

Microfossils from Chesapeake Bay Sediments: Illustrations and Species Database

by

Thomas M. Cronin, Robert S. Wagner, and Moira Slattery, editors

with the following sections:

Benthic Foraminifera by Scott E. Ishman, Alex W. Karlsen, Thomas M. Cronin

Diatoms by Lisa M. Weimer

Dinoflagellates by Stacey Verardo

Ostracodes by Thomas M. Cronin and Deena Grinbaum

Pollen by Debra A. Willard

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Introduction

This report presents scanning electron microscope (SEM) photomicrographs of 64 species and genera of benthic foraminifers, diatoms, dinoflagellate cysts, ostracodes and pollen that represent the most common microfossil species preserved in sediments from Chesapeake Bay. In addition to SEM photomicrographs, this report also presents quantitative abundance data documenting the stratigraphic distribution of most microfossil species in 25 sediment cores in five appendices, one for each major group of microfossils.

This study is part of an interdisciplinary research project designed to investigate the environmental trends and functioning of the bay ecosystem over interannual through millennial time scales through paleoecological studies of radiometrically dated sediment cores. The primary goal is to use ecologically sensitive species to understand temporal and spatial variability in salinity, sediment accumulation rates and budgets, dissolved oxygen, temperature, and faunal and floral trends in Chesapeake Bay and its major tributaries (Cronin *et al.* in press). These species' census data together with the SEM photographs form the taxonomic basis for studies on Chesapeake Bay ecosystem history (Cronin *et al.* submitted; Karlsen *et al.* submitted).

Chesapeake Bay is 320 km long, ~20-40 km wide, covers an area of 6,500 km², and drains 166,000 km² of watershed mainly in Maryland, Virginia, Pennsylvania, the District of Columbia and New York (Figure 1). As the nation's largest and most productive estuary, Chesapeake Bay faces complex environmental issues related to eutrophication and anoxia, turbidity and sedimentation, toxic dinoflagellates, and sea level rise, coastal erosion and submergence. For example, Chesapeake Bay experiences large seasonal and interannual variability in salinity, temperature, and dissolved oxygen (DO) that are strongly influenced by precipitation and river discharge from the watershed. Nutrient concentrations in its tributaries and ecological (microbial degradation) and physical processes (such as wind advection) in the estuary are also important factors in determining

seasonal and interannual variability in oxygen depletion. Many questions regarding the causes of environmental changes in the bay, particularly the contributions of anthropogenic factors like pollution, and climatological factors like precipitation and stream runoff can be answered through the reconstruction of paleoecological trends using microfossils.

To successfully apply microfossils to the reconstruction of Chesapeake Bay environments, however, one needs firm taxonomic and ecological foundations for the key species preserved in sediments. The literature on the major benthic and phytoplankton microfossil groups in east coast estuaries is sparse and widely scattered. Moreover, although there is a large amount of information on living macrobenthos, zooplankton and phytoplankton in Chesapeake Bay, there is relatively little published information available on the micropaleontology of Chesapeake Bay sediments. Among the exceptions, are studies of benthic foraminifers by Ellison and Nichols (1976), plant macrophytes by Davis (1985) and Brush and Davis (1984), and diatoms by Cooper and Brush (1991, 1993) and Cooper (1995), and ostracodes by Cronin (1979). This study attempts to assemble into a single report SEM illustrations and updated taxonomic identifications of the most important species of foraminifera, diatoms, dinoflagellate cysts, and ostracodes used in our paleoecological studies of the bay. It also provides SEM photographs of the major pollen types that have been transported into the bay from vegetation living in the surrounding watershed. Pollen in Chesapeake sediments is extremely useful in determining land-use changes and their impacts on the bay (e.g., Brush and DeFries, 1981; DeFries, 1986).

This study focused on microfossils from sediment cores taken in the middle regions of Chesapeake Bay (mostly mesohaline and lower polyhaline salinity regimes) and its major tributaries (Patuxent, Potomac, Choptank Rivers) (Figure 1). It is limited to microfossils preserved in sediments deposited during the late Holocene, the period covering the past 2000 years. Therefore, species characteristic of the lower bay (upper polyhaline and euhaline) and upper bay (oligohaline) regions and species that may have inhabited the bay during the early and middle Holocene (10,000 to 2,000 years ago) are not

included. Table 1 gives location information on the sediment cores for which microfossil data are presented below.

Format of the Microfossil Database

This report presents information on Chesapeake Bay microfossils in five sections -- one each for benthic foraminifers, diatoms, dinoflagellates, ostracodes and pollen. Each section contains the following. First, a short summary is given on the biology and ecology of the group and its occurrence in Chesapeake Bay sediments. These sections are meant to provide introductory background material and important references to the primary literature on the group's taxonomy and ecology for those readers wishing more information. A table lists the species for each group in each section.

Second, SEM plates and plate captions illustrate the most common species using specimens taken from the sediment cores listed in Table 1. This section is not intended to be a formal taxonomic treatment of a group. Rather it is intended to illustrate important species using the most up-to-date generic and specific nomenclature. In the case of many species, these are the first published scanning electron photomicrographs of the species from Chesapeake Bay.

Third, at the end of each section, there is an appendix giving the abundance of each species in sediment core samples. For some cores only one or two groups were analyzed depending on preservation and time constraints. In these appendices, species and genera are given in the columns and samples are ordered stratigraphically in the rows. Because radiometric dating for many sediment cores is still in progress, chronostratigraphic information is not given. For the dinoflagellate cysts, there is also a data file in the appendix giving species' distributions in 48 surface sediment samples from Chesapeake Bay, in addition to species' occurrences in two long sediment cores.

Acknowledgments

This research was funded through the USGS INATURES program. We appreciate the comments of John Barron, Joan Bernhard, Marty Buzas, Sherri Cooper, Lucy Edwards, Joseph Hazel, and Barun Sen Gupta with taxonomy of various groups of microfossils. Neil Waibel and Patrick Buchanan assisted in collecting, processing and identifying pollen; Rob Stamm and Jean Self-Trail provided assistance on the scanning electron microscope. We are grateful to Walter Boynton and Jerry Frank of University of Maryland's Chesapeake Bay Lab, and Randy Kerhin of Maryland Geological Survey, and Rick Younger of Maryland Department of Natural Resources and their crews, for assistance in obtaining sediment cores.

