler (1904, p. 115) as Cythere producta based on a male valve. Unfortunately, that name was preoccuppied. As a result, Puri (1953, p. 255) renamed it Murrayina howei. Marked sexual dimorphism in this group is confusing and leads to different interpretations of classification. Hazel (1967, pp. 21 and 22) considered Cythereis gunteri Howe and Chambers (1953) as the female of the male C. producta. Since Puri's name came 18 years later it is the junior synonym of C. gunteri. In my opinion, however, C. gunteri is actually Cythere martini Ulrich and Bassler (1904) (=Murrayina martini), a different species. In fact, it appears to this writer that both morphologic forms, Ulrich and Bassler's C. martini and C. producta (=M. howei), are the same sex of their respective species, probably males. McLean (1957) added confusion by incorrectly identifying Murrayina martini as Murrayina howei. His new species Murrayina barclayi appears to me to be M. howei.

There are no known modern occurrences of M. howei. It occurs throughout the Choptank in small percentages of the ostracode assemblage.

Murrayina martini (Ulrich & Bassler).--This species, as were the previous two, is plagued with taxonomic problems. The only correct identifications were made by Ulrich and Bassler (1904) and Swain (1948). Many authors have identified a "Trachyleberis (=Murrayina) martini," but in most cases it was Muellerina lienenklausi, as discussed above. Also, I believe that Cythereis gunteri of Howe and Chambers (1935) and Puri (1953) is a junior synonym. Adding to the confusion, McLean (1957) called this species Murrayina howei.

Benson (1967) reported a "Murrayina martini" from the Atlantic Ocean off North Carolina. Since he published no figure and since nearly everyone has incorrectly identified M. lienenklausi as M. martini, it seems quite possible that he made the same mistake. There are no other reports of living occurrences of the species. M. martini occurs throughout the Choptank with small percentages of the ostracade assemblage. The percentage increases somewhat in the Boston Cliffs and Conoy Members.

Neocytherideis fasciata (Brady & Robertson).--Modern distribution is in temperate waters. This is a plant-dwelling ostracode found in depths from 11 to 232 meters. The Choptank distribution is peculiar in that it is very consistent in the upper part of the Drumcliff Member but is

almost absent elsewhere. One occurrence was found in the Calvert Beach and Boston Cliffs Members, both at less than one percent of the ostracode assemblage.

Paracypris choctawhatcheensis Puri.--There are no known modern occurrences of this species. Choptank specimens are rare and occur only in the Calvert Beach and Drumcliff Members.

Paradoxostoma robusta Puri.--There are no known modern occurrences of this species, but the genus typically has a plant-dwelling mode of life. Choptank specimens are rare and are found only in the Drumcliff, St. Leonard, and Boston Cliffs Members.

Pokornyella punctistriata (Ulrich & Bassler)--This includes two described forms of Ulrich and Bassler (1904), Cythere francisca and Cythere punctistriata. The former is merely a juvenile of the latter. Malkin (1953, p. 796) put this species in the genus Hemicythere; although many of the characteristics are typical of that genus, the hinge is decidedly different from that of Hemicythere. C. punctistriata actually seems transitional between several genera and may represent a new hemicytherine genus. The Choptank form is temporarily placed in the genus Pokornyella.

There are no known living occurrences of this species.

Empirical evidence in this study suggests it was a very shallow marine ostracode. In fact, it was probably euryhaline, favoring slightly brackish environments. It occurs throughout the Choptank but is very sparse to absent in the Calvert Beach and Conoy Members. It is very important and abundant in the lowest Drumcliff Member along the Patuxent River and in the Boston Cliffs Member along the Choptank River.

Propontocypris howei Cushman.--This free-swimming ostracode is found in temperate water shallower than 155 meters. It is rare in the Choptank but is most frequent in the Drumcliff and Boston Cliffs Members.

Propontocypris sp.--Insofar as known, the species is extinct, but living members of the genus are free-swimming. Only a few valves were found in the Choptank and they came from one sample of the Drumcliff Member.

Pterygocythereis americana (Ulrich & Bassler)--Hazel (1967, pp. 39-40) discussed the taxonomic problems associated with this species, to which I have nothing to add. It is found in boreal and temperate seas often on mud substrates. The depth range is 12 to 238 meters. This species is usually considered a deeper water ostracode. It occurs throughout the Choptank with minor importance, except in the Conoy Member, where it is very abundant and important.

Semicytherura coryelli (Malkin).--Although this species is thought to be extinct, living members of the genus are characteristic of shallow-shelf and marginal-marine

assemblages. This is very rarely found deeper than 45 meters and is often euryhaline.

It is found throughout the lower four members of the Choptank and absent from the Conoy. In some sand lenses in the central Calvert Beach Member at Governor Run it was the most abundant ostracode. Parenthetically, it might be mentioned that samples of the Choptank that Malkin (1953) studied came from Governor Run. To date this species has been reported from only the Choptank. However, of two samples from the lower St. Marys Formation I examined, one contained a few specimens of this ostracode.

Semicytherura forulata (Edwards).--This species now lives in temperate and tropical seas. It is euryhaline and is found from marginal-marine environments to depths of 201 meters, usually less than 40 meters. In the Choptank specimens are infrequent and rare and appear only in the Drumcliff and Boston Cliffs Members.

Semicytherura reticulata (Edwards).--There are no known modern occurrences of this species. (See S. coryelli for comments about the genus.) In the Choptank specimens are very infrequent and rare having been found only in the lower part of the Boston Cliffs Member.

Tetracytherura shattucki (Ulrich & Bassler).--There are no known modern occurrences of this species, but the genus is usually found in shallow-shelf environments. In the Choptank this species occurs throughout the lower four members where it always constitutes a minor fraction of the

total ostracode assemblage; it is absent from the Conoy. Malkin (1953, p. 781) found it only in the Kirkwood of New Jersey and the Choptank. I found it in small abundance in the St. Marys Formation.

Gastropoda

The Choptank Formation is rather unexciting for snail lovers, as this class of molluscs is sparsely represented. In fact, if all specimens of the genus Turritella were removed from the fauna, the snails could be described as "rare". However, the species Turritella plebeia is so prolific that gastropods as a group are common. This one species is far more abundant than all others combined.

Shattuck (1904, pp. xcviii-cvii) lists 82 species of snails found by all workers prior to that time. In about six months of field study of the Choptank, I saw approximately one-third of those listed, nearly half of them based on less than a half dozen specimens each. Approximately ten species occur fairly frequently in the Drumcliff Member. In the other four members Turritella plebeia is frequent.

Busycon spp.--Johnson (1934, p. 9) said, "The Transatlantic Province [=temperate waters] can be characterized by that typical American genus Busycon, the region in which the oyster can be successfully propagated and in which the hard shell clam, Venus mercenaria, abounds." Members of this genus are surface-dwelling, carrion eaters. Whelks are very

rare in the Choptank and have been found only in the Drumcliff Member.

Caecum spp.--These small ciliary-feeders live under stones and in crevices on the inner shelf. Because specimens are extremely small, the genus is usually missed in field investigations. It has been found in samples from the Calvert Beach, Drumcliff, and Boston Cliffs Members.

Calliostoma spp.--These deposit scrapers typically live in shallow, marine water. Species of this genus can be found in shallow, marine water. Species of this genus can be found without too much trouble in the Drumcliff Member along the Patuxent River and along the Chesapeake Bay between Calvert Beach and Parker Creek and in the Boston Cliffs Member along the Choptank River.

Cancellaria spp.--Living species are highly specialized carnivores shooting poisoned barbs to disable their prey. Specimens are rare in the Drumcliff Member at its type locality.

Crepidula fornicata (Linne).--This species leads a sedentary existence commonly attached in stacks to other individuals of the species. It collects its food by ciliary currents of the gill. Modern occurrences are in boreal and temperate seas with a depth range of intertidal to 27 meters. Choptank specimens are found in the Drumcliff Member at its type locality.

Crepidula plana Say.--Modern occurrences are in boreal and temperate and rarely in tropical seas. Abbott(1954, p.

172) calls it, "A common shallow-water species." It leads a sedentary adult life, singly attached to the inside of large, dead shells. Food is collected by ciliary currents of the gill. This species is found in the Drumcliff Member at its type locality.

Crucibulum spp.--Living adults are sedentary, inhabiting shallow, marine environments and collecting food by ciliary currents of the gill. Specimens of this genus are rare in the Calvert Beach, Drumcliff, St. Leonard, and Boston Cliffs Members.

Ecphora quadricostata umbilicata (Wagner).--The genus and species are extinct but probably belong to or are closely related to Keen's family Thaididae (1958, p. 370). On their mode of life, she said, "The thaids are active predators, creeping about over rocks in pursuit of their prey--clams, mussels, barnacles, and so on." This species occurs throughout the formation but is rare.

Epitonium spp.--Modern representatives are thought to be carnivorous and inhabit shallow, near-shore environments. Specimens of this genus are rare but can be found in the Drumcliff Member and Boston Cliffs Member at its type locality.

Fissuridea spp.--The organisms probably were deposit scrapers in very shallow, marine environments. Specimens of this genus are rare in the Drumcliff Member.

Hastula spp.--In life, these organisms probably had the ability to paralyze prey by use of a poison gland.

Modern representatives are vagile just under the surface of the sea floor. In the Choptank this genus is very rare but can be found in the Drumcliff Member at its type locality.

Lunatia heros (Say).--Modern occurrences are in boreal and cold temperate environment with a depth range of intertidal to 31 meters but is typically in very shallow water. The moon snail plows about just beneath the surface of the sea floor hunting its prey which, when found, is enveloped in the massive foot, and an accessory boring organ applies to the boring site. The radula rasps with a circular motion into some convenient part of the shell. When the hole is completed, the proboscis is inserted to suck out the inside of the prey. Many of the Choptank bivalves are seen with naticid boreholes, which Carriker and Yochelson (1968, p. 137) have described as "truncated spherical paraboloids." The species is probably the second most abundant snail in the Choptank.

Nassarius spp.--Living species are scavengers plowing along the sea floor in search of carrion. This genus is rare in the Drumcliff Member.

Polinices duplicatus (Say).--Modern individuals live in the near-shore, shallow water of temperate seas. Their mode of life is similar to Lunatia heros discussed above. This species occurs in the lower four members of the Choptank.

Rhizorus spp.--In the Choptank this burrowing

opisthobranch is very rare and has been found only in the Drumcliff Member.

Scaphella typus (Conrad).--Living species of the genus are sand burrowers communicating with the surface by means of an inhalent siphon. This species is very rare and occurs only in the Drumcliff Member.

Siphonalia devexa (Conrad).--Living relatives are carnivorous but are more scavengers than active predators. This species is rare in the Drumcliff Member.

Teinostoma spp.--Due to their extremely small size, specimens are usually overlooked in field investigations, but samples examined for microfauna have yielded some.

Turritella spp.--Living Turritellas are found just below the sea floor but are vagile. They are gregarious and tend to form large colonies. Food is collected by ciliary feeding on finely sifted bottom deposits. This genus, particularly the species T. plebeia, is by far the most abundant snail throughout the Choptank. Some localities of the Drumcliff Member contain pockets of thousands of T. plebeia.

Urosalpinx cinerea (Say).--The present day oyster drill lives in very shallow marine environments in boreal and temperate waters. This carnivore drills holes in the shell of its prey to get at the meat. Choptank occurrences of this species are rare and only in the Drumcliff Member.

Vermetus graniferus (Say).--Living relatives are sessile, ciliary feeders. Choptank occurrences are rare and

only in the Drumcliff Member.

Bivalvia

Bivalves are much more abundant in the Choptank than snails. A very careful stratigraphic study of these molluscs was presented by Schoonover (1941b), to which the reader interested in the systematics and distributional data should refer. The following list of the more common Choptank bivalves includes brief statements of their life habits.

Aligena aequata (Conrad).--Living relatives of this genus attach to other invertebrates in a symbiotic relationship. Some individuals are known to live with annelids. Currents generated by the feeding host prove beneficial to these little bivalves in their own feeding.

Anadara staminea (Say).--This bivalve genus lives in shallow water attached by a massive byssus and is a suspension feeder.

Anodontia anodonta (Say).--Living species of this genus are infaunal, feeding through mucus tubes.

Anomia aculeata Gmelin.--This is one of the few Choptank mollusc species considered still living. Its modern distribution is in polar, boreal, and cold temperate water with a depth range of intertidal to 146 meters. A tough byssal plug projects through an opening in the lower valve and attaches to some object. The organism is a suspension feeder.

Apolymetis biplicata (Conrad).--Living species of this genus burrow into the substrate and feed by means of two slender, separated siphons. The shells characteristically lie partly on one side.

Asaphis centenaria (Conrad).--Living relatives of this genus are active burrowers and feed by means of siphons.

Astarte obruta Conrad and A. thisphila Glenn.--Members of this genus are most commonly found in cold water. Lacking siphons, they are infaunal, suspension feeders.

Atrina harrisii Dall.--Members of this genus are so fragile and brittle that in life they must be protected; hence, they are typically found in low-energy environments. The organism buries itself in the substrate with the pointed end of the shell down, anchored there by a tuft of fine fibers. Modern species are suspension feeders. A beautiful community of the Choptank species occurs in the Drumcliff Member on the east side of Breton Bay and appears to have been killed off by an influx of mud.

Callocardia (Agriopoma) subnasuta (Conrad).--This species is extinct but living forms of the genus are shallow, infaunal, siphon feeders.

Cardita granulata (Say) and C. protracta (Conrad).--Living species of the genus are shallow-water bivalves many attaching themselves under objects by a byssus. They are suspension feeders.

Cerastoderma laqueata (Conrad).--This species is extinct but was very common in the Choptank. This large,

robust species probably lived just below the sediment-water interface. Suspension feeding was accomplished by short, stubby siphons.

Corbula idonea Conrad and C. inaequalis Say.--The Choptank species is extinct but members of the genus are typically found clinging by a bysus under objects. They feed by means of short siphons.

Crassatella turgidula (Conrad) and C. marylandica (Conrad).--The Choptank species are extinct but the modern species of the genus prefer cool waters off the modern Atlantic Coast. This group is infaunal but since they have no siphons, the posterior end of their shell must be very near the sediment-water interface for suspension feedings.

Crassostrea carolinensis (Conrad).--Living species of the genus predominate in brackish water environments and in marine waters near the effluence of brackish water bodies. These suspension feeders are typically found only in very shallow water.

Diplodonta spp.--Three extinct species of this genus are found in the Choptank, two are common. These small bivalves form nests around themselves of mud particles agglutinated with mucus.

Dosinia acetabula Conrad.--Modern relatives of this genus are efficient burrowers in shallow water environments. They are suspension feeders by means of long, fused siphons.

Ensis ensiformis Conrad.--This species is extinct, but modern razor clams are considered among the best and

most active burrowers. They are siphonate suspension feeders, typically found in shallow water.

Glossus fraternus marylandicus (Schoonover).--Living relatives of the genus are suspension feeders through short siphons and inhabit soft substrates.

Hiatella arctica (Linne).--This is one of the very few Choptank molluscs considered to be living. This species is always byssally attached in various situations, e.g., in shells of dead animals, burrows of other molluscs, or some other sheltered cranny. The known depth range is intertidal to 46 meters. This bivalve is distributed in all marine climates from polar to tropical. Feeding takes place through siphons.

Isognomon maxillata (Deshayes).--This species is extinct but the living genus is generally restricted to shallow, warm temperate and tropical water. It is found attached to rocks or other objects and is a suspension feeder.

Lucinoma contracta (Say).--Modern species of the genus are infaunal and tend to be in substrates that have a sparse fauna. Several different lucinids may occur together in the same habitat. They feed through mucous tubes.

Lyropecten madisonius (Say).--This species is extinct, but scallops are quite numerous in the modern Atlantic Ocean. They have a peculiar mode of life for bivalves, in that they are free-swimming. Scallops are

suspension feeders. Choptank specimens are very abundant and some are exceptionally large.

Macrocallista marylandica (Conrad).--Living members of the genus are suspension feeders through short, fused siphons. Their shallow burrowing could classify them as part of the "barely-infauna".

Martesia ovalis (Say).--All Choptank specimens are found bored into valves of Isognomon maxillata. They fed from and communicated with the external environment by means of siphons.

Mercenaria mercenaria (Linné).--This is one of three fairly numerous Choptank bivalves considered still living. It is a temperate and boreal species found intertidally to 24 meters of water with none known living deeper than 11 meters. This infaunal, suspension feeder feeds by means of short, fused siphons. It prefers sandy substrates and sheltered environments.

Mercenaria spp.--In addition to the mercenarid mentioned above there are three extinct species. These probably preferred sandy substrates and shallow, sheltered environments, as well. In addition, they must have been infaunal, suspension feeders.

Mytilus conradinus d'Orbigny.--Living members of the genus characteristically cling by the byssus to the exposed faces of surf-beaten rocks, where the churning water brings a maximum amount of food and oxygen.

Nucula proxima Say.--This is the third Choptank

bivalve considered still living and today is a boreal and temperate water form. The depth range is intertidal to 183 meters but in the northern regions is predominantly shallow while in the tropics it is commonly found at the deeper end of its range. These burrowing forms gather food particles directly from the sediment with extensions of the labial palps.

Panope spp.--This cold-water group is one of the deepest burrowing of all the bivalves. They feed by means of very long siphons. In the Choptank this genus is peculiar in that it is always found double-valved and in living position and is practically the only bivalve in the major shell beds found in that arrangement.

Placopecten marylandicus Wagner.--This species is extinct, but suspension-feeding scallops are quite numerous in the modern Atlantic Ocean. They are free-swimming.

Semele subovata (Say).--This small species is extinct, but in modern oceans species of the genus are infaunal, siphon feeders.

Spisula subparilis (Conrad).--This is another very small, common, Choptank bivalve. Living species are most common near shore and in sandy substrates and use siphons for infaunal, suspension feeding.

Yoldia laevis (Say).--Living species of the genus are found predominantly in cold water. These burrowing forms gather food particles directly from the sediment with extensions of the labial palps. Preference for mud

substrates is shared by the modern and Choptank species.

Size-Frequency Study of Selected Bivalves

Size-frequency distributions have the potential for increasing the understanding of the paleoecology of fossil organisms. Seemingly, the uniformitarian approach of extrapolating principles of size-frequency distributions of living populations to fossil assemblages is the most rational. Studies by Craig and Hallam (1963), Craig and Oertel (1966), Craig (1967), and Hallam (1967) are the most helpful for this approach.

From their analyses of living populations and from the work of population ecologists, such as Deevey (1947) and Slobodkin (1961), it is apparent that many complex, interrelating parameters function to produce a size-frequency distribution. In fact, at this stage of development these parameters cannot really be adequately identified in fossil distributions. Hallam (1967, p. 40) made the summary statement, ". . . . information is unfortunately insufficient for the rigorous disentanglement of the several variables involved. . . ."

The primary factors considered (Craig & Oertel, 1966, and Hallam, 1967) are recruitment, growth-rate, coefficient of variation of growth-rate, mortality rate, cessation of growth, sorting by water currents, solution of small, thin shells, and selective fracturing and crushing of certain size-grades. (For a discussion of these

factors, the reader should refer to the two papers cited.)

Size-frequency distributions of selected Choptank bivalves are presented in text-figures 1 to 14. Numbers on the abscissa correspond to bivalve height measured in hundredths of a centimeter. Class sizes were selected in consideration of the data available. Numbers on the ordinate correspond to frequency of observations within class intervals.

For most of the data sources, separate graphs were made for right valves, left valves, and combined right and left valves. Comparisons of size-frequency distribution for opposed valves shows no significant difference. Minor differences occur in more or less accentuated peaks and presence and absence of very small peaks on "tails" of skewed distributions. This lack of significant variation suggests no selective sorting of either right or left valves, as shown by Lever, et al. (1958 and 1964), to occur on beaches.

One generality to be made about the distributions is the lack of the smallest sizes of shells. Of course, one problem with fossil bivalves is that the larval stage is not preserved. Thus the fossil distribution does not represent all of the ontogeny.

This explanation does not seem sufficient to explain the extreme lack of smaller shells as observed in text-figures 1A and 7A-D. These show the distributions for Dosinia acetabula and Macrocallista marylandica both

Text-Figure 1

Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

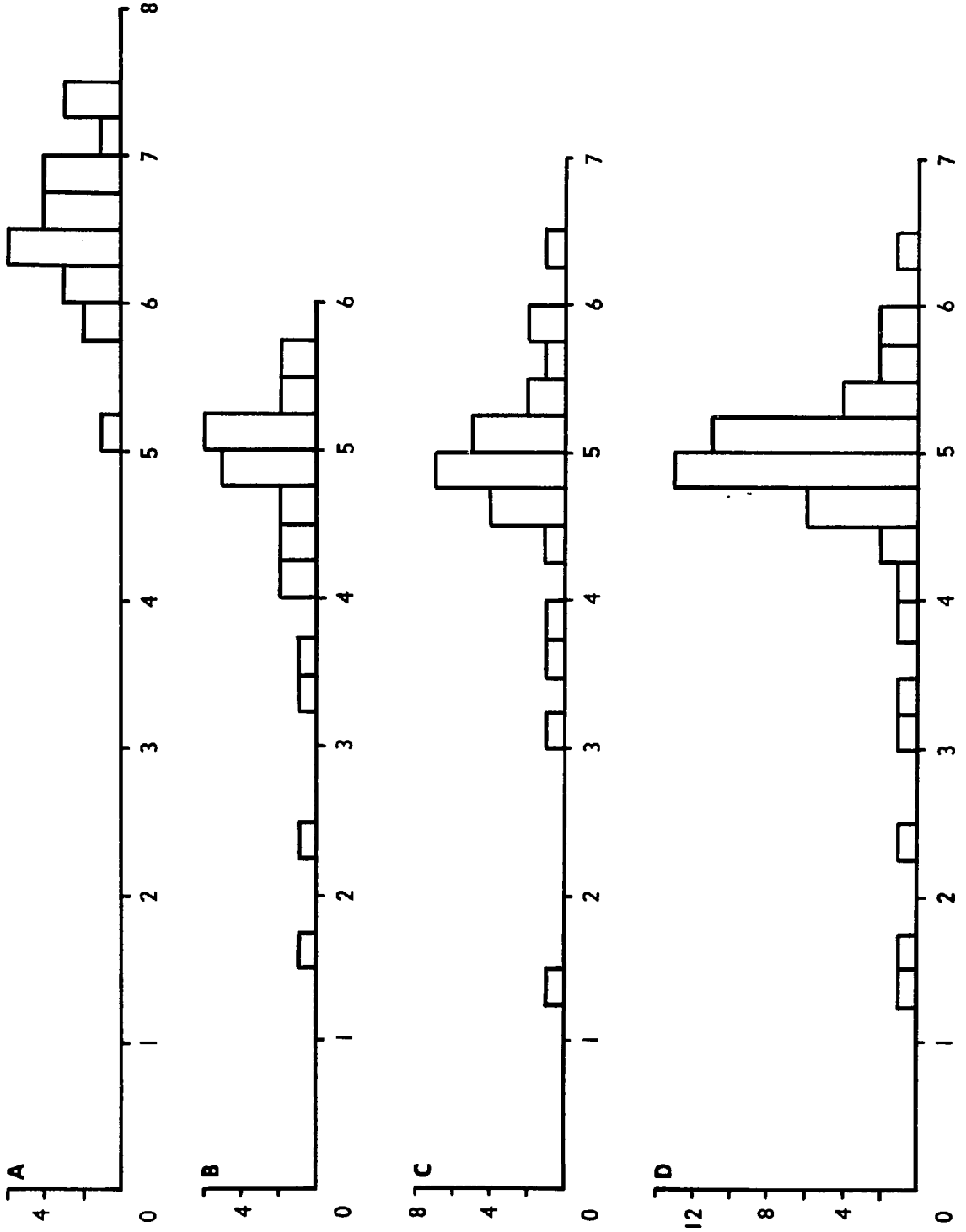
Text-fig. 1A. Right, left, and double valves of Dosinia acetabula. Lower increased macrofossil bed. Boston Cliffs Member. Locality 66-12.

Text-fig. 1B. Right valves of Crassatella marylandica. (Location as above.)

Text-fig. 1C. Left valves of Crassatella marylandica. (Location as above.)

Text-fig. 1D. Right, left, and double valves of Crassatella marylandica. (Location as above.)

Text-Figure 1



Text-Figure 2

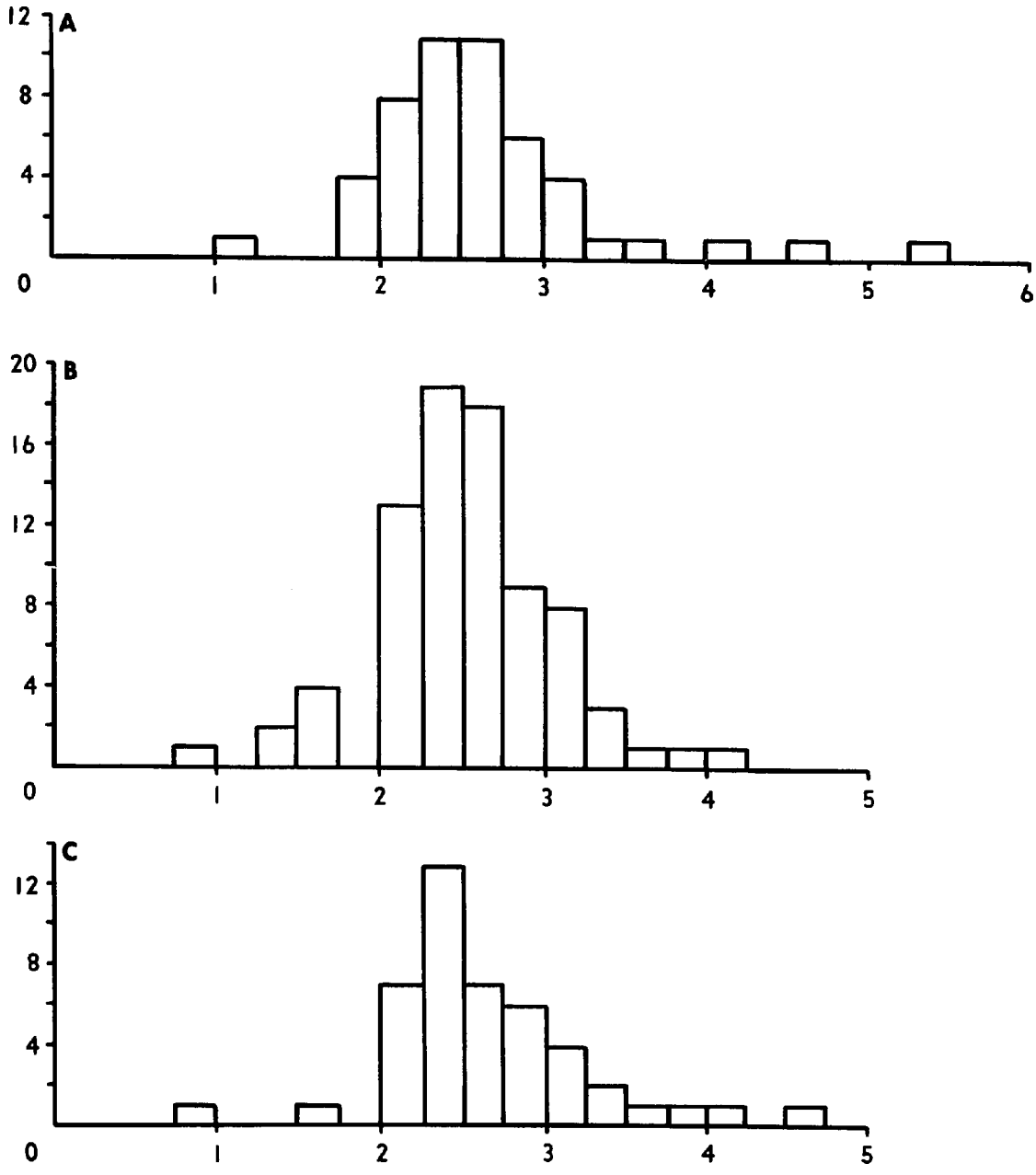
Size frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 2A. Right valves of Glossus fraternus marylandicus. Glossus-Turritella bed, upper Drumcliff Member. Locality 66-4.

Text-fig. 2B. Right, left, and double valves of Glossus fraternus marylandicus. (Location as above.)

Text-fig. 2C. Left valves of Glossus fraternus marylandicus. (Location as above.)

Text-Figure 2



Text-Figure 3

Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 3A. Right valves of Lyropecten madisonius. 1 foot 6 inches below Drumcliff-St. Leonard contact. Locality 66-6.

Text-fig. 3B. Left valves of Lyropecten madisonius. (Location as Text-fig. 3A.)

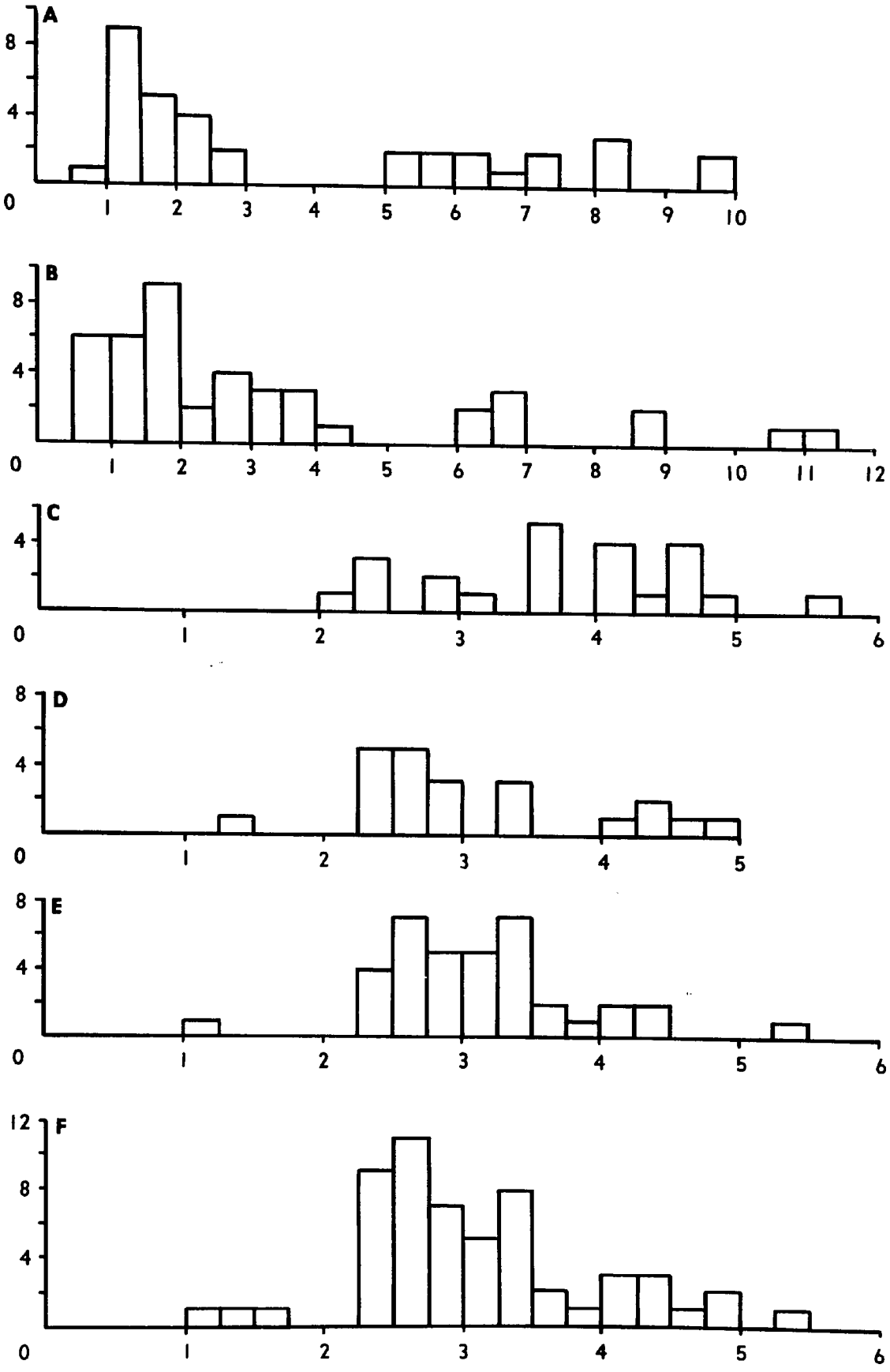
Text-fig. 3C. Right, left, and double valves of Glossus fraternus marylandicus. 1 foot 6 inches to 4 feet below Drumcliff-St. Leonard contact. Locality 66-6.

Text-fig. 3D. Left valves of Glossus fraternus marylandicus. 6 inches to 2 feet below Drumcliff-St. Leonard contact. Locality 66-7.

Text-fig. 3E. Right valves of Glossus fraternus marylandicus. (Location as Text-fig. 3D.)

Text-fig. 3F. Right, left, and double valves of Glossus fraternus marylandicus. (Location as Text-fig. 3D.)

Text-Figure 3



Text-Figure 4

Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 4A. Left valves of Anadara staminea. Anadara unit in the lower increased macrofossil bed. Boston Cliffs Member. Locality 67-52.

Text-fig. 4B. Right valves of Anadara staminea. (Location as above.)

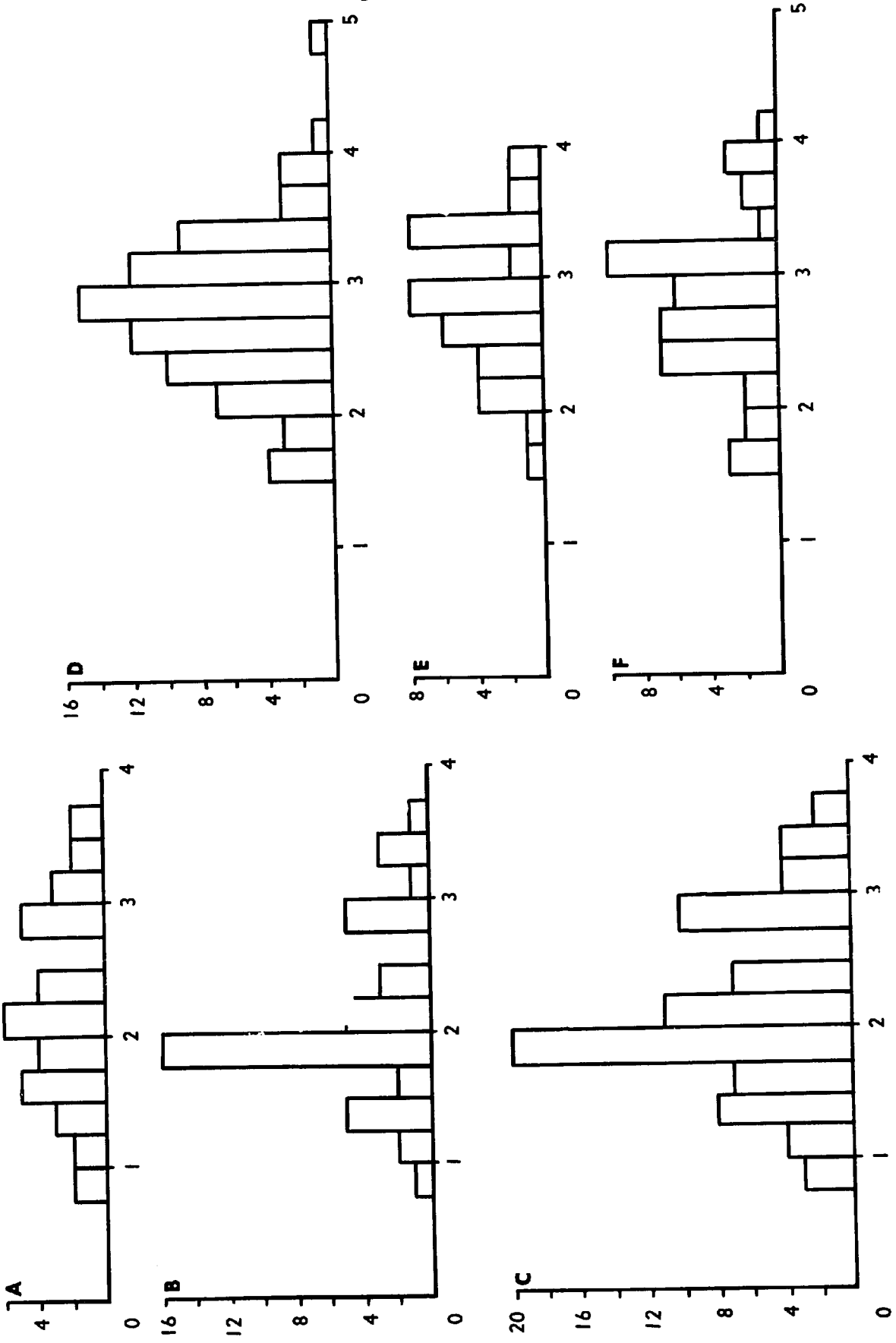
Text-fig. 4C. Right, left, and double valves of Anadara staminea. (Location as above.)

Text-fig. 4D. Right, left, and double valves of Glossus fraternus marylandicus. Upper Drumcliff Member. Locality 66-5.

Text-fig. 4E. Left valves of Glossus fraternus marylandicus. (Location as Text-fig. 4D.)

Text-fig. 4F. Right valves of Glossus fraternus marylandicus. (Location as Text-fig. 4D.)

Text-Figure 4



Text-Figure 5

Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 5A. Left valves of Glossus fraternus marylandicus. 6 inches to 1 foot 6 inches below Drumcliff-St. Leonard contact. Glossus-Turritella bed. Locality 66-6.

Text-fig. 5B. Right valves of Glossus fraternus marylandicus. (Location as above.)

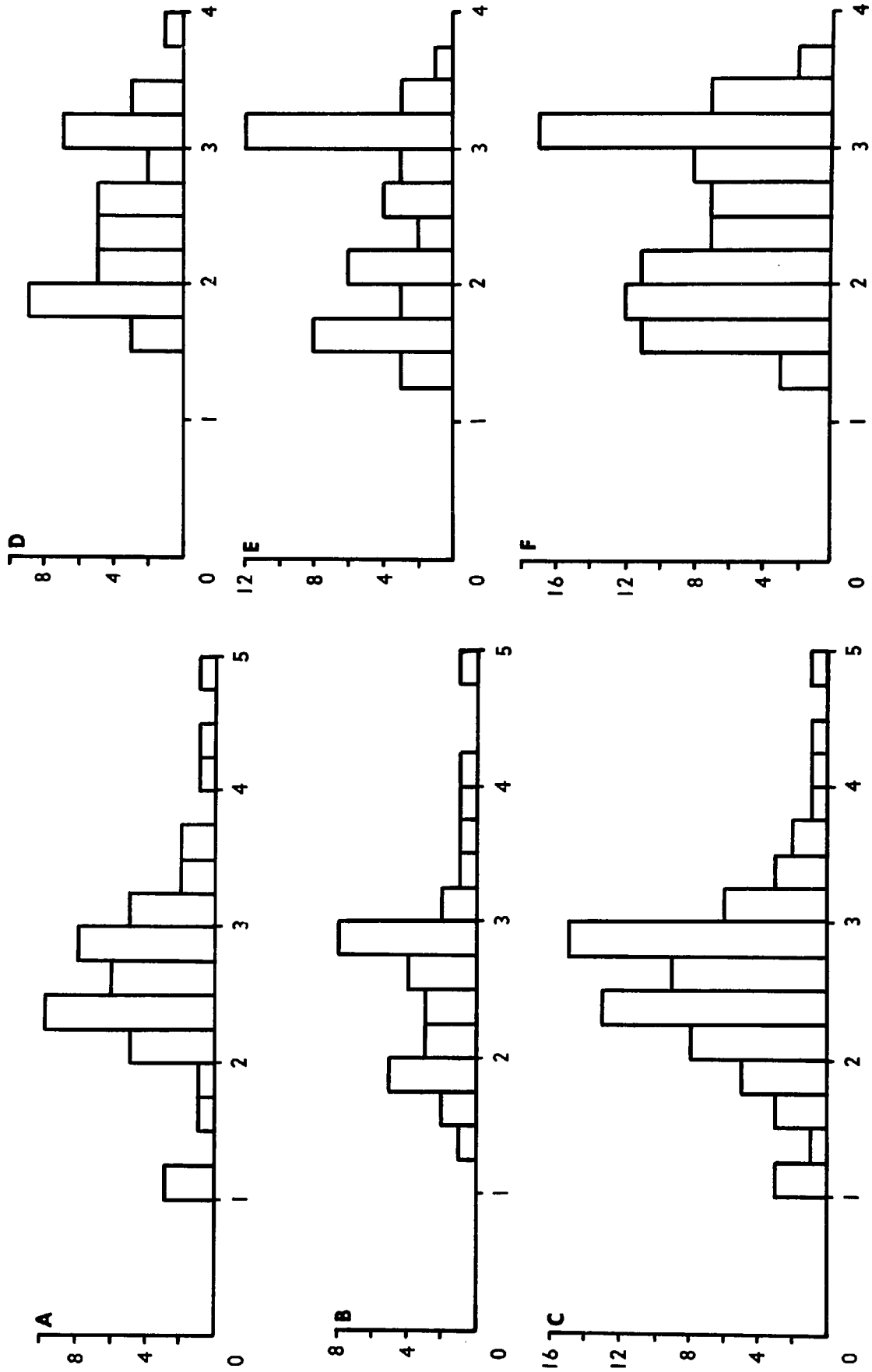
Text-fig. 5C. Right, left, and double valves of Glossus fraternus marylandicus. (Location as above.)

Text-fig. 5D. Left valves of Anadara staminea. Anadara unit in the lower increased macrofossil bed. Boston Cliffs Member. Locality 67-66.

Text-fig. 5E. Right valves of Anadara staminea. (Location as Text-fig. 5D.)

Text-fig. 5F. Right, left, and double valves of Anadara staminea. (Location as Text-fig. 5D.)

Text-Figure 5



Text-Figure 6

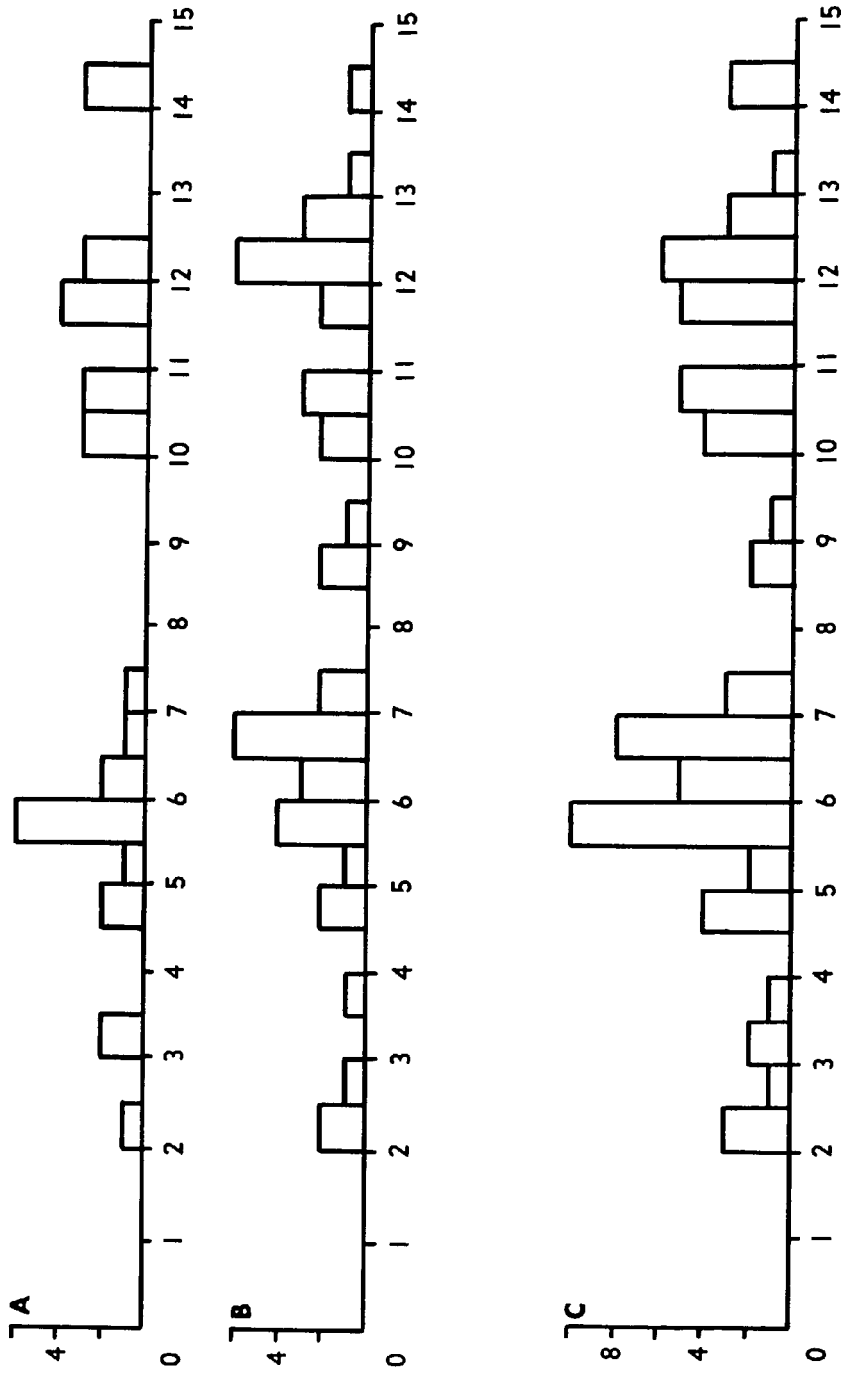
Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 6A. Right valves of Lyropecten madisonius. Lower increased macrofossil bed. Boston Cliffs Member. Locality 67-48.

Text-fig. 6B. Left valves of Lyropecten madisonius. (Location as above.)

Text-fig. 6C. Right, left, and double valves of Lyropecten madisonius. (Location as above.)

Text-Figure 6



Text-Figure 7

Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 7A. Right, left, and double valves of Macrocallista marylandica. Lower increased macrofossil bed. Boston Cliffs Member. From unit of sample 66-5-25.

Text-fig. 7B. Right valves of Macrocallista marylandica. Lower increased macrofossil bed. Boston Cliffs Member. Locality 66-12.

Text-fig. 7C. Left valves of Macrocallista marylandica. (Location as Text-fig. 7B.)

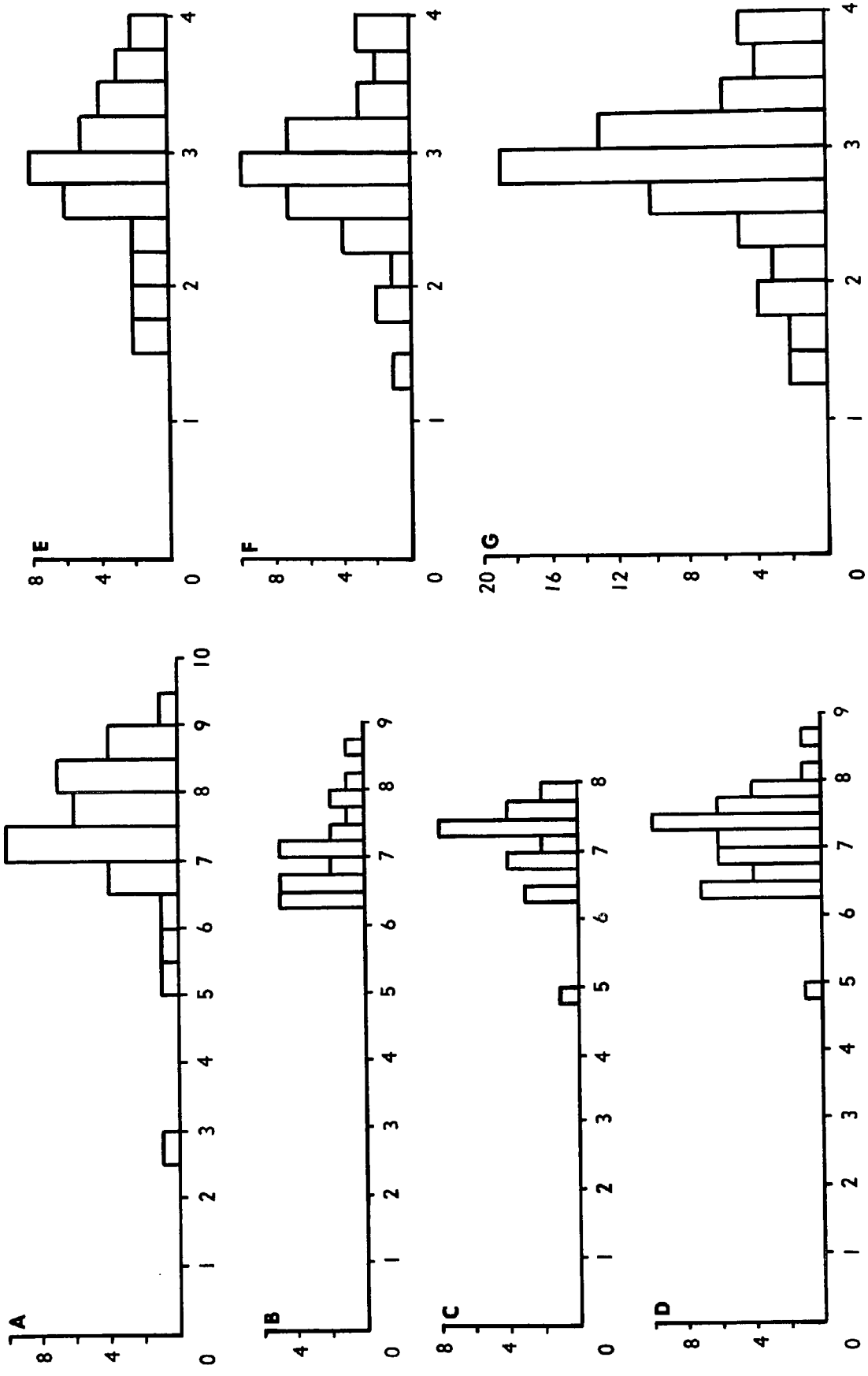
Text-fig. 7D. Right, left, and double valves of Macrocallista marylandica. (Location as Text-fig. 7B.)

Text-fig. 7E. Left valves of Anadara staminea. Anadara bed from lower increased macrofossil bed. Boston Cliffs Member. Locality 67-48.

Text-fig. 7F. Right valves of Anadara staminea. (Location as Text-fig. 7E.)

Text-fig. 7G. Right, left, and double valves of Anadara staminea. (Location as Text-fig. 7E.)

Text-Figure 7



Text-Figure 8

Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 8A. Right valves of Anadara staminea. Lower increased macrofossil bed. Boston Cliffs Member. Locality 66-12.

Text-fig. 8B. Left valves of Anadara staminea. (Location as above.)

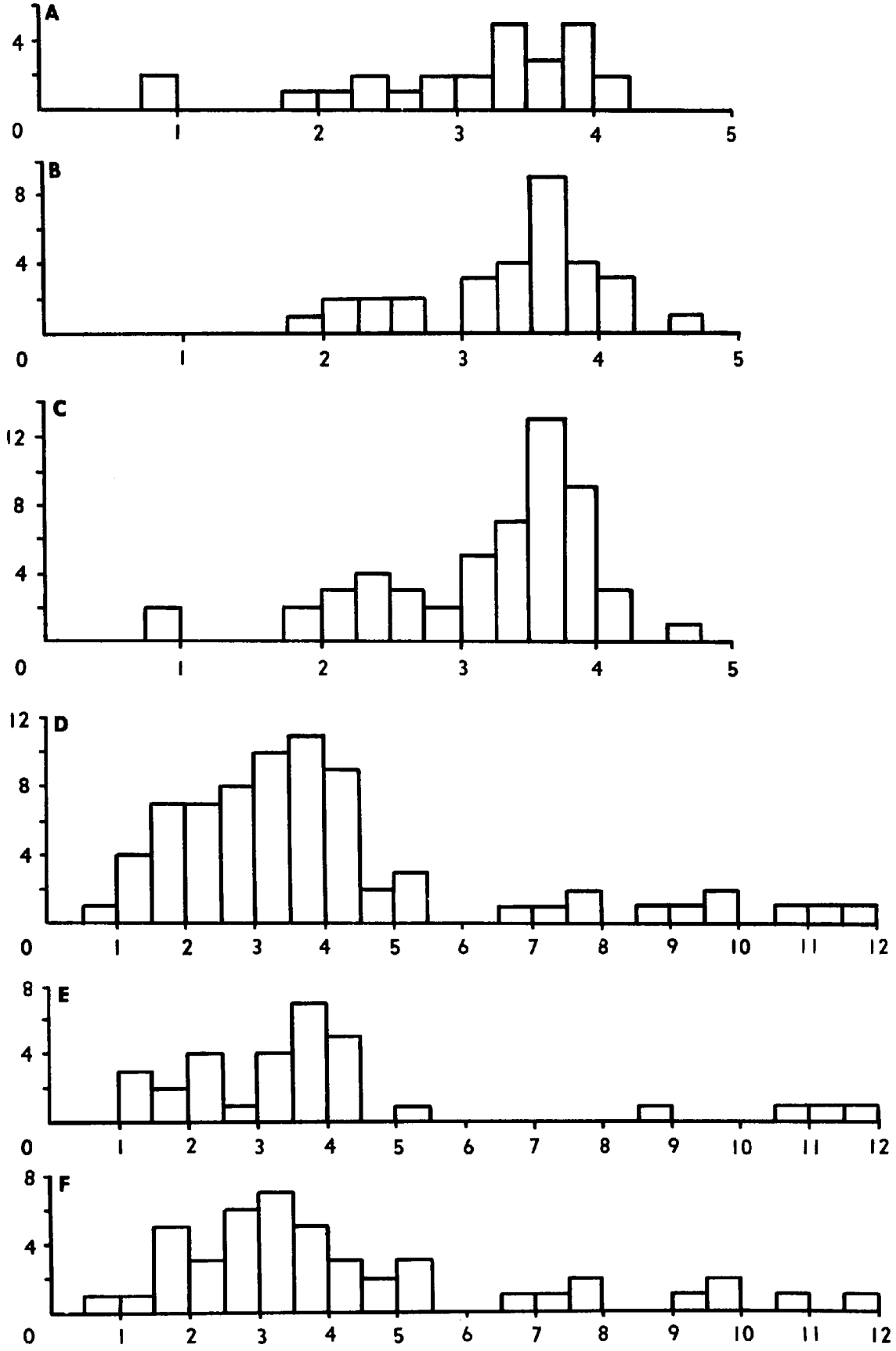
Text-fig. 8C. Right, left, and double valves of Anadara staminea. (Location as above.)

Text-fig. 8D. Right, left, and double valves of Lyropecten madisonius. (Location as above.)

Text-fig. 8E. Right valves of Lyropecten madisonius. (Location as above.)

Text-fig. 8F. Left valves of Lyropecten madisonius. (Location as above.)

Text-Figure 8



Text-Figure 9

Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 9A. Right, left, and double valves of Anadara staminea. Lower Drumcliff Member. Locality 66-5.

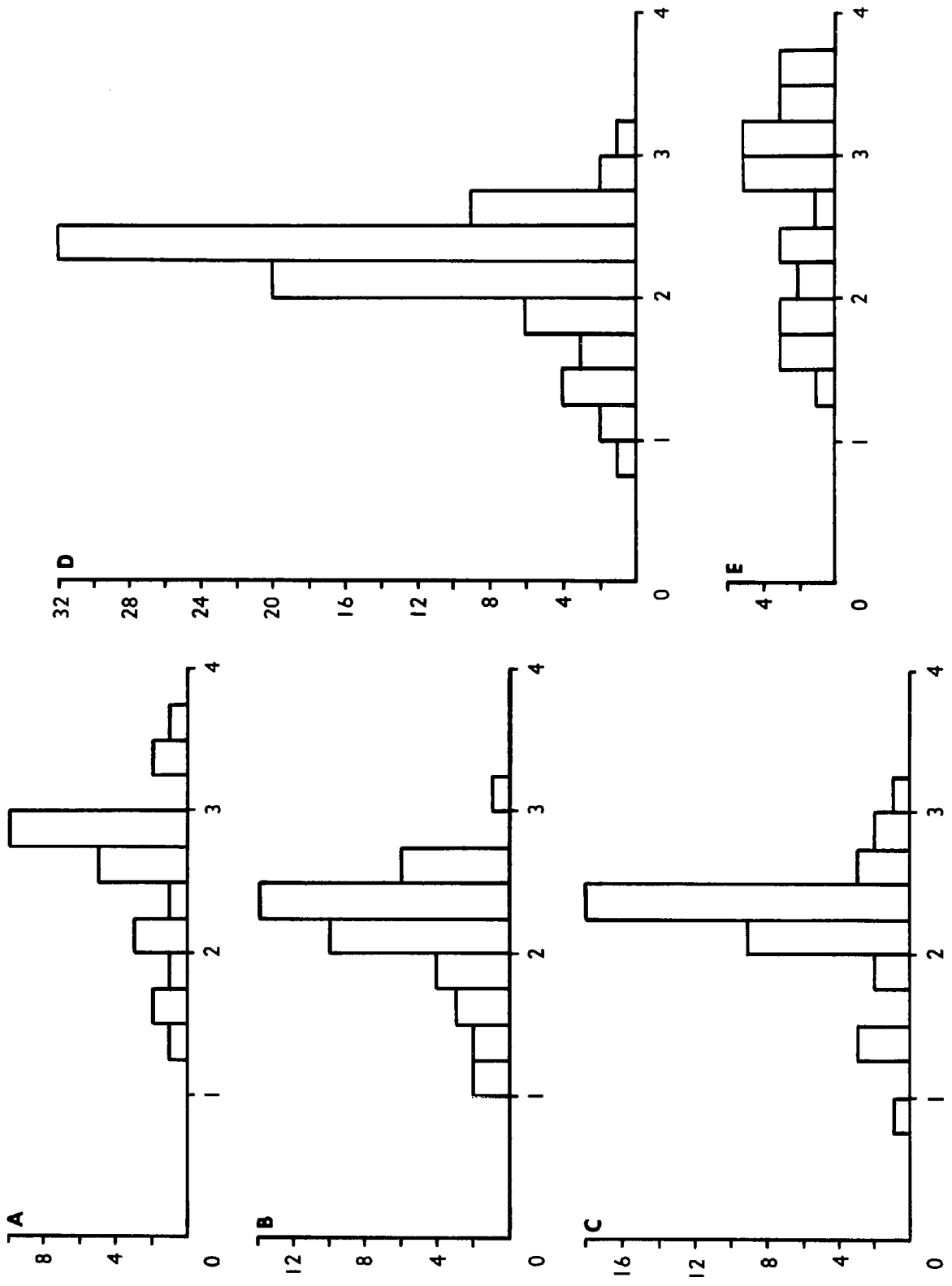
Text-fig. 9B. Left valves of Anadara staminea. Anadara bed of upper Drumcliff Member. Locality 66-6.

Text-fig. 9C. Right valves of Anadara staminea. (Location as Text-fig. 9B.)

Text-fig. 9D. Right, left, and double valves of Anadara staminea. (Location as Text-fig. 9B.)

Text-fig. 9E. Right, left, and double valves of Anadara staminea. 1 foot 6 inches to 6 feet below Drumcliff-St. Leonard contact. Locality 66-6.

Text-Figure 9



Text-Figure 10

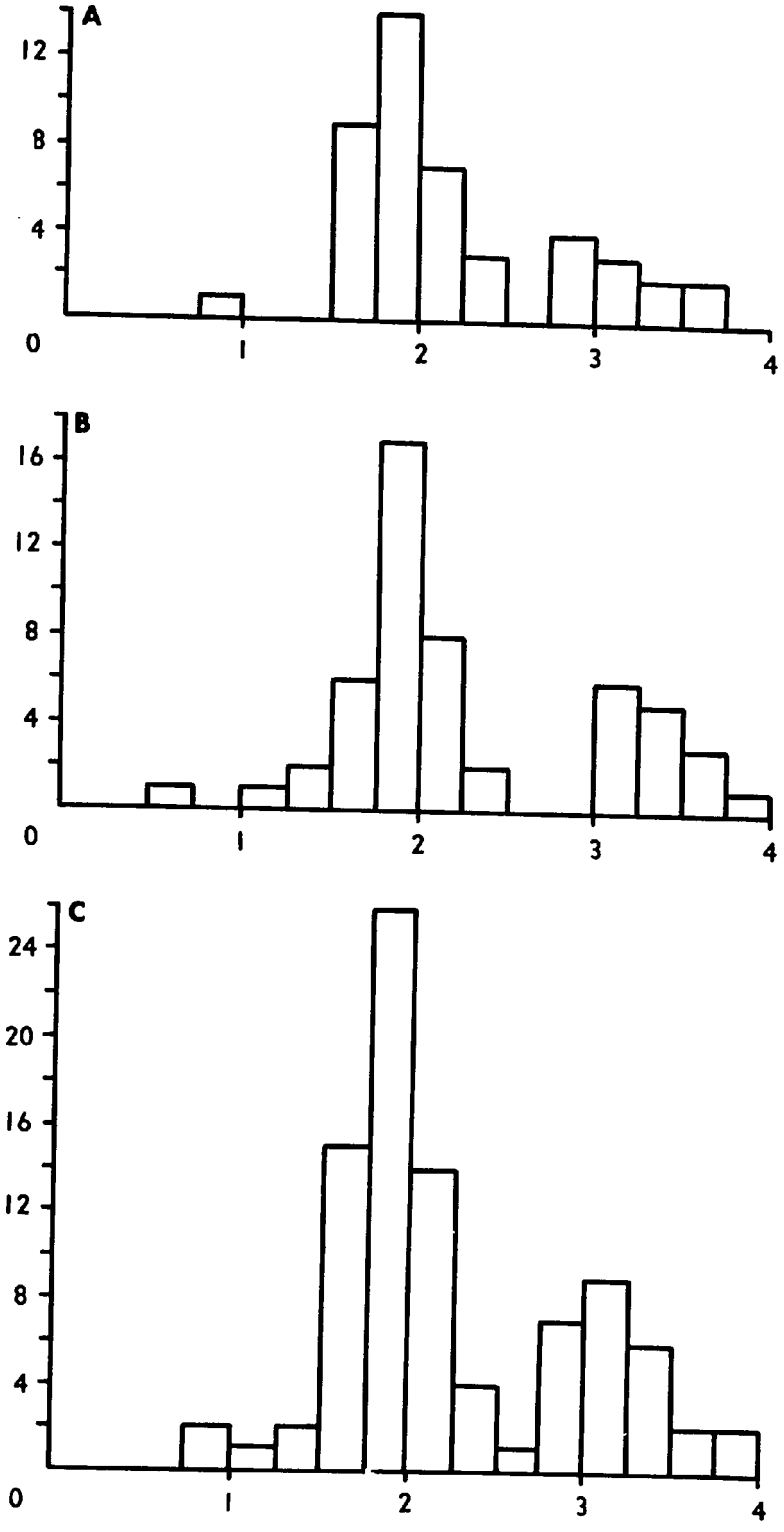
Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 10A. Right valves of Anadara staminea. Anadara bed of lower increased macrofossil bed. Boston Cliffs Member. Locality 67-51.

Text-fig. 10B. Left valves of Anadara staminea. (Location as above.)

Text-fig. 10C. Right, left, and double valves of Anadara staminea. (Location as above.)

Text-Figure 10



Text-Figure 11

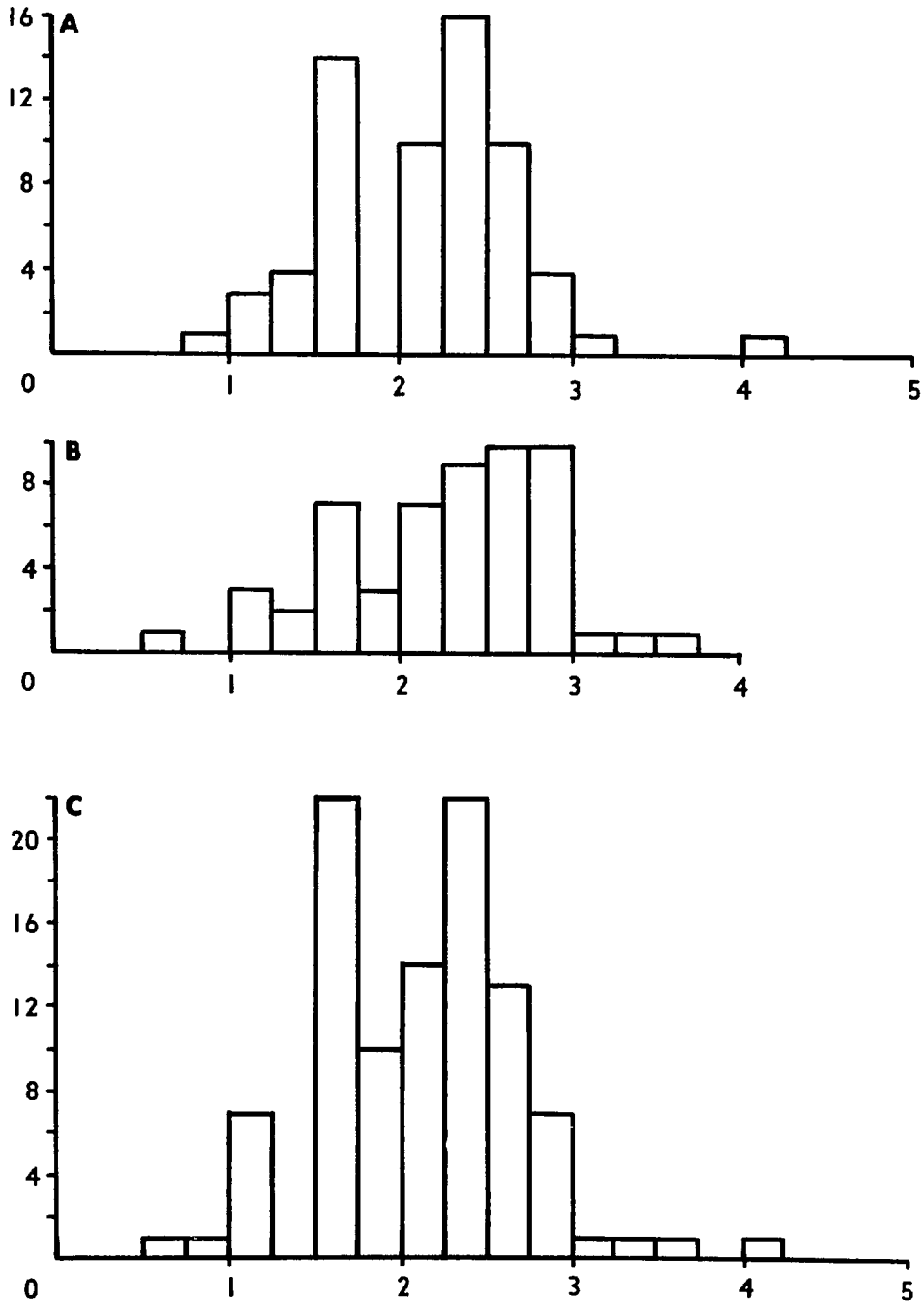
Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 11A. Left valves of Anadara staminea. Boston Cliffs Member. Specimens from sample unit 66-5-25.

Text-fig. 11B. Right valves of Anadara staminea. (Location as above.)

Text-fig. 11C. Right, left, and double valves of Anadara staminea. (Location as above.)

Text-Figure 11



Text-Figure 12

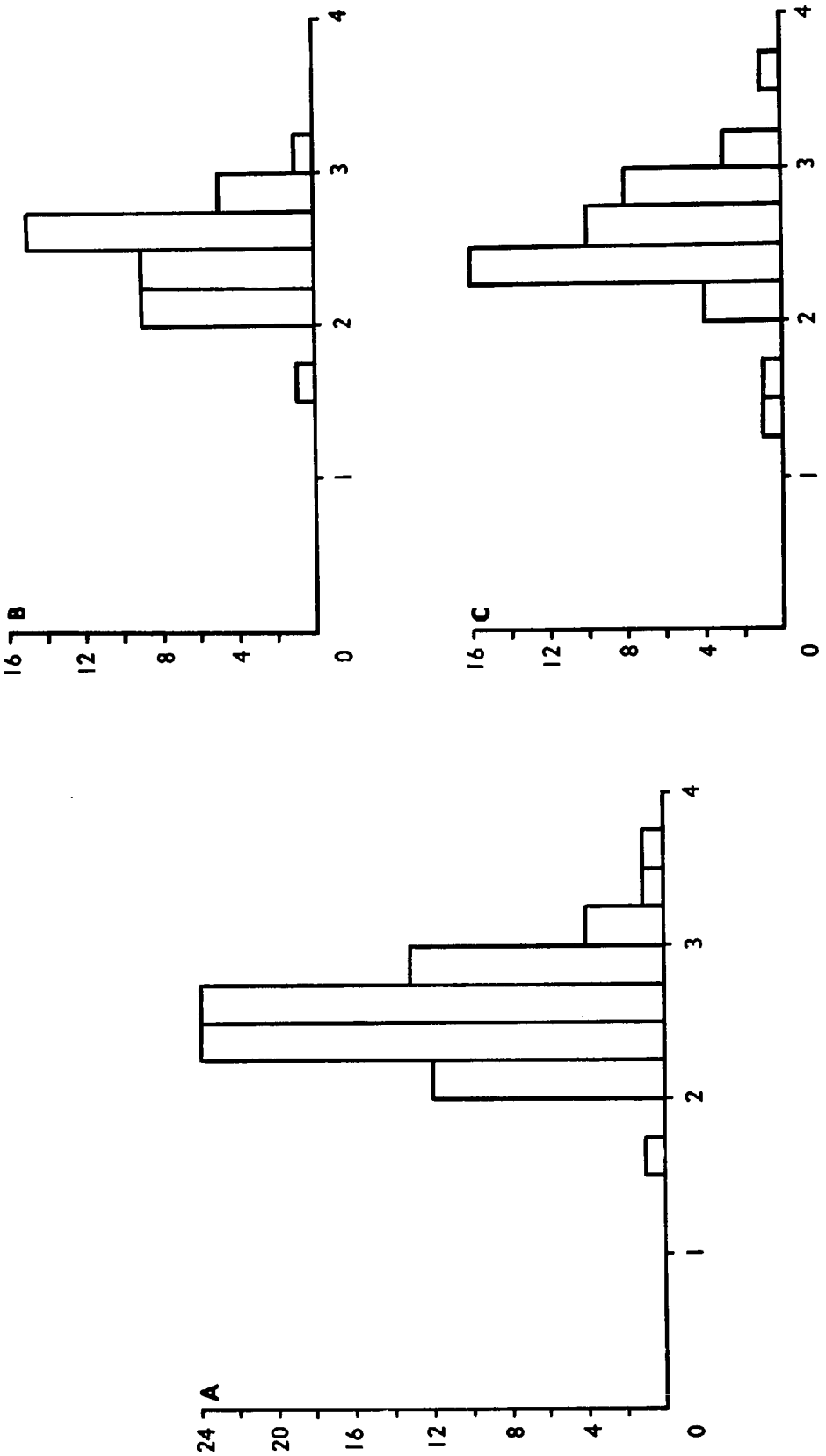
Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 12A. Right, left, and double valves of Anadara staminea. Lowest 1 foot of Boston Cliffs Member. Locality 66-5.

Text-fig. 12B. Right valves of Anadara staminea. (Location as above.)

Text-fig. 12C. Left valves of Anadara staminea. (Location as above.)

Text-Figure 12



Text-Figure 13

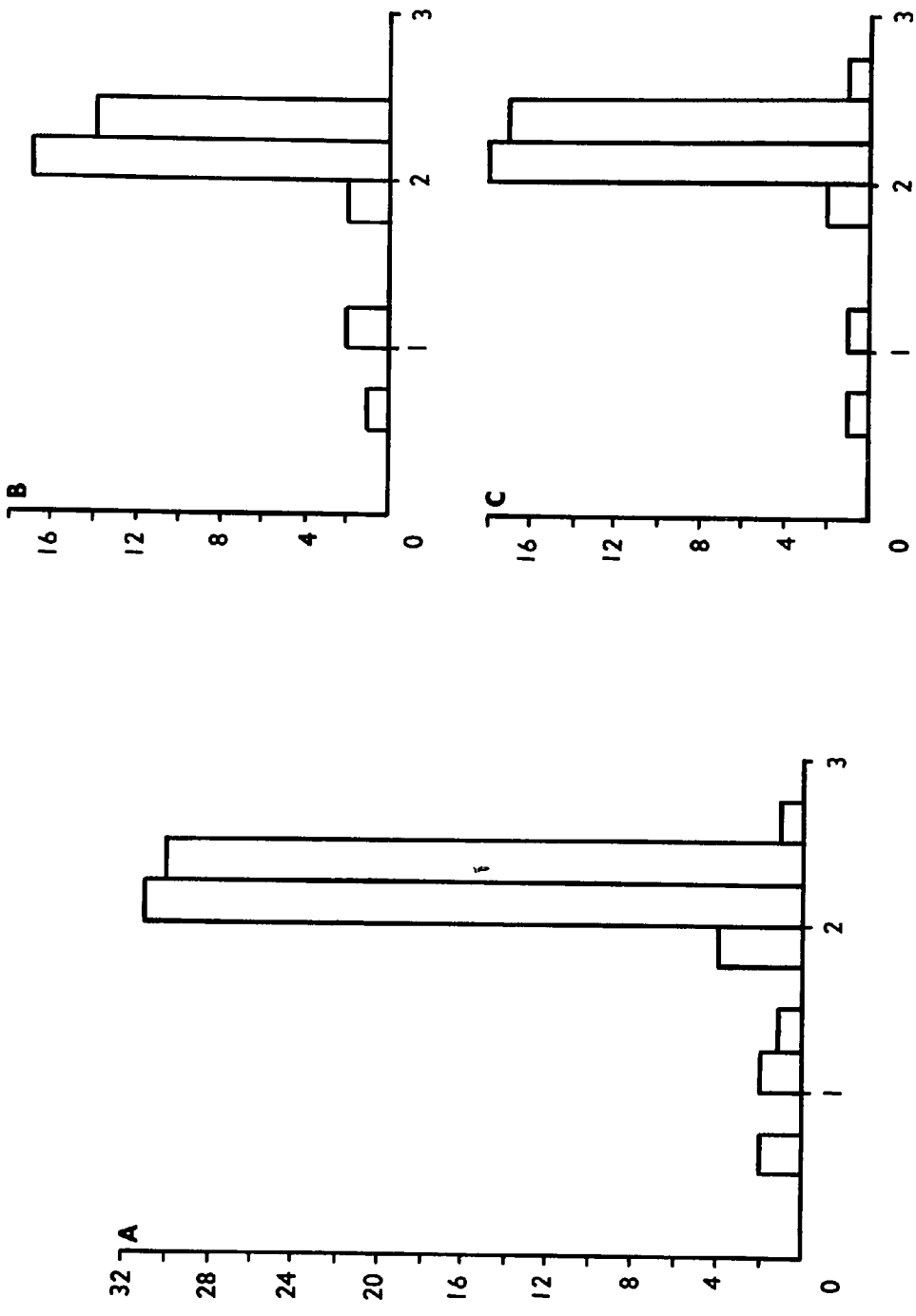
Size-frequency distributions. Size in centimeters along abscissa. Frequency along ordinate.

Text-fig. 13A. Right, left, and double valves of Astarte obruta. Lower increased macrofossil bed. Boston Cliffs Member. Locality 66-12.

Text-fig. 13B. Right valves of Astarte obruta. (Location as above.)

Text-fig. 13C. Left valves of Astarte obruta. (Location as above.)

Text-Figure 13



Text-Figure 14

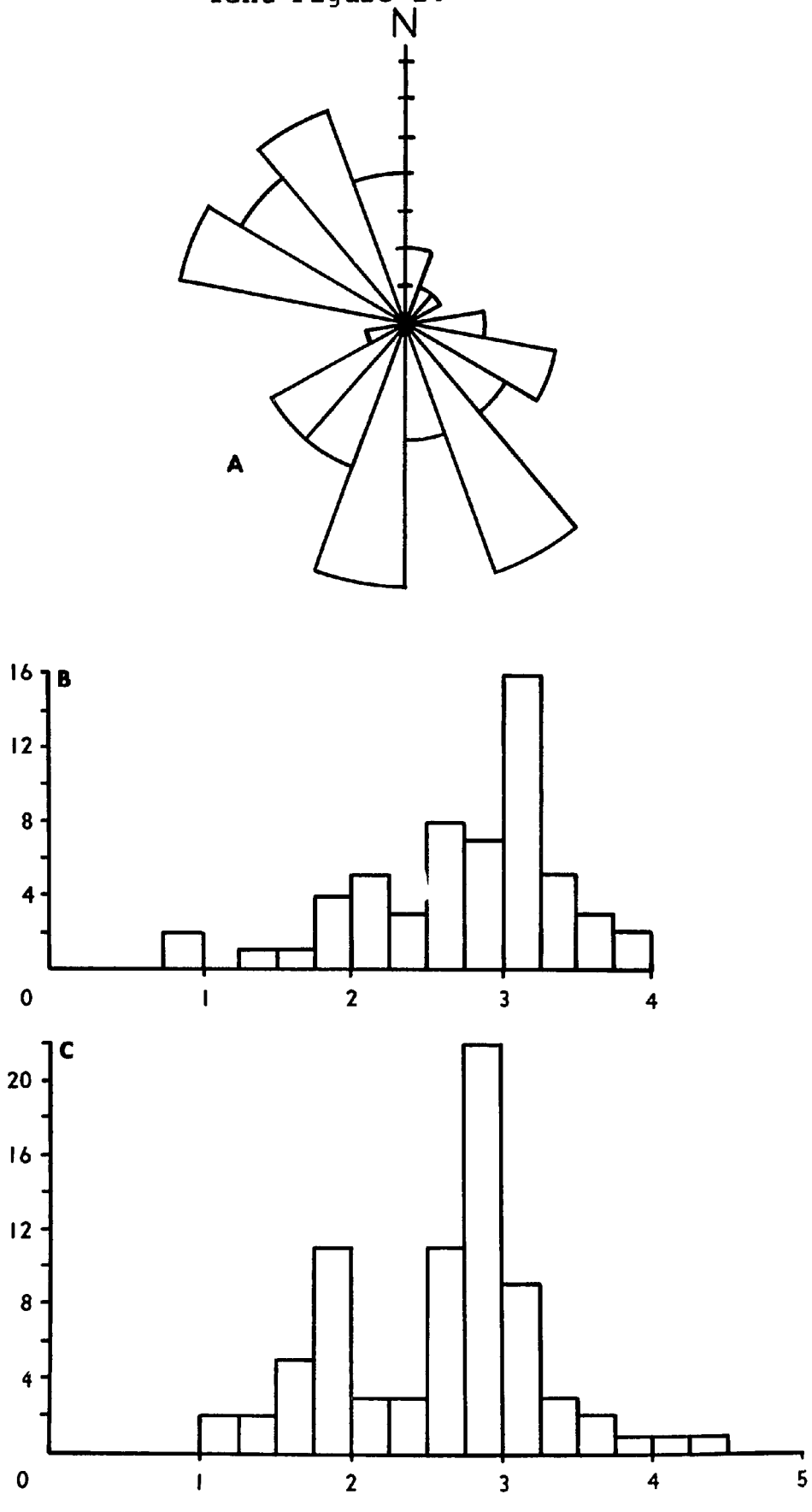
Size-frequency distribution and orientation data. Size in centimeters along abscissa. Frequency along ordinate. Orientation data grouped in 20° classes. Marks along North axis each correspond to one observation.

Text-fig. 14A. Orientation of Turritella plebeia. Glossus-Turritella bed of upper Drumcliff Member. Locality 66-6.

Text-fig. 14B. Right valves of Anadara staminea. Anadara bed of lower increased macrofossil bed. Boston Cliffs Member. Locality 66-9.

Text-fig. 14C. Left valves of Anadara staminea. (Location as Text-fig. 14B.)

Text-Figure 14



primarily clumped around 6 to 8 centimeters. Yet they have very rare occurrences of smaller individuals. This type of distribution would be interpreted as a "residual fossil community" according to the assessment procedures of Fagerstrom (1964). However, since the deposit from which these distributions came have innumerable small shells of other species, this does not seem to be a reasonable interpretation. It would seem more reasonable to suggest that these species had a rapid growth while young followed by a sudden reduction of the rate in the large animals. Possibly added to this was an increasing mortality rate.

Growth rings assist the study of Glossus fraternus marylandicus (text-fig. 2A-C, 3C-F, 4D-F, 5A-C). The size-frequency distributions are slightly left-skewed and several subtle peaks can be seen (see particularly text-fig. 3F). These peaks correspond to the growth rings, except for the peak near 1.0 centimeters which must be qualified. For most valves the first ring corresponds to the mode, around 2.5 centimeters. Only a few valves have a ring near 1.0 centimeters. Assuming that the growth rings represent cessation of growth in the winter and are therefore annular, and that there are two waves of recruitment each year (as known in the living animals in temperate and colder regions), the hypothesis put forward here is that G. f. marylandicus had a large spring recruitment followed by a small fall recruitment. Initial growth was great but rapidly declined.

The size-frequency distributions for the scallops

(text-figs. 3A, 3B, 6A-C, 8D-F) are quite interesting. The multi-peaked nature points out the fact that recruitment came in distinctly separated waves. The closer spacing of peaks at the right suggests a slight slowing of growth. One of the unique qualities of this distribution seems to be the very high initial mortality followed by a very low mortality. The distributions seem to suggest that the critical interval was up to 6 centimeters and that if a scallop could live to that size it could live to a very old age. Deevey (1947) suggested similar mortality to oysters and barnacles. Is it just a coincidence that these three organisms are all epifaunal, filter-feeding invertebrates or is this the characteristic mortality for all in this category? Slobodkin said (1961, p. 36), "Most of the animals that have a distinctive larval stage followed by metamorphosis into an adult condition have extremely high mortality in the young stages or in the transition from one mode of life to another." This may give some insight into the high initial mortality but still leaves unanswered the decreasing mortality and extremely large size of older individuals of Lyropecten madisonius.

Anadara staminea shows distributions that vary from being left-skewed to normal to right-skewed (text-figs. 4A-C, 5D-F, 7E-G, 8A-C, 9A-E, 10A-C, 11A, 11B, 12A-C, 14B, 14C). There is a possibility that this species is more phenotypically controlled than some of the other species. For example, the distribution is strongly right-skewed at

Boston Cliffs (text-figs. 8A-C), where the Boston Cliffs Member represents a shallower water environment than at any of the other localities sampled for the member. Bivalves are often bigger and more robust in shallow water, thus tending to make right-skewed, size-frequency distributions. Again, the polymodal distribution likely is indicative of distinctly separated waves of recruitment. These may be preserved as a result of the special mechanism of shell concentration, described later in this paper.

Size-frequency distributions for Astarte obruta (text-figs. 13A-C) and Crassatella marylandica (text-figs. 1B-D) from Boston Cliffs are essentially the same but with larger adults of Crassatella. Both distributions are strongly right-skewed and have almost no individuals larger than the adult mode. This pattern is very similar to the Anadara staminea population (text-figs. 8A-C) at this same locality. It appears that infant mortality was very low yet adult mortality was very high. This type of distribution, as suggested above, may be phenotypically controlled as a result of this very shallow environment. There is the possibility that this configuration is a result of selective sorting particularly relating to the origin of the shell beds. A mechanism is suggested later in this paper for the genesis of these deposits which may in fact remove some of the smaller shells. Yet, inasmuch as the deposit contains many small molluscs, ostracodes, and foraminifers it seems somewhat risky to ascribe to an hypothesis of

selective sorting.

Orientation Data

The direction of the apical end of Turritella plebeia was measured at five localities of the Drumcliff Member, and the data are presented in the form of rose diagrams (text-figs. 14A, 15A-D). Potter and Pettijohn (1963) have summarized interpretations of directional data.

Visual inspections of the snails in the outcrops gives the impression that they are randomly oriented. However, the plotted data reveals some opposed modes. For instance, in text-figure 15D there is a west mode opposed by an east mode and a north-northwest mode opposed by a southeast mode. Experimental studies, such as that of Kelling and Williams (1967), indicates that the current direction is parallel to the bisector of the angle made by the opposed modes or perpendicular to the modes if they are directly opposed.

None of the Turritella distributions show unequivocally a single current direction. However, there does seem to be a general trend in the Calvert Cliffs data (text-figs. 14A, 15A, 15D) indicating a northeast-southwest current. Because this direction parallels the depositional strike, the current may have been longshore current. There also seems to be some indication of a north-south current. In the Breton Bay data there appears to be evidence for northeasterly, easterly, and southeasterly flowing currents.

Text-Figure 15

Orientation data. Grouped in 20° classes. Marks along North axis each correspond to one observation. All specimens measured are Turritella plebeia.

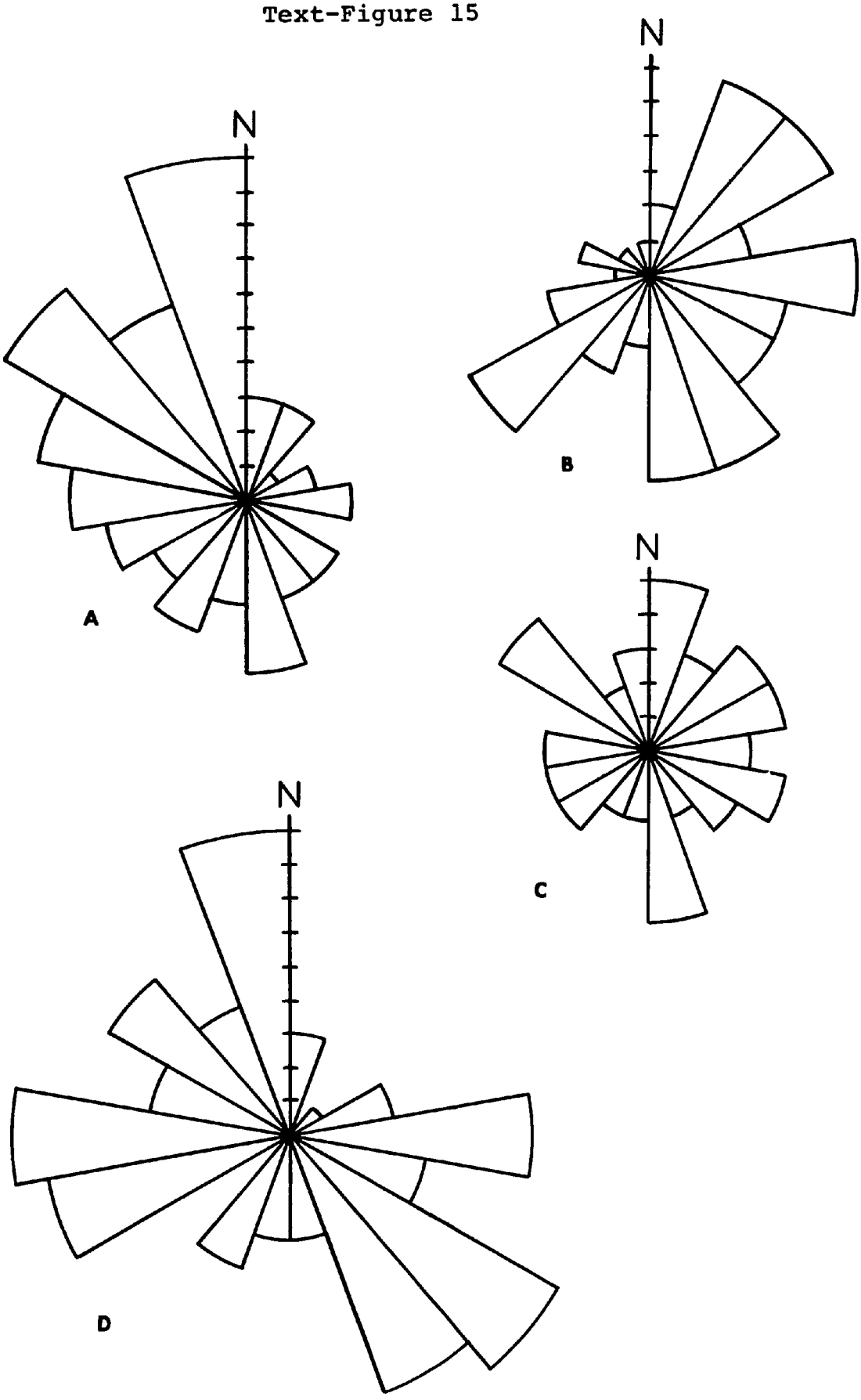
Text-fig. 15A. 3 feet 6 inches below Drumcliff-St. Leonard contact. Locality 66-5.

Text-fig. 15B. Drumcliff Member. Locality 66-34.

Text-fig. 15C. Drumcliff Member. Locality 66-36.

Text-fig. 15D. Drumcliff Member. Specimens from sample unit 66-4-1.

Text-Figure 15



Text-Figure 16

Turritella plebeia inclination data. Grouped in 10° classes. Marks along 0° axis each correspond to three observations.

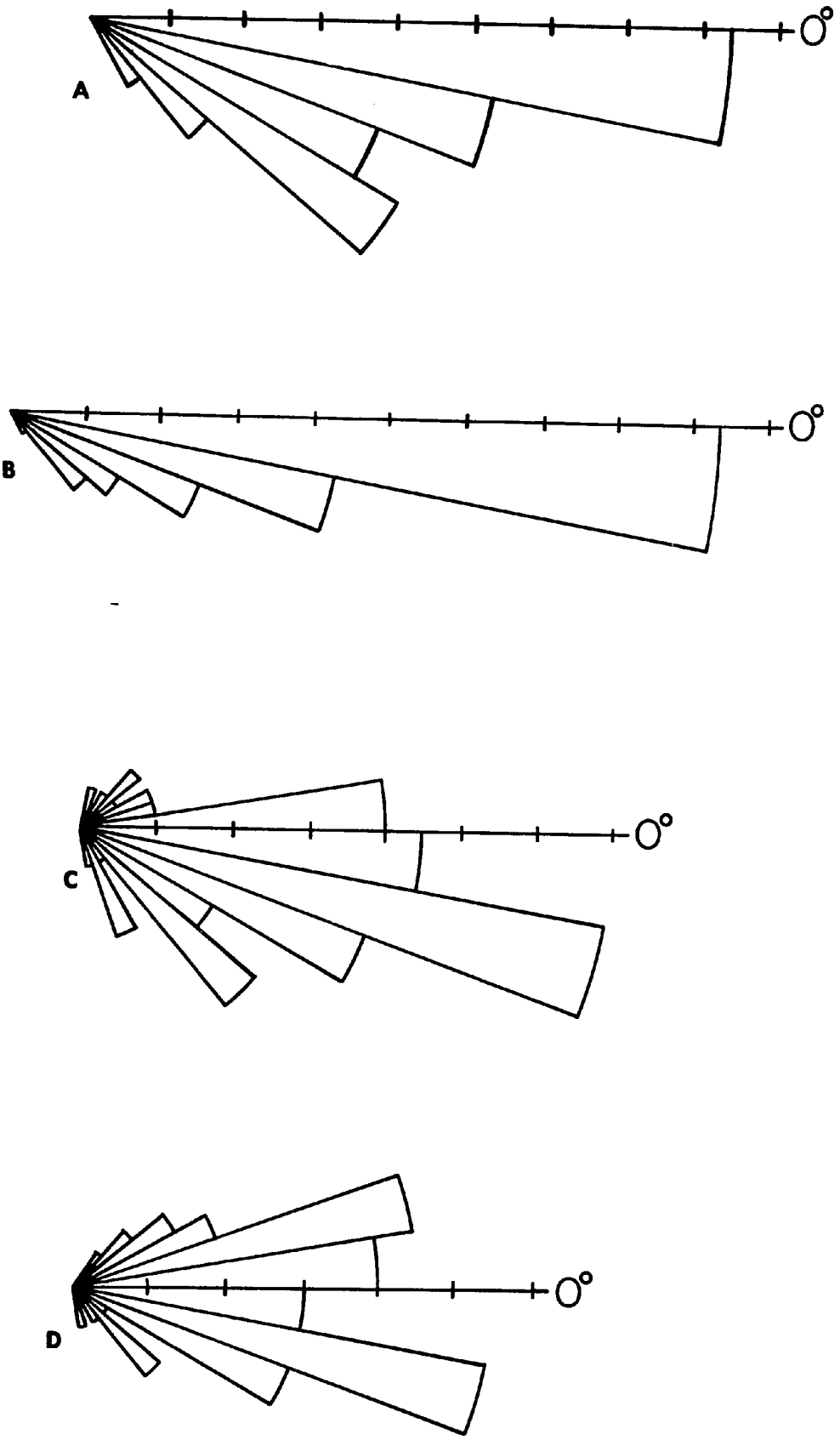
Text-fig. 16A. Inclination of shells from horizontal position. 3 feet 6 inches below Drumcliff-St. Leonard contact. Locality 66-5.

Text-fig. 16B. Inclination of shells from horizontal. Glossus-Turritella bed of upper Drumcliff Member. Locality 66-6.

Text-fig. 16C. Inclincation of apical tip of shells from horizontal. Drumcliff Member. Locality 66-34.

Text-fig. 16D. Inclination of apical tip of shells from horizontal. Drumcliff Member. Locality 66-36.

Text-Figure 16



One significant problem deserves mention. Measuring a random population from unconsolidated sediments is difficult. Study of fossils in lithified sediments is aided by the use of bedding-plane surfaces, but in unconsolidated sediments specimens are found on vertical surfaces. Even if an investigator concentrates on taking a random sample it is still easier to see a specimen parallel with the outcrop face than one perpendicular to it. It may be simple coincidence or it may be simple bias, but every direction graph in this paper shows prominent modes parallel with the face of the respective outcrops. Techniques for random sampling of directional properties will have to be developed to ensure credibility of data from unconsolidated sediments.

Accompanying the rose diagrams are four graphs (text-figs. 16A-D) of the inclination of specimens of Turritella. Text-figures 16C and 16D also show whether the apical tip was up or down. These serve to show the strong tendency for flat-lying specimens.