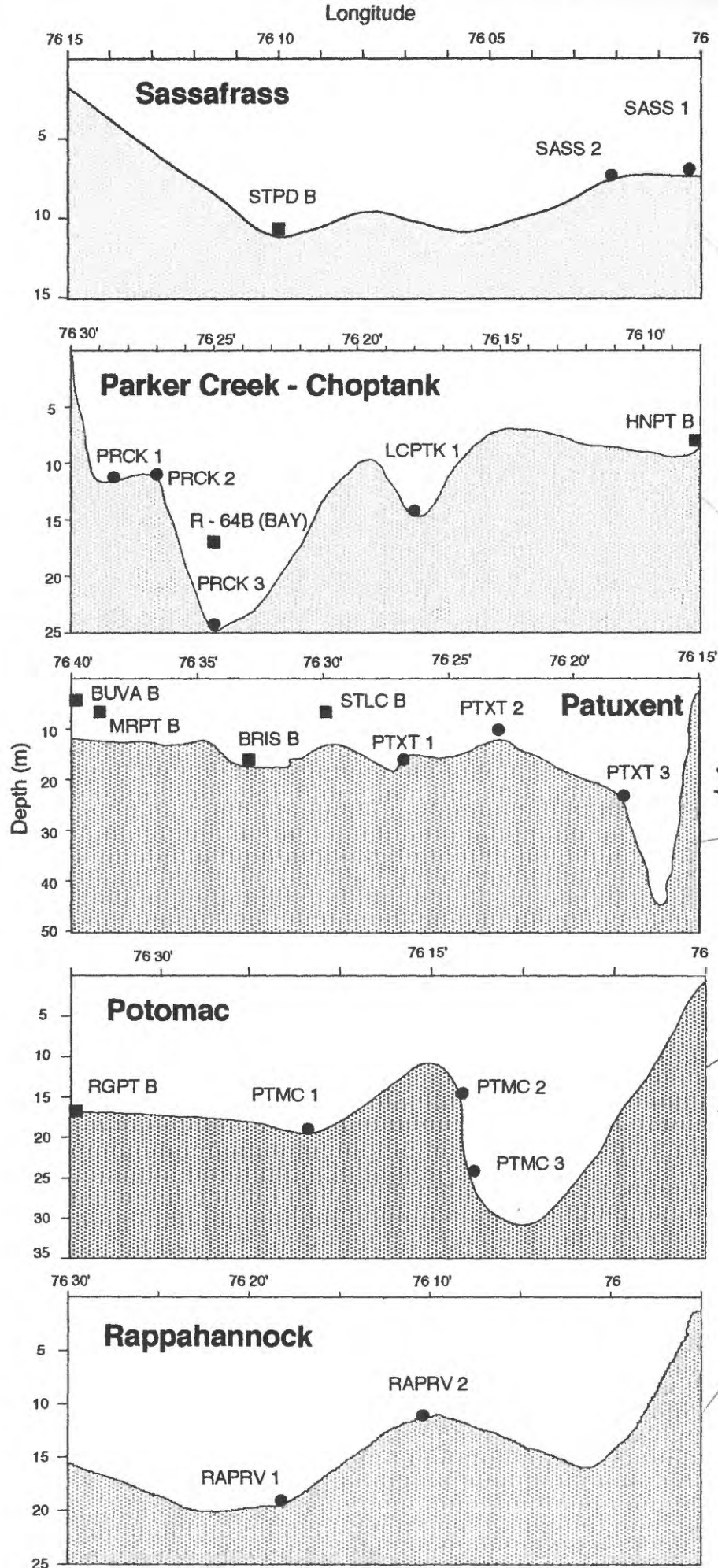
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Figure 1. Map showing core locations on main transects in Chesapeake Bay and its tributaries. See Table 1 for details.

Chesapeake Bay Core Transects



Chesapeake Ecosystem Project Core Summary

Table 1

Transect	Site	Core	type	Water Depth (m)	Latitude	Longitude	Core Length
Potomac	Potomac-1	PTMC 1-P-2	Piston	19	38°01.839'N	76°22.677'W	375 cm
	Potomac-1	PTMC 1-B-2	Box	19	38°01.839'N	76°22.677'W	20 cm
	Potomac-1	PTMC 1-G	Gravity	19	38°01.839'N	76°22.677'W	122cm
	Potomac-2	PTMC 2-P-2	Piston	13.2	37°58.400'N	76°13.733'W	354 cm
	Potomac-2	PTMC 2-B-2	Box	12	37°58.400'N	76°13.733'W	20 cm
	Potomac-3	PTMC 3-P-2	Piston	23.1	38 01.6118'N	76 13.1938'W	450 cm
	Potomac-3	PTMC 3-B-2	Box	22	38 01.6118'N	76 13.1938'W	20 cm
	Potomac-3	PTMC 3-G	Gravity	20	38°01.668'N	76°13.212'W	117cm
	Potomac-3	PTMC 3-G-2	Gravity	24.1	38 01.6118'N	76 13.1938'W	~100 cm
Patuxent	Ragged Point	RGPT	Box	16.5	38°09.86' N	76°35.52' N	24 cm
	Patuxent-1	PTXT 1-P-3	Piston	16.5	38°18.583'N	76°27.203'W	199 cm
	Patuxent-1	PTXT 1-B-3	Box	15	38°18.583'N	76°27.203'W	20 cm
	Patuxent-1	PTXT 1-G	Gravity	16.3	38°18.581'N	76°27.199'W	92cm
	Patuxent-2	PTXT 2-P-3	Piston	11.5	38°19.584'N	76°23.548'W	417 cm
	Patuxent-2	PTXT 2-B-3	Box	10	38°19.584'N	76°23.548'W	20 cm
	Patuxent-2	PTXT 2-G-2	Gravity	11.5	38°19.586'N	76°23.546'W	112cm
	Patuxent-2	PTXT 2-G-3	Gravity	11.5	38 19.588'N	76 23.540'W	100cm
	Patuxent-2	PTXT 2-G-4	Gravity	11.5	38 19.588'N	76 23.540'W	110cm
	Patuxent-3	PTXT 3-P-2	Piston	22.5	38°20.0007'N	76°18.5801'W	432 cm
	Patuxent-3	PTXT 3-B-2	Box	21	38°20.0007'N	76°18.5801'W	20 cm
	Patuxent-3	PTXT 3-G	Gravity	22.5	38°20.0007'N	76°18.5801'W	101cm
	Buena Vista	BUVA	Box	5	38°31.12' N	76°39.82' W	25 cm
	Marsh Point	MRPT	Box	7	38°26.81' N	76°39.13' W	25 cm
	Broomes Island	BRIS	Box	15	38°23.64' N	76°33.17' W	19 cm
	St. Leonard Creek	STLC	Box	6	38°22.88' N	76°30.06' W	21.5 cm

Table 1

Chesapeake Ecosystem Project Core Summary

Transect	Site	Core	type	Water Depth (m)	Latitude	Longitude	Core Length
Parker Creek	Parker Creek-1	PRCK 1-G	Gravity	10.7	38° 32.8657'N	76° 28.7112'W	122cm
	Parker Creek-2	PRCK 2-G	Gravity	11.4	38° 33.1552	76° 27.6069	122 cm
	Parker Creek-3	PRCK 3-G	Gravity	24.3	38° 32.6359'N	76° 25.6199'W	132 cm
	Parker Creek-1	PRCK 1-P-2	Piston	10.7	38 32.519'N	76 29.427'W	315 cm
	Parker Creek-2	PRCK 2-P-1	Piston	11.4	38 33.93'N	76 27.344'W	426
	Parker Creek-2	PRCK 2-P-2	Piston	11.4	38 33.93'N	76 27.344'W	?
	Parker Creek-3	PRCK 3-P-2	Piston	24.3	38° 32.6349'N	76 25.689'W	452cm
	Parker Creek-3	PRCK 3-B-2	Box	23	38° 32.6349'N	76 25.689'W	20 cm
	Little Choptank-1	LCPTK 1-P-1	Piston	13.9	38° 31.4916'N	76° 18.1990'W	455 cm
Susquehanna	Little Choptank-1	LCPTK 1-B-1	Box	13.5	38° 31.4916'N	76° 18.1990'W	20 cm
	Little Choptank-1	LCPTK 1-G	Gravity	13.9	38° 31.4916'N	76° 18.1990'W	122cm
	Horn Point	HNPT	Box	8	38°37.18'	76°08.09'	22 cm
	Sassafras-1	SASS 1-P	Piston	?	39 22.7583'N	76 00.0000'W	407 cm
	Sassafras-1	SASS1-G	Gravity	?	39 22.7583'N	76 00.0000'W	100 cm
	Sassafras-2	SASS 2-P	Piston	?	39 25.2493'N	76 02.2528'W	383 cm
	Sassafras-2	SASS 2-G	Gravity	?	39 25.2493'N	76 02.2528'W	100 cm
	Still Pond	STPD	Box	10.5	39°20.809'	76°10.724'	24 cm
	Rappahannock-1	RAPRV 1-P-2	Piston	19.7	37 35'53.30"	76 18'27.65"	232 cm
Rappahannock	Rappahannock-2	RAPRV 2-G	Gravity	~19	37 32.47'N	76 10'21.9"W	~100 cm
	Rappahannock-2	RAPRV 2-P-2	Piston	11.5	37 32.47'N	76 10'21.9"W	405
	R-64	R-64	Box	16.5	38°33.59'	76°25.63'	17 cm
	Point No Point	PNPT	Box	14	38°07.99'	76°15.13'	22 cm
Mainstem							

lithologic logs and X-radiographs are found in Kerhin et al. 1998

Chesapeake Bay Benthic Foraminifera

By Scott E. Ishman, Alex W. Karlsen, Thomas M. Cronin

Benthic foraminifera are single-celled organisms similar to amoeboid organisms in cell structure. The foraminifera differ in having granular rhizopodia and elongate filopodia that emerge from the cell body. Foraminifera are covered with an organic test that varies from a simple single chamber with an aperture to a complex, multichambered, perforate, calcitic wall, to an agglomeration of mineral grains embedded in the organic test. Benthic foraminifera occupy a wide range of marine environments, from brackish estuaries to the deep ocean basins and occur at all latitudes. Many species have well defined salinity and temperature preferences making them particularly useful for reconstructing past trends in ocean water salinity and temperature.

The distribution of modern benthic foraminifera from the Atlantic coastal margin of the United States and Gulf of Mexico have been studied extensively over the past several decades (see Buzas and Culver, 1980 and 1981 for comprehensive reviews). Many of the taxa have widespread distributions, inhabiting marshes, coastal estuaries, bays, lagoons, and the continental shelf. Comprehensive studies of benthic foraminiferal distributions and ecology in the Chesapeake Bay and its estuaries include papers by Ellison *et al.*, 1965; Nichols and Norton, 1969; Ellison, 1972; Buzas, 1974; and Ellison and Nichols, 1976; and in Gulf Coast Bays by Phleger, 1951, 1954, 1965; Parker *et al.*, 1953; Bandy, 1954; Phleger and Lankford, 1957; Benda and Puri, 1962; Frerichs, 1969; Lamb, 1972; Otvos, 1978; and Poag, 1981.

Several studies have contributed toward our understanding of the distribution of modern benthic foraminifera in Chesapeake Bay estuaries. Ellison *et al.* (1965) and Ellison and Nichols (1970) clearly illustrated distinct benthic foraminiferal assemblage distributions

associated with environmental changes from the marsh to the estuary, into the Bay and culminating on the Atlantic Shelf. Buzas (1974) described the vertical distribution of living *Ammobaculites* from the Rhode River estuary of the Chesapeake Bay. These studies have contributed greatly to the interpretation of benthic foraminiferal assemblages recovered from sediment cores to evaluate past changes in salinity, water temperature, and sea level. Ellison and Nichols (1976) have shown significant environmental changes in the Rappahannock River Estuary for the past 1500 to 3000 years.

The present study is part of a large study to document the benthic foraminiferal fauna in the Chesapeake Bay and its estuaries, and to determine temporal changes in the benthic foraminiferal communities throughout the last few millennia in the sedimentary record. Following the format used for other microfossil groups, there are two sections given here. The first consists of five plates of scanning electron photomicrographs illustrating 11 benthic foraminiferal taxa found in the mesohaline parts of the bay (Table 2). The species illustrated include the most common benthic foraminiferal species now living, or having lived in the middle regions of Chesapeake Bay over the past millennium. The second part consists of species census data for benthic foraminifera obtained from the box, piston, and gravity cores (Table 1).

Table 2. Some Benthic Foraminifer species from mid-Chesapeake Bay

Ammobaculites exiguus (Cushman and Bronnimann 1948)

Ammonia tepida (Cushman 1926)

Ammotium salsum (Cushman and Bronnimann 1948)

Buccella frigida (Cushman 1922)

Elphidium clavatum Cushman 1930

Elphidium excavatum (Terquem 1876)

Elphidium selseyense (Heron-Allen and Earland 1911)

Polymorphinidae

Quinqueloculina sp.

Trochammina macrescens (Brady 1870)

Trochammina inflata (Montagu 1808)

Trochammina sp.

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Plate 1

- 1) *Buccella frigida*, umbilical, PTMC 3-P-2 224-226 cm., x 212.
- 2) *Buccella frigida*, dorsal, PTMC 3-P-2 224-226 cm., x 242.
- 3) *Trochammina macrescens*, umbilical, JP-3 0-10 cm., x 160.
- 4) *Trochammina inflata*, dorsal, JP-3 0-10 cm., x 200.
- 5) *Trochammina* sp., dorsal, JP-3 0-10 cm., x 180.

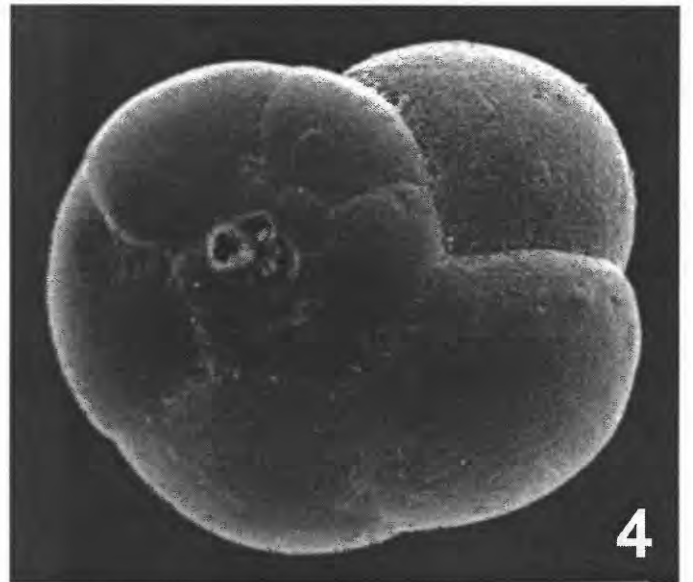
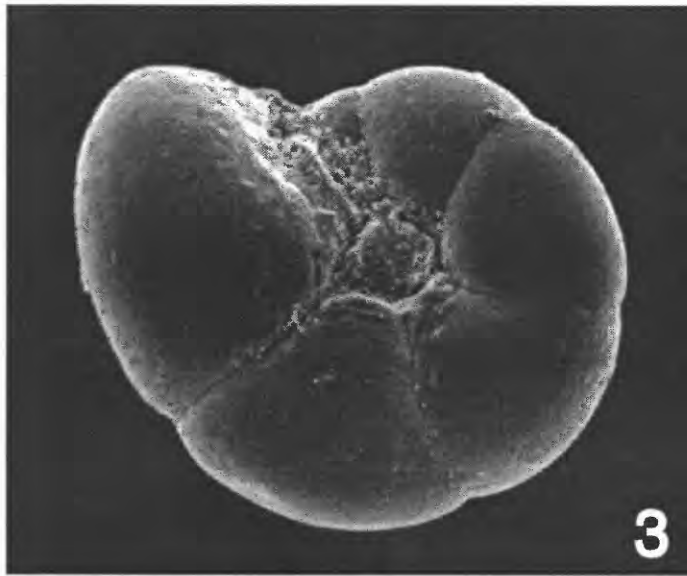
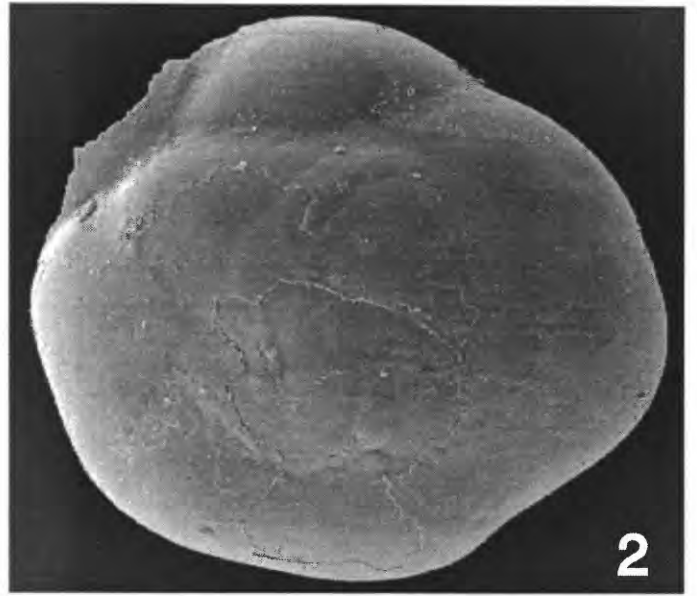
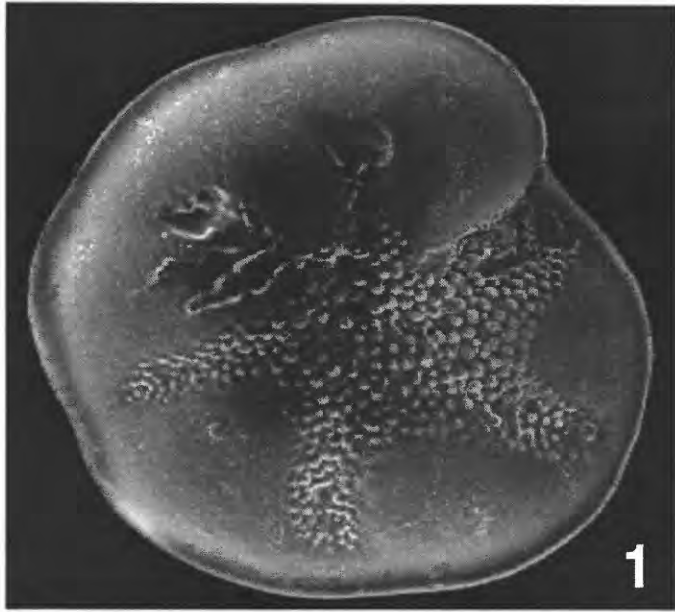