Interrelationships of Choptank Organisms

Interrelationships were undoubtedly as complex among organisms of the Choptank as among organisms living today. Ecologists are increasingly aware of symbiosis, commensalism, parasitism, and competition among the living biota. They have an enviable advantage over the paleoecologist in identifying and understanding these relationships. Yet, most of the conclusions about living animals have come from

laboratory investigations. Of course, the student of fossilized remains cannot observe this type of laboratory phenomena in ancient life.

The prime prerequisites for identifying interrelationships of the past are either to find the fossils together consistently in some arrangement or to see preservable marks left on a fossil by its comrade or enemy. This latter type of evidence is most easily recognized and probably holds the best hope for future analysis. The fine, pioneering work on general shell markings was presented by Boekschoten (1966, 1967).

More intensive study specifically on boreholes of naticid and muricid snails was undertaken by Carriker and Yochelson (1968). Carter (1968) also discussed predation of bivalves as related to paleoecology.

Foraminifera

Of the Foraminifera, only Cibicides lobatulus was seen in obvious association with other organisms. The shape of the dorsal side of this species strongly suggests that most individuals lived attached to objects. In fact, specimens were found attached to the external surface of bivalves, particularly epifaunal bivalves. The highest degree of association found was with scallops. If C. lobatulus was attached to the living scallop, it may have derived a feeding advantage from life on a free-swimming invertebrate. Of course, the foraminifer may

have used the shell as a place of attachment after the death of the host. At any rate, attachment during or after the life of the bivalves could scarcely be considered deleterious to the host but also of no advantage. This must be considered then as an example of commensalism.

Porifera

The sponge Cliona left its distinctive small borings in Choptank bivalves, but showed preference for specific hosts. All sponge borings are found on epifaunal molluscs. The most strongly attacked were the shells of the oyster, Crassostrea carolinensis. Many of the oysters, particularly those in the Boston Cliffs Member along the Choptank and Patuxent Rivers, are heavily riddled. Some limpet, scallop, and Isognomon shells have also been converted into sievelike objects.

It is particularly interesting that the Choptank shells of infaunal molluscs do not show sponge borings. As Boekschotten (1966) pointed out any calcareous shell being on the sea floor of the continental shelf is undoubtedly destined for sponge boring. This has special significance for the Choptank Formation, which in the two major shell beds contains millions of flat-lying, calcareous, infaunal, bivalves that have not been riddled by sponges. Seemingly, these valves could not possibly have accumulated "normally" on the sea floor.

Additional ecological information on Cliona supplied by Boekschoten (1966) is that the sponges avoid the heavy

water movement and sedimentation of beach and near-beach environments. He wrote (1966, p. 349), "Cliona is a marine sponge; only one occurrence in slightly brackish water is recorded from the coast of North Carolina. . . . Because calcareous substrata are less frequent in deeper water, the sponge is somewhat rarer below 200 m. It occurs at least down to 927 m."

Annelida

Marine annelids bore characteristic small tubes in shells. The best-known boring polychaete is Polydora, which excavates short, U-shaped, irregular tubes in shells. About the genus, Boekschoten said (1967, p. 353) that it "is restricted to shallow waters; a record from 52 m. depth near Helizoland is already very deep." Additionally he said, "Polydora is more prevalent below low water mark, on soft and muddy bottoms and in areas of low salinity."

Another interesting observation Boekschoten made (1966, p. 358) is that "there also is a difference in length of the tunnels, dependent on the substratum." Apparently, the tubes on living infaunal bivalves are about one-half as long as those on shells free on the sea floor. On Choptank infaunal bivalves the tubes ranged in length from about 0.1 to 0.2 centimeter while tubes on epifaunal scallops were as long as 1.0 centimeter.

In a discussion of the manner in which Polydora encounters its host Boekschoten (1966, p. 354) said,

> Cardium lives directly below the sediment, with the posterior part of the shell (from which the siphons issue) turned upward. When Polydora starts burrowing in the sediment this side of the shell is always encountered first. Thus all Cardium shells with bored posterior were attached in living position. . . . Only dead, loose, allochthonous specimens are bored all over the shell.

Of course, this is what we would intuitively expect, but with this insight it is difficult to understand the history of some shells collected from the Drumcliff Member at its type locality and some from the Boston Cliffs Member at its type locality. Some shells of Mercenaria campechiensis cuneata, M. mercenaria, M. plena, and Macrocallista marylandica, all infaunal bivalves, have concentrations of Polydora tubes centralized on the extreme anterior end.

Bryozoa

Animal interrelationships involving Choptank bryozoans exist in two categories. The first, and more commonplace are encrustations on bivalve, snail, and barnacle shells. Most examples of this type are found on the exterior surface of epifaunal shells, e.g., scallops, barnacles, and oysters. In general, encrustations on internal surfaces are rare, but this is the mode of occurrence on nearly all infaunal bivalves. Usually these shells are also more worn. In light of the fact that on modern, shallow ocean floors nearly everything from loose shells to beer bottles are encrusted by brozoans, it seems valid to conclude that very few infaunal molluscs were lying loose on the Choptank sea floor.

The second major category of bryozoan association is in the form of small bore holes. Boekschoten said (1966, p. 366), "The traces left by Electra monostachys in a shell consist of shallow oral depressions which are arranged in rows. The latter generally show a dendritic pattern." Electra is exclusively marine and sometimes brackish. Subtly defined pits characteristic of this genus were seen on only one Choptank shell.

Mollusca

The most common markings on Choptank shells are snail boreholes, predominantly the work of naticids. The second most common snail in the Choptank, Lunatia heros, is an efficient borer. This snail plows about just beneath the surface of the sea floor in search of prey. It wraps its large massive foot around the victim and begins a two-phased drilling program as described by Carriker and Yochelson (1968, p. 135).

In the chemical phase an accessory boring organ secretes an acid substance which acts on the shell at the site of penetration. In the mechanical phase the radula rasps off the weakened shell as minute flakes which are swallowed. Only the radula moves freely about the borehole. The description of the naticid borehole as a "truncated spherical paraboloid" fits the Choptank boreholes well. Of course, the goal of the snail is to consume the flesh of the host. This is the best example of predation

in the Choptank.

This basic understanding of the predation process raises two interesting problems. The first of these involves boreholes of the geometry described by Carriker and Yochelson (1968) in valves of Choptank ostracodes. It is difficult to comprehend why snails would prey on such small victims. Even for very small snails it would intuitively seem that the nourishment derived would not sufficiently replenish the energy expended.

The second problem is trying to explain why large numbers of scallops are bored by snails. The naticids plow around under the sea floor, while scallops enjoy a free-swimming existence. The question is, where does the predator meet the prey? When a dead scallop sinks to the bottom, the adductor muscle relaxes, and the valves open. Since the snails are known to search for the best location for drilling, it would be obvious that there would be no need to spend a week drilling an unnecessary hole. A second possibility is a scallop resting on the bottom found by the snail. However, the swimming ability is considered to have developed for the express purpose of excape from predation by invertebrates. With one quick "flap" of the valves the scallop should be able to escape the snail. I suggest that the scallops were buried alive by the passing of marine swell and became easy prey for the rapacious naticids. This proposed mechanism is discussed in much greater detail in the section on the origin

of the shell beds.

In addition to the naticids there are some rare muricids in the Choptank. There are also boring snails and discussed by Carriker and Yochelson (1968). Their characteristic boreholes were not seen in any of the Choptank material, however.

Associations involving Choptank bivalves are in two categories. The first is more of an inferred association. Erycinacean bivalves, of which Aligena aequata is a member, are commensalistic with various hosts. Living species of the genus mentioned are known to live with marine annelids in their burrow. As Boss explained (1965, p. 190), "The relative immobility of the hosts facilitates simple attachment or association by the commensal and the currents created by the processes of filter feeding generate a favorable environment for the small mollusks, which are themselves filter feeders." Apparently there is no evidence of deleterious effect on the host caused by the relationships.

The second type of bivalve association involves the boring of the small bivalve Martesia ovalis into the large, thick valves of Isognomon maxillata, an epifaunal bivalve. The relationship appears to be commensalistic with the shell of the host serving as a home for Martesia. Isognomon initially has thick shells, but also has the ability of the "pearl-making" bivalves to secrete coats of nacre on sources of irritation. In spite of extensive

boring in some valves it appears that Isognomon was able to maintain the interior as his exclusive domain. The host specificity shown by Martesia was very strong, although its borings were found in four other valves. One oyster, two Anadara, and one, well-worn Mercenaria were found with Martesia borings, but no well-preserved infaunal organisms were attached.

The ubiquitous barnacle, Balanus concavus, lived attached to exposed objects, e.g., loose shells and epifauna. In light of the knowledge that modern barnacles attach to nearly all hard objects in the sea, their very rare presence on infaunal, shelled animals suggests these potential attachment sites were never exposed above the sediment-water interface. The occurrence of gigantic as well as smaller specimens of Balanus are common on scallops. The barnacles show a definite preference for alignment parallel to the outer margin and very near to it, and somewhat surprisingly are nearly always on the lower valve. Considering the fact that large, ocean vessels and pleasure yachts are periodically forced into "dry dock" for removal of barnacles, it seems that Balanus must have upset the hydrodynamic qualities of the Choptank scallops to a considerable degree. It is difficult to imagine the association of Balanus with Lyropecten not being somewhat harmful to the host. Choptank oysters are also found with barnacles attached, but these are usually small.

PALEOSYNECOLOGY

This section deals with the ecology of fossil assemblages and their paleoenvironmental significance. For convenience the discussions of paleosynecology are grouped according to member.

Calvert Beach Member.--According to Gibson (1962, p. 63) the lowest Choptank represents warmer and shallower water environments than the upper Calvert Formation. Although I have not investigated the Calvert Formation, my data from the lowest Calvert Beach Member of the Choptank at the type locality (sample 67-65-2) suggests cooler and deeper water than Gibson postulated for beds at Governor Run. His fauna contained the first Maryland Miocene occurrence of three warm water species, Textularia gramen, Angulogerina occidentalis, and Elphidium advenum. My fauna contained none of these but contained two other warm species, Discorbis floridana and Pseudopolymorphina striata. However, Gibson also reported the latter species from the Calvert, so that in the present study only one additional warm foraminifer is known to occur at the base of the Choptank.

With regard to the depth change between formations, Gibson reported that five new shallow-water species made their appearance. Only one of these occurred in sample 67-65-2, and that was present in less than one percent of the foraminiferal assemblage. However, two of the five

most abundant species are considered to be most common in deeper water. Empirical evidence in this study has shown Textularia candeiana and Nonion pizarrense to be most numerous in assemblages with large percentages of the deeper-water ostracodes. Supportive evidence for deeper occurrences of Textularia candeiana is found off the present coast of New England, where Phleger (1952) found this species confined to a depth zone bounded by 90 and 300 meters.

The ostracode assemblage in 67-65-2 suggests the deepest, coldest environment in the lower four members of the Choptank. Three of the five most abundant ostracodes, including Henryhowella evax, Echinocythereis clarkana, and Cytheropteron sp., are all considered to indicate deep water. In fact, the second most numerous, H. evax, has a known, modern depth range of 155 to 677 meters.

Most of the ostracodes are found in cold water. Cushmanidea seminuda, Loxoconcha granulata, and Actinocythereis aff. A. gomillionensis are confined to cold temperate or colder water; and Cushmanidea ulrichi is primarily found in cold water. The only exclusively warm-water species found was Loxoconcha reticularis, making up less than one percent of the assemblage.

The snail Turritella plebeia is the dominant mollusc in the lower Calvert Beach Member. Specimens occur in clumps.

The basal sediments of the Calvert Beach Member at its type locality appear to have accumulated in about 45 to 60

meters of open ocean water. Biogeographically, the organisms indicate occurrence in the cold temperate province, possibly similar to the conditions existing today off the Atlantic Coast of southern Delmarva Peninsula.

Probably, Gibson's sample at Governor Run was taken from a group of sand lenses and stringers shown in plate 5. These local deposits represent much shallower conditions than sediments in sample 67-65-2. My sample 67-53-1 from Governor Run contains the first Chesapeake Group appearance of certain warm water species, that were previously listed by Gibson. His suggested introduction of Textularia gramen is strongly supported by sample 67-53-1 in which this species is the third most abundant foraminifer.

The warm-water ostracode Haplocytheridea bassleri also appears in the sand lenses at Governor Run. Of the five most abundant Ostracoda at both localities only Cushmanidea ulrichi is common to the two. The remaining four species at Governor Run are all very shallow water organisms, whereas the remaining four at Calvert Beach are much deeper. The sandy units at Governor Run were probably deposited in 15 to 25 meters of the open sea.

This same type of shallow-water sand lens occurs from Governor Run updip to Parker Creek, the northernmost Choptank appearance in the Calvert Cliffs. Sample 67-74-4 from the finer-grained Calvert Beach Member at Parker Creek is definitely from deeper water than the sand lenses.

Uvigerina subperegrina and Pterygocythereis americana, a deeper-water foraminifer and ostracode respectively, are important faunal elements.

The upper Calvert Beach Member at Pawpaw Hollow appears representative of shallower water conditions. In sample 66-35-1, Cibicides lobatulus strongly dominates the foraminiferal assemblage, certainly suggesting shallow, inner shelf conditions. The most abundant ostracodes are Cushmanidea ulrichi, Murrayina martini, Cushmanidea agricola, and Cytheretta burnsi with other very shallow ostracodes, such as, Aurila laevicula, Cytheromorpha warneri, Pokornyella punctistriata, and Semicytherura coryelli.

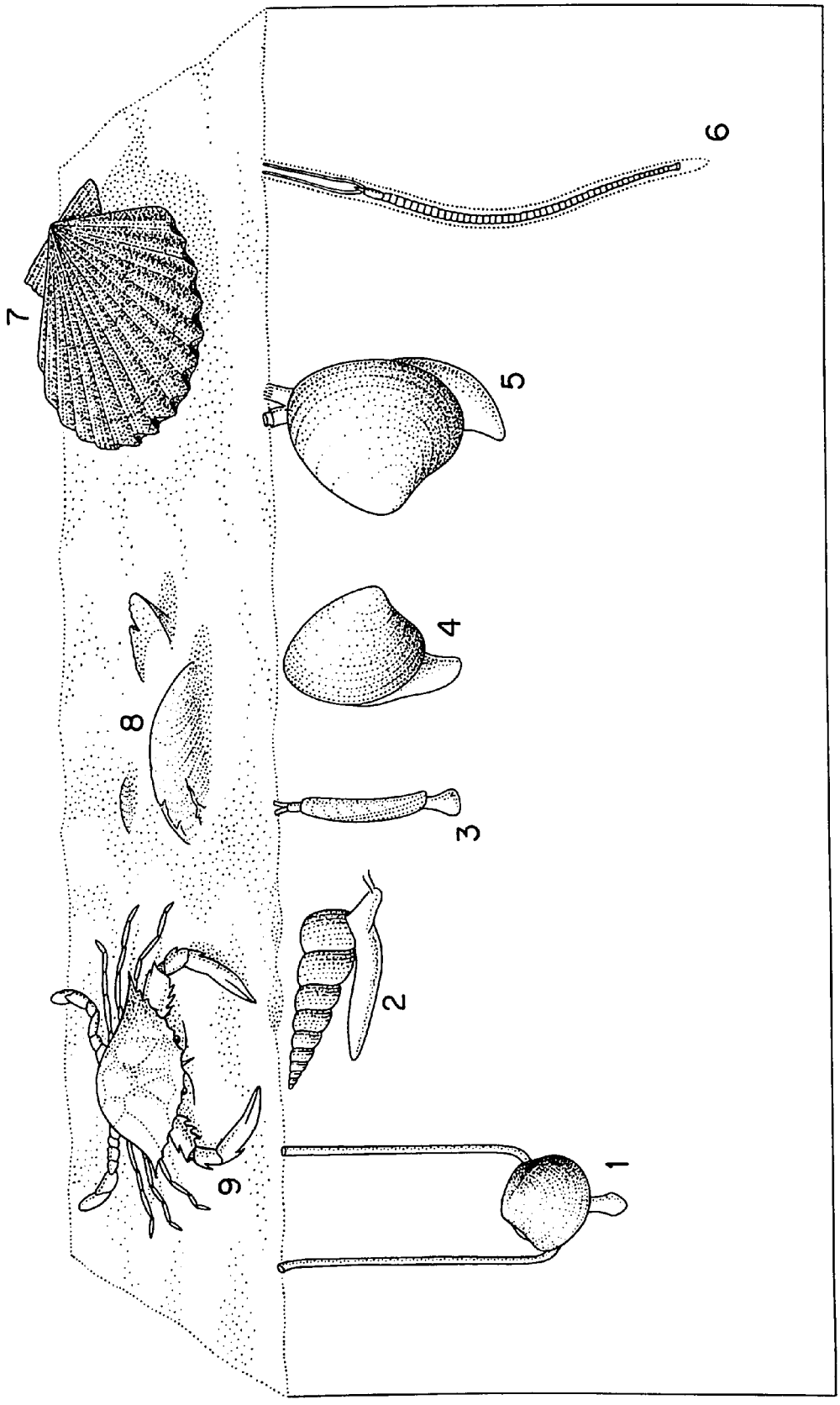
The microfauna indicates a shallowing and warming trend through the Calvert Beach Member. Probably these two factors are interrelated, as shallower waters even at the same latitude are warmer. Inasmuch as most of the microfauna indicates cold temperate seas but a few species suggest warmer water, the sediments of this member were probably deposited in conditions similar to that found today off the southern Delmarva Peninsular, where the mean annual surface-water temperature is approximately 15°C. (Ekman, 1953, p. 57).

Macrofauna is scarce in the Calvert Beach Member. However, there are a few, well-preserved life assemblages at Calvert Beach, Maryland (text-fig. 17, and pl. 7, 9). The organisms are predominantly shallow to medium depth burrowers and infaunal plowers. The only epifaunal animals are

Text-Figure 17

Organisms occurring in the Calvert Beach Member. The following illustrations show reconstructions of the life habits or occurrences: 1, lucinid bivalve; 2, Turritella plebeia; 3, Ensis ensiformis; 4, Glossus fraternus marylandicus; 5, Mercenaria sp.; 6, polychaete worm; 7, Lyropecten madisonius, free swimming; 8, loose shells of epifaunal bivalves; 9, crab.

Text-Figure 17



cheilostome bryozoans and rare, small scallops.

Dominating the macrofauna is the ubiquitous, gregarious snail Turritella plebeia (pl. 8). Of particular interest are the several lucinid bivalves, double-valved and in their characteristic living position. Allen (1958) indicated that the Lucinacea were successfully adapted to conditions in which food was at a minimum and where the oxygen content of the substrate was very low. He also observed that they tended to live in substrates possessing a very sparse fauna and that often several species of Lucinacea occur together. This insight into the lucinid habitat may help to explain the predominantly turritellid-lucinid communities at Calvert Beach.

This member also contains numerous biogenic sedimentary structures most of which do not appear to have been made by bivalves (pls. 7, 9, 10, 54). Probably marine, polychaete worms were also significant members of the Calvert Beach fauna. One striking characteristic of these burrowings is that they are nearly all either inclined or horizontal as opposed to vertical. McAlester and Rhoads (1967) suggested that horizontal burrowing is characteristic of deeper subtidal environments. This corroborates the microfaunal evidence.

Drumcliff Member.--The shell beds of this member continued the shallowing trend of the Calvert Beach Member. In general, these deposits require a special explanation as to their nature and origin and are treated in another

section of this paper.

The lowest Drumcliff shell beds in St. Marys County, however, do not need to be explained by a special mechanism. They are peculiar in that the dense accumulation of shells occurs in a continuation of the dusky blue, very muddy, very fine sand typical of the Calvert Beach (pl. 12). The organisms which produced these accumulations were all epifaunal, living attached to the hard substrate provided by this dense mud, attached to other organisms, or freed from substrate control by a swimming existence. In a slow-sedimentation environment dead animals could make up large parts of the substrate without impeding development of future epifaunal generations. They would merely create new places of attachment.

The most important fossil in these beds is the bivalve Isognomon maxillata, which frequently is the host for the boring bivalve Martesia ovalis. Of lesser importance are the ahermatypic coral Astrhelia palmata, the inarticulate brachiopod Discinisca lugubris, the scallops Placopecten marylandicus, and Lyropecten madisonius, and the barnacle Balanus concavus.

Additionally, the abundant epifauna is in itself an indication of the shallowing water. This mode of life is more common in shallow water than in deep and more common in warm water than in cold.

The microfaunal assemblages studied from these deposits are quite unusual. The Foraminifera are intensely

dominated by Cibicides lobatulus. North of Cole Creek this species makes up 94 percent of the Foraminifera, and at Sotterly, Maryland, it makes up 93 percent. Modern assemblages that are so strongly dominated by hyaline species are nearly always found in normal-to-high salinity, marginal-marine environments. The ostracode assemblage dominated by Hulingsina ashermani, Pokornyella punctistriata, and Cytheromorpha warneri indicates a very shallow environment, as well.

The basal Drumcliff beds along the Calvert Cliffs are not the same as along the Patuxent River. The sediment found along the Calvert Cliffs is a much better sorted sand with very little mud. The same fossils are present but many infaunal molluscs are mixed in. The basal beds here are much more typical of the member as a whole and are considered to have been created by the mechanism responsible for concentrating shells.

Most of the Drumcliff Member consists of alternating beds of increased number and size of densely packed shells with beds of reduced number and size of less densely packed shells. The macrofauna is very diverse and well preserved. Epifaunal specimens and species of snails are very abundant. In addition, the burrowing Veneracea and Pholodacea are very common. Also Polydora shell borings are abundant at some localities. All of these general characteristics of the macrofauna suggest very shallow marine environments for the Drumcliff.

Macrofaunal assemblages of this member are typically

dominated by the snail Turritella plebeia with Lunatia heros usually the second most abundant gastropod. Thorson (1957) discussed and listed many marine bottom communities, and in his cold water communities the most common snails were Turritella and Lunatia. The dominance of cold-water snail assemblages by these two species is probably a result of their infaunal life. This is contrary to the epifaunal life of most prosobranchs.

Assemblages of this member compare closely with Thorson's (1957) "Venus" communities in the cold water of the North Atlantic. In his "Venus" [=Mercenaria]--Spisula--Turritella--"Polynices" [=Lunatia] community an increase in loose sand would produce an increase in the number of individuals of Spisula and Turritella. This situation is a parallel of the Drumcliff assemblages where a great deal of loose sand occurs with a corresponding predominance of Turritella and Spisula.

The most common Drumcliff Foraminifera, in order of abundance, are Cibicides lobatulus, Valvulineria floridona, and Textularia gramen all shallow shelf organisms. Ostracode assemblages are not as strongly dominated but clearly the most important species are Hulingsina ashermani, Cushmanidea ulrichi, Cytheretta burnsi, and Loxoconcha granulata, a typical shallow shelf assemblage.

The various evidence strongly attests to a very shallow marine origin for the Drumcliff Member, with a probable depth range of 8 to 25 meters. Of course, it is reasonable

to assume that downdip in the subsurface the unit should have been deposited in deeper water.

The only outcrop exception to a very shallow marine interpretation is that found in the Nomini Cliffs of Virginia. Here the member is represented by very thin shell beds, and the microfauna suggests a distinctly deeper water environment than that for the typical Drumcliff. Four deep water ostracodes, Henryhowella evax, Echinocythereis clarkana, Pterygocythereis americana, and Cytheropteron sp., constitute 26 percent of the assemblage. This deeper water suggestion is echoed by the Foraminifera with an increase in Lagena spp. and Nonion spp. and a drastic decrease in the importance of Cibicides lobatulus. The Drumcliff Member in the Nomini Cliffs, such as it is, appears to have been deposited in about 35 to 50 meters of open ocean water. This somewhat different environment may help to explain the atypical outcrop expression.

Some unique shell beds appear in the upper Drumcliff Member from just north of Calvert Beach to just south of Parker Creek in the Calvert Cliffs. Typically, the shells of this member have a very jumbled appearance or at least have been concentrated in an unusual manner. Such is not the case with the upper few inches to four feet in the member north of Calvert Beach. Here lenses and other discontinuous beds with fairly well sorted to muddy sand contain discrete assemblages of infaunal molluscs (pl. 24), and some lenses with only well-sorted, fine to medium sand are barren

of macrofossils. Most of the bivalves are double-valved and excellently preserved. Some of the various molluscan associations are: Turritella, Turritella-Glossus, Glossus-Turritella-Corbula-Cerastoderma-Crassatella, Glossus-Turritella-Cerastoderma-Astarte, Anadara-Astarte-Glossus, Anadara, Astarte, and Anadara-Astarte.

Cursory and detailed examination of various microfaunal assemblages from these beds revealed very few specimens. Of those found, the predominant fossils are indicative of shallow water.

The discontinuous nature of the beds, the well-sorted sand, the discrete shallow-water, infaunal molluscan associations, and the rare shallow-water microfossils are all strong evidence of extremely shallow-water marine environments. This shifting sand substrate probably occurred in less than 10 meters of sea water.

St. Leonard Member.--At the same localities, north of Calvert Beach, an undulating, heterogeneous bed of mixed fossils and sediments occurs as a transition unit between the Drumcliff and St. Leonard Members. The latter, unlike any other member of the formation, decreases in thickness in the downdip direction. Even more interesting is the fact that the blue, muddy units measuring 20 feet thick in the Calvert Cliffs are correlated with a brown sand measuring only 4 feet thick along St. Leonard Creek only 3 miles to the southeast.

A profile was established along the "blue clay" in

the Calvert Cliffs by examining samples from this member at Parker Creek, the type locality at the Matoaka Cottages, Flag Ponds, and at Point of Rocks. In all samples the predominant foraminifer is Buccella mansfieldi. The most interesting characteristic of its distribution is the decrease in abundance and faunal dominance in the downdip direction. At Parker Creek the species comprises 77 percent of the foraminiferal assemblage, whereas, at Matoaka and Flag Ponds it is about 55 percent and at Point of Rocks it makes up 28 percent of the Foraminifera. The first three occurrences, particularly the first, are unusually large. Faunal dominance to this degree is typical of marginal-marine environments.

At the two most northern localities the most numerous ostracode is Actinocythereis aff. A. mundorffi, which was found nowhere else in this investigation. A little over half of sample 67-74-9 at Parker Creek and about one-quarter of sample 66-6-14 at Matoaka are made up of this species. However, in the next sample downdip at Flag Ponds Actinocythereis is totally absent with Haplocytheridea bassleri the most abundant ostracode here. This latter species is a marginal-marine to very shallow marine animal. In the last sample downdip the most common forms are Hulingsina ashermani and Cushmanidea ulrichi, which are very typical shallow shelf ostracodes.

Actinocythereis aff. A. mundorffi is extinct, but living species of the genus are well-known from marginal-

marine and nearshore environments. Based on the sedimentological facies relationships and the variation in microfaunal associations, the St. Leonard Member as seen along the Calvert Cliffs probably represents accumulation in a lower bay environment. Inasmuch as Actinocythereis aff. A. mundorffi only occurs in the St. Leonard Member north of Calvert Beach, it is considered confined to the lower bay environment. The fauna requires either normal marine salinity or higher. Mixing with more typical marine faunas occurs between Matoaka and Flag Ponds. Very shallow marine or near-marine conditions exist at Point of Rocks.

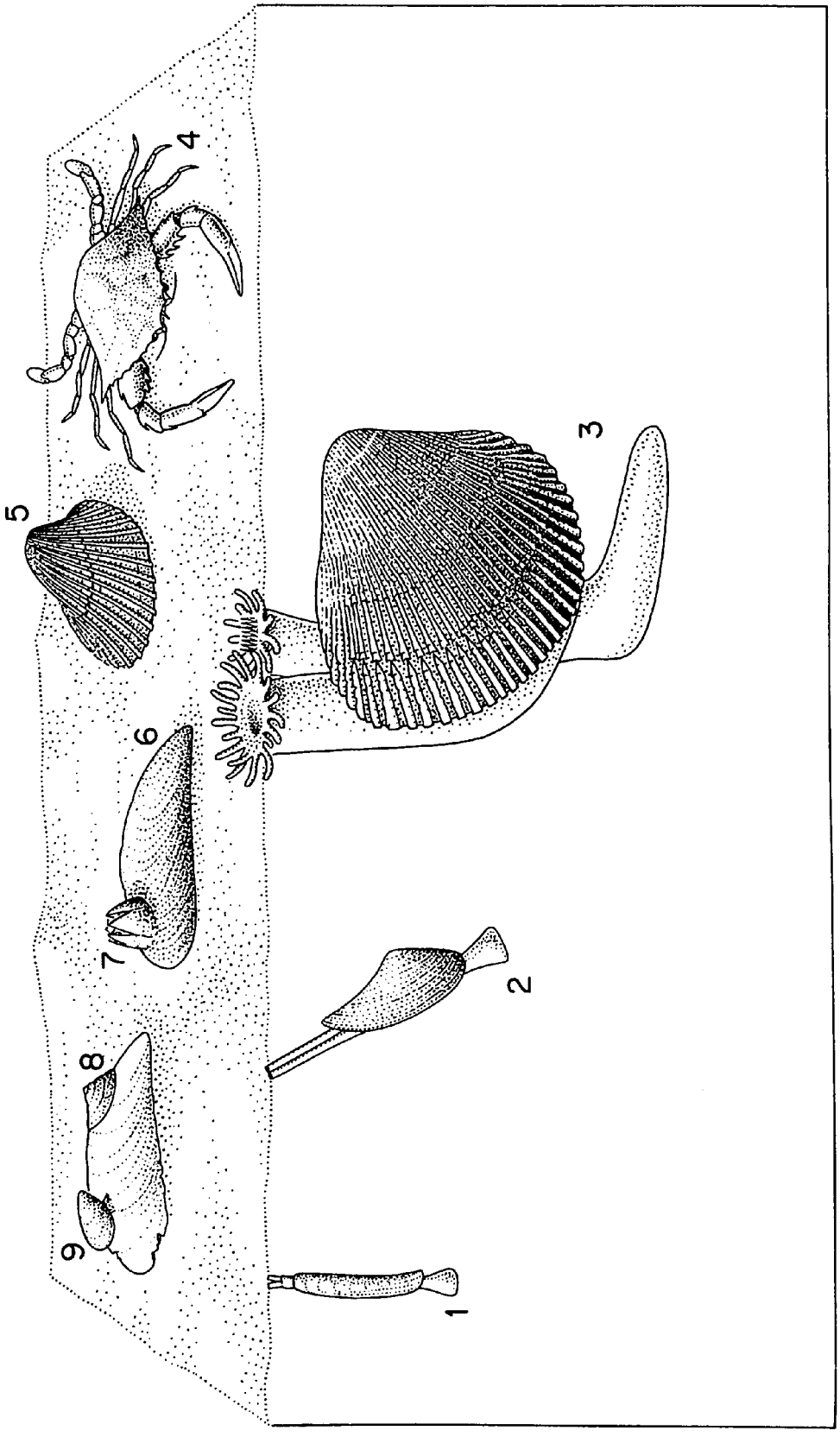
No microfauna was recovered from samples of the laterally equivalent thin, brown sand. However, the mottled sedimentary textures, the small lenses of well-sorted, fine sand, the elliptical burrows, and the few irregular, discontinuous laminations suggest the unit was deposited in a subaqueous, marginal-marine environment.

Macrofossils are very sparse in the St. Leonard Member, but a few occur in its exposure along the Calvert Cliffs (text-fig. 18). Two groups of organisms are associated with the member. Bivalves burrowing into mud substrates are: Yoldia laevis, Ensis ensiformis, and Nuculana. Epifaunal animals include: Discinisca lugubris, Balanus concavus, Mytilus conradinus, Anadara staminea, and the cold-water Anomia aculeata. Inasmuch as epifaunal organisms are very important in this member, it is clear that the St. Leonard is not a repeat of the conditions which produced the

Text-Figure 18

Organisms occurring in the St. Leonard Member. The following illustrations show reconstructions of the life habits or occurrences: 1, Ensis ensiformis; 2, Yoldia laevis; 3, Cerastoderma laqueata; 4, crab; 5, Anadara staminea; 6, loose shells of Mytilus conradinus; 7, Balanus concavus; 8, Crucibulum sp.; 9, Discinisca lugubris.

Text-Figure 18



Calvert Beach Member.

In addition, the microfaunal change from the Drumcliff Member showed that the deep-water animals either decreased in abundance or disappeared while the shallow-water animals increased in abundance or first appeared. Infaunal organisms left traces of vertical burrowing (pls. 28, 29, 63, 64, 65), which according to McAlester and Rhoads (1967) signifies shallow water. Faunal assemblages and sedimentological characteristics indicate that most of the exposed St. Leonard was deposited in marginal-marine environments. Thus, the shallowing trend of the lowest two members continued into the third.

Boston Cliffs Member.--The upper shell bed of the Choptank has many characteristics similar to the lower shell bed and probably represents a repetition of the same process of shell concentration. However, the Boston Cliffs Member differs distinctly.

The macrofaunal assemblages generally have a lower diversity of species, fewer epifaunal individuals, considerably fewer snails, slightly lower quantity of specimens per volume, and fewer small species. These characteristics all indicate either deeper or colder water than for the Drumcliff Member.

In general the microfaunal assemblages suggest that the Boston Cliffs Member was deposited in deeper and warmer water than the lower shell bed. However, the depth of water was still less than 30 to 35 meters and the paleotemperature

regime remained the cold temperate. The increased abundance and consistent occurrence of warm-water species, e.g., Haplocytheridea bassleri, Loxoconcha reticularis, Buccella mansfieldi, and the decreased abundance of cold-water species, e.g., Loxoconcha granulata, Globulina inaequalis, Lagena acuticosta, Lagena clavata, Uvigerina subperegrina, locate the Boston Cliffs Member farther south in the cold temperate water than the Drumcliff. This would then place the upper shell bed in the marine climate analagous to that found today between the mouth of the Chesapeake Bay and Cape Hatteras. The surface water of this area has a mean annual temperature of about 15 to 20°C. (Ekman, 1953, p. 57).

While the typical Boston Cliffs Member deviates distinctly from the Drumcliff Member, the Choptank River sections of the former differ little. Of the difference listed above for the member in general only the characteristic of "lower abundance of specimens per volume" is a significant variance of the Choptank River sections from the Drumcliff Member. In addition, most bivalves found in the Choptank River sections are bigger and more robust than the average specimens of the member. These observation of macroscopic characteristics, in addition to more abundant Polydora borings, indicate that the Boston Cliffs Member on the Eastern Shore was deposited in shallower water than its sediments on the Western Shore. Furthermore, sediments and fossils of the type localities of the Drumcliff and Boston Cliffs Members were deposited in similar depth environments,

probably less than 20 meters.

The microfaunal evidence supports this analysis. Sample 66-12-4 from the central part of the Boston Cliffs Member at its type locality contains a very shallow water foraminiferal assemblage. The most abundant Foraminifera in order are: Cibicides lobatulus, Textularia gramen, Buccella mansfieldi, Valvulineria floridana, and Buccella depressa. Additionally, the percentage of arenaceous foraminifers is high, which generally indicates an environment of lower than normal marine salinity. The most common species of the very shallow water, ostracode assemblage in order are: Cushmandea ulrichi, Pokornyella punctistriata, Muellerina lienenklausi, Cytheretta burnsi, Hulingsina ashermani.

In the same area the Boston Cliffs Member has an atypical base that contains an accumulation of Isognomon and Crassostrea shells (pl. 33). These beds show the strongest brackish water influence of any observed in the Choptank. Sample 67-79-2 contains a shallow inner shelf of brackish-water foraminiferal assemblage including, in order of abundance: Textularia gramen, Cibicides lobatulus, Buccella mansfieldi, Rotalia bassleri, and Quinqueloculina seminula. Additionally, of all the samples studied, this sample contains the highest percentage of agglutinated foraminifers. The Ostracoda are even more indicative of brackish water and dominated by Pokornyella punctistriata, Cytheromorpha warneri, Aurila laevicula, and Semicytherura coryelli. In

addition, each of the following brackish and very shallow-marine species occurs as two percent of the ostracodes: Cyprideis floridana, Haplocytheridea bassleri, Semicytherura reticulata, and Semicytherura forulata. This evidence may indicate the nearby effluence of the ancestor to the modern Patapsco or Patuxent Rivers, possibly even the Susquehanna River.

The typical macrofauna of the lower and middle Boston Cliffs is predominantly composed of infaunal bivalves (text-fig. 19). The commonly associated macrofossils are: Macrocallista marylandica, Dosinea acetabula, Corbula idonea, Cerastoderma laqueata, Crassatella marylandica, Anadara staminea, Lyropecten madisonius, Balanus concavus, Astarte obruta, Mercenaria spp., and Panope americana. This assemblage is somewhat similar to the "Venus" bottom communities of the North Atlantic as described by Thorson (1957, pp. 508-510).

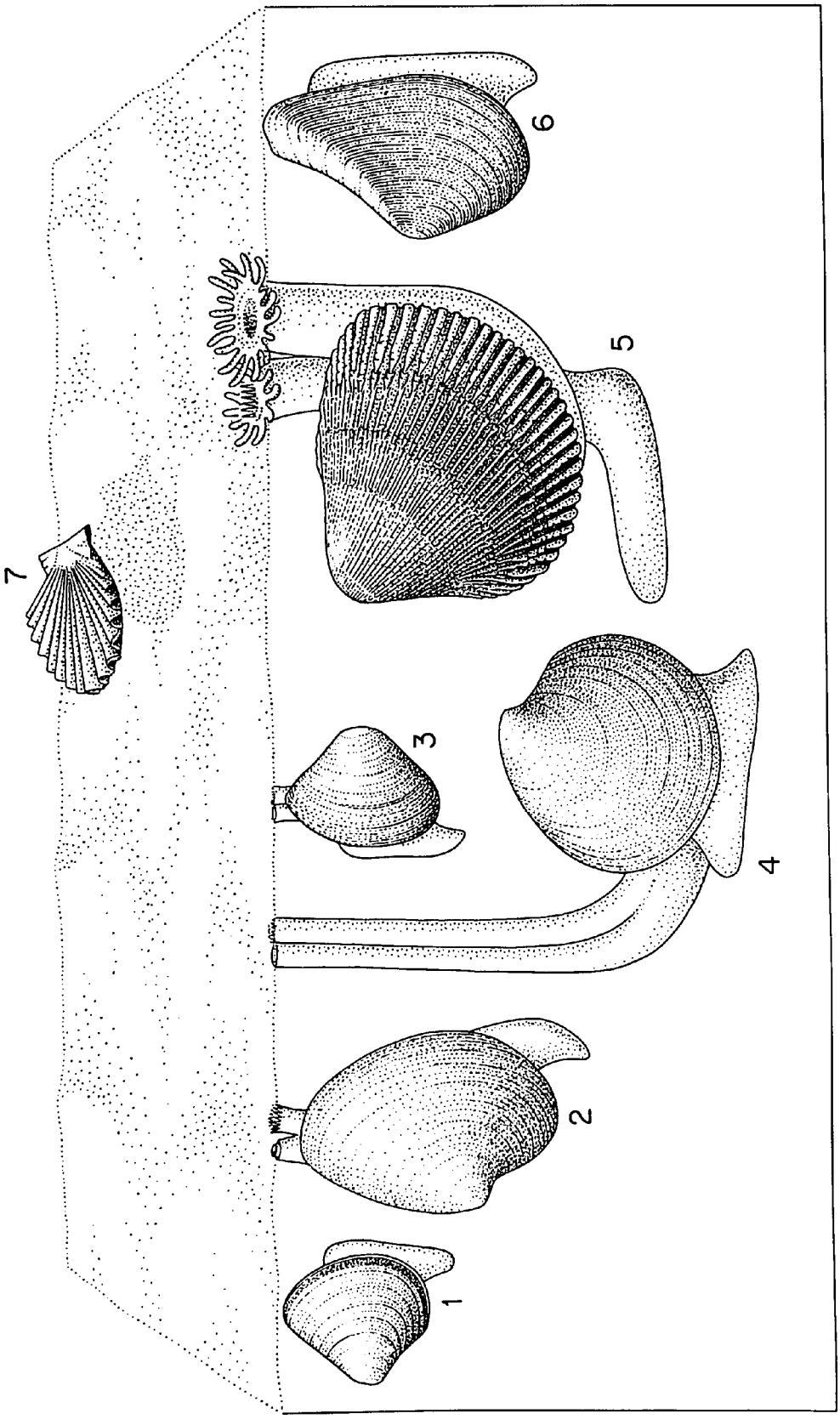
In the upper part of the member, but below the oxidized and indurated beds, is a series of thin units containing predominantly epifaunal animals. Shells of these oyster-scallop-barnacle assemblages are some of the largest found in the Choptank. However, these large shells grade below and above into accumulation of well-worn fragments. These epifaunal assemblages are an indication of shallowing water in the upper part of the Boston Cliffs Member.

Another special problem associated with the Boston Cliffs Member is the origin and environmental history of the

Text-Figure 19

Organisms commonly occurring in the Boston Cliffs Member. The following illustrations show reconstructions of the life habits or occurrences: 1, Astarte obruta; 2, Macrocallista marylandica; 3, Corbula idonea; 4, Dosinia acetabulum; 5, Cerastoderma laqueata; 6, Crassatella marylandica; 7, Lyropecten madisonius.

Text-Figure 19



strongly oxidized and indurated series of beds in its upper part (pls. 69, 73, 76). These characteristics and the leached out fossils make the upper units difficult for study. Beds immediately below these units were deposited on the shallow inner shelf and may indicate slight shallowing of the water.

The only sample from the oxidized-indurated series that produced a microfauna was 66-24-13, from a short distance north of Point of Rocks, Since only 19 foraminifers were found the data is insufficient, but of the species present the shallow-water Cibicides lobatulus and Textularia gramen are the most common. The ostracode data is much more adequate, with the presence of 173 specimens. The most numerous species of this very shallow marine assemblage is: Hulingsina ashermani, Cushmanidea ulrichi, Haplocytheridea bassleri, Semicytherura coryelli, and Cytheretta burnsi.

Where molds and casts can be identified, the predominant macrofaunal species are Lyropecten madisonius, Cerastoderma laqueata, Mytilus conradinus, Mercenaria spp., and Macrocallista marylandica. Since epifaunal species constitute a high percentage of the assemblages observed, these beds must have been deposited in shallow water. The history of the actual oxidation and lithification is uncertain. The shallowing trend of the depositional environments supports the possibility that the ocean receded sufficiently to subaerially expose the top of the Boston Cliffs Member.

Sediments of the upper Boston Cliffs were then oxidized and indurated. A second possibility is that percolating ground water was the lithifying and oxidizing agent.

In a very rare mode of preservation the upper Boston Cliffs Member was found neither oxidized nor indurated at locality 66-44 (pl. 45), north of Camp Conoy. Here the macrofauna consists of Lyropecten madisonius, Turritella plebeia, Crassatella marylandica, Cerastoderma laqueata, Macrocallista marylandica, Dosinea acetabula, and Crucibulum costatum. The Foraminifera indicate a very shallow-marine environment and are strongly dominated by Cibicides lobatulus which is followed in importance by Buccella mansfieldi, Buccella depressa, Textularia gramen, and Bulimina elongata. The very shallow-marine ostracode assemblage contains the following as most abundant: Loxoconcha granulata, Cytheretta burnsi, Cushmanidea ulrichi Murrayina martini, and Cytheromorpha warneri. This bed from the uppermost Boston Cliffs Member must have been deposited on the shallow, inner shelf. Because the only significant macroscopic difference between members is the quantity of shells and not the sedimentological characteristics, the break between members here is much less striking than is typically found. The characteristics of the Boston Cliffs Member at this locality discredits somewhat the idea of subaerial exposure but lends support to diagenetic changes, such as percolating ground water.

Conoy Member.--Sediments of this member are the most consistently fine-grained and muddy of any member in the

Choptank. The Conoy Member is unique in the formation in that it commonly has thickly-spaced, thin, parallel, bedding laminations (pls. 45; 47, fig. 1). Biogenic sedimentary structures are very rare. From an analysis of these sedimentological characteristics, it appears that the Conoy Member was deposited in deeper environments than the preceding members.

This interpretation is supported by the macrofauna. In comparison with assemblages from lower units of the Choptank, many deeper-water species have increased in abuncance in the Conoy Member while many shallow-water species have decreased.

Foraminifera that are markedly increased in abundance and importance in the Conoy Member are: Nonion mediocostatum, Nonion pizarrense, Textularia candeiana, and Lagena spp. The following shallow-water species show a distinct decrease in abundance and importance: Bolivina paula, Buliminella elegantissima, Cibicides lobatulus, Quinqueloculina seminula, Sigmomorphina concava, and Textularia gramen.

A similar trend occurs in the Ostracoda. The following deep-water species show an increase in abundance and importance in the Conoy Member: Cytheropteron sp., Echinocythereis clarkana, Henryhowella evax, Pterygocythereis americana. Complementing that increase, several shallow-water ostracodes decrease in abundance and importance: Campylocythere laevissima, Semicytherura coryelli,

Semicytherura forulata, Semicytherura reticulata, Eucythere gibba, Haplocytheridea bassleri, Hulingsina ashermani, and Tetracytherura shattucki.

Even though the faunal and sedimentological characteristics of the Conoy Member indicate that it was deposited in significantly deeper water than the other members, it still represents environments of the fairly shallow continental shelf. In the outcrop area sediments of the Conoy were probably deposited in about 35 to 50 meters of open ocean water.

The fauna strongly indicates that the Conoy Member sediments were deposited in cold temperate water. A few species indicating warmer water occur in very small percentages of the fauna. This probably indicates closer proximity to the warm temperate boundary than to the boreal boundary. In fact, the only Choptank occurrence of Cytherella sp., a warm-water ostracode, was in the Conoy Member at Horsehead Cliffs, Virginia. Fossils indicate that this member was probably deposited in environments similar to those found today between the mouth of the Chesapeake Bay and Cape Hatteras. The surface water of this area has a mean annual temperature of about 15 to 20°C. (Ekman, 1953, p. 57).

The Conoy Member and Choptank Formation are terminated above by an erosional and depositional unconformity (pls. 49, 50), as discussed previously. Possible local uplift followed the Choptank creating a shallow basin in the

Camp Conoy--Flag Ponds vicinity. This basin was then filled with sediments of the St. Marys Formation. The erosional nature of the unconformity may be seen elsewhere, as well (pls. 47, fig. 2; 48; 74).

ORIGIN OF THE CHOPTANK SHELL BEDS

Since 1685, when Martin Lister published a figure of Ecphora quadricostata, investigators have sought fossils from the prolific shell beds of the Chesapeake Group. That first American fossil came from the Miocene of Maryland. Even though these deposits have been well collected for nearly 300 years, very few investigators have been concerned over the manner in which they were formed. To date, only Mongin (1959) has published any suggestion as to their origin. In her opinion they represent transgressive beach accumulations.

While the two major shell beds are distinctly different, they share several characteristics critical to the understanding of their origins. The Drumcliff and Boston Cliffs Members are considered here to have been deposited in the same way. However, this conclusion was reached after a great deal of investigation, not before.

Probably the most striking feature of the shell beds is the prolific concentration of fossils (pls. 18, 25, 36-38). Another major difference from the other members is that the "non-shell" beds are predominantly dusky blue to dusky green, whereas the shell beds are predominantly very light to dark brown with shades of orange and yellow.

Additionally, these units show a general lack of inorganic and biogenic sedimentary structures.

Closer examination of these deposits reveals that they are not homogeneous. Rather, they consist of beds of abundant, densely packed, large shells and beds of less abundant, less densely packed, smaller shells (pls. 14, 16, 19, 32, 35, 38, 40, 56, 68). These two kinds of units intergrade with each other. At some localities the reduced macrofossil beds are much better sorted than the increased beds. This sedimentological association is much more common in the Drumcliff than in the Boston Cliffs Member. The difference in sorting rarely involves variation in the larger grain sizes but instead concerns the quantity of mud and silt. As a result, where the difference in sorting is very pronounced, as at Drumcliff, an accompanying color change makes the units even more distinct. The well-sorted units, predominantly sand, are light tan to very pale orange, whereas the poorly sorted, with increased mud and silt, are darker browns. Thus the reduced macrofossil beds are much lighter in color than the increased macrofossil beds.

It is interesting to note that nearly all of the infaunal bivalves are found flat lying (pl. 37), as well as most of the other large bivalves. In addition, many of these flat-lying shells are articulated, double valves. Of course, the living position of nearly all the infaunal bivalves is with the hingeline perpendicular to the sea floor, not parallel as in the Choptank shell beds. The one

principal exception to this reorientation rule is the group of very deep-burrowing bivalves, which includes Panope and Mya. These shells are always found vertical and double-valved in the Choptank, yet with no burrow structure.

If Mongin (1959) was correct in suggesting the shell beds were transgressive beach deposits, the shells should be well-worn, fragmented, and covered with encrusting organisms, such as bryozoans, barnacles, worm tubes, molluscs, and others. Even if these shells merely laid on the ocean floor after death and were forming prolific beds by a more or less "normal" accumulation, they should be covered with attached animals. However, encrusted infaunal bivalves are exceedingly rare in the Choptank. The shells are usually very well preserved with nearly all features of ornamentation remaining. In fact, some seldom-preserved features, e.g., hinge ligament and shell coloration, are present at various localities. Markings are found on a few infaunal bivalves suggesting interrelationship with other animals. However, these marks are predominantly the traces of two groups of animals, the naticid snails and the polychaete worms. Since these animals themselves are burrowers, the infaunal bivalves were victims of "subsurface attacks", not "seafloor attacks" as would occur with exposed shells.

As pointed out by E. G. Kauffman (personal communication), the hard shell substrate, formed by preexisting shell beds, would be impossible burrowing locations for future generations. Hence, after a shell pavement was

formed, even a thin one, future generations of infaunal bivalves would not return until a soft bottom was once again established. Yet, these shell beds range from a few feet to about 30 feet thick.

Another problem that must be resolved is the apparent "super-productivity" of the shell beds. A tremendously large number of fossils, not to mention the unpreserved organisms, occur in a comparatively small volume of sediments. Such apparently high productivity is unknown in modern environments.

One of the most amazing characteristics of the Drumcliff and Boston Cliffs Members is their extreme lateral extent. The beds can be traced in dip section, particularly along the Chesapeake Bay, for miles and can be correlated along strike for even greater distances. In short, these beds are found throughout the area of outcrop. One notable example of this great extent is found in the Boston Cliffs Member in which the same sequence of units can be found both at its type locality on the Choptank River and 60 miles away at the Nomini Cliffs of Virginia.

Mongin's (1959) suggestion that the shell beds were transgressive beach accumulations can be eliminated on the basis of the following considerations. First, a deposit as she envisioned would be made up almost entirely of shells that are well-worn, fragmented, and covered with encrusting organisms. Such is not the case in the Choptank, especially for the infaunal bivalves. Second, the faunal

evidence indicates deposition occurred on the inner shelf and not on a beach. Third, inorganic sedimentary structures indicative of a beach are absent. Lastly, while the Drumcliff Member developed during moderate transgressive conditions, the lower and central parts of the Boston Cliffs Member were produced during a regression.

Van Straaten (1952) recognized a shell bed at 20 to 30 centimeters below the sediment-water interface in the Dutch Wadden Sea. Since he found the worm Arenicola burrowing to the same depth and drawing food down through a tunnel, he suggested that the shell bed was a biogenic concentration. It seems unbelievable that the feeding of marine worms could concentrate such an even bed extending for miles as he described it. According to his own diagram (Van Straaten, 1952, fig. 4), the larger bivalves would be much too large to "tumble" down a worm's feeding shaft. Perhaps van Straaten had the cause and effect reversed. Possibly because the hard shell horizon is present the worms do not burrow through it but only to it. At any rate, it seems beyond the ability of marine worms to concentrate the large Choptank bivalves (e.g., 15 centimeters Lyropectens, 11 centimeters Macrocalistas, 12 centimeters Mercenarias, 8 centimeters Crassatellas). This feat is further complicated in the Choptank by the extreme lateral extent of the shell beds. The final evidence against this theory is the lack of biogenic structures in the shell beds.

Haas (1940) described molluscan accumulations resulting

from tropical storms. However, the deposits he described were much more local and variable than the Choptank shell beds. He also mentioned that one of the important zones of accumulation contained shells ground and pulverized to beach sand. No comparable unit exists in the Choptank.

Different types of mass mortality in the sea were reviewed by Brongersma-Sanders (1957). Investigators have attributed large-scale dying to such factors as volcanism, earth quakes, tsunamis, salinity changes, temperature changes, "red tide", and poisonous gases. However, these phenomena usually only act on a very few species, and seldom, if ever, cause great disasters for the infaunal communities. Mass mortalities are also insufficient for explaining the thickly stacked appearance of flat-lying bivalves.

One possible solution that must be considered is what might be called a "normal biological accumulation". In order to have so many fossils in the given amount of sediment some modification must be applied to the basic mechanism, e.g., winnowing of fine sediment or very little accompanying sedimentation.

Unfortunately, this mechanism, even with modifications, fails to explain several of the characteristics of the Choptank shell beds. Probably the most basic problem associated with this mechanism concerns the life habits of the burrowing bivalves. Since the shallow and medium depth infaunal bivalves are not found in living position but are found flat-lying, their reorientation must be

explained. If a bivalve ascended from its burrow, it could die on its side; but then the muscles and hinge ligament would decompose, the paired valves would be disassociated, and the hard shells would become encrusted by several types of organisms. The mechanism fails to explain the articulation and absence of epifauna on valves in the Choptank. Maybe even more fundamental is the question "Why would the bivalves leave their homes in the first place?" The ability to construct burrows is their adaptation for protection. These are not structures to be abandoned in time of trouble.

In addition to not accounting for the flat-lying occurrence of the shallow-burrowers, the "normal biological accumulation" mechanism fails to explain why the deep-burrowing bivalves are always found in the opposite orientation, that is, the normal, vertical, living position. It also does not justify the absence of burrows of the deep infaunal bivalves. The dusky blue to dusky green color of the "non-shell" beds must be a result of slightly reducing conditions below the sediment-water interface, whereas the light brown colors of the shell beds must be a result of slight oxidation. The "normal accumulation" mechanism cannot account for the difference.

This mechanism was used to explain shell deposits that may be near-modern analogs of the Choptank. Coleman and Gagliano (1964, p. 70) reported a "four foot thick concentration of shells and shell debris" in the vicinity of the Mississippi River Delta. Microfaunal evidence from the shell

beds indicated deposition in 60 to 80 feet of marine water. Later they added (Coleman and Gagliano, 1965, p. 143), "Shell concentrations or 'hashes' range in thickness from 5 cm. to 1 meter or more and show a dominance of organic over detrital deposition. Shell 'hashes' represent conditions of virtually no deposition or erosion. . . . Deep borings in the birdfoot delta have demonstrated that these shell beds are widespread and continuous, forming excellent stratigraphic markers."

The Gulf of Mexico shell beds appear very much like those of the Choptank. A "normal accumulation" with little sedimentation and erosion could be a valid explanation for these beds only if all the organisms are epifaunal. No mention was made about the life habits of animals in the deposits.

The continental shelf off the mouth of the Chesapeake Bay is another area known to have shell concentrations below the sediment-water interface. These deposits were skillfully described by Powers and Kinsman (1953) suggesting relationship to the traction zone in underwater sediments. They recognized two zones in the substrate. The upper zone had better sorting, smaller grain size, more abundant microfauna, and less abundant macrofauna than the lower zone. Conversely, the lower zone had poorer sorting, larger grain size occasionally including gravel, less abundant microfauna, and more abundant macrofauna than the upper. They called the upper the "traction zone" and the lower one the

the "accumulation zone". These two zones seem to be essentially the same as the reduced and increased macrofossil beds in the Choptank.

Powers and Kinsman (1953) related the vertical sorting, which creates the traction and accumulation zones, to the passing of marine swell. The typical period of swell reaching the U. S. coast is from 6 to 16 seconds with rare reports to as high as 22.5 seconds. According to Powers and Kinsman (1953) a swell with a period of 12 seconds would produce horizontal current velocities of more than 0.3 foot per second in water 70 feet deep. This would be sufficient to establish a pressure gradient on the bottom causing flow into the sediment and flow out accompanied by effusion of the substrate. At some depth the lifting action ceases and at that level they identified the base of the traction zone.

They suggested that "for a given water depth and swell period the permeability of the sediment is the most important factor determining the traction zone thickness. In other words, the more freely the water can circulate in the sediment the greater will be the lifting effect." This would explain why the traction zone is thinner where the grain size and sorting is less, as Powers and Kinsman observed. In fact, they found no traction zone in the clay cores.

They also recognized the importance of diminished wave energy with increased water depth. In their

investigation (Powers and Kinsman, 1953) shell beds were found in 45 to 145 feet of open marine water.

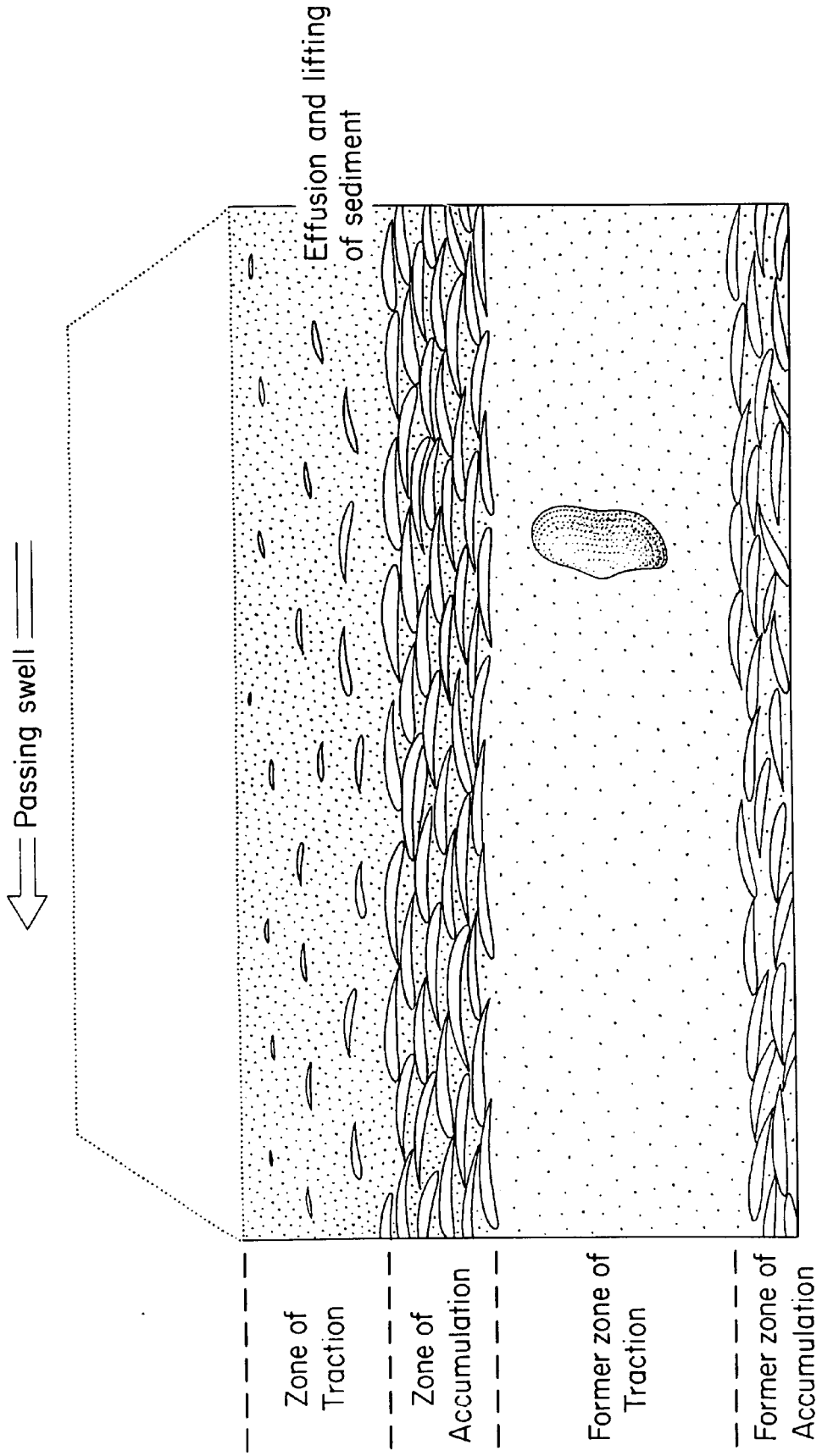
This mechanism of passing marine swell creating zones of traction and accumulation seems quite sufficient to account for the alternation of reduced and increased macrofossil beds (pl. 14, text-fig. 20) in the Choptank. The lifting effect caused by traction would also result in slight oxidation of the organic matter in the sediments, thus explaining color differences between the shell beds and the "non-shell" beds.

Traction on the bottom sediments also resolves the problems associated with the shallow infaunal bivalves. Since any given swell consists of a group of waves, the effect on the bottom is an alternation of flow into the substrate, accompanied by pressure, and flow out of the substrate, accompanied by release of pressure, with lifting and effusion of the sediment. During this confusion the bivalve, stationed in the middle of all the action, must have taken in quantities of harmful sediment. Even more likely though would be a reorientation of the bivalve as a result of the physical threshing. As the animal is lifted and released a more likely position is relocation on a flat side rather than on edge. Experimental evidence by Armstrong (1925) in the nearshore waters of California showed that reorientation of infaunal bivalves to greater than 45° away from the preferred living position would be fatal. Thus it appears that mere reorientation in the

Text-Figure 20

Mechanism of shell bed accumulation. Note shallow and medium depth infaunal bivalves in flat-lying position in zone of accumulation and deep burrowing Panope in living position.

Text-Figure 20



animal's own domain would leave it dead. This may account for well-preserved, double-valved, flat-lying specimens in the Choptank shell beds.

The passing of swell and subsequent swells could concentrate single and articulated valves in a subsurface zone of accumulation. In addition, this mechanism alleviates the need for accumulation of shells on the seafloor where they would get worn and be encrusted. Constant submersion in the substrate explains the lack of encrusting organisms on the shallow infauna.

One of the curious characteristics of the Choptank shell beds is that the snails do not seem as confined in the increased and reduced macrofossil units as do the bivalves. In light of the traction mechanism, it might be that the empty snail shells were concentrated as the other shells, but the live snails had the ability to readjust after the passing of the swell.

The effective depth of the lifting force is indicated by the deep burrowing species of Panope. Since specimens of these genera are always found in living position, the operative limit of traction must have been less than their living depth. Effusion of sediment above the bivalves also explains the lack of burrow structures associated with them.

The problem of concentrating specimens of scallop shells, particularly of living animals, is more complicated because of their free-swimming existence. However, a bivalve is not a very efficient swimmer and the churning of

water with the passing swell may have thrown it to the sea-floor. The animal would be even more helpless if it were pressed upside down on the floor, and due to the convexity of the lower valve, the most stable resting position is up-side down. With the effusion of silt and sand the scallop might have become partially mired in sediment, presenting a situation which its swimming mechanism would be incapable of correcting. Subsequent waves in the same swell could hopelessly bury the animal alive, thus preserving the valves intact as they are often found in the Choptank.

The lifting action in the zone of traction undoubtedly would remove existing sedimentary structures. This accounts for the absence of inorganic and biogenic structures in the Choptank shell beds.

Another observation of Powers and Kinsman (1953) correlates very well with the Choptank. They noted that the traction zone thickness varies with the degree of sorting, i.e., the thickness is greater in better sorted sediments and less in more poorly sorted sediments. This was explained to be a result of the greater degree of permeability in the sediments containing little mud. In the Choptank the Drumcliff Member sediments are better sorted and contain less mud than the sediments of the Boston Cliffs Member. To complete this contrast, the reduced macrofossil beds (=traction zone) of the Drumcliff are thicker than those of the Boston Cliffs Member.

One of the strongest attributes of the traction

mechanism is its ability to explain the apparent "super-productivity" in the Choptank. Sandy and silty substrates of the shallow inner shelf typically support some of the largest bottom communities, but by themselves they could not produce the quantity seen in the shell beds. However, as each swell passes, a large part of the fossilizable bottom community is killed off and concentrated in the zone of accumulation. This leaves the substrate that was initially teeming with life barren of part of its population. A new recruitment of organisms finds the bottom nearly virgin. This cycle of events could continue until there is a major change in depositional environment. Enticement of recruits to virgin substrates followed by mortal threshing qualifies the Choptank as a sort of Venus's flytrap.

The Choptank Formation has three "non-shell" members, in addition to the two major shell beds. As a result, any theory for the origin of the shell accumulations must account for their absence elsewhere. In light of the mechanism proposed and the reports of modern deposits, there appears to be an effective lower depth limit. The deeper environments and the high mud content in the Calvert Beach and Conoy Members probably account for the absence of concentrated shells in their sediments. In its outcrop the St. Leonard Member seems to represent marginal marine deposits. Powers and Kinsman (1953) did not find concentrated shell beds in the marginal marine Chesapeake Bay and suggested

that this was a result of very little swell.

Since swells at any given location are fairly frequent and since the Choptank shell beds typically contain fossils at various stages of growth, it may be that only infrequent marine swells of very great magnitude produced these deposits. It is also possible that only major swells are sufficient to reorient entrenched infaunal bivalves. If these restrictions do require abnormally intense energy, the dense concentration of shells may have been related to tropical storms. At this stage of investigation the frequency and magnitude of marine swells sufficient to account for the Choptank shell beds is unknown.

Inasmuch as inner shelf, concentrated shell beds have been found in modern sediments of the northwestern Atlantic Ocean, the Gulf of Mexico, and the Dutch Wadden Sea, and inasmuch as concentrated fossil shell beds have been found in inner shelf environments, these beds are likely to be much more important constituents in modern and fossil sediments than the little attention given to them indicates. The proposed swell-traction mechanism may have played a major role in inner shelf environments of the geological past.

DEPOSITIONAL HISTORY OF THE CHOPTANK FORMATION

The history of the Choptank Formation had its beginnings hundreds of millions of years before the Middle Miocene. Episodes of mountain building in the Paleozoic

established structural trends and sediment source areas. During the Mesozoic, mobility of the Salisbury Embayment first appeared to be significant.

However, the events of the Tertiary gave the Choptank its real uniqueness. The mid-Tertiary was a time of great structural disturbance. The major Antillian Revolution in the Antillean-Caribbean region was shaping the destiny of the Gulf Stream which is of major significance to the marine and coastal climates of Eastern United States. More locally, regional uplift of the ancient Appalachian Mountains supplied great volumes of terrigenous detritus to streams that emptied into the Atlantic Ocean.

The mobile Salisbury Embayment was a locus of accumulation for such discharged sediment. The particularly thick Chesapeake Group was deposited during the Middle and Late Miocene. While all of the units of the Chesapeake Group were formed in the temperate marine climate of the Atlantic Coastal Plain, a definite warming trend persists from the earliest beds to the latest.

The first of the Chesapeake Group formations, the Calvert, occurred in cold temperate marine water on the continental shelf. The exact structural relationship between the Calvert and overlying Choptank Formation is uncertain, but it does appear certain that the latter represented a shift to warmer and shallower water.

The lowest unit of the Choptank, the Calvert Beach Member, was deposited in the coldest water of any unit in

the formation. Its environments were slightly inimical to many types of bottom communities as evidenced by the bivalve dominance of the Lucinacea. The Drumcliff Member represents a shallowing of environments on the inner shelf and possibly slight warning. According to the hypothesis set forward in this paper, marine swells, possibly related to tropical storms, passed through the area establishing zones of traction and accumulation in the bottom deposits. This physical mechanism concentrated shells into great beds.

Maximum shallowing occurred during the St. Leonard Member. Marginal marine environments dominated this unit in the outcrop vicinity. The best delineated of these was the lower bay environment, which occurred in the area of the modern Calvert Cliffs. The slight warming trend continued into the Boston Cliffs Member, but the shallowing trend of the lowest three members was reversed. This member represents a return to open inner shelf environments, where the bottom was again swept by marine swells concentrating great volumes of shells.

Sediments of the Conoy Member were deposited in distinctly deeper water but still were probably shallower than 50 meters. Like the previous Choptank Members, the Conoy was deposited in the cold temperate marine climate. However, by the time of the Conoy the warming trend placed the member in the southern end of the cold temperate region. An erosional and depositional unconformity separates the Conoy from the overlying St. Marys Formation, which generally continues the deepening trend started in the Boston Cliffs Member.

APPENDICES

APPENDIX I

Description of Outcrops

The following abbreviations are used to designate logarithmically increasing relative abundances of fossils: R - rare, F - few, N - numerous, C - common, VC - very common, A - abundant, Fl - flood.

Locality 66-3. Mill Cove Construction Pit.

Construction pit 2.0 miles (2.2 miles by road) north of California, Md., St. Marys Co. 0.2 miles northeast of Mill Cove Road. Unnamed road to outcrops turns northeast of Mill Cove Road 0.3 miles northwest of intersection of Mill Cove Road and Myrtle Point Road. Owner said (June 1, 1966) this pit would be flooded to make a pond. 38° 19' 39" N. Lat.; 76° 30' 22" E. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation:		
Boston Cliffs Member, upper part		
4	Lithology: Light tannish-green fairly well-sorted, fine sand. Matrix seems structureless but contains numerous dark iron-brown concentric inclusions. Lower contact highly irregular but distinct color change. Upper contact slightly irregular. Fossils: Numerous molds and casts. Faunal list: Cerostoderma laqueata and Lyropecten madisonius. Sample 66-3-4, entire unit.	1' 0"
3	Lithology: Dark iron-stained, fairly well-sorted, fine to medium sand. Discontinuous, irregular, heavy, resistant iron bands from one to four cm. thick. Matrix appears structureless. Irregular lower contact, darker brown above. Upper	0' 9"

Unit		Thickness
	contact highly irregular but distinct because of marked color change. Fossils: Difficult to recognize species as all are represented by molds and casts of completely dissolved calcareous shells. Slight concentration in small pockets. Dense accumulation. Faunal list: C-Cerastoderma laqueata, Macrocallista marylandica, Anadara staminea, F-Turritella plebeia, R-Lyropecten madisonius, and Ecphora quadricostata umbilicata. Sample 66-3-3, entire unit.	
2	Lithology: Orangish-brown, fairly well sorted, fine to medium sand. Indistinct iron staining and darker brown color-mottling probably related to diagenetic activity which caused leaching of shells. Lower contact undulating and marked by disappearance of carbonaceous inclusions. Upper contact undulating and marked by disappearance of carbonaceous inclusions. Upper contact undulating.. Fossils: Difficult to identify species as all are represented by molds and casts of completely dissolved calcareous shells. Most are in localized pockets but do occur singly as well. Fairly dense accumulation of shells, particularly dense in pockets. Some found articulated but most are not. Fragmentation common. Slight preference for flat lying. Fossilized fauna is infaunal. Sample 66-3-2, entire unit.	1' 6"
1	Lithology: Orangish-brown, fairly well sorted, fine to medium sand. Black carbonaceous? inclusions occurring as irregular pockets up to 3 inches diameter making up 5 to 10 percent of total lithology. Nearly structureless but some indistinct color mottling and rare wavy color laminations probably related to diagenetic activity which caused leaching of shells. Lower contact covered. Upper contact apparently undulating and marked by absence of carbonaceous inclusions above. Fossils: Difficult to identify species as all are partially to completely dissolved calcareous shells. Most	2' 0"

Unit		Thickness
	are in localized pockets but do occur singly as well. Shells fairly dense. Most disarticulated. Fragmentation common. Slight preference for flat lying. Fossilized fauna is infaunal. Sample 66-3-1, entire unit.	
	Total thickness of exposed Boston Cliffs Member	5' 3"

Locality 66-4. 125 Feet South of Harper's Creek.

1.2 mile south of Western Shores, Md. Calvert Cliffs on Chesapeake Bay, Calvert Co., Md. 38° 28' 29" N. Lat.; 76° 29' 07" W. Lat.

Unit		Thickness
(Pleistocene, undifferentiated) Choptank Formation St. Leonard Member		
5	Lithology: Dark-gray, muddy, very fine sand. Vertical fractures on weathered surface. No sedimentary structures. Lower contact irregular. Upper contact distinct but undulating. Fossils: Macrofossils nearly absent. Faunal list: R-Discinisca lugubris, shark tooth. Sample 66-4-4, from 2' 8" to 4' 2" above base of unit.	7' 2"
4	Lithology: Dark olive-gray, poorly sorted, fine sand. Iron stained on weathered surface. No sedimentary structures. Lower and upper contacts irregular parallel. Fossils: Well preserved. Accumulation not dense but gradational from dense unit 3 below to lower St. Leonard Member above. Slight amount of pocketing in low areas of bed. Faunal list: C-Anodontia anodonta (some double valves), Astarte thisphila, F-Cerastoderma laqueata, R-Turritella plebeia, Discinisca lugubris, Anadara staminea, Panope sp. Sample 66-4-6, entire interval.	0' 4"
3	Lithology: Dark olive-brown, poorly sorted, fine sand. No apparent sedimentary structures. Lower contact grad-	0' 8"

Unit		Thickness
	ational. Upper contact gradational. Fossils: Well preserved. Articulated, double valves in abundance. Densely packed mollusk shells. Faunal list: A-Astarte thisphila, Anadara staminea, C-Glossus fraternus marylandicus, Turritella plebeia, F-Cerastoderma laqueata, Anodontia anodonta. Sample 66-4-3, entire unit.	
2	Lithology: Light-brown, very well sorted, fine to medium sand. No apparent sedimentary structures. Lower contact gradational. Upper contact gradational. Fossils: Excellently preserved. Densely packed except in best sorted sand which is less well packed with mollusks. Turritella increases in abundance with increased sorting, whereas Glossus increases in abundance with increased mud content. Shells primarily flat lying. Faunal list: F1-Turritella plebeia, (with many double valves). Sample 66-4-2, entire unit.	1' 2"
	Total thickness of exposed St. Leonard Member	9' 4"
Drumcliff Member		
1	Lithology: Light-gray, slightly muddy, fine sand. Structureless. Lower contact covered. Upper contact gradational. Fossils: Tremendous quantity with appearance of having been dumped. Extremely dense accumulation. Broken pieces abundant. Worn specimens rare. Astrhelia palmata and Isognomon maxillata conspicuously more worn than other species. Apparently no preferred orientations. Distribution of most species random, except Turritella plebeia, which is locally very abundant. Shells drilled by Naticidae and Muricidae common. Sponge bored shells present but rare. Isognomon maxillata commonly bored by Martesia ovalis. Few double valve bivalves, most single. Faunal list: F1-Turritella plebeia, A-Glossus fraternus marylandicus (some double), Crucibulum multilineatum	8' 1"

Unit	Thickness
Crucibulum costatum, C-Cerastoderma laqueata, Venericardia granulata, N-Astrhelia palmata, Lyropecten madisonius, F-Isognomon maxillata, Martesia ovalis, Vermetus graniferus, Anadara staminea, Astarte thisphila, Macrocallista marylandica, Balanus concavus, Mercenaria plena, Dosinia acetabula, Corbula idonea (some double), Lunatia heros, Crassatella turgidula (some double), R-Anodontia anodonta, Asaphis centenaria, Diplodontus acclinis (one double), Calliostoma peralveata, Calliostoma philantropa var., Calliostoma aphelia, Panope goldfussi (all double and in living position), Ecphora quadricostata umbilicata, Mercenaria mercenaria, Urosalpinx cinerea, Lunatia hemicrypta. Sample 66-4-1, at 5' from base of unit.	
Total thickness of exposed Choptank Formation	17' 5"
(Covered interval undoubtedly concealing upper Calvert Beach Member and lower Drumcliff Member.)	4' 8"

Locality 66-5. 1600 Feet North of Harper's Creek.

0.9 mile south of Western Shores, Md. Calvert Cliffs on Chesapeake Bay, Calvert Co., Md. 38° 28' 43" N. Lat.; 76° 29' 21" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Conoy Member		
31	Lithology: Dark grayish-blue, very muddy, very fine sand. Outcrop weathers to very light gray. Lithology similar to unit 30 except with deletion of black ?organic specs and clay mottled structures. Lower contact gradational. Upper contact distinct, erosional top of Choptank Fmn. Fossils: None found. Sample 66-5-35 from 1' 0" to 2' 0" above base of unit.	3' 0"
30	Lithology: Dark grayish-blue, very	2' 0"

Unit		Thickness
	muddy, very fine sand. Outcrop weathers to very light gray. Includes black ?organic specs up to 1.0 cm. long. Irregular bedding highlighted by small black specs. Mottled by greenish-gray clay with some inclusions up to 3" long. Contacts gradational. Fossils: Calcareous macrofossils nearly absent. One small, unidentified mollusc fragment. Sample 66-5-34 from 1' 0" to 2' 0" above base of unit.	
29	Lithology: Dark grayish-blue, very muddy, very fine sand. No sedimentary structures seen. Outcrop weathers to light bluish-gray. Lower contact slightly undulating but distinct. Upper contact gradational. Fossils: Calcareous shells leached out but molds common. Random distribution. Faunal list: C-Discinisca lugubris, Lyropecten madisonius, N-Crenella gubernatoria, R-Yoldia laevis, Anodontia anodonta. Sample 66-5-33 from 0' 6" to 1' 6" above base of unit.	1' 6"
	Total thickness of exposed Conoy Member	6' 6"
Boston Cliffs Member		
28	Lithology: Yellowish-gray, slightly muddy, very fine sand. Weathers to "iron oxide" brown and forms a very hard ledge. Most resistant bed in this section. No apparent sedimentary structures. Lower contact distinct and slightly undulating. Upper contact distinct and slightly undulating. Fossils: None. Sample 66-5-32 from entire interval.	0' 9"
27	Lithology: Light-gray, poorly sorted, fine sand. Mottled slightly with darker fine sand. Lower contact gradational. Upper contact undulating. Bed in Boston Cliffs indurated series. Fossils: Calcareous shells all leached out. Molds only. Apparently only flat lying Lyropecten madisonius. Sample 66-5-31 from 0' 6" to 1' 6" above base of unit.	1' 6"

Unit		Thickness
26	Lithology: Grayish-olive slightly muddy, fine sand. Weathered surface indurated. No sedimentary structures. Lower contact undulating. Upper contact undulating. Fossils: Calcareous shells completely leached. Fauna all flat lying Lyropecten madisonius. Sample 66-5-30 from entire unit.	1' 0"
25	Lithology: Light-olive, slightly muddy, very fine sand. No sedimentary structures. Lower contact gradational and slightly undulating. Upper contact undulating. Weathers to a very resistant unit. Fossils: Within bed there is an undulating line between shells which have been leached and those which have not. Even those below line show some chemical deterioration. Fauna dominated by Lyropecten madisonius (both double and single valves). Also Balanus concavus and Crenella gubernatoria. Sample 66-5-29 from entire interval.	1' 0"
24	Lithology: Light olive-brown slightly muddy, very fine sand. Nonresistant outcrop unit. No sedimentary structures. Lower contact undulating. Upper contact gradational. Unit weathers to reddish brown. Fossils: Smaller shells protruding on weathered surface. Chemical deterioration very pronounced. Fragmentation common. Wear common. Random distribution and orientation. Faunal list: A-Lyropecten madisonius, C-Cerastoderma laqueata, Balanus concavus, N-Macrocallista marylandica, Anadara staminea, Corbula idonea, F-Turritella plebeia, Corbula inaequalis, R-Crucibulum costatum. Sample 66-5-28 from entire interval.	1' 0"
23	Lithology: Dark olive-brown, slightly muddy, fine sand. No bedding laminations. Lower contact gradational and undulating. Upper contact undulating and fairly distinct. Fossils: On weathered surface appears as a coarse shell unit. Some shells heavily worn, others not. Large shells	0' 6"

Unit		Thickness
	are flat lying and predominantly convex upward. Local concentrations of Lyropecten, Lyropecten and Crassostrea, or heterogeneous fauna. Faunal list: A-Lyropecten madisonius (some double valves), C-Crassostrea carolinensis, N-Cerastoderma laqueata, Corbula idonea (some double valves), Macrocallista marylandica, Anadara staminea, Balanus concavus. Sample 66-5-27 from entire unit.	
22	Lithology: Dark olive-brown, muddy, fine sand. Weathers to light brown with smaller shells appearing at surface than in unit 21. Mottled by yellowish-gray, moderately well sorted, fine sand (some pockets up to 9 cm. diameter). No bedding laminations. Contacts gradational and undulating. Fossils: Shells constitute approximately 30% of unit. Well preserved. Apparently random orientation. Numerous fragments. One thin, concentrated bed of larger bivalves at 1' 6" above base of unit. Faunal list: F-Macrocallista marylandica, Corbula idonea (some double valves), Lyropecten madisonius, Cerastoderma laqueata (some double valves), Balanus concavus, Astarte obruta, Dosinia acetabula, Ecphora quadricostata. Sample 66-5-26 from 1' 0" to 2' 0" above base of unit.	2' 3"
21	Lithology: Dark yellowish-brown, slightly muddy, fine sand. Mottles of yellowish-gray, moderately well sorted, fine sand. No sedimentary structures. Contacts gradational. Matrix better sorted than 2 lower units. Fossils: Coarse, heavy shell bed. No secondary chemical deterioration. Most shells appear randomly distributed but large shells (particularly Lyropecten and Macrocallista) are flat lying and most of these are with the convex surface upward. Concentrated thin beds of Anadara, Lyropecten, Macrocallista. Faunal list: A-Anadara staminea, C-Macrocallista marylandica, Lyropecten madisonius, N-Crassatella marylandica, Corbula idonea (some double valves), Astarte obruta, Dosinia acetabula,	1' 6"

Unit		Thickness
	R-Ecphora quadricostata umbilicata, Turritella plebeia var. A, Anodontia anodonta, Corbula inaequalis, Diplodonta acclinis, Astrhelia palmata (very worn). Sample: 66-5-25 from 0' 0" to 1' 0" above base of unit.	
20	Lithology: Dark olive-brown, muddy, fine sand. Mottled with yellowish-gray, moderately well sorted, fine sand. No bedding laminations. Contacts gradational. Fossils: Increase in size of shell size from unit 19. Shells are partially leached and stained by iron oxide. Shells appear to have had very little wear or fragmentation before chemical deterioration. Apparently random orientation and distribution. No articulated, double valves. Mollusc shells constitute approximately 30% of unit. Faunal list: A-Anadara staminea, C-Lyropecten madisonius, N-Dosinia acetabula, F-Balanus concavus, Astarte obruta, R-Anodontia anodonta, Cerastoderma laqueata, Macrocallista marylandica, Ecphora quadricostata. Sample 66-5-24 from entire interval.	1' 0"
19	Lithology: Dark olive-brown, poorly sorted, muddy, fine sand. Additionally, small lenses of yellowish-gray, well-sorted, fine sand, some of which appear to be small scour and fill structures. Some irregular, iron-stained mottles. Also a few irregular mottles of St. Leonard dark-blue, muddy, very fine sand. No bedding laminations. Outcrop expression shows break to a nearly vertical slope. Contacts gradational. Fossils: Abundant fossil molluscan shells. Minor amounts of leaching of shell material. Except for 2 to 3 inch bed of Anadara, random distribution. No preferred orientation. Faunal list: C-Lyropecten madisonius, Anadara staminea, N-Macrocallista marylandica, R-Lunatia heros. Sample 66-5-22 from entire unit.	1' 0"
	Total thickness of Boston Cliffs Member	11' 6"

Unit		Thickness
St. Leonard Member		
18	Lithology: As unit 17 except dark olive-brown mottlings more common. Additionally, small lenses of yellow-gray, well-sorted, fine to medium sand. Contacts gradational. Fossils: Shell fragments common. Some wood fragments. Probably many species of molluscs, but difficult to recognize from fragments. Fragments seem randomly arranged. Faunal list: F-Lyropecten madisonius, Anadara staminea. Sample 66-5-23 from entire unit.	1' 3"
17	Lithology: Dark-blue, somewhat muddy, very fine sand. (Less mud than St. Leonard beds below.) Dark olive-brown mottlings more common. Many mottled structures seem to have burrow morphology. Contacts gradational. Fossils: Calcareous macrofossils common but mostly fragments. Some shells partially leached. Species are difficult to identify. Small, rare Lyropecten madisonius. Sample 66-5-21 from entire unit.	1' 0"
16	Lithology: Dark-blue, muddy, very fine sand. Minor mottling of dark olive-brown, muddy, fine sand in pockets less than 1.5 cm. diameter. No bedding laminations. Contacts gradational. Fossils: Numerous unidentified molds as in unit 15. In addition, some very poorly preserved calcareous shells. Sample 66-5-19 from 0' 0" to 1' 0" above base of unit. Sample 66-5-20 from 2' 0" to 3' 0" above base of unit.	4' 0"
15	Lithology: Dark-blue, muddy, very fine sand. Minor mottling of dark olive-brown, muddy, fine sand in pockets less than 1.5 cm. diameter. No bedding laminations. Contacts gradational. Fossils: No calcareous shell material preserved. Numerous unidentified molds. Numerous phosphatic Discinisca lugubris. Sample 66-5-18 from 0' 0" to 1' 0" above base of unit.	2' 0"

Unit		Thickness
14	Lithology: Dark-blue, muddy, very fine sand. Minor mottling of dark olive-brown, fine sand in pockets less than 1.5 cm. diameter. No bedding laminations. Contacts gradational. Fossils: None. Sample 66-5-17 from 0' 0" to 1' 0" above base of unit.	2' 0"
13	Lithology: Dark-blue, muddy, very fine sand. Minor mottling of dark olive-brown, muddy, fine sand in pockets less than 1.5 cm. diameter. No bedding laminations. Contacts gradational. Fossils: No calcareous shell material preserved. Molds numerous but difficult to identify. ?Cerastoderma laqueata. Sample 66-5-16 from 0' 0" to 1' 0" above base of unit.	2' 0"
12	Lithology: Dark-blue, muddy, very fine sand. Weathered surface dark olive-brown. Weathered outcrop surface has prominent vertical fractures. No sedimentary structures, apparently homogeneous. Contacts gradational. Fossils: None seen. Sample 66-5-15 from 0' 0" to 1' 0" above base of unit.	2' 0"
11	Lithology: Dark-blue, muddy, very fine sand. Weathered outcrop surface has prominent vertical fractures. No apparent sedimentary structures. Contacts gradational. Fossils: No preserved calcareous shells. Molds common, however, of Yoldia laevis. Sample 66-5-14 from 0' 0" to 1' 0" above base of unit.	2' 0"
10	Lithology: Dark-blue, muddy, very fine sand. Weathered outcrop surface has prominent vertical fractures. No apparent sedimentary structures. Contacts gradational. Fossils: No preserved calcareous shells. A few molds. Only one identified, Ensis ensiformis. Sample 66-5-13 from 0' 0" to 1' 0" above base of unit.	2' 0"
9	Lithology: Dusky-blue, poorly sorted,	2' 6"

Unit		Thickness
	very muddy, very fine sand. No apparent sedimentary structures. Lower contact undulating. Upper contact gradational. Fossils: Macrofossils absent. A few molds of Cerastoderma laqueata and Anadara staminea. Sample 66-5-12 from 0' 6" to 1' 6" above base of unit.	
8	Lithology: Dusky yellow-green, poorly sorted, muddy, very fine sand. Color mottlings of grayish olive-green, yellowish-gray, and dusky red-dish-brown. Texture mottlings range from mud to fine sand. No bedding laminations. Contacts undulating. Fossils: Preserved shells absent. A few molds of ?Anodontia anodonta. Sample 66-5-11 from entire unit.	1' 0"
	Total thickness of St. Leonard Member	21' 9"
Drumcliff Member		
7	Lithology: Heterogeneous lithology. Mixture of dusky-olive, muddy, very fine sand and dark iron-brown, muddy, fine sand. More dusky-olive sand and less brown sand than in unit 6. No apparent sedimentary structures. Lower contact gradational. Upper contact undulating but distinct. Fossils: Shells well preserved. Random distribution except for occa-sional thin lenses of very densely packed Turritella. Approximately 25-40% of bed mollusc shells. Fauna strongly dominated by Glossus and Turritella, which must account for 98% of fauna. Faunal list: F1-Glossus fraternus marylandicus (with quantity of single valves about equal to quantity of double valves), Turritella plebeia, F-Cerastoderma laqueata, Lunatia heros, R-Corbula idonea, Lunatia hemicrypta. Additionally, pieces of wood. Sample 66-5-10 from 0' 0" to 1' 0" above base of unit.	1' 4"

Unit		Thickness
6	Lithology: Heterogeneous lithology. Mixing of dusky-olive, muddy, very fine sand with dark iron-brown, muddy, fine sand. Mottled. No bedding laminations. Lower contact quite undulating appearing as slight channeling. Upper contact gradational. Fossils: Nicely preserved mollusc shells. Wear almost nonexistent. Decrease in density of accumulation. Unit 6 is approximately 30 to 40% fossil mollusc shells. Abundant articulated, double valves. Faunal list: A-Turritella plebeia, C-Glossus fraternus marylandicus (double valves), Cerastoderma laqueata (double valves), N-Crassatella turgidula (double valves), Diplodonta acclinis (double valves), Astarte thisphila (double valves), Lyropecten madisonius, Lunatia heros, Lunatia hemicrypta, F-Anadara staminea, Venericardia granulata (double valves), R-Siphonalia devexa, Isognomon maxillata, Dosinia acetabula (double valves), Corbula idonea. Additionally, pieces of wood. Sample 66-5-9 from 0' 6" to 1' 6" above base of unit.	2' 6"
5	Lithology: Yellowish-gray, slightly muddy, fine sand. Some small lenses of very light-gray, well-sorted, fine to medium sand. Sorting grades upward to better sorting. Due to fantastic accumulation of shells no sedimentary structures can be seen. Lower contact gradational. Upper contact distinct, undulating, appearing to be scour and fill. Fossils: Tremendous accumulation with appearance of having been dumped. Extremely dense. Great range in sizes of shells. Many shells very well worn, in addition many well preserved. Abundant shell fragments. Average size of shells gradually increases upward.	4' 0"

Unit		Thickness
	Faunal list: A-Lyropecten madisonius, C-Turritella plebeia, Turritella plebeia var. A, Macrocallista maryLandica, Balanus concavus, Isognomon maxillata, F-Cardita protracta, Cruciblulum multilineatum, Mercenaria spp., Astarte thisphila, Cerastoderma laqueata, Lunatia heros, Lunatia hemicrypta, Corbula idonea, Lucinoma contracta, Anodontia anodonta, Martesia ovalis, Panope goldfussi, (double articulated valves and in living position), Panope americana (double, articulated valves and in living position), Diplodonta acclinis, Anadara staminea, Glossus fraternus marylandicus, Cadulus newtonensis, Mercenaria campechiensis capax, Mercenaria plena, Asaphis centenaria, Corbula inaequalis, Dosinia acetabula, Aligena aequata, Crassatella turgidula, Fissuridea griscomi, Abertella aberti. Sample 66-5-7 from 0' 6" to 1' 6" above base of unit. Sample 66-5-8 from 2' 6" to 3' 6" above base of unit.	
	Total thickness of Drumcliff Member	7' 10"
Calvert Beach Member		
4	Lithology: Olive-gray, slightly muddy, fine sand. First bed above vertical break in slope of outcrop. Easily distinguished from bed above, which is dry on the surface, by being quite wet. Heavily burrowed unit with burrows filled with shell hash. Lower contact gradational but designated at break to larger shell fragments. Upper contact gradational to layer shell sizes but on weathered surface placed at water line. Fossils: Predominantly shell filling of burrows. Shell material from Drumcliff Member above. Shell material grades in size from smaller at base of unit to larger at top. Wear on shells common.	2' 0"

Unit		Thickness
	Fragmentation of shells common. Articulated, double valves rare. Most fragments not identified. Shells 50 to 75% of bed. Faunal list: R-Astarte thisphila, Lyropecten madisonius, Turritella plebeia. Sample 66-5-6 from 0' 9" to 1' 9" above base of unit.	
3	Lithology: Dusky olive-gray, muddy, very fine sand. No apparent sedimentary structures. Lower contact gradational. Upper contact gradational. Burrowing intense. Fossils: This unit is highly burrowed. Burrows filled with shell hash mixed in burrow from above. Approximately 30% of unit is shell hash, all pieces less than 2 cm. Size and number of shell fragments grading upward in unit. No species identified. Sample 66-5-5 from 0' 0" to 1' 0" above base of unit.	1' 0"
2	Lithology: As unit 1, except: 1) burrows are longer (average 2.0 to 3.0 cm., 2) most burrows contain concentrated shell hash, and 3) shell filled burrows increase from base of unit upward. Fossils: Abundant shell hash in burrows. Rare Lyropecten madisonius. Sample 66-5-3 from 0' 0" to 1' 0" above base of unit. Sample 66-5-4 from 2' 0" to 3' 0" above base of unit.	4' 0"
1	Lithology: Very dusky blue-green, muddy, very fine sand. Contains thin clay stringers (average about 2 cm. thick) laterally continuous at least a few hundred feet. Also a few discontinuous clay stringers. Many interesting sedimentary structures, including multi-walled, slime-lined, bivalve burrows, possible polychate burrow, other burrows of unknown affinity, mottles, distorted laminations, and scour and fill structures. Nearly all	3' 6"

Unit	Thickness
burrows range in diameter from 1.5 to 2.0 cm. Lower contact covered. Upper contact gradational and rather arbitrary. Fossils: Macrofossils extremely scarce fragments and unidentified. A few very small bivalves. Sample 66-5-2 from 1' 6" to 2' 6" above base of unit.	
Total thickness of exposed Calvert Beach Member	10' 6"
Total thickness of exposed Choptank Formation	58' 1"

Locality 66-6. Matoaka Cottages.