Plate 2

- 1) *Ammobaculites* sp., side view, PRCK 3-P-2 0-2 cm., x 220.
- 2) *Ammobaculites* sp., side view, BUVA 0-2 cm., x 200.
- 3) *Ammobaculites* sp., side view, RGPT 8/96 19-20 cm., x 160.
- 4) Polymorphinid, PTMC-3 Archive 358-360 cm., x 130.
- 5) *Miliammina fusca*, side view, JP-3 0-10 cm., x 300

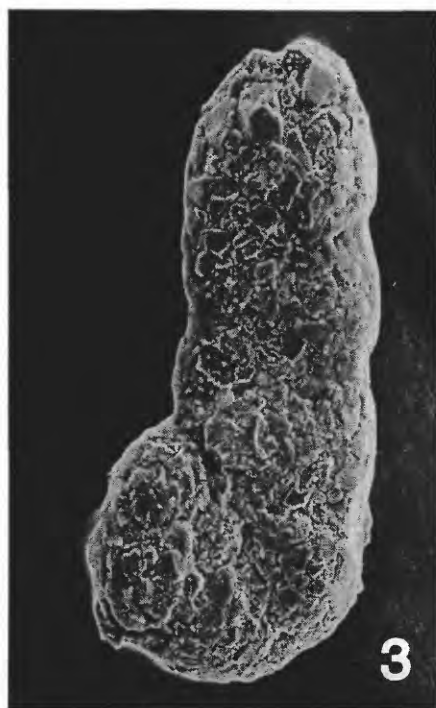
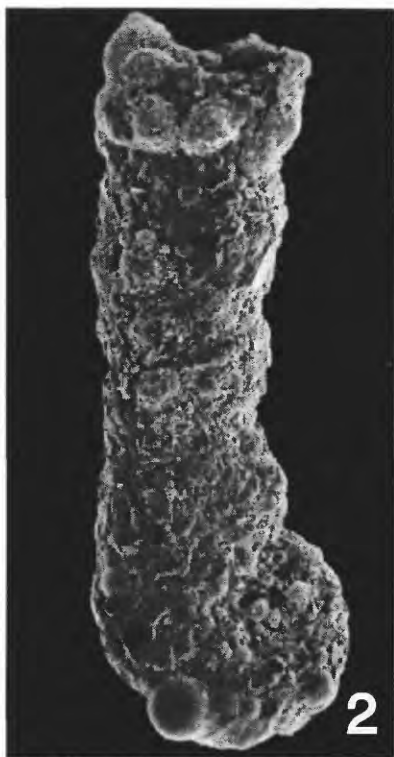
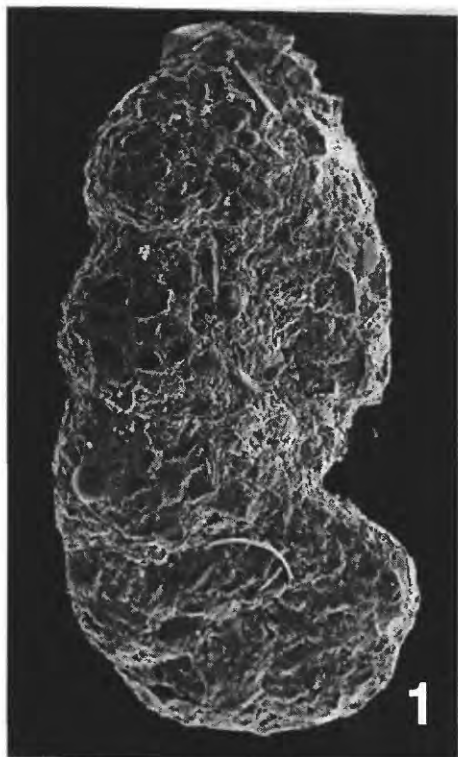


Plate 3

- 1) *Elphidium selseyense*, umbilical, R-64 0-2 cm., x 220.
- 2) *Elphidium selseyense*, large, PTMC 3-P-2A 36-38 cm., x 130.
- 3) *Elphidium clavatum*, small, PTMC 3-P-2A 36-38 cm., x 200.
- 4) *Elphidium clavatum*, small, PTMC-3 Archive 344-346 cm., x 200.