0.3 mile north of Calvert Beach, Md. Calvert Cliffs on Chesapeake Bay, Calvert Co., Md. 38° 28' 21" N. Lat.; 76° 28' 58" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Boston Cliffs Member		
17	Lithology: Light orangish-brown, muddy, fine sand. Mottled by iron oxide color streaks. No other apparent sedimentary structures. Lower contact gradational. Upper contact distinct. Fossils: Sparse. Calcareous shell material all leached. Random orientation and distribution. Species not identified. No sample.	1' 0"
16	Lithology: Light orangish-brown, muddy, fine sand. Rather unique base for Boston Cliffs Member which is usually gradational from St. Leonard Member. No apparent sedimentary structures. Lower contact distinct and quite sharp. Upper contacts gradational. Fossils: Very jumbled with fragmentation common. Random orientation and distribution. Dense	1' 0"

Unit		Thickness
	accumulation. Faunal list: Lyropecten madisonius, Crassostrea carolinensis, Balanus concavus, Mytilus conradinus, Crucibulum costatum, Anadara staminea, Cardita protracta, Discinisca lugubris, and bryozoans. Sample 66-6-23 from entire interval.	
	Total thickness of exposed Boston Cliffs Member	2' 0"
St.	Leonard Member - Type Section	
15	Lithology: Dusky greenish-blue, very muddy, very fine sand. With fairly big mottles and lenses of very light gray, well-sorted, fine sand. Lower contact gradation. Upper contact distinct and fairly straight. Fossils: Mottles probably result of bivalve burrowing. Some burrows also contain concentrated shell hash. Other fossils random orientation and distribution. Faunal list: C-Mytilus conradinus, N-Balanus concavus, F-Turritella plebeia var. A. Sample 66-6-21 from 0' 6" to 1' 6" above base of unit. Sample 66-6-22 from 1' 6" to 2' 6" above base of unit.	4' 0"
14	Lithology: Dusky greenish-blue, very muddy, very fine sand. Mottled by dusky-green clay and pale yellowish-brown, slightly muddy, fine sand. Lower contact gradational. Upper contact gradational to different fauna and increase in fauna. Fossils: Distinct increase in number of shells but still not a prolific accumulation. Some thin, undulating beds of thin shelled molluscs (Mytilus conradinus) but random distribution and orientation of other shells. Faunal list: VC-Mytilus conradinus, C-Discinisca lugubris, bryozoans, N-Lyropecten madisonius, Cerostoderma laqueata, Crucibulum multilineatum, R-Cardita protracta.	6' 0"

Unit		Thickness
	Sample 66-6-18 from 0' 6" to 1' 6" above base of unit. Sample 66-6-19 from 2' 6" to 3' 6" above base of unit. Sample 66-6-20 from 4' 6" to 5' 6" above base of unit.	
13	Lithology: Dusky greenish-blue, very muddy, very fine sand. Mottled by dusky-green clay and pale yellowish-brown, slightly muddy, fine sand. Contacts gradational. Fossils: Sparse. Well preserved. Small fossils and small fragments. Ransom distribution and orientation. Faunal list: N-Ensis ensiformis, Yoldia laevis, F-Cerastoderma laqueata, R-Mytilus conradinus, Balanus concavus, Anadara staminea. Sample 66-6-16 from 0' 6" to 1' 6" above base of unit. Sample 66-6-17 from 2' 6" to 3' 6" above base of unit.	4' 0"
12	Lithology: Dusky-blue, very muddy, very fine sand. No apparent sedimentary structures. Contacts gradational. Fossils: Sparse. Well preserved. Random distribution and orientation. All disarticulated. Faunal list: C-Ensis ensiformis, Yoldia laevis, N-Cerastoderma laqueata, Anadara staminea. Sample 66-6-15 from 0' 6" to 1' 6" above base of unit.	2' 0"
11	Lithology: Dusky greenish-blue, very muddy, very fine sand. No apparent sedimentary structures. Contacts gradational. Fossils: Sparse. Well preserved. Nearly all disarticulated. Faunal list: C-Discinisca lugubris, N-Crassatella turgidula, R-Mercenaria sp., Cadulus newtonensis, Ensis ensiformis, Corbula idonea, Lyropecten madisonius, Anadara staminea, Lucinoma contracta.	2' 0"

Unit		Thickness
	Sample 66-6-14 from 0' 6" to 1' 6" above base of unit.	
10	Lithology: Heterogeneous. Main lithology brownish-olive, muddy, fine sand. Mottled by dusky blue-green, very muddy, very fine sand. Latter lithology increasing toward top of unit and grading into it. Additional rare inclusions of very light gray, well sorted, fine sand. Possibly some poorly defined, irregular, color-bedding laminations. Lower contact undulating but distinct. Upper contact undulating and somewhat gradational. Fossils: Somewhat sparse. Some may be reworked from Drumcliff Member below. Faunal List: N-Dosinia acetabula (nearly all double valves and increasing in abundance toward top of unit), Lucinoma contracta (nearly all double valves), F-Anadara staminea (in small pocket, possibly reworked from Drumcliff Member), R-Discinisca lugubris, Corbula idonea, Glossus fraternus marylandicus, Crassatella marylandica, Cerastoderma laqueata. Sample 66-6-13 from entire interval.	1' 3"
	Total thickness of St. Leonard Member	19' 3"
Drumcliff Member		
9	Lithology: Brownish-gray, muddy, fine sand. Rare small lenses of well-sorted, medium sand. One Panope americana, double valved and in living position filled with second lithology. No bedding laminations. Lower contact undulating strongly. Upper contact undulating slightly. Unit almost appears to pinch out in places. Fossils: Very well preserved shells. Many double valves. Slight tendency for localized pockets. Fauna strongly dominated by Anadara and Astarte. Faunal list: A-Anadara staminea	0' 8"

Unit		Thickness
	(some doubles), VC-Astarte thisphila (more double valves than single, dissociated valves), F-Glossus fraternus marylandicus (more double valves than single, dissociated valves); R-Panope americana (all double valves, oriented in living position). Sample 66-6-12 from entire interval.	
8	Lithology: Dusky-blue, muddy, fine sand. No sedimentary structures. Contacts undulating. Fossils: Shells excellently preserved. Bivalves predominantly double valves. Fauna dominated by Glossus fraternus marylandicus. Fauna not very diverse. Faunal list: VC-Glossus fraternus marylandicus (double valves and single, dissociated valves approximately equal in number), C-Turritella plebeia, N-Cerastoderma laqueata, Astarte thisphila. Sample 66-6-11 from entire interval.	0' 10"
7	Lithology: Very pale orange, well-sorted, fine sand. Color mottled pale yellowish-brown. Thickness varies from 0' 0" to 0' 6". Contacts undulating. Fossils: None. Sample 6-610 from entire interval.	0' 6"
6	Lithology: Heterogeneous lithology. Very dark yellowish-brown, muddy, fine sand. Dusky brownish-blue, poorly sorted, muddy, very fine sand. Very pale orange, well-sorted, fine sand. Bed thickness distinctly varies within short distances. Mottles of different sediment textures and colors. No bedding laminations. Lower contact undulating. Upper contact undulating. Fossils: Heterogeneous distributions. Well preserved. Bed contains wood fragments all less than 3.0 cm. long.	0' 11"

Unit		Thickness
	Three main "end member" distributions: 1) Beds up to 10.0 cm. thick of extremely dense Turritella plebeia but varying greatly in thickness, even pinching out entirely. Contacts undulating considerably; 2) Faunas strongly dominated by Glossus fraternus marylandicus and Turritella plebeia. Thickness and corresponding preserved variable; 3) Very excellently preserved shells, some with remnants of the original hinge ligament, most bivalves with double, articulated valves. Thickness and corresponding lithology variable. Fauna: C-Glossus fraternus marylandicus, Turritella plebeia, Corbula idonea, Cerastoderma laqueata, F-Crassatella turgidula, N-Lunatia heros, R-Scaphella typus, and an unidentified Lucinid. Sample 66-6-9 from entire interval.	
5	Lithology: Pale yellowish-gray, moderately well sorted, fine sand. But with occasional pebble size quartz grains. No sedimentary structures. Lower contact gradational. Upper contact distinct and undulating. Fossils: Extremely dense. Wear and fragmentation fairly common. Random orientation of all except Panope which always occurs in living position and Lyropecten madisonius near the center of the unit where large valves are flat lying. Seems to be a general gradation to larger shells and fragments from base of unit to central area followed by a gradational decrease in size toward top of unit. Very diverse fauna with no faunal domination by a single or a few species. Faunal list: Snails - Turritella plebeia, Lunatia heros, Crucibulum multilineatum, Crucibulum costatum, Lunatia hemicrypta, Ecphora quadricostata umbilicata, Vermetus graniferus, Scaphella typus, Siphonolia	6' 0"

Unit		Thickness
	devexa, Urosalpinx cinerea, Turbonilla gubernatoria, Lunatia duplicata, Calliostroma aphelia, Calliostoma philanthropa, Teinostoma calvertense, Fissuridea griscomi, Caecum patuxentium, Pleurotoma choptankensis, Nassarius sp.; Bivalves - Lyropecten madisonius, Venericardia granulata, Glossus, fraternus marylandicus, Crassatella turgidula, Anadara staminea, Corbula idonea, Dosinia acetabula, Cerastoderma laqueata, Anodontia anodonta, Macrocallista marylandica, Isognomon maxillata, Asaphis centenaria, Astarte thisphila, Mercenaria plena, Mercenaria mercenaria, Mercenaria campechiensis capax, Nucula proxima, Yoldia laevis, Atrina harrisi, Cardita protracta, Lucinoma contracta, Lucina crenulata, Diplodonta subvexa, Aligena aequata, Apolymetis biplicata, Gari gubernatoria, Ensis ensiformis, Hiatella arctica, Panope americana, Anomia aculeata, Callocardia (Agriopoma) subnasuta, Mytilus conradinus, Semele subovata, Spisula subparilis, Panope goldfussi. Miscellaneous - Astrhelia palmata, Balanus concavus. Sample 66-6-6 from 0' 6" to 1' 6" from base of unit. Sample 66-6-7 from 2' 6" to 3' 6" from base of unit. Sample 66-6-8 from 4' 6" to 5' 6" from base of unit.	
4	Lithology: Olive-brown, muddy, fine sand. Weathers to pale yellowish-brown. Small lenses of very pale orange, well-sorted, fine sand with lenses less than 4 cm. No bedding laminations. Outcrop forms steeper slope than units above and below. Lower contact subtle, marked by 2 mm. Iron-oxide stained fine sand. Upper contact gradational. Fossils: Dense accumulation. All shells less than 4 cm. Fragmentation common. Wear common. Articulation common in small individuals but not in large ones. Many fragments not	0' 11-1/4"

Unit		Thickness
	easily identified. Partial Faunal List: N-Astarte thisphila, Turritella plebeia, Isognomon maxillata, Crucibulum multilineatum, Balanus concavus, Lyropecten madisonius, Turritella plebeia var. A, Lunatia heros. Sample 66-6-5 from entire bed.	
	Total thickness of Drumcliff Member	9' 10-1/4"
Calvert Beach Member		
3	Lithology: Bluish olive-green, muddy, fine sand. Weathers to pale yellowish-brown. Rare small lenses of very pale orange, well-sorted, fine sand, with lenses less than 4 cm. No bedding laminations. Lower contact gradational. Upper contact subtle 2 mm. iron-oxide stained, fine sand. Fossils: All shells less than 2 cm. Most fragments. Wear common. Apparent random distribution. Fragments not identified. Identified mollusks are Turritella plebeia and Astarte thisphila. Sample 66-6-3 from upper 0' 6" of unit 3 and bottom 0' 6" of unit 4. Sample 66-6-4 from 0' 6" to 1' 4" above base of unit.	1' 4"
2	Lithology: Dark grayish-blue, muddy, fine sand. Mottled by dark greenish-yellow mud. Lower contact gradational but marked by break to more vertical slope. Upper contact gradational. Fossils: Fragments concentrated in burrows. Little wear on shell fragments. All shells and fragments less than 2.0 cm. Most fragments near sides of burrows are parallel to the walls; most fragments near center of burrows are perpendicular to the walls. No fragments identified. Sample 66-6-2 from 0' 3" to 1' 0" above base of unit.	2' 0"
1	Lithology: Dark grayish-blue, muddy, fine sand. No bedding laminations.	1' 8"

Unit	Thickness
Mottled by grayish blue-green clay. Lower contact covered. Upper contact gradational. Fossils: Macrofossils scarce. Rare concentrated pockets of shell fragments which may be biogenic concentrations. No complete burrow profile seen. Shell concentrations are generally round and contain grayish blue-green clay as the mottles. No fragments identified. Sample 66-6-1 from 0' 6" to 1' 4" above base of unit.	
Total thickness of exposed Calvert Beach Member	5' 0"
Total thickness of exposed Choptank Formation	36' 1-1/4"

Locality 66-7. Flag Ponds Cliffs I.

First long line of cliffs south of Flag Ponds. 1.5 mile southeast of Long Beach, Md. Calvert Cliffs on Chesapeake Bay, Calvert Co., Md. 38° 26' 29" N. Lat.; 76° 27' 01" W. Long. Population statistics only at this locality. No measured section.

Locality 66-8. Grover Creek.

First cliff along Chesapeake Bay southeast of Grover Creek. 0.1 mile southeast of Camp Baybreeze (G.S.A.) 2.5 miles east southeast of Lusby, Md. Calvert Cliffs along the Chesapeake Bay, Calvert Co., Md. 38° 24'20" N. Lat.; 76° 24' 38" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated) St. Marys Formation Choptank Formation Conoy Member		
6	Lithology: Dusky greenish-blue, very muddy, very fine sand. Continuous, parallel, thin bedding laminations. Bed thickness varies from 1" to 6". Lower contact sharply undulating and very strikingly distinct. Upper contact distinct. Fossils: Very sparse. Only molds. Random orientation and distribution. Faunal list: F-Turritella plebeia, R-Yoldia laevis. Sample 66-8-7 from 0' 6" to 1' 6" above base of unit. Sample 66-8-8 from 3' 0" to 4' 0" above base of unit. Sample 66-8-9 from 5' 6" to 6' 6" above base of unit. Sample 66-8-10 from 8' 0" to 9' 0" above base of unit.	10' 6"
Boston Cliffs Member		
5	Lithology: Very dusky red, poorly sorted, fine sand. Heavily oxidized. Indurated. Lower contact undulating and distinct. Upper contact sharply undulating and very strikingly distinct. Fossils: None seen. Sample 66-8-6 from entire interval.	0' 8"
4	Lithology: Dark reddish-brown, muddy, fine sand. Strongly iron oxide stained. Small mottles of light gray clay. Lower contact straight and distinct. Upper contact undulating and distinct. Fossils: All calcareous shells leached out. Molds of large flat lying bivalves. Molds difficult to identify. Cerastoderma laqueata abundant. Sample 66-8-5 from entire interval.	1' 0"
3	Lithology: Light orangish-brown, slightly muddy, well-sorted, fine sand. No bedding laminations. Mottles of very pale orange, well-	0' 8"

Unit		Thickness
	sorted, fine sand. Lower contact slightly undulating and slightly gradational. Upper contact straight and distinct. Fossils: Increased macrofossil bed with many flat-lying, large bivalves. Turritella concentrated very densely in a 2.0" bed. Smaller bivalves tend more toward random distribution and orientation. Except for Turritella concentrated bed, fauna strongly dominated by bivalves, Faunal list: Fl-Turritella plebeia, A-Macrocallista marylandica, Cerastoderma laqueata, F-Dosinia acetabula, Anadara staminea, Balanus concavus, R-Astarte thisphila. Sample 66-8-4 from entire interval.	
2	Lithology: Light orangish-brown, slightly muddy, fine sand. Some color mottles to brighter oranges and darker browns. Also small lenses of very pale orange, well-sorted, fine sand. No bedding laminations. Contacts slightly undulating and slightly gradational. Fossils: Reduced macrofossil bed-reduced in quantity of macrofossils and drastically reduced size as a result of near elimination of larger bivalves. Apparently random orientation and distribution. Fauna strongly dominated by bivalves. Low faunal diversity. Faunal list: N-Anadara staminea, Cerastoderma laqueata, F-Macrocallista marylandica, Corbula idonea, Dosinia acetabula, R-Lyropecten madisonius. Sample 66-8-3 from entire interval.	1' 3"
1	Lithology: Light orangish-brown slightly muddy, fine sand. Lenses of very pale orange, well-sorted, fine sand less than 5.0 cm. No bedding laminations. Lower contact covered. Upper contact slightly undulating and slightly gradational.	1' 9"

Unit		Thickness
	Fossils: Increased macrofossil bed with many flat lying large bivalves. Prolific unit. Little wear or fragmentation. Large bivalves (Macrocallista, Lyropecten, and Cerastoderma) are the prominent fossils and the ones most consistently flat lying, convex upward. Smaller shells tend to be more random in orientation. Bivalves strongly dominate the fauna. Relatively low faunal diversity. Faunal list: A-Macrocallista marylandica, Lyropecten madisonius, VC-Cerastoderma laqueata, Anadara staminea, N-Dosinia acetabula, F-Balanus concavus, R-Turritella plebeia var. A. Sample 66-8-2 from 0' 6" to 1' 6" above base of unit.	
	Total thickness of exposed Boston Cliffs Member	5' 4"
	Total thickness of exposed Choptank Formation	15' 10"

Locality 66-9. 1/4 Mile Northwest of Morans Creek and 0.6 Mile Southeast of Camp Conoy (Y.M.C.A.).

1 3/4 miles northeast of Lusby, Md. Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 25' 24" N. Lat.; 75° 25' 38" W. Lat.

Unit		Thickness
St. Marys Formation	Base of formation marked by thin, undulating lenses of very light-gray, well-sorted, fine sand. That is followed by very dark greenish-brown, very muddy, very fine sand.	
Choptank Formation Conoy Member 14	Lithology: Dark greenish-blue, very muddy, very fine sand. Mottled by dusky-blue, very muddy, very fine	3' 0"

Unit		Thickness
	sand. Continuous, parallel, thin bedding laminations. Lower contact gradational. Upper contact distinct. Fossils: None seen. Sample 66-9-19 from 0' 6" to 1" 6" above base of unit.	
13	Lithology: Dusky-blue, very muddy, very fine sand. Continuous, parallel, thin laminations. Thick bedded. Contacts gradational. Fossils: All molds. No calcareous material seen. Fairly dense accumulation of Turritella plebeia. Sample 66-9-17 from 0' 6" to 1' 6" above base of unit. Sample 66-9-18 from 2' 6" to 3' 6" above base of unit.	4' 0"
12	Lithology: Dusky-blue, very muddy, very fine sand. Continuous, parallel, thin laminations. Thick bedded. Lower contact very distinct. Upper contact gradational. Fossils: Very rare molds. No calcareous material seen. Small Cerastoderma laqueata only fossils seen. Sample 66-9-13 from 0' 6" to 1' 6" above base of unit. Sample 66-9-14 from 2' 6" to 3' 6" above base of unit. Sample 66-9-15 from 4' 6" to 5' 6" above base of unit. Sample 66-9-16 from 5' 6" to 6' 6" above base of unit.	7' 0"
	Total thickness of exposed Conoy Member	14' 0"
Boston Cliffs Member		
11	Lithology: Dusky-yellow, poorly sorted, fine sand. Heavily oxidized. Variable oxidation causes variable coloration. Very resistant ledge. Most prominent ledge in section. No bedding laminations. Lower contact undulating. Upper contact slightly undulating and strikingly distinct.	5' 0"

Unit		Thickness
	Thin stringers of well-sorted, fine sand within this unit produce thin non resistant beds. Fossils: Prolific molds and casts. Calcareous material all leached out. Predominantly flat-lying large bivalves. Faunal list: F1-Lyropecten madisonius, C-Cerastoderma laqueata, N-Balanus concavus. Sample 66-9-11 from 0' 6" to 2' 0" above base of unit. Sample 66-9-12 from 2' 3" to 3' 0" above base of unit.	
10	Lithology: Reddish-brown, fairly well sorted, fine sand. Heavily oxidized. Less resistant than unit 9. No apparent sedimentary structures. Contacts slightly undulating. Fossils: Dense accumulation of molds and casts. All calcareous material leached out. Flat-lying scallops predominate. Faunal list: A-Lyropecten madisonius, N-Cerastoderma laqueata, F-Ecphora quadricostata umbilicata. Sample 66-9-10 from 0' 3" to 1' 0" above base of unit.	1' 9"
9	Lithology: Reddish-brown, poorly sorted, muddy, very fine sand. Heavily oxidized with variable staining causing color variations with reds, oranges, and browns. No apparent bedding structures. Contacts undulating. Forms indurated ledges. Fossils: Molds and casts bed. All calcareous material leached out. Fauna of large flat-lying bivalves. Faunal list: VC-Lyropecten madisonius, C-Cerastoderma laqueata, N-Dosinia acetabula, Macrocallista marylandica. Sample 66-9-9 from 0' 6" to 1' 0" above base of unit.	1' 0"
8	Lithology: Pale yellowish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts	1' 9"

Unit		Thickness
	broadly undulating. Fossils: Jumbled bed. Has appearance of having been dumped in. Random distribution and orientation except for flat-lying large Lyropecten. Fragments abundant. Wear common. Dense accumulation. Faunal list: VC-Crassostrea carolinensis, C-Lyropecten madisonius, Cerastoderma laqueata, N-Anadara staminea, F-Astarte obruta, Turritella plebeia. Sample 66-9-8 from 0' 6" to 1' 6" from base of unit.	
7	Lithology: Pale yellowish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts slightly gradational and broadly undulating. Fossils: Increased macrofossil bed-increased in number of large bivalves. Large bivalves show strong tendency to be flat-lying. Only small amount wear and fragmentation. Prolific accumulation of shells. Fauna predominantly bivalves. Low faunal diversity. Faunal list: A-Cerastoderma laqueata, N-Macrocallista marylandica, F-Lyropecten madisonius, Astarte obruta, Turritella plebeia. Sample 66-9-7 from 0' 3" to 1' 3" above base of unit.	1' 6"
6	Lithology: Pale yellowish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts slightly gradational and broadly undulating. Fossils: Reduced macrofossil bed. Few large bivalves. The few large bivalves are all flat-lying. One thin bed (up to 10.0 cm. thick) of concentrated Anadara staminea. Low faunal diversity. Fragments present but not predominant. Some specimens well worn, others well preserved. Faunal list: F1-Anadara staminea	2' 3"

Unit		Thickness
	(about half as many double valves as single valves), N-Lyropecten madisonius, F-Balanus concavus, Turritella plebeia var. A., Macrocallista marylandica, Astarte obruta. Sample 66-9-5 from 0' 0" to 1' 0" above base of unit.	
5	Lithology: Pale yellowish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts slightly gradational and broadly undulating. Fossils: Increased macrofossil bed-increased in number of fossils and in numbers of large bivalves. Wear very pronounced in a few specimens but most in good shape. Fragmentation moderate. Random distribution except for thin concentrated bed of Anadara staminea. Large bivalves predominantly flat lying, convex upward. Faunal list: VC-Anadara staminea (many double valves), C-Macrocallista marylandica (some double valves), N-Cerastoderma laqueata, F-Mercenaria plena (some double valves), Dosinia acetabula, R-Astarte obruta, Turritella variabilis alticostata. Sample 66-9-6 from entire interval.	1' 0"
4	Lithology: Pale yellowish-brown, slightly muddy, fine sand. Mottles of very pale-orange, well-sorted, fine sand. Contacts slightly gradational and broadly undulating. Fossils: Relatively common but a reduced macrofossil bed compared to units 5 and 7. The few larger macrofossils present are predominantly flat lying, convex upward. Faunal list: C-Anadara staminea, Balanus concavus, F-Macrocallista marylandica, Lyropecten madisonius, R-Ecphora quadricostata umbilicata, Glossus fraternus marylandicus. Sample 66-9-4 from 0' 6" to 1' 6" above base of unit.	1' 6"

Unit		Thickness
3	Lithology: Dark olive-brown, slightly muddy, fine sand. Lenses of pale-orange, fairly well sorted, fine sand up to 25.0 cm. in length. Lower contact gradational and undulating. Upper contact gradational and undulating. Fossils: Few but gradationally increasing upward. Random orientation. Faunal list: N-Anadara staminea, F-Macrocallista marylandica, Lyropect-madisonius, Crassostrea carolinensis, Balanus concavus. Sample 66-9-3 from 0' 2" to 0' 8" above base of unit.	1' 0"
	Total thickness of Boston Cliffs Member	16' 9"
St. Leonard Member		
2	Lithology: Dusky-blue, very muddy, very fine sand. Mottles of pale yellowish-brown, fairly well sorted, fine sand fairly common and gradationally increase from base of unit upward. Contacts gradational. Fossils: Increase of shell material over unit 1 but still sparse. Fossils constitute possibly 5% of unit. Random orientation and distribution. Faunal list: N-Balanus concavus, F-Macrocallista marylandica, Turritella plebeia var. A.	1' 0"
1	Lithology: Dusky-blue, very muddy, very fine sand. Rare brown color-mottles of less than 2.0 cm. No other sedimentary structures. Lower contact covered. Upper contact gradational. Fossils: Few small fossils and small pieces. Fossil shells constitute approximately 1 to 2% of the unit. Apparently random distribution and orientation. Faunal list: F-Balanus concavus, R-Lyropecten madisonius. Sample 66-9-1 from 0' 6" to 1' 3" above base of unit.	1' 6"
	Total thickness of exposed	

Unit	Thickness
St. Leonard Member	2' 6"
Total thickness of exposed Choptank Formation	33' 3"

Locality 66-10. 0.45 Mile Northwest of Morans Creek and 0.35 Mile Southeast of Camp Conoy (Y.M.C.A.).

1.75 mile northeast of Lusby, Md. Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 25' 39" N. Lat.; 76° 25' 47" W. Long.

Unit		Thickness
Choptank Formation (Covered)		
St. Leonard Member		
7	Lithology: Dark olive-brown, muddy, fine sand. Mottled by reddish-brown, muddy, fine sand. No bedding laminations. Lower contact gradational and undulating. Upper contact covered. Fossils: More abundant than previous units but still only about 5% of unit. Macrofossils mostly unidentifiable fragments. Apparently random orientation and distribution. Partial faunal list: F-Anadara staminea, Cerastoderma laqueata. Sample 66-10-7 from 0' 0" to 1' 0" above base of unit.	2' 0"
6	Lithology: Mottled heterogeneous lithology. Approximately 80% of unit -- moderate yellowish-brown, muddy, fine sand. Approximately 10% of unit -- dark-blue, very muddy, very fine sand. Some irregular, wavy bedding laminations. Contacts gradational. Fossils: A few unidentified fragments. Apparently random orientation and distribution. Sample 66-10-6 from 0' 6" to 1' 6" above base of unit.	2' 0"

Unit		Thickness
5	Lithology: Mottled heterogeneous lithology. Approximately 50% of unit dark-blue, very muddy, very fine sand. Approximately 40% of unit - moderate yellowish-brown, muddy, fine sand. Approximately 10% of unit - very pale-orange, well-sorted, fine sand. Some faintly defined irregular, wavy bedding. Contacts gradational. Fossils: No macrofossils. Samples 66-10-5 from 0' 6" to 1' 6" above base of unit.	2' 0"
4	Lithology: Dark-blue, very muddy, very fine sand. Mottles of very light bluish-gray, well-sorted, medium sand probably the result of biogenic activity. Some oxidation around mottles. Contacts gradational. Fossils: No macrofossils. Sample 66-10-4 from 0' 6" to 1' 6" above base of unit.	2' 0"
3	Lithology: Dark-blue, very muddy, very fine sand. No bedding laminations. Rare, thin, dark-blue clay lenses. For most part seems structureless. Lower contact undulating and marked by 3.0 mm. oxidized band in unit 2. Upper contact gradational. Fossils: Very rare fragments. No species identified. Apparent random distribution and orientation. Sample 66-10-3 from 0' 6" to 1' 6" above base of unit.	2' 0"
2	Lithology: Dark-blue, very muddy, very fine sand. Thickness varying from 0' 9" to 2' 0". Weathers to greener color than superjacent bed. Some subtly defined irregular wavy bedding laminations. Burrowing extensive. All vertical or close to vertical burrows. All burrows approximately 2.0 cm. in diameter and constant in thickness. Some burrows with flat-lying, irregularly spaced laminae. Distance between laminae varies from	1' 6"

Unit		Thickness
	1.0 mm. to 20.0 mm. No particular organism in obvious association with these biogenic structures. Lower contact with slight local undulations but distinct. Upper contact undulating and marked by 3.0 mm. oxidized band. Fossils: A few mollusc shells in thin discontinuous beds. A non-prolific bed. Faunal list: F-Ensis ensiformis, Diplodonta acclinis, Turritella plebeia var. A.	
	Total thickness of exposed St. Leonard Member	11' 6"
Drumcliff Member		
1	Lithology: Dusky greenish-blue, very muddy, very fine sand. No bedding laminations. Lower contact covered. Upper contact distinct but slightly undulating. Outcrop expression is a fairly resistant unit at the base of the cliffs. Some local indurations helps hold the resistant slope. Fossils: Dense accumulation. Shells very abundant throughout but much more so in inverted cone-shaped shafts (see pl. 26, fig. 2) probably produced by crab burrowing. Largest shells are predominantly flat-lying but around and in ?burrows orientation is more random. Wear and fragmentation present but not common. High faunal diversity. Faunal list: A-Lyropecten madisonius, Isognomon maxillata, Cerastoderma laqueata, C-Ecphora quadricostata, Corbula idonea (some double valves), Balanus concavus, Turritella plebeia, N-Astarte thisphila, Anadara staminea, Martesia ovalis, F-Crassatella turgidula, Glossus fraternus marylandicus, Lunatia heros, Lithophaga ionensis, R-Asaphis centenaria, Dosinia acetabula, Siphonalia devexa,	1' 6"

Unit		Thickness
	Abertella aberti, Calliostoma philanthropa. Numerous pieces of wood. Sample 66-10-1 from entire bed.	
	Total thickness of exposed Choptank Formation	13' 0"

Locality 66-11. 0.25 Mile Southeast of Camp Conoy (Y.M.C.A.).

0.55 mile northwest of Morans Creek. 1.75 mile northeast of Lusby, Md. Calvert Cliffs along the Chesapeake Bay, Calvert Co., Md. 38° 25' 38" N. Lat.; 76° 25' 51" W. Long.

Unit		Thickness
St. Marys Formation	Unconformity marked by thin lenses of very light gray, well-sorted, fine sand.	
Choptank Formation		
Conoy Member		
16	Lithology: Dusky-blue, very muddy, very fine sand. Thin, parallel, bedding laminations. Thick-bedded. Lower contact very abrupt. Upper contact distinct. Fossils: Very rare. Only molds. Random distribution and orientation. Lyropecten madisonius the only identified species. Sample 66-11-18 from 1' 0" to 2' 0" above base of unit. Sample 66-11-19 from 3' 0" to 4' 0" above base of unit. Sample 66-11-20 from 5' 0" to 6' 0" above base of unit. Sample 66-11-21 from 7' 0" to 8' 0" above base of unit. Sample 66-11-22 from 9' 0" to 10' 0" above base of unit. Sample 66-11-23 from 11' 0" to 12' 0" above base of unit.	13' 6"
Boston Cliffs Member		
15	Lithology: Dark yellowish-orange,	3' 0"

Unit		Thickness
	poorly sorted, very muddy, fine sand. Heavily oxidized. Difficult to distinguish any sedimentary structures. Lower contact undulating. Upper contact undulating and strikingly distinct. Fossils: Decrease in number. Heavy leaching has left molds and casts. Random distribution. Large bivalves flat lying. Faunal list: C-Lyropecten madisonius, N-Cerastoderma laqueata, F-Ecphora quadricostata. Sample 66-11-17 from 1' 0" to 2' 0" above base of unit.	
14	Lithology: Moderate greenish-yellow, poorly sorted, fine sand. Weathers to reddish-brown. Indurated. Heavily oxidized. Difficult to distinguish any sedimentary structures. Contacts undulating. Fossils: Prolific accumulation but most are molds and casts. Abundant, large, flat-lying bivalves. Shells strongly leached and stained. Fauna predominantly Lyropecten madisonius and Balanus concavus. Sample 66-11-16 from 0' 6" to 1' 6" above base of unit.	2' 0"
13	Lithology: Yellowish-orange, muddy, fine sand. Mottled by light-gray clay which is indurated. No bedding laminations. Lower contact undulating. Upper contact strongly undulating. Fossils: Prolific accumulation but heavily leached. Fragmentation common. Large, flat-lying shells very abundant. Faunal list: F1-Lyropecten madisonius, A-Cerastoderma laqueata, N-Balanus concavus, F-Ecphora quadricostata. Sample 66-11-15 from 0' 6" to 1' 6" above base of unit.	2' 6"
12	Lithology: Reddish-brown, slightly muddy, fine sand. Mottles of very pale-orange, well-sorted, fine sand.	2' 0"

Unit		Thickness
	More mottles of pale yellowish-brown, slightly muddy, fine sand. Lower contact slightly undulating. Upper contact undulating. Fossils: Very dense accumulation. Random distribution. Large amount of sponge boring. Wear and fragmentation common, yet some shells beautifully preserved. Fauna strongly dominated by the oysters and scallops. Scallops predominantly flat lying. Faunal list: F1-Lyropecten madisonius, A-Crassostrea carolinensis, F-Balanus concavus, Corbula inaequalis, Cerastoderma laqueata, Anadara staminea, Crassatella turgidula. Sample 66-11-14 from 0' 3" to 1' 6" above base of unit.	
11	Lithology: Reddish-brown, slightly muddy, fine sand. Numerous mottles of light brownish-gray, slightly muddy, fine sand. Some irregular oxidation streaks. Lower contact gradational. Upper contact slightly undulating. Fossils: Increased macrofossil bed. Large increase in quantity of large, flat-lying bivalves. Little wear and fragmentation. Random distribution. Faunal list: A-Cerastoderma laqueata, C-Macrocallista marylandica, N-Lyropecten madisonius, F-Dosinia acetabula, Crassatella marylandica, R-Corbula idonea. Sample 66-11-13 from entire interval.	1' 6"
10	Lithology: Dark olive-brown, muddy, fine sand. Abundant mottles that are better sorted than main matrix. Possibly some subtle, irregular, discontinuous bedding laminations. Contacts slightly gradational and undulating. Fossils: Reduced macrofossil bed. Number of larger flat-lying bivalves greatly reduced. Little wear and fragmentation. Completely a bivalve assemblage. Faunal diversity low.	1' 0"

Unit		Thickness
	Faunal list: Macrocallista marylandica, Mercenaria sp. (some double valves), Lyropecten madisonius, Corbula idonea (some double valves), Dosinia acetabula, Anadara staminea. Sample 66-11-12 from entire interval.	
9	Lithology: Dark olive-brown, muddy, fine sand. Mottles of well-sorted, fine sand with lighter brown colors. No bedding laminations seen. Contacts gradational. Fossils: Increased macrofossil bed. Large, well-preserved, flat-lying, bivalves very common. Smaller shells tend to be more randomly oriented. Random distribution except for concentrated band of Anadara staminea near top of unit. Faunal list: A-Anadara staminea, C-Lyropecten madisonius (some double valves), Cerastoderma laqueata, Macrocallista marylandica, F-Balanus concavus, R-Astarte obruta. Sample 66-11-11 from 1' 0" to 2' 0" above base of unit.	2' 0"
8	Lithology: Dark-brown, muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts slightly undulating and gradational. Fossils: Increase in number and size of shells and shell fragments. Apparently random distribution and orientation. Fairly prolific accumulation of shells. Low faunal diversity. Faunal list: Turritella plebeia, Balanus concavus, Anadara staminea, Lyropecten madisonius, Mytilus conradinus. Sample 66-11-10 from 0' 6" to 1' 6" above base of unit.	1' 6"
	Total thickness of Boston Cliffs Member	15' 6"
St. Leonard Member		
7	Lithology: Dark-brown, slightly muddy, fine sand. A few mottles of very pale-orange, well-sorted, fine sand. No bedding laminations.	3' 0"

Unit		Thickness
	Contacts gradational. Rare small clay lenses with irregular bedding. Fossils: Rare fragments increasing upward. Most unidentifiable. Rare Lyropecten madisonius. Sample 66-11-8 from 0' 6" to 1' 6" above base of unit. Sample 66-11-9 from 1' 6" to 2' 6" above base of unit.	
6	Lithology: Dark-brown, slightly muddy, fine sand. Rare small mottles of light-gray clay. Some wavy, discontinuous, subtle bedding laminations. Contacts gradational. Fossils: No macrofossils seen. Sample 66-11-7 from 0' 6" to 1' 6" above base of unit.	2' 0"
5	Lithology: Heterogeneous sediment types. Dark-brown, muddy, fine sand. Heavily mottled. Mottled by dusky greenish-blue, very muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Contacts undulating slightly and gradational. Fossils: No macrofossils seen. Sample 66-11-5 from entire interval.	1' 3"
4	Lithology: Transition between bed 3 and bed 5. Basic sediment type is dusky greenish-blue, very muddy, fine sand. Heavily mottled by dark-brown, poorly sorted, muddy fine sand. Also mottled by very pale-orange, well-sorted, fine sand. Contacts slightly undulating and gradational. Fossils: No macrofossils seen. Sample 66-11-6 from entire interval.	1' 3"
3	Lithology: Dusky greenish-blue, very muddy, fine sand. No bedding laminations. Rare lenses of clay less than 3.0 cm. long. Lower contact undulating and gradational. Upper contact undulating and gradational. Fossils: No identifiable macrofossils. Small shell fragments constitute less than 1% of unit. Sample 66-11-3 from 0' 6" to 1' 6" above base of unit.	3' 6"

Unit		Thickness
	Sample 66-11-4 from 2' 6" to 3' 6" above base of unit.	
2	Lithology: Dusky greenish-blue, very muddy, fine sand. No bedding laminations. Mottled by very light bluish-gray, well-sorted, fine sand. Lower contact sharply undulating. Upper contact undulating and gradational. Fossils: A few fossils that appear to be reworked product from Drumcliff Member. A few yards to the northwest (along the cliffs) there are no fossils at this stratigraphic level. Apparently random orientation and distribution. Faunal list: F-Anadara staminea, Cerastoderma laqueata, Astarte thisphila, Turritella plebeia. Sample 66-11-2 from entire interval.	0' 4"
	Total thickness of St. Leonard Member	11' 4"
Drumcliff Member		
1	Lithology: Dusky-blue, very muddy, fine sand. Weathers to brownish-gray. Locally indurated where fossils were locally leached out and solutions permeated surrounding sediments eventually lithifying. No inorganic sedimentary structures. Lower contact covered. Upper contact undulating. Fossils: Very dense accumulation. Shells very abundant throughout but much more so in inverted cone-shaped shafts probably produced by crab burrowing. Shells often parallel sides of vertical shafts but are also horizontal. Most large bivalves are flat lying but a few are vertical. Some thin, parallel beds of shells but sharply undulate. Faunal diversity high. Faunal list: Isognomon maxillata, Lyropecten madisonius, Ecphora quadricostata, Astarte thisphila, Panope goldfussi (all double valves and in	2' 10"

Unit		Thickness
	living position), Cerastoderma laqueata, Dosinia acetabula, Glossus fraternus marylandicus, Corbula inaequalis, Asaphis centenaria, Anadara staminea, Turritella plebeia, Balanus concavus, Mercenaria sp. Sample 66-11-1 from 1' 3" to 2' 6" above base of unit.	
	Total thickness of exposed Choptank Formation	43' 2"

Locality 66-12. Boston Cliffs.

Choptank River. (Type section for the Choptank Fmn. and for the Boston Cliffs Mbr.) 1.8 mile south southeast of Dover Bridge (bridge over Choptank River for Maryland Highway #331). Across Choptank River from Frazier Neck. 4.0 miles southeast of Easton, Md., Talbot County.

38° 44' 00" N. Lat.; 76° 00' 53" W. Long.

Unit		Thickness
Choptank Formation		
	(Covered)	
	Boston Cliffs Member - Type section	
7	Lithology: Yellowish-brown, well-sorted, fine sand. No sedimentary structures. Lower contact distinct and straight. Upper contact covered. Fossils: Extremely dense accumulation. Predominantly shell hash. Sponge boring common. Faunal list: A-Lyropecten madisonius, C-Balanus concavus, F-Mercenaria sp.	0' 8"
6	Lithology: Yellowish-brown, slightly muddy, fine sand. No sedimentary structures. Oxidized upper Boston Cliffs bed. Slightly and locally indurated. Fossils: Large flat-lying bivalves. Dense accumulation. Random distribution.	1' 3"

Unit		Thickness
	Faunal list: Fl-Lyropecten madisonius, C-Isognomon maxillata, F-Macrocallista marylandica. Sample 66-12-6 from entire interval.	
5	Lithology: Reddish-brown, slightly fine sand. Rare mottles of very pale-orange, well-sorted, fine sand. No bedding laminations. Lower contact slightly undulating. Upper contact distinct and straight. Fossils: Increased macrofossil bed. Increased in number of large, flat-lying bivalves. Increased in number of shells. Very well preserved. Dense accumulation. Distribution random. Sponge boring common. Large bivalves flat lying. Faunal list: A-Lyropecten madisonius, Crassostrea carolinensis, VC-Macrocallista marylandica, Anadara staminea, C-Mercenaria spp., Balanus concavus, N-Corbula idonea, F-Lunatia heros, Turritella plebeia var A., R-Epitonium marylandicum. Sample 66-12-5 from entire interval.	1' 6"
4	Lithology: Reddish-brown, slightly muddy, fine sand. No bedding laminations. Contacts slightly gradational and slightly undulating. Fossils: Reduced macrofossil bed. Reduced number of fossil shells and reduced number of large, flat-lying bivalves. Very nicely preserved shells. Faunal list: N-Crassatella marylandica, Macrocallista marylandica, Lyropecten madisonius (small), F-Cerastoderma laqueata, Crassostrea carolinensis, R-Diplodonta sp., Semele subovata, Lunatia heros, Astarte obruta, Anadara staminea, Balanus concavus, Calliostoma wagneri, Caecum patuxentium, Polinices duplicatus, Callocardia (Agriopoma) subnasuta, Dosinia acetabula, Lucina crenulata. Sample 66-12-4 from 0' 3" to 1' 3" above base of unit.	1' 6"
3	Lithology: Moderate reddish-brown,	2' 6"

Unit		Thickness
	slightly muddy, fine sand. Mottled by very pale-orange, well sorted, fine sand. No sedimentary structures. Contacts slightly gradational and slightly undulating. Fossils: Increased macrofossil bed. Most strikingly increased in large, flat-lying bivalves. Also increased in numbers of fossils. Very prolific accumulation. Nearly all large bivalves are flat-lying, and most of those lie convex upward. Average size of bivalves here seems significantly larger than in outcrops on the Western Shore. Faunal diversity also seems higher than in Western Shore outcrops. Very nicely preserved fossils. Faunal list: A-*Astarte obruta*, VC-*Crasatella marylandica*, *Anadara staminea* (some double valves), N-*Corbula idonea*, F-*Lunatia heros*, *Lyropecten madisonius*, *Turritella variablis cumberlandia*, *Mercenaria* spp., R-*Turritella plebeia* var. A, *Balanus concavus*, *Ecphora quadricostata umbilicata*, *Discinisca lugubris*, *Calliostoma wagneri*, *Crucibulum costatum*, *Busycon* sp. Sample 66-12-3 from 1' 0" to 2' 0" above base of unit.	
2	Lithology: Reddish-brown, fairly well sorted, fine sand. No sedimentary structures. Lower contact slightly gradational and undulating. Upper contact slightly gradational and slightly undulating. Fossils: Very sparse. A few fragments, mostly unidentified. Only a small *Lyropecten madisonius* identified. Sample 66-12-2 from 1' 0" to 2' 0" above base of unit.	2' 6"
1	Lithology: Reddish-brown, muddy, fine sand. No apparent sedimentary structures. Lower contact covered. Upper contact undulating and gradational. Fossils: Very dense accumulation.	2' 10"

Unit		Thickness
	Apparent random orientation and distribution. Wear and fragmentation common. Oysters particularly worn. Sponse boring common. Faunal diversity low. Faunal list: F1-Crassostrea carolinensis (many in clusters but nearly no double valves), A-Balanus concavus, F-Mercenaria sp., Isognomon maxillata. Sample 66-12-1 from 0' 6" to 1' 6" above base of unit.	
	Total thickness of exposed Boston Cliffs Member	12' 9"

Locality 66-13. Island Creek.

South bank of Island Creek. 1.5 mile upstream from mouth of Island Creek at Choptank River. 2.5 mile southeast of Oxford, Md., Talbot Co. 38° 40' 09" N. Lat.; 76° 07' 56" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Boston Cliffs Member		
1	Lithology: Reddish-brown, slightly muddy, fine sand. Weathers dark reddish-brown. No sedimentary structures. Lower contact covered. Upper contact distinct and slightly undulating. Fossils: Very dense accumulation. Very jumbled. Large amount of shell hash. Distribution and orientation very random. Sponge boring common. Barnacles heavily encrusted by bryozoans. Some calcareous material possibly leached. Faunal list: F1-Crassostrea carolinensis, Lyropecten madisonius, A-Balanus concavus, C-bryozoans. Sample 66-13-1 from 1' 0" to 2' 0" above base of unit. Sample 66-13-2 from 2' 6" to 3' 6" above base of unit.	3' 6"

Locality 66-14. Drumcliff.

Natural cliff in southwestern bank of Patuxent River. Between Cole Cr. and St. Thomas Cr. 3.0 miles south of Hollywood, Md. Across Patuxent River, straight south, from Broomes Island. St. Marys Co., Md. 38° 23' 19" N. Lat.; 76° 33' 37" W. Long.

(Called both "Drum Cliff" and "Jones Wharf" in the Md. Geol. Surv. 1904 Miocene Report).

Lower part of this outcrop was seen only after high, heavy wave erosion had cleaned out debris from base of outcrop. Additionally, Calvert Beach Member was seen only at low tide.

	Unit	Thickness
	(Pleistocene, undifferentiated) Choptank Formation Boston Cliffs Member Undescribed and unmeasured.	
	St. Leonard Member St. Leonard sand filling deep channels down into Drumcliff Member. Channels 3 to 5 feet wide and 3 to 4 feet deep. Unmeasured.	
	Drumcliff Member - Type section	
16	Lithology: Light orangish-brown, slightly muddy, fine sand. Gradational unit from unit 15 below and forming a receding ledge away from prominence of unit 15 ledge. No sedimentary structures. Lower contact gradational. Upper contact sharp and distinct - channeled from above and filled with non-fossiliferous St. Leonard sand. Fossils: Tremendous accumulation of shells with appearance of having been dumped in. Decrease in shell size from unit 15. Fauna even more diverse than unit 15. Tremendous	3' 0"

Unit		Thickness
	abundance of very small molluscs. Fragments abundant. Partial faunal list: Isognomon maxillata, Cerastoderma laqueata, Anadara staminea, Lunatia heros, Macrocallista marylandica, Corbula idonea, Ecphora quadricostata umbilicata, Turritella plebeia, Balanus concavus, Lyropecten madisonius. Sample 66-14-11 from 0' 6" to 1' 6" above base of unit.	
15	Lithology: Reddish-brown, muddy, fine sand. Upper prominent ledge. No sedimentary structures. Contacts gradational. Fossils: Tremendous accumulation of shells with appearance of having been dumped in. Random distribution and orientation. Very diverse fauna. Tremendous abundance of very small molluscs. Increased macrofossil bed. Partial faunal list: Macrocallista marylandica, Lunatia heros, Turritella plebeia, Turritella plebeia var. A., Lyropecten madisonius, Cerastoderma laqueata, Corbula idonea, Balanus concavus, Crassatella turgidula, Anadara staminea. Sample 66-14-10 from 0' 6" to 1' 6" above base of unit.	2' 0"
14	Lithology: Very pale-orange, well-sorted, medium sand. Nonresistant bed. No sedimentary structures. Contacts gradational. Fossils: Gradational between reduced macrofossil bed below (unit 13) and increased macrofossil bed above (unit 15). Vertical concentrations of Turritella. Most bivalves and Turritella flat-lying. Well preserved. Partial faunal list: F1-Turritella plebeia, N-Lyropecten madisonius Panope americana (all double valves in living position), Corbula idonea, F-Lunatia heros, Macrocallista marylandica, Mercenaria campechiensis cuneata.	2' 0"

Unit		Thickness
	Sample 66-14-9 from 0' 6" to 1' 6" above base of unit.	
13	Lithology: Very pale-orange, well-sorted, fine to medium sand. Minor resistant layer. No sedimentary structures. Contacts gradational. Fossils: Well-preserved. Moderate accumulation. Random distribution. Reduced macrofossil bed - reduced number of large, flat-lying bivalves. Partial faunal list: VC-Turritella plebeia, F-Lyropecten madisonius, Panope americana. Sample 66-14-8 from entire interval.	0' 6"
12	Lithology: Very pale-orange, well-sorted, fine to medium sand. Rarely mottled by orangish-white, well-sorted, fine sand. No bedding laminations. Forms nonresistant outcrop. Contacts gradational. Fossils: Reduced macrofossil bed. Reduced number of large macrofossils. Reduced number of shells. Some Turritella appear in vertical concentrations. Well preserved. Panope all occur with double valves and in living position. Faunal list: VC-Turritella plebeia, F-Panope americana, Cerastoderma laqueata. Sample 66-14-7 from 1' 0" to 2' 0" above base of unit.	3' 0"
11	Lithology: Moderate-brown, muddy, fine sand. Forms prominent resistant ledge. No sedimentary structures. Contacts gradational. Fossils: Increased macrofossil bed. Increased number of fossil shells and increased number of large, flat-lying bivalves. Well preserved. Random distribution. Partial faunal list: Fl-Isognomon maxillata, A-Lunatia heros, Turritella plebeia, C-Lyropecten madisonius, N-Balanus concavus, Mercenaria campechiensis cuneata (some double	1' 6"

Unit		Thickness
	valves), Cerastoderma laqueata, Macrocallistta marylandica. Sample 66-14-6 from entire interval.	
10	Lithology: Very pale-orange, fairly well sorted, fine sand. No sedimentary structures. Contacts gradational. Fossils: Reduced macrofossil bed. Reduced number of fossils and number of large, flat-lying bivalves. Well preserved. Random distribution. Faunal list: N-Turritella plebeia, F-Lunatia heros, Cerastoderma laqueata. Sample (None).	0' 6"
9	Lithology: Pale yellowish-brown, slightly muddy, fine sand. No sedimentary structures. Contacts gradational. Fossils: Increased macrofossil bed. Increased number of large, flat-lying bivalves. Well preserved. Random distribution. Faunal list: C-Cerastoderma laqueata, Lunatia heros, Mercenaria campechiensis cuneata, Macrocallista marylandica, N-Corbula idonea. Sample 66-14-5 includes units 7, 8, and 9.	0' 6"
8	Lithology: Very pale-orange, fairly well sorted, fine sand. No sedimentary structures. Contacts gradational. Fossils: Reduced macrofossil bed. Reduced number of fossils and number of large flat-lying bivalves. Well preserved. Random distribution. Faunal list: N-Turritella plebeia, F-Lunatia heros, Cerastoderma laqueata. Sample 66-14-5 includes units 7, 8 and 9.	0' 6"
7	Lithology: Pale yellowish-brown,	0' 6"

Unit		Thickness
	slightly muddy, fine sand. No sedimentary structures. Contacts gradational. Fossils: Increased macrofossil bed. Increased number of large, flat-lying bivalves. Well preserved. Random distribution. Faunal list: C-Cerastoderma laqueata, Lunatia heros, Mercenaria campechiensis cuneata, Macrocallista marylandica, N-Corbula idonea, F-Panope americana (double valves and in living position). Sample 66-14-5 includes units 7, 8, and 9.	
6	Lithology: Very pale-orange, fairly well sorted, fine sand. No sedimentary structures. Contacts gradational. Fossils: Reduced macrofossil bed. Reduced in number and reduced in number of large, flat-lying bivalves. Well preserved. Slight indication of some vertical concentrations possibly representing burrow fillings. Faunal list: N-Turritella plebeia, F-Lunatia heros, Cerastoderma laqueata, Mercenaria campechiensis cuneata. Sample 66-14-4 from 1' 6" to 2' 6" above base of unit.	4' 0"
5	Lithology: Very pale-orange, well-sorted, fine sand. No sedimentary structures. Contacts gradational. Fossils: Slightly increased macrofossil bed. Bed of increased large, flat-lying bivalves. Well preserved. Many articulated, double valves. Faunal list: C-Mercenaria spp., F-Anodontia anodonta, Turritella plebeia. Sample 66-14-3 from 0' 0" to 1' 0" above base of unit.	1' 10"
4	Lithology: Very pale-orange, well-sorted, fine sand. Lenses of light orangish-brown, slightly muddy, fine sand. No bedding laminations. Forms non-resistant outcrop. Contacts gradational.	4' 0"

Unit		Thickness
	Fossils: Small macrofossils. Reduced macrofossil bed. No large macrofossils. Some fragments. Turritella plebeia only macrofossil identified. Sample 66-14-2 from 2' 0" to 3' 0" above base of unit.	
3	Lithology: Very pale yellowish-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Unit forms a slight ledge. Lower contact slightly undulating and slightly gradational. Upper contact gradational. Fossils: Fragments very abundant. Larger bivalves predominantly flat-lying. Most fragments unidentified. Partial faunal list: A-Turritella plebeia, VC-Cerastoderma laqueata. Sample 66-14-1 from 0' 10" to 1' 6" above base of unit.	2' 0"
2	Lithology: Olive-gray, muddy, fine sand. Extensively burrowed possibly by bivalves. Lower contact slightly undulating and marked by appearance of Isognomon. Upper contact gradational. Fossils: Low faunal diversity. High faunal dominance. Four dominant forms are well preserved. Large bivalves exhibit tendency for flat-lying. Corals tend to be clumped. Faunal list: F1-Isognomon maxillata, VC-Astrhelia palmata, C-Lyropecten madisonius, N-Placopecten marylandicus. Additionally, some rare pockets of unidentified shell hash. Sample (None).	1' 11"
	Total thickness of Drumcliff Member	27' 9"
Calvert Beach Member		
1	Lithology: Olive-gray, muddy, fine sand. Extensively burrowed possibly by bivalves. Lower contact Patuxent River water level at low tide. Upper	1' 0"

Unit		Thickness
	contact slightly undulating and marked by appearance of Isognomon. Fossils: No preserved hard parts of macroscopic animals. Biogenic activity preserved, however, in the appearance of burrows. Sample (None).	
	Total thickness of measured Choptank Formation	28' 9"

Locality 66-15. Flag Ponds Ia.

Approximately 100 feet northwest of Flag Ponds I (locality 66-7). 1.5 mile southeast of Long Beach, Md. Natural outcrop in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 26' 29" N. Lat.; 76° 27' 02" W. Long.

(Covered)		
Choptank Formation		
Conoy Member		
17	Lithology: Dusky greenish-blue, very muddy, very fine sand. Mottled by dark greenish-gray, very muddy silt. This latter sediment type also forms subtle, irregular, discontinuous, bedding laminations. Some laminations continuous for several feet. Lower contact straight and distinct. Upper contact covered. Fossils: Rare. Mostly molds and casts but rarely shell fragments which show slight leaching. Molds and casts of fragments difficult to identify. Rare small wood fragments. Faunal list: R-Lyropecten madisonius, Mytilus conradinus, Cerastoderma laqueata. Sample 66-15-21 from 0' 6" to 1' 6" above base of unit. Sample 66-15-22 from 3' 0" to 4' 0" above base of unit. Sample 66-15-23 from 5' 6" to 6' 6" above base of unit.	11' 6"

Unit		Thickness
Boston Cliffs Member		
16	Lithology: Heterogeneous. Dark olive-brown, poorly sorted, fine sand. Mottled by dusky greenish-blue, muddy, fine sand. Surface heavily oxidized. No bedding laminations. Lower contact undulating broadly. Upper contact straight and distinct. Fossils: Dense accumulation. Fragmentation common. Little wear. Abundant large, flat-lying bivalves. Faunal list: Lyropecten madisonius, Dosinia acetabula, Balanus concavus, Turritella plebeia, Discinisca lugubris. Sample 66-15-20 from 0' 6" to 1' 9" above base of unit.	2' 0"
15	Lithology: Medium light-gray, very muddy, very fine sand. Indurated unit. Texture mottling to poorly sorted sediment. Contacts undulating. Fossils: Dense accumulation of molds and casts. Back from weathered surface there are some calcareous shells. Predominantly large, flat-lying bivalves. Random distribution. Faunal list: Lyropecten madisonius, Cerastoderma laqueata, Mercenaria sp. Sample 66-15-19 from entire interval.	1' 0"
14	Lithology: Medium light-gray, muddy, fine sand. Mottled by light-gray, well-sorted, fine sand. Contacts broadly undulating and distinct. Fossils: Dense accumulation. Little fragmentation. Fairly high percentage of bivalves found with articulated valves. Random distribution. Faunal list: C-Lyropecten madisonius, Cerastoderma laqueata, Ecphora quadricostata	1' 0"

Unit		Thickness
	umbilicata, N-Mercenaria sp., Turritella plebeia var. A, F-Balanus concavus, bryozoans, R-Astarte obruta, Panope americana (all in living position). Sample 66-15-18 from entire interval.	
13	Lithology: Medium light-gray, muddy, very fine sand. Indurated unit. Very resistant outcrop. No sedimentary structures. Contacts undulating and distinct. Fossils: Large, flat-lying bivalves. Random distribution. Predominantly Lyropecten madisonius, but also Balanus concavus. Sample 66-15-17 from entire interval.	1' 0"
12	Lithology: Light olive-brown, muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Lower contact fairly straight and distinct. Upper contact undulating lithological break. Partially indurated. Fossils: Dense accumulation. Little wear. Fragmentation common. Random orientation and distribution. Faunal list: Lyropecten madisonius, Turritella plebeia var. A, Cerastoderma laqueata, Anadara staminea, Dosinia acetabula, Corbula idonea, Balanus concavus, Turritella plebeia. Sample 66-16-16 from 0' 0" to 1' 0" above base of unit.	2' 0"
11	Lithology: Dark olive-brown, muddy, fine sand. Rare mottles of very pale-orange, well-sorted, fine sand. Lower contact slightly gradational. Upper contact quite distinct. Fossils: Dense accumulation. Fragmentation common. Little wear. Distribution random. Orientation random except for large, flat-lying bivalves. Faunal list: C-Crassostrea carolinensis, Cerastoderma laqueata, Lyropecten	1' 0"

Unit		Thickness
	madisonius, Balanus concavus, N-Corbula idonea, Anadara staminea, F-Turritella plebeia, R-Turritella plebeia var. A. Sample 66-15-15 from entire interval.	
10	Lithology: Dark olive-brown, muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts slightly gradational. Fossils: Increased macrofossil bed. Many large, flat-lying bivalves. Little wear or fragmentation. Orientation random except for large, flat-lying bivalves. Distribution random. Shells prolific but less than average prolific shell bed. Faunal list: C-Macrocallista marylandica, Cerastoderma laqueata, N-Lyropecten madisonius, Corbula idonea (many double valves), N-Balanus concavus, R-Turritella plebeia var. A. Sample 66-15-14 from 0' 0" to 1' 0" above base of unit.	1' 6"
9	Lithology: Dark olive-brown, muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts gradational. Fossils: Large macrofossil bed. Dense accumulation. Wear not significant. Some fragmentation. Panope doubled-valved and in living position. Other large bivalves flat-lying. Other fossils appear in random orientation. Concentrated layering of Anadara staminea toward top of unit, increase in number of Macrocallista toward top of unit, and general increase in size of larger fossils from base of unit to top. One Crassatella found with bryozoan encrusting cardinal teeth. One large scallop found with valves closed over valve of another large scallop. Faunal list: F1-Anadara staminea, C-	3' 0"

Unit		Thickness
	Lyropecten madisonius (numerous large, double valves) Macrocallista marylandica (some double valves), N-Panope americana (all double and in living position), Cerastoderma laqueata, Mercenaria plena, Turritella plebeia var. A, Crassostrea carolinensis, Anodontia anodonta (some double valves), F-Crassatella marylandica, Dosinia acetabula (some double valves), Corbula idonea (some double valves), Astarte abruta. Sample 66-15-12 from 0' 6" to 1' 6" above base of unit. Sample 66-15-13 from 2' 0" to 3' 0" above base of unit.	
8	Lithology: Heterogeneous. Four types: 1) pale yellowish-brown, slightly muddy, fine sand, 2) dark olive-brown, muddy, fine sand, 3) very pale-orange, well-sorted, fine sand, and 4) dusky greenish-blue, very muddy, very fine sand. Heavy mottling probably the result of burrowing organisms. Contacts gradational. Fossils: Fairly prolific but a reduced macrofossil bed. Fragmentation abundant but pieces larger than in unit 7. Wear abundant. Random orientation. Shell hash concentrated in burrows. Faunal list: Corbula idonea, Lyropecten madisonius, Crassostrea carolinensis, Macrocallista marylandica, Balanus concavus, Dosinia acetabula, Turritella plebeia var. A. Sample 66-15-11 from 0' 0" to 1' 0" above base of unit.	1' 3"
7	Lithology: Very heterogeneous. Three principal sediment types: 1) dark olive-brown, slightly muddy, fine sand, 2) very pale-orange, well-sorted, fine sand, and 3) dusky greenish-blue, very muddy, very fine sand. Unit somewhat	0' 10"

Unit		Thickness
	gradational. Contacts gradational. Fossils: Fairly prolific but a reduced macrofossil bed. Wear and fragmentation abundant. Burrow concentrations of shell fragments in addition to very pale-orange, well-sorted, fine sand. Random orientation and distribution except for burrow concentrations. Most fragments unidentified. Faunal list: Corbula idonea, Turritella plebeia var. A, Lyropecten madisonius, Balanus concavus. Sample 66-15-10 from entire interval.	
	Total thickness of Boston Cliffs Member	14' 7"
St. Leonard Member		
6	Lithology: Dark olive-brown, slightly muddy, fine sand. Mottled by dusky greenish-blue, very muddy, very fine sand. Also mottled by very pale-orange, well-sorted, fine sand. On weathered surface can see irregular, discontinuous, subtle, bedding laminations. Laminations result of slight textural differences--muddier layers are more resistant and sandier layers are more non-resistant. Laminations commonly cut by long, thin, vertical burrows. Gradational unit between St. Leonard Member and Boston Cliffs Member. Contacts gradational. Fossils: Most are small unidentified fragments. Shell hash is concentrated in burrows, which increase into Boston Cliffs Member Balanus concavus only fossil identified. Sample 66-15-9 from 1' 0" to 2' 0" above base of unit.	2' 8"
5	Lithology: Dusky greenish-blue, very muddy, very fine sand. Mottled by grayish-brown, slightly muddy, silt. Also mottled by very pale-orange, well-sorted, fine sand. On	5' 6"

Unit		Thickness
	weathered surface can see irregular, discontinuous, subtle, bedding laminations. Laminations result of slight textural differences - muddier layers are more resistant and sandier layers are more nonresistant. Laminations commonly cut by long, thin, vertical burrows. Contacts gradational. Fossils: Few. Well preserved. Predominantly thin shelled. Random orientation. Random distribution of larger, more completely intact specimens. A few straight, thin layers of thin-shelled bivalves. Some layers very long and continuous; others very local. Burrows give sediment the mottled effect. Some burrows contain greenish-yellow clay possibly the result of defecation by the burrowing organism. Some burrows contain shell hash. Faunal list: F-Lucinoma contracta, Ensis ensiformis, Mytilus conradinus, R-Discinisca lugubris. Sample 66-15-6 from 0' 6" to 1' 6" above base of unit. Sample 66-15-7 from 2' 6" to 3' 6" above base of unit. Sample 66-15-8 from 4' 6" to 5' 6" above base of unit.	
4	Lithology: Dusky greenish-blue, very muddy, very fine sand. Weathers to dark olive-brown. Rare mottles of very light bluish-gray, well-sorted, fine sand. On weathered surface can see irregular, discontinuous, subtle, bedding laminations. Laminations result of slight textural differences - muddier layers are more resistant and sandier layers are more nonresistant. Laminations commonly cut by long, thin, vertical burrows. Lower contact undulating and quite distinct. Upper contact gradational. Fossils: Very rare. Only macrofossils seen were Ensis ensiformis. Sample 66-15-4 from 0' 6" to 1' 6" above base of unit. Sample 66-15-5 from 2' 6" to 3' 6"	4' 0"

Unit		Thickness
	above base of unit.	
	Total thickness of St. Leonard Member	13' 2"
Drumcliff Member		
3	Lithology: Dusky greenish-blue, very muddy, very fine sand. Thickness of unit varies from 0' 6" to 0' 11" with average about 0' 10". Mottled by moderate-brown, slightly muddy, fine sand. No bedding laminations. Dense hard unit. Lower contact undulating and distinct. Upper contact undulating and quite distinct. Fossils: Very dense accumulation. Many very thin shelled bivalves. Distributed in pronounced undulating thin beds. Shells oriented, parallel to undulating thin beds. Faunal list: A-Mytilus conradinus, C-Ensis ensiformis, Yoldia laevis, Cerastoderma laqueata, Modiolus ducatelli?, Discinisca lugubris, bryozoans, F-Lyropecten madisonius, Balanus concavus, R-Turritella plebeia var. A., Lunatia heros. Sample 66-15-3 from entire interval.	0' 10"
2	Lithology: Dark olive-brown, muddy, fine sand. Mottled by brown, slightly muddy, fine sand. No sedimentary structures. Lower contact undulating and slightly gradational. Upper contact undulating and distinct. Fossils: Excellently preserved. Little wear or fragmentation. Very dense accumulation. Apparently random distribution and orientation. Very diverse fauna. Numerous pieces of wood burrowed by shipworm. Skate plate. Faunal list: A-Anadara staminea (a few double valves), Turritella plebeia, VC-Glossus fraternus marylandicus, C-Corbula idonea (many double valves), Astarte thisphila, N-Lunatia heros, Astarte obruta,	1' 8"

Unit		Thickness
	F-Macrocallista marylandica, Panope americana, R-Asaphis centenaria, Ecphora quadricostata umbilicata, Venericardia granulata. Sample 66-15-2 from 0' 9" to 1' 8" above base of unit.	
1	Lithology: Heterogeneous. Basic sediment type is dusky-blue, very muddy, fine sand. Heavily mottled by: 1) dusky-blue mud, 2) very pale-orange, well-sorted, fine sand, and 3) medium to light-gray clay. Toward base of unit clay is locally indurated. No bedding laminations. Lower contact covered. Upper contact undulating and slightly gradational. Fossils: Dense accumulation all over but particularly dense accumulation in vertical, inverted cone-shaped shaft probably the result of crab burrowing. Very diverse fauna. Numerous pieces of wood. Partial faunal list: VC-Cerastoderma laqueata, Turritella plebeia, Glossus fraternus marylandicus, C-Isognomon maxillata, Corbula idonea, Lyropecten madisonius, N-Ecphora quadricostata umbilicata, Anadara staminea, Macrocallista marylandica, F-Astarte thisphila. Sample 66-15-1 from 0' 6" to 1' 6" above base of unit.	1' 9"
	Total thickness of exposed Drumcliff Member	4' 3"
	Total thickness of exposed Choptank Formation	43' 6"

Locality 66-17. Cole Creek.

0.4 mile north of Cole Creek and 0.6 mile north of Hollywood Shores, Md. Natural outcrop in low bluff in southwest bank of Patuxent River. St. Marys Co., Md. 38° 24' 03" N. Lat.; 76° 35' 24" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member, Lower		
4	Lithology: Dusky greenish-blue, very muddy, very fine sand. Shells from irregular, discontinuous bedding. Lower contact undulating. Upper contact distinct. Fossils: Shelly bed. Many small, well-worn, fragments. Shells in irregular, discontinuous layers. Large Isognomon complete and in vertical or inclined orientation. Prolific shell bed. Faunal list: C-Isognomon maxillata, Lyropecten madisonius, Balanus concavus, Discinisca lugubris, F-Martesia ovalis (bored into Isognomon), R-Cerastoderma laqueata, Mercenaria sp. Sample 66-17-1 from entire interval.	1' 0"
3	Lithology: Dusky greenish-blue, very muddy, very fine sand. No apparent sedimentary structures. Lower contact at top of concretions. Upper contact slightly undulating. Fossils: Few molds and casts. Calcareous shells leached out. Random distribution. Faunal list: F-Isognomon maxillata, R-Discinisca lugubris, Balanus concavus. Sample 66-17-2 from entire interval.	1' 0"
2	Lithology: Dusky greenish-blue, very muddy, very fine sand. Concretion layer cemented by solution of calcitic Isognomon shells. Contacts top and bottom of concretions. Concretions with no internal structure. Fossils: Molds and casts of Isognomon maxillata. Sample (None).	0' 4"
1	Lithology: Dusky greenish-blue, very muddy, fine sand. No apparent inorganic sedimentary structures. Extensively burrowed. Lower contact covered. Upper contact marked by layer of concretions.	3' 6"

Unit		Thickness
	Fossils: All molds and casts. Prolific shell bed. Concentrated layer of Isognomon maxillata at 20" above base of unit. Isognomon predominantly flat-lying. Faunal list: A-Isognomon maxillata, Discinisca lugubris. Sample (None).	
	Total thickness of exposed Drumcliff Member	5' 10"

Locality 66-18. Drumcliff.

0.8 mile east of Hollywood Shores, Md. South of Broomes Island, across the Patuxent River. Natural outcrop in southwestern bank of the Patuxent River. St. Marys Co., Md. Only one bed critically examined. No measured section. Outcrop contains Drumcliff, St. Leonard, and Boston Cliffs Members. 38° 23' 21" N. Lat.; 76° 33' 53" W. Long.

Unit		Thickness
Choptank Formation Drumcliff Member (Reduced macrofossil bed immediately below upper Isognomon resistant ledge.)		
1	Lithology: Very pale reddish-brown, well-sorted, fine sand. No sedimentary structures. Contacts gradational. Fossils: Reduced macrofossil bed. Reduced in concentrating of shells. Reduced in number of shells. Reduced number of large shells. Shells still very numerous. Very well preserved. Apparently random distribution. Very diverse fauna. Diverse snail fauna. Partial faunal list: Snails - Turritella plebeia, Turritella plebeia var. A., Lunatia heros, Lunatia hemicrypta, Polinices duplicatus, Crucibulum costatum,	6' 0"

Unit	Thickness

Crucibulum multilineatum, Siphonalia devexa, Urosalpinx cinerea, Calliotoma aphelia, Calliostoma philantropa, Ecphora quadricostata umbilicata, Busycon spiniger var., Busycon coronatum var. rugosum, Crepidula fornicata, Crepidula plana, Drilla limatula, Ecphora tampaensis, Epitonium marylandicum, Epitonium sayanum, Hastula inornata, Mangelia parva, Nassarius peraltoides, Pleurotoma (Hemipleurotoma) choptankensis, Rhizorus iotus marylandicus, Fissuridea griscomi, Turricula rugata, Cancellaria alternata. Bivalves - Isognomon maxillata, Lyropecten madisonius, Astarte thisphila, Asaphis centenaria, Cerastoderma laqueata, Anodontia anodonta, Panope americana, Mercenaria campechiensis cuneata, Mercenaria mercenaria, Anadara staminea, Crassatella turgidula, Astarte thisphila, Cardita protracta, Lucina crenulata, Semele subovata, Spisula subparilis, Ensis ensiformis, Apolymetis biplicata, Aligena aequata, Atrina harrisi, Callocardia subnasuta, Corbula cuneata, Corbula inaequalis, Diplodonta acclinis, Venericardia granulata.
Sample 66-18-1 from 6' 0" to 7' 0" below contact of Drumcliff and St. Leonard Members.

Locality 66-19 and Locality 67-61. East End of Drumcliff.

0.3 mile west of mouth of St. Thomas Creek and Captain Point. Directly south, across the Patuxent River from Broomes Island. Natural outcrop in southwest bank of Patuxent River. St. Marys Co., Md. 38° 23' 20" N. Lat.; 76° 33' 20" W. Long.

(Section only partially described in detail.)

Unit		Thickness
Choptank Formation		
Boston Cliffs Member		
14	Upper Boston Cliffs oxidized and indurated beds. Upper contact not seen.	
13	Lithology: Pale reddish-brown, slightly muddy, fine sand. No sedimentary structures. Lower contact gradational. Upper contacts distinct. Fossils: Reduced macrofossil bed. Primarily coarse shell hash. Random orientation and distribution. Most fragments unidentified. Faunal list: C-Crassostrea carolinensis, Lyropecten madisonius. Sample (None).	1' 6"
12	Lithology: Pale reddish-brown, slightly muddy, fine sand. No sedimentary structures. Contacts gradational. Fossils: Increased macrofossil bed. Dense accumulation. Increased number of large macrofossils. Coarse shell hash, in addition to larger complete specimens. Faunal list: A-Crassostrea carolinensis, Lyropecten madisonius, C-Anadara staminea, Cerastoderma laqueata, Macrocallista marylandica, F-Mercenaria sp., Turritella plebeia, R-Ecphora quadricostata umbilicata. Sample (None).	1' 6"
11	Lithology: Pale reddish-brown, slightly muddy, fine sand. No sedimentary structures. Contacts gradational. Fossils: Reduced macrofossil bed. Primarily a coarse shell hash. Random orientation and distribution. Most fragments unidentified. Faunal list: C-Balanus concavus, N-Lyropecten madisonius, F-Crassostrea carolinensis. Sample 67-61-3 from entire interval.	0' 9"
10	Lithology: Pale reddish-brown, slightly muddy, fine sand. No sedimentary structures. Contacts gradational.	3' 3"

Unit		Thickness
	Fossils: Increased macrofossil bed. Dense accumulation. Increased number of large macrofossils. Coarse shell hash, in addition to larger complete specimens. Faunal list: A-Crassostrea carolinensis, Lyropecten madisonius, C-Anadara staminea, Cerastoderma laqueata, Macrocallista marylandica, F-Mercenaria sp., Turritella plebeia, R-Ecphora quadricostata umbilicata. Sample 67-61-2 from 1' 0" to 2' 0" above base of unit.	
9	Lithology: Pale reddish-brown, slightly muddy, fine sand. No sedimentary structures. Lower contact straight and distinct. Upper contact gradational. Fossils: Reduced macrofossil bed. Primarily a coarse shell hash. Random orientation and distribution. Most fragments unidentified. Partial faunal list: N-Lyropecten madisonius, Crassostrea carolinensis, F-Balanus concavus. Sample (None).	2' 7"
	Total thickness of measured Boston Cliffs Member	9' 7"
St. Leonard Member		
8	Lithology: Pale yellowish-brown, poorly sorted, muddy, fine sand. No apparent inorganic sedimentary structures. Mottling probably produced by burrowing. Contacts straight and distinct. Fossils: None seen. Sample 67-61-1 from 2' 0" to 3' 0" above base of unit.	5' 0"
7	Lithology: Reddish-brown, poorly sorted, muddy, fine sand with some coarse grains. No inorganic sedimentary structures. Mottling probably produced by burrowing. Contacts straight and distinct. Fossils: A few molds and casts. All	1' 0"

Unit		Thickness
	calcareous shells leached out. No identified species. Sample 67-61-5 from entire interval.	
	Total thickness of St. Leonard Member	6' 0"
Drumcliff Member		
6	Unconsolidated, upper, reduced, macrofossil-bed. Upper contact straight and distinct.	2' 10"
5	Indurated, upper, increased macrofossil-bed.	1' 0"
4	Unconsolidated, middle, reduced macrofossil-bed. Sample 67-61-4 from 7' 3" to 8' 3" above base of unit.	8' 11"
3	Indurated, middle, increased macrofossil-bed.	1' 2"
2	Unconsolidated, lower, reduced macrofossil-bed.	3' 10"
1	Indurated, lower, increased macrofossil-bed.	3' 7"
	Total thickness of exposed Drumcliff Member	21' 4"
	Total thickness of measured Choptank Formation	36' 11"

Locality 66-20. 0.5 Mile North of Sotterly Mansion. 3.0 miles northeast of Hollywood, Md. Natural outcrop in low bluffs along southwestern shore of Patuxent River. St. Marys Co., Md. 38° 22' 59" N. Lat.; 76° 32' 27" W. Long.

(Covered)

Unit		Thickness
Choptank Formation		
Drumcliff Member, Lower		
2	Lithology: Dusky-blue, very muddy, very fine sand. Heavily burrowed. No inorganic sedimentary structures. Lower contact gradational. Upper contact covered. Fossils: Prolific accumulation. Faunal list: Fl-Isognomon maxillata, F-Lyropecten madisonius, R-Martesia ovalis, ?Atrina sp. Sample (None).	2' 0"
1	Lithology: Dusky-blue, very muddy, very fine sand. Heavily burrowed. No inorganic sedimentary structures. Lower contact covered. Upper contact gradational. Fossils: Layers of concentrated, flat-lying Isognomon. Specimens between layers are vertical or inclined. Prolific accumulation. Burrows abundant but no organisms preserved in obvious association. Faunal list: A-Isognomon maxillata, R-Discinisca lugubris. Sample 66-20-1 from 2' 0" to 3' 0" above base of unit.	4' 0"
	Total thickness of exposed Drumcliff Member	6' 0"

Locality 66-21. I Camp Conoy (Y.M.C.A.).

First major cliffs to northwest of where camp road runs down to beach. Natural exposure in Calvert Cliffs along Chesapeake Bay. 1.8 miles northeast of Lusby, Md. Calvert County. 38° 25' 51" N. Lat.; 76° 26' 05" W. Long. (Locality includes Boston Cliffs Member, Conoy Member, lower St. Marys Formation, and Pleistocene. Only Conoy Member and Choptank-St. Marys contact studied in detail.)

Unit		Thickness
St. Marys Formation		
Choptank Formation		
Conoy Member		
2	Lithology: Dusky greenish-blue, very muddy, very fine sand. Rare mottles of dark grayish-green, muddy, very fine sand. Surface heavily weathered to light brownish-gray and may obscure parallel bedding laminations usually seen in Conoy Member. Lower contact straight and distinct. Upper contact depositional unconformity. Unconformity bored from above and borings contain dark chocolate brown, muddy, fine sand of St. Marys Formation, above. Immediately above contact of Choptank and St. Marys are thin local lenses of very light-gray, well sorted, fine sand. Fossils: Rare molds and casts. Calcareous shells leached out. Random orientation and distribution. Faunal list: R-Mercenaria sp., Dosinia acetabula, Cerastoderma laqueata, Yoldia laevis. Sample 66-12-1 from 1' 0" to 2' 0" above base of unit. Sample 66-21-2 from 3' 6" to 4' 6" above base of unit. Sample 66-21-3 from 7' 6" to 8' 6" above base of unit. Sample 66-21-4 from 11' 6" to 12' 6" above base of unit. Sample 66-21-5 from 14' 6" to 15' 6" above base of unit.	16' 0"
Boston Cliffs Member		
1	Mostly covered by debris	23' 0"
	Total thickness of exposed Choptank Formation	39' 0"

Locality 66-22. Scientists Cliffs.

Unnamed ravine and creek in hills west of Scientists Cliffs, Md. Natural outcrop in small creek bed. About 1000 yards west of the Chesapeake Bay. Scientists Cliffs, Calvert

Co., Md. 38° 31' 13" N. Lat.; 76° 31' 01" W. Long. (Future investigators may never find this section. The writer was led to the location by field assistant Mr. David Showalter, who played in these hills as a youngster.)

Unit		Thickness
(Pleistocene)		
Choptank Formation		
St. Leonard Member		
4	Lithology: Dark greenish-gray, very muddy, very fine sand. No sedimentary structures. Lower contact gradational. Upper contact distinct. Fossils: Few molds and casts. All calcareous shells leached out. Random orientation and distribution. Only fossil identified Yoldia laevis. Sample 66-22-4 from 0' 0" to 1' 0" above base of unit.	2' 3"
3	Lithology: Dusky greenish-blue, very muddy, very fine sand. No sedimentary structures. Lower contact undulating and distinct. Upper contact gradational. Fossils: Few. Some show chemical deterioration. Some molds and casts. Faunal list: R-Anodontia anodonta, Discinisca lugubris. Sample 66-22-3 from 0' 3" to 1' 3" above base of unit.	2' 3"
	Total thickness of exposed St. Leonard Member	4' 6"
Drum Cliff Member		
2	Lithology: Dusky greenish-blue, very muddy, very fine sand. No inorganic, sedimentary structures. Lower contact undulating and slightly gradational. Upper contact undulating. Fossils: Prolific accumulation. Little wear or fragmentation. Shells seen concentrated in vertical and inclined, inverted, conical shafts.	1' 0"

Unit		Thickness
	High faunal diversity. Faunal list: Glossus fraternus marylandicus, Panope americana (double valved and in living position), Dosinia acetabula, Corbula idonea, Lyropecten madisonius, Cerastoderma laqueata, Ecphora quadricostata umbilicata, Lucinoma contracta, Astarte obruta (some double valves), Macrocallista marylandica, Turritella plebeia, Cerastoderma laqueata, Corbula inaequalis, Asaphis centenaria, Venericardia granulata. Sample 66-22-2 from entire interval.	
1	Lithology: Light brownish-gray, muddy, fine sand. Mottled by dusky greenish, blue, very muddy, very fine sand. Lower contact covered. Upper contact undulating and slightly gradational. Fossils: Prolific accumulation. Very jumbled. Very random orientation and distribution. Fragmentation abundant. Shells mostly of fairly small size. High faunal diversity. Partial faunal list: Lyropecten madisonius, Cerastoderma laqueata, Panope americana, Crucibulum multilineatum, Isognomon maxillata, Glossus fraternus marylandicus, Balanus concavus, Mytilus conradinus. Sample 66-22-1 from 0' 9" to 1' 9" above base of unit.	2' 9"
	Total thickness of exposed Drumcliff Member	3' 9"
	Total thickness of exposed Choptank Formation	8' 3"

Locality 66-23. Point of Rocks.

(Also called Rocky Point on some maps.) 2.2 miles east of Lusby, Md. Natural outcrop in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 24' 52" N. Lat.; 76° 24' 58" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Conoy Member		
13	Lithology: Dusky greenish-blue, very muddy, very fine sand. Lithology appears very dense. Outcrop weathers to oxidized vertical fractures. Continuous, parallel, bedding laminae. Distance separating laminae different for different sets of laminae. Laminae the result of finer texture than surrounding matrix. Lower contact straight and distinct. Upper contact distinct, depositional unconformity. Choptank - St. Marys contact bored and burrowed. Fossils: Rare molds and casts. Mostly unidentifiable fragments.	14' 7"
12	Lithology: Dark grayish-green, poorly sorted, very muddy, fine sand. Grain size varies from clay to pebble. Rare mottles of light-gray, fairly well sorted, fine sand. Bed weathers to dark reddish-brown. Resistant on weathered surface. Lower contact undulating and distinct. Upper contact straight and distinct. Fossils: Few casts and molds. Random orientation and distribution. Faunal list: R-Turritella plebeia, Cerastoderma laqueata, Lyropecten madisonius. Sample 66-23-12 from 0' 6" to 1' 6" above base of unit.	1' 9"
	Total thickness of exposed Conoy Member	16' 4"
Boston Cliffs Member		
11	Lithology: Bright yellowish-orange, poorly sorted, fine sand. Heavily oxidized. Bed indurated by case hardening. Unconsolidated sediment under exterior crust. Lower contact straight and distinct. Upper contact undulating and distinct. Fossils: Prolific shell bed but all	2' 0"

Unit		Thickness
	molds and casts. Larger, flat-lying bivalves toward base of bed while molds and casts are of fragments toward top of bed. Low faunal diversity. Faunal list: VC-Lyropecten madisonius, Cersatoderma laqueata, ?Mercenaria sp. Sample (None).	
10	Lithology: Heavily oxidized, muddy, fine sand. Indurated bed. No apparent sedimentary structures. Contacts straight and distinct. Fossils: Prolific shell bed, but all leached to varying degrees. Molds, casts, and chemically deteriorated shells. Faunal list: VC-Cerastoderma laqueata, C-Lyropecten madisonius. Sample (None).	2' 10"
9	Lithology: Dark olive-brown, poorly sorted, muddy, fine sand. No bedding laminations. Mottled by very pale-orange, well-sorted, fine sand. Lower contact distinct and slightly undulating. Upper contact distinct and straight. Fossils: Increased macrofossil bed. Increased number of large, flat-lying bivalves. Random distribution. Low faunal diversity. Faunal list: C-Cerastoderma laqueata, Anadara staminea, Lyropecten madisonius, N-Crassostrea carolinensis, Balanus concavus, F-Macrocallista marylandica. Sample 66-23-11 from entire interval.	1' 0"
8	Lithology: Dark reddish-brown, poorly sorted, muddy, fine sand. No sedimentary structures. Lower contact straight and distinct. Upper contact distinct and slightly undulating. Fossils: Reduced macrofossil bed. Reduced number of large, flat-lying bivalves. Low faunal diversity. Random distribution.	1' 0"

Unit		Thickness
	Faunal list: C-Cerastoderma laqueata, N-Macrocallista marylandica, Corbula idonea, F-Crassostrea carolinensis, Lyropecten madisonius. Sample 66-23-10 from entire interval.	
7	Lithology: Heterogeneous. Strong color differences. Moderate-brown, slightly muddy, fine sand. Dark olive-brown, muddy, fine sand. Dusky greenish-blue, very muddy, very fine sand. Light-gray, well-sorted, fine sand. Strongly mottled. Lower contract gradational and undulating. Upper contact straight and distinct. Fossils: Reduced macrofossil bed. Smaller shells predominate. Well preserved. Low faunal diversity. Fewer shells. Faunal list: VC-Cerastoderma laqueata, N-Macrocallista marylandica, Corbula idonea, F-Lyropecten madisonius, R-Discinisca lugubris. Sample 66-23-9 from entire interval.	0' 8"
6	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by dark olive-brown, muddy, fine sand. Also some mottling by light-gray, well-sorted, fine sand. Bed remains approximately same thickness but undulates slightly. Contacts gradational and undulating. Fossils: Prolific shell bed. Upper increased macrofossil bed. Increased number of large flat-lying bivalves. Well preserved. Random distribution. Low faunal diversity. Faunal list: VC-Macrocallista marylandica, Cerastoderma laqueata, N-Lyropecten madisonius, Corbula idonea, F-Anadara staminea, R-Astarte obruta. Sample 66-23-8 from entire interval.	0' 11"
5	Lithology: Heterogeneous. Moderate-brown, slightly muddy, fine sand. Commonly mottled by pale yellowish-brown, fairly well sorted, fine sand. Some pockets of light-gray, well sorted, fine sand. Few mottles of dark olive-brown, muddy, fine sand. Contacts gradational.	1' 6"

Unit		Thickness
	Fossils: Reduced macrofossil bed. Strong reduction in number of large, flat-lying bivalves. Low faunal diversity. Well preserved. Faunal list: N-Lyropecten madisonius (some double valves), Corbula idonea, Macrocallista marylandica, R-Crassatella marylandica, Turritella variabilis cumberlandia. Sample 66-23-7 from 0' 3" to 1' 6" above base of unit.	
4	Lithology: Moderate-brown, slightly muddy, fine sand. Rare, subtle mottles of very pale-orange, well sorted, fine sand. No bedding laminations. Contacts gradational. Fossils: Lower, increased macrofossil bed. Many large, flat-lying bivalves. A layer of concentrated Anadara staminea in upper part of bed. Prolific shell bed. Moderate to low faunal diversity. Faunal list: F1-Anadara staminea (some double valves), A-Lyropecten madisonius (some double valves), C-double valves), N-Balanus concavus, F-Corbula idonea, Dosinia acetabula, R-Astarte obruta, Turritella variabilis cumberlandia. Sample 66-23-5 from 0' 3" to 1' 3" above base of unit. Sample 66-23-6 from 1' 6" to 2' 6" above base of unit (the concentrated Anadara interval).	2' 6"
3	Lithology: Dark olive-brown, muddy, fine sand. Mottled by very pale-orange, well sorted, fine sand. Lower contact gradational and irregular. Upper contact gradational. Fossils: Prolific accumulation of calcareous shells. Fragments common. Significant wear on some specimens, others show little wear. Large bivalves predominantly flat-lying, convex upward. Faunal list: VC-Lyropecten madisonius, Anadara staminea, C-Ecphora	1' 8"

Unit		Thickness
	quadricostata umbilicata, N-Balanus concavus, F-Dosinia acetabula, R-Corbula idonea, Discinisca lugubris, Turritella variabilis var. alticostata. Sample 66-23-4 from 0' 3" to 1' 8" above base of unit.	
	Total thickness of Boston Cliffs Member	14' 1"
St. Leonard Member		
2	Lithology: Dark olive-brown, slightly muddy, fine sand. Mottled by dusky greenish-blue, muddy, fine sand. Also some mottling of very pale-orange, well-sorted, fine sand. Contacts irregular and gradational. Fossils: Few unidentifiable fragments of macrofossils. Few molds and casts. Lyropecten madisonius only identified fossil. Sample 66-23-2 from 0' 0" to 0' 8" above base of unit. Sample 66-23-3 from 0' 8" to 1' 9" above base of unit.	1' 9"
1	Lithology: Dusky greenish-blue, slightly muddy, fine sand. Mottles of dark grayish-green, muddy, fine sand probably the result of burrowing. Local oxidation produced some color mottling of moderate brown to reddish brown. No bedding laminations. Lower contact covered. Upper contact gradational and irregular. Fossils: Rare unidentifiable fragments. Fragments concentrated with the grayish-green mottles. Both features probably the result of biogenic activity. Sample 66-23-1 from entire interval.	1' 6"
	Total thickness of exposed St. Leonard Member	3" 3"
	Total thickness of exposed Choptank Formation	33' 8"

Locality 66-24 and Locality 67-49. North Point of Rocks.

First major point northwest of Point of Rocks (locality 66-23). 2.0 miles east northeast of Lusby, Md. Natural outcrop in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 25' 03" N. Lat.; 76° 25' 11" W. Long.