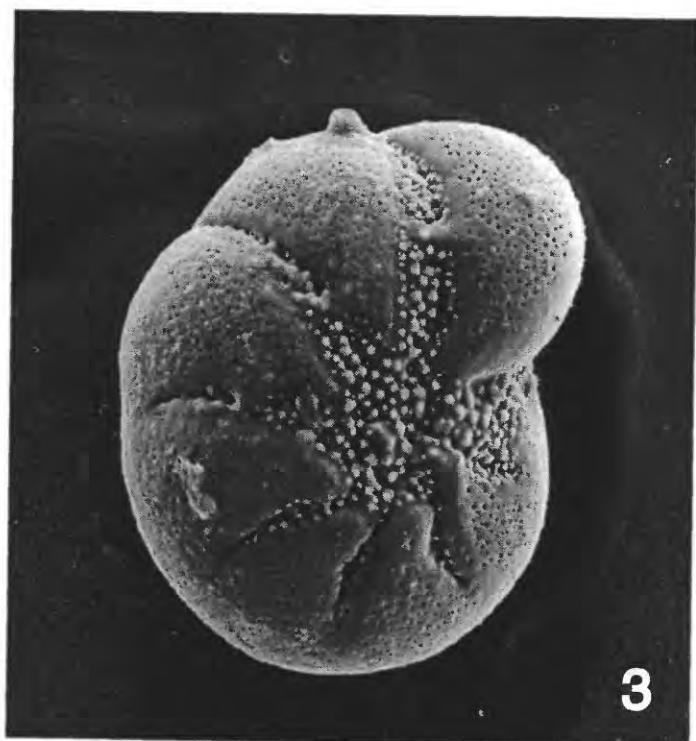
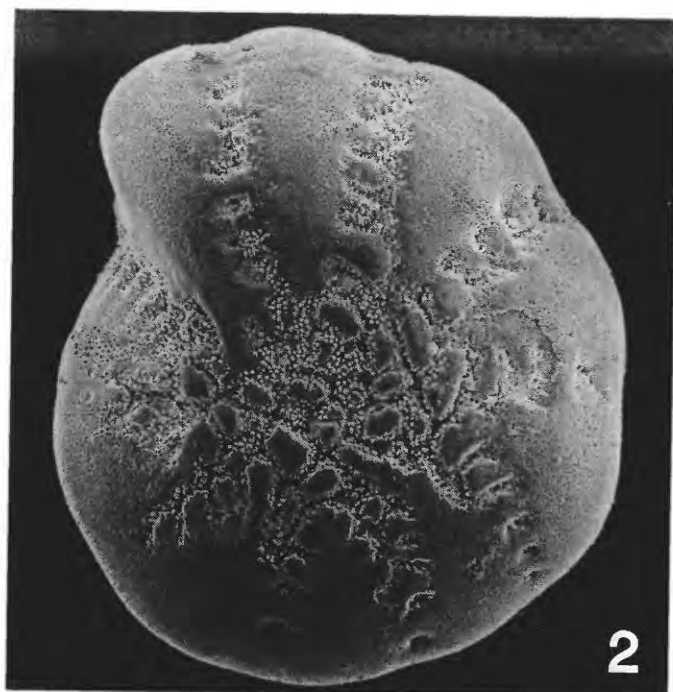


Plate 4

- 1) *Ammonia tepida*, dorsal, Tangiers-5 0-2 cm., x 160.
- 2) *Ammonia tepida*, umbilical, Tangiers-5 0-2 cm., x 200.
- 3) *Ammonia tepida*, spiral view, PTXT 2-P-5 286-288 cm., x 260.
- 4) *Ammonia tepida*, umbilical view, PTXT 2-P-5 214-216 cm., x 260.
- 5) *Ammonia tepida*, umbilical view, RGPT 8/96 7-8 cm., x 130.
- 6) *Ammonia tepida*, spiral view, PTXT 2-P-5 10-12 cm., x 130.

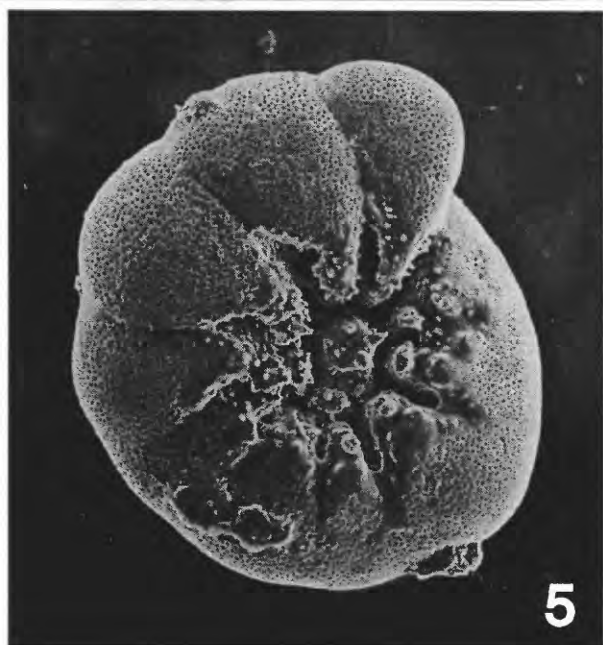
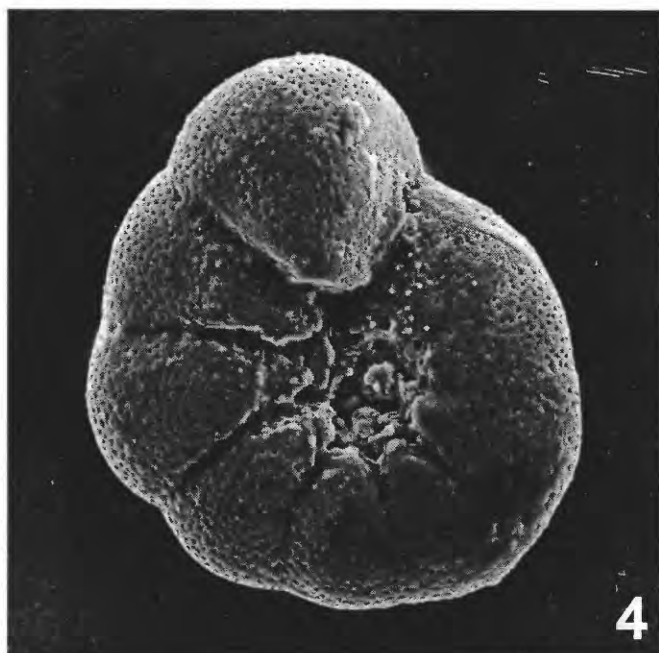
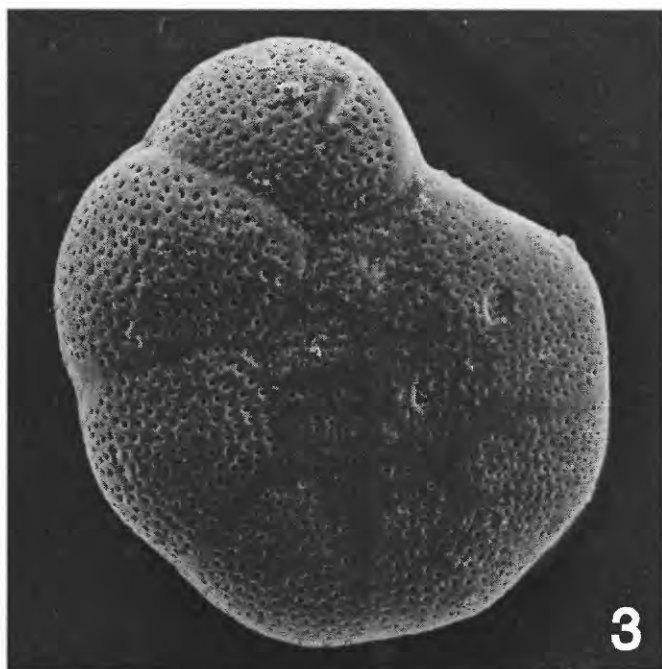
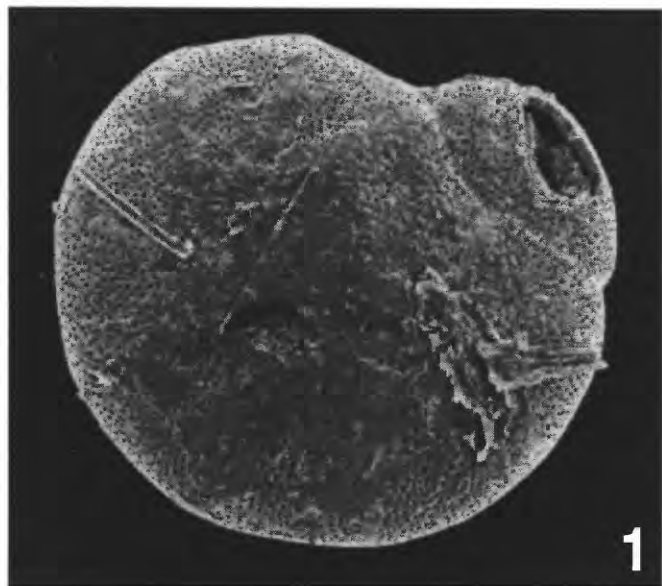
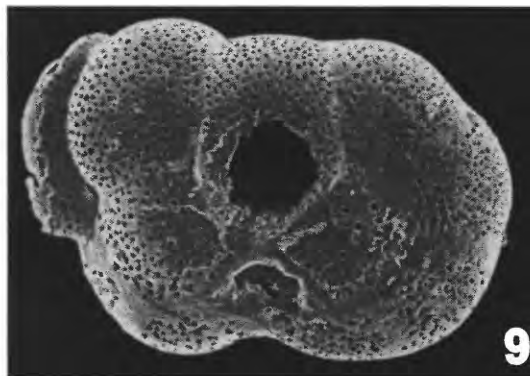
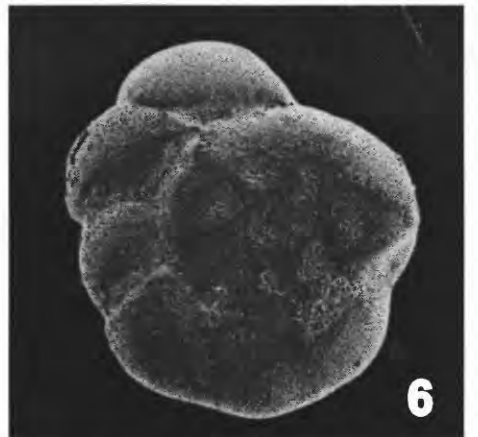
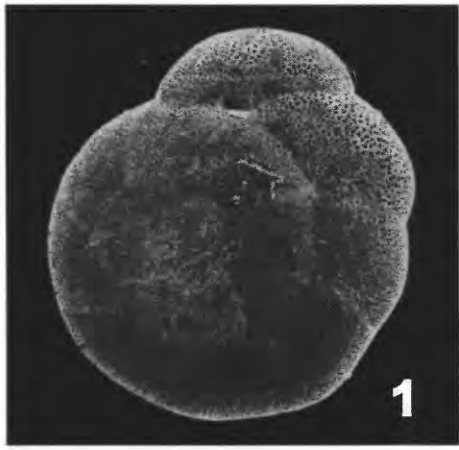


Plate 5-Deformed Foraminifera

All photographs are of *Ammonia*

- 1) Normal test, dorsal view, BRIS 6/97 0-10 cm., x 160.
- 2) Normal test, umbilical view, BRIS 6/97 0-10 cm., x 180.
- 3) Abnormal chamber shape, HNPT 7/96 0-10 cm., x 300.
- 4) Reduced-size chamber, HNPT 7/96 0-10 cm., x 260.
- 5) Distorted chamber shape or change in coiling direction, PTXT 2-P-5 0-10 cm., x 240.
- 6) Development of the high spiral face, PRCK 3-P-2 0-10 cm., x 180.
- 7) Non-developed test, BRIS 6/97 0-10 cm., x 130.
- 8) "Protruded umbilical", HNPT 7/96 0-10 cm., x 130.
- 9) Distorted chamber shape or change in coiling direction, PTXT 2-P-5 0-10 cm., x 320.

See Geslin *et al.* 1998 for discussion of terminology of test morphological deformities.



Depth (cm)	<i>E. seiseyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>Ammonobaculites</i>	<i>B. frigida</i>	Total
1	4		1			5
3	48		44	3		95
5	10			1		11
7	33			3		36
9	101	3				104
11	24					24
13	25					25
15	110	11				121
17	106	3	2			111
19	70	15	1			86
21	54	21		2		77
23	79	23				102
25	92	8				100
27	65	28	2	2		97
29	72	20	13			105
31	16	15	2			33
33	21	85				106
35	47	49	4			100
37	56	45	1			102
39	48	27	2			77
41	43	18	2			63
43	22	1				23
45	29	3	1			33
47	1					1
49	16	3	3			22
51	94	20				114
53	21	82				103
55	11	97				108
57	1	92				93
59	15	83				98
61	6	26	4			36
63	14	78				92
65	15	77				92
67	2	86				88
69	18	72				90
71	10	35				45
73	20	40				60
75	18	64				82
77	38	53				91
79	4	69				73
81	3	91				94
83	3	25				28
85		10				10
87	5	83				88
89		7				7
91	1	24				25
93		16		6		22
95		11		3		14
97		54				54
99	4	97				101
101	3	65		1		69
103	1	6				7
105		25				25
107	25	61		1		87
109	24	29				53
111	60	35				95
113	32	64	3			99
115	26	89				115
117	12	70	3	12		97
119	9	36				45
121		17				17
123	1	54	1			56
125	1	28				29
127	1	27				28
129	10	90				100
131		44				44
133	4	96				100
135	9	33				42
137	4	32	1			37
139	6	35				41
141	7	24	1			32
143	1	25				26

Depth (cm)	<i>E. selseyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>Ammobaculites</i>	<i>B. frigida</i>	Total
145	6	11				17
147	25	12	2			39
149						0
151						0
153	2					2
155	1					1
157	4	1		1		6
159						0
161	8					6
163	8		1			9
165	3					3
167	6	1				7
169	6	1				7
171	27					27
173	4					4
175	20		1			21
177	5					5
179	21					21
181	121	1				122
183	40	4				44
185	39					39
187	12					12
189	52					52
191	76					76
193	98	1	1		1	101
195	104					104
197	76					76
199	100					100
201	62	16			1	99
203	15	6	2			23
205	6		1			7
207	4					4
209	66	15				61
211	5					5
213	14					14
215	63					63
217	29					29
219	37					37
221	53	47	1			101
223	73	24	5			102
225	52	4	25		3	84
227	17	4	3			24
229	41	64	5			110
231	5		1			6
233	4					4
235	8					8
237	49	10	15			74
239	24					24
241	17					17
243	89				1	90
245	6					6
247						0
249	51	30				81
251	9					9
253	16					16
255	8					8
257	9					9
259	12					12
261	59	40	1			100
263	7					7
265	2					2
267	1					1
269	1					1
271	28	8				36
273	4					4
275	6					6
277	1					1
279	1					1
281	1					1
283	93	6				99
285	2					2
287	2					2
289	2					2
291	15					15
293	89	11				100
295	1					1
297	3					3

Depth (cm)	<i>E. selseyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>Ammoniaculites</i>	<i>B. frigida</i>	Total
299						0
301						0
303						0
305						0
307	6					6
309						0
311	2					2
313	1					1
315	1					1
317	6					6
319						0
321						0
323	3					3
325	23	4				27
327	9					9
329	2					2
331	8					8
333	3					3
335	30	4				34
337						0
339	1					1
341						0
343						0
345	4	8			3	15
347						0
349						0
351	3					3
353						0
355	1					1
357	57	48			2	107
359	1					1
361	100					100
363	77				3	80
365	36		5			41
367	66	33	4		5	108
369						0
371	1					1
373						0
375	2					2
377	6					6
379	56	5	2		3	66
381						0
383	3					3
385	3					3
387						0
389	8					8
391						0
393						0
395	21	2				23
397						0
399	3					3
401	4					4
403	32	3				35
405	34	1				35
407						0
409	2					2
411	89	1	2		3	95
413	33		7			40
415	2					2
417						0
419	40					40
421	65	1	1			67
423	2					2
425						0
427	73	1			1	75
429	8					8
431	3					3
433						0
435	3					3
437						0
439	27					27
441	8	1	1			10
443	5					5
445	6					6
447	40					40
449	3					3