Unit		Thickness
St. Marys Formation		
Choptank Formation		
Conoy Member		
18	Lithology: Dark bluish-gray, very muddy, fine sand. Rare mottles of light-gray, well-sorted, fine sand. Some thin, parallel, continuous, bedding laminations. Thick bedded. Lower contact distinct and straight. Upper contact channeled and filled with St. Marys sediments. Fossils: Rare molds and casts. Random distribution. None identified. Sample 66-24-16 from 1' 6" to 2' 6" above base of unit.	11' 4"
17	Lithology: Dark bluish-gray, muddy, very fine sand. Weathers to light gray. Some local oxidations. No bedding laminations. Lower contact distinct and slightly undulating. Upper contact distinct and straight. Fossils: Molds and casts numerous. Random distribution. Difficult to identify species. Only one identified, Lyropecten madisonius. Sample 66-24-15 from entire interval.	1' 6"
	Total thickness of Conoy Member	12' 10"
Boston Cliffs Member		
16	Lithology: Heavily oxidized, very poorly sorted, fine sand. Indurated bed. Weathers to bright brownish yellow. Contacts undulating. Fossils: Prolific shell bed. Large, flat-lying bivalves predominate.	0' 6"

Unit		Thickness
	Random distribution. Many specimens have been partially leached out. Faunal list: Lyropecten madisonius, Atrina harrisi, Cerastoderma laqueata, Balanus concavus, Macrocallista marylandica. Sample (None).	
15	Lithology: Light-gray, muddy, fine sand. No sedimentary structures. Heavily oxidized. Indurated bed. Contacts slightly undulating. Fossils: (None). Sample (None).	0' 6"
14	Lithology: Heavily oxidized, very poorly sorted, fine sand. Indurated bed. Weathers to bright brownish yellow. Contacts undulating. Fossils: Prolific shell bed. Large, flat-lying bivalves predominate. Random distribution. Many specimens have been partially leached out. Faunal list: Lyropecten madisonius, Atrina harrisi, Cerastoderma laqueata, Balanus concavus, Macrocallista marylandica. Sample (None).	3' 0"
13	Lithology: Pale reddish-brown, slightly muddy, fine sand. Mottled by light-gray, well-sorted, fine sand. No bedding laminations. Contacts undulating and slightly gradational. Basal indurating bed. Strongly oxidized. Fossils: Prolific accumulation. Many specimens have been partially leached out. Fragments predominate. Wear abundant. Random distribution. Most fossils are large, flat-lying bivalves. Faunal list: A-Lyropecten madisonius, C-Cerastoderma laqueata, Crassostrea carolinensis, Balanus concavus, Macrocallista marylandica. Sample 66-24-13 from entire unit.	1' 6"
12	Lithology: Pale yellowish-brown, fairly well sorted, fine sand. Mottled by reddish-brown, slightly muddy, fine	1' 6"

Unit		Thickness
	sand. No bedding laminations. Contacts undulating and slightly gradational. Fossils: Increased macrofossil bed. Increased number of large, flat-lying bivalves. Increased number of calcareous shells. Random distribution. Small shells apparently randomly oriented. Some shells with great wear, particularly Lyropecten and Anadara. Faunal list: VC-Crassostrea carolinensis, Anadara staminea, C-Lyropecten madisonius, Macrocallista marylandica, N-Cerastoderma laqueata, Corbula idonea. Sample 66-24-12 from 0' 0" to 1' 0" above base of unit.	
11	Lithology: Heterogeneous. Olive-brown, very muddy, fine sand. Very pale-orange, well-sorted, fine sand. Moderate-brown, slightly muddy, fine sand. Grayish-brown, muddy, fine sand. No bedding laminations. Lower contact rises and falls slightly in section. Upper contact broadly undulates, and slightly gradational. Fossils: Prolific, but somewhat reduced. Reduced in number of large, flat-lying bivalves. Fragmentation common. Some shells extremely worn. Random distribution. Faunal list: C-Cerastoderma laqueata, Crassostrea carolinensis, N-Balanus concavus, F-Turritella plebeia var. A, Macrocallista marylandica. Sample 66-24-11 from 0' 6" to 1' 6" above base of unit.	2' 0"
10	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by dark olive-brown, muddy, fine sand. Contacts slightly gradational and rise and fall in section. Fossils: Increased macrofossil bed. Prolific accumulation. Increased number of large, flat-lying bivalves. Shells well preserved with little wear. Random distribution. Faunal list: VC-Macrocallista	1' 0"

Unit		Thickness
	marylandica (some double valves), C-Cerastoderma laqueata, N-Corbula idonea, Dosinia acetabula, F-Lyropecten madisonius, R-Ecphora quadricostata umbilicata. Sample 66-24-10 from entire interval.	
9	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Contacts slightly gradational. Upper contact broadly and distinctly undulating. Fossils: Reduced macrofossil bed. Reduced number of calcareous macrofossils. Reduced number of large, flat-lying bivalves. Random distribution. Faunal list: N-Corbula idonea, Astarte obruta, Cerastoderma laqueata, Turritella plebeia var. A, F-Macrocallista marylandica (some double valves), Lyropecten madisonius, Anadara staminea. Sample 66-24-9 from entire interval.	1' 3"
8	Lithology: Moderate-brown, slightly muddy, fine sand. Heavily mottled by dark olive-brown, muddy, fine sand. Also mottles of very pale-orange, well-sorted, fine sand. Contacts gradational. Fossils: Lower increased macrofossil bed. Marked increase in number of shells. Marked increase in number of large, flat-lying bivalves. Random distribution except for concentrated layer of Anadara near top of unit. Faunal list: A-Anadara staminea, VC-Macrocallista marylandica (some double valves), Lyropecten madisonius, N-Cerastoderma laqueata, Dosinia acetabula, R-Ecphora quadricostata umbilicata.	3' 0"
7	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Also mottled by dark olive-brown, very muddy, fine sand. No bedding laminations. Contacts gradational. Fossils: Prolific shell bed. Calcareous shells comprise ten to	1' 6"

Unit		Thickness
	fifteen percent of unit. Random orientation and distribution. Fragmentation common. Faunal list: Lyropecten madisonius, Anadara staminea, Dosinia acetabula, Macrocallista marylandica. Sample 66-24-6 from 0' 0" to 1' 0" above base of unit.	
	Total thickness of Boston Cliffs Member	15' 9"
St. Leonard Member		
6	Lithology: Pale reddish-brown, muddy, fine sand. Heavily mottled by small lenses of very pale-orange, well-sorted, fine sand. Slight surface hardening. Break to a more vertical slope. Contacts gradational. Fossils: Rare fragments of calcareous shells but too broken to identify. Random orientation and distribution. Sample 66-24-6 from 0' 0" to 1' 0" above base of unit.	1' 0"
5	Lithology: Pale reddish-brown, fairly well-sorted, fine sand. Heavily oxidized. No bedding laminations. Contacts gradational. Fossils: None. Sample 66-24-5 from 1' 6" to 2' 6" above base of unit.	3' 9"
4	Lithology: Light-gray, muddy, fine sand. Heavily mottled by pale reddish-brown, well-sorted, fine sand. Heavily oxidized. Few burrows, Lower contact gradational. Oxidized mottles increase upward. Fossils: None. A few burrows are present but with no internal structures. Sample 66-24-4 from 1' 0" to 2' 0" above base of unit.	2' 0"
3	Lithology: Light-gray, well-sorted, fine to medium sand. No apparent sedimentary structures. Unit looks	2' 6"

Unit		Thickness
	heavily oxidized, probably after sedimentation. Lower contact gradational and irregular. Upper contact gradational. Fossils: Two molds may be Anodontia anodonta. Round, 2.0 cm. thick burrow with no internal structures. Sample 66-24-3 from 1' 0" to 2' 0" above base of unit.	
2	Lithology: Dusky greenish-blue, muddy, very fine sand. A few small grayish-green clay blebs. No sedimentary structures. Lower contact distinct and undulating. Upper contact gradational and irregular. Fossils: Rare fragments broken beyond recognition. Random orientation and distribution. Sample 66-24-2 from entire interval.	1' 10"
	Total Thickness of St. Leonard Member	11' 1"
Drumcliff Member		
1	Lithology: Dusky greenish-blue, very muddy, fine sand. No sedimentary structures. Lower contact covered. Upper contact undulating. Fossils: Prolific accumulation. Very diverse fauna. Little wear. Both fragments and complete specimens in abundance. Orientation and distribution random. Partial faunal list: C-Lyropecten madisonius, N-Anadara staminea, Dosinia acetabula, Balanus concavus, F-Gari (Gari) gubernatoria, Macrocallista marylandica, Crassatella turgidula, Astarte thisphila, Astarte obruta, Cerastoderma laqueata, Ecphora quadricostata umbilicata, Mytilus conradinus, Diplodonta acclinis, Atrina harrisi, Mercenaria spp., Anodontia anodonta. Sample 66-24-1 from entire interval.	0' 9"
	Total thickness of exposed Choptank Formation	40' 5"

Locality 66-25. Flag Pond II.

At south end of long line of continuous cliffs south of Flag Ponds. 2.0 miles south of Long Beach, Md. Natural outcrop in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 26' 16" N. Lat.; 76° 26' 40" W. Long.

Unit		Thickness
St. Marys Formation	Lowest unit has dark chocolate-brown, muddy, fine sand and contains a shell hash. Sample 66-25-23 from 0' 0" to 0' 7" above base of formation. Sample 66-25-24 from 1' 11" to 2' 11" above base of formation. Sample 66-25-25 from 4' 6" to 5' 5" above base of formation. Sample 66-25-26 from 6' 11" to 7' 11" above base of formation. Sample 66-25-27 from 9' 5" to 10' 5" above base of formation. 0' 7" Prominent indurated ledge starting at 12' 7" above base of St. Marys Formation.	
Choptank Formation Conoy Member 21	Lithology: Dusky greenish-blue, muddy, very fine sand. Subtle mottles of light grayish-green, muddy, very fine sand. Parallel, continuous, thin, bedding laminations. Variable distance separating laminae, up to 2.0'. Lower contact distinct and slightly undulating. Upper contact distinct and slightly undulating. Fossils: Rare. Predominantly thin-shelled bivalves. Rare small ?burrow concentrations of small fragments, otherwise random distribution. Faunal list: R-Yoldia laevis, Mytilus conradinus, ?Ensis ensiformis, Ecphora quadricostata. Sample 66-25-19 from 0' 0" to 1' 0" above base of unit. Sample 66-25-20 from 2' 6" to 3' 6" above base of unit.	8' 1"

Unit		Thickness
	Sample 66-25-21 from 5' 0" to 6' 0" above base of unit. Sample 66-25-22 from 7' 6" to 8' 1" above base of unit.	
20	Lithology: Dark olive-brown, very muddy, fine sand. Mottled by reddish-brown, slightly muddy, fine sand. Rare mottles of dusky greenish-blue, muddy, very fine sand. No bedding laminations. Heterogeneous sediments. Contacts slightly undulating. Fossils: Quite common. Many probably reworked from Boston Cliffs Member. Wear and fragmentation common. Random distribution. Larger shells flat lying. Smaller shells seem randomly oriented. Faunal list: C-Lyropecten madisonius, N-Mytilus conradinus, Balanus concavus, Dosinia acetabula, Turritella plebeia, F-Cerastoderma laqueata, Mercenaria sp. (some double valves), R-Isognomon maxillata. Sample 66-25-18 from 0' 3" to 1' 3" above base of unit.	1' 6"
	Total thickness of Conoy Member	9' 7"
Boston Cliffs Member		
19	Lithology: Grayish-blue, very muddy, very fine sand. Indurated unit. No apparent sedimentary structures. Contacts slightly undulating and distinct. Fossils: Abundant, large, flat-lying Lyropecten madisonius. Some molds and casts. Shells partially or completely leached. No sample.	0' 10"
18	Lithology: Reddish-brown, muddy, fine sand. Oxidation causing color mottling with various browns, reds, and oranges. Contacts slightly undulating and distinct. Fossils: Abundant, large, flat-lying Lyropecten madisonius. Sample 66-25-17 from entire interval.	0' 6"

Unit		Thickness
17	Lithology: Light-gray, very poorly sorted, fine sand. No apparent sedimentary structures. Contacts undulating and distinct. Fossils: Prolific accumulation. Predominantly large, flat-lying bivalves. Random distribution. Faunal list: A-Lyropecten madisonius, VC-Atrina harrisi, C-Macrocallista marylandica, R-Crucibulum multilineatum. No sample.	0' 10"
16	Lithology: Dark-brown, slightly muddy, fine sand. No sedimentary structures. Lower contact slightly gradational and essentially straight. Upper contact undulating and distinct. Fossils: Prolific accumulation of shells. Fragments common but distinct proportionate increase in large, complete bivalves. Large bivalves predominantly flat-lying. Some wear on specimens. Random distribution. Faunal list: C-Lyropecten madisonius, Dosinia acetabula, Macrocallista marylandica, N-Cerastoderma laqueata, Balanus concavus, Corbula idonea. Sample 66-25-16 from 1' 0" to 2' 0" above base of unit.	2' 0"
15	Lithology: Light-gray, well-sorted fine sand. Mottled by reddish-brown, muddy, fine sand. Also small lenses of light-gray clay which are indurated. No bedding laminations. Contacts slightly gradational. Fossils: Prolific accumulation. Very hashy. Abundant fragmentation of shells. Wear common. Large proportion of fragments are flat-lying. Random distribution. Faunal list: VC-Lyropecten madisonius, Anadara staminea, N-Balanus concavus, Turritella plebeia var. A., Corbula idonea, F-Mytilus conradinus, Dosinia acetabula, R-Astarte obruta, Crassostrea carolinensis. Sample 66-25-14 from 0' 3" to 1' 3" above base of unit. Sample 66-25-15 from 2' 3" to 3' 3" above base of unit.	4' 1"

Unit		Thickness
14	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts undulating and slightly gradational. Fossils: Prolific accumulation. Very hashy. Some specimens well worn, others well preserved. A concentrated pocket of Anadara staminea, otherwise, random orientation and distribution. Abundant fragmentation of shells. Faunal list: VC-Lyropecten madisonius, Crassostrea carolinensis, C-Anadara staminea, Balanus concavus, Cerastoderma laqueata, N-Corbula idonea, Dosinia acetabula, F-Turritella plebeia var. A, R-Astarte obruta. Sample 66-25-13 from 1' 0" to 2' 0" above base of unit.	2' 3"
13	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts undulating and slightly gradational. Fossils: Reduced macrofossil bed. Reduced number of macrofossils. Reduced number of large, flat-lying bivalves. Whole assemblage looks more jumbled and dumped than unit 13. Random orientation and distribution. Fragments numerous. Some specimens worn. Faunal list: C-Balanus concavus, N-Lyropecten madisonius, Corbula idonea, Anadara staminea, Cerastoderma laqueata, Turritella plebeia var. A, F-Macrocallista marylandica, Mercenaria sp., R-Mytilus sp. Sample 66-25-12 from entire unit.	1' 0"
12	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts undulating and slightly gradational. Fossils: Increased macrofossil bed. Large, flat-lying bivalves abundant. No wear. Beautifully preserved. Some bivalves with remnants of original hinge ligament. Some bivalves with shell coloration preserved.	1' 0"

Unit		Thickness
	Few fragments. Faunal list: VC-Macrocallista marylandica (many double valves), Dosinia acetabula (many double valves), Corbula idonea (many double valves) C-Cerastoderma laqueata, N-Crassatella marylandica (many double valves). Sample 66-25-11 from entire interval.	
11	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts undulating and slightly gradational. Fossils: Anadara staminea bed. Increased macrofossil bed. Well preserved. Little wear. A few large, flat-lying bivalves. Rare fragments. A great concentration of Anadara, both double and single valves. Faunal list: F1-Anadara staminea, R-Macrocallista marylandica, Cerastoderma laqueata, Astarte obruta, Dosinia acetabula, Turritella variabilis cumberlandia. Sample 66-25-10 from entire interval.	0' 8"
	Total thickness of Boston Cliffs Member	13' 2"
St. Leonard Member		
10	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted fine sand. No bedding laminations. Lower contact fairly distinct, marked by appearance of large complete bivalves. Upper contact undulating and slightly gradational. Fossils: Increased macrofossil bed. Great increase in complete, large, flat-lying bivalves. Well preserved. Little wear. Few fragments. Faunal list: A-Anadara staminea (some tremendous local layers), VC-Lyropecten madisonius (many double valves), Macrocallista marylandica (many double valves), C-Cerastoderma laqueata, F-Mercenaria sp.,	1' 8"

Unit		Thickness
	Crassatella marylandica. Sample 66-25-9 from 0' 0" to 1' 0" above base of unit.	
9	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts gradational. Fossils: Prolific shell bed. Increased amount of shell material. Increasing shell size to appearance of complete specimens. Wear abundant. Fragments very common. Faunal list: Mytilus conradinus, Turritella plebeia var. A., Lyropecten madisonius, Crassatella marylandica, Anadara staminea, Macrocallista marylandica, Dosinia acetabula, Astarte obruta, Balanus concavus, Crassostrea carolinensis, Anodontia anodonta. Sample 66-25-8 from 0' 6" to 1' 6" above base of unit.	2' 2"
8	Lithology: Moderate-brown, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Also some mottles of dark olive-brown, slightly muddy, fine sand. No bedding laminations. Contacts gradational. Fossils: A nonprolific shell unit. Wear common. Fragments common, but none identified. Fragments may have come from unit 9, above, as a result of biogenic activity. Sample 66-25-7 from 0' 0" to 1' 0" above base of unit.	1' 6"
7	Lithology: Dark olive-brown, muddy, fine sand. Mottled by moderate-brown, slightly muddy, very fine sand. Rare small dusky greenish-blue, muddy, very fine sand. No bedding laminations. Contacts gradational. Fossils: Very rare. Only one identified, Astarte thisphila? Sample 66-25-6 from 0' 6" to 1' 6" above base of unit.	2' 6"

Unit		Thickness
6	Lithology: Dark olive-brown, muddy, fine sand. Mottled by moderate-brown, slightly mottled, fine sand. Rare dusky greenish-blue, muddy, very fine sand. No macrofossils seen. Sample 66-25-5 from 0' 6" to 1' 6" above base of unit.	2' 0"
5	Lithology: Dark olive-brown, muddy, fine sand. Rare mottles of dusky greenish-blue, muddy, very fine sand. Mottling probably result of biogenic activity. Contacts gradational. Fossils: Few unidentifiable fragments seen. Sample 66-25-4 from 0' 0" to 1' 0" above base of unit.	1' 6"
4	Lithology: Strikingly mottled. Dusky greenish-blue, very muddy, very fine sand. Mottled by dark olive-brown, very muddy, very fine sand. Mottled by moderate-brown, slightly muddy, fine sand. Mottling probably the result of biogenic activity. Contacts gradational. Fossils: Few unidentifiable fragments of calcareous shells. Samples 66-25-3 from entire interval.	1' 0"
3	Lithology: Dusky greenish-blue, very muddy, fine sand. Mottled by light-gray, well-sorted, fine sand. Also mottled by moderate-brown, slightly muddy, fine sand. Intensely burrowed. Contacts gradational. Fossils: Mostly small unidentifiable fragments. Nonprolific shell unit. Random distribution. Faunal list: N-*Ensis ensiformis*, F-*Discinisca lugubris*, R-*Cerastoderma laqueata*. Sample 66-25-2 from 0' 0" to 1' 0" above base of unit.	2' 0"
2	Lithology: Dusky greenish-blue, very	1' 0"

Unit		Thickness
	muddy, very fine sand. Rare mottles of light-gray, well-sorted, fine sand. Heavily burrowed. No bedding laminations. On weathered surface unit is bluer and muddier than St. Leonard sediments above. Lower contact gradational and irregular. Upper contact gradational. Fossils: A nonprolific shell unit, but still a few shells. Nearly all specimens double valved and in living positions. No single bivalve found. Profuse biogenic activity. Difficult to dig out enough of thin shells from dense sediments to identify. Well preserved. Faunal list: F-Gari gubernatoria (all double valved and in living position), Discinisca lugubris, R-Cerastoderma laqueata. Sample 66-25-1 from entire interval.	
	Total thickness of St. Leonard Member	15' 4"
Drumcliff Member		
1	Lithology: Dusky-blue, muddy, fine sand. No sedimentary structures. Lower contact covered. Upper contact gradational and irregular, based on presence of fossils below contact and absence of prolific fossils above. Fossils: Prolific accumulation of shells. Mostly thin-shelled individuals. Random orientation and distribution. Fairly high faunal diversity. Well preserved. Partial faunal list: VC-Mytilus conradinus, C-Cerastoderma laqueata, Balanus concavus, N-Corbula idonea, Anodontia anodonta, F-Macrocallista marylandica, Lyropecten madisonius. Sample 66-25-28 from entire interval.	1' 0"
	Total thickness of exposed Choptank Formation	39' 1"

Locality 66-26. South Point of Rocks.

Major point 0.3 mile southeast of Point of Rocks. Approximately 1000 feet northwest of Camp Baybreeze (G.S.A.). 2-1/4 miles east of Lusby, Md. Natural outcrop in Calvert Cliffs along Chesapeake Bay. Calvert Co., Md. 38° 24' 36" N. Lat.; 76° 24' 49" W. Long.

Unit		Thickness
St. Marys Formation Choptank Formation Conoy Member		
13	Lithology: Dusky grayish-green, very muddy, very fine sand. Very dense sediment. Mottled by light greenish-gray, muddy, very fine sand. Also mottled by light-gray, well-sorted, fine sand. Parallel, somewhat discontinuous, thin, bedding laminations. Fossils: Rare molds and casts. Random distribution. Faunal list: R-Yoldia laevis, Turritella plebeia. Sample 66-26-14 from 0' 0" to 1' 0" above base of unit. Sample 66-26-15 from 2' 6" to 3' 6" above base of unit. Sample 66-26-16 from 5' 0" to 6' 0" above base of unit. Sample 66-26-17 from 7' 6" to 8' 6" above base of unit.	9' 0"
Boston Cliffs Member		
12	Lithology: Light-gray, very muddy, poorly sorted, medium sand. Heavily oxidized. No apparent sedimentary structures. Lower contact distinct and locally appears bored. Upper contact straight and distinct. Fossils: Abundant molds and casts, predominantly flat-lying. No sample.	1' 4"
11	Lithology: Bright brownish-yellow, poorly sorted, fine sand. Heavily oxidized. No apparent sedimentary structures. Lower contact distinct and slightly undulating. Upper	0' 6"

Unit		Thickness
	contact distinct and locally appears bored. Fossils: Prolific accumulation. All molds and casts. Random distribution. Most specimens flat-lying. Difficult to identify. Only Lyropecten madisonius identified. Sample 66-26-12 from entire interval.	
10	Lithology: Dark yellowish-brown, poorly sorted, fine sand. Indurated bed. Heavily oxidized. No apparent sedimentary structures. Lower contact distinct. Upper contact distinct and slightly undulating. Fossils: Heavily leached. Abundant molds and casts. Random distribution. Difficult to identify. Only Lyropecten madisonius identified. Sample 66-26-13 from entire interval.	0' 8"
9	Lithology: Pale yellowish-brown, poorly sorted, fine sand. Indurated bed. No apparent sedimentary structures. Lower contact undulating and distinct. Upper contact distinct. Fossils: Partially leached. Some molds and casts. Looks rather jumbled. Fragmentation common. Orientation and distribution random. Low faunal diversity. Faunal list: VC-Lyropecten madisonius, C-Balanus concavus, F-Corbula idonea. No sample.	2' 0"
8	Lithology: Very dark yellowish-orange, muddy, fine sand. Strongly mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Lower contact gradational. Upper contact slightly undulating and distinct. Fossils: Prolific accumulation of shells. Largely hashy. Few complete specimens. Random orientation and distribution. Faunal list: VC-Lyropecten madisonius, F-Corbula idonea, Macrocallista marylandica, Cerastoderma laqueata. Sample 66-26-11 from entire interval.	1' 3"

Unit		Thickness
7	Lithology: Very dark yellowish-orange, muddy, fine sand. No apparent sedimentary structures. Lower contact straight and slightly gradational. Upper contact gradational. Fossils: Prolific accumulation of shells. Shells begin at base of bed but grade upward into nearly solid shell bed. Nearly all large, complete specimens. Most flat-lying bivalves but a few vertical. Assemblage strongly dominated by oysters and scallops. Very low faunal diversity. Faunal list: Fl-Crassostrea carolinensis, Lyropecten madisonius, R-Macrocallista marylandica (bored by sponges). Sample 66-26-10 from entire interval.	1' 0"
6	Lithology: Very dark yellowish-orange, slightly muddy, fine sand. No bedding laminations. Lower contact distinct and strongly undulating. Upper contact straight and slightly gradational. Fossils: Reduced macrofossil bed. Reduced number of shells. Reduced number of large, flat-lying bivalves. Nearly all single valves. Little wear. Random distribution. Low faunal diversity. Faunal list: A-Cerastoderma laqueata, F-Lyropecten madisonius, Anadara staminea. Sample 66-26-9 from entire interval.	0' 10"
5	Lithology: Very dark yellowish-orange, slightly muddy, fine sand. No bedding laminations. Lower contact slightly gradational and strongly undulating. Upper contact distinct and strongly undulating. Fossils: Increased macrofossil bed. Predominantly large, flat-lying bivalves. Very well preserved. Nearly all shells flat	1' 0"

Unit		Thickness
	lying and convex upward. Random distribution. Faunal list: A-Macrocallista marylandica, VC-Cerastoderma laqueata, N-Lyropecten madisonius, Dosinia acetabula, F-Crassatella marylandica, R-Corbula idonea. Sample 66-26-8 from entire interval.	
4	Lithology: Very dark yellowish-orange, slightly muddy, fine sand. No bedding laminations. Lower contact irregular and gradational. Upper contact slightly gradational and strongly undulating. Fossils: Reduced macrofossil bed. Reduced number of shells. Reduced number of large flat-lying bivalves. Some shells heavily bored by sponges. Some pockets of concentrated Turritella plebeia, otherwise random distribution. Faunal list: F1-Turritella plebeia, N-Lyropecten madisonius (a few double valves), Macrocallista marylandica, Dosinia acetabula, Anadara staminea (some double valves), Cerastoderma laqueata, R-Anodontia anodonta, Corbula idonea, Crucibulum costatum. Sample 66-26-5 from entire interval. Sample 66-26-6 from Turritella pocket in lower part of unit.	1' 6"
3	Lithology: Very dark yellowish-orange, slightly muddy, fine sand. Heavily mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Lower contact very undulating. Upper contact irregular and gradational. Fossils: Increased macrofossil bed. Increased number of shells. Increased number of large, flat-lying bivalves. Prolific accumulation of shells. Shells well preserved. Little wear. Little fragmentation. Double	2' 0"

Unit		Thickness
	valves very common. Layer of concentrated Anadara staminea. Faunal list: Fl-Anadara staminea, VC-Lyropecten madisonius, Macrocallista marylandica, Dosinia acetabula, N-Balanus concavus, R-Turritella variabilis cumberlandia, Anodontia anodonta. Sample 66-26-3 from 0' 0" to 1' 0" above base of unit. Sample 66-26-7 from Anadara bed at top of unit.	
2	Lithology: Very dark yellowish-orange, slightly muddy, fine sand. Rare mottles of very pale-orange, well-sorted, fine sand. No bedding laminations. Lower contact slightly undulating. Upper contact strongly undulating. Fossils: Reduced macrofossil bed. Reduced number of shells. Reduced number of large, flat-lying bivalves. Well preserved. Random distribution. Faunal list: C-Anadara staminea, Lyropecten madisonius, F-Cerastoderma laqueata, R-Ecphora quadricostata umbilicata, Balanus concavus. Sample 66-26-2 from entire interval.	0' 9"
1	Lithology: Very dark, yellowish-orange, poorly sorted, fine sand. Rare mottles of grayish-red, poorly sorted, fine sand. No bedding laminations. Lower contact covered. Upper contact slightly undulating. Fossils: Prolific accumulation of shells. Much of the unit is shell hash. Oysters are all well preserved, however. Random distribution. Faunal list: C-Crassostrea, carolinensis, Lyropecten madisonius (mostly small specimens), N-Cerastoderma laqueata, Anadara staminea, F-Macrocallista marylandica, R-Ecphora quadricostata umbilicata.	1' 9"

Unit		Thickness
	Sample 66-26-1 from 0' 0" to 1' 0" above base of unit.	
	Total thickness of exposed Boston Cliffs Member	14' 7"
	Total thickness of exposed Choptank Formation	23' 7"

Locality 66-27. Cuckold Creek I.

On the north bank of the northernmost "finger" of the three western "fingers" of Cuckold Creek. 1.6 mile northwest of Clarks Landing, Md. 2.4 miles east northeast of Hollywood, Md. St. Marys Co., Md., 38° 21' 13" N. Lat.; 76° 31' 44" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
	Drumcliff Member, upper	
1	Lithology: Pale reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact covered. Upper contact distinct with Pleistocene above. Fossils: Dense accumulation of shells. High faunal diversity. Accumulation has jumbled appearance. Random orientation and distribution. Partial faunal list: C-Macrocallista marylandica, Anadara staminea (some double valves), Corbula idonea, N-Lunatia heros, Astarte obruta, Turritella plebeia, F-Anodontia anodonta (all double valves), Cerastoderma laqueata. Sample 66-27-1 from entire interval.	1' 0"

Locality 66-28. Cuckold Creek II.

On the south bank of the northernmost "finger" of the three western "fingers" of Cuckold Creek. 1.6 mile northwest of Clarks Landing, Md. 2.3 miles east northeast of Hollywood, Md. St. Marys Co., Md. 38° 21' 12" N. Lat.; 76° 31' 50" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member		
1	Lithology: Pale reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact covered. Upper contact distinct with Pleistocene above. Fossils: Somewhat reduced macrofossil bed. Few large, flat-lying bivalves. Reduced number of shells from unit 1 in 66-27, short distance away. Random distribution. Faunal list: N-Anadara staminea, Corbula idonea, Turritella plebeia, F-Lunatia heros, Macrocallista marylandica (flat-lying specimens), Astarte obruta, Crassatella turgidula, Cerostoderma laqueata, Anodontia anodonta. Sample 66-29-1 from entire interval.	1' 6"

Locality 66-29. Cuckold Creek III.

On the south bank of the northernmost "finger" of the three western "fingers" of Cuckold Creek. 1.4 mile northwest of Clarks Landing, Md. 2.4 miles east northeast of Hollywood, Md. St. Marys Co., Md. 38° 21' 02" N. Lat.; 76° 31' 41" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Boston Cliffs Member		
4	Lithology: Heavily oxidized reddish-brown, poorly sorted, medium sand, indurated bed. No apparent sedimentary structures. Contacts straight and distinct. Fossils: All molds and casts. Prolific accumulation. Predominantly flat-lying. Random distribution. High faunal dominance. Lyropecten madisonius only fossil found. No sample.	0' 3"
3	Lithology: Very light-gray, poorly sorted, medium sand. Not indurated. No apparent sedimentary structures. Contacts straight and distinct. Fossils: None. No sample.	0' 5"
2	Lithology: Pale reddish-brown, poorly sorted, muddy, medium sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Lower contact slightly gradational. Upper contact straight and distinct. Partially indurated. Fossils: All molds and casts. Prolific accumulation. Predominantly flat-lying. Random distribution. High faunal dominance. Lyropecten madisonius only fossil found. No sample.	4' 6"
1	Lithology: Pale reddish-brown, poorly sorted, muddy, fine sand. Mottled by very pale-orange, well-sorted fine sand. No bedding laminations. Lower contact distinct and strongly undulating. Upper contact slightly gradational. Fossils: Prolific accumulation. Somewhat jumbled. Random distribution. Dominated by oysters and scallops. Faunal list: A-Crassostrea	4' 3"

Unit		Thickness
	carolinensis, Lyropecten madisonius, F-Astarte obruta, Corbula idonea, Macrocallista marylandica, Cerastoderma laqueata, Balanus concavus. Sample 66-29-1 from 1' 0" to 2' 0"	
	Total thickness of exposed Boston Cliffs Member	9' 5"
St. Leonard Member		
1	Lithology: Heterogeneous. Light olive-green, muddy fine sand. Moderate-brown, poorly sorted, muddy, fine sand. Pale reddish-brown, muddy, fine sand. Very pale-orange, well-sorted, fine sand. Irregular, discontinuous bedding. Some bedding laminations which appear to be either wave ripple marks or distorted laminations. Lower contact covered. Upper contact distinct and strongly undulating. Fossils: Rare molds and casts. Random distribution. Only Lyropecten madisonius found. Sample 66-29-2 from 3' 6" to 4' 6" above base of unit.	6' 6"
	Total thickness of exposed Choptank Formation	15' 11"

Locality 66-30. Cuckold Creek IV.

On the north bank of the central "finger" of the three western "fingers" of Cuckold Creek. 1.2 mile west northwest of Clarks Landing. 2.6 miles east of Hollywood, Md. St. Marys Co., Md. 38° 20' 56" N. Lat.; 76° 31' 29" W. Long.

Unit		Thickness
Choptank Formation		
Drumcliff Member, upper		
2	Lithology: Pale reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures.	1' 6"

Unit		Thickness
	Lower contact slightly gradational. Upper contact covered. Fossils: Prolific accumulation. Very dense. Only bivalves found. Fauna noticeably dominated by Cerastoderma. Faunal list: Fl-Cerastoderma laqueata, N-Macrocallista marylandica, F-Corbula idonea, Lyropecten madisonius, R-Astarte obruta. Sample 66-30-2 from entire interval.	
1	Lithology: Pale reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact covered. Upper contact slightly gradational. Fossils: Prolific accumulation. Large bivalves predominantly flat-lying. Random distribution. Faunal list: VC-Macrocallista marylandica, N-Cerastoderma laqueata, Corbula idonea, Lyropecten madisonius, F-Astarte obruta, Panope americana (all double-valved and in living position). Sample 66-30-1 from entire interval.	0' 8"
	Total thickness of exposed Drumcliff Member	2' 2"

Locality 66-31. Hickory Landing Creek.

Natural outcrop on south bank of Hickory Landing Creek. 0.9 mile southwest of Clarks Landing. 2.4 miles north of California, Md. St. Marys Co., Md. 38° 19' 56" N. Lat.; 76° 30' 58" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member, upper		
2	Lithology: Pale reddish-brown, slightly muddy, fine sand. Not indurated. No apparent sedimentary	1' 0"

Unit		Thickness
	structures. Lower contact distinct and slightly undulating. Upper contact distinct with Pleistocene. Fossils: Reduced macrofossil size from unit 1. Well-preserved shells. Random distribution. Bivalves predominantly flat-lying. Partial faunal list: C-Crassatella turgidula, Isognomon maxillata, N-Lyropecten madisonius, Atrina harrisi, Cerastoderma laqueata. Sample 66-31-I from entire interval.	
1	Lithology: Pale reddish-brown, muddy, fine sand. Indurated unit. No apparent sedimentary structures. Lower contact covered. Upper contact distinct and slightly undulating. Fossils: All shells leached out. Molds and casts. Prolific accumulation. Exclusively large, flat-lying, bivalves. Random distribution. High faunal dominance. Faunal list: A-Lyropecten madisonius, Isognomon maxillata. No sample.	1' 0"
	Total thickness of exposed Drumcliff Member	2' 0"

Locality 66-32. South Mouth of Hungerford Creek.

2.0 miles north northeast of Solomons Island, Md. Natural outcrop in low bluff along the eastern shore of Patuxent River. Calvert Co., Md. 38° 28' 49" N. Lat.; 76° 28' 14" W. Long.

Unit		Thickness
(Pleistocene undifferentiated)		
Choptank Formation		
Conoy Member		
1	Lithology: Dusky-blue, silty mud. Continuous, thin, parallel, bedding laminations. Contacts distinct and fairly straight. Fossils: Only fossils seen were	2' 4"

Unit		Thickness
	heavily concentrated Turritella plebeia in pockets. Turritella only seen from 0' 9" to 1' 6" above base of unit. Sample 66-32-1 from 0' 9" to 1' 6" above base of unit.	
Boston Cliffs Member, upper		
1	Lithology: Dark reddish-brown, poorly sorted, fine sand. Indurated unit. No apparent sedimentary structure. Lower contact covered. Upper contact distinct and fairly straight. Fossils: All leached out. Predominantly large, flat-lying bivalves. Prolific accumulation. All molds and casts. High faunal dominance. Faunal list: A-Lyropecten madisonius. No sample.	1' 0"
	Total thickness of exposed Choptank Formation	3' 4"

Locality 66-33. Pawpaw Point I.

Natural outcrop in bluff along northwestern shore of Breton Bay. About 800 feet west of extreme tip of Pawpaw Point. Across Breton Bay from Abells Wharf and Lovers Point. 1.8 miles southwest of waterfront at Leonardtown, Md. St. Marys Co., Md. 38° 15' 49" N. Lat.; 76° 39' 38" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member		
6	Lithology: Very pale-orange, well-sorted, fine sand. Slight mottling to pale yellowish-brown coloring. No bedding laminations. Lower contact gradational. Upper contact distinct and slightly undulating. Fossils: Prolific accumulation of shells. Turritella concentrated in	1' 0"

Unit		Thickness
	lenses, otherwise random distribution. Atrina in living position. Turritella and Lyropecten predominantly flat-lying. Low faunal diversity. Faunal list: A-Turritella plebeia, VC-Atrina harrisi, N-Glossus fraternus marylandicus, F-Lyropecten madisonius. Sample 66-33-6 from entire interval.	
5.	Lithology: Very pale-orange, well-sorted, fine sand. Slight mottling to pale yellowish-brown coloring. No bedding laminations. Contacts gradational. Fossils: Prolific accumulation of shells. Turritella concentrated in lenses. Panope in living position. 1.0 cm. constant thickness burrow with no internal structures and 15.0 cm. long. Fauna strongly dominated by Turritella plebeia. Faunal list: Fl-Turritella plebeia, F-Anodontia anodonta, Panope goldfussi (all double valves and in living position), Ecphora quadricostata umbilicata, R-Lyropecten madisonius. Sample 66-33-5 from entire interval.	1' 0"
4	Lithology: Very pale-orange, well-sorted, fine sand. Abundant mottles of pale yellowish-brown, slightly muddy, fine sand. No bedding laminations. Contacts gradational. Fossils: Prolific accumulation of shells. Faunal diversity high. Turritella concentrated in lenses. Large bivalves predominantly flat lying. Cerastoderma laqueata (some double valves), N-Mercenaria plena (some double valves and some askew), Glossus fraternus marylandicus, Corbula idonea, Panope americana (all in living position), Dosinia acetabulum, F-Anodontia anodonta, R-Anadara staminea, Lunatia hemicrypta, Lunatia heros, Lyropecten madisonius, Asaphis centenaria, Scaphella typa.	1' 0"

Unit		Thickness
	Sample 66-33-4 from entire interval.	
3	Lithology: Light olive-gray, slightly muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Also mottled by moderate-brown, muddy, fine sand. Lower contact distinct and slightly undulating. Upper contact gradational. Fossils: Reduced macrofossil bed. Greatly reduced number of macrofossils. Random distribution. Faunal list: C-Anodontia anodonta (many double valves both in living position and flat lying), Turritella plebeia, Mercenaria plena (some double valves askew). Sample 66-33-3 from entire interval.	1' 0"
2	Lithology: Dusky-blue, slightly muddy, fine sand. No inorganic structures. Multi-walled, slime-lined burrows abundant. Lower contact gradational. Upper contact distinct and slightly undulating. Fossils: Prolific accumulation of shells. Bimodal distribution of sizes of molluscs--very large molluscs and very small molluscs abundant. Bivalves predominantly flat lying except Atrina harrisi. Isognomon concentrated in layers. Some small shell hash layers less than 3 in. thick. Faunal list: A-Isognomon maxillata, Atrina harrisi (all double valved and in living position), F-Balanus concavus, Astarte thisphila, R-Dosinia acetabulum, Lucinoma contracta, Glossus fraternus marylandicus, Crassatella turgidula. Sample 66-33-2 from 0' 6" to 1' 6" above base of unit.	1' 6"
1	Lithology: Dusky-blue, slightly muddy, fine sand. No inorganic structures. One multi-walled, slime-lined, vertical burrow seen, with diameter of 2.5 cm. Lower contact covered. Upper contact gradational.	1' 0"

Unit		Thickness
	Fossils: Prolific accumulation of shells. Bimodal distribution of sizes of molluscs--very large molluscs abundant and very small molluscs abundant. Bivalves predominantly flat-lying. Random distribution. Fauna distinctly dominated by Isognomon maxillata. Faunal diversity fairly high. Evidences of biogenic activity. Faunal list: Fl-Isognomon maxillata, VC-Lyropecten madisonius, N-Mercenaria sp., Fissurella griscomi, F-Crassatella turgidula, R-Glossus fraternus marylandicus, Vermetus graniferous, Anomia aculeata, Turritella plebeia var. A. Sample 66-33-1 from entire interval.	
	Total thickness of exposed Drumcliff Member	6' 6"

Locality 66-34. Pawpaw Point II.

Natural outcrop in bluff along northwestern shore of Breton Bay. About 100 feet west of extreme tip of Pawpaw Point. Across Breton Bay from Abells Wharf and Lovers Point. 1.8 miles southwest of waterfront at Leonardtown, Md. St. Marys Co., Md. 38° 15' 48" N. Lat.; 76° 39' 21" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member		
11	Lithology: Very pale-orange, well-sorted, fine sand. No apparent sedimentary structures. Lower contact gradational. Upper contact distinct and slightly undulating. Fossils: Prolific accumulation of shells. Upward gradation of more complete shells. Many small molluscs. High faunal dominance. Faunal list: C-Cerastoderma laqueata, Lyropecten madisonius, N-Turritella plebeia, Mercenaria sp.,	1' 0"

Unit		Thickness
	F-Atrina harrisi, Dosinia acetabulum, Macrocallista marylandica, Corbula idonea, R-Ecphora quadricostata umbilicata, Apolymetis biplicata. Sample 66-34-10 from entire interval.	
10	Lithology: Very pale-orange, well-sorted, fine sand. No apparent sedimentary structures. Lower contact slightly undulating. Upper contact gradational. Fossils: Reduced macrofossil bed. Few shells. All specimens are fragments. Specimens well worn. Only Cerastoderma laqueata identified. Sample 66-34-9 from 1' 0" to 2' 0" above base of unit.	3' 0"
9	Lithology: Reddish-brown, well-sorted fine sand. No apparent sedimentary structures. Contacts slightly undulating. Fossils: Reduced macrofossil bed. Reduced number of shells. Fragmentation and wear common. Faunal list: N-Mercenaria sp., Anodontia anodonta, F-Cerastoderma laqueata, Lyropecten madisonius, R-Macrocallista marylandica. Sample 66-34-8 from entire interval.	0' 9"
8	Lithology: Light-gray, fairly well sorted, fine sand. No apparent sedimentary structures. Lower contact gradational. Upper contact slightly undulating. Fossils: Prolific accumulation of shells. Low faunal diversity. Well preserved. Faunal list: VC-Turritella plebeia, C-Atrina harrisii, Mercenaria sp. Sample 66-34-7 from 0' 0" to 1' 0" above base of unit.	4' 6"
7	Lithology: Light-gray, fairly well-sorted, fine sand. No apparent sedimentary structures. Lower contact distinct and undulating. Upper contact gradational. Fossils: Prolific accumulation of shells. Shells predominantly concentrated in lenses. High faunal diversity. Faunal list: Fl-Turritella plebeia, C-Cerastoderma laqueata, Mercenaria sp., N-	2' 6"

Unit		Thickness
	Lunatia heros, Lunatia hemicrypta, F-Panope americana (all double valves and in living position), R-Balanus concavus, Crassatella turgidula, Dosinia acetabulum, Crucibulum costatum.	
6	Lithology: Light olive-gray slightly muddy, fine sand. Sparsely color-mottled to pale yellowish-brown. No bedding laminations. Lower contact gradational and irregular. Upper contact distinct and undulating. Fossils: Well preserved. Prolific accumulation of shells. Faunal list: C-Atrina harrisii (all double valves and in living position), Mercenaria sp. Cerastoderma laqueata, R-Lyropecten madisonius, Asaphis centenaria. Sample 66-34-5 from entire interval.	0' 9"
5	Lithology: Very pale-orange, well-sorted, fine sand. Mottled by light-gray, slightly muddy, fine sand. No bedding laminations. Contacts gradational and irregular. Fossils: Prolific accumulation of shells. Turritella no longer concentrated into layers and lenses. Orientation and distribution random. Faunal list: A-Turritella plebeia, N-Mercenaria sp., F-Lucinoma contracta, Cerastoderma laqueata, R-Siphonalia devexa, Lunatia heros. Sample 66-34-4 from entire interval.	1' 0"
4	Lithology: Pale yellowish-brown, slightly muddy, fine sand. Color mottled to light olive gray. No bedding laminations. Lower contact gradational. Upper contact gradational and irregular. Fossils: Prolific accumulation of shells. Low faunal diversity. High faunal dominance. Well preserved. Turritella concentrated in lenses and layers. Faunal list: F1-Turritella plebeia, C-Mercenaria sp. Sample 66-34-3 from entire interval.	1' 0"
3	Lithology: Pale yellowish-brown,	1' 6"

Unit		Thickness
	slightly muddy, fine sand. Color mottled to light olive gray. No bedding laminations. Lower contact undulating and distinct. Upper contact gradational. Fossils: Prolific accumulation of shells. Turritella heavily concentrated in layers and lenses. Faunal list: Fl-Turritella plebeia, C-Mercenaria sp., F-Glossus fraternus marylandicus, R-Anodontia anodonta. Sample 66-34-2 from 0' 0" to 1' 0" above base of unit.	
2	Lithology: Very pale-orange, well-sorted, fine sand. Strongly mottled by light olive-brown, muddy, fine sand. No bedding laminations. Lower contact undulating and slightly gradational. Upper contact slightly undulating and distinct. Fossils: Prolific accumulation of shells. Turritella concentrated in lenses. Large bivalves predominantly flat-lying. Faunal list: A-Turritella plebeia, C-Mercenaria plena, N-Cerastoderma laqueata, F-Panope americana (all in living positions), Dosinia acetabulum, Corbula idonea, Glossus fraternus marylandicus, R-Anodontia anodonta, Lunatia heros. Sample 66-34-1 from entire interval.	1' 0"
1	Lithology: Light olive-gray, slightly muddy, fine sand. Mottled slightly. Slime-lined, multi-walled burrows common. No bedding laminations. Lower contact covered. Upper contact undulating and slightly gradational. Fossils: Mollusk shells common. Well preserved. Faunal list: N-Anodontia anodonta, Turritella plebeia, F-Isognomon maxillata, Astarte thisphila, Mercenaria sp. Sample 66-34-11 from entire interval.	1' 0"
	Total thickness of exposed Drumcliff Member	18' 0"

Locality 66-35. Pawpaw Hollow.

Natural outcrop in bluffs near center of Pawpaw Hollow,

between Pawpaw Point and Mulberry Point. Northwestern shore of Breton Bay across from Lovers Point and Abells Wharf. 1.4 miles southwest of waterfront at Leonardtown, Md. St. Marys Co., Md. 38° 16' 08" N. Lat.; 76° 39' 11" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member		
11	Lithology: Pale yellowish-orange, fairly well sorted, fine sand. No apparent sedimentary structures. Lower contact straight and distinct. Upper contact hidden in brush. Fossils: Prolific accumulation of shells. Turritella plebeia concentrated in pockets. Shells predominantly flat-lying. Faunal list: A-Turritella plebeia, C-Mercenaria sp., N-Lyropecten madisonius, R-Ecphora quadricostata umbilicata. Sample 66-35-11 from 0' 6" to 1' 6" above base of unit.	2' 6"
10	Lithology: Pale olive-brown, fairly well sorted, fine sand. No apparent sedimentary structures. Contacts straight and distinct. Fossils: Common. Distribution random. Shells predominantly flat-lying. Faunal list: C-Turritella plebeia, Mercenaria mercenaria. Sample 66-35-10 from 0' 0" to 1' 6" above base of unit.	3' 0"
9	Lithology: Very pale-orange, very well sorted, fine sand. Some subtle color mottlings to pale olive-green. Lower contact distinct. Upper contact distinct and straight. Fossils: Slightly localized. Predominantly flat-lying. Faunal list: F1-Turritella plebeia, F-Mercenaria mercenaria. Sample 66-35-9 from 0' 3" to 1' 6" above base of unit.	1' 8"
8	Lithology: Pale olive-brown, well-sorted, fine sand. No apparent sedimentary structures. Contacts distinct.	1' 0"

Unit		Thickness
	Fossils: Numerous small fragments. Random distribution. Faunal list: F-Turritella plebeia, R-Crassatella turgidula, Mercenaria sp. Sample 66-35-8 from entire interval.	
7	Lithology: Moderate reddish-brown, fairly well sorted, fine sand. Color mottled to light olive-brown. Lower contact broadly undulating and distinct. Upper contact distinct. Fossils: One layer of concentrated, flat-lying, Isognomon maxillata. Other than that only a few fragments. Few Turritella plebeia. Sample 66-35-7 from 0' 3" to 1' 6" above base of unit.	1' 9"
6	Lithology: Light olive-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts undulating and distinct. Fossils: Prolific accumulation of shells. Subtle appearance that shells are concentrated in layers. Most large bivalves flat-lying but some vertical or inclined. Faunal list: Fl-Isognomon maxillata (many double valves), VC-Lyropecten madisonius, N-Vermetus graniferus, F-Mercenaria mercenaria, R-Astarte thisphila, Corbula idonea, Crassatella turgidula. Sample 66-35-6 from 0' 0" to 1' 6" above base of unit.	1' 9"
5	Lithology: Dusky bluish-green, slightly muddy, fine sand. Mottled by moderate-brown, slightly muddy, fine sand. Unit thickness varies greatly. Contacts strongly undulating. Fossils: Prolific accumulation of shells. Abundant small organic hash. Large bivalves predominantly flat-lying. Random distribution. Faunal list: VC-Isognomon maxillata (double valves), C-Discinisca lugubris, Crucibulum costatum. Sample 66-35-5 from entire interval.	0' 5"

Unit		Thickness
4	Lithology: Dark yellowish-brown, slightly muddy, very fine sand. No apparent sedimentary structures. Contacts undulating. Fossils: Prolific accumulation of shells. Bimodal distribution of shell sizes--small fragments forming shell hash and large complete bivalves, Most large bivalves flat-lying. Faunal list: VC-Isognomon maxillata (double valves), Atrina harrisii (double valves), N-Turritella plebeia, F-Mercenaria sp., R-Dosinia acetabulum, Cerastoderma laqueata. Sample 66-35-4 from entire interval.	0' 8"
3	Lithology: Dusky bluish-green, very muddy, very fine sand. Strongly mottled by moderate-gray, very muddy, very fine sand and dark olive-brown, very muddy, very fine sand. Mottling probably the result of biogenic activity. No bedding laminations. Lower contact gradational. Upper contact undulating and distinct. Fossils: Prolific accumulation of shells. Two layers of concentrated large, flat-lying bivalves. Small molluscs (predominantly snails) concentrated in vertical or inclined shafts, probably representing burrow concentrations. One 1-1/2 foot long burrow at 45° with horizontal and containing in bottom Panope americana, double valved and in living position. Faunal list: A-Turritella plebeia, N-Cerastoderma laqueata, Panope americana (double valves and in living position), Lyropecten madisonius, F-F-Mercenaria sp. Anodontia anodonta, Lunatia heros, R-Panope goldfussi (double valved and in living position), Ecphora quadricostata umbilicata, Crassatella turgidula, Glossus fraternus marylandicus, Lucinoma contracta. Sample 66-35-3 from entire interval.	1' 3"
	Total thickness of exposed Drumcliff Member	14' 0"

Unit		Thickness
Calvert Beach Member		
2	Lithology: Dusky bluish-green, very muddy, very fine sand. Mottled by dark greenish-yellow, very muddy, very fine sand. Contacts gradational. Fossils: Few fragments. Increase in size of fragments from unit 1. Increase in number of fragments from unit 1. Random distribution and orientation. Faunal list: F-Turritella plebeia, Mercenaria sp., Lyropecten madisonius. Sample 66-35-2 from 0' 0" to 1' 0" above base of unit.	1' 8"
1	Lithology: Dusky bluish-green, very muddy, very fine sand. Mottled by greenish-gray, fairly well sorted, fine sand. Mottles appear to be lense-shaped. No bedding structures. Lower contact covered. Upper contact gradational. Fossils: Very rare unidentifiable fragments. Only Cerastoderma laqueata identified. Sample 66-35-1 from 0' 0" to 1' 0" above base of unit.	2' 0"
	Total thickness of exposed Calvert Beach Member	3' 8"
	Total thickness of exposed Choptank Formation	17' 8"

Locality 66-36. East side of Breton Bay.

0.9 mile south of Abells Wharf. 1.0 mile east of Protestant Point. 2-2/3 mile south of Leonardtown, Md. Natural outcrop in low bluffs along the eastern shore of Breton Bay. St. Marys Co., Md. 38° 14' 55" N. Lat.; 76° 39' 07" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member		
5	Lithology: Moderate reddish-brown,	0' 8"

Unit		Thickness
	slightly muddy, fine sand. Mottled by light greenish-gray, fairly well sorted, fine sand. No bedding laminations. Lower contact straight and distinct. Upper contact distinct and slightly undulating. Fossils: Prolific accumulation of shells. One striking character of unit is that a large proportion of the bivalves are in living position. Random distribution. Faunal list: A-Atrina harrisii (all double valves and in living position), VC-Turritella plebeia, C-Asaphis centenaria (double valves and in living position), Mercenaria sp. N-Lucinoma contracta (double valves, flat-lying), F-Discinisca lugubris, Lyropecten madisonius, R-Lunatia heros. Sample 66-36-5 from entire interval.	
4	Lithology: Dark olive-brown, muddy, fine sand. Mottled by very pale-orange, well-sorted, fine sand. Mottling probably result of biogenic activity. Some irregular, discontinuous bedding. Lower contact straight and distinct. Fossils: Prolific accumulation of shells. Random distribution. Well-preserved mollusc shells. Faunal list: A-Turritella plebeia, N-Mercenaria sp., Lunatia heros, F-Atrina harrisii (double valves and in living position), Asaphis centenaria, R-Cerastoderma laqueata, Corbula inaequalis. Sample 66-36-4 from 0' 6" to 1' 6" from entire interval.	2' 2"
3	Lithology: Dark grayish-green, muddy, fine sand. Mottled by dark olive-brown, muddy, fine sand. No bedding laminations. Contacts distinct and slightly irregular (placed at top and bottom of Atrina). Fossils: Prolific shell bed. Most striking feature is densely packed community of Atrina all double valved and in living position. Change of sediment type near top of	0' 11"

Unit		Thickness
	shells may explain extinction of this community. Other bivalve species also in living position and double valved. One Panope found in living position in bottom of 1' 0" burrow. Faunal list: F1-Atrina harrisii (all double valves and in living position), C-Mercenaria sp. (many double valves, flat-lying), Turritella plebeia, N-Panope americana (all double valves and in living position), Asaphis centenaria (double valves and in living position), F-Anadara staminea, Discinisca lugubris, R-Cerastoderma laqueata, Siphonalia devexa. Sample 66-36-3 from entire interval.	
2	Lithology: Dark greyish-green, fine sand. Prominent 2.0' to 3.0" lenses of light gray, well-sorted, fine sand. No bedding laminations. Lower contact straight and distinct. Upper contact distinct and slightly irregular. Fossils: Reduced number. Well-preserved mollusc shells. Random distribution. Faunal list: C-Turritella plebeia, Mercenaria sp., N-Lyropecten madisonius, Lucinoma contracta. Sample 66-36-2 from entire interval.	1' 3"
1	Lithology: Dark grayish-green, muddy, fine sand. Subtle mottles of greenish-gray, fairly well sorted, fine sand. No bedding laminations. Lower contact covered by beach. Upper contact straight and distinct. Fossils: Prolific accumulation of shells. Turritella plebeia grade from lesser concentration to four layers of tremendous concentration. Shells predominantly flat-lying. Faunal list: F1-Turritella plebeia, C-Mercenaria sp. (some double valves),	2' 0"

Unit		Thickness
	Lucinoma contracta (some double valves), N-Panope americana (all double valves and in living position), F-Glossus fraternus marylandicus, Lyropecten madisonius. Sample 66-36-1 from 0' 6" to 1' 6" above base of unit.	
	Total thickness of exposed Drumcliff Member	7' 0"

Locality 66-37. Cuckold Creek V.

On south bank of middle "finger" of the three western "fingers" of Cuckold Creek. 1.5 mile west of Clarks Landing, Md. 2.3 miles east of Hollywood, Md. St. Marys Co., Md. 38° 20' 50" N. Lat.; 76° 31' 47" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member		
4	Lithology: Pale reddish-orange, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact gradational and irregular. Upper contact distinct and slightly undulating. Fossils: Reduction in size of most specimens. Prolific accumulation of shells. Somewhat hashy accumulation. Random distribution. Faunal list: A-Cerastoderma laqueata, C-Turritella plebeia, Anadara staminea, N-Corbula idonea, Dosinia acetabulum. Sample 66-37-2 from 0' 0" to 1' 0" above base of unit.	1' 6"
3	Lithology: Moderate reddish-orange, slightly muddy, fine sand. Sparsely mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts gradational and irregular. Fossils: Prolific accumulation of shells. Random distribution.	1' 6"

Unit		Thickness
	Macrocallista and Turritella flat-lying. Faunal list: C-Macrocallista maryandica, Cerastoderma laqueata, Turritella plebeia, F-Anadara staminea, R-Crassatella turgidula. Sample 66-37-4 from 0' 3" to 1' 0" above base of unit.	
2	Lithology: Pale reddish-orange, slightly muddy, fine sand. Strongly mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Lower contact gradational. Upper contact gradational and irregular. Fossils: Prolific accumulation of shells. Apparently random orientation and distribution. Fauna dominated by Cerastoderma. Faunal list: A-Cerastoderma laqueata, N-Lyropecten madisonius, Turritella plebeia. Sample 66-37-3 from entire interval.	1' 0"
1	Lithology: Pale reddish-orange, fairly well sorted, fine sand. Rare mottles of light-gray, slightly muddy, fine sand. Lower contact covered by beach. Upper contact gradational. Fossils: Very dense accumulation. Random distribution. Predominantly flat-lying bivalves. Double valves fairly common. High faunal diversity. Faunal list: VC-Turritella plebeia, C-Anadara staminea, Isognomon maxillata, Lyropecten madisonius, Glossus fraternus marylandicus, N-Corbula idonea (some double valves), Mercenaria sp., F-Astarte thisphila, Astarte obruta, Lunatia heros, Lunatia hemicryptus, Crassatella turgidula, Asphis centenaria, Dosinia acetabulum (some double valves), R-Corbula inaequalis, Busycon corontum rugosum.	2' 6"

Unit		Thickness
	Sample 66-37-1 from 0' 0" to 1' 6".	
	Total thickness of exposed Drumcliff Member	6' 6"

Locality 66-38. Mill Cove I.

West bank of center "finger" of three "fingers" of Mill Cove. 0.8 Mile south of Clarks Landing. 2.2 miles north of California, Md. St. Marys Co., Md. 38° 19' 47" N. Lat.; 76° 30' 16" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member		
3	Lithology: Moderate reddish-orange fairly well sorted, fine sand. No apparent sedimentary structures. Lower contact slightly undulating and irregular. Upper contact covered. Fossils: Prolific accumulation of shells. Distinct increase in number of bivalves from unit 2. Large number of double bivalves. Random distribution. Faunal list: VC-Anadara staminea (many double valves), Cerastoderma laqueata, C-Lyropecten madisonius (many double valves), Turritella plebeia, N-Astarte thisphila (many double valves), Anodontia anodonta (many double valves). Sample 66-38-2 from entire interval.	1' 4"
2	Lithology: Moderate reddish-orange, muddy, fine sand. Rare lenses of light gray, very muddy, fine sand. No bedding laminations. Lower contact distinct. Upper contact undulating and irregular. Fossils: Prolific accumulation of shells. Random orientation and distribution. High faunal diversity. Faunal list: A-Turritella plebeia,	1' 8"

Unit		Thickness
	C-Corbula idonea, Lyropecten madisonius, N-Astarte thisphila, F-Isognomon maxillata, Glossus fraternus marylandicus, Anadara staminea, Atrina harrisii, Diplodonta acclinis, R-Busycon sp., Panope americana (double valves and in living position). Sample 66-38-1 from 0' 3" to 1' 3" above base of unit.	
1	Heavily indurated unit with prolific accumulation of Isognomon maxillata all leached out. No sample.	?
	Total thickness of measured Drumcliff Member	3' 0"

Locality 66-39. Mill Creek I.

Natural exposure in west bank of Mill Creek, 1.2 mile south southwest of Clarks Landing. 2.0 miles north of California, Md. St. Marys Co., Md. 38° 19' 37" N. Lat.; 76° 30' 50" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member		
4	Lithology: Very pale-orange, very well sorted, fine sand. No apparent sedimentary structures. Lower contact gradational and slightly irregular. Upper contact covered. Fossils: Very dense accumulation. Predominantly thin-shelled specimens. Predominantly flat-lying shells. Random distribution. Fairly high faunal diversity. Faunal list: F1-Cerastoderma laqueata, C-Anadara staminea, Turritella plebeia, N-Lyropecten madisonius, F-Atrina harrisii (double valves but flat-lying), Macrocallista marylandica, R-Astarte thisphila, Corbula idonea,	2' 6"

Unit		Thickness
	Glossus fraternus marylandicus. Sample 66-39-2 from 0' 6" to 1' 6" above base of unit.	
3	Lithology: Moderate reddish-brown, muddy, fine sand. No apparent sedimentary structures. Lower contact covered. Upper contact gradational and slightly irregular. Fossils: Prolific accumulation of shells. Predominantly thin-shelled molluscs. Predominantly flat-lying shells. Random distribution of shells. Fairly high faunal diversity. Faunal list: A-Turritella plebeia, VC-Anadara staminea (many double valves), Cerastoderma laqueata, N-Glossus fraternus marylandicus, Macrocallista marylandica, F-Corbula idonea, Lunatia heros, R-Crassatella turgidula. Sample 66-39-1 from 0' 0" to 1' 6" above base of unit.	2' 0"
2	(Covered interval.)	3' 0"
1	Heavily indurated unit with prolific accumulation of Lyropecten madisonius all leached out. No sample.	1' 0"
	Total thickness of exposed Drumcliff Member	8' 6"

Locality 66-40. Mill Creek II.

Natural outcrop in east bank of Mill Creek. 1.0 mile south southwest of Clarks Landing. 2-1/4 miles north of California, Md. St. Marys Co., Md. 38° 19' 48" N. Lat.; 76° 30' 47" W. Long.

Unit	Thickness
(Covered)	
Choptank Formation	
Drumcliff Member	

Unit		Thickness
4	Lithology: Reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact distinct and straight. Upper contact covered. Fossils: Prolific accumulation of shells. Random distribution. Fairly high faunal diversity. Faunal list (including specimens identified in laboratory examination of small fractions): A-Isognomon maxillata (many double valves), VC-Corbula idonea, C-Lyropecten madisonius, Martesia ovalis, N-Lucina crenulata, Turritella plebeia var. A, Turritella plebeia, Astarte thisphila, F-Spisula subparilis, Anadara staminea, Cerastoderma laqueata, Calliostoma philanthropa, Cancellaria (Sveltia) patuxentia, R-Lithophaga ionensis, Crassinella dupliniana, Calliostoma aphelia, Cominella? multirugata, Ecphora quadricostata umbilicata. Sample 66-40-3 from entire interval.	0' 8"
3	Lithology: Reddish-brown, muddy, fine sand. No apparent sedimentary structures. Lower contact irregular and gradational. Upper contact distinct and straight. Fossils: Sparse. Random distribution. Faunal list: C-Turritella plebeia. Sample 66-40-2 from entire interval.	0' 9"
2	Lithology: Moderate reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact distinct and fairly straight. Upper contact irregular and gradational. Fossils: Abundant. All slightly hashy. Wear common. Random orientation and distribution. Very jumbled appearance. Fairly high faunal diversity. Faunal list: (including specimens identified in laboratory examination of small fractions): Fl-Spisula	1' 3"

Unit		Thickness
	subparilis, A-Corbula inaequalis, VC-Lyropecten madisonius, Turritella plebeia var. A, C-Turritella plebeia, Lucina crenulata, N-Cerastoderma laqueata, Anadara staminea, Astarte thisphila, F-Mytilus conradinus, Semele subovata, Ecphora quadricostata umbilicata, Calliostoma aphelia, R-Turritella plebeia octonaria, Aligena aequata, Corbula idonea, Diplodonta subvexa, Dosinia acetabulum, Ensis ensiformis, Erycina speciosa, Glossus fraternus marylandicus, Caecum patuxentium, Crucibulum multilineatum, Epitonium expansum. Sample 66-40-1 from entire interval.	
1	Lithology: Heavily indurated unit with prolific accumulation of Lyropecten madisonius all leached out. No sample.	0' 9"
	Total thickness of exposed Drumcliff Member	3' 5"

Locality 66-41. Cuckold Creek VI.

Natural exposure on south bank of northern "finger" of northern "finger" of three western fingers of Cuckold Creek. 1.6 mile northwest of Clarks Landing. 2.3 miles east of Hollywood, Md. St. Marys Co., Md. 38° 21' 07" N. Lat.; 76° 31' 47" Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Boston Cliffs Member		
4	Lithology: Pale reddish-orange, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact distinct and fairly straight. Upper contact covered. Upper Boston Cliffs indurated series. Fossils: Prolific molds and casts.	2' 0"

Unit		Thickness
	All shell material leached out. Random distribution. Large, flat-lying bivalves. Low faunal diversity. Fauna predominantly Cerastoderma laqueata. No sample.	
3	Lithology: Moderate reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact distinct but poorly exposed. Upper contact distinct and fairly straight. Fossils: Prolific accumulation of shells. Low faunal diversity. Random distribution. Faunal list: A-Crassostrea carolinensis, Lyropecten madisonius, F-Corbula idonea. Sample 66-41-3 from 0' 0" to 1' 0" above base of unit.	3' 6"
	Total thickness of exposed Boston Cliffs Member.	5' 6"
St. Leonard Member		
2	Lithology: Moderate reddish-orange, muddy, fine sand. No apparent sedimentary structures. Contacts distinct but poorly exposed. Fossils: None seen. Sample 66-41-2 from 0' 0" to 1' 6" above base of unit.	5' 2"
Drumcliff Member, upper		
1	Lithology: Moderate reddish-brown muddy fine sand. No apparent sedimentary structures. Lower contact covered by beach. Upper contact poorly exposed. Fossils: Prolific accumulation of shells. Very hashy. A few complete specimens. Random distribution. Faunal list: C-Turritella plebeia, Anadara staminea. Sample 66-41-1 from entire interval.	0' 10"
	Total thickness of exposed Choptank Formation	11' 6"

Locality 66-42. Breedens Point.

Approximately 750 feet east of Breedens Point on the eastern

shore of St. Leonard Cr. at the mouth of Rollins Cove. 1.4 mile west of Lusby, Md. Calvert Co., Md. 38° 24' 25" N. Lat.; 76° 28' 54" W. Long.

	Unit	Thickness
	(Pleistocene, undifferentiated)	
	Choptank Formation	
	Boston Cliffs Member	
8	Lithology: Pale olive-gray, slightly muddy, fine sand. Finely mottled by pale olive-brown, slightly muddy, fine sand. No bedding laminations. Lower contact gradational. Upper contact distinct and slightly undulating. Fossils: Numerous shells. Size and number of specimens increase upward in unit. Mostly fragments but a few complete Lyropecten valves. Low faunal diversity. Faunal list: N-Lyropecten madisonius, F-Crassostrea carolinensis. Sample 66-42-7 from 0' 0" to 1' 0" above base of unit.	1' 6"
	St. Leonard Member	
7	Lithology: Light olive-brown, muddy, fine sand. Color mottlings to pale olive. Poorly defined, low-angle, planar, cross-bedding with laminations about 4 inches long. Poorly defined, slightly wavy bedding. Lower contact undulating and distinct. Upper contact gradational. Fossils: Rare small fragments. Random orientation and distribution. Only Balanus concavus identified. Sample 66-42-6 from 1' 6" to 2' 6" above base of unit.	4' 0"
	Drumcliff Member	
6	Lithology: Light-gray, well-sorted, subangular, fine to medium sand. Mottled by moderate reddish-orange, slightly muddy, fine to medium sand. No bedding laminations. Contacts slightly undulating. Fossils: Very dense accumulation. Fairly well preserved--only a few well worn. Predominantly flat-lying	2' 0"

Unit		Thickness
	shells. Some concentrated layers of flat-lying shells. High faunal diversity. Low faunal dominance. A few probable bivalve burrows. Faunal list: A-Turritella plebeia, VC-Cerastoderma laqueata, Anadara staminea, C-Lyropecten madisonius, Corbula idonea, Lunatia heros, N-Scaphella typa, Astarte thisphila, Glossus fraternus marylandicus, Crassatella turgidula, F-Ecphora quadricostata umbilicata, Busycon sp., Venericardia granulata, Macrocallista marylandica, Panope americana, Calliostoma philanthropa, Siphonalia devexa, R-Dosinia acetabula. Sample 66-42-5 from 0' 0" to 1' 0" above base of unit.	
5	Lithology: Moderate reddish-brown, poorly sorted, subangular, fine sand. No apparent sedimentary structures. Contact slightly undulating and gradational. Fossils: Prolific accumulation of shells. Very jumbled appearing accumulation. All specimens very well worn. Fragmentation common. Faunal list: VC-Cerastoderma laqueata, Corbula idonea, C-Turritella plebeia, Macrocallista marylandica, N-Astarte thisphila, Panope americana, F-Ecphora quadricostata umbilicata, Anodontia anodonta. Sample 66-42-4 from entire interval.	0' 6"
4	Lithology: Light-gray, well-sorted, angular, medium sand. No apparent inorganic sedimentary structures. Contacts undulating. Locally indurated, but not as common as in units 1 and 2. Fossils: Very dense accumulation. Very jumbled appearing accumulation. Many large, complete molluscs. Wear common. Fragmentation common. High faunal diversity. Low faunal dominance. Random distribution. Rare bivalve burrows containing	0' 11"

Unit		Thickness
	concentrated shell hash. Faunal list: C-Cerastoderma laqueata, Macrocallista marylandica, Corbula idonea, Isognomon maxillata, Lyropecten madisonius, Turritella plebeia, N-Astarte thisphila, Mercenaria sp., Lunatia heros, F-Ecphora quadricostata umbilicata, Crassatella turgidula, Balanus concavus, Anodontia anodonta, Panope americana (double valves and in living position), R-Lunatia hemicryptus, Dosinia acetabulum. Sample 66-42-3 from entire interval.	
3	Lithology: Light-gray, fairly well sorted, angular, fine to medium sand. Rare oxidation mottles to moderate reddish-orange. No bedding laminations. Contacts undulating and irregular. Fossils: Very dense accumulation. Slightly hashy. Unit well burrowed, probably both by crabs and bivalves. Flat-lying fragments and complete specimens concentrated into layers. Wear very common. Fragmentation abundant. Very jumbled appearing accumulation of shells. High faunal diversity. Reduced size from units 1 and 2. Faunal list: C-Turritella plebeia, Cerastoderma laqueata, N-Macrocallista marylandica, Mercenaria sp., Lyropecten madisonius, Corbula idonea, Crassatella turgidula, Lunatia heros, F-Isognomon maxillata, R-Scaphella typa, Anadara staminea, Astarte thisphila, Apolymetis biplicata. Sample 66-42-2 from entire interval.	0' 10"
2	Lithology: Light olive-brown, muddy, fine sand. Partially indurated. Mottled by light-gray,	2' 6"

Unit		Thickness
	muddy, fine sand. Lower contact distinct and undulating. Upper contact undulating and irregular. Fossils: Prolific accumulation of shells. Shells predominantly flat-lying and concentrated into layers. Layers locally disrupted by what may have been crab burrowing. Shells partially leached. High faunal dominance. Low faunal diversity. Faunal list: F1-Isognomon maxillata, R-Lyropecten madisonius. No sample.	
1	Lithology: Light olive-brown, muddy, fine sand. Partially indurated. No apparent sedimentary structures. Lower contact covered by beach. Upper contact distinct and undulating. Fossils: Prolific accumulation of shells. Large, flat-lying bivalves. High faunal dominance. Low faunal diversity. Random distribution. Faunal list: F1-Isognomon maxillata. Sample 66-42-1 from entire interval.	1' 4"
	Total thickness of exposed Drumcliff Member	8' 1"
	Total thickness of exposed Choptank Formation	13' 7"

Locality 66-43. Mackall's Landing.

Natural outcrop in bluffs southwest of Mackall's Landing. Western shore of St. Leonard Creek. Northwest across St. Leonard Creek from Rodney Point. 2.5 miles southwest of Lusby, Md. Calvert Co., Md. 38° 23' 38" N. Lat.; 76° 29' 53" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Boston Cliffs Member		
11	Lithology: Pale reddish-brown, fairly well sorted, fine sand. Slightly indurated unit. No apparent sedimentary structures. Contacts distinct and slightly undulating. Fossils: Prolific accumulation of shells. Very hashy accumulation. Mostly unidentifiable fragments. Only a few scallops complete. Scallops concentrated in layers. Faunal list: C-Lyropecten madisonius, Balanus concavus. Sample 66-43-10 from entire interval.	1' 3"
10	Lithology: Pale reddish-brown, fairly well-sorted, fine sand. Rare mottles of very pale-orange, well sorted, fine sand. No bedding laminations. Lower contact gradational and slightly undulating. Upper contact distinct and slightly undulating. Fossils: Increased macrofossil bed. Increased number of shells. Increased number of large bivalves. Predominantly flat-lying bivalves. Random distribution. Faunal list: C-Lyropecten madisonius, Crassostrea carolinensis, Balanus concavus, N-Cerastoderma laqueata, Turritella plebeia, Anadara staminea, F-Dosinia acetabulum, Corbula idonea, Astarte obruta. Sample 66-43-9 from entire interval.	1' 6"
9	Lithology: Pale reddish-brown, well-sorted, fine sand. Mottled by very pale orange, well-sorted, fine sand. No bedding laminations. Contacts gradational and slightly undulating. Fossils: Reduced macrofossil bed. Reduced number of large bivalves. Reduced number of shells. Random distribution.	1' 3"

Unit		Thickness
	Faunal list: C-Crassostrea carolinensis, F-Cerastoderma laqueata, Lyropecten madisonius, Balanus concavus, Astarte obruta. Sample 66-43-8 from 0' 3" to 1' 3" above base of unit.	
8	Lithology: Pale reddish-brown, slightly muddy, fine sand. Rare mottles of very pale-orange, well-sorted, fine sand. Contacts gradational and slightly undulating. Fossils: Prolific accumulation of shells. Increased macrofossil bed. Prominent, large, flat-lying bivalves. Fragmentation common. Wear common. Random distribution. Faunal list: C-Lyropecten madisonius, Macrocallista marylandica, Crassostrea carolinensis, Anadara staminea, Balanus concavus, N-Dosinia acetabulum, F-Crassatella marylandica. Sample 66-43-7 from 0' 0" to 1' 0" above base of unit.	2' 3"
7	Lithology: Moderate reddish-orange, slightly muddy, fine sand. Rare mottles of pale yellowish-orange, well-sorted, fine sand. Contacts gradational and slightly undulating. Fossils: Prolific accumulation of shells. Wear common. Fragmentation common. Random orientation and distribution. Faunal list: VC-Crassostrea carolinensis, C-Lyropecten madisonius, Balanus concavus, F-Corbula idonea, Cerastoderma laqueata, Anadara staminea, R-Astarte obruta. Sample 66-43-6 from 1' 0" to 2' 0" above base of unit.	2' 9"
6	Lithology: Pale olive-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts gradational and slightly undulating. Fossils: Mostly fragments but complete oyster shells numerous. Partially	2' 0"

Unit		Thickness
	leached. Random distribution. Faunal list: C-Crassostrea carolinensis, F-Lyropecten madisonius. Sample 66-43-5 from 1' 0" to 2' 0" above base of unit.	
	Total thickness of exposed Boston Cliffs Member	11' 0"
St. Leonard Member		
5	Lithology: Pale olive-brown, fairly well sorted, fine sand. No apparent sedimentary structures. Contacts gradational. Fossils: Few. All molds and casts. Random distribution. High faunal dominance. Only Mytilus conradinus found. No sample.	3' 0"
4	Lithology: Pale olive-brown, fairly well sorted, fine sand. No apparent sedimentary structures. Lower contact distinct and nearly straight. Upper contact gradational. Fossils: Few. All fragments. Most fragments unidentifiable. Partially leached. Random distribution. Faunal list: F-Lyropecten madisonius, R-Balanus concavus. Sample 66-43-4 from 0' 6" to 1' 6" above base of unit.	2' 0"
	Total thickness of St. Leonard Member	5' 0"
Drumcliff Member		
3	Lithology: Moderate reddish-brown, slightly muddy, fine sand. Mottled by light-gray, well-sorted fine sand. No bedding laminations. Lower contact distinct and strongly undulating, almost appearing as channeling. Upper contact distinct and nearly straight. Fossils: Prolific accumulation of shells. Accumulation very jumbled and mixed. Fragmentation abundant.	0' 6"

Unit		Thickness
	Wear abundant. Mostly unidentifiable fragments. Random orientation and distribution. Faunal list: F-Panope americana (all double valves and in living position), Cerastoderma laqueata, Anadara staminea. Sample 66-43-3 from entire interval.	
2	Lithology: Light-gray, fairly well sorted, very fine sand. Heavily indurated forming very resistant exposure. No apparent sedimentary structures. Rare thin layers not indurated and containing well-sorted, fine sand. Lower contact distinct and slightly undulating. Upper contact distinct and strongly undulating, almost appearing as channeling. Fossils: Prolific accumulation of shells but all aragonitic material leached out. Predominantly large, flat-lying bivalves, with a few Isognomon inclined. Low faunal diversity. High faunal dominance. Faunal list: F1-Isognomon maxillata, Lyropecten madisonius, A-Balanus concavus, C-Martesia ovalis (all burrowed into Isognomon). Sample 66-43-2 from 3' 6" to 4' 0" above base of unit.	10' 3"
1	Lithology: Pale olive-gray, muddy, very fine sand. Mottled by light reddish-orange, fairly well sorted, fine sand. Lower contact covered by beach. Upper contact distinct and slightly undulating. Fossils: Few. Mostly molds and cast. Large, flat-lying bivalves. Martesia burrowed into Isognomon. Low faunal diversity. Faunal list: N-Isognomon maxillata (some double valves), Lyropecten madisonius, F-Martesia ovalis. Sample 66-43-1 from 2' 0" to 3' 0" above base of unit.	4' 6"
	Total thickness of exposed Drumcliff Member	15' 3"
	Total thickness of exposed Choptank Formation	31' 3"

Locality 66-44. Between Flag Ponds Cliffs and Camp Conoy.

0.5 mile northwest of Camp Conoy (Y.M.C.A.). 2.0 miles southeast of Long Beach, Md. Natural outcrop in Calvert Cliffs along the Chesapeake Bay. 1.9 mile northeast of Lusby, Md. Calvert Co., Md. 38° 26' 08" N. Lat., 76° 26' 26" W. Long.

Unit		Thickness
St. Marys Formation		
Choptank Formation		
Conoy Member		
3	Lithology: Dusky grayish-green, poorly sorted, very fine sand. Rare mottles of light-gray, well-sorted, very fine sand. Few bivalves burrows. Parallel, continuous, thin, bedding laminae. Thick bedded. Lower contact straight and distinct. Upper contact distinct but irregular. Fossils: Rare fragments. Rare complete specimens of Atrina harrisii in lower part of unit. Sample 66-44-3 from 0' 3" to 1' 3" above base of unit.	12' 6"
Boston Cliffs Member		
2	Lithology: Dark greenish-gray, poorly sorted, very fine sand. Mottled by dusky blue-green, slightly muddy, very fine sand. Some subtle, irregular, discontinuous bedding. Contacts straight and distinct. Fossils: Prolific accumulation of shells. Mostly large, flat-lying bivalves. Well-preserved shells. Faunal list: A-Lyropecten madisonius, Turritella plebeia, C-Crassatella marylandica, Cerastoderma laqueata, Macrocallista marylandica (many double valves), N-Dosinia acetabulum, F-Crucibulum costatum. Sample 66-44-2 from entire interval.	1' 4"

Unit		Thickness
1	Lithology: Dusky blue-green, muddy, very fine sand. Mottled by dark greenish-gray, slightly muddy, fine sand. Subtle, irregular, discontinuous bedding. Lower contact distinct channeling. Upper contact straight. Fossils: Prolific accumulation of shells. Random distribution. Faunal list: VC-Lyropecten madisonius, C-Balanus concavus, N-Turritella plebeia, F-Crucibulum sp., Dosinia acetabulum. Sample 66-44-1 from entire interval.	1' 0"
	(Covered--Lower part of section covered by heavy debris.)	
	Total thickness of exposed Boston Cliffs Member	2' 4"
	Total thickness of exposed Choptank Formation	14' 10"

Locality 66-45. Hellen Bar in Turner Cove.

Natural outcrop on Hellen Bar in Turner Cove on the eastern shore of the Patuxent River. 3.5 miles northwest of Solomons Island, Md. Calvert Co., Md. 38° 22' 05" N. Lat.; 76° 29' 08" W. Long.

Unit		Thickness
	(Pleistocene, undifferentiated)	
	Choptank Formation	
	Drumcliff Member	
3	Lithology: Very light olive-brown, muddy, fine sand. Abundant oxidation stains. No apparent sedimentary structures. Contacts distinct and slightly undulating. Fossils: Prolific accumulation but all leached out. Predominantly flat-lying molds and casts. Faunal list: VC-Isognomon maxillata, Lyropecten madisonius, C-Balanus concavus, N-Astrhelia palmata, F-Crassatella turgidula, R-Macrocallista	1' 3"

Unit		Thickness
	marylandica. No sample.	
2	Lithology: Very light olive-brown, muddy, fine sand. Abundant oxidation stains. No apparent sedimentary structures. Contacts distinct and slightly undulating. Fossils: Prolific accumulation of shells. Local leaching out of fossils. Predominantly flat-lying fossils. Random distribution. Faunal list: VC-Isognomon maxillata, Lyropecten madisonius, C-Balanus concavus, N-Astrhelia palmata, F-Crassatella turgidula, R-Macrocallista marylandica. Sample 66-45-1 from entire interval.	1' 9"
1	Lithology: Light-gray, well-sorted, angular, medium sand. Heavily indurated unit. Cement probably secondary. No apparent sedimentary structures. Contacts distinct and slightly undulating. Fossils: Prolific accumulation of shells. Predominantly flat-lying bivalves. Partially leached. Low faunal diversity. Increased macrofossil bed. Faunal list: VC-Isognomon maxillata, Lyropecten madisonius, VC-Balanus concavus. No sample.	2' 0"
	Total thickness of exposed Drumcliff Member	5' 0"

Locality 66-46. Hellen Creek at Tongue Cove.

Natural exposure on northern point formed by the junction of Hellen Creek and Tongue Cove. 3.0 miles north northwest of Solomons Island, Md. Calvert Co., Md. 38° 21' 52" N. Lat.; 76° 28' 29" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Boston Cliffs Member		
7	Upper Boston Cliffs oxidized and indurated series. No sample.	6' 0"
6	Lithology: Moderate olive-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact gradational. Upper contact distinct and nearly straight. Fossils: Prolific accumulation of shells. Predominantly large, flat-lying bivalves. Also local concentrations of fairly densely packed Atrina in living position. Otherwise apparently random distribution of shells. Faunal list: VC-Cerastoderma laqueata, C-Atrina harrisii, N-Lyropecten madisonius, Crassostrea carolinensis, F-Balanus concavus, R-Asaphis centenaria (double valve and in living position). Sample 66-46-6 from entire interval.	1' 0"
5	Lithology: Moderate olive-brown, slightly muddy, fine sand. Some subtle, irregular, discontinuing, bedding laminations. Contacts gradational. Fossils: Prolific accumulation of shells but nearly no small, hashy material as in unit 4. Predominantly large, flat-lying bivalves. Random distribution. Faunal list: VC-Cerastoderma laqueata, N-Lyropecten madisonius, F-Balanus concavus, R-Panope americana (double valve and in living position), Dosinia acetabulum. Sample 66-46-5 from 0' 0" to 1' 0" above base of unit.	1' 6"
4	Lithology: Light orangish-brown, slightly muddy, fine sand. Mottled by light-gray, muddy, fine sand.	1' 6"

Unit		Thickness
	No bedding laminations. Contacts gradational. Fossils: Prolific accumulation of shells. Many shells appear in great local concentrations. Shell hash in concentrations. Concentrations may be fillings in crab burrows. Faunal list: Fl-Turritella plebeia, C-Corbula idonea, Lyropecten madisonius, N-Cerastoderma laqueata, Balanus concavus, F-Anadara staminea, R-Dosinia acetabulum, Panope americana. Sample 66-46-4 from 0' 0" to 1' 0" above base of unit.	
3	Lithology: Light olive-brown, fairly well-sorted, fine sand. Mottled by very pale orange, well-sorted, fine sand. No bedding laminations. Contacts gradational. Fossils: Predominantly fragments. Some complete oysters, scallops, and banacles. Random distribution. Faunal list: N-Crassostrea carolinensis, Lyropecten madisonius, Balanus concavus. Sample 66-46-3 from 0' 0" to 0' 9" above base of unit.	1' 9"
2	Lithology: Light olive-brown, fairly well-sorted, fine sand. Mottled by very pale-orange, well-sorted, fine sand. No bedding laminations. Contacts gradational. Fossils: Increase in quantity and size of fragments from unit 1. Most fragments unidentified. Random distribution of fragments. Faunal list: N-Lyropecten madisonius, Balanus concavus. Sample 66-46-2 from 0' 0" to 1' 0" above base of unit.	2' 4"
	Total thickness of exposed Boston Cliffs Member	14' 1"
St. Leonard Member, upper		
1	Lithology: Moderate reddish-brown,	1' 5"

Unit		Thickness
	slightly muddy, fine sand. Few mottles of very pale orange, well-sorted, fine sand. No bedding laminations. Lower contact covered by beach. Upper contact gradational. Fossils: Rare fragments. Short, elliptical, discontinuous, bivalve burrows. Random distribution of fragments. Sample 66-46-1 from 0' 0" to 1' 0" above base of unit.	
	Total thickness of exposed Choptank Formation	15' 6"

Locality 66-47. North of Cove Point.

1.8 mile northwest of Cove Point. 0.2 mile southeast of Grays Creek. 2.8 miles east southeast of Lusby, Md. Natural exposure in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 24' 02" N. Lat.; 76° 24' 24" W. Long.

Unit		Thickness
St. Marys Formation		
Choptank Formation		
Conoy Member		
2	Lithology: Dusky-blue, very muddy, silt. Thin, continuous, parallel, bedding laminations. Thick bedded. No apparent biogenic sedimentary structures. Contacts distinct and fairly straight. Fossils: Concentrated lenses of molds and casts of Turritella plebeia. Except for those lenses only rare Yoldia laevis. Sample 66-47-1 from 2' 0" to 3' 0" above base of unit.	11' 0"
Boston Cliffs Member		
1	Lithology: Dark reddish-brown, muddy, fine sand. Indurated unit.	1' 2"

Unit	Thickness
No apparent sedimentary structures. Lower contact covered by beach. Upper contact nearly straight and distinct. Fossils: Prolific accumulation of shells. Predominantly large, flat-lying, scallops with a prominent epifauna of barnacles. Faunal list: Fl-Lyropecten madisonius, VC-Balanus concavus. No sample.	
	13' 2"

Locality 67-48. 400 feet north of Point of Rocks. 2.2 miles east of Lusby, Md. Natural exposure in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 24' 55" N. Lat.; 76° 25' 01" W. Long. Description of part of the section only.

Unit	Thickness
St. Marys Formation Choptank Formation Conoy Member Undescribed and unmeasured.	
Boston Cliffs Member Upper Boston Cliffs Member undescribed. The several units with preserved fossils up to the base of the upper Boston Cliffs oxidized and indurated beds.	11' 3"
St. Leonard Member 1 Lithology: Dusky greenish-blue, muddy, fine sand. Heavily mottled in upper 0' 5" with yellowish-brown, muddy, fine sand. Mottling probably from organisms burrowing down from Boston Cliffs Member. Lower contact covered by beach. Upper contact gradational and irregular. Fossils: Few fragments of calcitic shells. Random distribution. Faunal list: F-Balanus concavus. Sample 67-48-1 from 2' 6" to 3' 3" above base of unit.	3' 11"
Total thickness of measured	

Unit	Thickness
Choptank Formation	15' 2"

Locality 67-49. (See locality 66-24).

Locality 67-50. Between Flag Ponds Cliffs and Camp Conoy.

Natural exposure in Calvert Cliffs along the Chesapeake Bay. 1.4 mile southeast of Flag Ponds. 2.3 miles southeast of Long Beach, Md. 4.6 miles northwest of Cove Point lighthouse. Calvert Co., Md. 38° 26' 08" N. Lat.; 76° 26' 28" W. Long. Description of part of section only.

Unit		Thickness
St. Marys Formation		
Choptank Formation		
Conoy Member		
2	Lithology: Dusky bluish-gray, muddy, very fine sand. Parallel, continuous, thin, bedding laminations. Thick bedded. Lower contact straight and distinct. Upper contact distinct and bored by organisms from St. Marys sea. Fossils: Sparse. Atrina harrisii mostly concentrated into layers of flat-lying shells, but a few randomly distributed in living position. A few Turritella plebeia randomly distributed in unit. Sample 66-50-2 from 1' 6" to 2' 0" above base of unit.	12' 6"
Boston Cliffs Member		
1	Lithology: Dusky yellowish-brown, very muddy, very fine sand. No apparent sedimentary structures. Lower contact deeply channeled. Upper contact straight and distinct. Fossils: Prolific accumulation of shells. Bivalves predominantly flat lying. Random distribution. Faunal list: A-Turritella plebeia, C-Dosinia acetabulum, Atrina harrisii, N-Astarte obruta, Ecphora	2' 0"

Unit	Thickness
quadricostata umbilicata, F-Crassatella marylandica. Sample 67-50-1 from 0' 9" to 1' 6" above base of unit.	
Total thickness of exposed Choptank Formation	14' 6"

Locality 67-51. Between Camp Conoy and Morans Creek. 0.1 mile northwest of Morans Creek. 0.7 mile southeast of Camp Conoy (Y.M.C.A.). 0.8 mile northwest of Point of Rocks. 1.8 mile northeast of Lusby, Md. Natural exposure in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 25' 19" N. Lat.; 76° 25' 34" W. Long. Section not described. Date taken from Boston Cliffs Member for population analysis.

Locality 67-52. Between Camp Conoy and Morans Creek. 0.5 mile southeast of Camp Conoy (Y.M.C.A.). 0.3 mile northwest of Morans Creek. 0.9 mile northwest of Point of Rocks. 1.8 mile northeast of Lusby, Md. Natural exposure in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 25' 26" N. Lat.; 76° 25' 39" W. Long. Section not described. Data taken from Boston Cliffs Member for population analysis.

Locality 67-53. Governor Run. 0.4 mile north of Governor Run Road. 2.3 miles south of Parker Creek. 1.3 mile east of Port Republic, Md.

Natural exposure in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 30' 16" N. Lat.; 76° 30' 24" W. Long. Only portion of section described.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Boston Cliffs Member		12' 0"
	Undescribed,	
St. Leonard Member		18' 0"
	Undescribed.	
Drumcliff Member		5' 0"
	The accumulation of fossil shells in the unit appears graded with small shell hash at the base grading to large fragments and complete shells near the top. The base contains reworked particles of the dusky blue, very fine sand from the Calvert Beach Member.	
Calvert Beach Member		
	The Calvert Beach Member at this locality has several light brown sand units and thin stringers. Bounding planes of these units undulate very broadly but very distinctly.	
6	(Similar to unit 2)	3' 4"
5	(Similar to unit 1)	0' 8"
4	(Similar to unit 2)	0' 8"
3	(Similar to unit 1)	0' 3"
2	Lithology: Dusky-blue, very muddy, very fine sand. Dense and sticky. No apparent sedimentary structures. Contacts distinct and undulating. Fossils: Sparse. Random distribution. Faunal list: F-Balanus concavus, R-Atrina harrisii. Sample 66-53-2 from entire interval.	0' 8"

Unit		Thickness
1	Lithology: Light-brown, muddy, fine to medium sand. Reworked clay particles up to 5 inches in diameter. No apparent internal sedimentary structures. Contacts parallel but undulating very broadly and deeply. This unit occurs from 5' 7" to 6' 7" below Calvert Beach-Drumcliff contact. Fossils: Sparse, fine, shell hash. Random distribution. Faunal list: R-Abertella aberti, Balanus concavus, Lyropecten madisonius. Sample 66-53-1 from entire interval.	1' 0"
(Covered)		
	Total thickness of exposed Calvert Beach Member	6' 7"
	Total thickness of exposed Choptank Formation	41' 7"

Locality 67-54. Cuckold Creek VII.

Natural exposure on south bank of middle "finger" of three western "fingers" of Cuckold Creek. 1.2 mile west of Clarks Landing. 2.6 miles east of Hollywood, Md. St. Marys Co., Md. 38° 20' 49" N. Lat.; 76° 31' 29" W. Long. Section very similar to section at locality 66-29.

Unit		Thickness
(Covered)		
Choptank Formation		
Boston Cliffs Member		
2	Lithology: Pale reddish-brown, poorly sorted, muddy, fine sand. No apparent sedimentary structures. Lower contact distinct and undulating. Upper contact covered. Fossils: Prolific accumulation of oysters and scallops. Somewhat jumbled. Random distribution. Faunal list: A-Crassostrea	1' 6"

Unit		Thickness
	carolinensis, Lyropecten madisonius. No sample.	
St. Leonard Member		
1	Lithology: Pale olive-green, poorly sorted, fine sand. Lower contact covered by beach. Upper contact undulating and distinct. Fossils: Few molds and casts. No sample.	6' 6"
	Total thickness of exposed Choptank Formation	8' 0"

Locality 67-55. Mill Cove II.

Natural exposure in western bank of central "finger" of three "fingers" of Mill Cove. 1.0 mile south of Clarks Landing. 1.1 mile north of California, Md. St. Marys Co., Md. 38° 19' 40" N. Lat.; 76° 30' 17" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member		
3	Lithology: Light olive-brown, slightly muddy, fine to medium sand. Subtle color mottling to light brown. No bedding laminations. Lower contact gradational. Upper contact concealed. Fossils: Prolific accumulation of shells. Predominantly flat-lying, single valves. Predominantly thin-shelled specimens. Random distribution. Faunal list: VC-Turritella plebeia, C-Cerastoderma laqueata, Macrocallista marylandica, N-Lyropecten madisonius, F-Corbula idonea, R-Glossus fraternus marylandicus, Astarte thisphila.	1' 6"
2	Lithology: Light olive-brown, slightly muddy, fine sand. Subtle color mottling. Contacts gradational. Fossils: Prominent scallop layer.	0' 4"

Unit		Thickness
	Prolific accumulation of shells. Predominantly flat-lying shells. Faunal list: A-Lyropecten madisonius, VC-Cerastoderma laqueata, C-Turritella plebeia, N-Astarte thisphila, Crassatella turgidula, F-Ecphora quadricostata umbilicata, R-Corbula idonea. No sample.	
1	Lithology: Light olive-brown, slightly muddy, fine sand. Subtle color mottling. Lower contact covered. Upper contact gradational. Fossils: Prolific accumulation of shells. Predominantly flat-lying, single valves. Predominantly thin-shelled specimens. Fairly high faunal diversity. Faunal list: VC-Cerastoderma laqueata, N-Astarte thisphila, Crassatella turgidula, Lyropecten madisonius, F-Ecphora quadricostata umbilicata, Turritella plebeia, R-Corbula idonea. Sample 67-55-1 from 0' 6" to 1' 6" above base of unit.	2' 0"
(Covered interval)		
	Total thickness of exposed Drumcliff Member	3' 10"

Locality 67-56. Governor Run Road.

North bank of road cut along Governor Run Road, State Highway 509. 0.5 mile west of Governor Run, Md. 0.4 mile west of Governor Run bridge. 0.4 mile east of Port Republic, Md. Calvert Co., Md. 38° 29' 59" N. Lat.; 76° 30' 52" W. Long. Description starts 5' 4" above level of highway surface.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member		
1	Lithology: Moderate reddish-orange, slightly muddy, fine to medium sand. No apparent sedimentary structures. Contacts concealed. Fossils: Very dense accumulation.	0' 10"

Unit		Thickness
	Shells very jumbled. Nearly all single valves. Random orientation and distribution. Fair preservation. Some wear and fragmentation. High faunal diversity. Faunal list: C-Anadara staminea, Eyropecten madisonius, Cerastoderma laqueata, N-Turritella plebeia, Corbula idonea, F-Crassatella turgidula, Astarte thisphila, Dosinia acetabulum, Macrocallista marylandica, R-Glossus fraternus marylandicus, Lunatia heros. Sample 67-56-1 from entire interval.	

Locality 67-57. Bowens Grocery.

Roadcut in Dares-Wilson Road (Maryland State Highway 555) about 50 yards north and across road from Bowens Grocery. 1/4 mile south of Wilson, Md. 0.45 mile south of junction of Maryland highways 263 and 555. 38° 36' 24" N. Lat.; 76° 31' 33" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Boston Cliffs Member		
3	Lithology: Moderate reddish-brown, muddy, fine sand. Heavily indurated unit. No apparent sedimentary structure. Lower contact distinct. Upper contact concealed. Fossils: Fl-Lyropecten madisonius, F-Crassostrea carolinensis. No sample.	2' 6"
2	Lithology: Moderate reddish-brown, slightly muddy, angular, fine sand. Color mottlings to lighter and darker browns. Lower contact gradational. Upper contact distinct. Fossils: Locally leached out. Prolific accumulation of shells. Random distribution. Not as well preserved as unit 1. Faunal list: N-Balanus concavus, F-Lyropecten madisonius, Crassostrea	1' 6"

Unit		Thickness
	carolinensis. Sample 67-57-1 from entire interval.	
1	Lithology: Moderate reddish-brown, slightly muddy, angular, fine sand. Color mottling to lighter and darker browns. Lower contact covered. Upper contact gradational. Fossils: Well preserved. Prolific accumulation of shells. Random distribution. Faunal list: N-Balanus concavus, F-Lyropecten madisonius, Crassostrea carolinensis. Sample 67-57-2 from 0' 0" to 0' 7" above base of unit.	0' 9"
	Total thickness of exposed Boston Cliffs Member	4' 9"
	(Covered interval above highway)	6' 1"

Locality 67-58. Paris.

Natural outcrop in hill 0.8 mile east of Paris, Md. 0.2 mile south of Md. highway 260. 1.8 mile west of West Beach, Md. Calvert Co., Md. 38° 42' 02" N. Lat.; 76° 33' 56" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated) Choptank Formation Boston Cliffs Member		
5	Lithology: Moderate reddish-orange, slightly muddy, fine to medium sand. Oxidized. Indurated unit. Solution of calcite from shells, redistribution, and recementation. No apparent sedimentary structures. Contacts distinct. Fossils: Prolific accumulation, shells all leached out. Molds and casts. Faunal list: F1-Lyropecten madisonius, A-Balanus concavus. No sample.	1' 2"
4	Lithology: Heavily oxidized, well-sorted, fine to medium sand. Occasional wavy and irregular	2' 2"

Unit		Thickness
	bedding. Lower contact scour and fill. Upper contact distinct. Fossils: None seen. Sample 67-58-4 from 0' 4" to 1' 0" above base of unit.	
3	Lithology: Very heterogeneous. Varies from very light-gray, well-sorted, fine sand to moderate reddish-orange, muddy, fine sand. Possible planar cross-lamination accumulation of shells. Lower contact gradational. Upper contact extremely undulating and very distinct. Fossils: Very dense accumulation. Shells very jumbled. Fragmentation abundant. Wear abundant. But a few shells in very good condition. Some shell material flat lying. Some shell material appears to be in planar cross-laminations. A few burrows which may have been from bivalves. Faunal list: VC-Lyropecten madisonius, Crassostrea carolinensis, Balanus concavus, C-Macrocallista marylandica, N-Turritella plebeia var. A, Cerastoderma laqueata, F-Ecphora quadricostata umbilicata, Astarte obruta, Corbula idonea, Mercenaria, sp., Anodontia anodonta, R-Crassatella marylandica, Panope sp., and a crab claw. Sample 67-58-3 from 0' 0" to 1' 0" above base of unit.	1' 11"
	Total thickness of exposed Boston Cliffs Member	5' 3"
St. Leonard Member		
2	Lithology: Pale reddish-orange, slightly muddy, fine sand. Subtle color mottlings to lighter browns and to more vivid oranges. Lighter brown mottling may be result of burrowing. No inorganic sedimentary structures. Contacts gradational.	3' 0"

Unit		Thickness
	Fossils: Quite sparse. All shell fragments. Gradational increase in number of shell fragments from unit 1. Few shell hash concentrations in burrows. None identified. Sample 67-58-2 from 0' 0" to 1' 0" above base of unit.	
1	Lithology: Pale reddish-orange, slightly muddy, fine sand. Subtle color mottlings to lighter browns and to more vivid orange. No apparent sedimentary structures. Lower contact covered. Upper contact gradational. Fossils: Very rare small fragments. None identified. Sample 67-58-1 from 0' 0" to 1' 0" above base of unit.	2' 9"
	Total thickness of exposed St. Leonard Member	5' 9"
	Total thickness of exposed Choptank Formation	11' 0"

Locality 67-59. Sandgates.

Natural exposure in low bluffs along the western shore of the Patuxent River at Sandgates, Md. 0.2 mile south of Cat Creek. 0.2 mile south of Cape St. Marys Marina. St. Marys Co., Md. 38° 25' 00" N. Lat.; 76° 37' 05" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member		
7	Lithology: Dark grayish-green, muddy, fine sand. Intensely burrowed and mottled. No apparent inorganic sedimentary structures. Lower contact gradational. Upper contact distinct and nearly straight. Fossils: Prolific accumulation of shells. Predominantly large, flat-lying bivalves. Aragonite preserved.	1' 8"

Unit		Thickness
	Isognomon bored by sponges and bivalve, Martesia. Low faunal diversity. Faunal list: C-Atrina harrisii (double valves), Isognomon maxillata (double valves), Lyropecten madisonius, Martesia ovalis (double valves in living position). Sample 67-59-7 from 0' 8" to 1' 8" above base of unit.	
6	Lithology: Dark reddish-brown, muddy, fine sand. Heavily oxidized. Mottled by burrowing. No inorganic sedimentary structures. Contacts gradational. Fossils: Prolific accumulation of shells. All aragonitic shells are leached out. Molds and casts. Faunal list: VC-Atrina harrisii (many double valves; some flat-lying; some in living position), C-Discinisca lugubris, F-?Crucibulum sp. Sample 67-59-6 from 1' 0" to 2' 0" above base of unit.	2' 6"
5	Lithology: Dusky-blue, muddy, fine sand. No inorganic sedimentary structures. Slime-lined, bivalve burrows common. Contacts gradational. Fossils: Common. Molds and casts. All calcareous material has been leached out. Phosphatic brachiopods preserved. Low faunal diversity. Faunal list: C-Lyropecten madisonius, Discinisca lugubris. No sample.	2' 10"
4	Lithology: Moderate brown, muddy, fine sand. No apparent sedimentary structures. Lower contact distinct and irregular. Upper contact gradational. Fossils: Common. Molds and casts. All calcareous material has been leached out. Phosphatic brachipods preserved. Low faunal diversity.	1' 0"

Unit		Thickness
	Faunal list: C-Lyropecten madisonius, Discinisca lugubris. No sample.	
	Total thickness of exposed Drumcliff Member	8' 0"
?Calvert Beach Member		
3	Lithology: Dusky blue-green, muddy, fine sand. Mottled by pale greenish-gray, well-sorted, fine sand. Mottling result of burrowing. Some burrows filled with dusky green, very muddy, silt. No bedding laminations. Contacts distinct and irregular. Fossils: Very rare fragments. None identified. No sample.	1' 3"
2	Lithology: Dusky blue-green, muddy, fine sand. Mottled by pale greenish-gray, well-sorted, fine sand. Mottlings result of burrowing. No bedding laminations. Smooth, irregularly spaced, flat-lying concretions. Contacts distinct and irregular. Fossils: None seen. No sample.	1' 0"
1	Lithology: Dusky blue-green, muddy, fine sand. Mottled by pale greenish-gray, well-sorted, fine sand. Mottlings result of burrowing. Some burrows filled with dusky-green, very muddy silt. No bedding laminations. Lower contact subtle. Upper contact distinct and irregular. Fossils: Very rare fragments. None identified. Sample 67-59-5 from 1' 6" to 2' 6" above base of unit.	3' 4"
	Total thickness of exposed ?Calvert Beach Member	5' 7"
	Total thickness of exposed Choptank Formation	13' 7"

Locality 67-60. St. Thomas Creek.

Natural exposure in south bank of eastern tributary of St. Thomas Creek. 0.7 mile south southwest of Captain Point. 1-1/4 mile west of Sotterly. 2.4 miles north northeast of Hollywood, Md. St. Marys Co., Md. 38° 22' 46" N. Lat.; 76° 33' 26" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member, lower		
2	Lithology: Dusky-brown, muddy, fine sand. Heavily indurated unit. No apparent sedimentary structures. Contacts concealed. Fossils: Prolific accumulation of shells. Shells all leached out. Largely shell hash. Faunal list: VC-Isognomon maxillata. No sample.	1' 6"
1	Lithology: Dusky-green, muddy, fine sand. No apparent inorganic sedimentary structures. Abundant bivalve burrows. Contacts concealed. Fossils: Prolific accumulation of shells. Predominantly flat-lying bivalves but a few vertical or inclined. Low faunal diversity. Isognomon concentrated in bands. Faunal list: F1-Isognomon maxillata, N-Discinisca lugubris, Lyropecten madisonius. Sample 67-60-1 from 0' 0" to 0' 9" above base of unit.	2' 2"
	Total thickness of exposed Drumcliff Member	3' 8"

Locality 67-61. (See locality 66-19).

Locality 67-63. Captain Point-Sotterly.

Natural exposure along western shore of Patuxent River. 0.4 mile southeast of Captain Point. 3/4 mile northwest

of Sotterly. 3.0 miles northeast of Hollywood, Md. St. Marys Co., Md. 38° 23' 04" N. Lat.; 76° 32' 43" W. Long. Section only for purposes of important measurements.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member		
2	Middle increased macrofossil bed. Indurated.	2' 0"
1	Lower reduced macrofossil bed.	5' 0"
	Total thickness of exposed Drumcliff Member	7' 0"

Locality 67-64. Sotterly.

Natural exposure along western shore of Patuxent River. 0.5 mile northwest of Sotterly.. 0.6 mile southeast of Captain Point. 3.1 miles northeast of Hollywood, Md. St. Marys Co., Md. 38° 23' 00" N. Lat.; 76° 32' 30" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
Drumcliff Member		
6	Lithology: Dusky-brown, muddy, fine sand. Indurated bed. No apparent sedimentary structures. Lower contact gradational. Upper contact covered. Fossils: Prolific accumulation of shells. Shells all leached out. Molds and casts. Predominantly flat-lying bivalves but some inclined. Most specimens double valves. Faunal list: Fl-Isognomon maxillata. No sample.	2' 6"
5	Lithology: Pale yellowish-brown, fairly well sorted, fine sand. No apparent sedimentary structures. Contacts gradational.	1' 1"

Unit		Thickness
	Fossils: Increased macrofossil bed. Prolific accumulation of shells. Predominantly large, flat-lying, complete bivalves. Some double valves, most single. Fragmentation common. Faunal list: A-Cerastoderma laqueata, C-Macrocallista marylandica, Mercenaria spp., N-Crassatella turgidula, F-Turritella plebeia, Lyropecten madisonius. Sample 67-64-4 from entire interval.	
4	Lithology: Dusky yellowish-brown, muddy, fine sand. No sedimentary structures. Contacts gradational. Fossils: Reduced macrofossil bed. Most specimens small fragments. Some small complete specimens. Most fragments unidentified. Faunal list: N-Turritella plebeia, F-Balanus concavus, Astrhelia palmata, R-Fissuridea griscomi. Sample 67-64-3 from entire interval.	0' 11"
3	Lithology: Grayish-brown, muddy, fine sand. No apparent sedimentary structures. Contacts gradational. Fossils: Prolific accumulation of large, flat-lying bivalves. High faunal dominance. Low faunal diversity. Faunal list: Fl-Isognomon maxillata, F-Lyropecten madisonius, R-Martesia ovalis. Sample 67-64-2 from entire interval.	1' 0"
2	Lithology: Dusky-blue, muddy, fine sand. No apparent sedimentary structures. Partially to completely indurated. Contacts gradational. Fossils: Prolific accumulation of large, flat-lying bivalves. High faunal dominance. Very low faunal diversity. Faunal list: Fl-Isognomon maxillata. No sample.	0' 8"
1	Lithology: Dark grayish-green, muddy,	3' 6"

Unit		Thickness
	fine sand. No inorganic sedimentary structures. Mottling by burrowing bivalves abundant. Lower contact covered by beach. Upper contact gradational. Fossils: Three layers (at 0' 6", 0' 11", 2' 2" above base of unit) of concentrated, flat-lying Isognomon. Between layers Isognomon occur vertical and inclined. Prolific accumulation of shells. Faunal list: A-Isognomon maxillata, R-Lyropecten madisonius. Sample 67-64-1 from 1' 1" to 2' 1" above base of unit.	
	Total thickness of exposed Drumcliff Member	8' 8"

Locality 67-65. Calvert Beach.

Natural exposure in Calvert Cliffs along western shore of Chesapeake Bay at Calvert Beach, Md. Calvert Co., Md. 38° 28' 05" N. Lat.; 76° 28' 37" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Drumcliff Member		
12	Lithology: Pale reddish-brown, very muddy, fine to medium sand. No apparent sedimentary structures. Lower contact gradational. Upper contact distinct. Fossils: Very dense accumulation. Accumulation very jumbled. Shells all leached out. No species identified. No sample.	6' 0"
11	Lithology: Pale reddish-brown, very muddy, fine to medium sand. No sedimentary structures seen. Contacts gradational. Fossils: Dense accumulation of shells. Jumbled accumulation. Great range in sizes of specimens. Little wear. High faunal diversity.	1' 0"

Unit		Thickness
	Faunal list: VC-Turritella plebeia, C-Cerastoderma laqueata, Lyropecten madisonius, N-Macrocallista marylandica, Discinisca lugubris, F-Lunatia heros, Glossus fraternus marylandicus, Mercenaria sp., R-Astarte thisphila, Panope americana (double valves and in living position), Asaphis centenaria. Sample 67-65-10 from 0' 6" to 1' 0" above base of unit.	
10	Lithology: Heterogeneous. Dusky yellowish-brown, muddy, fine sand. Pale yellowish-brown, muddy, fine sand. Dusky-blue, muddy, fine sand. Some definite burrowing. Contacts gradational. Fossils: Very dense accumulation of shells, very jumbled accumulation. High faunal diversity. Fairly high faunal dominance. Partial faunal list: F1-Isognomon maxillata (many double valves), Astrhelia palmata, VC-Balanus concavus, C-Turritella plebeia, N-Discinisca lugubris, F-Lyropecten madisonius. Sample 67-65-9 from 0' 6" to 1' 6" above base of unit.	2' 1"
	Total thickness of exposed Drumcliff Member	9' 1"
Calvert Beach Member--Type section		
9	Lithology: Dark greenish-gray, muddy, fine sand. Mottled by light-gray, well-sorted, fine sand probably as a result of burrowing. No bedding laminations. Lower contact straight and clearly defined. Upper contact gradational. Fossils: Only fine shell hash. All fragments less than 1/2 inch. Sample 67-65-8 from 0' 6" to 1' 6" above base of unit.	1' 9"
8	Lithology: Olive-gray, muddy, very fine sand. Local scour and fill structures. Multi-walled,	2' 6"

Unit		Thickness
	slime-lined, vertical, bivalve burrows. Burrow laminae flat bottomed in vertical burrows. Burrows constant diameter. Many burrows filled with light-gray, well-sorted, fine sand, and some filled with dark greenish-yellow, muddy, fine sand. Contacts straight and clearly defined. Fossils: Bivalves all double and in living position. Some subtle layering of Turritella. Strong pocketing of Turritella. Faunal list: VC-Turritella plebeia, F-Lucinoma contracta, Diplodonta subvexa, R-Lyropecten madisonius. Sample 67-65-7 from 0' 9" to 1' 9" above base of unit.	
7	Lithology: Dark grayish-green, very muddy, very fine sand. Local scour and fill structures. Multi-walled, slime-lined, bivalve burrows inclined, vertical, and nearly horizontal. Burrow laminae flat bottomed in vertical burrows. Laminae slightly concave in inclined or nearly horizontal burrows. Burrows constant diameter. Contacts straight and clearly defined. Fossils: Bivalves all double and in living position. Some subtle layering of Turritella. Strong pocketing of Turritella. Largest Turritella pocket 13 inches across and 4 inches deep. Some Turritella pockets appear as scour and fill structures. Faunal list: VC-Turritella plebeia, F-Lucinoma contracta, Diplodonta subvexa, R-Lyropecten madisonius. Sample 67-65-6 from 0' 9" to 1' 9" above base of unit.	2' 6"
6	Lithology: Dark grayish-green, muddy silt. Profusely burrowed. No bedding laminations. Lower contact straight and clearly defined.	0' 3"

Unit		Thickness
	Upper contact straight and distinct. Fossils: Rare small snails. Faunal list: R-Turritella plebeia. Sample 67-65-5 from entire interval.	
5	Lithology: Dark grayish-green, muddy, very fine sand. Scour and fill structures up to ten inches across and four inches deep. Multi-walled, slime-lined burrows vertical, inclined, and nearly horizontal. Most all bottom laminae in burrows flat except in inclined burrows where some are curved downward approaching shape of burrow. Burrows nearly constant diameter. Contacts straight and clearly defined. Fossils: Somewhat reduced in number of shells from unit 4. Nearly all complete specimens. May well be a living assemblage. Well preserved. Bivalves double and in living position. Faunal list: VC-Turritella plebeia, C-bryozoans, F-Diplodonta subvexa, Glossus fraternus marylandicus, Balanus concavus, R-Ensis ensiformis, Lucinoma contracta. No sample.	0' 11"
4	Lithology: Dark grayish-green, very muddy, very fine sand. Possibly some localized, thin, irregular, wavy bedding. Some scour and fill structures. Profusely burrowed by bivalves and possibly polychaetes. Abundant multi-walled, slime-lined burrows. Lower contact slightly gradational. Upper contact straight and clearly defined. Fossils: Increase in shell material from unit 3. Shell hash more common than lower beds. Strongly dominated by Turritella plebeia. Faunal list: A-Turritella plebeia, C-bryozoans, N-Glossus fraternus marylandicus, F-Lucinoma contracta, Lyropecten madisonius, R-Turritella variabilis cumberlandia, Discinisca lugubris, Mercenaria sp., and pieces of wood. Sample 67-65-4 from 0' 5" to 1' 1" above base of unit.	1' 5"

Unit		Thickness
3	Lithology: Dark grayish-green, muddy, fine sand. Possibly some localized, thin, irregular, wavy bedding. Some scour and fill structures up to six inches across. Profusely burrowed by bivalves and possibly polychaetes. Abundant multi-walled, slime-lined burrows. Burrows all seem constant diameter. Contacts slightly gradational. Fossils: Appears to be a life assemblage. Double valves in living position very common. All well preserved. Faunal list: C-Turritella plebeia, N-Lucinoma contracta, Glossus fraternus marylandicus, F-Diplodonta subvexa, Mercenaria sp. Sample 67-65-3 from 0' 3" to 0' 10" above base of unit.	0' 11"
2	Lithology: Dark grayish-green, muddy, fine sand. Possibly some localized, thin, irregular, wavy bedding. Some scour and fill structures up to six inches across. Profusely burrowed by bivalves and possibly polychaetes. Abundant multi-walled, slime-lined burrows. Contacts slightly gradational. Fossils: Concentrated layer of Turritella. Very heavily concentrated in some burrows. Specimens nearly all complete. Piece of wood. Faunal list: F1-Turritella plebeia, N-Cerastoderma laqueata, R-Lyropecten madisonius. Sample 67-65-2 from entire interval.	0' 4"
	Total thickness of Calvert Beach Member	10' 7"
	Total thickness of exposed Choptank Formation	19' 8"
Calvert Formation ("Zone 15")		
1	Lithology: Dark grayish-green, muddy	1' 7"

Unit		Thickness
	fine sand. Possibly some thin, irregular, wavy bedding in pockets--not throughout unit. Some scour and fill structures up to six inches across. Profusely burrowed by bivalves and possibly polychaetes. Abundant multi-walled, slimed-lined burrows. Lower contact under water. Upper contact slightly gradational. Fossils: Rare fragments of Turritella plebeia. Sample 67-65-1 from 0' 6" to 1' 3" above base of unit.	

Locality 67-66. Camp Conoy II.

Natural exposure in Calvert Cliffs along the Chesapeake Bay at Camp Conoy (Y.M.C.A.). First exposure south of camp road to beach along cliffs. 1.8 mile northeast of Lusby, Md. Calvert Co., Md. 38° 25' 44" N. Lat.; 76° 25' 55" W. Long. Section no measured or described. Population data taken.

Locality 67-67. Mouth of St. Leonard Creek.

Natural exposure in low bluff at south side of mouth of St. Leonard Creek on Patuxent River. 2.8 miles southwest of Lusby, Md. Calvert Co., Md. 38° 23' 14" N. Lat.; 76° 29' 55" W. Long.

Unit		Thickness
(Covered) Choptank Formation St. Leonard Member		
5	Lithology: Moderate reddish-brown, slightly muddy, fine sand. No apparent sedimentary structures. Lower contact distinct. Upper contact covered. Fossils: Very rare. Faunal list: R-Crassostrea carolinensis. No sample.	2' 0"

Unit		Thickness
Drumcliff Member		
4	Lithology: Moderate reddish-brown, slightly muddy, fine sand. Mottled by light-gray, well-sorted, fine sand. No bedding laminations. Lower contact gradational. Upper contact distinct. Fossils: Prolific accumulation of shells. Accumulation very jumbled and mixed. Fragmentation abundant. Wear abundant. Mostly unidentifiable fragments. Random orientation and distribution. Faunal list: F-Cerastoderma laqueata, Anadara staminea, Balanus concavus, Corbula idonea, Astarte thisphila, Lyropecten madisonius; R-Panope americana. No sample.	0' 6"
3	Lithology: Light-gray, fairly well sorted, very fine sand. Heavily indurated forming very resistant exposure. No apparent sedimentary structures. Contacts gradational. Fossils: Prolific accumulation but all aragonitic shells leached out. Predominantly large, flat-lying bivalves. Low faunal diversity. Faunal list: Fl-Isognomon maxillata. No sample.	4' 0"
2	Lithology: Light-gray, fairly well sorted, very fine sand. Heavily indurated forming very resistant exposure. No apparent sedimentary structures. Contacts gradational. Fossils: Prolific accumulation but all aragonitic shells leached out. Predominantly large, flat-lying bivalves. Low faunal diversity. Faunal list: Fl-Isognomon maxillata, A-Discinisca lugubris. No sample.	2' 0"
1	Lithology: Light-gray, fairly well sorted, very fine sand. Heavily indurated forming very resistant exposure. No apparent sedimentary structures. Lower contact covered. Upper contact gradational.	3' 0"

Unit		Thickness
	Fossils: Prolific accumulation but all aragonitic shells leached out. Predominantly large, flat-lying bivalves. Low faunal diversity. Faunal list: Fl-Isognomon maxillata. No sample.	
	Total thickness of exposed Drumcliff Member	9' 6"
	Total thickness of exposed Choptank Formation	11' 6"

Locality 67-68. Hellen Creek.

Natural exposure in northwestern bank of Hellen Creek. 1.2 mile northeast of mouth with Patuxent River. 1.3 mile west northwest of Appeal, Md. 3.5 miles north of Solomons Island. Calvert Co., Md. 38° 22' 26" N. Lat.; 76° 28' 16" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
St. Leonard Member		
3	Lithology: Moderate reddish-brown, muddy, fine sand. No apparent sedimentary structures. Lower contact abrupt and distinct but slightly irregular. Upper contact covered. Fossils: None seen. Sample 67-68-2 from entire interval.	0' 8"
Drumcliff Member		
2	Lithology: Moderate reddish-brown, muddy, fine sand. No apparent sedimentary structures. Lower contact distinct. Upper contact abrupt and distinct but slightly irregular. Fossils: Prolific accumulation of shells. Predominantly large, complete specimens. Low faunal diversity. Faunal list: Fl-Isognomon maxillata, N-Lyropecten madisonius, Balanus concavus. Sample 67-68-1 from entire interval.	0' 7"

Unit		Thickness
1	Lithology: Moderate reddish-brown, muddy, fine sand. Indurated unit. No apparent sedimentary structures. Lower contact covered. Upper contact distinct. Fossils: Prolific accumulation. Partially to completely indurated. Predominantly large, flat-lying bivalves. Low faunal diversity. Faunal list: A-Isognomon maxillata, Lyropecten madisonius. No sample.	1' 0"
	Total thickness of exposed Drumcliff Member	1' 7"
	Total thickness of exposed Choptank Formation	2' 3"

Locality 67-69. Coster.

Natural exposure along eastern shore of Patuxent River at Coster, Md. 2.5 miles north northwest of Solomons Island. Between mouths of Hungerford and Hellen Creeks. Calvert Co., Md. 38° 21' 17" N. Lat.; 76° 28' 40" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Conoy Member		
1	Lithology: Dusky-blue, silty mud. Thin, parallel, continuous, bedding laminations. Thick bedded. Contacts distinct and nearly straight. Fossils: Sparse except at 16 inches above base of unit where a layer of lenses of concentrated Turritella plebeia occurs. Shells all leached out. No sample.	7' 0"
Boston Cliffs Member		
1	Lithology: Oxidized-brown, muddy, fine sand. No apparent sedimentary structures. Lower contact covered. Upper contact distinct and nearly	0' 9"

Unit		Thickness
	straight. Fossils: None seen. No sample.	
	Total thickness of exposed Choptank Formation	7' 9"

Locality 67-70. East Nomini Cliffs.

Natural exposure in Nomini Cliffs along western shore of Potomac River. 1.6 mile east northeast of Stratford Hall, Va. 1.2 mile west of Currioman Bay. Westmoreland Co., Va. 38° 10' 05" N. Lat.; 76° 47' 52" W. Long.

Unit		Thickness
St. Marys Formation		
Choptank Formation		
?Conoy Member		
13	Lithology: Dusky-olive, muddy, very fine sand. No apparent sedimentary structures. Lower contact straight and distinct. Upper contact slightly gradational probably as a result of boring and burrowing animals. St. Marys Fmn. is dark chocolate brown and has many more molds and casts. Fossils: Few molds and casts. None identified. Sample 67-70-13 from 7' 0" to 8' 0" above base of unit.	14' 0"
?Boston Cliffs Member		
12	Lithology: Dusky-olive, muddy, fine sand. Weathers to dark chocolate brown. Exposure forms resistant ledge. No apparent sedimentary structures. Lower contact slightly gradational. Upper contact straight and distinct. Fossils: Increased macrofossil bed. Prolific accumulation of shells. Random distribution. Partial faunal list: VC-Glossus fraternus marylandicus, C-unidentified Venerid bivalves, ?Callocardia subnasuta, N-Dosinia acetabula, F-Balanus concavus, Discinisca lugubris. Sample 67-70-12 from entire unit.	1' 3"

Unit		Thickness
11	Lithology: Dusky-olive, muddy, very fine sand. No apparent sedimentary structures. Contacts slightly gradational. Fossils: Reduced macrofossil bed. Reduced number of shells. Many fragments. Mostly thin shells. Random distribution. Faunal list: F-Venerid bivalves, Discinisca lugubris, R-Panope sp., Turritella plebeia. Sample 67-70-11 from entire interval.	0' 8"
10	Lithology: Dusky-olive, muddy, very fine sand. No apparent sedimentary structures. Contacts distinct, irregular, and slightly gradational. Fossils: Prolific accumulation of shells. Most thin-shelled bivalves. Increased macrofossil unit. Many not identified. Faunal list: C-Mercenaria sp., N-Turritella plebeia, Lucinoma contracta, F-Panope americana, R-Ecphora quadricostata umbilicata. Sample 67-70-10 from entire interval.	1' 1"
	Total thickness of ?Boston Cliffs Member	3' 0"
?St. Leonard Member		
9	Lithology: Dusky-olive, muddy silt. Very dense. No apparent sedimentary structures. Contacts distinct, irregular, and slightly gradational. Fossils: Rare. Thin-shelled bivalves. None identified. Sample 67-70-9 from 2' 0" to 2' 6" above base of unit.	7' 4"
?Drumcliff Member		
8	Lithology: Dusky-olive, muddy, very fine sand. No apparent sedimentary structures. Contacts distinct, irregular, and slightly gradational. Forms slightly resistant exposure. Fossils: Increased macrofossil bed. Prolific accumulation of shells.	0' 9"

Unit		Thickness
	Predominantly flat-lying bivalves. Difficult to extract for identification. Greater diversity than shown by faunal list. Partial faunal list: VC-Turritella plebeia, C-?Callocardia subnasuta, N-Mytilus conradinus, F-Lyropecten madisonius, R-Hiatella arctica. Sample 67-70-8 from entire unit.	
7	Lithology: Dusky-olive, muddy, very fine sand. No apparent sedimentary structures. Contacts distinct, irregular, and slightly gradational. Fossils: Reduced macrofossil bed. Difficult to extract for identification. Partial faunal list: N-Crucibulum costatum, F-Glossus fraternus marylandicus, Ensis ensiformis. Sample 67-70-7 from 1' 6" to 2' 6" above base of unit.	3' 0"
6	Lithology: Heterogeneous. Dusky-brown, slightly muddy, very fine sand. Mottled by very pale orange, well-sorted, very fine sand and dusky-olive, muddy, very fine sand. Contacts distinct, irregular, and slightly gradational. Forms a slightly resistant exposure. Fossils: Increased macrofossil bed. Predominantly flat-lying bivalves. Faunal list: C-Lucinoma contracta (some double valves in living position), N-Mercenaria sp., Dosinia acetabulum, F-Turritella plebeia, R-Ecphora quadricostata umbilicata. Sample 67-70-6 from 0' 0" to 1' 0" above base of unit.	1' 5"
5	Lithology: Heterogeneous. Dusky-olive, muddy, very fine sand. Also dusky-brown, muddy, very fine sand. Also pale-orange, well-sorted, very fine sand. Single-walled, bivalve burrows. Contacts distinct, irregular, and slightly gradational. Fossils: Reduced macrofossil bed. Mostly single valves.	2' 2"

Unit		Thickness
	Faunal list: F-Mercenaria sp., Glossus fraternus marylandicus, R-Dosinia acetabulum. Sample 67-70-5 from 1' 0" to 1' 6" above base of unit.	
4	Lithology: Dusky-olive, muddy, fine sand. Some mottles of light-gray, well-sorted, fine sand. Contacts distinct and irregular. Fossils: Many flat-lying, double bivalves. Difficult to extract for identification. Some shells filled with light-gray, well-sorted, fine sand. Partial faunal list: N-Isognomon maxillata, Turritella plebeia, F-Glossus fraternus marylandicus, Lucinoma contracta, Mercenaria sp. Sample 67-70-4 from entire interval.	1' 1"
	Total thickness of ?Drumcliff Member	8' 5"
Calvert Beach Member (probably)		
3	Lithology: Dusky-olive, muddy, fine sand. Rare mottles of moderate brown, slightly muddy, very fine sand. No bedding laminations. Lower contact straight and distinct. Upper contact distinct and irregular. Fossils: A few, thin layers of flat-lying Glossus fraternus marylandicus. Sample 67-70-3 from 3' 8" to 4' 8" above base of unit.	9' 2"
2	Lithology: Dark olive-brown, muddy, fine sand. Some mottling to moderate brown. Exposure thin, oxidized, resistant layer. Contacts straight and distinct. Fossils: Layer of prolific, flat-lying, thin-shelled bivalves. Low faunal diversity. Faunal list: VC-Glossus fraternus marylandicus, R-Lyropecten madisonius, Discinisca lugubris. Sample 67-70-2 from entire interval.	0' 2"
1	Lithology: Dusky-olive, muddy, very	3' 8"

Unit		Thickness
	fine sand. Rare mottles of moderate-brown, slightly muddy, fine sand. Lower contact slightly gradational, apparently as the result of burrowing. Upper contact straight and distinct. Fossils: Rare. Faunal list: R-Discinisca lugubris. Sample 67-70-1 from 1' 6" to 2' 4" above base of unit.	
	Total thickness of Calvert Beach Member	13' 0"
	Total thickness of Choptank Formation	45' 9"
Calvert Formation		
"Zone 15" (probably)	Lithology: Moderate-brown, slightly muddy, fine sand.	2' 3"
"Zone 14" (probably)		0' 9"
(Undifferentiated)		4' 0"
	Total thickness of exposed Calvert Formation	7' 0"

Locality 67-71. South of Western Shores.

0.1 mile north of Harpers Creek. 1.1 mile south of Western Shores, Md. 1.1 mile west of St. Leonard, Md. Natural exposure in Calvert Cliffs along the Chesapeake Bay. Calvert Co., Md. 38° 28' 35" N. Lat.; 76° 29' 13" W. Long.

Unit		Thickness
St. Marys Formation (Several undifferentiated units)		
3	Lithology; Dusky-brown, slightly muddy, fine to medium sand. "Basal sand"? Upper contact parallel with lower contact of Conoy Member. Unit fills undulating surface. Lower contact distinct, slightly irregular, and broadly undulating. Upper contact distinct and nearly straight.	1' 1"

Unit		Thickness
	Fossils: Abundant fragments. Most all leached out.	
2	Lithology: Concretion layer. Dusky-brown, muddy, fine sand. Unit constand thickness. Fossils: None seen. No sample.	0' 3"
	Total thickness of measured St. Marys Formation	1' 4"
Choptank Formation Conoy Member 1	Lithology: Dusky-blue, very muddy, very fine sand. Thin, parallel, continuous, bedding laminations. No biogenic structures. Lower contact distinct and fairly straight. Upper contact distinct, slightly irregular and broadly undulating. Upper contact here is probably an erosional unconformity. Fossils: Rare molds. Faunal list: R-Lyropecten madisonius. Sample 67-71-1 from 2' 6" to 3' 4" above base of unit.	4' 5"
	(Covered Interval--Beach to top of Boston Cliffs Member)	43' 0"

Locality 67-72. West Nomini Cliffs.

Natural exposure in Nomini Cliffs along the western shore of the Potomac River. 1.8 mile northeast of Stratford Hall, Va. 2.0 miles west of Currioman Bay. Westmoreland Co., Va. 38° 09' 59" N. Lat.; 76° 48' 44" W. Long.

Unit		Thickness
St. Marys Formation Choptank Formation Conoy Member 18	Lithology: Dusky-blue, muddy, very fine sand. No apparent sedimentary structures.	14' 0"

Unit		Thickness
	Contacts distinct and nearly straight. Fossils: Rare molds and casts. Random distribution. None identified. No sample.	
Boston Cliffs Member		
17	Upper Boston Cliffs oxidized and indurated series.	2' 9"
16	Lithology: Moderate-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts undulating. Fossils: Reduced macrofossil bed. Reduced in size only. Predominantly small fragments. Some small complete specimens. Amount of shell material not reduced, however. Large amount of broken shell material. Most fragments unidentified. Faunal list: VC-Lyropecten madisonius, N-Balanus concavus. Sample 67-72-10 from entire interval.	1' 0"
15	Lithology: Moderate-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts undulating. Fossils: Increased macrofossil bed. Increased number of shells. Increased number of large bivalves. Many large, flat-lying bivalves. Random distribution. Faunal list: A-Cerastoderma laqueata, VC-Macrocallista marylandica, N-Mercenaria sp., Corbula idonea, F-Lyropecten madisonius, R-Ecphora quadricostata umbilicata. Sample 67-72-9 from entire interval.	1' 3"
14	Lithology: Moderate-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts undulating. Fossils: Reduced macrofossil bed. Reduced size. Predominantly thin-shelled or small specimens. Shells fairly abundant. Random distribution.	0' 9"

Unit		Thickness
	Faunal list: VC-Cerastoderma laqueata, N-Anadara staminea, Corbula idonea. Sample 67-72-8 from entire interval.	
13	Lithology: Moderate-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts undulating. Fossils: Unit part of the lower increased macrofossil bed. Low faunal diversity. High faunal dominance. Large, flat-lying Macrocallista marylandica very common. No sample.	1' 0"
12	Lithology: Moderate-brown, slightly muddy, fine sand. No apparent sedimentary structures. Contacts undulating. Fossils: Unit part of the lower increased macrofossil bed. Very jumbled. Appears to be bimodal distribution of shell sizes. Random orientation and distribution. Faunal list: C-Lyropecten madisonius, Cerastoderma laqueata, Corbula idonea, N-Anadara staminea, Turritella plebeia, Dosinia acetabulum, Crassatella marylandica, Astarte obruta, Balanus concavus, F-Mercenaria sp., R-Ecphora quadricostata umbilicata, Macrocallista marylandica. Sample 67-72-7 from entire unit.	2' 3"
11	Lithology: Dusky-blue, muddy, fine to medium sand. No apparent sedimentary structures. Contacts undulating. Fossils: Unit part of the lower increased macrofossil bed. Low faunal diversity. High faunal dominance. Predominantly flat-lying Cerastoderma laqueata and Dosinia acetabulum, both common. No sample.	0' 9"
10	Lithology: Dusky-blue, muddy, fine to medium sand. No apparent sedimentary structures. Contacts undulating.	0' 6"

Unit		Thickness
	Fossils: Unit part of the lower increased macrofossil bed. Low faunal diversity. High faunal dominance. Apparently random orientation of flood of Anadara staminea. No sample.	
9	Lithology: Dusky-blue, muddy, fine to medium sand. No apparent sedimentary structures. Lower contact gradational and somewhat irregular. Upper contact undulating. Fossils: Unit part of the lower increased macrofossil bed. Low faunal diversity. High faunal dominance. Large, flat-lying Lyropecten madisonius, very common. No sample.	0' 4"
	Total thickness of Boston Cliffs Member	10' 7"
?St. Leonard Member		
8	Lithology: Dusky-green, slightly muddy, fine sand. Irregular color mottles to dark greenish gray and dark olive. Contacts gradational and somewhat irregular. Fossils: Generally very sparse. However, few very thin layers of moderate number of shells. Faunal list: F-Cerastoderma laqueata, Anadara staminea, R-Crassatella turgidula, Mercenaria sp., Turritella plebeia, Balanus concavus. Sample 67-72-6 from 4' 0" to 5' 0" above base of unit.	12' 9"
Drumcliff Member		
7	Lithology: Dusky-olive, slightly muddy, fine to medium sand. No apparent sedimentary structures. Contacts gradational and somewhat irregular. Fossils: Increased macrofossil bed. Increased number of shells. Third of three thin layers of shells. Mostly thin-shelled bivalves. Random distribution.	0' 9"

Unit		Thickness
	Faunal list: C-Glossus fraternus marylandicus, Dosinia acetabulum, Turritella plebeia, Cerastoderma laqueata, N-unidentified Venerid bivalves, F-Lyropecten madisonius, Atrina harrisii, Corbula idonea, Discinisca lugubris. Sample 67-72-5 from entire interval.	
6	Lithology: Dark brownish-olive, muddy, fine sand. No apparent sedimentary structures. Contacts gradational and somewhat irregular. Fossils: Reduced macrofossil bed. Rare fragments only. No sample.	1' 6"
5	Lithology: Dark brownish-olive, muddy, fine sand. No apparent sedimentary structures. Contacts gradational and somewhat undulating and irregular. Fossils: Increased macrofossil bed. Increased number of shells. Second of three, thin shell layers. Random distribution. Faunal list: F-Dosinia acetabulum, Corbula idonea. Unidentified Venerid bivalves. No sample.	0' 4"
4	Lithology: Dark brownish-olive, muddy, fine sand. No apparent sedimentary structures. Contacts gradational and somewhat undulating and irregular. Fossils: Rare. Specimens almost appear post-depositionally crushed. Random distribution. Faunal list: R-Corbula idonea, Dosinia acetabulum. Sample 67-72-4 from entire interval.	0' 9"
3	Lithology: Dark brownish-olive, muddy, fine sand. No apparent sedimentary structures. Contacts gradational and somewhat undulating and irregular.	1' 1"

Unit		Thickness
	Fossils: Prolific accumulation of shells. Mostly thin-shelled bivalves. First of three shell layers. Random distribution. Faunal list: VC-Glossus fraternus marylandicus, C-Dosinia acetabulum, F-Astarte thisphila, unidentified Venerid bivalves, R-Asaphis centenaria, Discinisca lugubris, Lucinoma contracta, Corbula idonea, Atrina harrisii, Lyropecten madisonius. Sample 67-72-3 from entire interval.	
2	Lithology: Dusky-olive, very muddy, very fine sand. Very dense. Weathers to blocky fractures. No apparent sedimentary structures. Lower contact undulating. Upper contact somewhat undulating and irregular, also gradational. Fossils: Rare aragonitic bivalves. Rare ?Venerid bivalves. Sample 67-72-2 from 1' 10" to 2' 6" above base of unit.	5' 8"
1	Lithology: Dusky-olive, muddy, very fine sand. No apparent sedimentary structures. Lower contact covered by beach. Upper contact slightly undulating. Fossils: Prolific accumulation of shells. Predominantly flat-lying shells. Well preserved. Faunal list: VC-Turritella plebeia, C-Glossus fraternus marylandicus, N-Isognomon maxillata, Diplodonta subvexa, F-unidentified Venerid bivalves, Lucinoma contracta, Lyropecten madisonius, R-Discinisca lugubris, Cerastoderma laqueata, Lyropecten sp. Sample 67-72-1 from 2' 10" to 3' 10" above base of unit.	4' 4"
	Total thickness of exposed Drumcliff Member	14' 5"
	Total thickness of exposed Choptank Formation	52' 9"

Locality 67-73. Horsehead Cliffs.

Natural exposure at the east point of Horsehead Cliffs along the western shore of the Potomac River. 1/3 mile west of mouth of The Big Meadow Creek. 1.6 mile northwest of Stratford Hall, Va. Westmoreland State Park, Westmoreland Co., Va. 38° 10' 13" N. Lat.; 76° 51' 32" W. Long.

Unit		Thickness
St. Marys Formation		
Choptank Formation		
Conoy Member		
10	Lithology: Dusky-blue, very muddy silt. Very dense unit. No apparent sedimentary structures. Contacts straight and distinct. Fossils: Rare, unidentified, aragonitic fragments. Sample 67-73-9 from 3' 0" to 3' 6" above base of unit.	6' 1"
9	Lithology: Dusky-green, very muddy silt. Few lenses of pale-brown, muddy, fine sand. Contacts straight and distinct. Fossils: Rare, aragonitic fragments. Most fragments unidentified. Random distribution. Faunal list: R-Panope americana (double valves and in living position). Sample 67-73-8 from 1' 0" to 1' 6" above base of unit.	3' 3"
	Total thickness of Conoy Member	9' 4"
Boston Cliffs Member		
8	Lithology: Moderate reddish-orange, poorly sorted, fine sand. Upper Boston Cliffs heavily oxidized and indurated series. Apparently no sedimentary structures. Lower contact slightly gradational. Upper contact straight and distinct.	1' 2"

Unit		Thickness
	Fossils: Few leached bivalves. Predominantly flat lying. Random distribution. Many unidentified molds of fragments. Faunal list: F-Cerastoderma laqueata. No sample.	
7	Lithology: Dark-brown, very muddy, very fine sand. Few mottles of very pale orange, well-sorted, very fine sand. No bedding laminations. Lower contact distinct and fairly straight. Upper contact slightly gradational. Fossils: Few unidentified fragments. Sample 67-73-7 from 1' 0" to 2' 0" above base of unit.	2' 6"
6	Lithology: Dark-brown, very muddy, very fine sand. Few mottles of very pale orange, well-sorted, very fine sand. No bedding laminations. Contacts distinct and fairly straight. Fossils: Prolific accumulation of shells. A little hashy. Jumbled accumulation. Fragmentation common. Random orientation and distribution. Faunal list: A-Turritella plebeia, N-Isognomon maxillata, F-Mercenaria sp., Cerastoderma laqueata, Lyropecten madisonius, Balanus concavus, Diplodonta acclinis, R-Panope americana. Sample 67-73-6 from 0' 9" to 1' 6" above base of unit.	1' 6"
	Total thickness of Boston Cliffs Member	5' 2"
St. Leonard Member		
5	Lithology: Dark-brown, very muddy, very fine sand. Irregular color mottles to dark brownish olive. Contacts distinct and fairly straight. Fossils: Very rare fragments. None identified. Random distribution. Sample 67-73-5 from 1' 3" to 2' 3" above base of unit.	5' 9"

Unit		Thickness
Drumcliff Member		
4	Lithology: Pale yellowish-brown, fairly well sorted, fine sand. No apparent sedimentary structures except for rare blebs of dark-brown clay. Double valves of Isognomon contain this clay. Lower contact gradational. Upper contact straight and fairly distinct. Fossils: Prolific accumulation of shells. Small and profuse shell fragments. Random orientation and distribution. Few nearly complete specimens. Most unidentified shell hash. Faunal list: C-Isognomon maxillata (some double valves), N-Lyropecten madisonius, F-Mercenaria sp., R-Ecphora quadricostata umbilicata. Sample 67-73-4 from 0' 6" to 1' 0" above base of unit.	1' 6"
3	Lithology: Dark-brown varying to dark brownish-green, very muddy, very fine sand and moderate-brown, slightly muddy, fine sand. Some mottles of very pale-orange, well-sorted, fine sand. Contacts gradational. Fossils: Fairly prolific accumulation of shells. Fine shell hash in second lithologic type described above. Partially complete shells. Faunal list: N-Isognomon maxillata, R-Mercenaria sp., Lyropecten madisonius, Ecphora quadricostata umbilicata. Sample 67-73-2 from 0' 3" to 1' 0" above base of unit.	1' 3"
	Total thickness of Drumcliff Member	2' 9"
Calvert Beach Member		
2	Lithology: Dark-brown varying to dark brownish-green, very muddy, very fine sand. Forms nonresistant slope. Some burrows containing very pale-orange, well-sorted, fine sand. Lower contact slightly	1' 6"

Unit		Thickness
	gradational. Upper contact gradational. Fossils: No macrofossils seen. Diatoms extremely prolific. Sample 67-73-2 from 0' 6" to 1' 0" above base of unit.	
1	Lithology: Dark yellowish-brown, slightly muddy, very fine sand. Irregularly mottled with various browns. Possibly once was thin-bedded but greatly disturbed by biogenic activity. Very irregularly bedded. No well-defined bivalve burrows. Lower contact distinct and fairly straight. Upper contact slightly gradational. Forms slightly resistant exposure. Fossils: Rare. One thin layer of bivalves at 2' 6" above base of unit. Shells partially to completely leached out. Faunal list: R-Dosinia acetabulum. Sample 67-73-1 from 2' 0" to 3' 0" above base of unit.	4' 10"
	Total thickness of Calvert Beach Member	6' 4"
	Total thickness of Choptank Formation	29' 4"

Calvert Formation, undifferentiated 15' 6"

Locality 67-74. Parker Creek.

Natural exposure in Calvert Cliffs along the Chesapeake Bay. 0.15 mile south of Parker Creek. 3.5 miles east of Prince Frederick, Md. Calvert Co., Md. 38° 32' 05" N. Lat.; 76° 31' 04" W. Long.

Unit		Thickness
(Covered)		

Unit		Thickness
Choptank Formation		
Boston Cliffs Member		
12	Lithology: Light olive-brown, very muddy, very fine sand. No apparent sedimentary structures. Lower contact distinct and straight. Upper contact covered. Fossils: Increased macrofossil bed. Many fragments. Wear common. Random distribution. Fairly high faunal dominance. Faunal list: A-Anadara staminea, N-Lyropecten madisonius, Dosinia acetabulum, F-Corbula idonea, R-Ecphora quadricostata umbilicata. No sample.	2' 0"
11	Lithology: Light olive-brown, muddy, fine sand. No apparent sedimentary structures. Contacts distinct and straight. Fossils: Nearly none. Very rare fragments. No sample.	2' 0"
10	Lithology: Light olive-brown, very muddy, very fine sand. No apparent sedimentary structures. Lower contact gradational. Upper contact distinct and straight. Fossils: Increased macrofossil bed. Many fragments. Wear common. Random distribution. Fairly high faunal dominance. Faunal list: F1-Anadara staminea, N-Lyropecten madisonius, Dosinia acetabulum, F-Corbula idonea, R-Ecphora quadricostata umbilicata. Sample 67-74-10 from entire interval.	1' 0"
9	Lithology: Light olive-brown, very muddy, fine sand. No apparent sedimentary structures. Contacts gradational. Fossils: Few double-valved bivalves. Gradational unit to unit 10. Random distribution. Faunal list: F-Modiolus sp., Mercenaria sp. No sample.	1' 0"

Unit		Thickness
	Total thickness of exposed Boston Cliffs Member	6' 0"
St. Leonard Member		
8	Lithology: Dark greenish-blue, muddy silt. Very dense and hard. No apparent sedimentary structures. Contacts slightly gradational. Fossils: Few. Predominantly thin-shelled bivalves. Mostly fragments. Two thin layers (less than 1 inch thick) of Anadara staminea. Faunal list. F-Ensis ensiformis (some double valves), Anadara staminea, Corbula idonea (some double valves). Sample 67-74-9 from 1' 0" to 2' 0" above base of unit.	10' 6"
7	Lithology: Light olive-brown, muddy, very fine sand. Some color mottling of browns probably caused by oxidation. No apparent sedimentary structures. Lower contact straight and distinct. Upper contact slightly gradational. Fossils: Few. Almost all complete, double valves. All leached out. Random distribution. Faunal list: F-Lucinoma contracta, Dosinia acetabulum.	1' 0"
	Total thickness of St. Leonard Member	11' 6"
Drumcliff Member		
6	Lithology: Pale reddish-orange, fairly well sorted, fine sand. Slight color mottling with various browns, probably the result of oxidation. No apparent sedimentary structures. Forms resistant exposure. Lower contact gradational. Upper contact straight and distinct. Fossils: Prolific accumulation of shells. Prominent shell layer. Abundant wear. Random distribution.	1' 8"

Unit		Thickness
	Faunal list: C-Cerastoderma laqueata, Mercenaria sp., Dosinia acetabulum, Glossus fraternus marylandicus, Lyropecten madisonius, Turritella plebeia, N-Corbula idonea, Lunatia heros, F-Anodontia anodonta, Crassatella turgidula, Isognomon maxillata, R-Astarte thisphila, Asaphis centenaria. Sample 67-74-8 from 0' 0" to 1' 0" above base of unit.	
5	Lithology: Pale reddish-orange, fairly well sorted, fine sand. Slight color mottling with various browns, probably the result of oxidation. No apparent sedimentary structures. Lower contact straight and distinct. Upper contact gradational. Fossils: Prolific accumulation of shells. Small fragments very common. Wear common. Mostly shell hash. Most shells difficult to identify. Random orientation and distribution. Faunal list: C-Turritella plebeia, Lyropecten madisonius, F-Crassatella turgidula, Mytilus conradinus, Balanus concavus. Sample 67-74-7 from 1' 0" to 2' 0" above base of unit.	3' 3"
	Total thickness of Drumcliff Member	4' 11"
Calvert Beach Member		
4	Lithology: Light olive-brown, muddy, fine sand. Some very irregular bedding, some scour and fill structures, and some discontinuous, low-angle, planar cross-laminations. Some thin (less than 1/2" diameter) multi-walled, slime-lined burrows. Also some larger, slime-lined burrows (1 to 1-1/4" diameter). Lower contact gradational. Upper contact straight and distinct. Fossils: Few. Nearly all fragments. Random distribution. Faunal list: R-Turritella plebeia.	1' 2"

Unit		Thickness
	Sample 67-74-6 from entire interval.	
3	Lithology: Very heterogeneous. Dark-brown, slightly muddy, very fine sand. Dark brownish-green, very muddy, very fine sand. Light-gray, very well sorted, fine sand. Very pale orange, well-sorted, fine sand. Light olive-brown, muddy, fine sand. Some very irregular bedding, some scour and fill structures, and some discontinuous low-angle, planar cross-laminations. Some thin (less than 1/2") multi-walled, slime-lined burrows. Also some larger, slime-lined burrows (1 to 1-1/4" diameter). Contacts gradational. Fossils: Few. Mostly fragments. Faunal list: R-Turritella plebeia, Ensis ensiformis. Sample 67-74-5 from entire interval.	1' 3"
2	Lithology: Dark-brown, slightly muddy, very fine sand. Mottled by very pale orange, well-sorted fine sand. Also mottled by dark greenish-brown, muddy, very fine sand. No bedding laminations. Lower contact straight and distinct. Upper contact gradational. Fossils: Rare. Random distribution. Faunal list: R-Turritella plebeia, Yoldia laevis. Sample 67-74-4 from 3' 0" to 4' 0" above base of unit.	6' 0"
1	Lithology: Dusky blue-green, muddy, very fine sand. A few "balls" of Calvert, "zone 15", reworked in base of unit. Thin layers within unit of pale-brown, slightly muddy, very fine sand. Layers are actually made of irregular lenses. Some lenses may have low-angle, planar cross-laminations. Thin layers give distinct appearance of parallel, thick bedding. A few bivalve burrows. Lower contact distinct and	4' 7"

Unit	Thickness
straight. Upper contact straight and distinct. Fossils: Common. Well-preserved aragonitic molluscan shells. Faunal list: C-Turritella plebeia, N-Yoldia laevis, F-Ensis ensiformis, R-Calliostoma aphelia, Nassarius sp. Sample 67-74-2 from 1' 3" to 2' 3" above base of unit. Sample 67-74-3 from 3' 8" to 4' 1" above base of unit (from one of the thin, sandy layers).	
Total thickness of Calvert Beach Member	13' 0"
Total thickness of Choptank Formation	35' 5"
Calvert Formation	
"Zone 15" Sample 67-74-1 from 2' 0" to 3' 0" above base of unit.	3' 9"
(Undifferentiated)	16' 6"
Total thickness of exposed Calvert Formation	20' 3"

Locality 67-75. Kenwood Beach.

Natural exposure in Calvert Cliffs along Chesapeake Bay at Kenwood Beach, Md. 0.4 mile southeast of Governor Run Road. Calvert Co., Md. 38° 29' 42" N. Lat.; 76° 30' 03" W. Long. Partial section description--upper Calvert and Calvert Beach Member of Choptank.

Unit	Thickness
Choptank Formation	
Drumcliff Member Undescribed and unmeasured.	
Calvert Beach Member	
3 Lithology: Dusky-olive, very muddy,	11' 0"

Unit		Thickness
	very fine sand. Lenses of light-gray, well-sorted, fine sand occur in large numbers in layers giving this unit a distinct bedded appearance. Lower contact slightly gradational. Upper contact slightly gradational but distinct. Fossils: Mostly fragments. Random distribution. Low faunal diversity. Faunal list: C-Turritella plebeia, N-Yoldia laevis, R-Ensis ensiformis, scaphopod. Sample 67-75-3 from 2' 6" to 3' 6" above base of unit. Sample 67-75-4 from 7' 6" to 8' 6" above base of unit.	
2	Lithology: Dark greenish-brown, muddy, fine sand. Rare mottling by dark brownish-green, very muddy, fine sand. No bedding laminations. Lower contact slightly gradational, irregular, and subtle. Upper contact slightly gradational. Fossils: Distinct increase in preserved fauna from unit 1. Well preserved. Low faunal diversity. Faunal list: C-Turritella plebeia, N-Lucinoma contracta, Diplodonta subvexa, R-Mercenaria sp. Sample 67-75-2 from 0' 3" to 1' 3" above base of unit.	4' 3"
	Total thickness of Calvert Beach Member	15' 3"
Calvert Formation "Zone 15"		
1	Lithology: Heterogeneous. Dark brown, very fine, muddy sand. Dark brownish-green, very muddy, very fine sand. Very pale orange, well-sorted, fine sand. The first two sediment types are irregularly mottled. The third sediment type is found in multi-walled burrows and in lense showing irregular bedding. Lower contact irregular and slightly gradational. Upper	3' 6"

Unit		Thickness
	contact slightly gradational, irregular, and subtle. Fossils: Rare pockets containing a few Turritella plebeia. Rare wood fragments. Sample 67-75-1 from 2' 0" to 3' 0" above base of unit.	
"Zone 14"		4' 0"
	Total thickness of exposed Calvert Formation	7' 6"

Locality 67-76. Hambrooks Bar.

Natural exposure in southern bank of Choptank River. 0.3 mile west of Hambrooks Bar. 1.0 mile northwest of Cambridge, Md. Dorchester Co., Md. 38° 35' 31" N. Lat.; 76° 05' 30" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated) Choptank Formation Conoy Member		
1	Lithology: Dusky-olive, muddy, fine sand. No inorganic sedimentary structures seen. Rare biogenic structures. Lower contact covered by beach. Upper contact distinct and nearly straight. Fossils: None seen. Sample 67-76-1 from 2' 0" to 3' 0" above base of unit.	4' 2"

Locality 67-77. Grubin Neck.

Natural exposure in low bluffs of western side of Grubin Neck along the Choptank River. 0.45 mile north northwest of tip of Howell Point. 3.0 miles northwest of Cambridge, Md. Talbot Co., Md. 38° 37' 01" N. Lat.; 76° 06' 50" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		4' 0"
(Unknown stratigraphic placement)		
2	Lithology: Light-gray, very muddy, very fine sand. No apparent sedimentary structures. Lower contact slightly gradational. Upper contact distinct and slightly undulating. Fossils: Few molds and casts of bivalves but do not appear to be Choptank. None identified. Spiral burrow. No sample.	2' 8"
Choptank Formation		
Conoy Member		
1	Lithology: Dark-gray, very muddy, very fine sand. Some parallel bedding. 2 to 3 inch beds. No biogenic structures seen. Lower contact covered by beach. Upper contact slightly gradational. Fossils: None seen. Sample 67-77-1 from entire interval.	1' 6"

Locality 67-78. State Hospital, Cambridge.

Natural exposure along the southern shore of Choptank River at State Hospital, Cambridge, Md. 0.9 mile southeast of Choptank River Bridge. Dorchester Co., Md. 38° 33' 48" N. Lat.; 76° 02' 57" W. Long.

Unit		Thickness
(Pleistocene, undifferentiated)		
Choptank Formation		
Conoy Member		
1	Lithology: Dusky-blue, very fine, muddy sand. No apparent inorganic sedimentary structures. Intensely burrowed with multi-walled, slime-lined burrows up to 1.5 inch diameter. Also some slime-lined, spiral burrows. Lower contact covered by beach. Upper contact distinct and fairly straight. Fossils: None seen. No sample.	5' 0"

Locality 67-79. South Boston Cliffs.

Natural exposure in low bluffs across Choptank River from Frazier Neck. Downstream and across small creek from Boston Cliffs Locality 66-12. 4.0 miles southeast of Easton, Md. Talbot Co., Md. 38° 43' 41" N. Lat.; 76° 01' 00" W. Long. Only units described are those which occur stratigraphically lower than those at locality 66-12.

Unit		Thickness
Choptank Formation Boston Cliffs Member (Remainder of Boston Cliffs section described at locality 66-12)		
3	Lithology: Moderate reddish-orange, muddy, fine sand. No apparent sedimentary structures. Contacts gradational. Fossils: Extremely prolific accumulation. Increased macrofossil bed. Many large, complete, bivalves. Random distribution. Faunal list: VC-Anadara staminea, C-Mercenaria sp., Dosinia acetabulum, Macrocallista marylandica, Crassatella marylandica, N-Anodontia anodonta, Lyropecten madisonius, Crassostrea carolinensis, Isognomon maxillata. Sample 67-79-3 from entire interval.	1' 3"
2	Lithology: Moderate reddish-brown, muddy, fine sand. No apparent sedimentary structures. Contacts gradational. Fossils: Prolific accumulation of shells. Gradational in size from unit 1 to larger sizes. Very hashy accumulation. Wear common. Fragmentation common. Random distribution. Low faunal diversity. High faunal dominance. Faunal list: VC-Crassostrea carolinensis, C-Crucibulum multilineatum, Caecum pattuxentium, N-Isognomon maxillata, F-Nucula sp., Columbella communis, Cadulus	1' 4"

Unit		Thickness
	newtonensis, R-Epitonium sayanum, Teinostoma greensboroensis. Sample 67-79-2 from entire interval.	
1	Lithology: Dusky-blue, muddy, fine sand. No apparent sedimentary structures. Lower contact covered by beach. Upper contact gradational. Fossils: Prolific accumulation of shells. Wear common. Fragmentation common. Very hashy accumulation. Random distribution. Low faunal diversity. High faunal dominance. Faunal list: VC-Crassostrea carolinensis, N-Isognomon maxillata. Sample 67-79-1 from 0' 2" to 0' 8" above base of unit.	0' 9"
	Total thickness of measured Boston Cliffs Member	3' 4"

Locality 67-80. Brick Wall Landing.

Natural exposure in eastern bank of Choptank River. 0.5 mile northeast of Brick Wall Landing. 3.0 miles north of Denton, Md. 2-3/4 miles southwest of Greensboro, Md. Caroline Co., Md. 38° 56' 11" N. Lat.; 76° 49' 45" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
?Calvert Beach Member		
1	Lithology: Dusky-blue, very muddy silt. No apparent sedimentary structures. Lower contact covered by river. Upper contact covered. Fossils: None seen. Sample 67-80-1 from 0' 6" to 1' 6" above base of unit.	2' 6"

Locality 67-81. South of Greensboro I.

Natural exposure in eastern bank of Choptank River. 3/4 mile south of Greensboro, Md. 0.2 mile upstream from locality 67-82. Caroline Co., Md. 38° 57' 49" N. Lat.; 75° 48' 43" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
?Calvert Beach Member		
1	Lithology: Thin, interbedded sediments. Beds of dark-brown, very muddy silt interbedded with light gray, well-sorted, fine sand. Beds slightly irregular but all thin. Beds range from 1/16 to 2 inches, with most less than 1 inch. No biogenic structures. Lower contact in the river. Upper contact covered. Fossils: None seen. Sample 67-81-1 from 1' 2" to 2' 3" above base of unit.	3' 7"

Locality 67-82. South of Greensboro II.

Natural exposure in western bank of Choptank River. 3/4 mile southwest of Greensboro, Md. Locality below Maryland Highway #480. Caroline Co., Md. 38° 57' 50" N. Lat.; 75° 48' 55" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
?Drumcliff Member		
2	Lithology: Moderate reddish-orange, muddy, fine sand. No apparent sedimentary structures. Lower contact slightly gradational. Upper contact covered. Fossils: Prolific accumulation but all leached out. Very difficult to identify any species from the cross sections of molds. Common Lyropecten madisonius only fossil identified. No sample.	1' 6"

Unit		Thickness
?Calvert Beach Member		
1	Lithology: Thin, interbedded sediments. Beds of dark-brown, very muddy silt interbedded with light-gray, well-sorted, fine sand. Beds slightly irregular, but all thin. Beds range from 1/16 to 2 inches, with most less than 1 inch. Small scour and fill structures with largest being 7.5 inches long and 1.5 inch deep. One single-set, ripple-drift structure seen. Rare low-angle, cross-laminations with all less than 6 inches long. No apparent biogenic structures. Lower contact in river. Upper contact slightly gradational. Fossils: None seen. No sample.	5' 0"
	Total thickness of exposed Choptank Formation	6' 6"

Locality 67-83. Lyford Landing.

Natural exposure in western bank of Choptank River. 0.5 mile upstream from Lyford Landing. 4-1/4 miles west of Hobbs, Md. 3.0 miles southwest of Denton, Md. Caroline Co., Md. 38° 50' 58" N. Lat.; 75° 51' 43" W. Long.

Unit		Thickness
(Covered)		
Choptank Formation		
?St. Leonard Member		
1	Lithology: Dusky-blue, very muddy silt. No apparent sedimentary structures. Lower contact under river level. Upper contact covered. Fossils: Very rare. Leached out. One mold of Yoldia laevis. Sample 67-83-1 from 0' 6" to 1' 6" above base of unit.	8' 6"

APPENDIX II

Foraminifera and Ostracoda in Choptank Samples

This section contains lists of the microfauna found in certain samples collected from the Choptank Formation. For more complete information about each of the localities, the reader should refer to Appendix I.

The notations with each sample signify the following: n_b = number of benthonic Foraminifera, $\%_a$ = percentage of agglutinated specimens in the total benthonic foraminiferal assemblage, $\%_i$ = percentage of calcareous, imperforate specimens in the total benthonic foraminiferal assemblage, $\%_p$ = percentage of planktonic Foraminifera in the total foraminiferal assemblage, n_o = number of ostracodes, and x = specimens present but percentage not computed. The number to the left of each species corresponds to the percentage occurrence of that species in the benthonic foraminiferal assemblage or in the ostracode assemblage. Where the species constituted less than 1.0 percent of the total, the designation "t" signifies trace proportions.

Sample 66-4-6.-0.5 mile north of Calvert Beach, Maryland. Lower St. Leonard Member.

(No specimens present.)

Sample 66-5-10.-0.8 mile north of Calvert Beach, Maryland. Upper Drumcliff Member.

n_b = 5 $\%_a$ = o

n_o = 10 $\%_i$ = 0

$\%_p$ = 38

Foraminifera	Ostracoda
40 Lagena substriata	40 Pterygocythereis americana
20 L. laevis	20 Cushmanidea ulrichi
20 Pseudopolymorphina dumblei	20 Bensonocythere whitei
20 P. striata	10 Hulingsina ashermani
	10 Muellerina lienenklausi

Sample 66-5-11.-0.8 mile north of Calvert Beach, Maryland. Lower St. Leonard Member.

(No specimens present.)

Sample 66-5-25.-0.8 mile north of Calvert Beach, Maryland. Central Boston Cliffs Member.

$n_b = 68$ $\quad \%_a = 6$

$n_o = 76$ $\quad \%_i = 0$

$\%_p = 1$

Foraminifera	Ostracoda
31 Buccella mansfieldi	51 Hulingsina ashermani
31 Cibicides lobatulus	17 Cytheretta burnsi
22 Buccella depressa	8 Cushmanidea ulrichi
4 Textularia gramen	7 Bensonocythere whitei
3 Pseudopolymorphina dumblei	7 Murrayina martini
3 Discorbis candeiana	5 M. howei
1 Nonion marylandicum	1 Cushmanidea seminuda
1 N. pizarrense	1 Cytheropteron sp.
1 Valvulineria floridana	1 Echinocythereis clarkana
	1 Loxoconcha granulata

Sample 66-5-27.-0.8 mile north of Calvert Beach, Maryland. Central Boston Cliffs Member.

$n_b = 165$ $\quad \%_a = 2$

$n_o = 129$ $\quad \%_i = 0$

$\%_p = 0$

Foraminifera	Ostracoda
49 Cibicides lobatulus	35 Cushmanidea ulrichi
22 Buccella depressa	12 Hulingsina ashermani
19 B. mansfieldi	11 Muellerina lienenklausi
2 Nonion marylandicum	11 Cytheretta burnsi
2 N. pizarrense	10 Murrayina martini

Foraminifera (continued)
2 Valvulineria floridana
2 Textularia gramen
t Pseudopolymorphina dumblei
t Discorbis floridana

Ostracoda (continued)
3 Campylocythere laevissima
3 Pokornyella punctistriata
2 Cytheridea subovalis
2 Cytheromorpha warneri
2 Eucythere gibba
2 Loxoconcha granulata
2 L. reticularis
2 Tetracytherura shattucki
t Cytheropteron sp.
t Semicytherura coryelli
t Bensonocythere whitei

Sample 66-5-28.-0.8 mile north of Calvert Beach, Maryland. Central Boston Cliffs Member.

n_b = 25
n_o = 0

$\%_a$ = 0
$\%_i$ = 0
$\%_p$ = 0

Foraminifera
84 Buccella mansfieldi
8 Cibicides lobatulus
4 Discorbis floridana
4 Nonion medio-costatum

Sample 66-5-33.-0.8 mile north of Calvert Beach, Maryland. Lower Conoy Member.

(No specimens present.)

Sample 66-6-7.-Matoaka Cottages, Maryland. Central Drumcliff Member.

n_b = 4152
n_o = 1065

$\%_a$ = 19
$\%_i$ = 5
$\%_p$ = t

Foraminifera
45 Valvulineria floridana
13 Cibicides lobatulus
8 Textularia consecta
6 T. gramen

Ostracoda
19 Loxconcha granulata
16 Cytheretta burnsi
15 Cushmanidea ulrichi
11 Hulingsina ashermani

Foraminifera (continued)
5 Quinqueloculina seminula
3 Spiroplectammina exilis
2 Buccella depressa
2 Nonion pizarrense
2 Pseudopolymorphina striata
2 Rotalia bassleri
2 Virgulina miocenica
1 Buccella mansfieldi
1 Nonion marylandicum
1 N. medio-costatum
1 Textularia candeiana
t Bulimina elongata
t Entosolenia lucida
t Hanzawaia concentrica
t Lagena substriata
t L. tenuis
t Massilina glutinosa
t Robulus americanus
t Textularia ultima-inflata
t Uvigerina subperegrina
t Sigmormorphina concava
t Discorbis floridana
t Lagena sp. L. A.
t Massilina sp. M. A.
t Globulina inaequalis
t Massilina mansfieldi
t M. quadrans
t Quinqueloculina contorta
t Cibicides floridana
t Sigmomorphina williamsoni
t Buliminella subfusiformis
t Marginulina sp.
x Bolivina paula
x Buliminella elegantissima

Ostracoda (continued)
10 Muellerina lienenklausi
5 Bensonocythere whitei
4 Cytheropteron sp.
3 Propontocypris howei
2 Actinocythereis exanthemata
2 Cytheridea subovalis
2 Cytheromorpha warneri
2 Semicytherura coryelli
2 Loxoconcha reticularis
2 Tetrachtherura shattucki
2 Pterygocythereis americana
1 Murrayina martini
t Echinocythereis clarkana
t Eucythere declivis
t E. gibba
t Haplocytheridea bassleri
t Henryhowella evax
t Pokornyella punctistriata
t Murrayina howei
t Neocytheridels fasciata
t Paradoxostoma robusta

Sample 66-6-10.-Matoaka Cottages, Maryland. Upper Drumcliff Member.

$n_b = 83$ $\%_a = 14$

$n_o = 14$ $\%_i = 0$

$\%_p = 0$

Foraminifera
36 Valvulineria floridana
24 Cibicides lobatulus
13 Pseudopolymorphina striata
10 Textularia consecta

Ostracoda
36 Hulingsina ashermani
14 Cytheretta burnsi
7 Actinocythereis exanthemata

Foraminifera (continued)
5 Spiroplectammina exilis
4 Buccella mansfieldi
4 Rotalia bassleri
1 Bulimina elongata
1 Lagena laevis
1 Nonion marylandicum
1 Virgulina miocenica

Ostracoda (continued)
7 Loxoconcha granulata
7 Propontocypris howei
7 Pterygocythereis americana
7 Bensonocythere whitei
7 Muellerina lienenklausi

Sample 66-6-14.-Matoaka Cottages, Maryland. Lower St. Leonard Member.

n_b = 1190
n_o = 3531

$\%_a$ = 17
$\%_i$ = 0
$\%_p$ = 0

Foraminifera
53 Buccella mansfieldi
9 B. depressa
9 Textularia gramen
5 Valvulineria floridana
5 Discorbis floridana
4 Spiroplectammina aff. S. exilis
4 Cibicides lobatulus
3 Massilina glutinosa
2 Bulimina elongata
1 Miliammina fusca
t Hanzawaia concentrica

Ostracoda
23 Actinocythereis aff. A. mundorffi
20 Cushmanidea ulrichi
18 Cytheridea subovalis
8 Loxoconcha granulata
7 Cytheretta burnsi
5 Cytheromorpha warneri
3 Pokornyella punctistriata
3 Murrayina martini
2 Actinocythereis exanthemata
2 Cushmanidea agricola
2 Loxoconcha reticularis
1 Semicytherura coryelli
1 Haplocytheridea bassleri
1 Murrayina howei
1 Tetracytherura shattucki
t Henryhowella evax
t Hulingsina ashermani
t Muellerina lienenklausi
t Pterygocythereis americana
t Bensonocythere whitei
t Paradoxostoma robusta

Sample 66-8-3.-South of Grover Creek, Maryland. Central Boston Cliffs.

n_b = 3046
n_o = 1432

$\%_a$ = 16
$\%_i$ = t
$\%_p$ = t

Foraminifera		Ostracoda	
42	Buccella mansfieldi	37	Cushmanidea ulrichi
18	Cibicides lobatulus	15	Cytheretta burnsi
12	Buccella depressa	12	Hulingsina ashermani
7	Textularia consecta	8	Muellerina linenklausi
7	T. gramen	6	Cytheridea subovalis
4	Nonion marylandicum	5	Loxoconcha granulata
4	Valvulineria floridana	4	Murrayina martini
3	Textularia ultima-inflata	2	Pokornyella punctistriata
1	Pseudopolymorphina dumblei	1	Campylocythere laevissima
1	Discorbis floridana	1	Haplocytheridea bassleri
t	Bulimina elongata	1	Murrayina howei
t	Hanzawaia concentrica	1	Tetracytherura shattucki
t	Nonion medio-costatum	1	Bensonocythere whitei
t	N. pizarrense	t	Actinocythereis exanthemata
t	Pseudopolymorphina striata	t	Cytheromorpha warneri
t	Quinqueloculina seminula	t	Cytheropteron sp.
t	Textularia candeiana	t	Semicytherura coryelli
x	Bolivina paula"	t	Echinocythereis clarkana
x	Buliminella elegantissima	t	Eucythere gibba
		t	Propontocypris howei
		t	Pterygocythereis americana

Sample 66-1-5.-1/4 mile south of Camp Conoy, Maryland. Central St.Leonard Member.

(No specimens present.)

Sample 66-11-7.-1/4 mile south of Camp Conoy,.Maryland. Upper St. Leonard Member.

(No specimens present).

Sample 66-12-4.-Boston Cliffs, Maryland. Central Boston Cliffs Member.

n_b = 9672 $\quad$ $\%_a$ = 25

n_o = 1860 $\quad$ $\%_i$ = 0

$\%_p$ = 0

Foraminifera		Ostracoda	
41	Cibicides lobatulus	33	Cushmanidea ulrichi
22	Textularia gramen	14	Pokornyella punctistriata

Foraminifer (continued)
17 Buccella mansfieldi
8 Valvulineria floridana
7 Buccella depressa
1 Textularia consecta
t Nonion marylandicum
t N. medio-costatum
t N. pizarrense
t Pseudopolymorphina dumblei
t Textularia candeiana
t T. ultima-inflata
t Discorbis floridana
t Sigmomorphina concava

Ostracoda (continued)
14 Muellerina lienenklausi
11 Cytheretta burnsi
9 Hulingsina ashermani
6 Murrayina martini
3 M. howei
2 Cushmanidea seminuda
2 Bensonocythere whitei
1 Cytheromorpha warneri
t Actinocythereis exanthemata
t Campylocythere laevissima
t Cytheridea subovalis
t Cytheropteron sp.
t Haplochteridea subovata
t Henryhowella evax
t Loxoconcha granulata
t Pterygocythereis americana
t Propontocypris howei

Sample 66-14-7.-Drumcliff, Maryland. Central Drumcliff Member.

n_b = 114
n_o = 51

$\%_a$ = 5
$\%_i$ = t
$\%_p$ = 2

Foraminifera
39 Cibicides lobatulus
17 Valvulineria floridana
15 Pseudopolymorphina striata
8 P. dumblei
3 Buccella depressa
3 Nonion pizarrense
3 Spiroplectammina exilis
3 Textularia consecta
2 Buccella mansfieldi
2 Lagena substriata
2 Nonion marylandicum
2 Virgulina miocenica
t Bulimina elongata
t Hanzawaia concentrica
t Lagena tenuis
t Quinqueloculina seminula
t Discorbis floridana

Ostracoda
31 Hulingsina ashermani
27 Cytheretta burnsi
16 Cushmanidea ulrichi
8 Loxoconcha granulata
6 Murrayina howei
4 Cytheropteron sp.
2 Actinocythereis exanthemata
2 Cushmanidea seminuda
2 Tetracytherura shattucki
2 Bensonocythere whitei

Sample 66-17-1.-North of Cole Creek, Maryland. Lower

Drumcliff Member.

n_b = 6375
n_o = 185

$\%_a$ = 2
$\%_i$ = 0
$\%_p$ = 0

Foraminifera	Ostracoda
94 Cibicides lobatulus	32 Pokornyella punctistriata
2 Valvulineria floridana	18 Hulingsina ashermani
2 Textularia gramen	14 Cytheromorpha warneri
t Hanzawaia concentrica	8 Cushmanidea ulrichi
t Nonion medio-costatum	6 Murrayina martini
t Discorbis floridana	5 Muellerina lienenklausi
t Textularia consecta	4 Loxoconcha granulata
t Nonion pizarrense	2 Cytheretta burnsi
t Pseudopolymorphina striata	2 Semicytherura coryelli
t Buccella depressa	2 Bensonocythere whitei
t B. mansfieldi	2 Paracypris choctawhatcheensis
t Lagena clavata	1 Actinocythereis exanthemata
t L. substriata	1 Tetracytherura shattucki
t Nonion marylandicum	t Cytheretta ulrichi
t Pseudopolymorphina dumblei	t Cytheropteron sp.
t Bulimina elongata	
t Spiroplectammina exilis	
t Uvigerina subperegrina	
t Virgulina miocenica	
t Robulus americana	
t Textularia candeiana	

Sample 66-18-1.-Drumcliff, Maryland. Central Drumcliff Member.

n_b = 374
n_o = 87

$\%_a$ = 11
$\%_i$ = 6
$\%_p$ = 0

Foraminifera	Ostracoda
60 Cibicides lobatulus	24 Cytheretta burnsi
8 Valvulineria floridana	17 Loxoconcha granulata
8 Hanzawaia concentrica	16 Cushmanidea ulrichi
6 Quinqueloculina seminula	13 Hulingsina ashermani
6 Spiroplectammina exilis	8 Murrayina martini
3 Textularia consecta	7 Semicytherura coryelli
2 Buccella depressa	6 Loxoconcha reticularis
2 Nonion marylandicum	3 Tetracytherura shattucki
2 Pseudopolymorphina striata	3 Bensonocythere whitei
2 Discorbis floridana	1 Cushmanidea seminuda

Foraminifera (continued)
1 Textularia candeiana
t Bulimina elongata
t Pseudopolymorphina dumblei
t Textularia gramen
t T. ultima-inflata

Ostracoda (continued)
1 Eucythere declivis

Sample 66-20-1.-Sotterly, Maryland. Lower Drumcliff Member.

n_b = 7767
n_o = 905

$\%_a$ = 2
$\%_i$ = t
$\%_p$ = t

Foraminifera
93 Cibicides lobatulus
2 Textularia gramen
2 Valvulineria floridana
t Uvigerina subperegrina
t Bulimina elongata
t Nonion medio-costatum
t N. pizarrense
t Quinqueloculina seminula
t Hanzawaia concentrica
t Lagena substriata
t L. clavata
t L. laevis
t Rotalia bassleri
t Nonion marylandicum
t Textularia consecta
t Virgulina miocenica
t Nonionella auris
t Spiroplectammina exilis
t Dentalina communis

Ostracoda
29 Hulingsina ashermani
14 Cytheromorpha warneri
12 Pokornyella punctistriata
8 Muellerina lienenklausi
7 Semicytherura coryelli
6 Loxoconcha granulata
6 Cushmanidea ulrichi
3 Cytheridea subovalis
2 Cytheretta burnsi
2 Campylocythere laevissima
2 Marrayina martini
2 Bensonocythere whitei
1 Eucythere declivis
t Actinocythereis exanthemata
t Aurila laevicula
t Haplocytheridea bassleri
t Loxoconcha reticularis
t Bythocythere bifurcata
t Paracypris choctawhatcheenis
t Tetracytherura shattucki
t Paradoxostoma robusta
t Pterygocythereis americana
t Propontocypris howei
t P. sp. P. A

Sample 66-21-4.-Camp Conoy, Maryland. Upper Conoy Member.

(No specimens present.)

Sample 66-23-1. Point of Rocks, Maryland. Upper St.

Leonard Member.

n_b = 29
n_o = 28

$\%_a$ = 3
$\%_i$ = 0
$\%_p$ = 0

Foraminifera
28 Buccella mansfieldi
24 Cibicides lobatulus
21 Valvulineria floridana
10 Nonion marylandicum
7 Lagena substriata
3 Buccella depressa
3 Nonion medio-costatum
3 Textularia gramen

Ostracoda
32 Hulingsina ashermani
29 Cushmanidea ulrichi
7 Pokornyella punctistriata
7 Loxoconcha granulata
4 Actinocythereis exanthemata
4 Cytheridea subovalis
4 Cytheretta burnsi
4 Murrayina martini
4 Tetracytherura shattucki
4 Pterygocythereis americana
4 Bensonocythere whitei

Sample 66-23-4.-Point of Rocks, Maryland. Lower Boston Cliffs Member.

n_b = 133
n_o = 58

$\%_a$ = 4
$\%_i$ = 0
$\%_p$ = 1

Foraminifera
31 Buccella depressa
26 B. mansfieldi
18 Cibicides lobatulus
8 Valvulineria floridana
5 Nonion medio-costatum
2 Hanzawaia concentrica
2 Lagena clavata
2 L. substriata
2 Nonion pizarrense
2 Textularia consecta
2 T. gramen
t Bulimina elongata
t Pseudopolymorphina dumblei
t Virgulina miocenica

Ostracoda
47 Cushmanidea ulrichi
12 Loxoconcha reticularis
9 Hulingsina ashermani
8 Muellerina lienenklausi
7 Cytheretta burnsi
5 Murrayina martini
4 Pokornyella punctistriata
3 Cytheromorpha warneri
3 Haplocytheridea bassleri
3 Murrayina howei
1 Semicytherura coryelli
1 Echinocythereis clarkana
1 Loxoconcha granulata
1 Bensonocythere whitei

Sample 66-23-9.-Point of Rocks, Maryland. Upper Boston Cliffs Member.

n_b = 1131
n_o = 484

$\%_a$ = 7
$\%_i$ = 1
$\%_p$ = 9

Foraminifera
42 Buccella depressa
24 Cibicides lobatulus
20 Buccella mansfieldi
6 Textularia gramen
2 Valvulineria floridana
1 Hanzawaia concentrica
1 Nonion marylandicum
1 Quinqueloculina seminula
1 Textularia consecta
t Massilina glutinosa
t Nonion medio-costatum
t N. pizarrense
t Pseudopolymorphina dumblei
t Robulus americanus
t Textularia ultima-inflata
t Discorbis floridana

Ostracoda
26 Cushmanidea ulrichi
26 Hulingsina ashermani
24 Cytheretta burnsi
4 Muellerina lienenklausi
4 Murrayina martini
3 Pokornyella punctistriata
3 Haplocytheridea basslerri
3 Loxoconcha reticularis
1 L. granulata
1 Bensonocythere whitei
t Actinocythereis exanthemata
t Cushmanidea seminuda
t C. agricola
t Cytheromorpha warneri
t Cytheropteron sp.
t Semicytherura coryelli
t S. forulata
t Murrayina howei
t Tetracytherura shattucki
t Pterygocythereis americana

Sample 66-23-13.-Point of Rocks, Maryland. Lower Conoy Member.

(No specimens present.)

Sample 66-24-7.-North Point of Rocks, Maryland. Lower Boston Cliffs Member.

n_b = 11
n_o = 19

$\%_a$ = 9
$\%_i$ = 0
$\%_p$ = 8

Foraminifera
36 Buccella depressa
18 Nonion marylandicum
18 N. medio-costatum
9 Pseudopolymorphina dumblei
9 Textularia gramen
9 Discorbis floridana

Ostracoda
42 Cushmanidea ulrichi
16 Murrayina martini
11 Tetracytherura shattucki
5 Cytheretta burnsi
5 Cytheropteron sp.
5 Haplocytheridea bassleri
5 Pokornyella punctistriata
5 Loxoconcha granulata
5 L. reticularis

Sample 66-24-13.-North Point of Rocks. Upper Boston Cliffs Member.

n_b = 19
n_o = 173

$\%_a$ = 21
$\%_i$ = 0
$\%_p$ = 0

Foraminifera
42 Cibicides lobatulus
16 Textularia gramen
11 Nonion marylandicum
11 Virgulina miocenica
5 Buccella depressa
5 B. mansfieldi
5 Hanzawaia concentrica
5 Textularia consecta

Ostracoda
28 Hulingsina ashermani
17 Cushmanidea ulrichi
11 Haplocytheridea bassleri
10 Semicytherura coryelli
9 Cytheretta burnsi
6 Loxoconcha granulata
6 Muellerina lienenklausi
4 Tetracytherura shattucki
3 Semicytherura forulata
1 Campylocythere laevissima
1 Cytheromorpha warneri
1 Pokornyella punctistriata
t Cytheropteron sp.
t Echinocythereis clarkana
t Eucythere gibba
t Murrayina martini

Sample 66-24-16.-North Point of Rocks. Lower Conoy Member.

(No specimens present.)

Sample 66-25-4.- Flag Ponds II, Maryland. Central St. Leonard Member.

n_b = 1382
n_o = 150

$\%_a$ = 2
$\%_i$ = 0
$\%_p$ = t

Foraminifera
57 Buccella mansfieldi
29 Valvulineria floridana
5 Cibicides lobatulus
4 Discorbis floridana
1 Hanzawaia concentrica
1 Nonion medio-costatum

Ostracoda
46 Haplocytheridea bassleri
29 Cushmanidea ulrichi
7 Hulingsina ashermani
4 Pokornyella punctistriata
3 Cushmanidea seminuda
3 Loxoconcha reticularis

Foraminifera (continued)
1 Textularia gramen
t Buccella depressa
t Bulimina elongata
t Lagena acuticostata
t L. substriata
t Nonion marylandicum
t Pseudopolymorphina striata
t Textularia ultima-inflata
t Uvigerina subperegrina
t Globulina inaequalis
t Sigmomorphina concava
t Elphidium advenum

Ostracoda (continued)
2 Muellerina lienenklausi
1 Cytheretta burnsi
1 Semicytherura coryelli
1 Murrayina martini
1 Tetracytherura shattucki
t Pterygocythereis americana

Sample 66-25-11.-Flag Ponds II, Maryland. Central Boston Cliffs Member.

$n_b = 68$
$n_o = 76$

$\%_a = 15$
$\%_i = 1$
$\%_p = 1$

Foraminifera
37 Cibicides lobatulus
32 Buccella depressa
10 Textularia gramen
6 Buccella mansfieldi
4 Textularia consecta
3 Nonion marylandicum
1 Hanzawaia concentrica
1 Quinqueloculina seminula
1 Valvulineria floridana
1 Virgulina miocenica
1 Elphidium poeyanum

Ostracoda
28 Cushmanidea ulrichi
24 Hulingsina ashermani
21 Cytheretta burnsi
5 Loxoconcha reticularis
4 Murrayina martini
4 Muellerina lienenklausi
3 Haplocytheridea bassleri
3 Loxoconcha granulata
3 Tetracytherura shattucki
1 Semicytherura coryelli
1 Pokornyella punctistriata
1 Murrayina howei
1 Pterygocythereis americana
1 Bensonocythere whitei

Sample 66-25-12.-Flag Ponds II, Maryland. Central Boston Cliffs Member.

$n_b = 130$
$n_o = 141$

$\%_a = 16$
$\%_i = 4$
$\%_p = 0$

Foraminifera
31 Cibicides lobatula
21 Buccella mansfieldi
16 B. depressa
10 Textularia gramen
4 Nonion marylandicum
4 Quinqueloculina seminula
3 Hanzawaia concentrica
3 Textularia consecta
3 T. ultima-inflata
2 Nonion pizarrense
2 Pseudopolymorphina dumblei
2 Valvulineria floridana

Ostracoda
24 Cushmanidea ulrichi
24 Cytheretta burnsi
20 Hulingsina ashermani
6 Haplocytheridea bassleri
5 Loxoconcha granulata
4 Pokornyella punctistriata
4 Murrayina martini
4 Muellerina lienenklausi
2 Tetracytherura shattucki
1 Semicytherura coryelli
1 Bensonocythere whitei
t Campylocythere laevissima
t Cushmanidea seminuda
t Echinocythereis clarkana
t Loxoconcha reticularis

Sample 66-25-15.-Flag Ponds II, Maryland. Upper Boston Cliffs Member.

n_b = 47
n_o = 397

$\%_a$ = 11
$\%_i$ = 0
$\%_p$ = 0

Foraminifera
45 Cibicides lobatulus
17 Buccella mansfieldi
15 B. depressa
11 Textularia gramen
2 Hanzawaia concentrica
2 Lagena substriata
2 Pseudopolymorphina dumblei
2 Valvulineria floridana
2 Virgulina miocenica
2 Cibicides floridanus

Ostracoda
42 Haplocytheridea bassleri
19 Cytheretta burnsi
15 Hulingsina ashermani
6 Cushmanidea ulrichi
4 Semicytherura coryelli
4 Loxoconcha granulata
2 Campylocythere laevissima
2 Pokornyella punctistriata
2 Muellerina lienenklausi
1 Cytheromorpha warneri
1 Tetracytherura shattucki
t Echinocythereis clarkana
t Loxoconcha reticularis
t Murrayina howei
t M. martini
t Pterygocythereis americana
t Bensonocythere whitei

Sample 66-25-21.-Flag Ponds II, Maryland. Central Conoy Member.

n_b = 635
n_o = 669

$\%_a$ = 5
$\%_i$ = 0
$\%_p$ = t

Foraminifera	Ostracoda
40 Nonion medio-costatum	46 Pterygocythereis americana
22 Buccella depressa	16 Cytheretta burnsi
10 Lagena laevis	11 Murrayina martini
8 Nonion pizarrense	10 Cushmanidea ulrichi
8 Buccella mansfieldi	3 Cytheridea subovalis
3 Cibicides lobatulus	3 Cushmanidea agricola
3 Textularia candeiana	3 Murrayina howei
2 Vavulineria floridana	2 Cytheretta ulrichi
t Bulimina elongata	2 Cytheropteron sp.
t Hanzawaia concentrica	1 Cytheromorpha warneri
t Lagena tenuis	1 Echinocythereis clarkana
t Massilina glutinosa	t Henryhowella evax
t Miliammina fusca	t Loxoconcha granulata
t Nonionella auris	t L. reticularis
t Pseudopolymorphina dumblei	t Actinocythereis aff. A. gomillionensis
t Rotalia bassleri	
t Textularia consecta	t Bensonocythere whitei
t T. gramen	

Sample 66-25-23.-Flag Ponds II, Maryland. Lower St. Marys Formation.

n_b = 1255
n_o = 676

$\%_a$ = 3
$\%_i$ = 0
$\%_p$ = 0

Foraminifera	Ostracoda
39 Cibicides lobatulus	21 Actinocythereis exanthemata
21 Nonion pizarrense	20 Cytheretta burnsi
18 Buccella mansfieldi	15 Murrayina martini
12 Nonion medio-costatum	9 M. howei
3 Bulimina elongata	9 Cytheretta ulrichi
3 Discorbis floridana	5 Loxoconcha reticularis
2 Miliammina fusca	5 Pterygocythereis americana
1 Textularia candeiana	4 Cytheridea subovalis
1 Valvulineria floridana	3 Cushmanidea ulrichi
t Hanzawaia concentrica	3 Loxoconcha granulata
t Textularia gramen	2 Cytheromorpha warneri
	2 Henryhowella evax
	t Cytheropteron sp.
	t Echinocythereis clarkana
	t Muellerina lienenklausi

Sample 66-25-27.-Flag Ponds II, Maryland. Lower St. Marys Formation.

n_b = 513
n_o = 774

$\%_a$ = t
$\%_i$ = 0
$\%_p$ = t

Foraminifera
47 Buccella mansfieldi
27 Cibicides lobatulus
20 Buccella depressa
3 Hanzawaia concentrica
t Lagena substriata
t Rotalia bassleri
t Textulari gramen
t Valvulineria floridana
t Discorbis floridana

Ostracoda
40 Cushmanidea agricola
12 Cytheridea subovalis
12 Murrayina martini
11 Cushmanidea ulrichi
11 Cytheretta burnsi
4 Murrayina howei
4 Pterygocythereis americana
2 Cytheromorpha warneri
t Actinocythereis exanthemata
t Cytheropteron sp.
t Semicytherura coryelli
t Echinocythereis clarkana
t Haplocytheridea bassleri
t Loxoconcha granulata
t Tetracytherura shattucki

Sample 66-25-28.-Flag Ponds II, Maryland. Upper Drumcliff Member.

n_b = 3255
n_o = 2147

$\%_a$ = 9
$\%_i$ = t
$\%_p$ = t

Foraminifera
52 Buccella mansfieldi
14 Cibicides lobatulus
10 Valvulineria floridana
9 Textularia gramen
8 Buccella depressa
3 Hazawaia concentrica
3 Discorbis floridana
1 Rotalia bassleri
t Bulimina elongata
t Nonion marylandicum
t Pseudopolymorphina dumblei
t Quinqueloculina seminula
t Spiroplectammina exilis
t Lagena sp. L. A
t Elphidium poeyanum

Ostracoda
25 Haplocytheridea bassleri
22 Cushmanidea ulrichi
12 Pokornyella punctistriata
11 Cytheromorpha warneri
7 Hulingsina ashermani
5 Loxoconcha reticularis
3 Semicytherura coryelli
3 Paracytheridea shattucki
2 Cytheretta burnsi
2 Loxoconcha granulata
2 Bensonocythere whitei
1 Campylocythere laevissima
1 Murrayina martini
t Actinocythereis exanthemata
t Aurila laevicula
t Cytheridea subovalis
t Cushmanidea agricola

Ostracoda (continued)
t Henryhowella evax
t Muellerina lienenklausi
t Murrayina howei
t Neocytherideis fasciata
t Pterygocythereis americana

Sample 66-26-2.-South Point of Rocks, Maryland. Lower Boston Cliffs Member.

(No specimens present.)