Depth (cm)	<i>Elphidium</i>	<i>Ammonia</i>	<i>Ammobaculites</i>	Total
1	8	1	2	11
6	5	12	1	18
11	5	1		6
16	107	3	2	112
21	11			11
26	34	27	31	92
31	53	28	22	103
36	47	17	24	88
41	101		17	118
46	88	1	1	90
51	76	1	3	80
56	64	3	8	75
61	53	18	25	96
66	39	9	49	97
71	79	26	48	153
76	53	25	32	110
81	79	5	33	117
86	90	3	41	134
91	117	1	1	119
96	118			118
101	100			100
106	93		12	105
111	102			102

Depth (cm)	<i>E. selseyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>Ammobaculites</i>	<i>Quinqueloculina sp.</i>	Total
1	21		77	5		103
3	23		73	3		99
5	23		69			92
7	37	3	60			100
9	22	4	68			94
11	11	3	86			100
13	16		83			99
15	55	10	30			95
17	84	14	6			104
19	84	17	2	5		108
21	62	42	2			106
23	60	22	13			95
25	51	15	29	3		98
27	39	34	32	1		106
29	38	29	19	13		99
31	24	38	10	28		100
33	46	16	32	1		95
35	47	8	26	19		100
37	39	3	25	33		100
39	26	16	37	21		100
41	32	15	42	6		95
43	36	12	53	16		117
45	55	5	54	19		133
47	42	6	33	15		96
49	54	9	52	8		123
51	69	14	11			94
53	81	14	4	1		100
55	78	17	12	4		111
57	77	14	7	5		103
59	62	27	8	9		106
61	58	29	7	2		96
63	62	41	3	3		109
65	52	58		1		111
67	65	39	2	4		110
69	77	36				113
71	62	32				94
73	59	41		1		101
75	61	25	3	2		91
77	69	17	2	4		92
79	81	17	7	1		106
81	61	23	8	5		97
83	56	29	7			92
85	63	13	19	9		104
87	51	19		10		80
89	52	23	10			85
91	48	6	23	25		102
93	43	11	20	33		107
95	65	52	9	14		140
97	16	2	3	106		127
99	26	8	11	93		138
101	7		6	89		102
103	60	10	26	68		164
105	10		6	77		93
107	63	8	63	48		182
109	10		20	66		96
111	25	1	7	59		92
113	32	12	25	48		117
115	17	7	12	115		151
117	32	3	12	56		103
119	37	9	13	98		157
121	18	1	3	77		99
123	71	11	14	10		106

Depth (cm)	<i>E. selseyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>Ammobaculites</i>	<i>Quinqueloculina</i> sp.	Total
125	33	8	11	21		73
127	74	11	24	23		132
129	51	7	16	44		118
131	47	23	11	8		89
133	64	24	10	6		104
135	42	17	19	14		92
137	58	36	7	4		105
139	50	36	27	4		117
141	65	29	8			102
143	88	21	6			115
145	86	21	2	1		110
147	83	8	3			94
149	70	29	4	3		106
151	30	33	5	26		94
153	127	50	1	5		183
155	68	67		2		137
157	57	34		5		96
159	73	13		28		114
161	40	21	13	28		102
163	28	2		70		100
165	64	11	1	16		92
167	58	8	2	32		100
169	65	9	1	29		104
171	61	8		13		82
173	87	22	1	1		111
175	60	31	2	7		100
177	64	39		1		104
179	14	90	1	12		117
181	43	72	2	1		118
183	55	56	7	8		126
185	87	13				100
187	76	30	3	9		118
189	82	14	3	16		115
191	63	20		37		120
193	59	22	2	18		101
195	56	7	24	17		104
197	84	21	1	2		108
199	57	13	8	14		92
201	70	23		1		94
203	53	14	24	7		98
205	69	37	13	2		121
207	43	15	33	5		96
209	101	18	1			120
211	79	16	33	5		133
213	90	37	32			159
215	33	18	54			105
217	51	4	11	61		127
219	56	8	34	5		103
221	70	27	8			105
223	86	22	11			119
225	149	61	2			212
227	63	22	12	3		100
229	112	16	13	35		176
231	89	13	4	2		108
233	163	30	4			197
235	69	19	5			93
237	89	21	4			114
239	53	48	1			102
241	78	32	1			111
243	69	35	8			112
245	45	38	8			91
247	87	11	7			105
249	96	8	1	10		115
251	45	10	6	46		107
253	58	4	1	58		121
255	23	7	2	60		92
257	77	16	2	7		102
259	57	28	3	17		105
261	108	22	4	5		139

Depth (cm)	<i>E. selseyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>Ammobaculites</i>	<i>Quinqueloculina</i> sp.	Total
263	36	69	1	7	1	114
265	148	32	1	2		183
267	90	27	1	2		120
269	82	14		3		99
271	85	3		12		100
273	119	11	3			133
275	73	18	1	16		108
277	124	14	4	1		143
279	81	13	2	4		100
281	106	14	4	1		125
283	44	8		38		90
285	93	6	2	3		104
287	9	3	3	86		101
289	56	8		36		100
291	28	3	1	65		97
293	33	1		58		92
295	61	7		33		101
297	105	6	2	2		115
299	64	24	2	3		93
301	72	15		4		91
303	75	28	1	4	1	109
305	81	28	1			110
307	93	27	1	2		123
309	91	18	1	1		111
311	55	38	3	2		98
313	76	27		1		104
315	73	56	1	1		131
317	51	39				90
319	34	81	2	2		119
321	33	61	1			95
323	58	45				103
325	61	50		1		112
327	94	32	1	1		128
329	69	19		3		91
331	62	27	5	9		103
333	59	46	1			106
335	68	22		7		97
337	67	20	1	6		94
339	71	15	4	10		100
341	74	12		6		92
343	78	21	2	10		111
345	57	20	3	4		84
347	59	13	1	19		92
349	49	12				61
351	12	1	6	86		105
353	28	8	1	66		103
355	38	14	1	40		93
357	49	35	2	4		90
359	65	11	2	15		93
361	87	6	2	6		101
363	15	3		3		21
365	84	4	3			91
367	86	11	5	1		103
369	138	4				142
371	74	21				95
373	62	45				107
375	66	43				109
377	64	37				101
379	56	46				102
381	65	19				84
383	74	14	1			89
385	111	38	1	2		152
387	72	20				92
389	41	55				96
391	71	21	1			93
393	75	38				113
395	105	24	1			130
397	103	15				118
399	116	18	1	9		144

Depth (cm)	<i>E.selseyense</i>	<i>E.excavatum</i>	<i>E.clavatum</i>	<i>A.tepida</i>	<i>Ammobaculites</i>	Total
1			1		1	2
3			8	23	5	36
5			10	54	2	66
7		1	43	57	0	101
9		5	20	75	2	102
11		5	39	59	0	103
13		14	61	23	2	100
15		10	78	11	1	100
17		3	87	5	5	100
19		1	90	8	1	100
21		6	50	11	33	100
23		4	44	6	50	104
25		9	34	1	57	101
27		4	61	7	54	126
29		4	25	11	60	100
31		1	28	37	37	103
33		2	28	42	28	100
35			42	21	41	104
37		6	65	19	16	106
39		3	63	27	10	103
41			57	17	26	100
43		10	64	10	16	100
45		6	88	3	5	102
47		1	93	1	5	100
49		2	96		4	102
51		7	66	8	19	100
53		8	53	9	34	104
55		3	57	9	31	100
57		2	81	13	4	100
59		2	67	24	13	106
61		2	80	13	9	104
63		3	99	2		104
65			47	33	30	110
67		1	32	24	44	101
69		2	36	24	46	108
71		1	43	30	26	100
73		2	41	40	19	102
75		3	41	32	24	100