Sample 66-26-5.-South Point of Rocks, Maryland. Central Boston Cliffs Member.

n_b = 2590
n_o = 912

$\%_a$ = 9
$\%_i$ = t
$\%_p$ = t

Foraminifera
42 Buccella mansfieldi
31 Cibicides lobatulus
7 Textularia gramen
5 Buccella depressa
5 Valvulineria floridana
5 Nonion marylandicum
1 Pseudopolymorphina dumblei
t Bulimina elongata
t Entosolenia lucida
t Nonion medio-costatum
t N. pizarrense
t Pseudopolymorphina striata
t Quinqueloculina seminula
t Textularia consecta
t T. ultima-inflata
t Virgulina miocenica
t Sigmomorphina concava
x Bolivina paula
x Buliminella elegantissima

Ostracoda
40 Cushmanidea ulrichi
14 Cytheretta burnsi
13 Hulingsina ashermani
8 Muellerina lienenklausi
4 Murrayina martini
4 Loxoconcha reticularis
3 Cytheridea subovalis
3 Pokornyella punctistriata
2 Campylocythere laevissima
2 Loxoconcha granulata
2 Murrayina howei
2 Bensonocythere whitei
1 Cytheromorpha warneri
t Cytheropteron sp.
t Semicytherura coryelli
t Echinocythereis clarkana
t Eucythere gibba
t Haplocytheridea bassleri
t Tetracytherura shattucki
t Pterygocythereis americana

Sample 66-26-7.-South Point of Rocks, Maryland. Central Boston Cliffs Member.

n_b = 707
n_o = 315

$\%_a$ = 7
$\%_i$ = t
$\%_p$ = 0

Foraminifera	Ostracoda
35 Buccella mansfieldi	39 Cushmanidea ulrichi
28 Cibicides lobatulus	15 Cytheretta burnsi
11 Nonion marylandicum	14 Loxoconcha reticularis
10 Buccella depressa	9 Hulingsina ashermani
7 Textularia gramen	6 Murrayina martini
3 Entosolenia lucida	3 M. howei
1 Nonion pizarrense	2 Semicytherura coryelli
t N. medio-costatum	2 Echinocythereis clarkana
t Bolivina paula	2 Haplocytheridea bassleri
t Buliminella elegantissima	2 Bensonocythere whitei
t Bulimina elongata	2 Muellerina lienenklausi
t Pseudopolymorphina dumblei	t Cushmanidea seminuda
t P. striata	t Pokornyella punctistriata
t Quinqueloculina seminula	t Loxoconcha granulata
t Textularia consecta	t Tetracytherura shattucki
t Valvulineria floridana	t Propontocypris howei
t Virgulina miocenica	t Pterygocythereis americana
t Discorbis floridana	

Sample 66-26-15.-South Point of Rocks, Maryland.

Central Conoy Member.

(No specimens present.)

Sample 66-29-2.-Cuckold Creek III, Maryland. Central St. Leonard Member.

(No specimens present.)

Sample 66-34-2.-Pawpaw Point II, Maryland. Lower Drumcliff Member.

n_b = 14,612
n_o = 982

$\%_a$ = 19
$\%_i$ = t
$\%_p$ = t

Foraminifera	Ostracoda
31 Cibicides lobatulus	18 Cushmanidea ulrichi
19 Valvulineria floridana	12 Cytheridea subovalis
12 Textularia consecta	11 Murrayina martini
7 Buccella mansfieldi	10 Hulingsina ashermani
6 Spiroplectammina exilis	8 Cytheretta burnsi
5 Buccella depressa	7 Loxoconcha granulata
4 Hanzawaia concentrica	6 Cytheretta ulrichi
3 Nonion marylandicum	4 Muellerina lienenklausi
3 N. pizarrense	4 Murrayina howei
3 Virgulina miocenica	3 Cytheromorpha warneri

Foraminifera (continued)
2 Nonion medio-costatum
1 Bulimina elongata
t Bolivina paula
t Buliminella elegantissima
t Lagena acuticostata
t L. clavata
t L. substriata
t Nonionella auris
t Pseudopolymorphina dumblei
t P. striata
t Quinqueloculina seminula
t Robulus americanus
t Textularia candeiana
t T. gramen
t Uvigerina subperegrina
t Discorbis floridana
x Entosolenia lucida
x Lagena sp. L. A

Ostracoda (continued)
3 Echinocythereis clarkana
3 Bensonocythere whitei
2 Actinocythereis exanthemata
2 Cytheropteron sp.
2 Semicytherura coryelli
2 Pterygocythereis americana
1 Cushmanidea agricola
t C. seminuda
t Henryhowella evax
t Propontocypris howei
t Cytherois fischeri

Sample 66-34-4.-Pawpaw Point II, Maryland. Central Drumcliff Member.

n_b = 7959
n_o = 842

$\%_a$ = 14
$\%_i$ = 0
$\%_p$ = t

Foraminifera
21 Valvulineria floridana
18 Buccella mansfieldi
17 Cibicides lobatulus
10 Buccella depressa
7 Textularia consecta
6 Spiroplectammina exilis
6 Nonion marylandicum
3 N. medio-costatum
3 N. pizarrense
3 Virgulina miocenica
t Bolivina paula
t Bulimina elongata
t Epistominella pontoni
t Entosolenia lucida
t Hanzawaia concentrica
t Lagena clavata
t L. laevis
t L. substriata
t Pseudopolymorphina dumblei
t P. striata
t Rotalia bassleri

Ostracoda
33 Cushmanidea ulrichi
16 Murrayina martini
9 Hulingsina ashermani
7 Cytheridea subovalis
6 Cytheretta burnsi
4 Muellerina lienenklausi
3 Cushmanidea seminuda
3 Loxoconcha granulata
3 Murrayina howei
2 Actinocythereis exanthemata
2 Cushmanidea agricola
2 Cytheretta ulrichi
2 Cytheromorpha warneri
2 Paracytheridea shattucki
1 Cytheropteron sp.
1 Echinocythereis clarkana
1 Propontocypris howei
1 Pterygocythereis americana

Foraminifera (continued)
t Textularia candeiana
t T. gramen
t Uvigerina subperegrina
t Sigmomorphina concava
t Discorbis floridana

Sample 66-35-1.-Pawpaw Hollow, Maryland. Upper Calvert Beach Member.

n_b = 1856
n_o = 435

$\%_a$ = 6
$\%_i$ = 0
$\%_p$ = t

Foraminifera
62 Cibicides lobatulus
8 Buccella mansfieldi
6 Valvulineria floridana
5 Textularia gramen
4 Nonion pizarrense
4 Buccella depressa
3 Nonion marylandicum
2 Hanzawaia concentrica
2 Discorbis floridana
1 Nonion medio-costatum
t Bulimina elongata
t Elphidium advenum
t Lagena substriata
t Massilina glutinosa
t Robulus americanus
t Textularia consecta
t Virgulina miocenica

Ostracoda
38 Cushmanidea ulrichi
12 Murrayina martini
10 Cushmanidea agricola
7 Cytheretta burnsi
7 Murrayina howei
7 Hulingsina ashermani
4 Semicytherura coryelli
3 Cytheromorpha warneri
3 Bensonocythere whitei
2 Cytheridea subovalis
2 Pokornyella punctistriata
2 Loxoconcha granulata
1 Actinocythereis exanthemata
t Aurila laevicula
t Cytheretta ulrichi
t Muellerina lienenklausi
t Pterygocythereis americana

Sample 66-36-5.-East Breton Bay, Maryland. Central Drumcliff.

n_b = 2517
n_o = 151

$\%_a$ = 5
$\%_i$ = 0
$\%_p$ = 7

Foraminifera
59 Cibicides lobatulus
15 Valvulineria floridana
5 Buccella depressa
5 Spiroplectammina exilis
3 Nonion marylandicum

Ostracoda
42 Cushmanidea ulrichi
13 Murrayina martini
11 M. howei
8 Cytheretta burnsi
5 Hulingsina ashermani

Foraminifera (continued)
3 Buccella mansfieldi
2 Nonion pizarrense
2 Discorbis floridana
t Bulimina elongata
t Entosolenia lucida
t Hanzawaia concentrica
t Lagena clavata
t L. substriata
t L. tenuis
t Nonion medio-costatum
t Pseudopolymorphina dumblei
t P. striata
t Rotalia bassleri
t Textularia consecta
t T. gramen
t Uvigerina subperegrina
t Virgulina miocenica
t Lagena sp. L. A

Ostracoda (continued)
5 Loxoconcha granulata
3 Actinocythereis exanthemata
3 Cushmanidea seminuda
3 Cytheropteron sp.
1 Cytheromorpha warneri
1 Semicytherura coryelli
1 Propontocypris howei
1 Pterygocythereis americana
1 Bensonocythere whitei
1 Muellerina lienenklausi

Sample 66-40-1. Mill Creek II, Maryland. Upper Drumcliff Member.

n_b = 1495
n_o = 378

$\%_a$ = 12
$\%_i$ = t
$\%_p$ = t

Foraminifera
36 Valvulineria floridana
26 Cibicides lobatulus
10 Nonion pizarrense
9 Textularia consecta
4 Buccella depressa
2 Nonion medio-costatum
2 Pseudopolymorphina striata
2 Globulina inaequalis
1 Pseudopolymorphina dumblei
1 Textularia gramen
1 Sigmomorphina concava
t Buccella mansfieldi
t Bulimina elongata
t Hanzawaia concentrica
t Lagena substriata
t L. tenuis
t Nonion marylandicum
t Spiroplectammina exilis
t Robulus americanus
t Rotalia bassleri
t Textularia candeiana
t T. ultima-inflata

Ostracoda
28 Hulingsina ashermani
22 Loxoconcha granulata
15 Cytheretta burnsi
6 Cushmanidea ulrichi
6 Murrayina howei
4 Tetracytherura shattucki
3 Cytheropteron sp.
3 Bensonocythere whitei
2 Cushmanidea seminuda
2 Murrayina martini
2 Pterygocythereis americana
2 Neocytherideis fasciata
1 Actinocythereis exanthemata
1 Cushmanidea agricola
1 Cytheromorpha warneri
t Campylocythere laevissima
t Cytheridea subovalis
t Semicytherura coryelli
t Eucythere declivis
t E. gibba
t Pokornyella punctistriata

Foraminifera (continued)
t Virgulina miocenica
t Discorbis floridana

Sample 66-40-3.-Mill Creek II, Maryland. Upper Drumcliff Member.

n_b = 11,356
n_o = 1,042

$\%_a$ = 10
$\%_i$ = t
$\%_p$ = t

Foraminifera
54 Cibicides lobatulus
18 Valvulineria floridana
5 Textularia gramen
4 Nonion pizarrense
3 N. medio-costatum
3 Textularia consecta
2 Hanzawaia concentrica
2 Rotalia bassleri
1 Buccella depressa
1 Spiroplectammina exilis
1 Pseudopolymorphina dumblei
t P. striata
t Buccella mansfieldi
t Bulimina elongata
t Lagena laevis
t L. substriata
t L. tenuis
t Massilina glutinosa
t Quinqueloculina seminula
t Robulus americanus
t Textularia candeiana
t Virgulina miocenica
t Discorbis floridana
t Cancris sagra
t Sigmomorphina concava
t Marginulina sp. M. A.
t Dentalina sp.
t D. communis
t Globulina inaequalis

Ostracoda
17 Hulingsina ashermani
16 Loxoconcha granulata
13 Cushmanidea ulrichi
10 Muellerina lienenklausi
10 Cytheretta burnsi
5 Cytheropteron sp.
3 Actinocythereis exanthemata
3 Cytheromorpha warneri
3 Tetracytherura shattucki
3 Pterygocythereis americana
3 Neocytherideis fasciata
2 Semicytherura coryelli
2 Echinocythereis clarkana
2 Murrayina martini
2 Bensonocythere whitei
1 Eucythere declivis
1 E. gibba
t Cytheridea subovalis
t Semicytherura forulata
t Pokornyella punctistriata
t Loxoconcha reticularis
t Paradoxostoma robusta

Sample 66-41-1.-Cuckold Creek VI, Maryland. Upper Drumcliff Member.

n_b = 579
n_o = 475

$\%_a$ = 14
$\%_i$ = 0
$\%_p$ = t

Foraminifera
66 Cibicides lobatulus
13 Textularia gramen
10 Valvulineria floridana
2 Discorbis candeiana
2 Pseudopolymorphina striata
2 Buccella mansfieldi
t B. depressa
t Bulimina elongata
t Nonion medio-costatum
t N. pizarrense
t Pseudopolymorphina dumblei
t Spiroplectammina exilis
t Rotalia bassleri
t Textularia consecta
t T. ultima-inflata
t Virgulina miocenica
t Globulina inaequalis

Ostracoda
28 Cytheretta burnsi
18 Hulingsina ashermani
13 Loxoconcha granulata
11 Muellerina lienenklausi
10 Bensonocythere whitei
6 Cushmanidea ulrichi
2 Cytheridea subovalis
2 Cytheropteron sp.
2 Pokornyella punctistriata
2 Tetracytherura shattucki
2 Neocytherideis fasciata
t Actinocythereis exanthemata
t Cushmanidea seminuda
t Cytheromorpha warneri
t Echinocythereis clarkana
t Eucythere declivis
t Haplocytheridea bassleri
t Murrayina martini
t Pterygocythereis americana
t Propontocypris howei

Sample 66-41-2.-Cuckold Creek VI, Maryland. Lower St. Leonard Member.

(No specimens present.)

Sample 66-43-2.-Mackall's Landing, Maryland. Central Drumcliff Member.

n_b = 540
n_o = 218

$\%_a$ = 5
$\%_i$ = t
$\%_p$ = t

Foraminifera
54 Valvulineria floridana
32 Cibicides lobatulus
5 Buccella depressa
5 Textularia gramen
x Bolivina paula
x Buliminella elegantissima
t Bulimina elongata
t Hanzawaia concentrica
t Nonion marylandicum
t Quinqueloculina seminula
t Robulus americanus
t Rotalia bassleri
t Discorbis floridana

Ostracoda
57 Cushmanidea ulrichi
14 Murrayina martini
8 Hulingsina ashermani
7 Aurila laevicula
5 Muellerina lienenklausi
2 Murrayina howei
2 Bensonocythere whitei
1 Cytheretta burnsi
1 Semicytherura coryelli
t Cytheromorpha warneri
t Loxoconcha granulata
t Pterygocythereis americana

Sample 66-44-2.-1/2 mile north of Camp Conoy, Maryland.

Upper Boston Cliffs Member.

n_b = 989
n_o = 679

$\%_a$ = 10
$\%_i$ = 0
$\%_p$ = t

Foraminifera
40 Cibicides lobatulus
27 Buccella mansfieldi
9 B. depressa
7 Textularia gramen
4 Bulimina elongata
3 Massilina glutinosa
2 Discorbis floridana
2 Nonion pizarrense
2 Lagena substriata
2 L. sp. L. A
t L. laevis
t L. tenuis
t Nonion medio-costatum
t Nonionella auris
t Pseudopolymorphina dumblei
t Textularia consecta
t Valvulineria floridana

Ostracoda
24 Loxoconcha granulata
19 Cytheretta burnsi
15 Cushmanidea ulrichi
13 Murrayina martini
12 Cytheromorpha warneri
4 Pterygocythereis americana
3 Hermanites sp.
2 Echinocythereis clarkana
2 Loxoconcha reticularis
2 Murrayina howei
1 Cytheropteron sp.
t Actinocythereis exanthemata
t Cytheridea subovalis
t Cushmanidea agricola
t Semicytherura coryelli
t Neocytherideis fasciata
t Tetracytherura shattucki
t Propontocypris howei
t Paradoxostoma robusta
t Cytherois fischeri
t ?Machaerina sp.

Sample 66-44-3.-1/2 mile north of Camp Conoy, Maryland.

Lower Conoy Member.

n_b = 15,390
n_o = 3,724

$\%_a$ = 7
$\%_i$ = 0
$\%_p$ = t

Foraminifera
82 Buccella mansfieldi
5 Bulimina elongata
4 Textularia consecta
2 Massilina glutinosa
2 Lagena substriata
1 Nonion pizarrense
t Lagena sp. L. B
t L. laevis
t Buccella depressa

Ostracoda
21 Cushmanidea ulrichi
16 Murrayina martini
15 Cytheretta burnsi
10 Murrayina howei
8 Pterygocythereis americana
6 Cytheromorpha warneri
5 Cushmanidea agricola
5 Echinocythereis clarkana
4 Loxoconcha granulata

Foraminifera
t Cibicides lobatulus
t Hanzawaia concentrica
t Nonion medio-costatum
t Nonionella auris
t Robulus americanus
t Textularia gramen
t T. ultima-inflata
t Valvulineria floridana
t Discorbis floridana
t Textularia sp.

Ostracoda
3 Cytheropteron sp.
2 Cytheridea subovalis
2 Loxoconcha reticularis
t Actinocythereis exanthemata
t Cytheretta ulrichi
t Pokornyella punctistriata
t Hulingsina ashermani
t Muellerina lienenklausi

Sample 66-47-1.-North of Cove Point, Maryland. Lower Conoy Member.

(No specimens present.)

Sample 67-53-1.-Governor Run, Maryland. Central Calvert Beach Member.

n_b = 20,008
n_o = 12,536

$\%_a$ = 15
$\%_i$ = 0
$\%_p$ = t

Foraminifera
46 Cibicides lobatulus
20 Valvulineria floridana
15 Textularia gramen
7 Nonion marylandicum
3 N. pizarrense
3 Bulimina elongata
2 Nonion medio-costatum
1 Discorbis floridana
t Buccella mansfieldi
t Hanzawaia concentrica
t Nonionella auris
t Sigmomorphina concava
t Spiroplectammina exilis
t Robulus americanus
t Rotalia bassleri
t Textularia ultima-inflata
t Uvigerina subperegrina
t Cancris sagra
t Virgulina punctata
x Bolivina paula

Ostracoda
30 Semicytherura coryelli
24 Cushmanidea ulrichi
13 Hulingsina ashermani
8 Haplocytheridea bassleri
7 Campylocythere laevissima
6 Tetracytherura shattucki
4 Bensonocythere whitei
3 Pokornyella punctistriata
2 Cushmanidea seminuda
2 Cytheretta burnsi
1 Loxoconcha granulata
1 Muellerina lienenklausi
t Actinocythereis exanthemata
t Cytheromorpha warneri
t Eucythere declivis
t E. gibba
t Henryhowella evax
t Loxoconcha reticularis
t Murrayina howei

Sample 67-58-1.-Paris, Maryland. Probably upper St. Leonard Member.

n_b = 1709
n_o = 200

$\%_a$ = 8
$\%_i$ = t
$\%_p$ = t

Foraminifera
44 Buccella mansfieldi
28 Valvulineria floridana
11 Cibicides lobatulus
7 Textularia gramen
4 Nonion marylandicum
2 Discorbis floridana
t Cibicides floridanus
t Bolivina paula
t Buccella depressa
t Bulimina elongata
t Hanzawaia concentrica
t Lagena clavata
t L. substriata
t L. tenuis
t Nonion medio-costatum
t Quinqueloculina seminula
t Sigmomorphina concava
t Robulus americanus
t Textularia candeiana
t Cancris sagra
t Globulina inaequalis
t Lagena sp. L. A

Ostracoda
32 Cushmanidea ulrichi
20 Cytheretta burnsi
18 Hulingsina ashermani
10 Haplocytheridea bassleri
8 Bensonocythere whitei
4 Muellerina lienenklausi
3 Pokornyella punctistriata
1 Actinocythereis exanthemata
1 Campylocythere laevissima
1 Cushmanidea seminuda
1 Murrayina howei
t Cytheridea subovalis
t Eucythere gibba
t Henryhowella evax
t Murrayina martini

Sample 67-65-2.-Calvert Beach, Maryland. Lower Calvert Beach Member.

n_b = 19,136
n_o = 1,669

$\%_a$ = 13
$\%_i$ = t
$\%_p$ = 0

Foraminifera
38 Cibicides lobatulus
26 Valvulineria floridana
15 Nonion pizarrense
7 Spiroplectammina exilis
6 Textularia candeiana
4 Nonion medio-costatum
t N. marylandicum
t Discorbis floridana
t Lagena substriata
t L. tenuis
t Massilina glutinosa
t Robulus americanus
t Entosolenia lucida

Ostracoda
17 Muellerina lienenklausi
16 Henryhowella evax
15 Cushmanidea ulrichi
7 Echinocythereis clarkana
6 Cytheropteron sp.
5 Hulingsina ashermani
4 Loxoconcha granulata
4 Cytheromorpha warneri
3 Pterygocythereis americana
3 Actinocythereis exanthemata
2 A. sp. A. gomillionensis
2 Cushmanidea agricola
2 Cytheretta burnsi

Foraminifera (continued)
t Bulimina elongata
t Quinqueloculina seminula
t Sigmomorphina williamsoni
t Pseudopolymorphina striata
t Rotalia bassleri
t Globulina inaequalis
t Nonionella sp.
t Uvigerina subperegrina

Ostracoda (continued)
2 C. ulrichi
2 Semicytherura coryelli
2 Murrayina martini
1 Cytheridea subovalis
1 Cushmanidea seminuda
t Pokornyella punctistriata
t Loxoconcha reticularis
t Murrayina howei
t Paracypris choctawhatcheenis
t Tetracytherura shattucki
t Bensonocythere whitei
t Propontocypris howei

Sample 67-65-9.-Calvert Beach, Maryland. Lower Drumcliff Member.

n_b = 25,870
n_o = 2,218

$\%_a$ = 14
$\%_i$ = t
$\%_p$ = t

Foraminifera
38 Cibicides lobatulus
23 Valvulineria floridana
8 Textularia gramen
3 Bulimina elongata
3 Uvigerina subperegrina
2 Hanzawaia concentrica
2 Nonion pizarrense
2 Textularia candeiana
2 T. consepta
1 Buccella mansfieldi
1 Nonion marylandicum
1 N. medio-costatum
t Buccella depressa
t Cibicides floridanus
t Lagena tenuis
t Massilina glutinosa
t Pseudopolymorphina striata
t Quinqueloculina seminula
t Sigmomorphina concava
t Spiroplectammina exilis
t Robulus americanus
t Textularia ultima-inflata
t Virgulina miocenica
t Globulina inaequalis

Ostracoda
21 Cushmanidea ulrichi
14 Semicytherura coryelli
11 Hulingsina ashermani
10 Cytheretta burnsi
8 Pokornyella punctistriata
5 Loxoconcha granulata
5 Muellerina lienenklausi
5 Murrayina martini
4 Cushmanidea seminuda
3 Bensonocythere whitei
2 Cytheridea subovalis
2 Henryhowella evax
2 Murrayina howei
1 Loxoconcha reticularis
1 Tetracytherura shattucki
t Actinocythereis exanthemata
t A. sp. A. gomillionensis
t Campylocythere laevissima
t Cushmanidea agricola
t Haplocytheridea bassleri

Sample 67-70-15.-East Nomini Cliffs, Virginia. Lower

St. Marys Formation.

(No specimens present.)

Sample 67-71-1.-1.1 mile south of Western Shores, Maryland. Central Conoy Member.

(No specimens present.)

Sample 67-72-3.-West Nomini Cliffs, Virginia. Central Drumcliff Member.

n_b = 1427 $\%_a$ = 18

n_o = 331 $\%_i$ = 0

$\%_p$ = 0

Foraminifera	Ostracoda
35 Valvulineria floridana	15 Cytheretta ulrichi
14 Spiroplectammina exilis	14 Muellerina lienenklausi
11 Nonion medio-costatum	11 Henryhowella evax
11 Buccella mansfieldi	9 Hulingsina ashermani
9 Nonion pizarrense	9 Loxoconcha granulata
5 Cibicides lobatulus	7 Echinocythereis clarkana
3 Bulimina elongata	6 Cytheridea subovalis
3 Lagena substriata	5 Actinocythereis exanthemata
2 Textularia consecta	5 Pterygocythereis americana
2 Virgulina miocenia	4 Cytheretta burnsi
1 Textularia gramen	3 Cytheropteron sp.
t Buccella depressa	2 Actinocythereis sp. A. gomillionensis
t Hanzawaia concentrica	2 Cushmanidea ulrichi
t Lagena tenuis	2 Cytheromorpha warneri
t Miliammina fusca	2 Murrayina howei
t Nonion marylandicum	2 M. gunteri
t Pseudopolymorphina striata	1 Tetracytherura shattucki
t Discorbis floridana	t Cushmanidea agricola
	t Haplocytheridea? sp.

Sample 67-72-8.-West Nomini Cliffs, Virginia. Central Boston Cliffs Member.

n_b = 3256 $\%_a$ = 11

n_o = 7261 $\%_i$ = t

$\%_p$ = t

Foraminifera
43 Buccella mansfieldi
31 Cibicides lobatulus
7 Textularia gramen
5 Nonion pizarrense
4 Textularia consecta
2 Hanzawaia concentrica
2 Nonion marylandicum
2 Valvulineria floridana
1 Virgulina miocenica
t Buccella depressa
t Miliammina fusca
t Nonion medio-costatum
t Pseudopolymorphina striata
t Quinqueloculina seminula
t Spiroplectammina exilis
t Textularia candeiana
t T. ultima-inflata
t Discorbis floridana

Ostracoda
56 Haplocytheridea bassleri
12 Cytheretta burnsi
11 Cushmanidea ulrichi
7 Hulingsina ashermani
4 Loxoconcha reticularis
2 Basslerites tenmilecreekensis
2 Muellerina lienenklausi
1 Murrayina howei
1 M. martini
t Actinocythereis sp.
A. gomillionensis
t Cushmanidea seminuda
t C. agricola
t Cytheretta ulrichi
t Cytheromorpha warneri
t Pokornyella punctistriata
t Loxoconcha granulata
t Tetracytherura shattucki
t Pterygocythereis americana

Sample 67-73-2.- Horsehead Cliffs, Virginia. Upper Calvert Beach Member.

(No specimens present.)

Sample 67-73-4.-Horsehead Cliffs, Virginia. Central Drumcliff Member.

n_b = 66,444
n_o = 2,692

$\%_a$ = 15
$\%_i$ = t
$\%_p$ = t

Foraminifera
48 Cibicides lobatulus
15 Valvulineria floridana
8 Bulimina elongata
7 Textularia gramen
5 Spiroplectammina exilis
4 Nonion pizarrense
3 Virgulina miocenica
2 Textularia candeiana
1 Nonion medio-costatum
1 Nonionella auris
t Hanzawaia concentrica

Ostracoda
14 Cytheromorpha warneri
13 Muellerina lienenklausi
12 Cushmanidea ulrichi
9 Cytheridea subovalis
9 Loxoconcha granulata
7 Hulingsina ashermani
6 Pokornyella punctistriata
4 Pterygocythereis americana
4 Murrayina martini
3 M. howei
3 Cytheretta burnsi

Foraminifera (continued)
t Lagena clavata
t L. substriata
t Massilina glutinosa
t Nonion marylandicum
t Quinqueloculina seminula
t Robulus americanus
t Rotalia bassleri
t Textularia ultima-inflata
t Uvigerina subperegrina
t Discorbis floridana
t Pyrgo subsphaerica
t Nodosaria catesbyi

Ostracoda (continued)
3 Cytheropteron sp.
2 Actinocythereis exanthemata
2 Semicytherura coryelli
2 Eucythere gibba
2 Henryhowella evax
1 Cytheretta ulrichi
t Actinocythereis aff. A. gomillionensis
t Cushmanidea seminuda
t C. agricola
t Echinocythereis clarkana
t Haplocytheridea bassleri
t Tetracytherura shattucki
t Bensonocythere whitei

Sample 67-63-8.-Horsehead Cliffs, Virginia. Lower Conoy Member.

n_b = 16,968
n_o = 435

$\%_a$ = 15
$\%_i$ = 0
$\%_p$ = t

Foraminifera
29 Nonion pizarrense
23 Valvulineria floridana
14 Nonion medio-costatum
12 Spiroplectammina exilis
7 Buccella mansfieldi
5 Bulimina elongata
2 Cibicides lobatulus
2 Textularia candeiana
2 Uvigerina subperegrina
1 Nonion marylandicum
1 Virgulina miocenica
t Buccella depressa
t Lagena substriata
t Massilina glutinosa
t Pseudopolymorphina striata
t Rotalia bassleri
t Textularia gramen
t Cancris sagra
t Discorbis floridana

Ostracoda
17 Cytheridea subovalis
15 Cytheropteron sp.
11 Pterygocythereis americana
10 Loxoconcha granulata
10 Henryhowella evax
9 Cushmanidea ulrichi
8 Cytheretta ulrichi
8 Muellerina lienenklausi
6 Echinocythereis clarkana
4 Cytheromorpha warneri
2 Actinocythereis sp.
t Campylocythere sp.
t Cushmanidea seminuda
t Hulingsina ashermani
t Cytherella sp.

Sample 67-73-9.-Horsehead Cliffs, Virginia. Central Conoy Member.

(No specimens present.)

Sample 67-74-4.-Parker Creek, Maryland. Central Calvert Beach Member.

n_b = 13,061
n_o = 3,412

$\%_a$ = 6
$\%_i$ = t
$\%_p$ = t

Foraminifera

33 Cibicides lobatulus
30 Valvulineria floridana
10 Uvigerina subperegrina
5 Textularia gramen
5 Nonion marylandicum
4 N. medio-costatum
2 Bulimina elongata
2 Hanzawaia concentrica
2 Nonion pizarrense
1 Lagena substriata
1 Nonionella auris
t Marginulina sp. M. B
t Cibicides floridana
t Bolivina plicatella
t Buccella mansfieldi
t Entosolenia lucida
t Lagena acuticostata
t L. clavata
t L. tenuis
t Quinqueloculina seminula
t Robulus americanus
t Rotalia bassleri
t Textularia consecta
t T. ultima-inflata
t Virgulina miocenica
t Discorbis floridana
t Lagena sp. L. A
t Elphidium poeyanum
t Spiroplectammina mississippiensis

Ostracoda

28 Cushmanidea ulrichi
13 Cytheridea subovalis
8 Cushmanidea agricola
7 Pterygocythereis americana
6 Loxoconcha granulata
6 Cytheretta ulrichi
6 Semicytherura coryelli
5 Cytheromorpha warneri
5 Hulingsina ashermani
5 Muellerina lienenklausi
3 Echinocythereis clarkana
2 Murrayina martini
1 Cushmanidea seminuda
t Actinocythereis exanthemata
t Cytheretta burnsi
t Cytheropteron sp.
t Eucythere gibba
t Haplocytheridea bassleri
t Henryhowella evax
t Pokornyella punctistriata
t Loxoconcha reticularis
t Murrayina howei
t Neocytherideis fasciata
t Tetracytherura shattucki
t Bensonocythere whitei

Sample 67-74-9.-Parker Creek, Maryland. Lower St. Leonard Member.

n_b = 1387
n_o = 1868

$\%_a$ = 13
$\%_i$ = 0
$\%_p$ = 0

Foraminifera

77 Buccella mansfieldi
5 Spiroplectammina aff. S. exilis
4 Textularia gramen
2 Bulimina elongata
2 Discorbis floridana
2 Massilina glutinosa
2 Rotalia bassleri
2 Textularia candeiana
1 Nonion pizarrense
t Buliminella elegantissima
t Cibicides lobatulus
t Hanzawaia concentrica
t Lagena substriata
t Nonion medio-costatum

Ostracoda

51 Actinocythereis sp. A. mundorffi
26 Cytheridea subovalis
6 Loxoconcha granulata
3 Cushmanidea ulrichi
3 Loxoconcha reticularis
2 Cytheretta burnsi
2 Cytheromorpha warneri
2 Murrayina martini
2 Pterygocythereis americana
1 Cytheretta ulrichi
t Actinocythereis exanthemata
t Cytheropteron sp.
t Echinocythereis clarkana
t Pokornyella punctistriata
t Murrayina howei

Sample 67-74-10.-Parker Creek, Maryland. Lower Boston Cliffs Member.

$n_b = 3623$
$n_o = 2736$

$\%_a = 4$
$\%_i = 0$
$\%_p = t$

Foraminifera

46 Cibicides lobatulus
21 Discorbis floridana
11 Buccella mansfieldi
10 Rotalia bassleri
3 Hanzawaia concentrica
2 Massilina glutinosa
2 Textularia gramen
2 Valvulineria floridana
t Buccella depressa
t Bulimina elongata
t Miliammina fusca
t Nonion marylandicum
t N. medio-costatum
t Virgulina miocenica
t Cancris sagra

Ostracoda

25 Loxoconcha granulata
12 Cytheridea subovalis
12 Cushmanidea ulrichi
10 Murrayina martini
7 Cytheretta burnsi
6 Hermanites sp.
6 Cytheromorpha warneri
5 Pokornyella punctistriata
4 Actinocythereis exanthemata
3 Loxoconcha reticularis
2 Pterygocythereis americana
1 Semicytherura coryelli
1 S. reticulata
1 Murrayina howei
t Aurila laevicula
t Campylocythere laevissima
t Cushmanidea seminuda
t C. agricola
t Semicytherura forulata
t Haplocytheridea bassleri
t Hulingsina ashermani

Ostracoda (continued)
t Muellerina lienenklausi
t Tetracytherura shattucki
t Bensonocythere whitei
t Propontocypris howei
t Paradoxostoma robusta

Sample 67-77-1.-Grubin Neck, Maryland. Central Conoy? Member.

(No specimens present.)

Sample 67-79-2.-South Boston Cliffs, Maryland. Lower Boston Cliffs Member.

n_b = 29,560 $\%_a$ = 29
n_o = 36,002 $\%_i$ = 8
$\%_p$ = t

Foraminifera
29 Textularia gramen
26 Cibicides lobatulus
19 Buccella mansfieldi
8 Rotalia bassleri
8 Quinqueloculina seminula
5 Hanzawaia concentrica
2 Valvulineria floridana
t Elphidium poeyanum
t Buccella depressa
t Nonion pizarrense
t Pseudopolymorphina dumblei
t Robulus americanus
t Textularia consecta
t T. ultima-inflata
t Cancris sagra
t Discorbis floridana
x Bulimina elongata

Ostracoda
32 Pokornyella punctistriata
22 Cytheromorpha warneri
16 Aurila laevicula
8 Semicytherura coryelli
4 Muellerina lienenklausi
3 Cushmanidea ulrichi
2 Haplocytheridea bassleri
2 Semicytherura forulata
2 S. reticulata
2 Tetracytherura shattucki
2 Cyprideis floridana
1 Bensonocythere whitei
t Actinocythereis exanthemata
t Campylocythere laevissima
t Hermanites sp.
t Cushmanidea seminuda
t Cytheretta burnsi
t Hulingsina ashermani
t Loxoconcha granulata
t L. reticularis
t Pterygocythereis americana
t Cytherois fischeri
t Propontocypris sp.

Sample 67-81-1.-South of Greensboro, Maryland. Central Calvert Beach Member.

(No specimens present.)

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PLATE 1: A nearly complete section of the Choptank Formation between localities 66-6 and 66-4, Calvert Cliffs, Calvert Co., Maryland. (Vicinity of principal reference section and type section of the St. Leonard Member.) Note basal sand of St. Leonard Member.

Plate 1

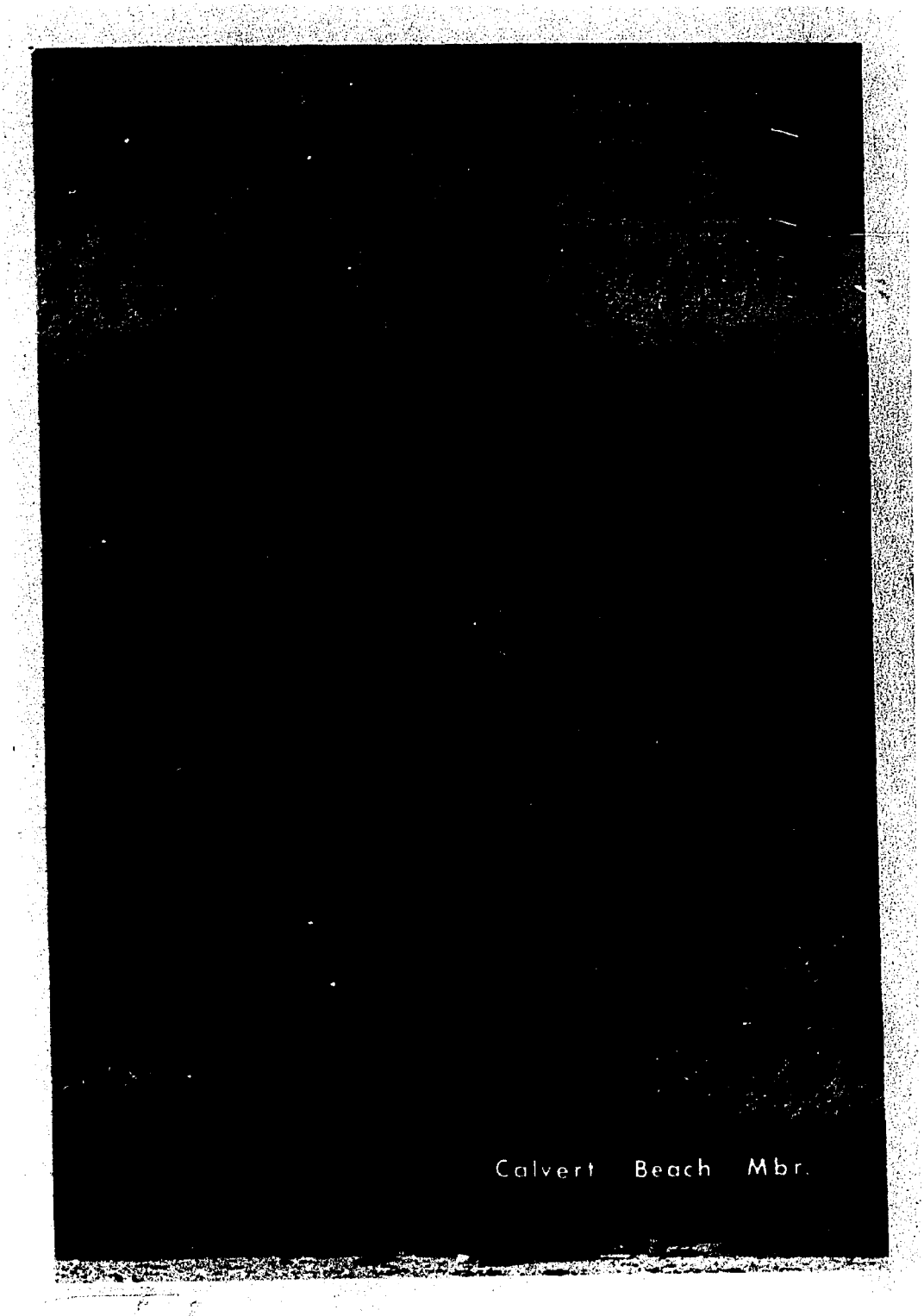


PLATE 2: Principal reference section of the Choptank Formation. Locality 66-5, Calvert Cliffs, Calvert Co., Maryland.

Plate 2

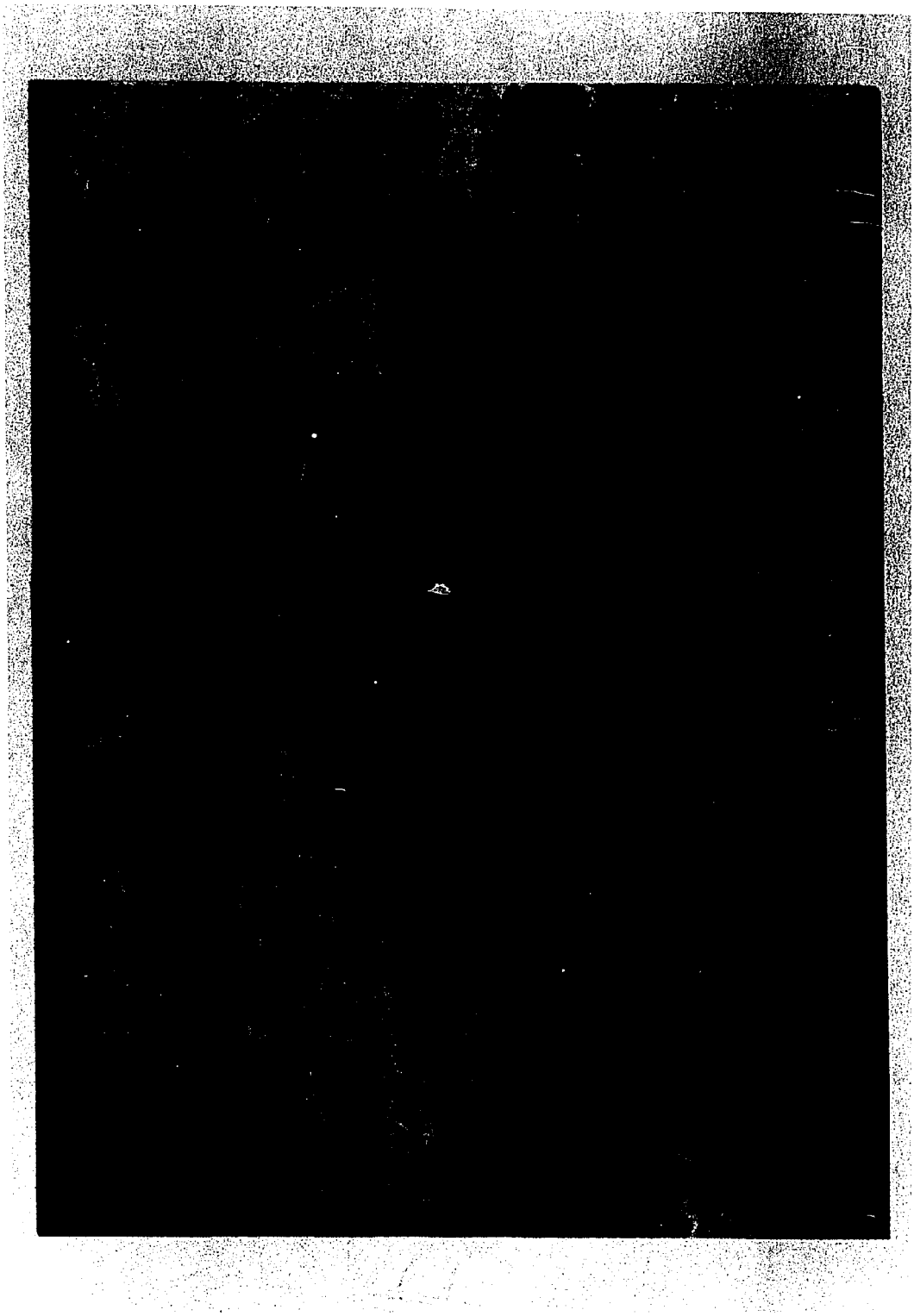


PLATE 3: Locality 66-6, type section for St. Leonard Member and view of Calvert Cliffs north along Chesapeake Bay to Parker Creek. Arrow #1 points to section in Plate 1. Arrow #2 points to section in Plate 2.

Plate 3

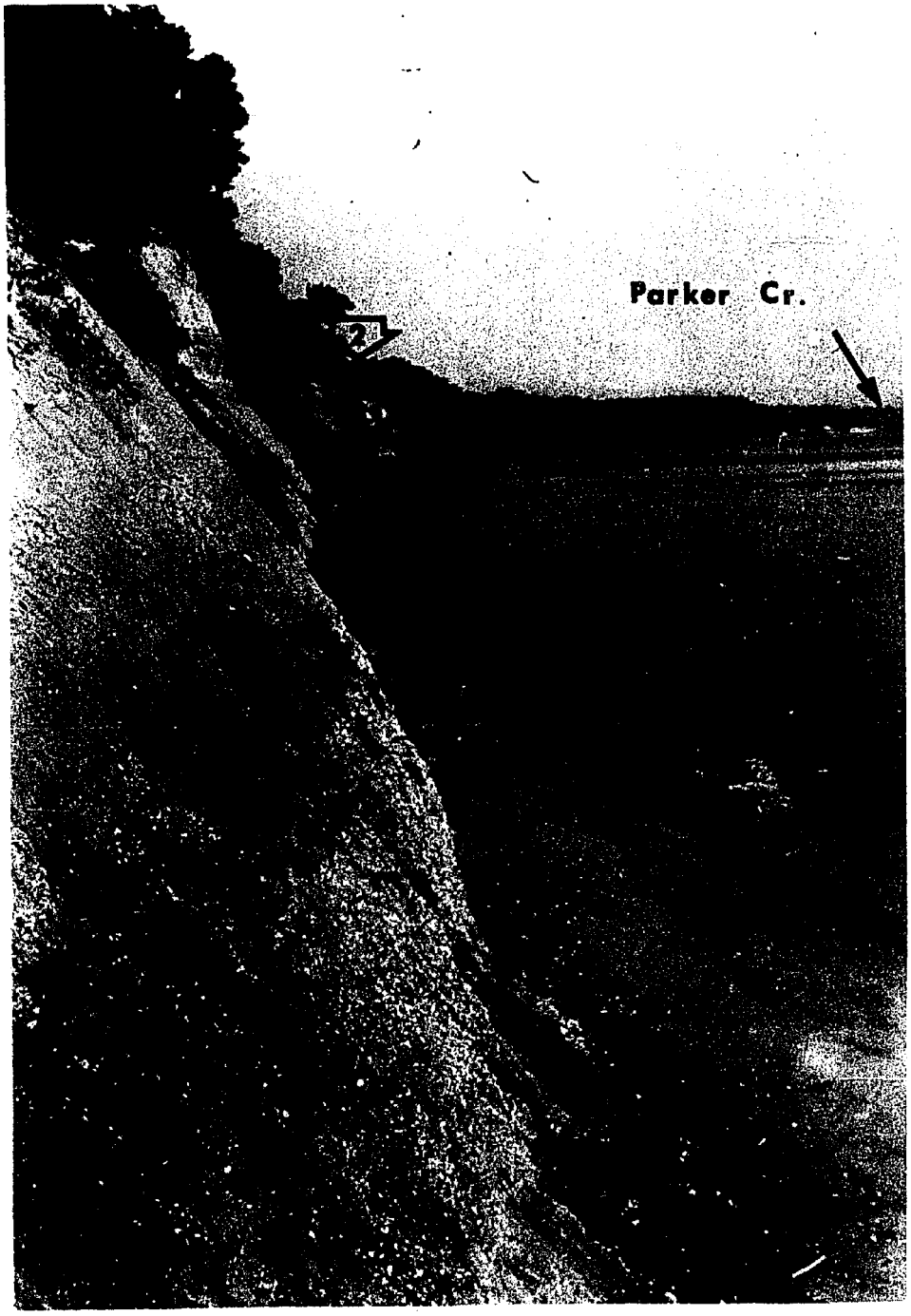


PLATE 4: First cliffs south of Parker Creek along Chesapeake Bay. Arrows point out line of leaching which probably corresponds to the "unconformity" recognized by G. B. Shattuck. Lighter band below "unconformity" and intersecting arrow at left is "zone 14" of the Calvert Formation. The lighter colored beds at the center peak of the cliffs are in the Boston Cliffs Member. The beds two-thirds up from the base and weathering into blocky fractures are in the St. Leonard Member.

Plate 4

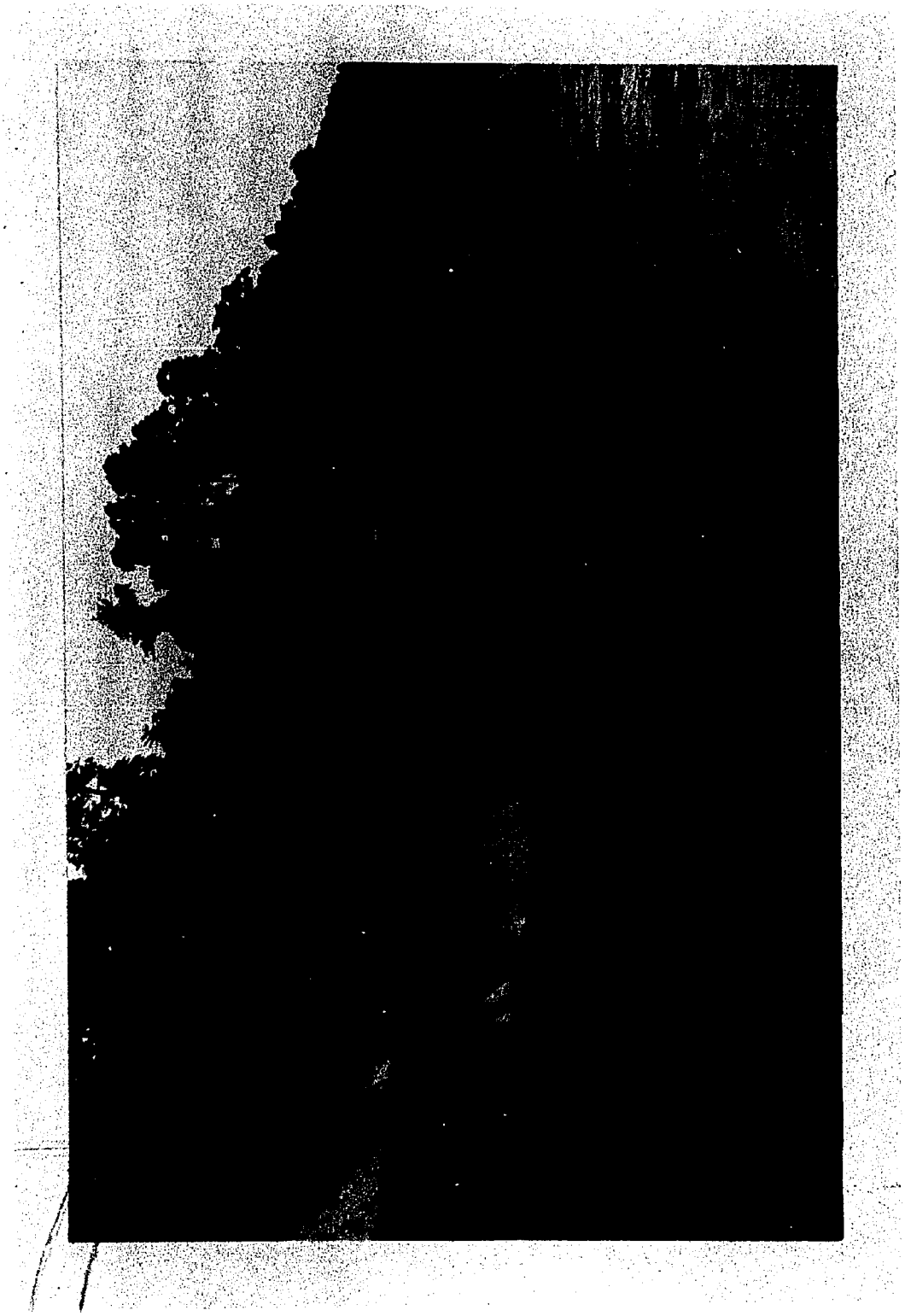


PLATE 5: T. M. Kelly pointing to contact between the Calvert Formation and Choptank Formation (Calvert Beach Member). Shelly bed at level of Kelly's face is "zone 14" of the Calvert. "Zone 15" of the Calvert extends from that bed to the end of the pointer. Shelly bed at top is in the Drumcliff Member. Note sandy beds in the lower part of the Calvert Beach Member marked by arrows. Near locality 67-53, approximately one half mile north of Governor Run, Maryland.

Plate 5

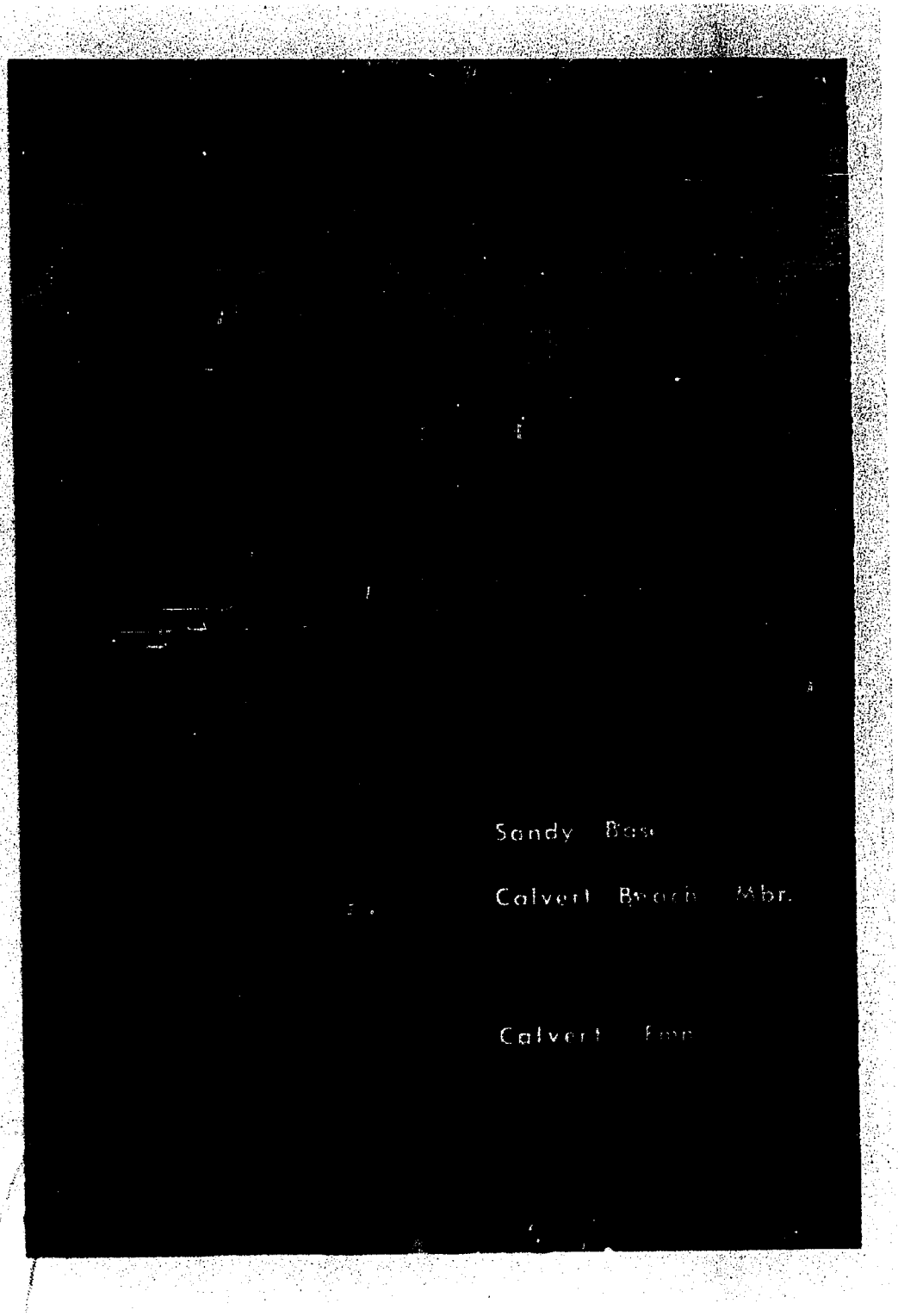


PLATE 6: T. M. Kelly pointing to Choptank-Calvert boundary in Calvert Cliffs, south of Kenwood Beach, Maryland. Note slight increase in shell content in Choptank from Calvert. Shelly bed at base is in "zone 14" of the Calvert.

Plate 6

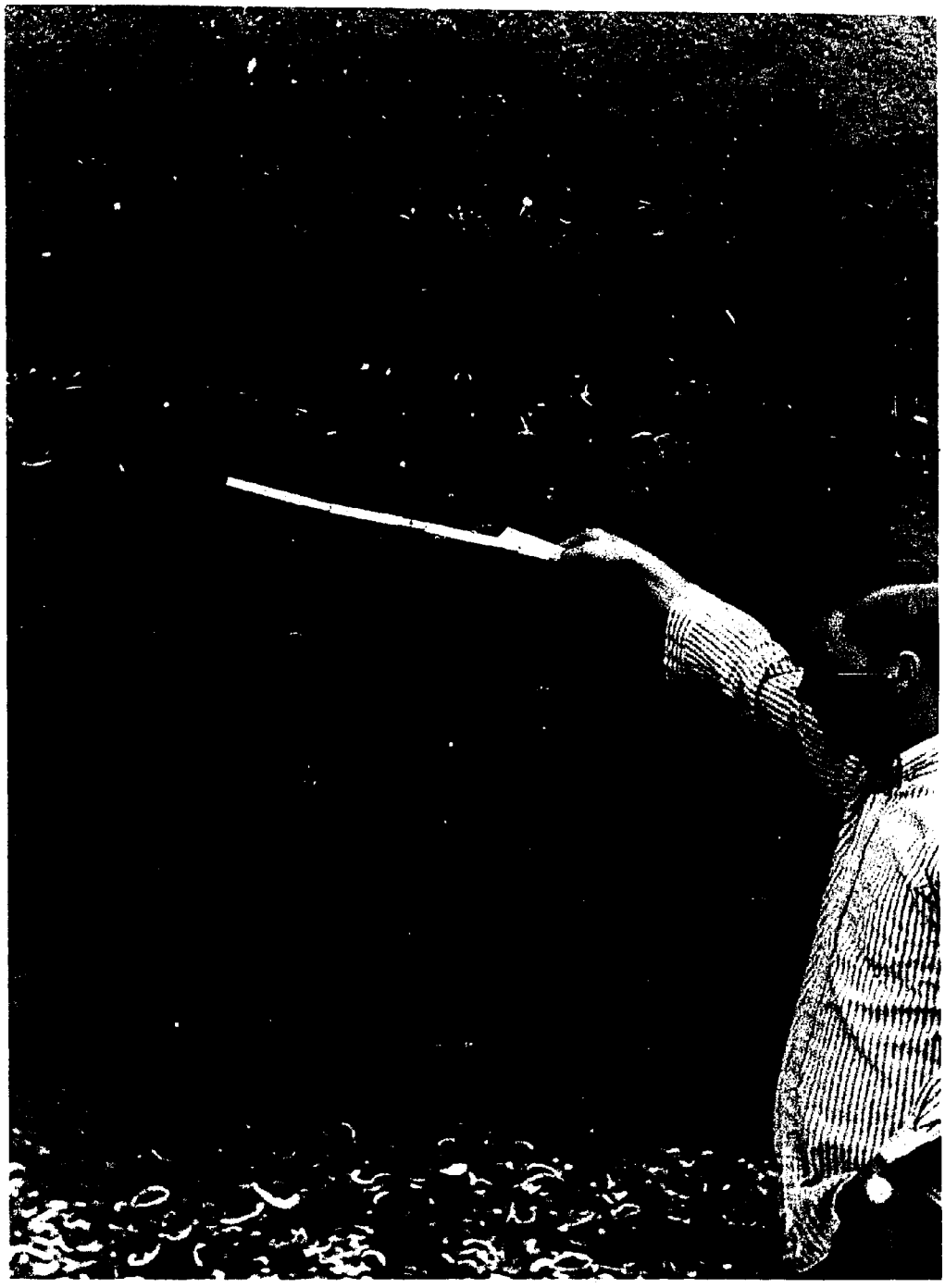


PLATE 7: Type locality of the Calvert Beach Member, Calvert Beach, Maryland. Calvert Beach Member has some bivalves articulated and in living position, notably Lucinoma contracta and Diplodonta subvexa. The basal portion of the Drumcliff Member, above, is profusely packed with the bivalve, Isognomon maxillata, and the coral, Astrhelia palmata. "Zone 15" of the Calvert Formation occurs below the lower arrow. The Drumcliff Member occurs above the upper arrow.

Plate 7

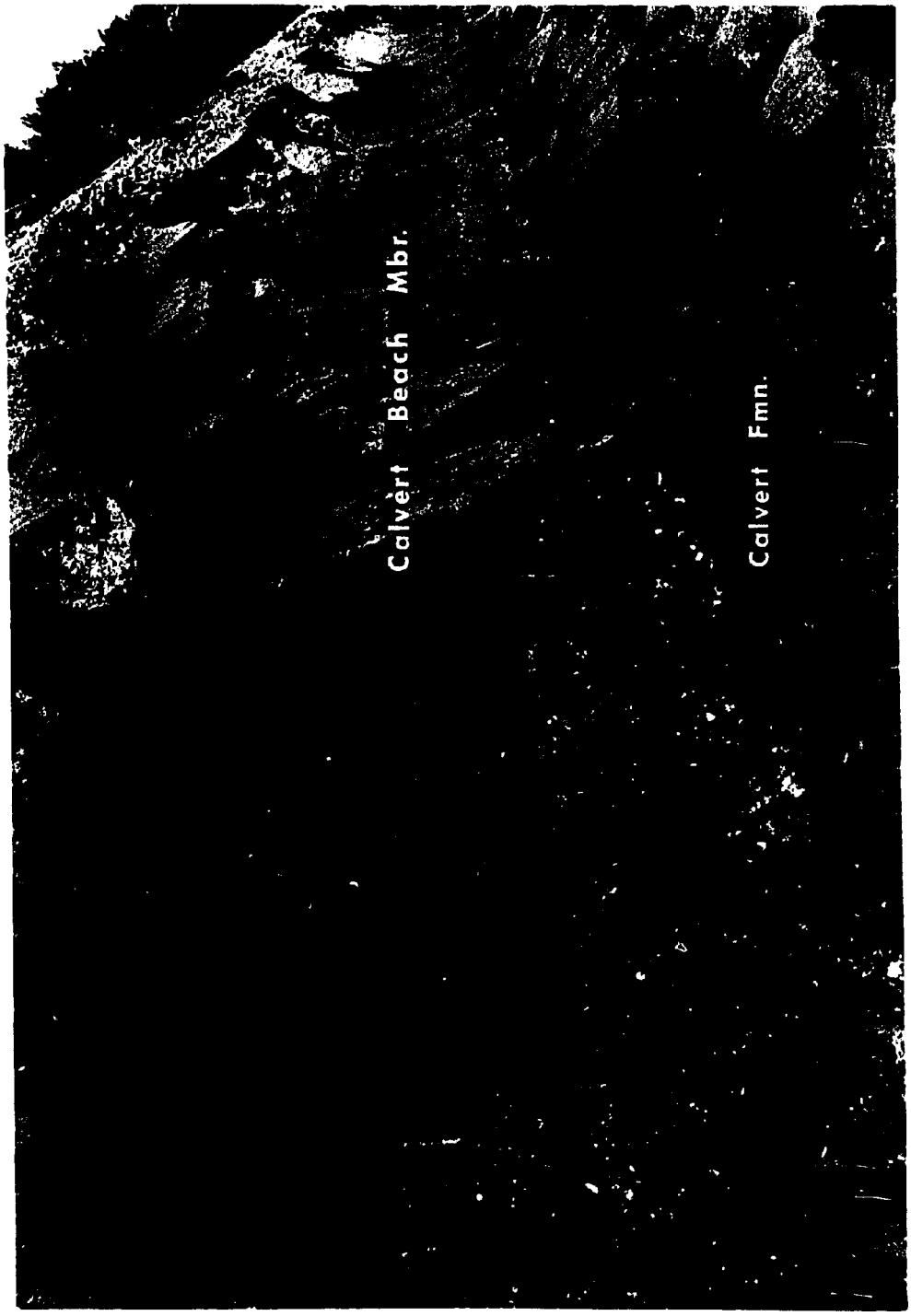


PLATE 8: Channel (about 30 inches across and 6 inches deep) filled with Turritella plebeia. Calvert Beach Member, locality 67-65, Calvert Beach, Calvert Cliffs, Calvert Co., Maryland.

Plate 8

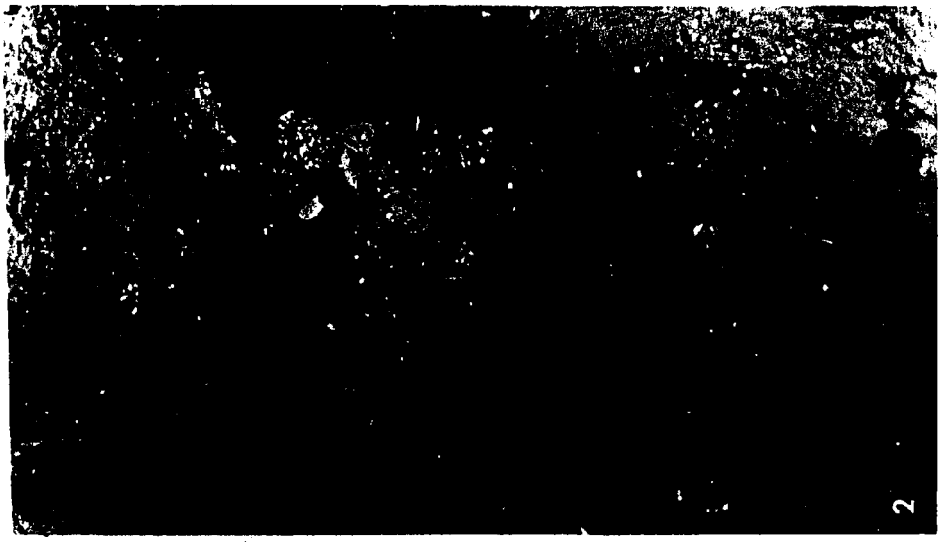


PLATE 9: Type locality of the Calvert Beach Member, Calvert Beach, Maryland.

Figure 1: Large pocket of snails, Turritella plebeia. Lucina contracta in life orientation.

Figure 2: Burrowed central portions of member.

Plate 9



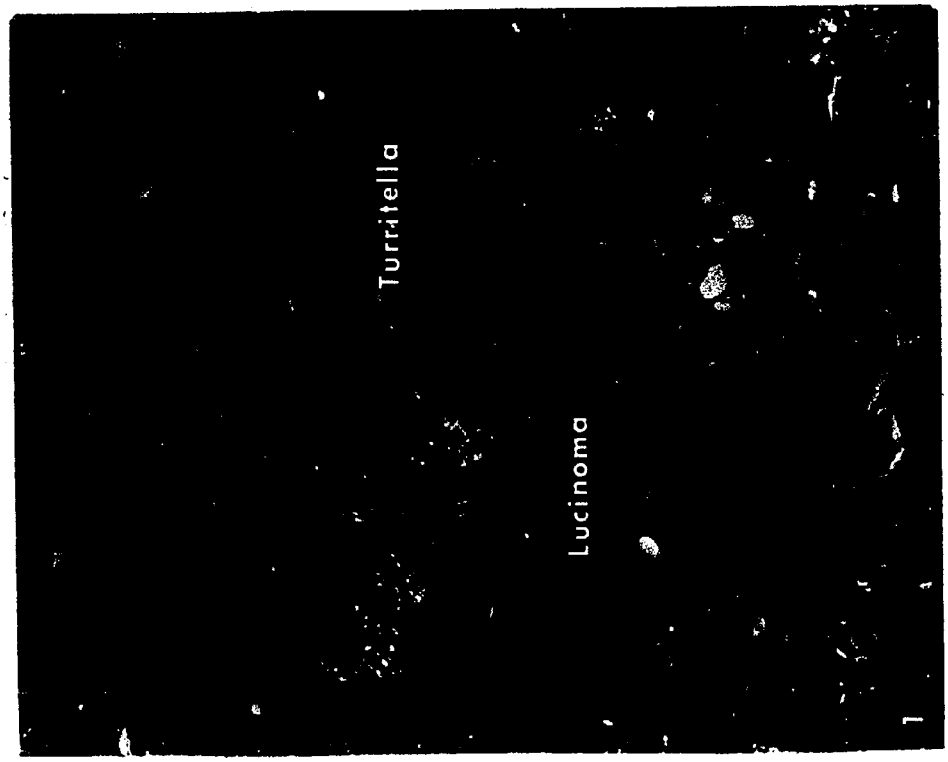


PLATE 10: Burrows in Calvert Beach Member.

Figure 1: Shell-lined burrow possibly of a marine worm. Locality 66-6, Calvert Cliffs, Calvert County, Maryland.

Figure 2: Slime-lined burrow, some minor biogenically concentrated shell accumulations, and some blebs of finer textured sediment. Locality 66-6, Calvert Cliffs, Calvert County, Maryland.

Figure 3: Ensis ensiformis in upper left-hand corner and long, thin, diagonal, multi-walled burrow (of Ensis?). Locality 67-65, Calvert Cliffs at Calvert Beach, Maryland.

Plate 10

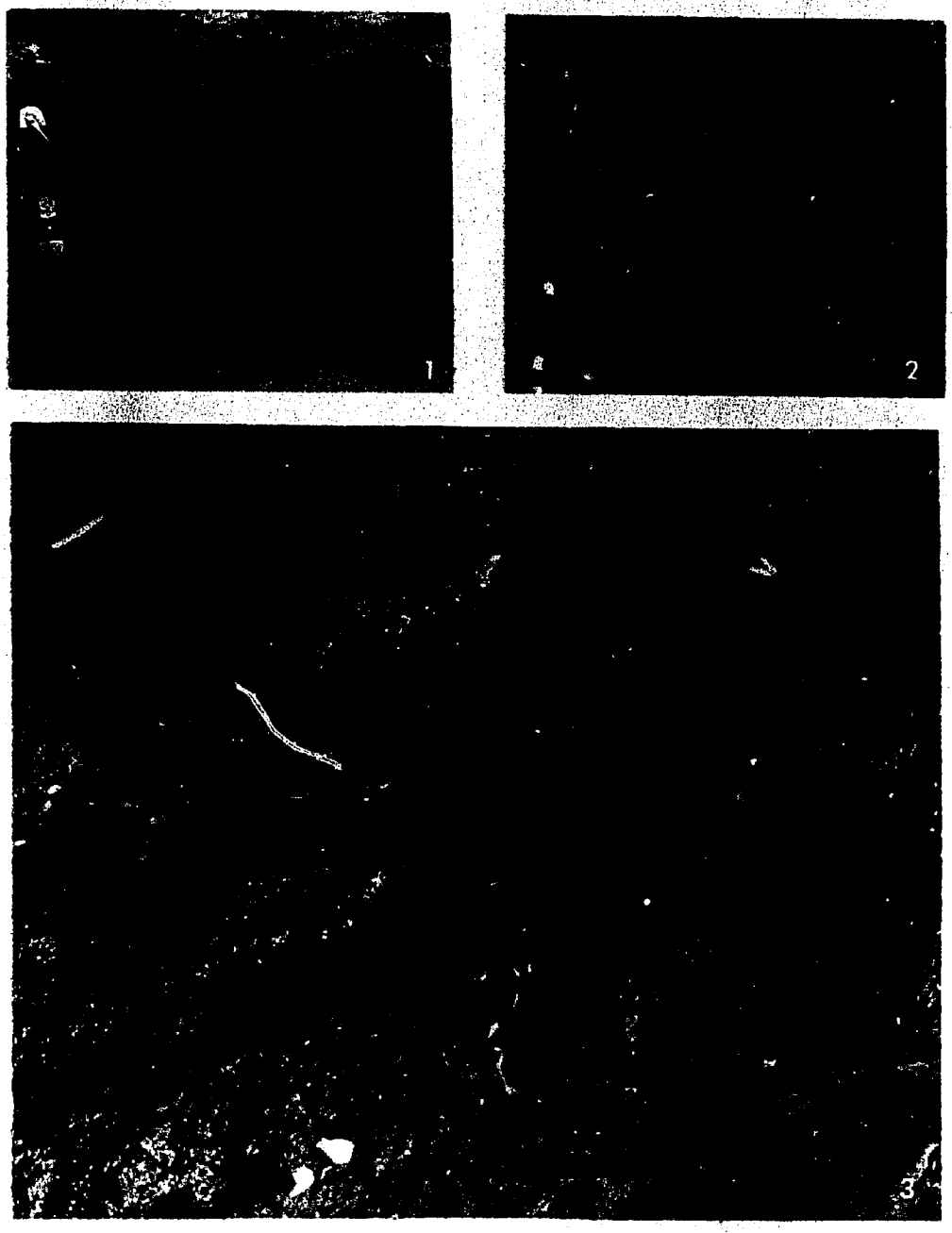


PLATE 11: Transition from Calvert Beach Member to Drumcliff Member. Layer of double, articulated valves of Isognomon maxillata right above knife handle. Locality 66-35, Pawpaw Hollow, western shore of Breton Bay, St. Marys County, Maryland.

Plate 11



PLATE 12: Lower Drumcliff Member at its type locality. Lower half of figure shows dominant Isognomon maxillata, also the coral, Astrhelia palmata, and the scallop, Placopeten marylandicus. Note reduced macrofossil bed above that, followed by an increased macrofossil bed. Drumcliff along the Patuxent River, St. Marys County, Maryland.

Plate 12

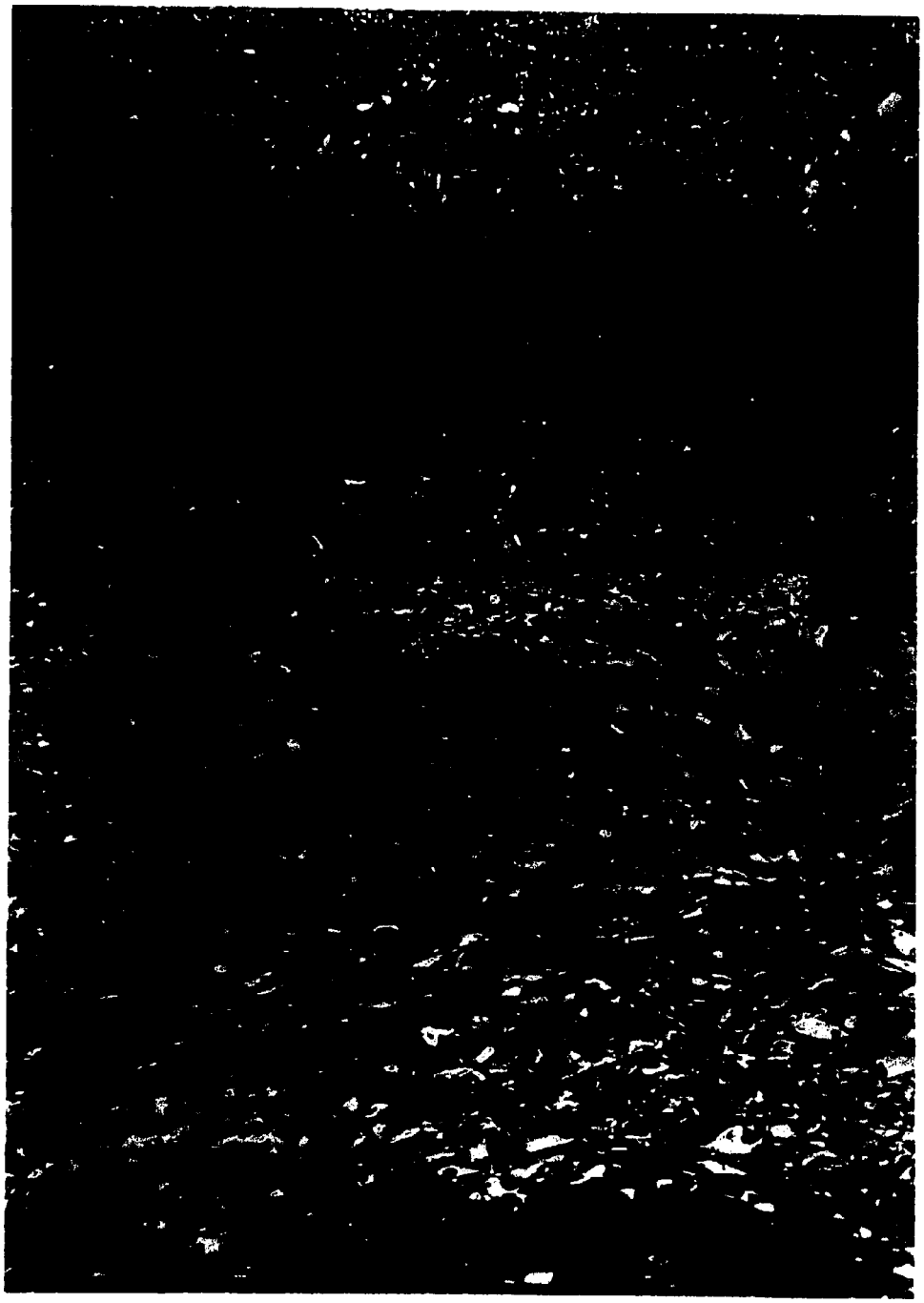


PLATE 13: Calvert Beach-Drumcliff transition at locality 66-5. Arbitrary boundary selected at horizon of knife. Calvert Cliffs, Calvert County, Maryland.

Plate 13



PLATE 14: Type section of the Drumcliff Member. Note distinct reduced and increased macrofossil beds. Increased shell beds form a somewhat more resistant ledge than reduced shell beds.

Reduced shell beds have fairly well sorted sands while increased shell beds contain sediments somewhat poorly sorted. Drumcliff along Patuxent River, St. Marys County, Maryland.

Plate 14

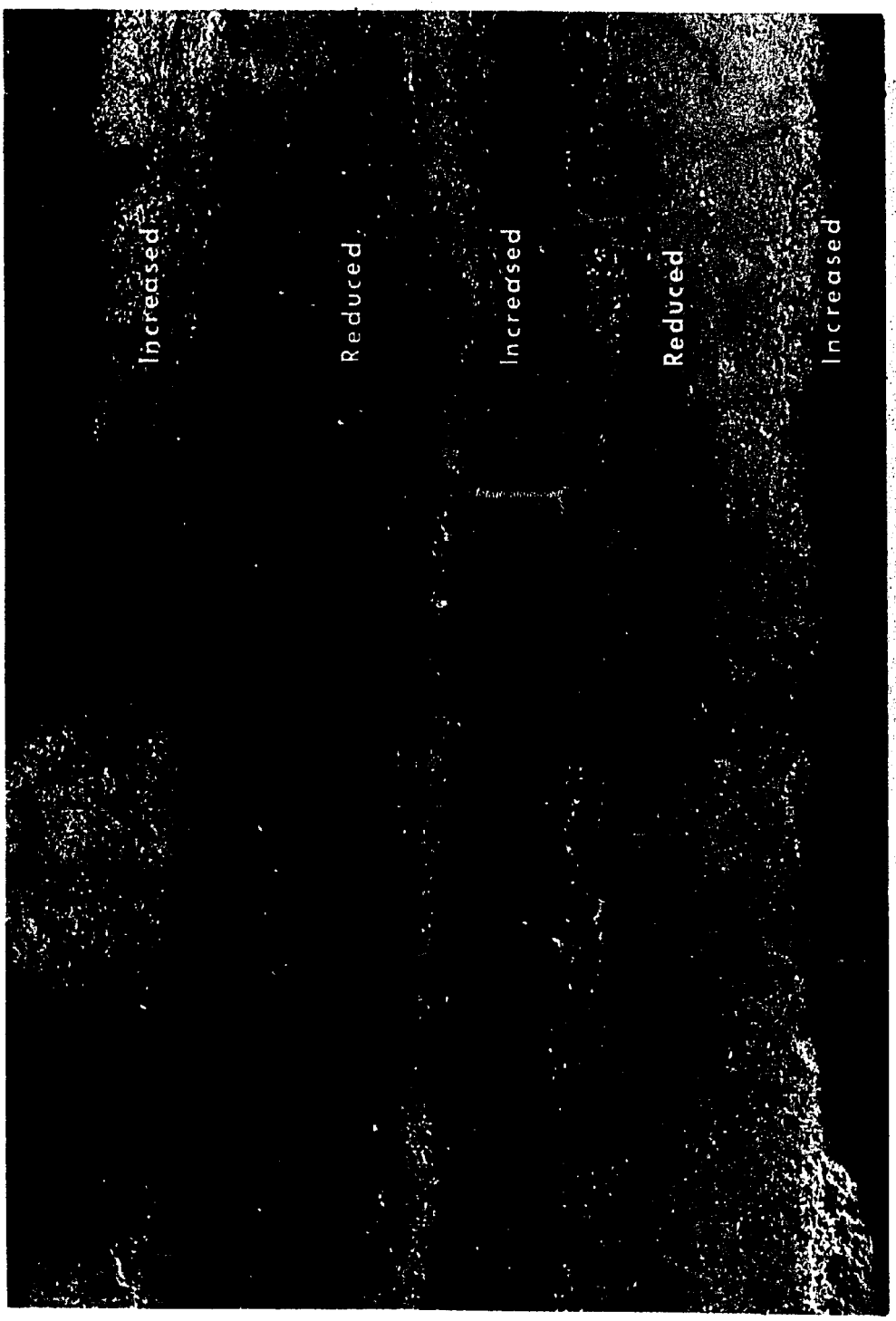


PLATE 15: Section from top of lower increased macrofossil bed of Plate 14 to lower part of central increased macrofossil bed. Drumcliff Member at Drumcliff along Patuxent River, St. Marys County, Maryland.

Plate 15

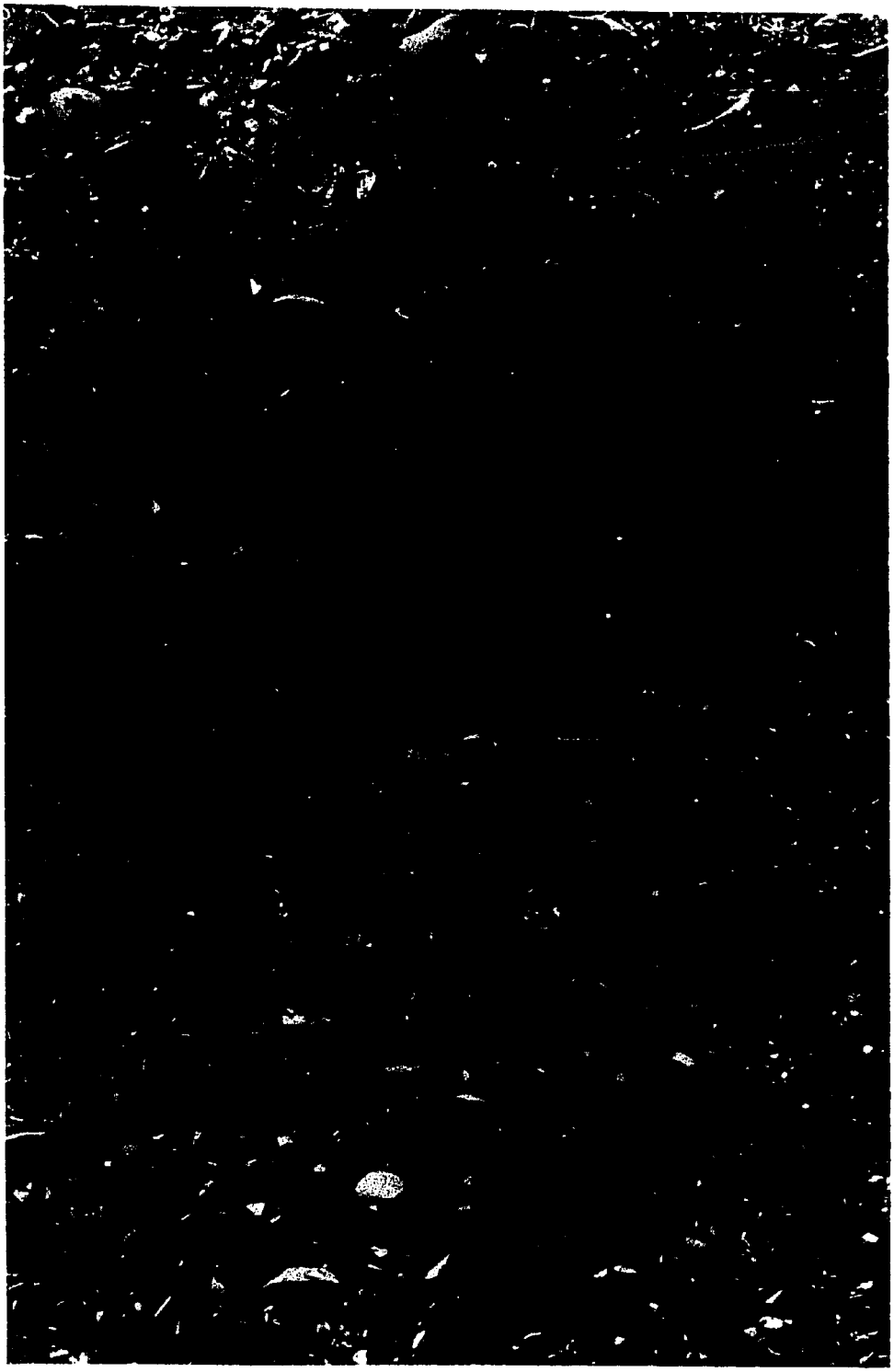


PLATE 16. From lower reduced up into central increased macrofossil bed. Drumcliff Member at Drumcliff along Patuxent River, St. Marys County, Maryland.

Plate 16

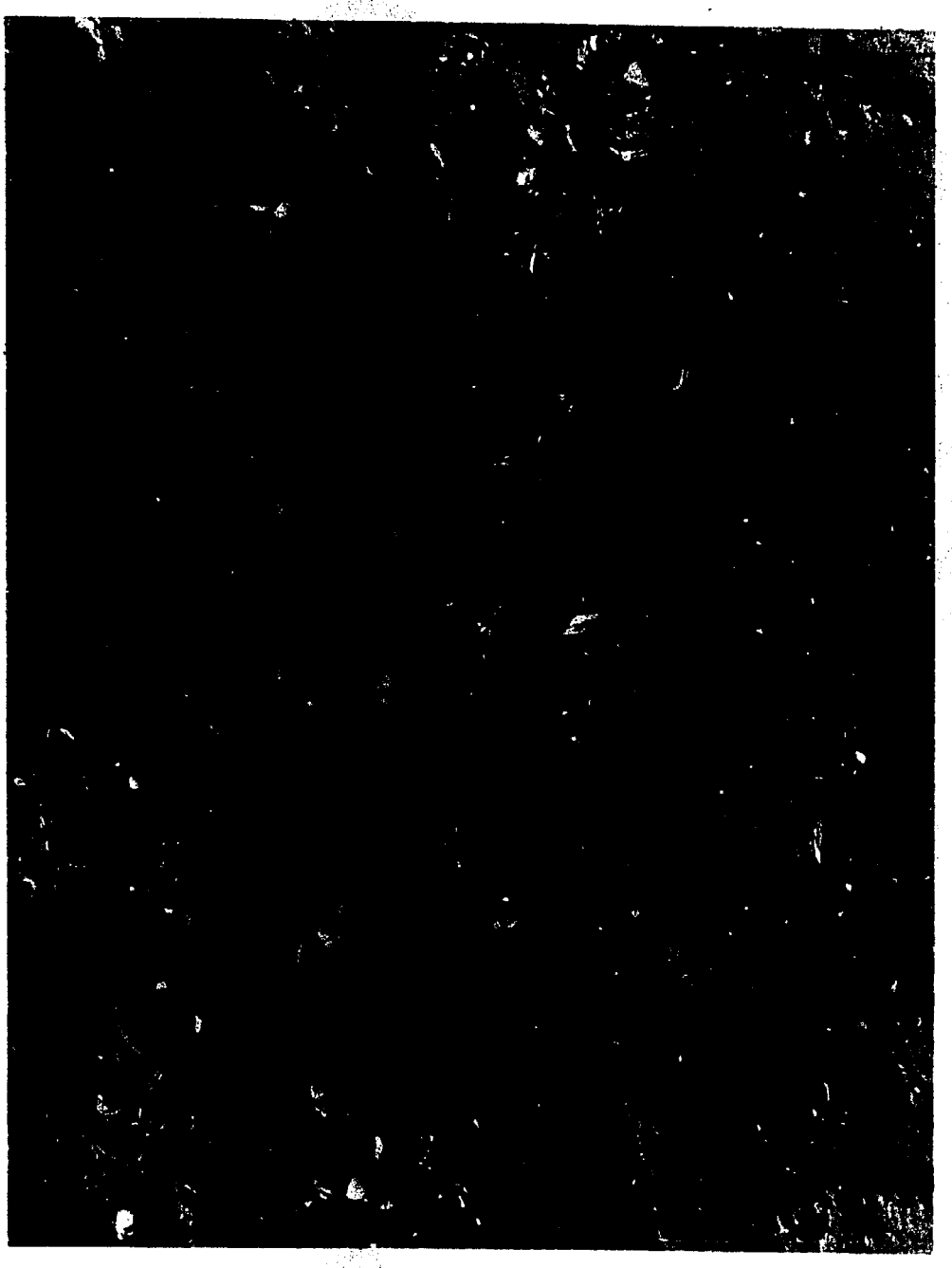


PLATE 17: Lower increased macrofossil bed with *Mercenaria* and *Cerastoderma* predominantly. Drumcliff Member at Drumcliff along Patuxent River, St. Marys County, Maryland.

Plate 17

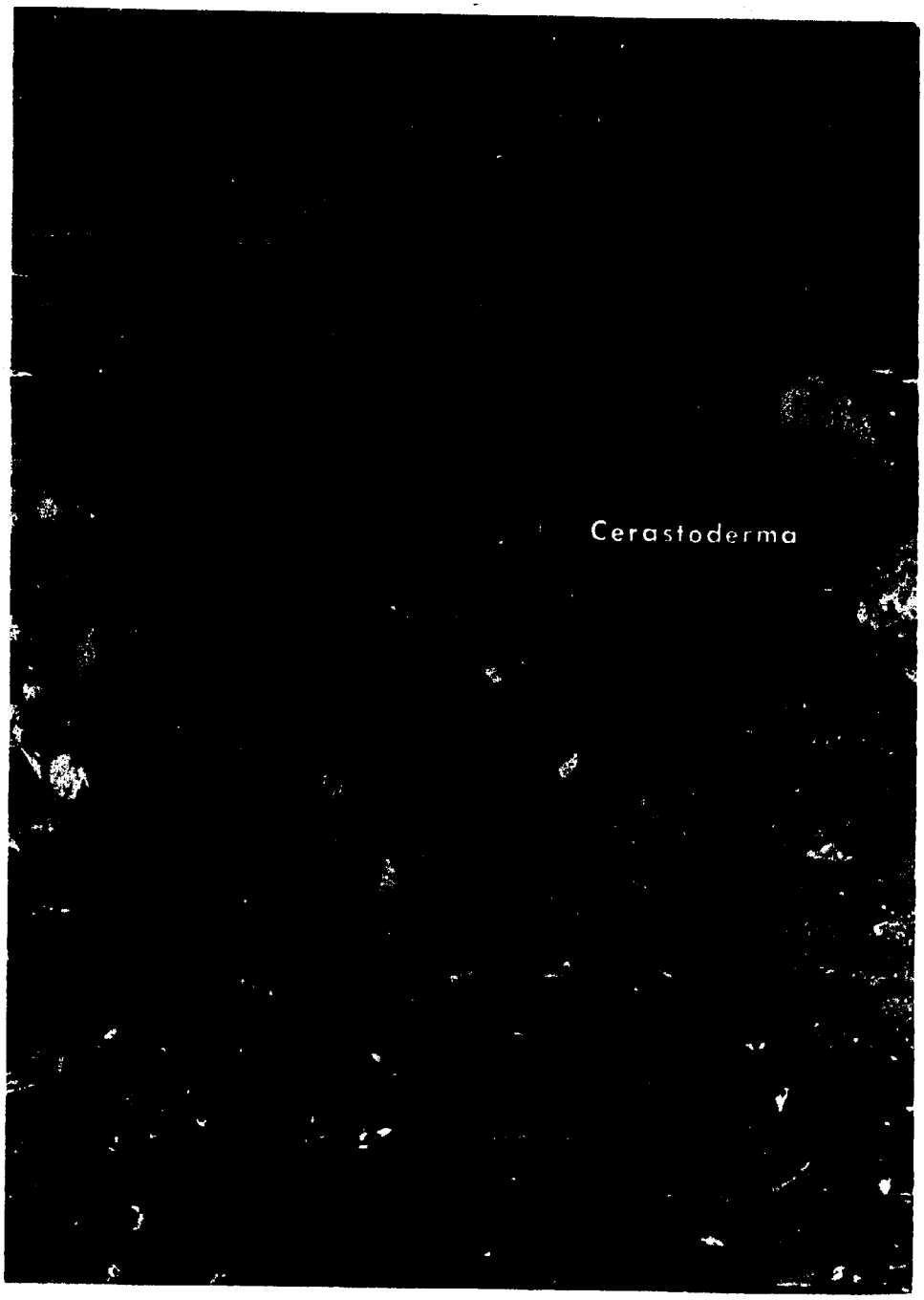


PLATE 18: Upper Isognomon ledge (also upper increased macrofossil bed at bottom of figure. Gradation upward to smaller sizes of shells. Upper Drumcliff Member at downstream end of Drumcliff, locality 67-61, St. Marys County, Maryland.

Plate 18

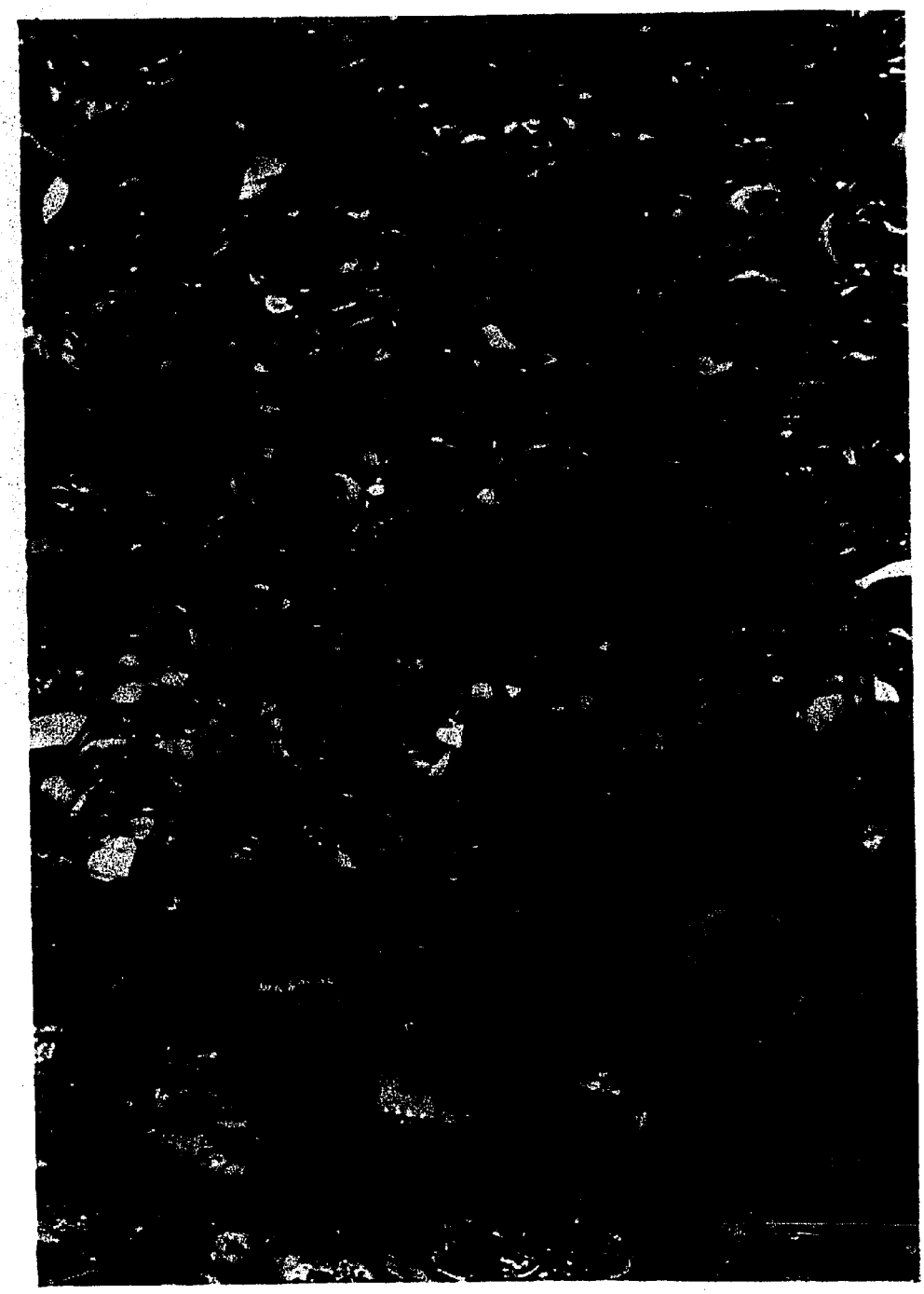


PLATE 19: Upper Drumcliff Member. Note reduced and increased macrofossil beds and Panope (marked by arrows) with articulated valves and in living position. Note St. Leonard channel into Drumcliff Member. Drumcliff along the Patuxent River, St. Marys County, Maryland.

Plate 19

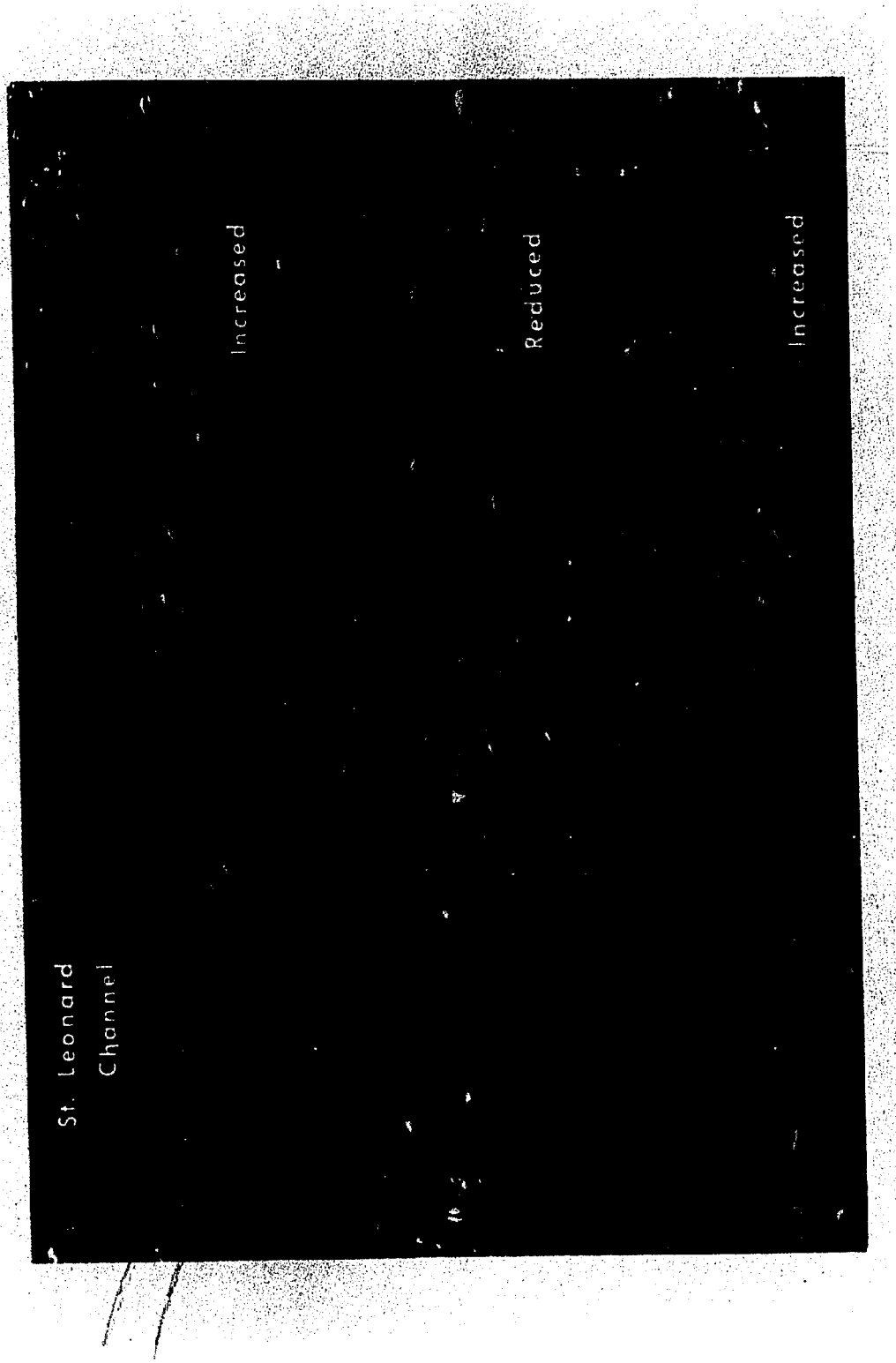


PLATE 20:

Figure 1: Panope americana with valves articulated and in living position. Drumcliff Member, locality 66-6, Calvert Cliffs, Calvert County, Maryland.

Figure 2: Anadara staminea, double valves open or askew from lower increased macrofossil bed. Boston Cliffs Member. Locality 66-23, Point of Rocks, Calvert Cliffs, Calvert County, Maryland.

Plate 20

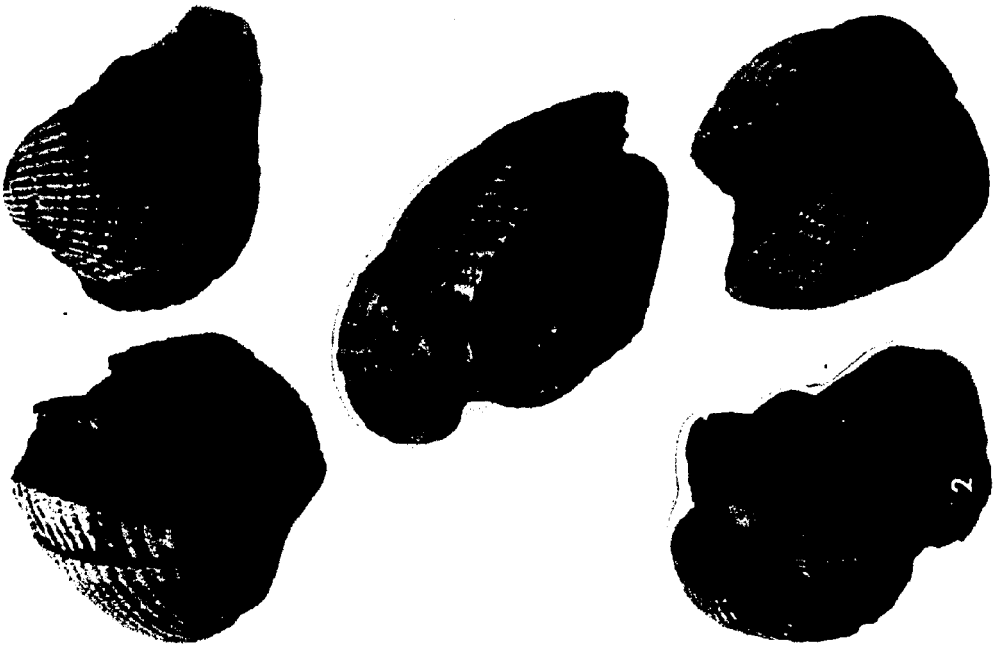




PLATE 21: Section at locality 66-19, downstream end of Drumcliff along the Patuxent River, St. Marys County, Maryland. Note strongly indurated increased macrofossil beds forming prominent ledges. Note reduced and increased macrofossil beds in Boston Cliffs Member (arrow with "r" points out reduced macrofossil bed and arrows with "i" point out increased macrofossil beds).

Plate 21

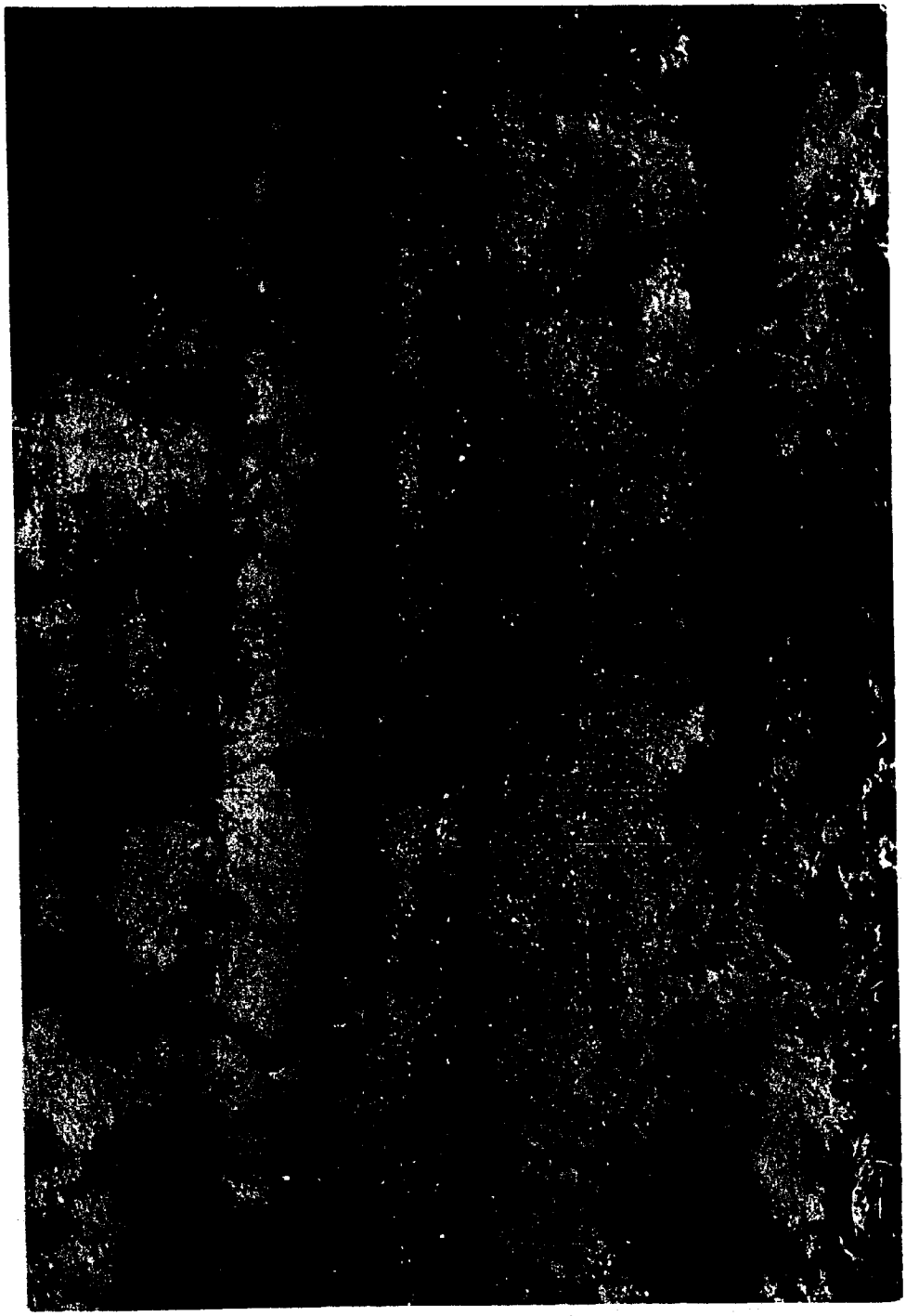


PLATE 22: Drumcliff Member with abundant Turritella plebeia at locality 66-34, Pawpaw Point on the eastern shore of Breton Bay, St. Marys County, Maryland.

Plate 22

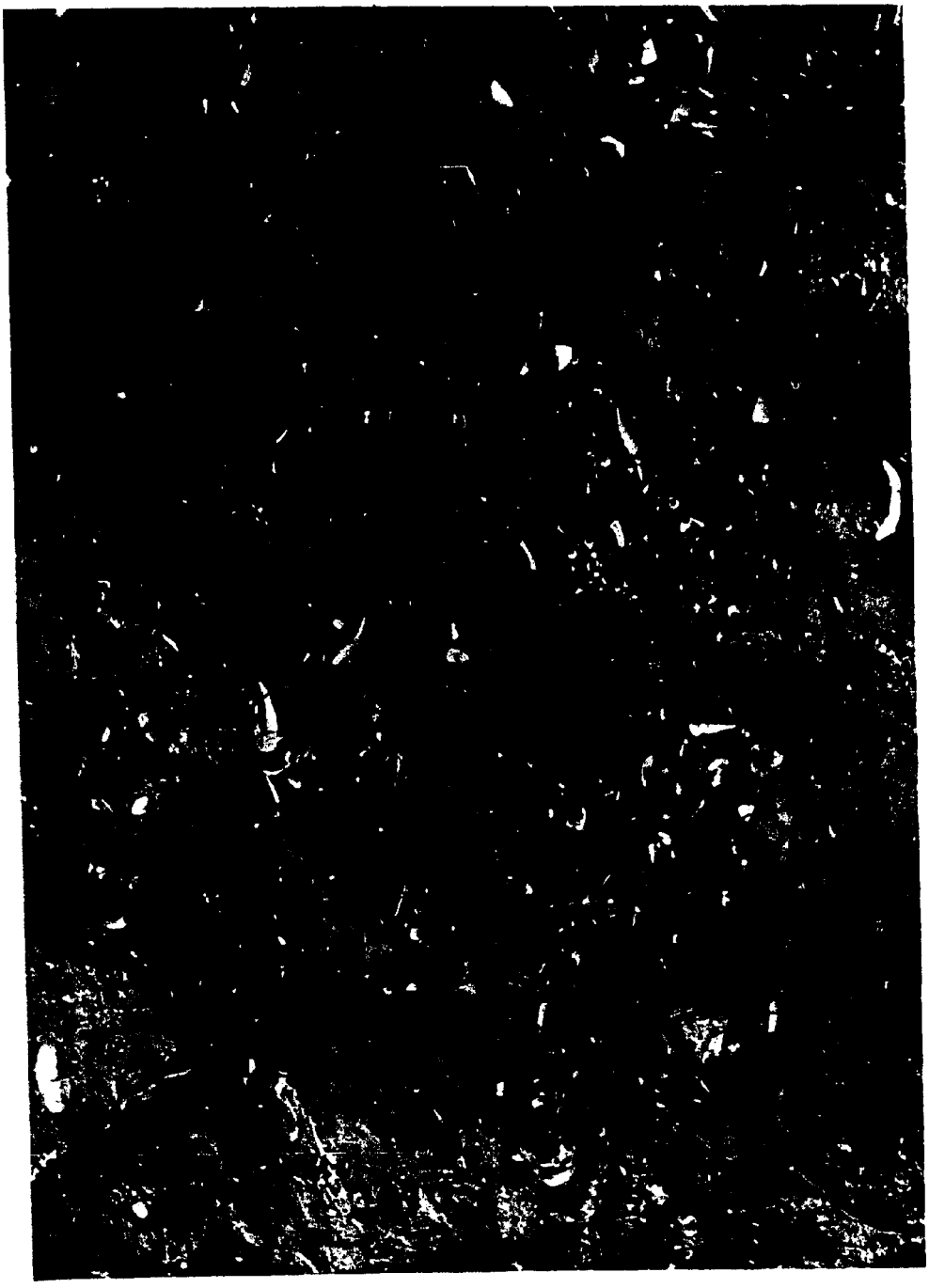


PLATE 23: One of the common lensoid pockets of the high-spired snail Turritella plebeia. Drumcliff Member. Locality 66-34, Pawpaw Point on the eastern shore of Breton Bay, St. Marys County, Maryland.

Plate 23

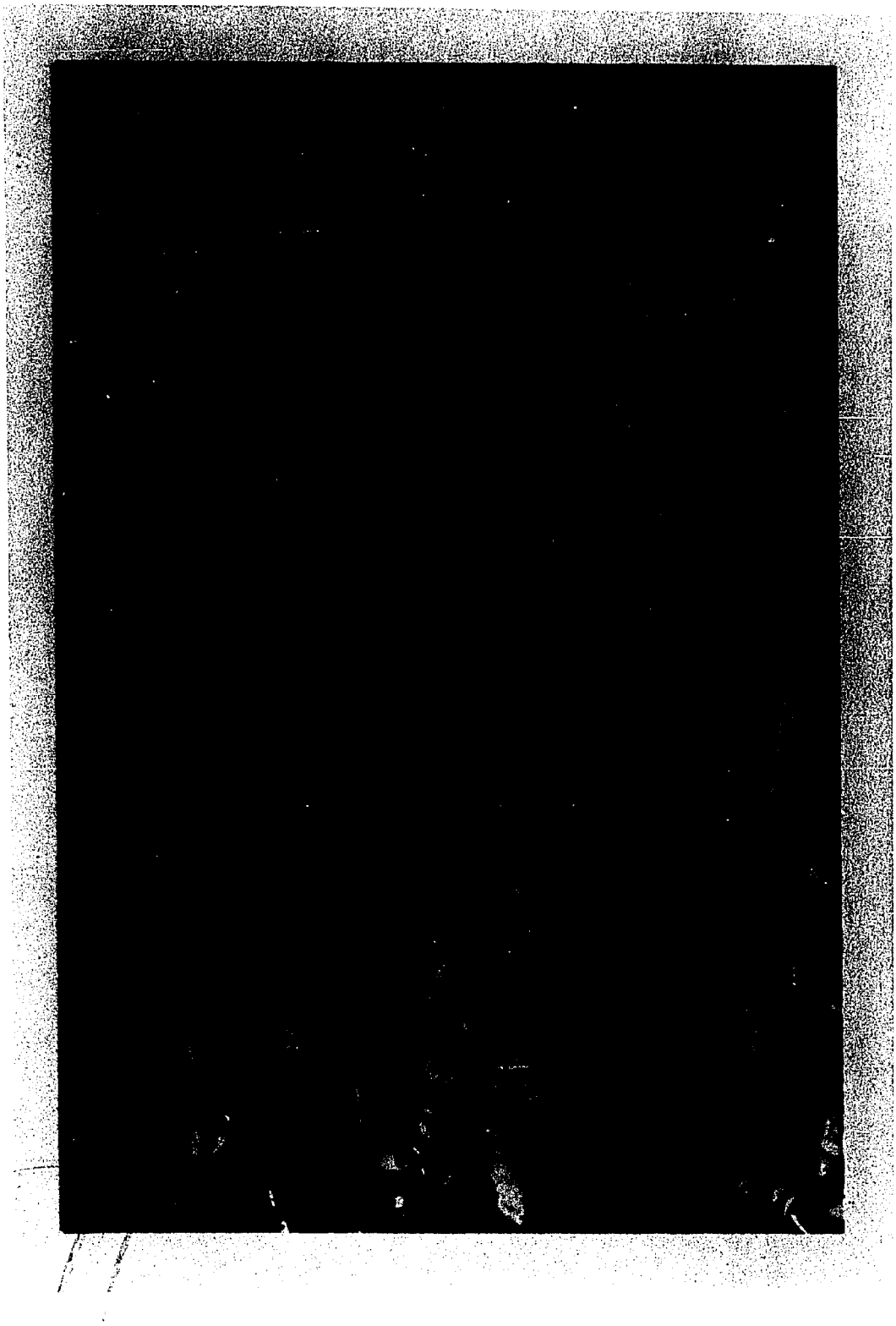


PLATE 24: Upper beds, Drumcliff Member. Discontinuous and variable thickness beds, including lensoid pockets of Turritella plebeia and of Glossus fraternus marylandicus - Turritella plebeia. Locality 66-6, Calvert Cliffs, Calvert County, Maryland.

Plate 24

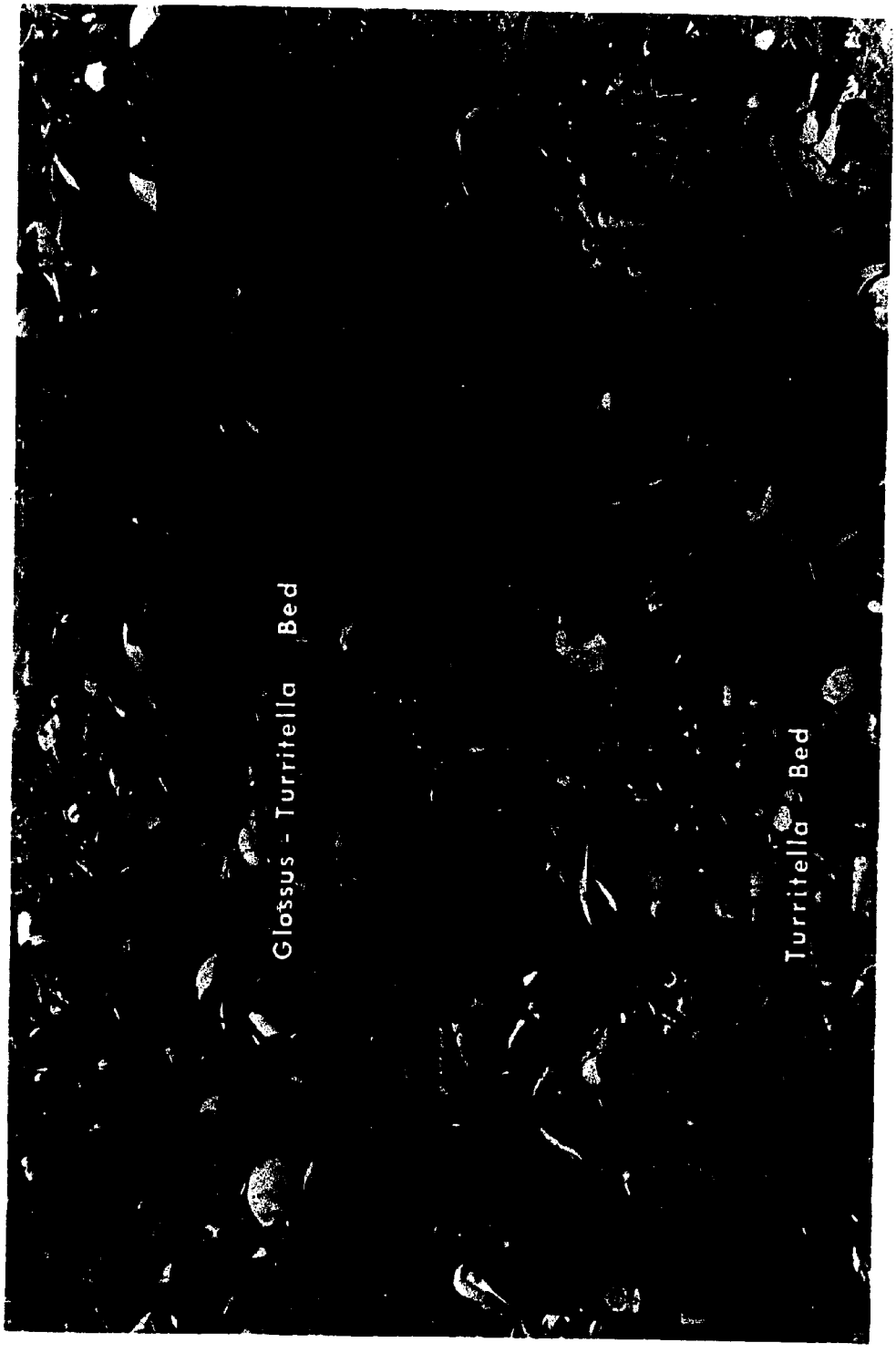


PLATE 25: Upper Drumcliff Member showing predominantly Cerastoderma laqueata, Turritella plebeia, and Anadara staminea. Locality 66-39, Mill Creek, St. Marys County, Maryland.

Plate 25

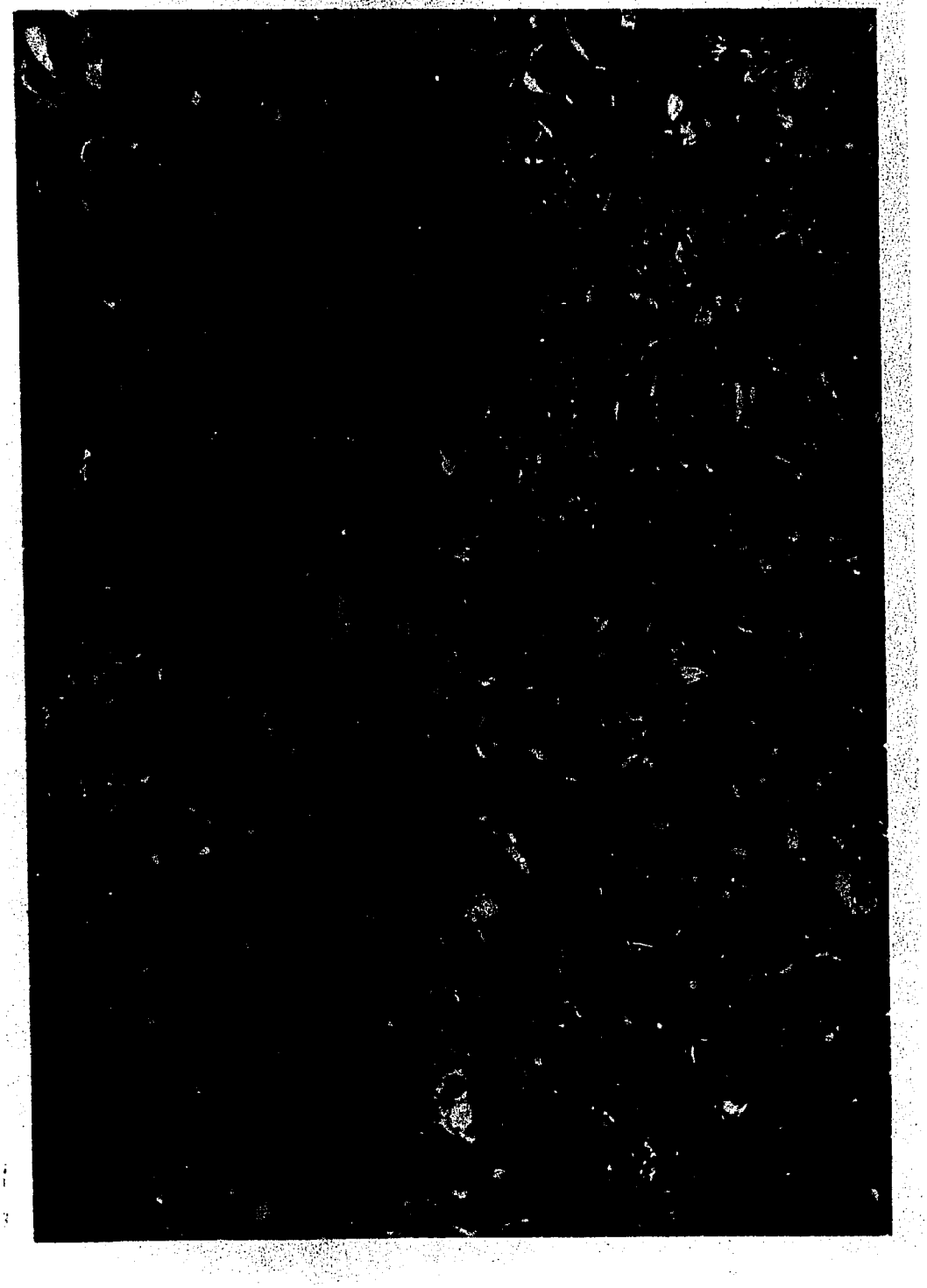


PLATE 26:

Figure 1: Section at Mackall's Landing, locality 66-43, on the west bank of St. Leonard Creek, Calvert County, Maryland. Note thick section of heavily indurated Drumcliff Member.

Figure 2: Crab burrows containing concentrations of mollusks in upper Drumcliff Member. Lowest St. Leonard visible above. Locality 66-10.

Plate 26

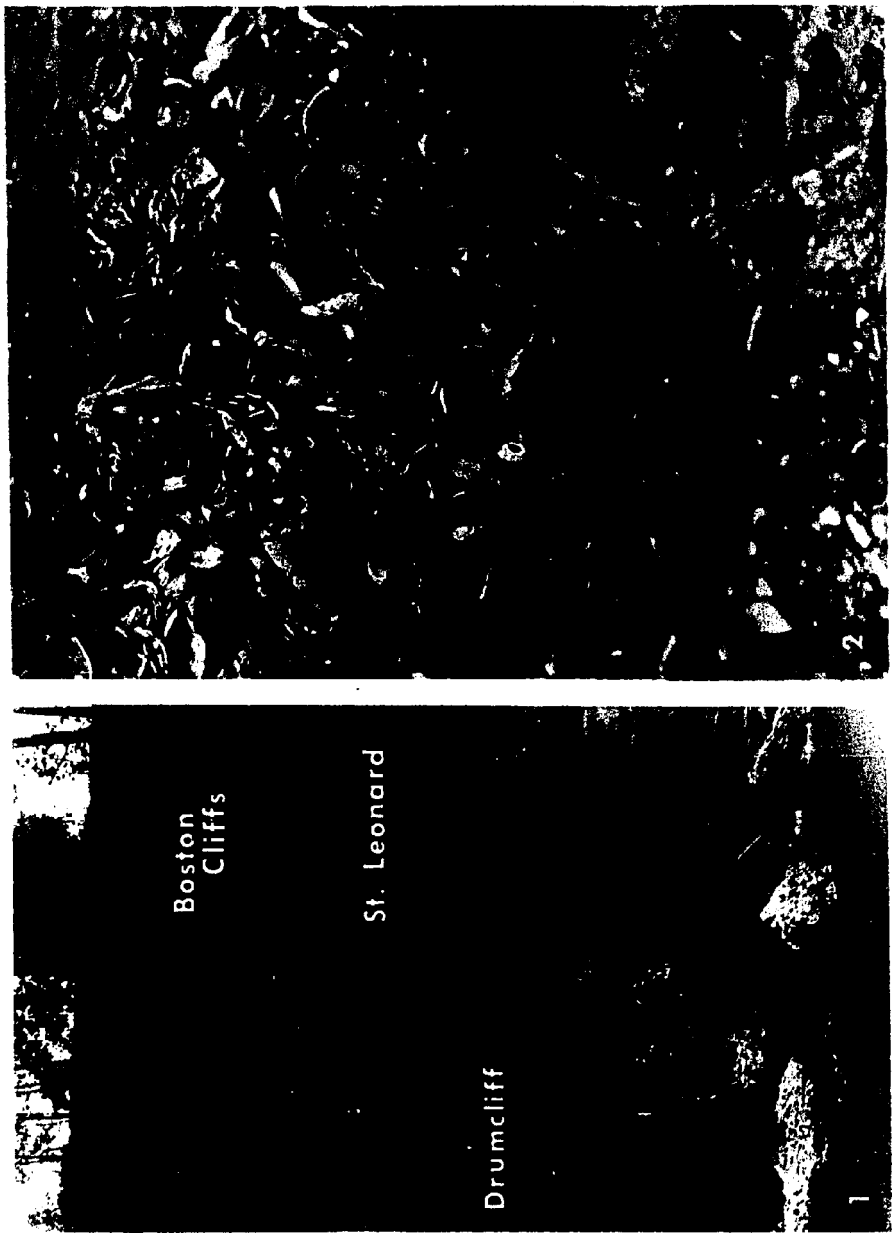


PLATE 27: Drumcliff Member and St. Leonard Member at Breedens Point on the east bank of St. Leonard Creek, Calvert County, Maryland. Approximately the lower two-thirds of the Drumcliff is dominanted by Isognomon maxillata. Above that shell size decreases to the St. Leonard.

Plate 27

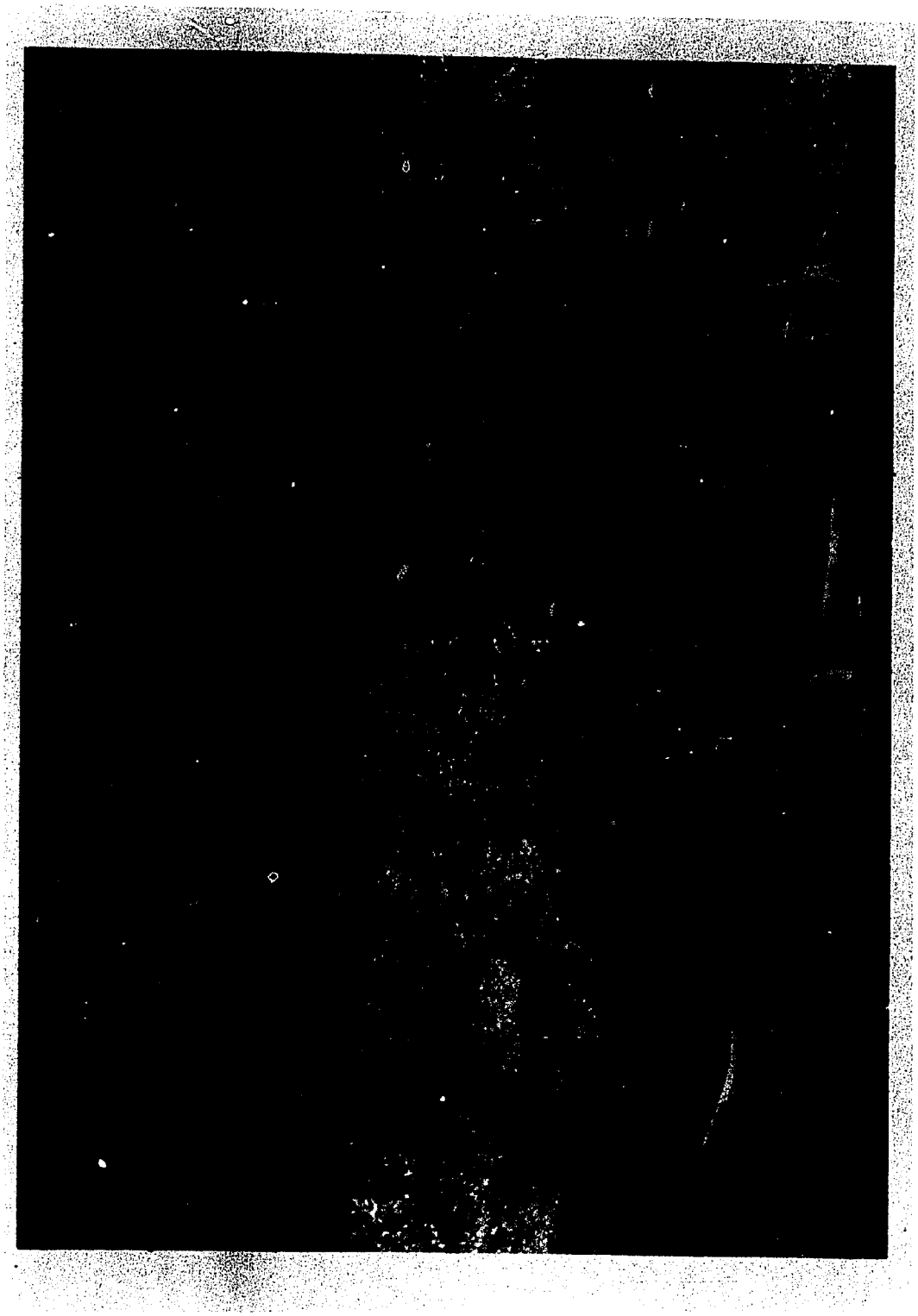


PLATE 28: Biogenic sedimentary structures in St. Leonard Member between Flag Ponds and Camp Conoy, Calvert County, Maryland.

Figure 1: Bivalve burrow and wavy laminations.

Figure 2: Polychaete? tube and wavy laminations.

Plate 28

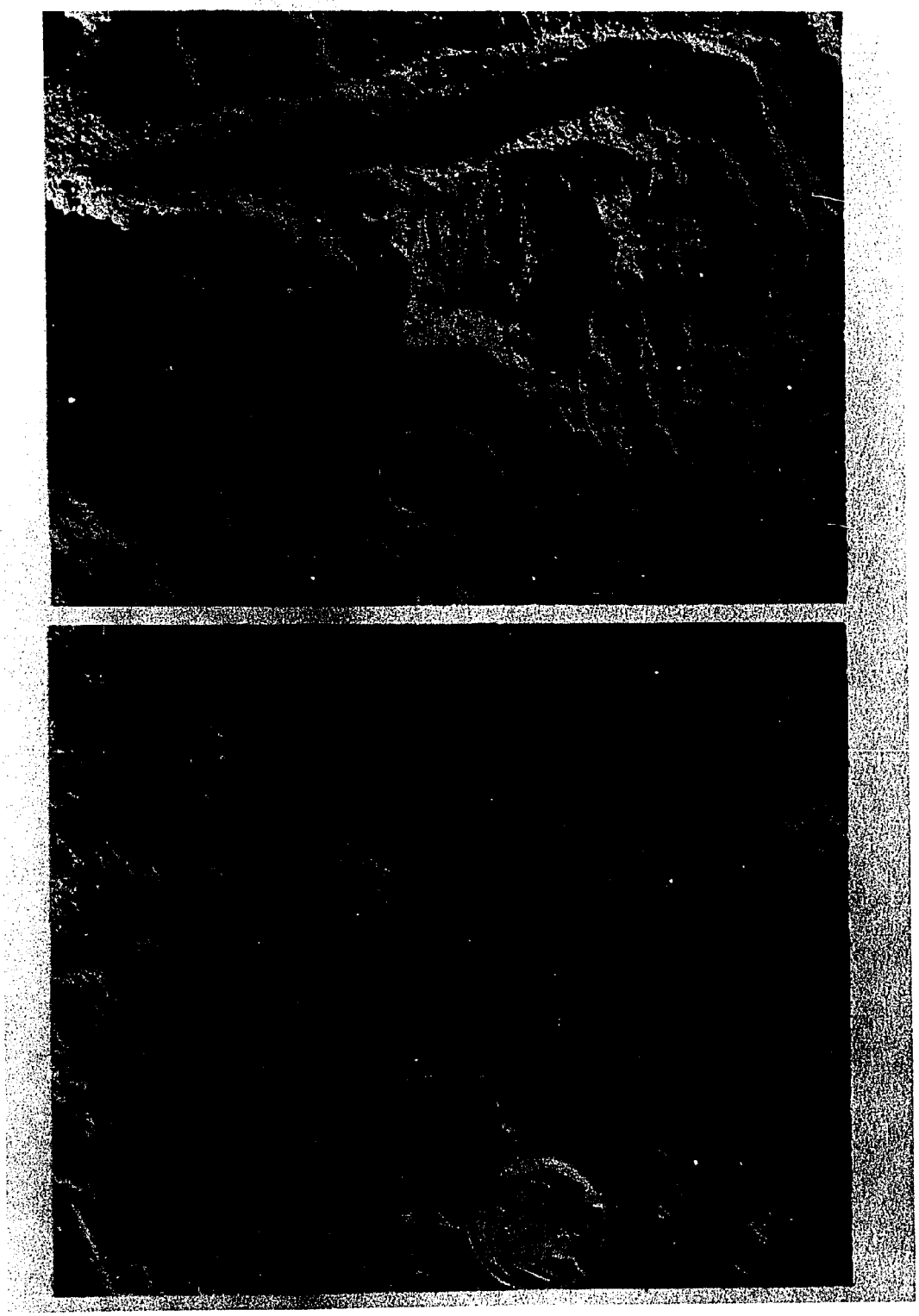


PLATE 29: Biogenic sedimentary structures in St. Leonard Member between Camp Conoy and 67-51, Calvert Cliffs, Calvert County, Maryland.

Figure 1: Prominent bivalve multi-walled, slime-lined burrow and biogenically disturbed sedimentary laminations.

Figure 2: "Corkscrew" burrow of unknown origin and wavy laminations.

Figure 3: Slime-lined, multi-walled burrow with nodose exterior.

Plate 29

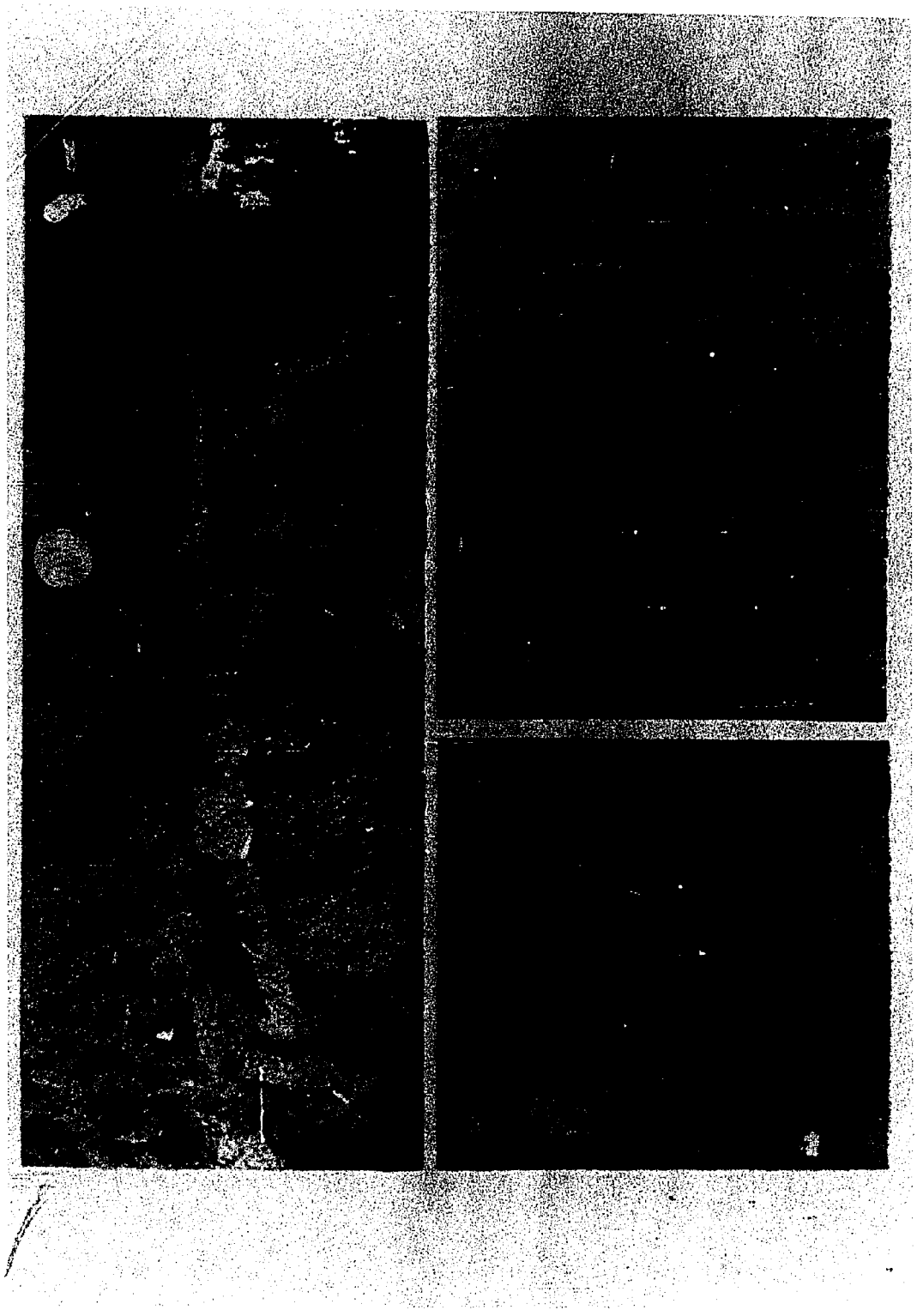


PLATE 30: Knife in outcrop (lower right corner) marks arbitrary boundary between St. Leonard Member (below) and Boston Cliffs Member (above). Close-up of scraped area in Plate 31. Note near vertical cliff formed by Boston Cliffs Member and break in slope below and above marking the approximate contact with the St. Leonard and Conoy Members, respectively. Note increased and reduced macrofossil beds in the Boston Cliffs. Principal reference section for formation, locality 66-5, Calvert Cliffs, Calvert County, Maryland.

Plate 30

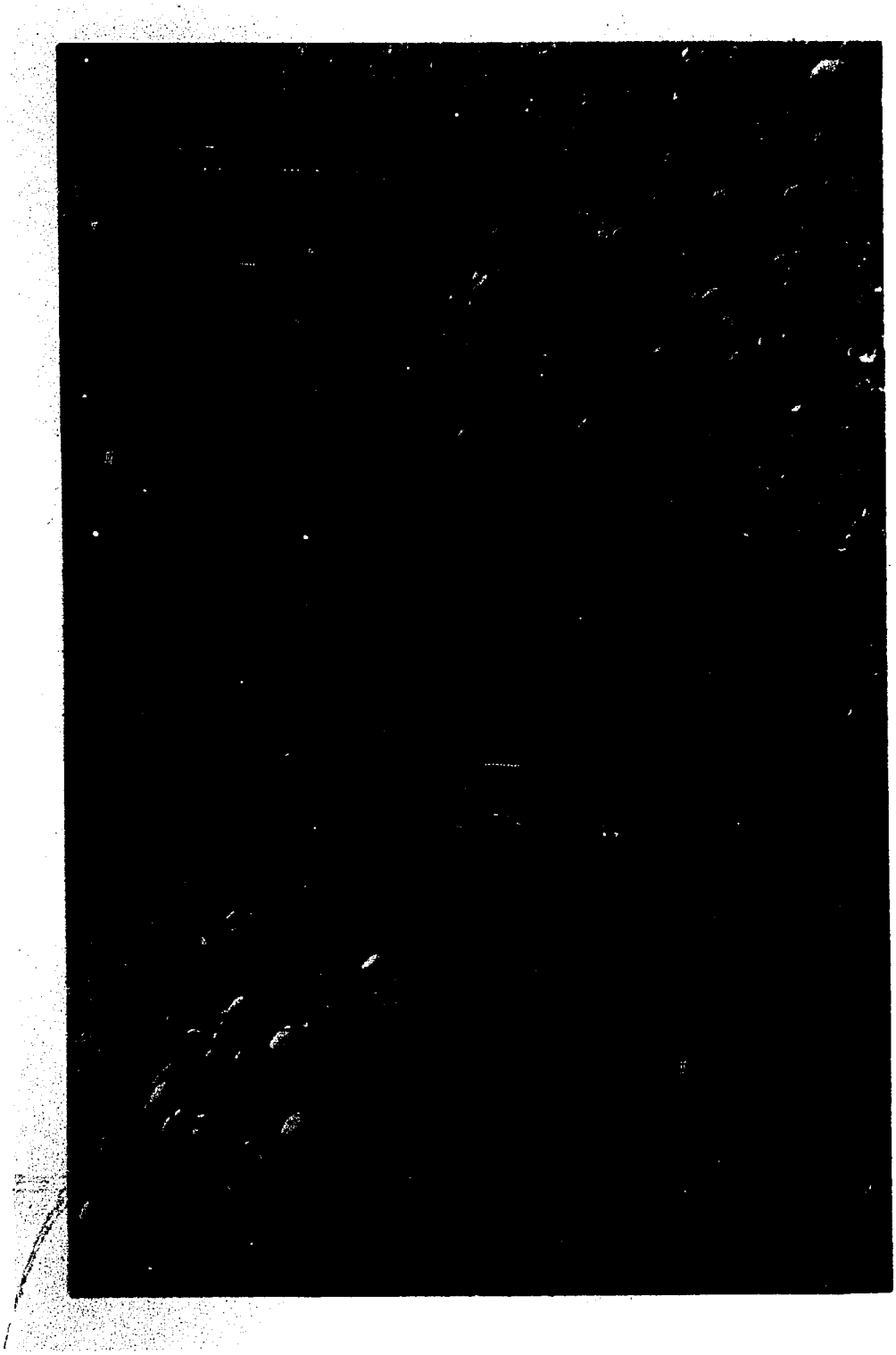


PLATE 31: Knife stuck in arbitrary boundary between St. Leonard and Boston Cliffs Members. (Close up of scraped area in lower right Plate 30.) Principal reference section for formation, locality 66-5, Calvert Cliffs, Calvert County, Maryland.

Plate 31

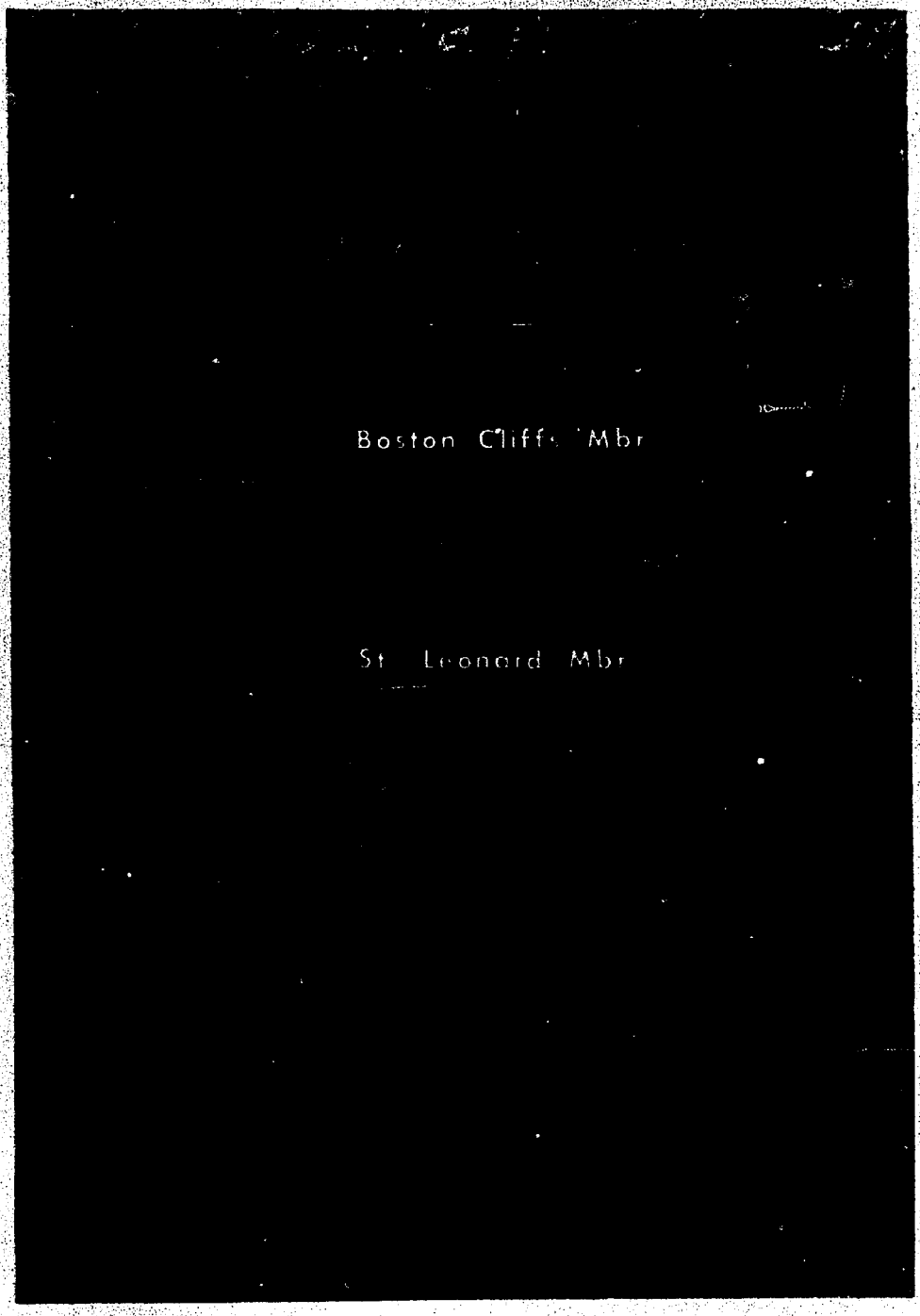


PLATE 32: Type section of Choptank Formation and Boston Cliffs Member. Writer's hands mark bottom and top of reduced macrofossil bed. Locality 66-12, Boston Cliffs along Choptank River, Talbot County, Maryland.

Plate 32



PLATE 33: Lowest portion of Boston Cliffs Member exposed in vicinity of type section. Densely packed fossils, predominantly Crassostrea carolinensis, also with Isognomon maxillata. Water in foreground is Choptank River. Locality 67-79, Choptank River, Talbot County, Maryland.

Plate 33



PLATE 34: Lower increased macrofossil bed with many of the larger fossils Dosinia acetabula. First plate of three showing vertical sequence of views of the type section of Boston Cliffs Member and Choptank Formation. Locality 66-12, Boston Cliffs along Choptank River, Talbot County, Maryland.

Plate 34



PLATE 35: Lower increased and reduced macrofossil beds. Second plate of three showing vertical sequence at type section of Boston Cliffs Member and Choptank Formation. Locality 66-12, Boston Cliffs along Choptank River, Talbot County, Maryland.

Plate 35

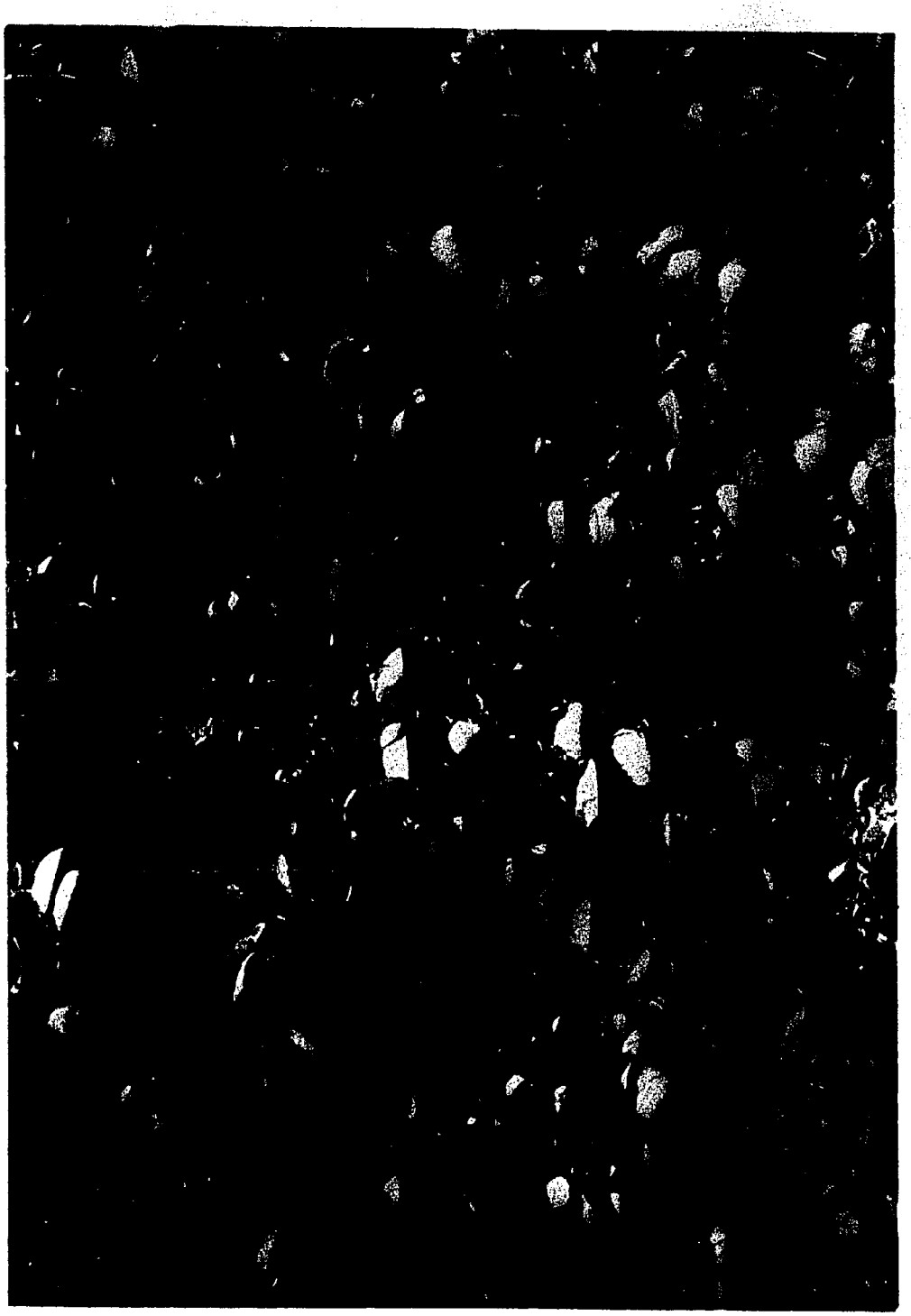


PLATE 36: In vertical sequence: reduced, increased, and upper "hashy" macrofossil beds grading upward into indurated sequence. Third plate of three showing vertical sequence at type section of Boston Cliffs Member and Choptank Formation. Locality 66-12, Boston Cliffs along Choptank River, Talbot County, Maryland.

Plate 36

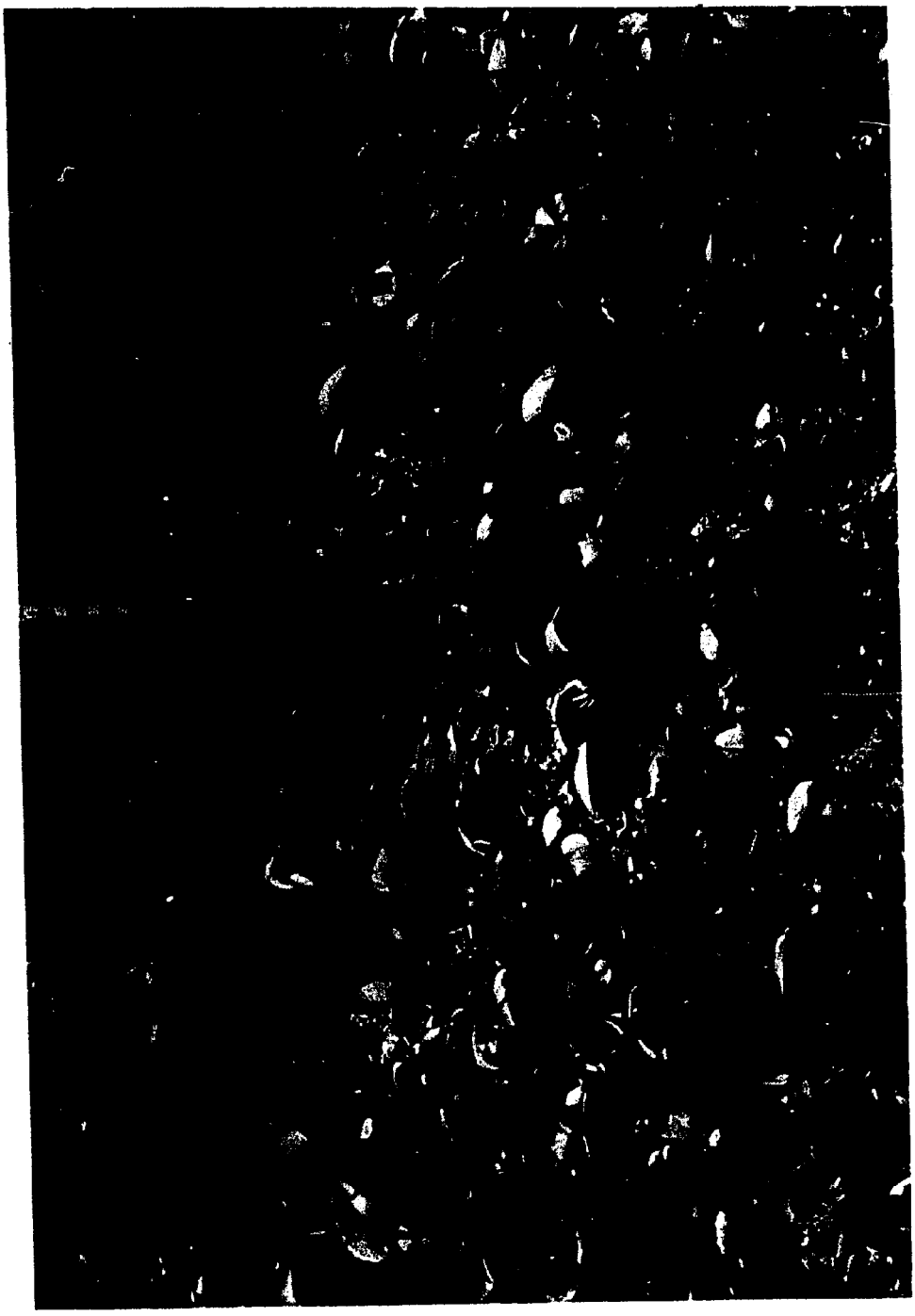


PLATE 37: Boston Cliffs Member from upper portion of lower increased macrofossil bed to about the base of the sequence of indurated beds. Note thin band of Anadara staminea in top of lower increased macrofossil bed. Note predominant flat-lying, convex-upward orientation of bivalves. Note partially reduced macrofossils above lower part of upper increased macrofossil bed. About one half mile south of Camp Conoy, Calvert Cliffs, Calvert County, Maryland.

Plate 37

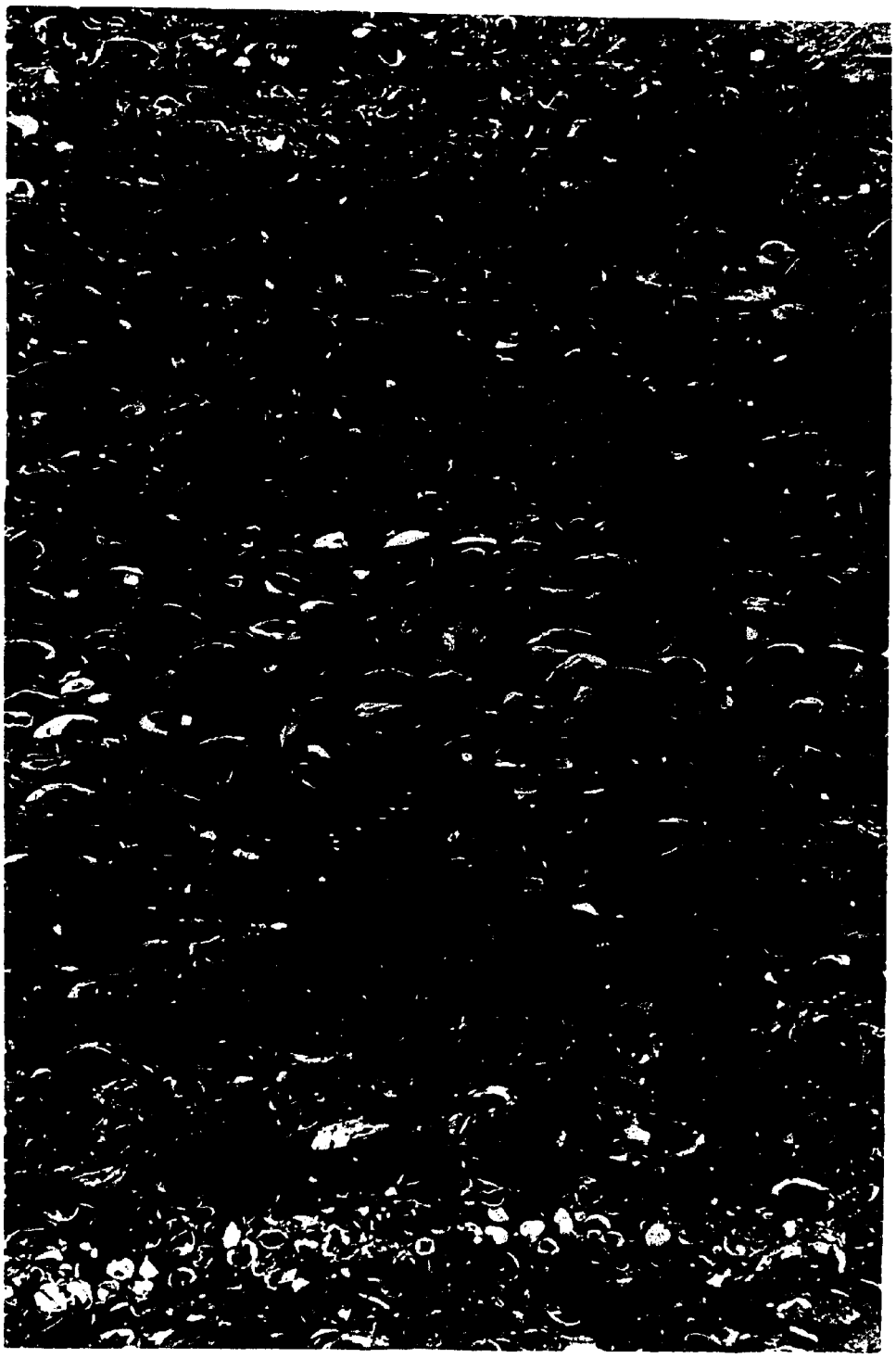


PLATE 38: Boston Cliffs Member. Note increased and reduced macrofossil beds. Note preponderance of Anadara staminea at top of lower increased macrofossil bed. Approximately one half mile south of Camp Conoy, Calvert Cliffs, Calvert County, Maryland.

Plate 38

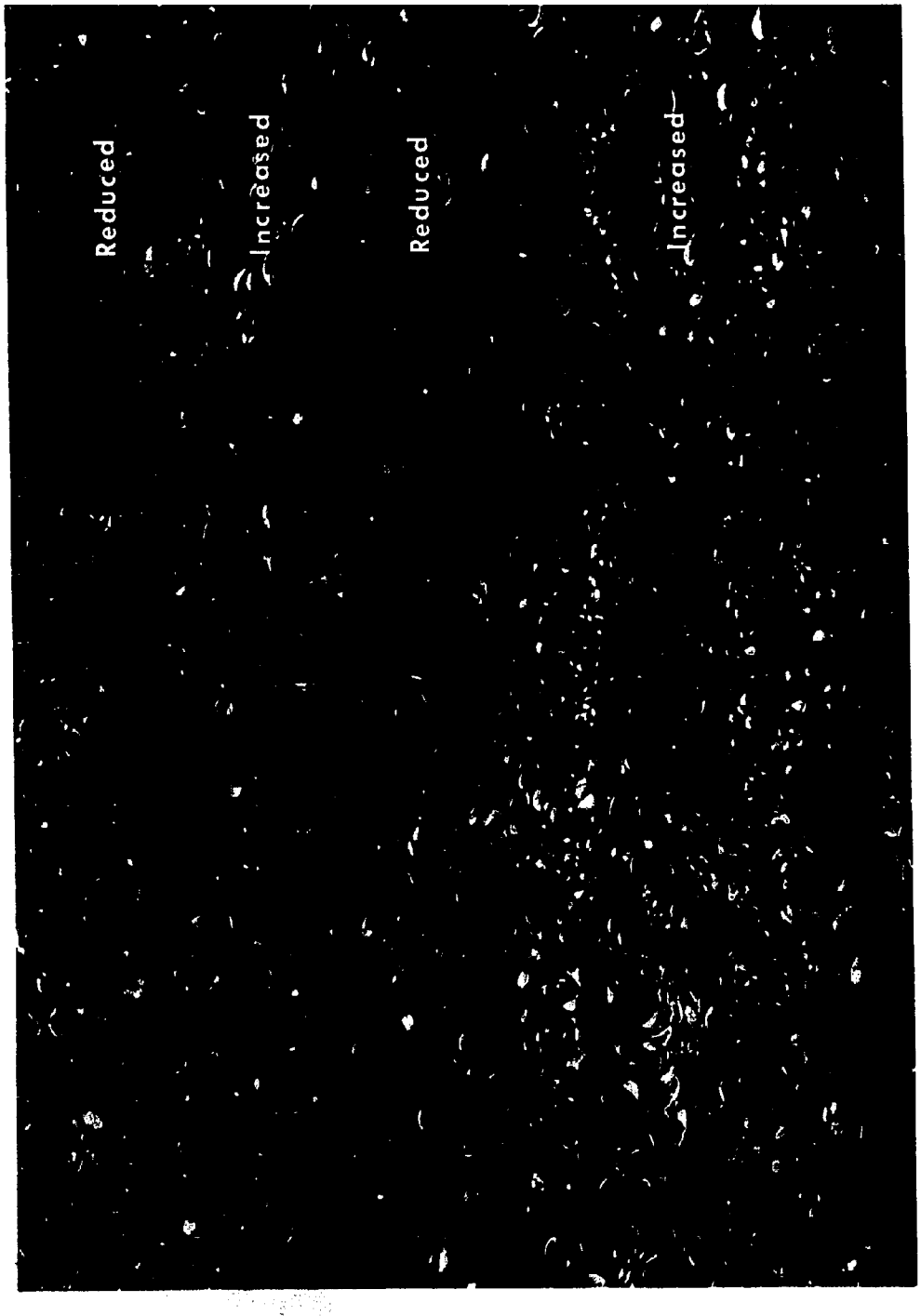


PLATE 39: Boston Cliffs Member about half of a mile south of Camp Conoy Y. M. C. A., Calvert Cliffs, Calvert County, Maryland. Note large scale corss stratification in shells (predominantly Anadara staminea) in lower increased macrofossil bed.

Plate 39

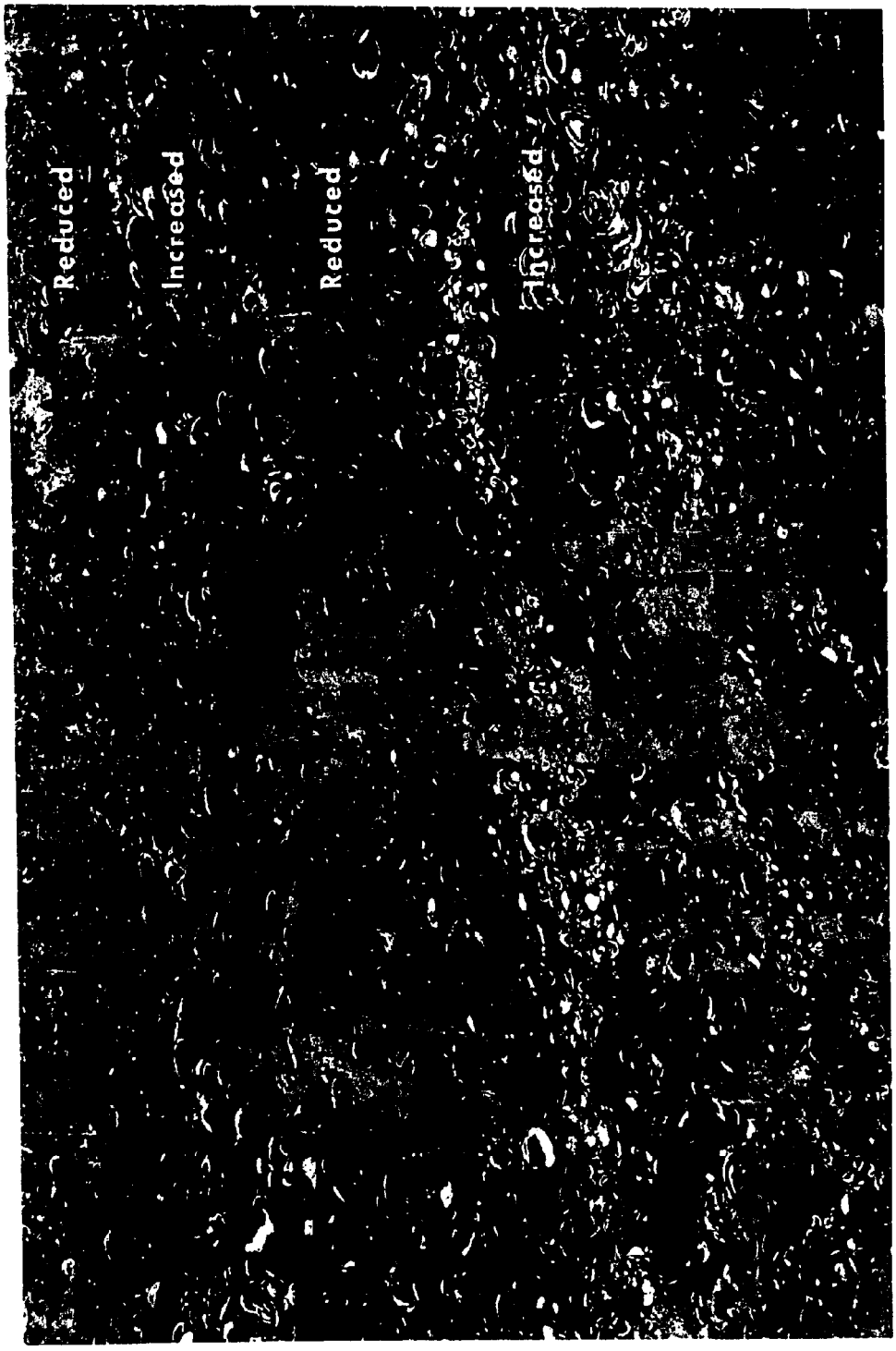


PLATE 40: Lower increased macrofossil bed at bottom of figure. Note double but partly open Anadara staminea. Central three-fourths of figure shows reduced macrofossil bed. Upper portion of figure shows upper increased macrofossil bed. Cross section of larger fossils are Cerastoderma laqueata and Macrocallista marylandica. Boston Cliffs Member. Approximately half a mile south of Camp Conoy Y. M. C. A., Calvert Cliffs, Calvert County, Maryland.

Plate 40

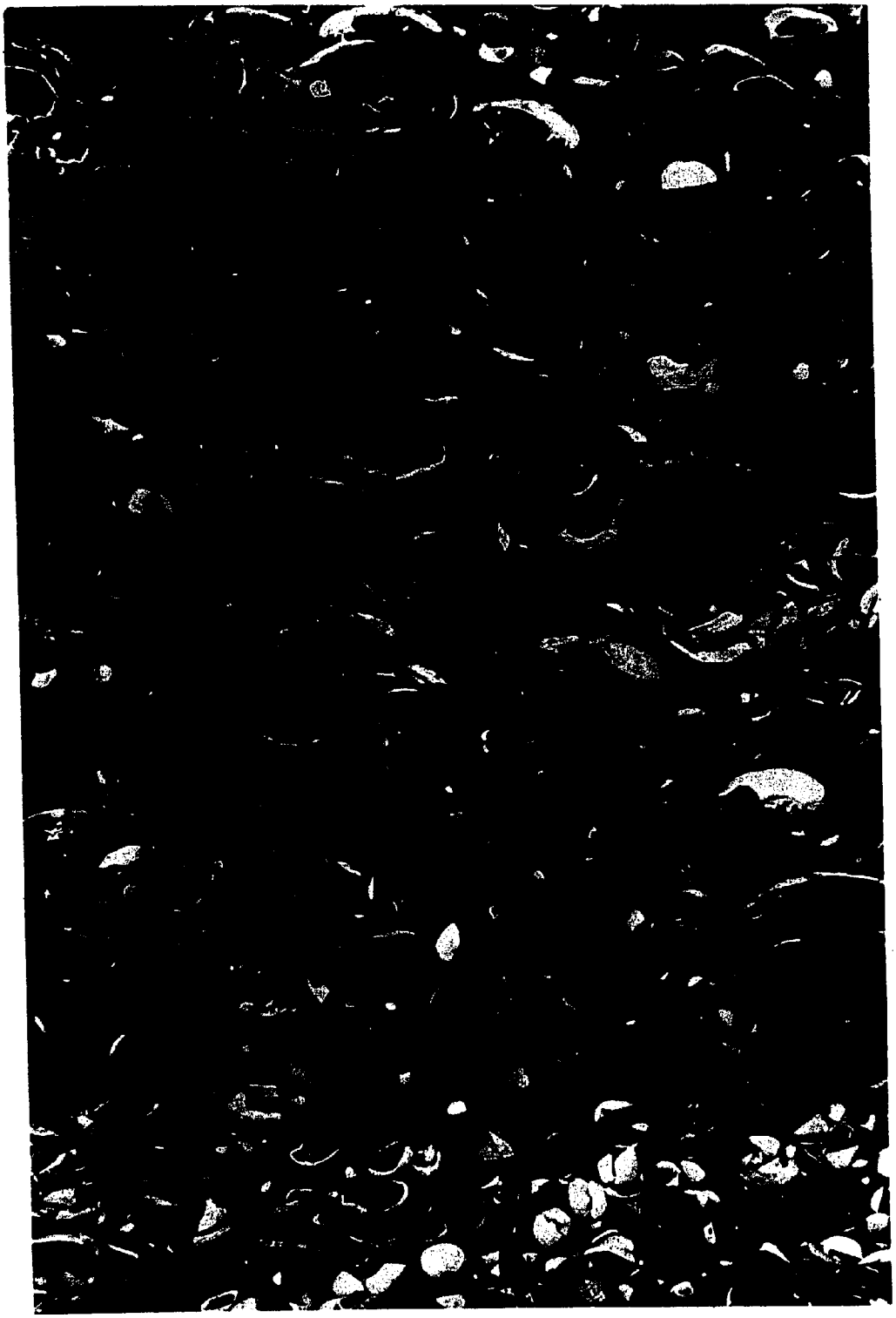


PLATE 41:

Figure 1: Close-up of double Anadara staminea in Plate 40. Note maximum ligamental opening.

Figure 2: Scour and fill sedimentary structures. St. Leonard Member. Between Flag Ponds and Camp Conoy, Calvert Cliffs, Calvert County, Maryland.

Plate 41

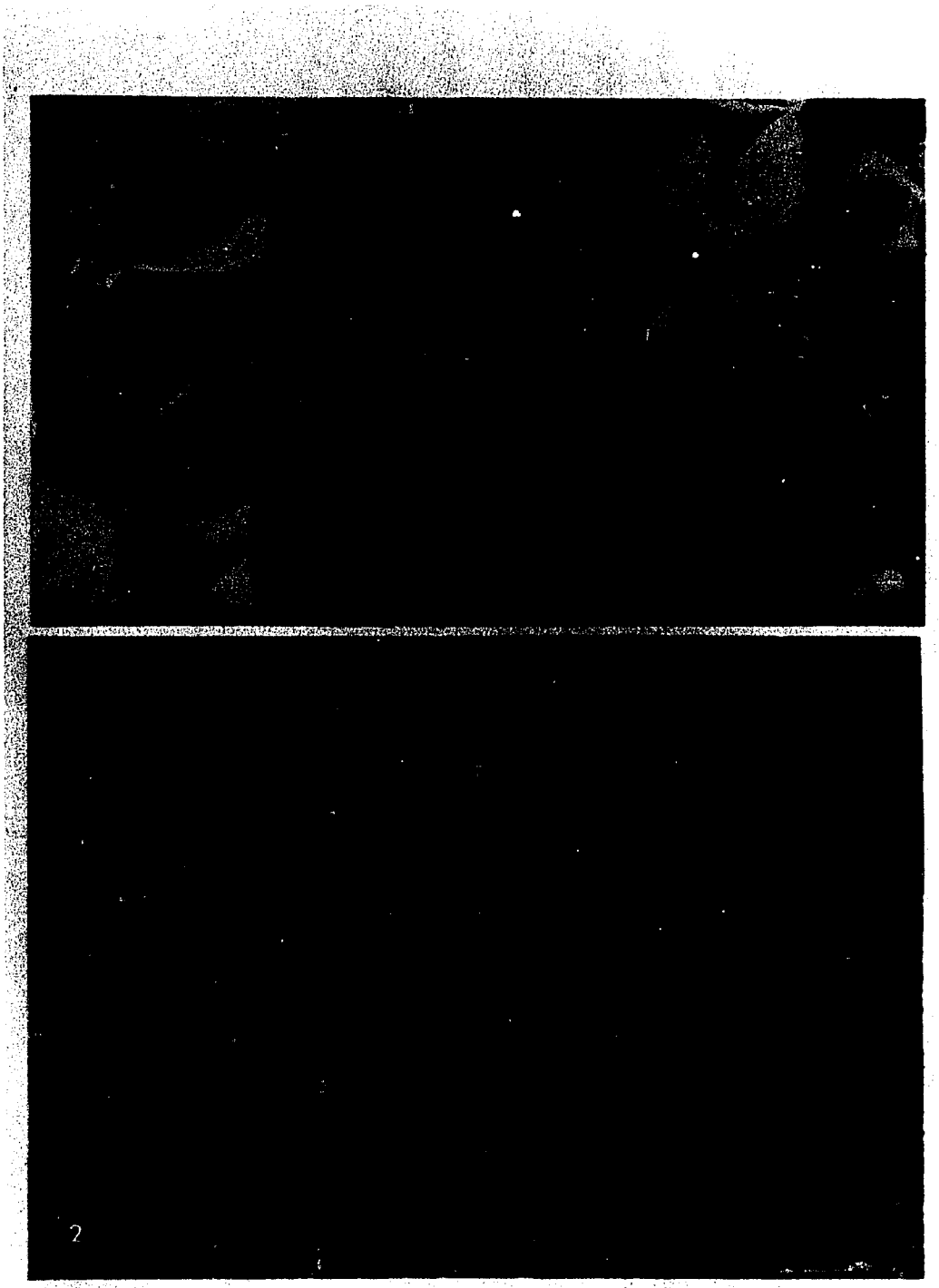


PLATE 42: Upper increased macrofossil bed of Boston Cliffs Member. Cross sections are mostly Macrocallista marylandica and Crassatella marylandica. Approximately half a mile south of Camp Conoy, Calvert Cliffs, Calvert County, Maryland.

Plate 42

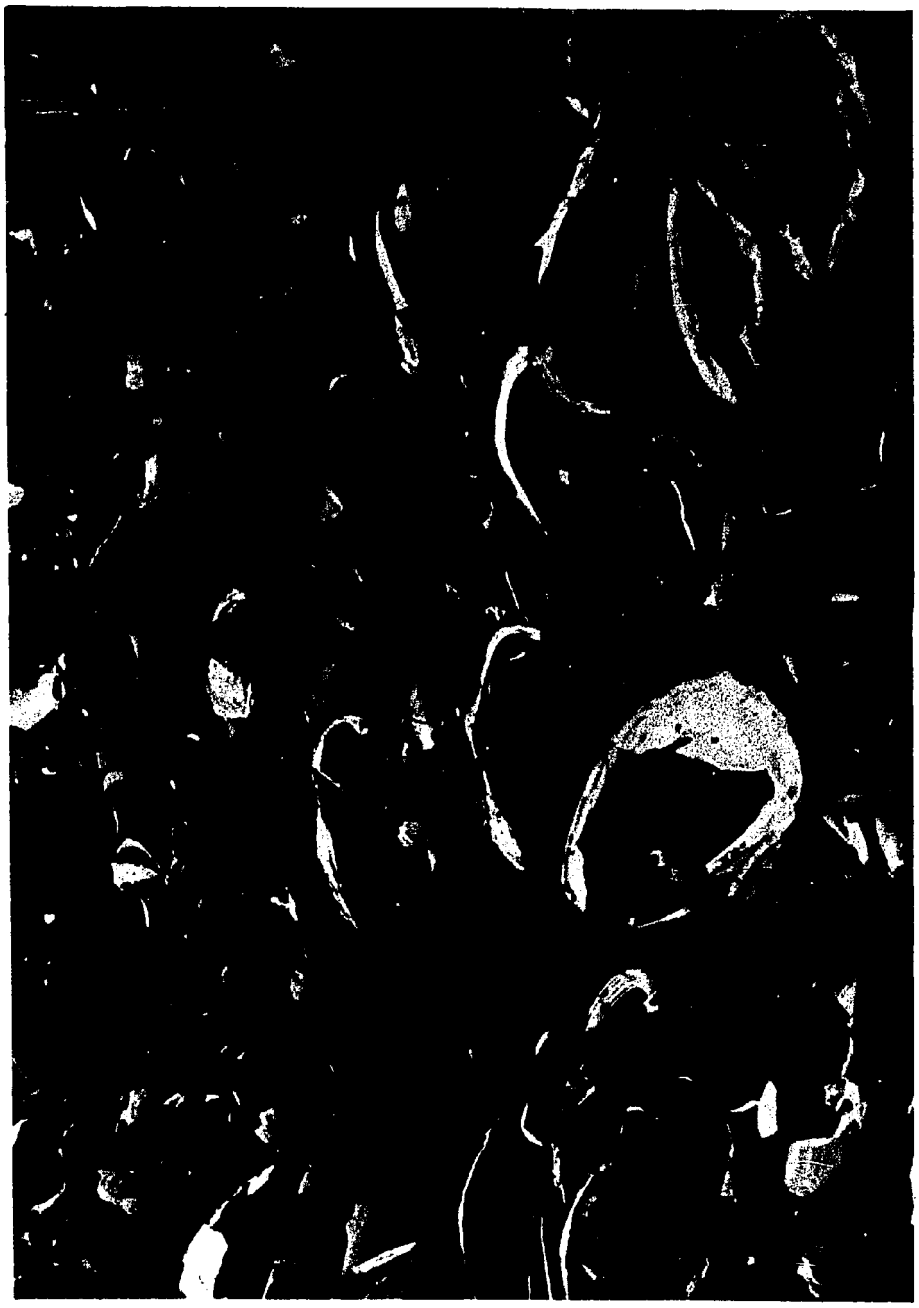


PLATE 43: Upper increased macrofossil bed to about base of indurated sequence, Boston Cliffs Member. Note partially reduced macrofossil bed above the upper increased macrofossil bed (at base of figure). Oyster, Crassostrea carolinensis, common in beds immediately below indurated sequence (at top of figure). Most larger bivalves in upper increased macrofossil bed are Macrocallista marylandica. Many of the thin bivalves in the central portion of the figure are Cerastoderma laqueata. Approximately half a mile south of Camp Conoy Y. M. C. A., Calvert Cliffs, Calvert County, Maryland.

Plate 43

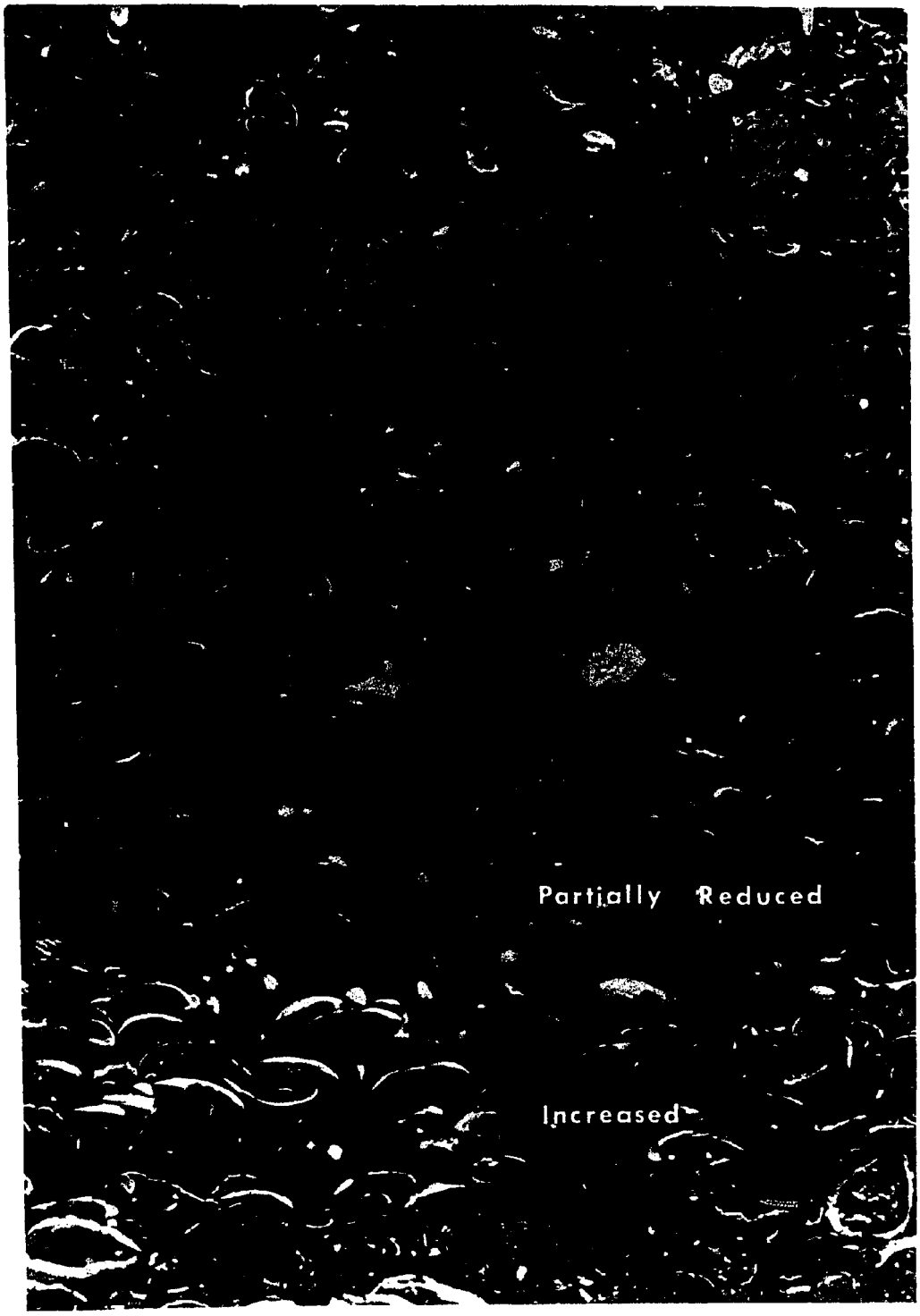


PLATE 44: Central Boston Cliffs Member. Central portion of figure shows greatly concentrated shell fragments in pockets with corresponding lithologic change possibly the result of crab burrowing. Above are abundant Cerastoderma laqueata looking much like the upper increased macrofossil bed of Boston Cliffs Member along the Chesapeake Bay. Locality 66-46, east bank of Helen Creek at mouth of Tongue Cove, Calvert County, Maryland.

Plate 44

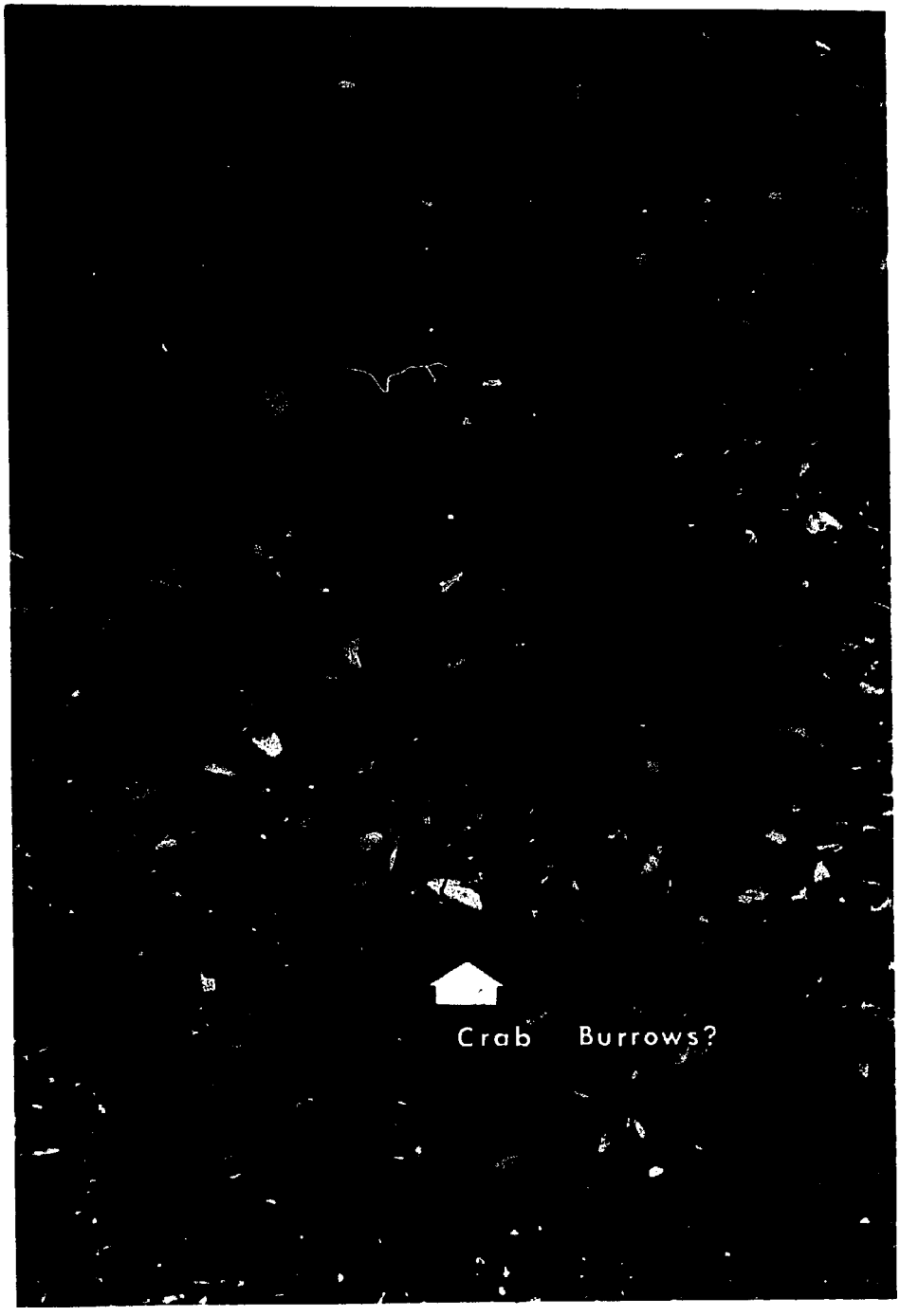


PLATE 45: Upper Boston Cliffs Member, Conoy Member, and lower St. Marys Formation. Note parallel laminations (marked by small arrows) and thick bedding in Conoy Member. Note blocky fracturing and steep face of outcrop expression of Conoy Member. Formation boundary bored from above. Locality 66-44, between Flag Ponds and Camp Conoy, Calvert Cliffs, Calvert County, Maryland.

Plate 45



PLATE 46: Conoy Member with thin, concentrated accumulation of Turritella plebeia molds and casts. Locality 66-47, north of Cove Point Marsh, Calvert Cliffs, Calvert County, Maryland.

Plate 46

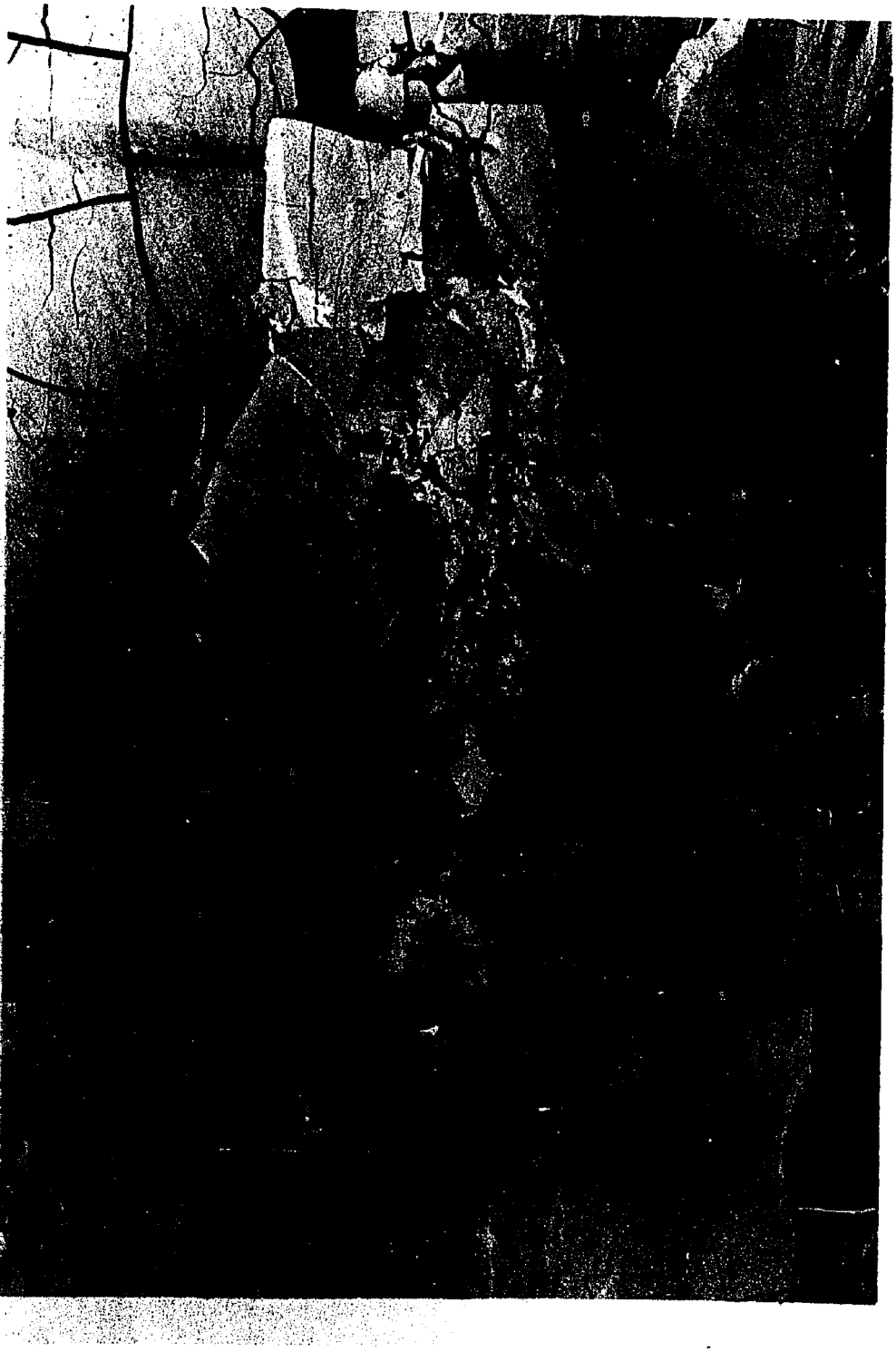


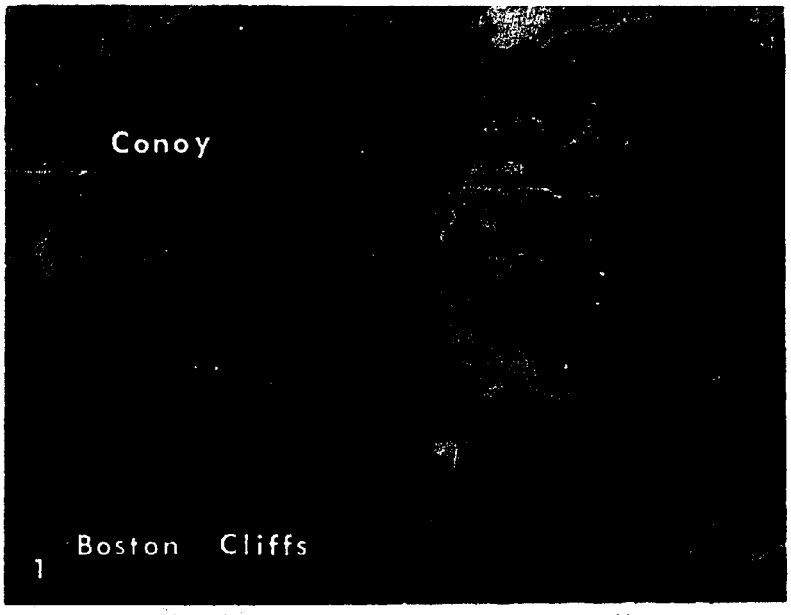
PLATE 47:

Figure 1: Top Boston Cliffs Member and lower Conoy Member. Note parallel laminations and thick bedding in Conoy Member. Locality 66-8, Calvert Cliffs south of Grover Creek, Calvert County, Maryland.

Figure 2: Locality 67-71, 1.1 miles south of Western Shores, Maryland. Choptank Formation, lower St. Marys Formation, and Pleistocene section near principal reference section.

Note particularly very thin Conoy Member here with variable thickness "basal sand" of St. Marys immediately above. Within one-fourth mile south Conoy is twice as thick. Plate 48 shows close-up of this critical interval. Conoy is between the arrow points. St. Marys "basal sand" is thin, dark band immediately above upper arrow point. All members of Choptank are present here with Calvert Beach Member at base. Cliff here is about 125 feet high.

Plate 47



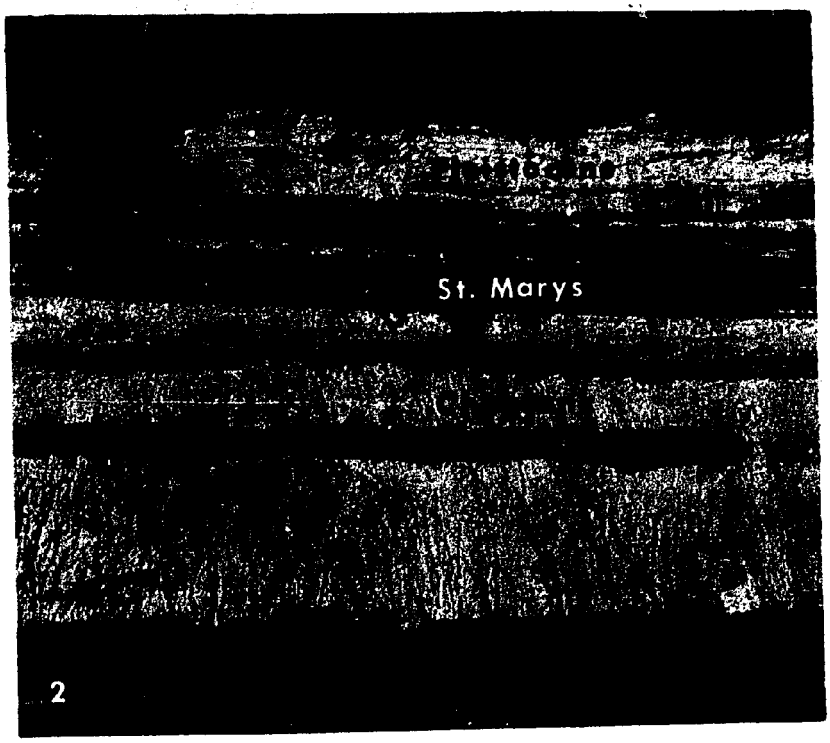


PLATE 48: Close-up of top of Choptank and base of St. Marys as seen in Plate 47, figure 2. Conoy Member here is 53 inches thick. Undulating unconformity between Choptank and St. Marys. Immediately above that is a three-inch concretion bed. Main body of St. Marys "basal sand" varies in thickness along here from about one foot to two feet.

Plate 48

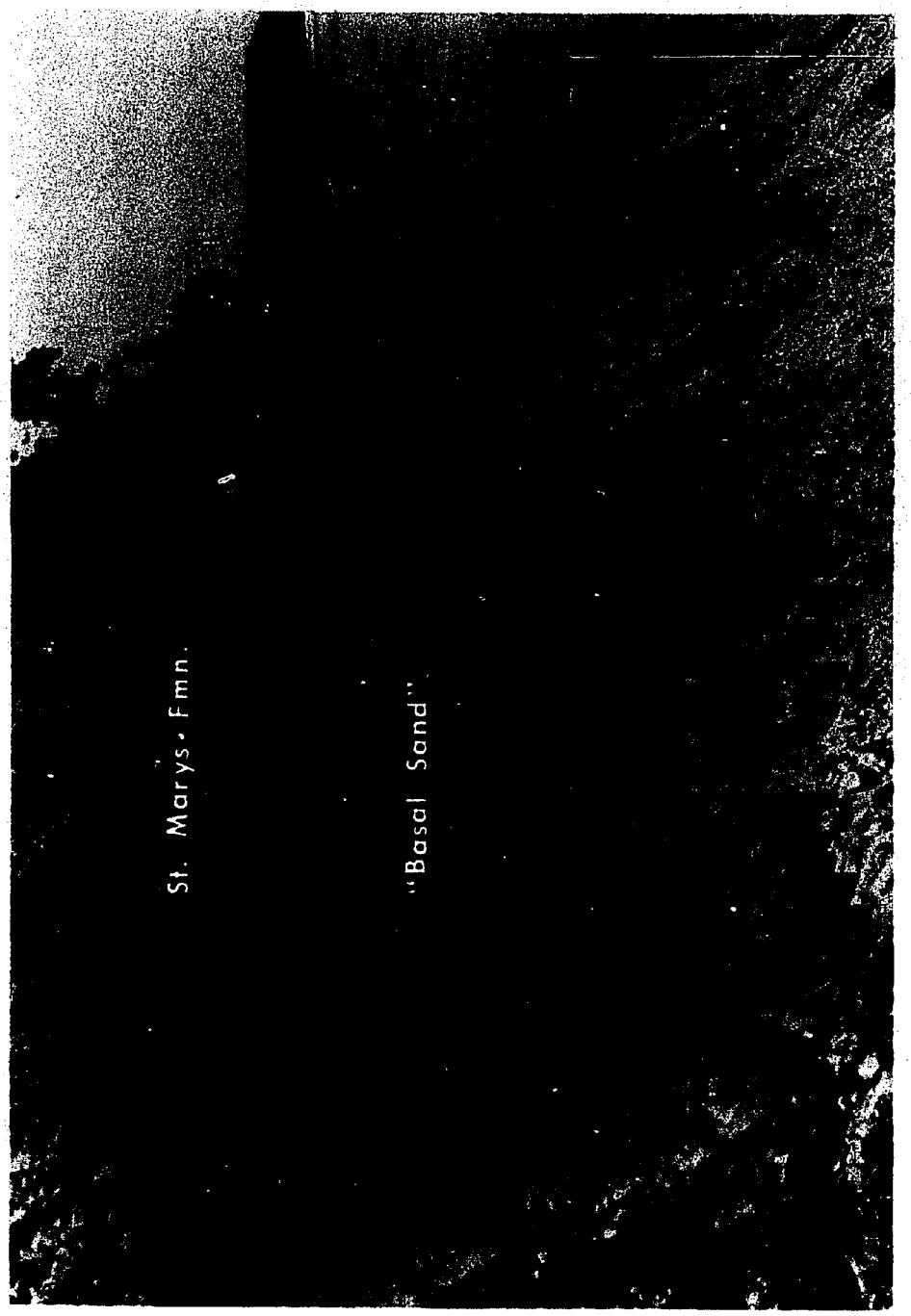


PLATE 49: (Figures are different perspectives of same cliff section.) Calvert Cliffs at Camp Conoy Y. M. C. A. Good view of unconformable relationships around Choptank-St. Marys boundary. Type area for Conoy Member. Double-headed arrow on right of figure 2 shows thickness of St. Marys at north end of Conoy Cliff not present at south end of Conoy Cliff. Single-headed arrow at left marks Choptank-St. Marys unconformity and location of Plate 50.

Plate 49



PLATE 50: (See Plate 49 for location.) Choptank-St. Marys unconformity. Note borings (unretouched photo) down into Conoy and filled with sediment from the St. Marys. Note stringy, discontinuous, very well sorted "basal sand" of St. Marys. Arrows point out some borings. Mechanical pencil in lower right provides scale.

Plate 50

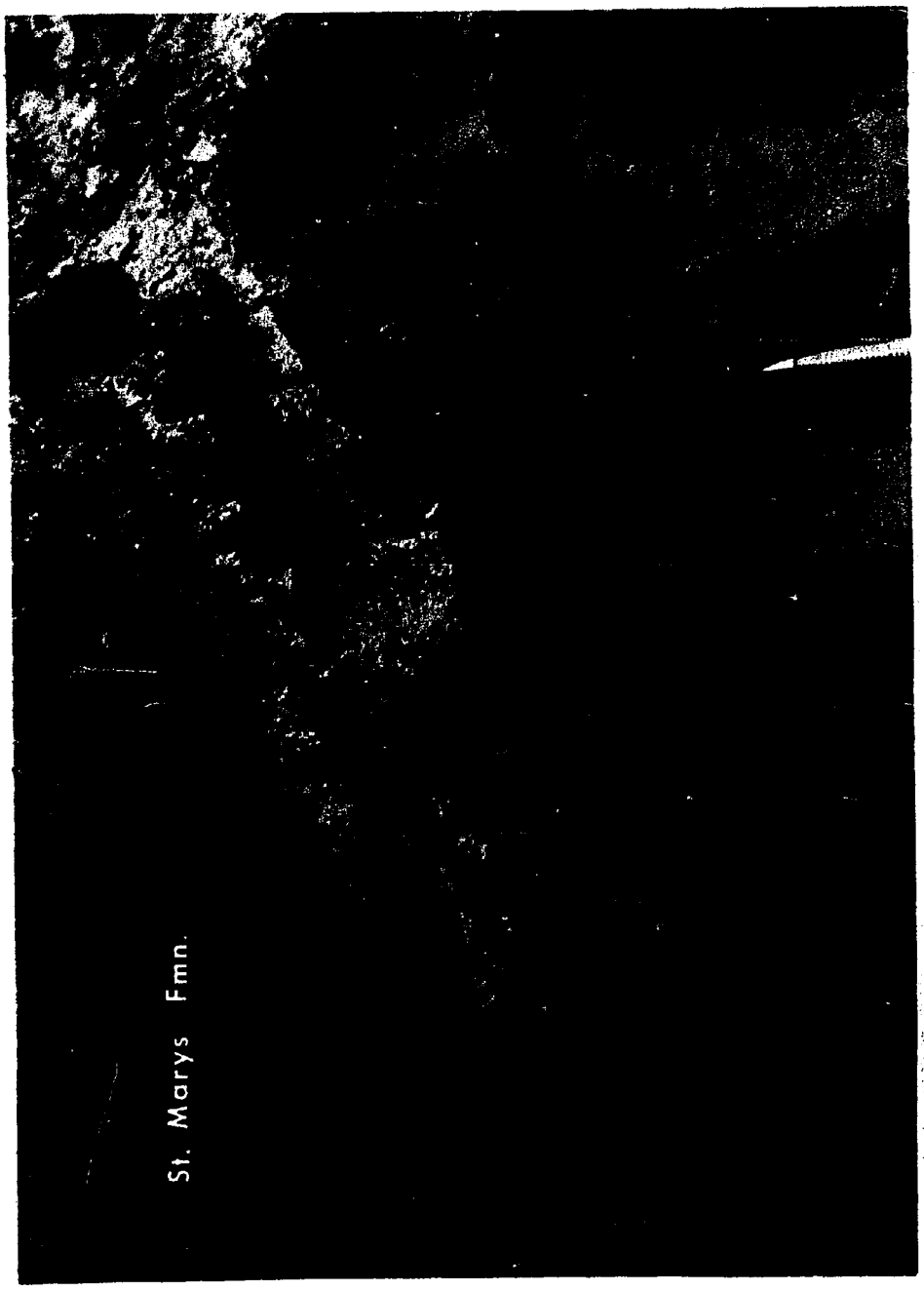


PLATE 51: Boston Cliffs Member and Conoy Member, lower units of the St. Marys Formation, and Pleistocene deposits in a view of the Calvert Cliffs at North Point of Rocks, Calvert County, Maryland. (The horizon of the Chesapeake Bay appears level with the top of the Boston Cliffs Member.)

Plate 51

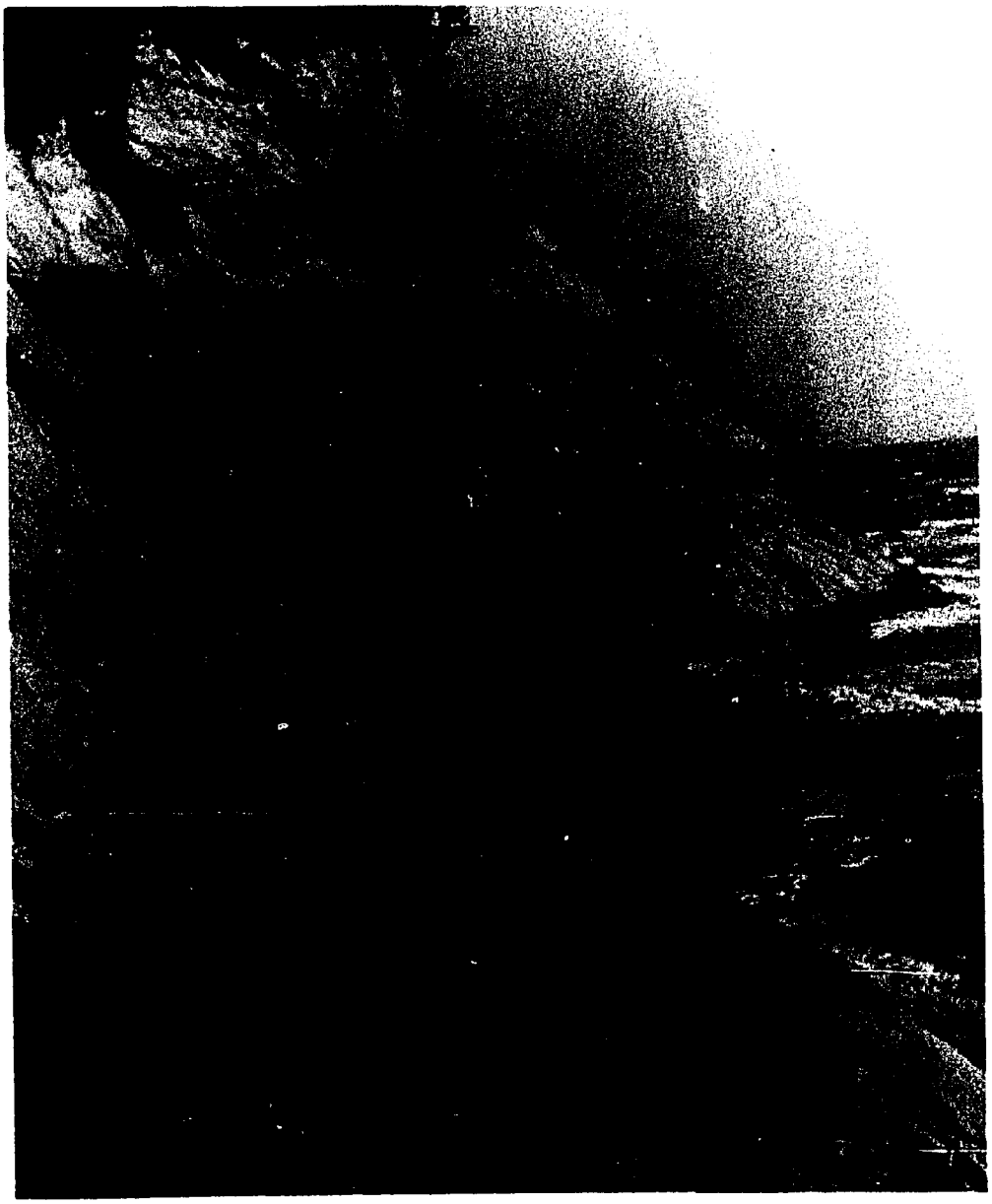


PLATE 52: Locality 67-70, Nomini Cliffs, Westmoreland County, Virginia.

Plate 52

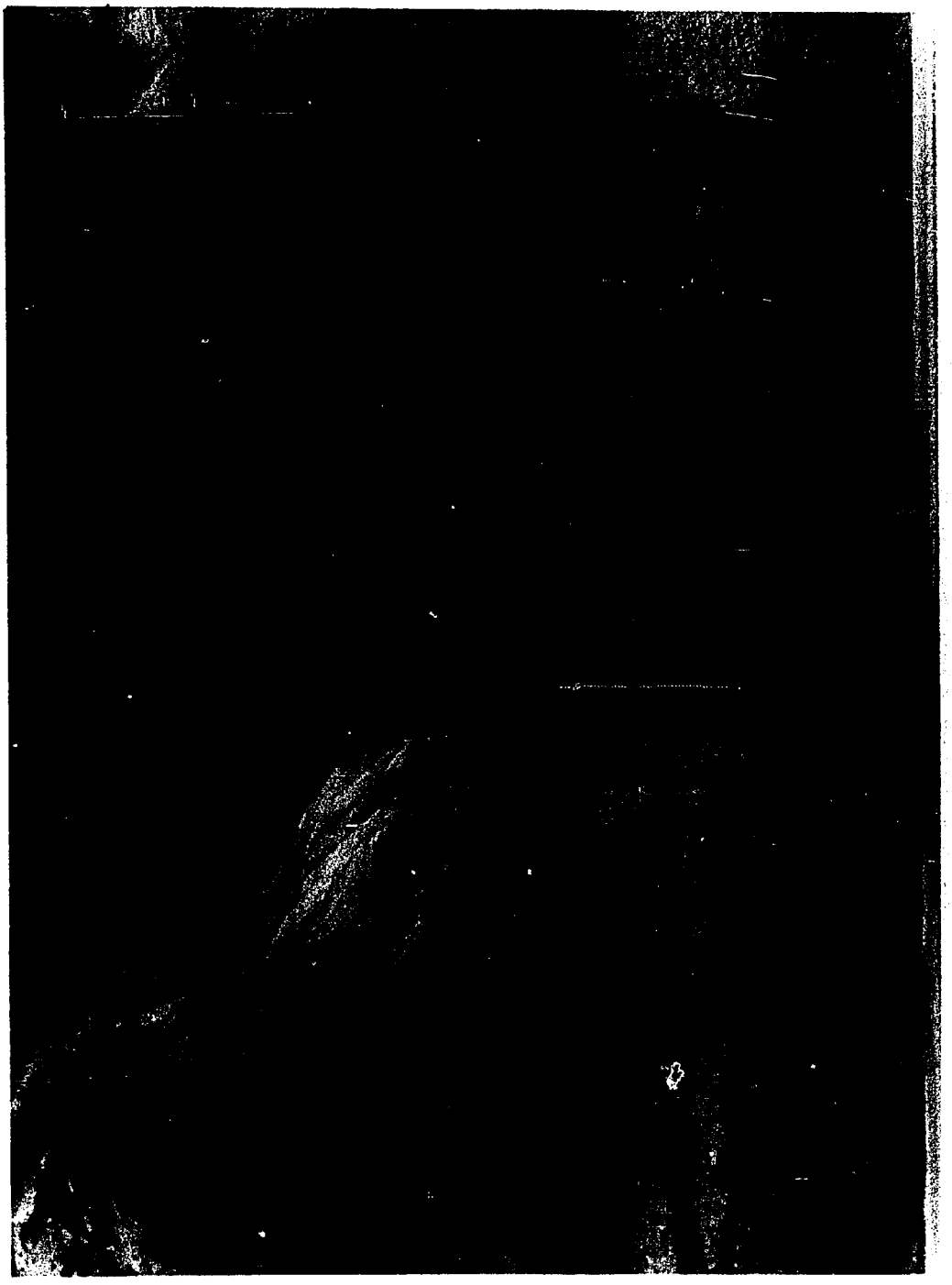


PLATE 53: View of the Calvert Cliffs from Flag Ponds. The Conoy Member is between the arrow points. These cliffs contain localities 66-7, 66-15, and 66-25 and expose the Drumcliff, St. Leonard, Boston Cliffs and Conoy Members of the Choptank and lower units of the St. Marys Formation.

Plate 53

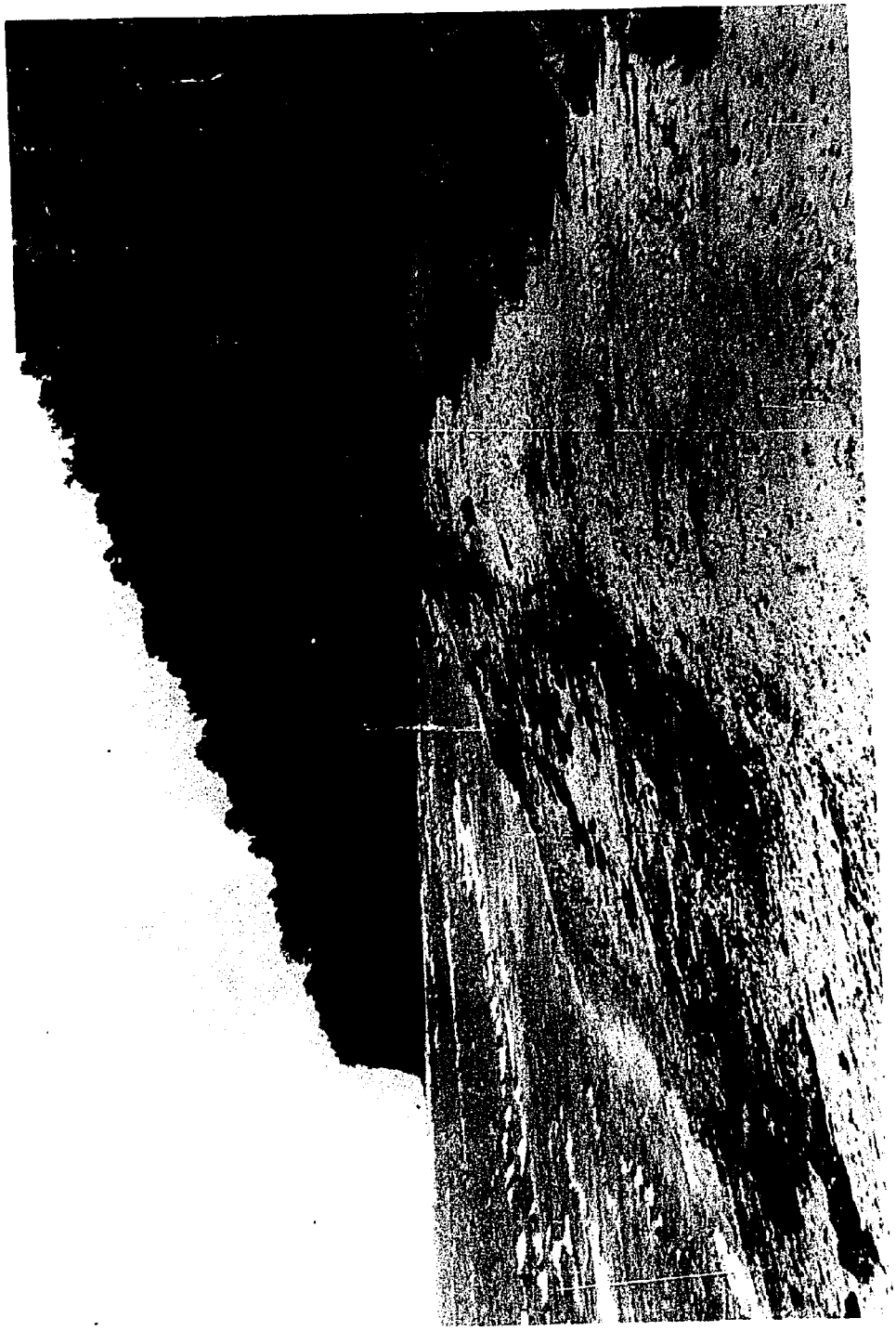


PLATE 54: Burrows in the type section of the Calvert Beach Member, Calvert Beach, Maryland.

Plate 54

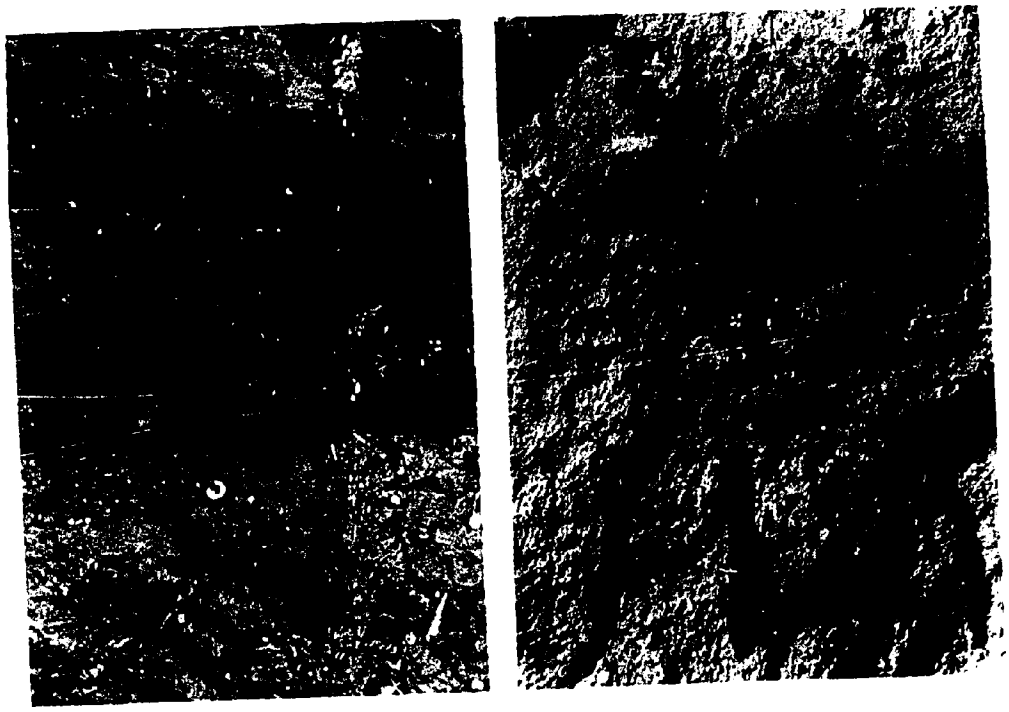


PLATE 55: Very low in the Drumcliff Member at locality 66-35 in Pawpaw Hollow on the east side of Breton Bay, St. Marys County, Maryland. The prominent fossils are Turritella and Mercenaria.

Plate 55



PLATE 56: Middle reduced macrofossil bed in the type locality of the Drumcliff Member. Top of figure shows gradation to larger and more macrofossils. Drumcliff along the Patuxent River, St. Marys County, Maryland.

Plate 56

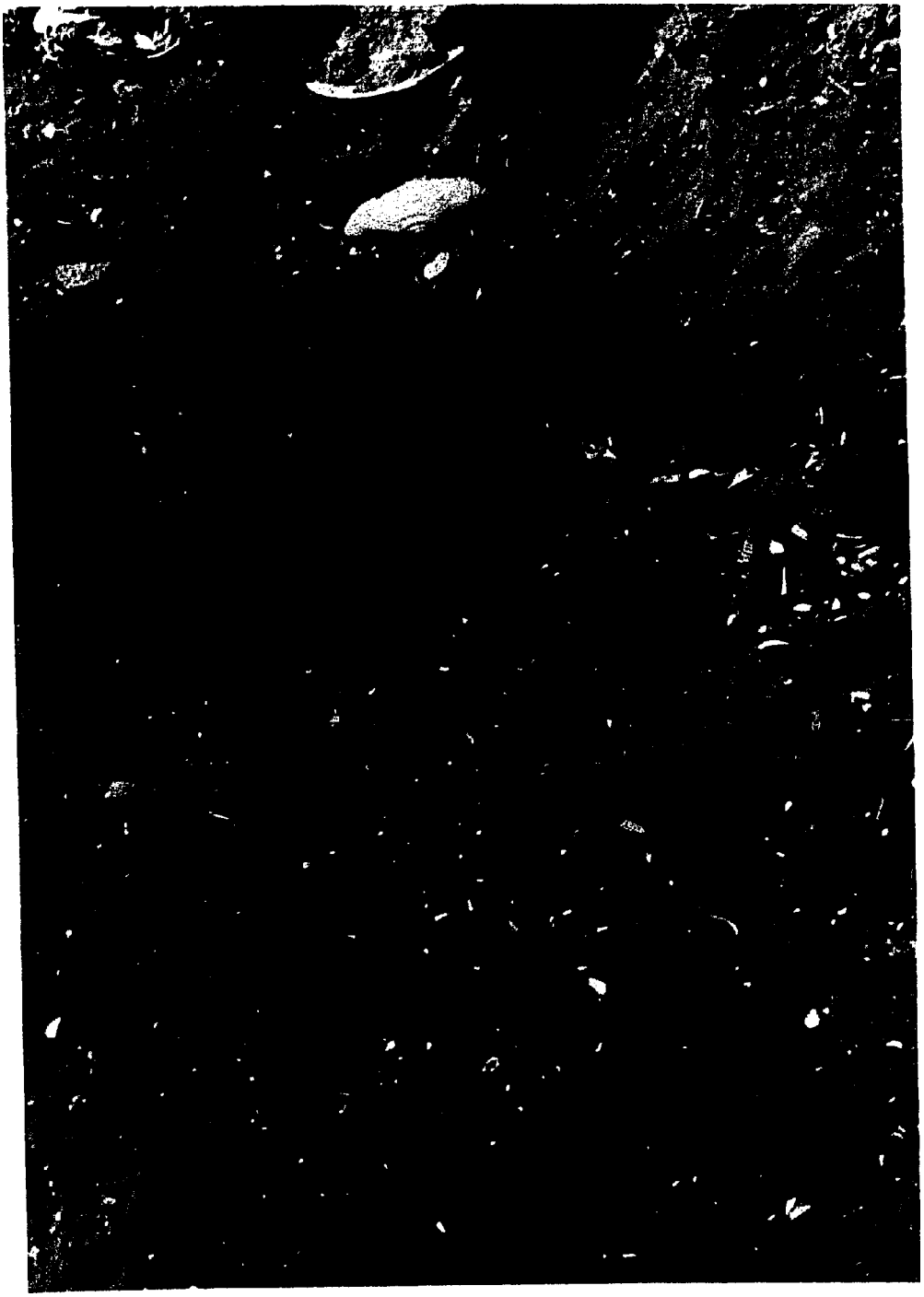


PLATE 57: Upper part of the Drumcliff Member and lower part of the St. Leonard Member. Drumcliff Member shows distinct reduced and increased macrofossil beds and gradations between. Note several large Panope in living position in Drumcliff Member. Deep channels filled with St. Leonard sand. Drumcliff along the Patuxent River, St. Marys County, Maryland.

Plate 57

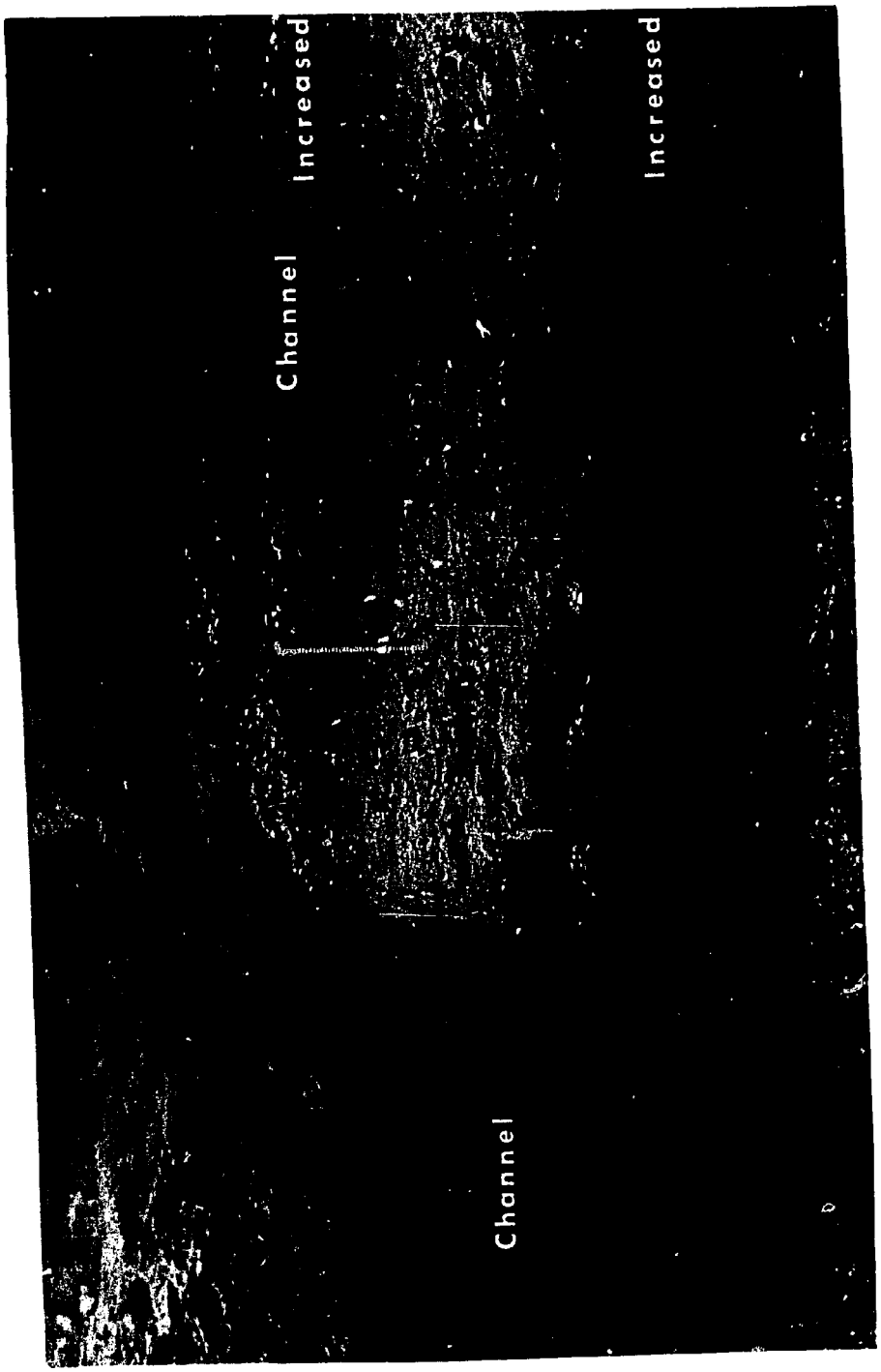


PLATE 58: Upper Isognomon indurated ledge with reduced macrofossil bed below and gradation to smaller shells above. Upper Drumcliff Member, downstream end of Drumcliff, localities 66-19 and 67-61, along Patuxent River, St. Marys County, Maryland.

Plate 58

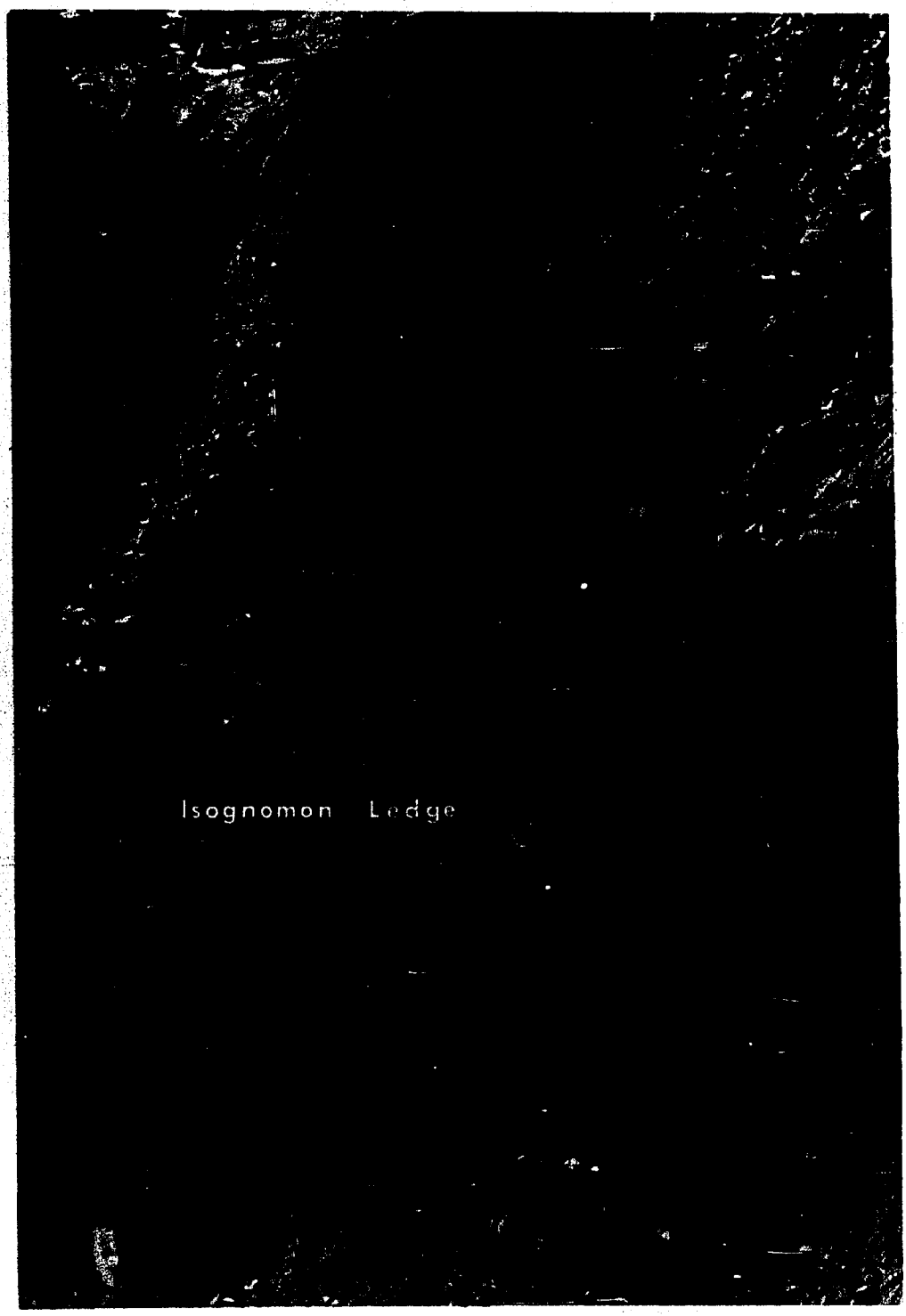


PLATE 59: Concentrated Isognomon bed. Drumcliff Member. Drumcliff along Patuxent River, St. Marys County, Maryland.

Plate 59



PLATE 60: Indurated upper Drumcliff Member. Typical appearance for downdip outcrops of this member. Dark clay in upper right corner is lower St. Leonard Member. Calvert Cliffs south of Flag Ponds, Calvert County, Maryland.

Plate 60



PLATE 61: Upper Drumcliff, St. Leonard, and Boston Cliffs Members with arrows marking member boundaries. Note upper Isognomon ledge starting in the lower left corner of figure. Note "basal sand" of St. Leonard Member. Note reduced and increased macrofossil beds in the Boston Cliffs Member. Downstream end of Drumcliff, localities 66-19 and 67-61, along Patuxent River, St. Marys County, Maryland.

Plate 61

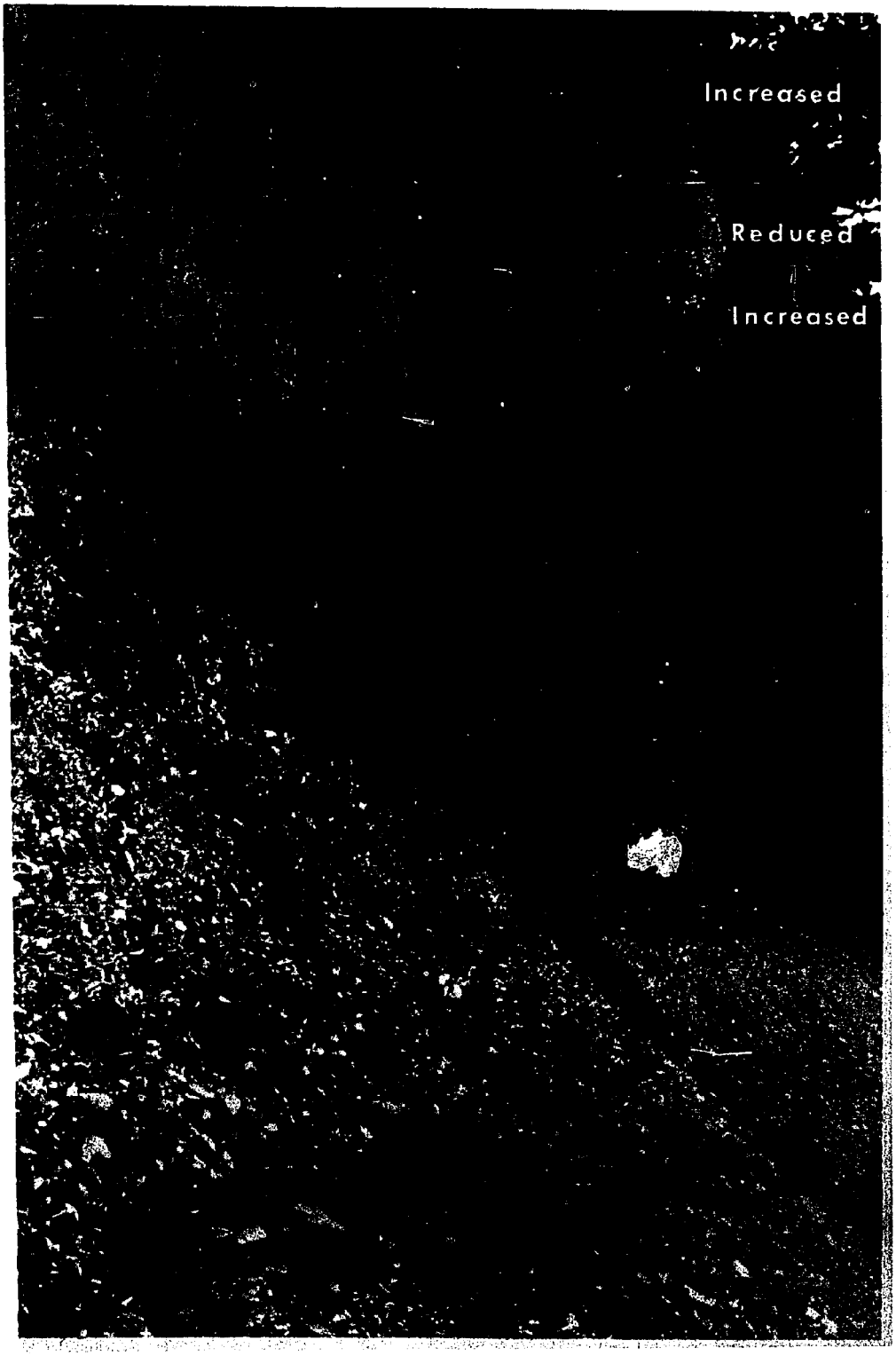


PLATE 62: Drumcliff and St. Leonard Members. Partially indurated Isognomon bed below with decreasing shell size up to contact with St. Leonard. Locality 66-42, Breedens Point, on east bank of St. Leonard Creek, Calvert County, Maryland.

Plate 62



PLATE 63: Heavily burrowed St. Leonard Member south of locality 66-44, Calvert Cliffs, Calvert County, Maryland.

Plate 63

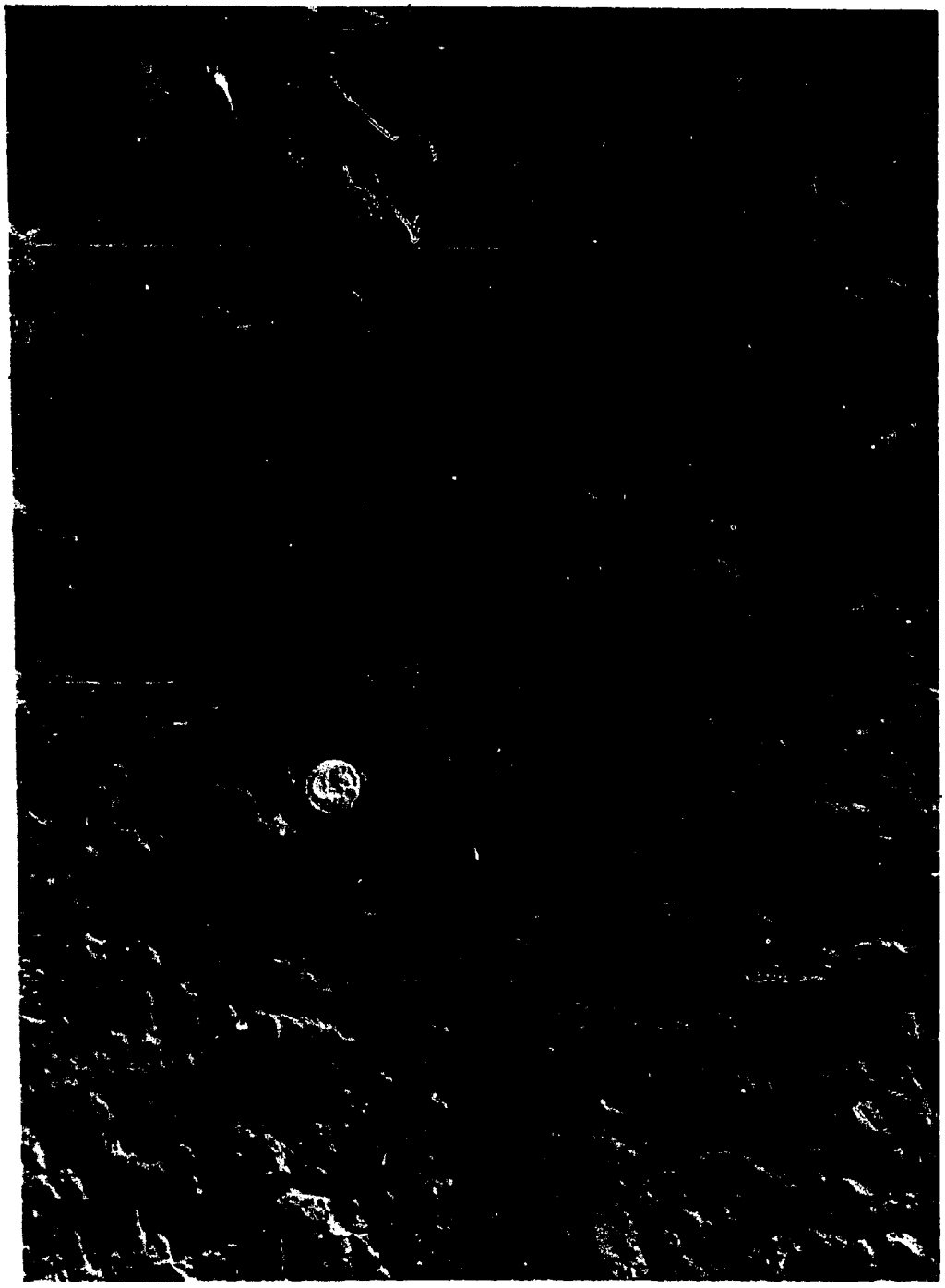


PLATE 64: Heavily burrowed St. Leonard Member south of locality 66-44, Calvert Cliffs, Calvert County, Maryland.

Plate 64

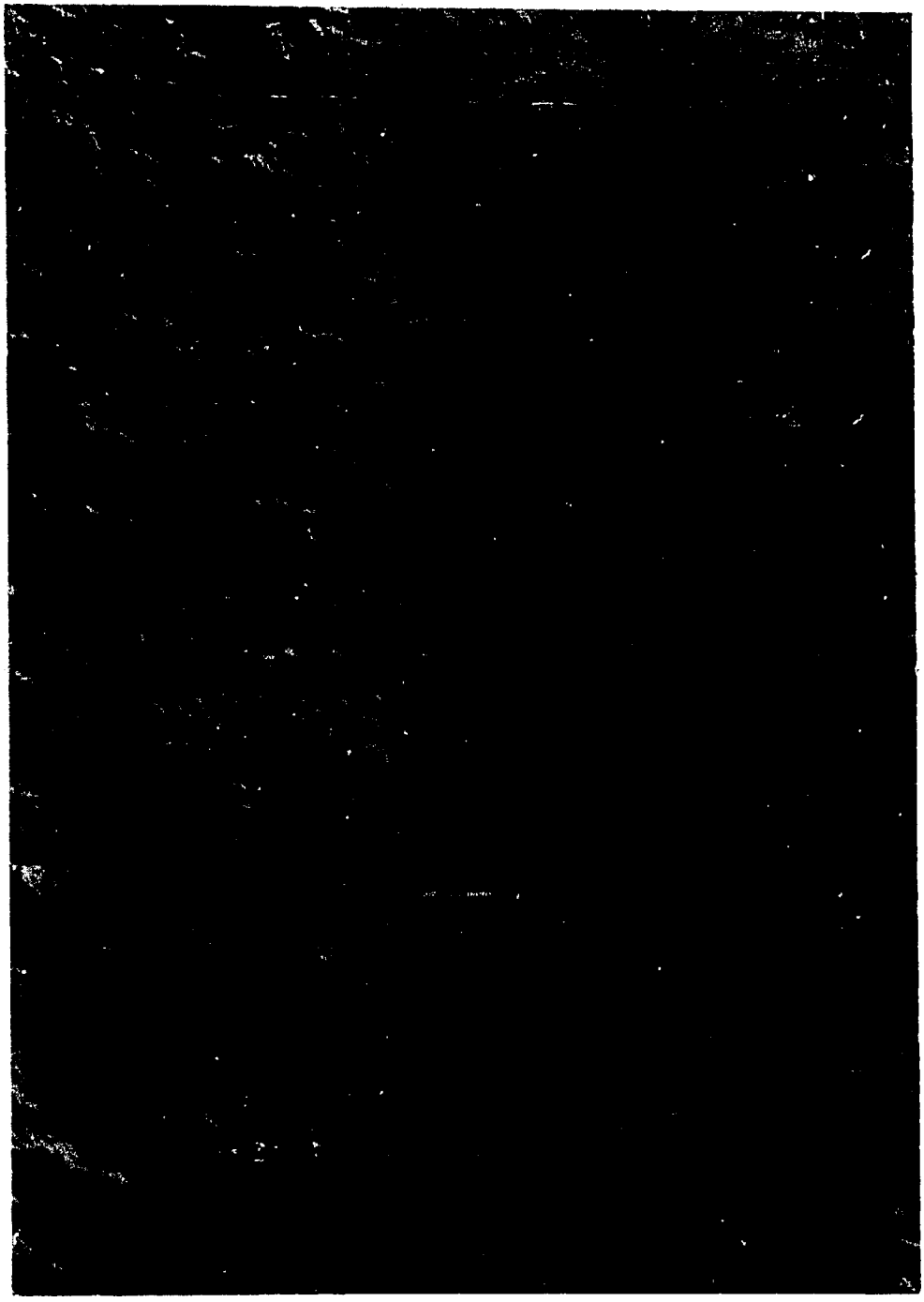


PLATE 65: Burrow on left may well be from a bivalve. Disturbed laminations on right may be the result of biogenic activity. Locality 66-44, Calvert Cliffs, Calvert County, Maryland.

Plate 65

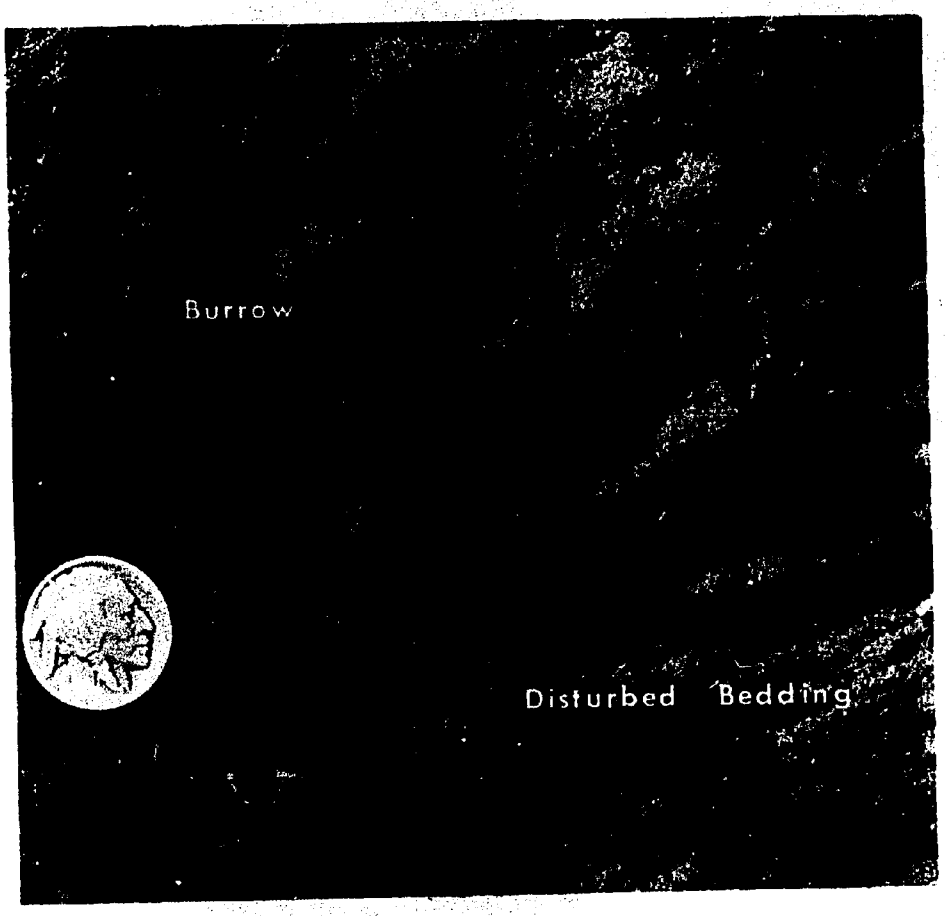


PLATE 66: Locality 66-12. Type locality of the Choptank Formation and the Boston Cliffs Member. Boston Cliffs along west bank of the Choptank River, Talbot County, Maryland.

Plate 66

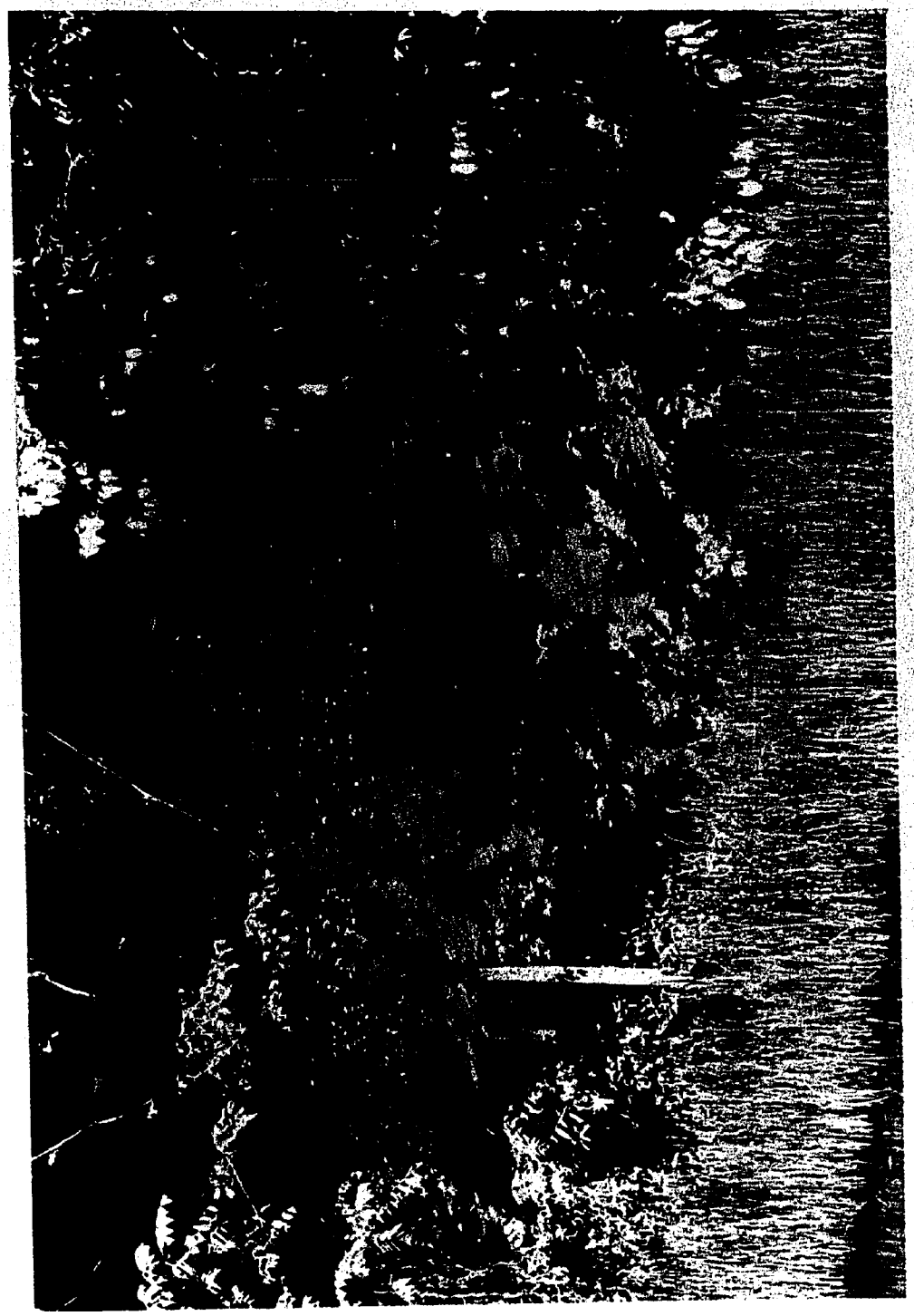


PLATE 67: Arrow marks boundary between Boston Cliffs Member and Pleistocene. Locality 67-79. Boston Cliffs Member in vicinity of type locality for the formation and the member. Approximately 0.4 mile downstream from section in Plate 66. Boston Cliffs along west bank of the Choptank River, Talbot County, Maryland.

Plate 67

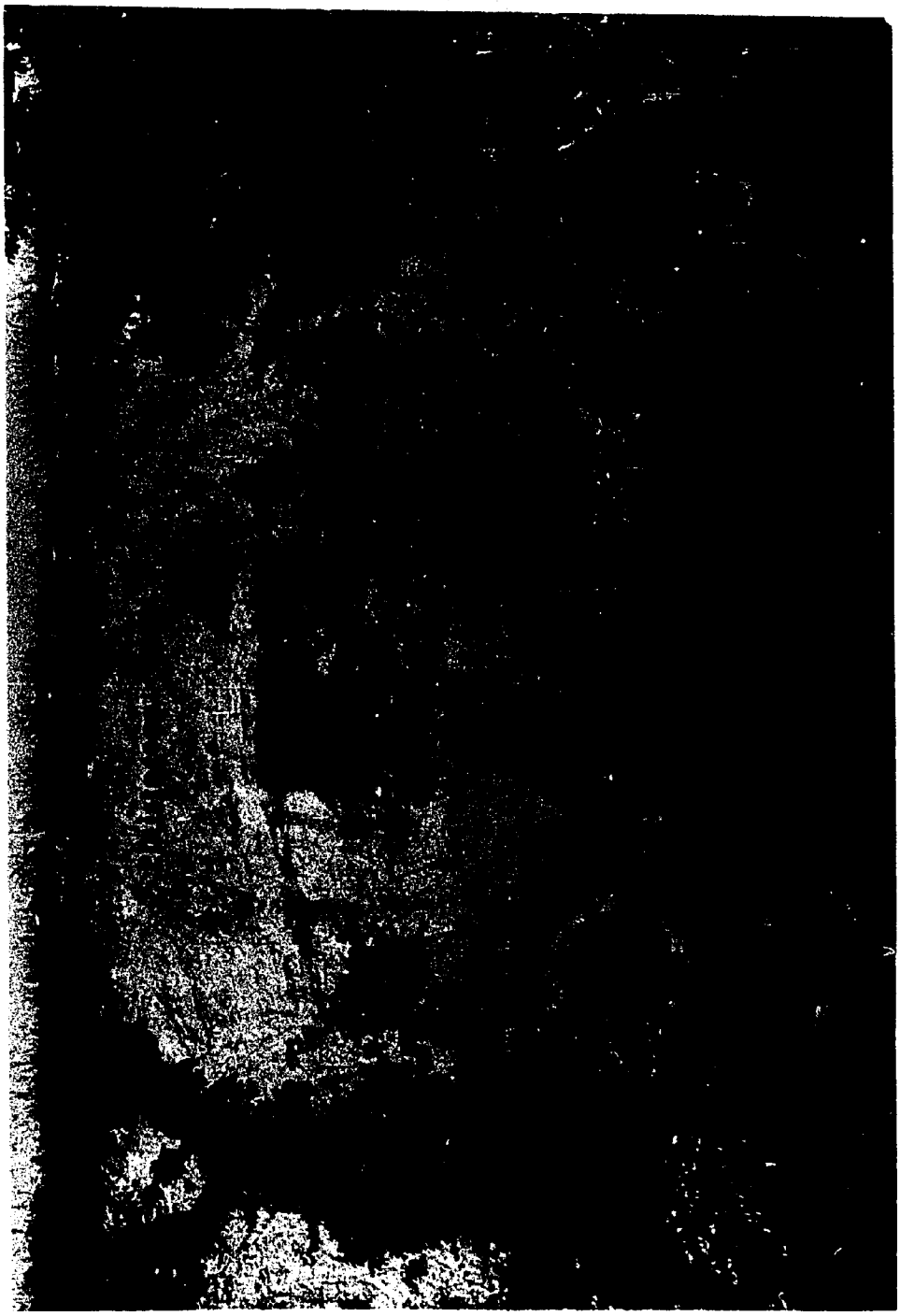


PLATE 68: Boston Cliffs Member excluding the upper indurated beds. Note beds of reduced numbers of large macrofossils. Note lower increased macrofossil bed dominanted by Lyropecten, Anadara, and Macrocallista, central increased macrofossil bed with predominant Macrocallista and Cerastoderma, and upper increased macrofossil bed of oysters and scallops. Locality 66-26, first point south of Point of Rocks, Calvert Cliffs, Calvert County, Maryland.

Plate 68

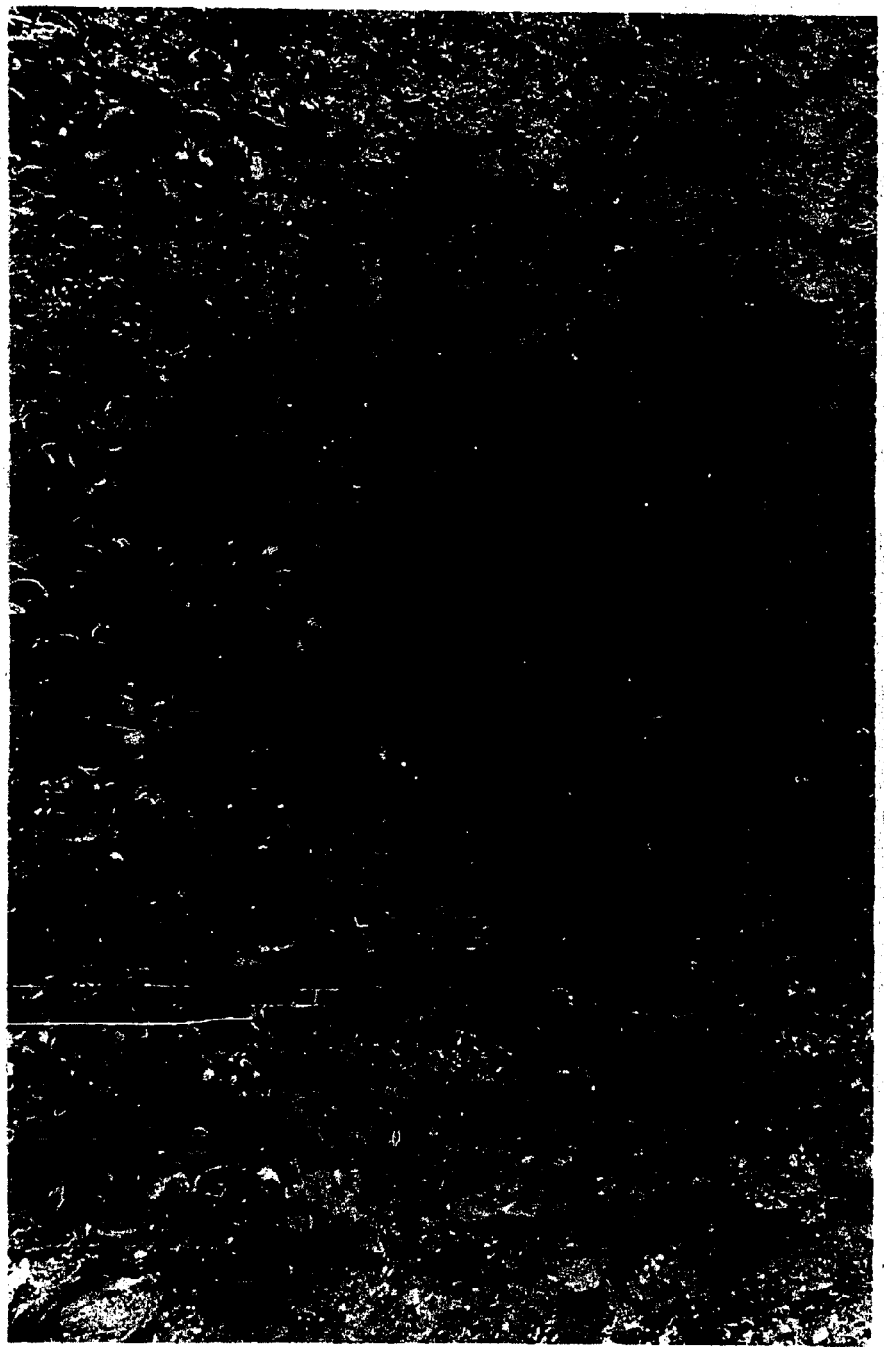


PLATE 69:

Figure 1: Upper St. Leonard Member and Boston Cliffs Member. Note gradational change from St. Leonard Member to Boston Cliffs Member. Note resistant ledge formed by upper indurated sequence of Boston Cliffs Member. Note reduced and increased macrofossil beds. (Indurated beds could be considered an increased bed, since they contain profuse molds and casts of large macrofossils.) Locality 66-23 approximately 75 yards north of Point of Rocks, Calvert County, Maryland.

Figure 2: Lower increased macrofossil bed of the Boston Cliffs Member. Numbered bivalves: 1 - Anadara staminea, 2 - Lyropecten madisonius, 3 - Mercenaria sp., 4 - Macrocallista marylandica, 5 - Dosinia acetabula. Locality 66-8, south of Grover Creek, Calvert Cliffs, Calvert County, Maryland.

Figure 3: Bed of Anadara staminea, below knife. Lower increased macrofossil bed of the Boston Cliffs Member. Between localities 67-51 and 66-9, Calvert Cliffs, Calvert County, Maryland.

Plate 69

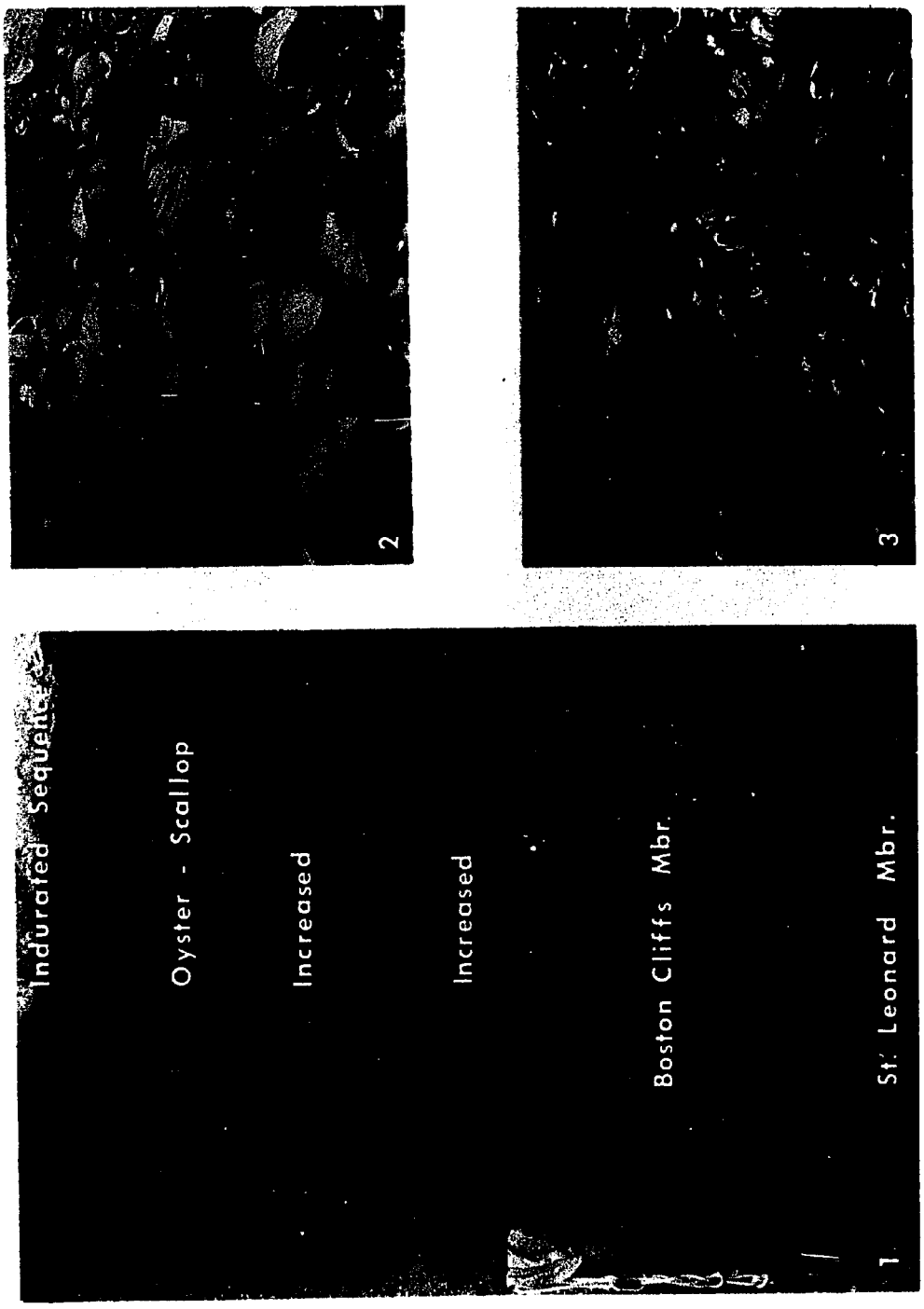

Indurated Sequence
Oyster - Scallop
Increased
Increased
Boston Cliffs Mbr.
St. Leonard Mbr.
1
2
3

PLATE 70: Predominantly Anadara staminea in the lower increased macrofossil bed of the Boston Cliffs Member. Note Macrocallista marylandica articulated and lying on its side. Between localities 66-9 and 66-10, Calvert Cliffs, Calvert County, Maryland.

Plate 70

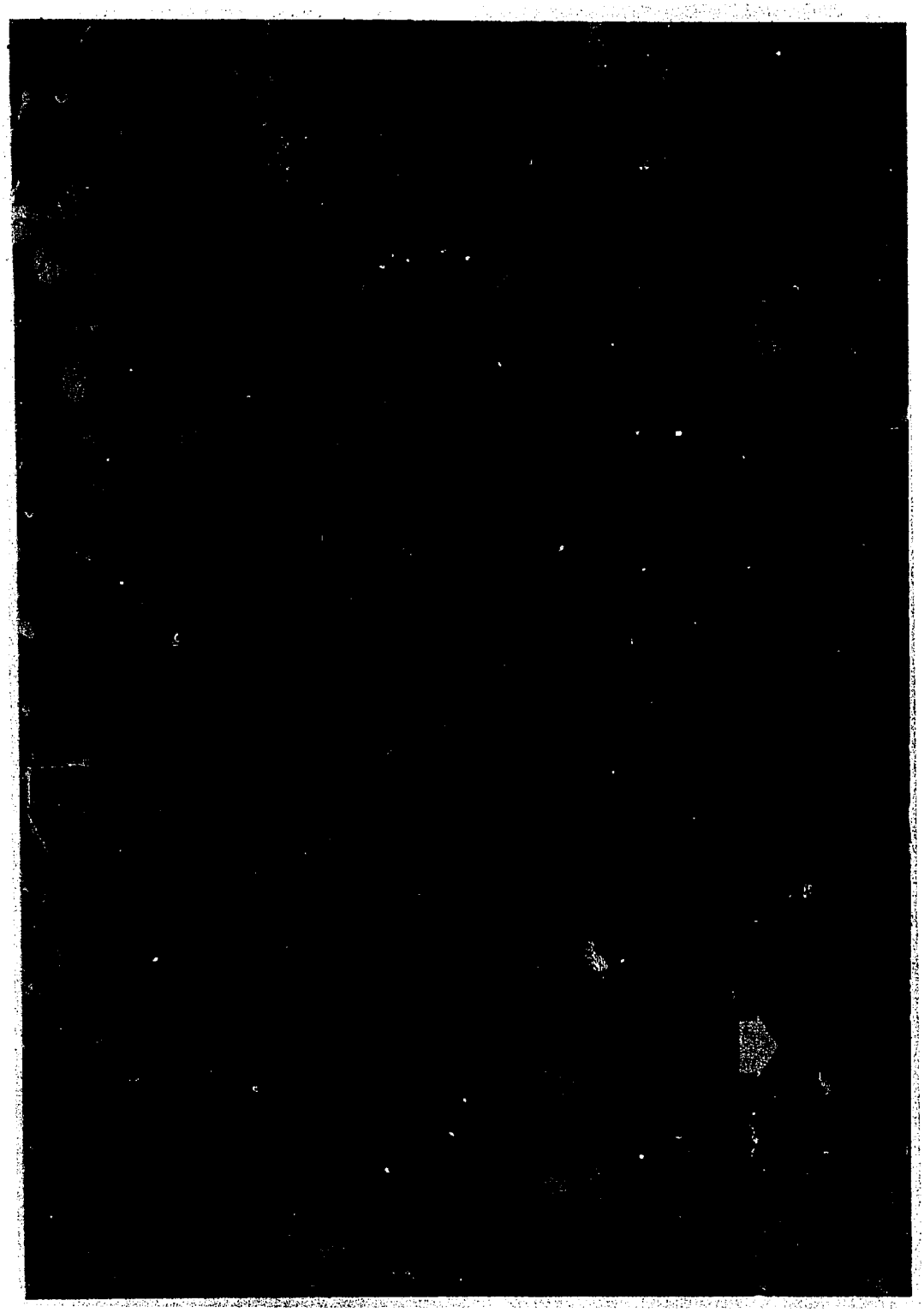


PLATE 71: Boston Cliffs Member with prominent scallops (Lyropecten madisonius) and Anadara staminea in lower half of figure. Locality 66-44, Calvert Cliffs, Calvert County, Maryland.

Plate 71



PLATE 72: Anadara staminea band in lower increased macrofossil bed of Boston Cliffs Member. Between localities 66-9 and 66-10, Calvert Cliffs, Calvert County, Maryland.

Plate 72

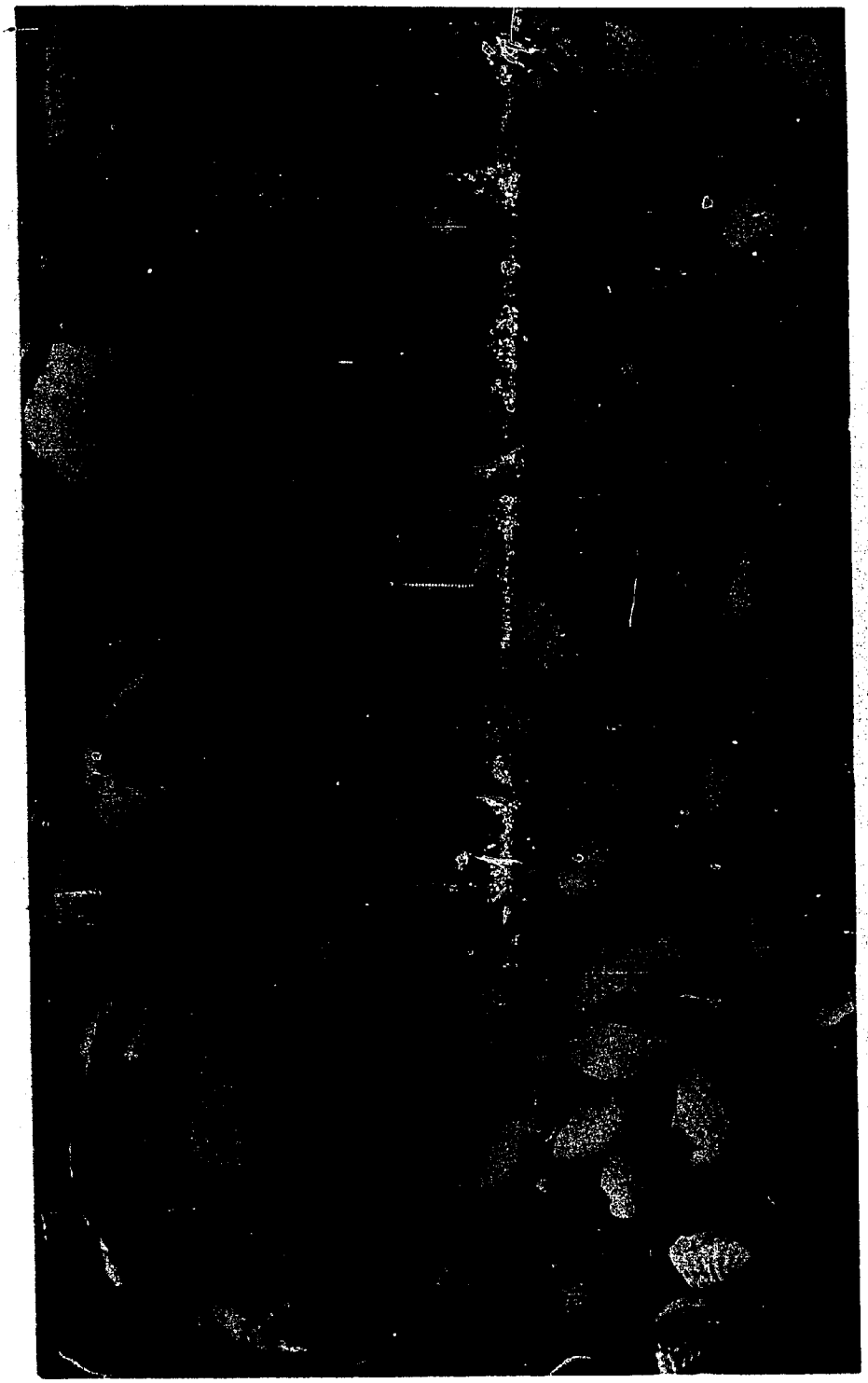


PLATE 73: Upper Boston Cliffs Member and lowermost Conoy Member. Knife in middle of heavily oxidized and indurated sequence at top of Boston Cliffs Member. Arrow marks boundary between Boston Cliffs and Conoy. Locality 66-8, south of Grover Creek, Calvert Cliffs, Calvert County, Maryland.

Plate 73



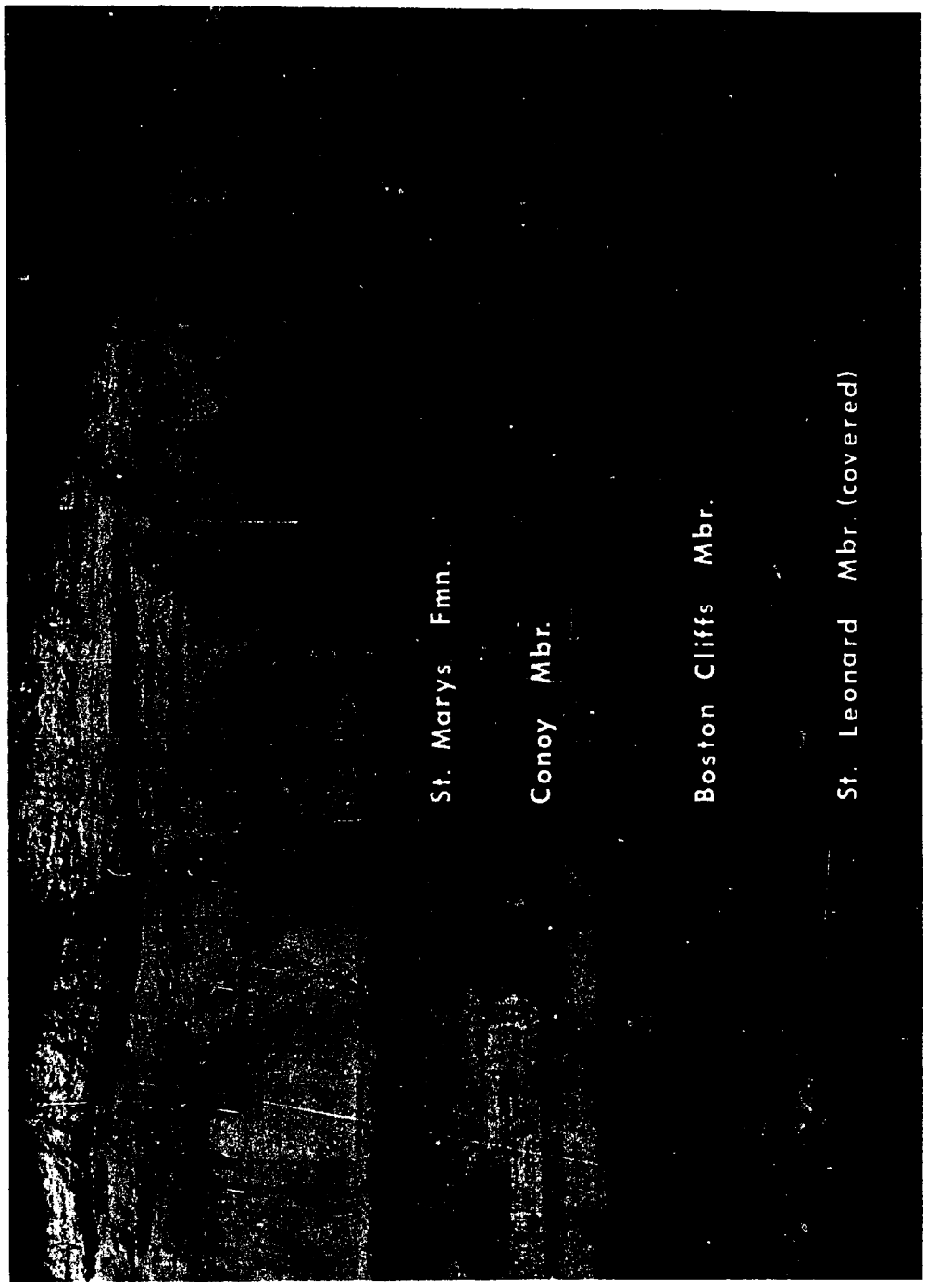
PLATE 74: Close-up of Choptank-St. Marys boundary as seen on Plate 48. Lower arrow marks boundary between Choptank, Conoy Member, and "basal sand" of St. Marys Formation. Upper arrow marks top of "basal sand".

Plate 74

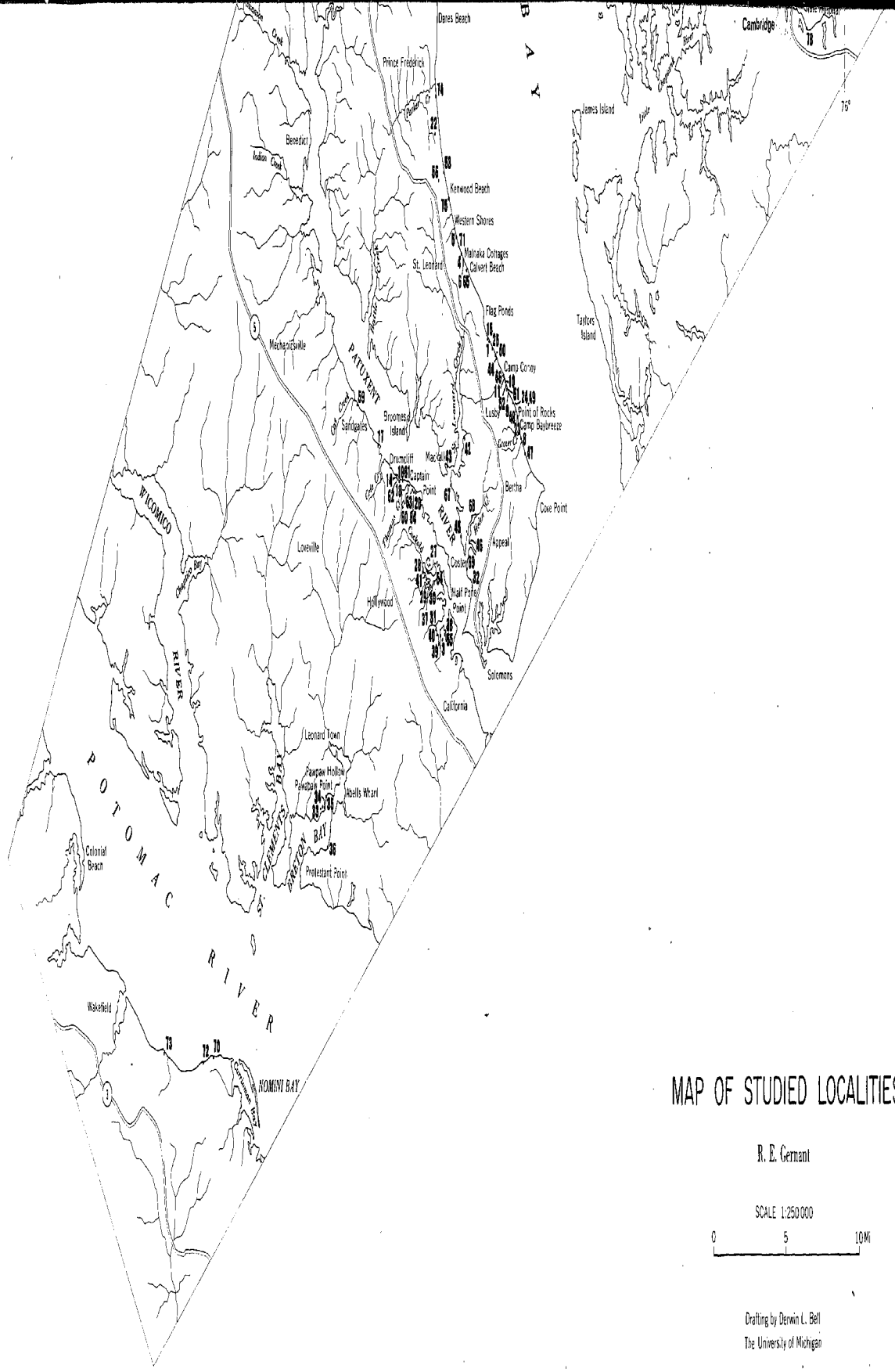


PLATE 75: Calvert Cliffs at 67-52 with shores of Chesapeake Bay. Calvert County, Maryland.

Plate 75


St. Marys Fmn.
Conoy Mbr.
Boston Cliffs Mbr.
St. Leonard Mbr. (covered)


MARYLAND
DELAWARE
VIRGINIA
Washington
INDEX MAP
77
76
39
38
CHESAPEAKE BAY
HERRING BAY
Fairhaven
Holland Point
Parks
West Beach
Chesapeake Beach
Randle Cliff Beach
Lower Marlboro
Plum Point
Wilson
Dares Beach
Prince Frederick
Benedict
Indian Creek
Hunting Creek
Fishing Creek
Plum Point Creek
MILES RIVER
EASTERN BAY
Wye Island
Queen Anne
Denton
Greensboro
Lyford Landing
Easton
Poplar Island
Tilghman Island
Oxford
Cover Bridge
Boston Cliffs
Frazier Neck
Choptank
Federalsburg
CHOPTANK RIVER
Cook Point
Grubin Neck
Hambrooks Bar
TRIPPE BAY
Cambridge
State Hospital
James Island
Tar Bay
Harris Creek
Broad Creek
Tred Avon River
Island Creek
Dividing Creek
Back Creek
Deep Creek
Tuckahoe Creek
Choptank River
Hunting Creek
Bayly Creek
Cabin Creek
Harris Creek
Broad Creek
Tred Avon River
Island Creek
Dividing Creek
Back Creek
Deep Creek
Tuckahoe Creek
Choptank River
Hunting Creek
Bayly Creek
Cabin Creek
DELAWARE
MARYLAND
39°
76°
75°
38°
50
51
57
74
22
83
82
81
80
63
18
19
77
78
76
33
331



MAP OF STUDIED LOCALITIES

R. E. Grant

SCALE 1:250 000

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Drafting by Derwin L. Bell
The University of Michigan