Depth (cm)	<i>E.selseyense</i>	<i>E.excavatum</i>	<i>E.clavatum</i>	<i>A.tepida</i>	<i>Ammobaculites</i>	Total
77		2	29	29	40	100
79		1	18	21	60	100
81		2	20	10	73	105
83		2	30	3	67	102
85		4	16	6	74	100
87		4	30	4	68	106
89		8	36	6	57	107
91		7	58	5	43	113
93	3	9	52	6	36	106
95	2	15	73	3	13	106
97		5	98	1	2	106
99		1	96	2	1	100

Depth (cm)	<i>E. selseyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>Ammobaculites</i>	Total
101	75	13	16	1	105
111	93	5	6		104
121	78	8	13	1	100
131	79	8	17	1	105
141	74	18	9	1	102
151	60	12	14	2	88
161	85	16			101
171	87	9		1	92
181	82	9	2		93
191	88	11	2		101
201	78	9	3		90
211	75	4			79
221	94	10	3		107
231	63	5	13		81
241	75	8	6		89
251	73	4	13		90

Depth (cm)	<i>E. selseyense/clavatum</i>	<i>E. excavatum</i>	<i>A. tepida</i>	<i>Ammobaculites</i>	Total
91	5	93	2		100
101	75	13	16	1	105
111	93	5	6		104
121	78	8	13	1	100
131	79	8	17	1	105
141	74	18	9	1	102

Depth (cm)	<i>E. seleyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>B. frigida</i>	Total
1	6	4	90		100
3	30	19	58		107
5	20	41	39		100
7	65	20	17		102
9	43	40	19		102
11	62	33	5		100
13	46	54	2		102
15	66	18	16		100
17	35	47	18		100
19	63	25	13		101
21	31	55	15		101
23	55	37	16		108
25	36	28	37		101
27	51	38	18		107
29	36	55	10		101
31	33	65	7		105
33	5	90	5		100
35	20	42	40		102
37	20	10	29		59
39	20	3	78		101
41	23	9	9		41
43	58	41	3		102
45	53	37	10		100
47	54	50	3		107
49	65	35			100
51	72	28	3		103
53	57	40	3		100
55	55	27	3		85
57	35	23	2		60
59	89	12	2		103
61	93	5	2		100
63	76	18	6		100
65	75	11	15		101
67	75	13	5		93
69	80	12	8		100
71	90	8	2		100
73	84	17	1		102
75	79	18	3		100
77	69	26	6		101
79	49	45	4		98
81					0
83					0
85					0

Depth (cm)	<i>E.selseyense/excavatum</i>	<i>E.clavatum</i>	<i>A.tepida</i>	<i>Ammobaculites</i>	Total
1	5	3	91	183	282
6	9		17	331	357
11	17	2	12	240	271
16	18	38	1	257	314
21	49	3	6	364	422
26	18	11		195	224
31	19		152	240	411
36	24	20	60	163	267
41	53	19	41	313	426
46	45	37	9	142	233
51	2			1	3
56	79	15	2	1	97
61	84	7	1	1	93
66	90	5			95
71	76	7			83
76	29	3			32
81	84	7			91
86	60	26	3		89
91	77	1			78
96	81	7	1		89
101	97		2		99
106	6				6
111					0
116	20				20
121	2				2

Depth (cm)	<i>E. seleyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>B. frigida</i>	Total
87					0
89					0
91					0
93					0
95					0
97					0
99					0
101					0
103					0
105					0
107					0
109					0
111					0
113					0
115					0
117					0
119					0
121	97	7	5	2	111
123	87	4	9		100
125	19	1	3		23
127	56	2	3		61
129	78	7	9	1	95
131	2		2		4
133	51		1	2	54
135	83	17			100
137	63	3	1		67
139	61	36	3		100
141	80	19	1	1	101
143	88	17	1		106
145	106	14		1	121
147	107	9	2	1	119
149	92	8	2	1	103
151	87	9	4		100
153	100	9			109
155	57	15	2		74
157	76	24			100
159	87	14	1		102
161	66	13	2		81
163	73	8			81
165	52	15	6	3	76
167	15	15	2		32
169	71	7	2	2	82
171	93	2	5		100
173	66	2	7		75
175	75	3	1	3	82
177	3				3
179	91	8	1		100
181	38	3	4		45
183	33		2	1	36

Depth (cm)	<i>E. seleyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>B. frigida</i>	Total
185	94	6	2		102
187	90	3			93
189	16	2	9		27
191	86	1	1	1	89
193	97	4	2		103
195	96	1			97
197	87	2	1		90
199	74		1		75
201	51			1	52
203	95	5			100
205	90	10			100
207	93	7			100
209	88	12			100
211	86	14			100
213	79	19		2	100
215	81	17	2		100
217	92	7		1	100
219	81	23	1		105
221	77	23			100
223	58	42			100
225	75	25			100
227	79	21			100
229	104	34			138
231					0
233	61				61
235	109				109
237	81	17	3		101
239					0
241					0
243					0
245					0
247					0
249					0
251					0
253					0
255					0
257					0
259	1				1
261	3				3
263					0
265					0
267	1				1
269					0
271					0
273					0
275					0
277					0
279					0
281					0

Depth (cm)	<i>E. seleyense/excavatum</i>	<i>E. clavatum</i>	<i>A. tepida</i>	<i>B. frigida</i>	Total
283					0
285					0
287	1				1
289	18				18
291	107		1		108
293	99		1		100
295	100				100
297	90		5		95
299	84	16			100
301	34				34
303	37				37
305	74	18	1		93
307	98	2			100
309	94	7			101
311	98		2		100
313	63	33	2	2	100
315	78	14	2	1	95
317	28	72			100
319	68	32			100
321	48	52			100
323	72	27		1	100
325	92	6		2	100
327	85	14	1		100
329	81	19		1	101
331	76	22	1	1	100
333	66	31		3	100
335	97	3			100
337	74	26			100
339	65	35			100
341	68	43	1		112
343	29	71			100
345	55	49			104
347	86	18			104
349	79	37			116
351	97	4	3		104
353	95	2	1	2	100
355	97	4	1		102
357	81	19			100
359	86	10	3	1	100
361	96	4			100
363	97	2		1	100
365	92	8			100
367	97	4		1	102
369	75	24		1	100

Depth (cm)	<i>E.selseyense/excavatum</i>	<i>E.clavatum</i>	<i>A.tepida</i>	<i>Ammobaculites</i>	Total
10	27	48	25		100
15	3	92	8		103
20	13	68	24		105
25	8	81	11		100
40	10	90			100
50	19	84	1		104
60	27	65	8		100
70	9	104	1		114
80	31	70			101
90	31	53	8	8	100
100	83	12	6	3	104
110	72	23	5	2	102
120	68	15	9	8	100
130	37	27	34	5	103
140	80	18	9	2	109
150	34	65	1		100
160	79	11	6	4	100
170	94	10	6		110
180	82	12	8		102
190	85	11	4	5	105
200	72	15	12	1	100
210	85	20	11	5	121
220	62	38	3		103
230	74	15	11	2	102
240	27	1	2		30
250	110		2		112

Depth (cm)	<i>Elphidium</i>	<i>Ammonia</i>	<i>Ammobaculites</i>	<i>Miliammina</i>	Total
0.5		84	6	10	100
1.5		9		7	16
2.5		1		1	2
3.5		1			1
4.5					0
5.5		1			1
6.5	10	90			100
7.5	12	88			100
8.5	37	74	1		112
9.5	33	65	2		100
10.5	44	55	4		103
11.5	29	65	10		104
12.5	82	18			100
13.5	1	6	4		11
14.5	9	4	6		19
15.5	1	0	41	1	43
16.5	5	3	3		11
17.5			2		2
18.5	8	1	11		20
19.5	2		1		3

Depth (cm)	<i>Elphidium</i>	<i>Ammonia</i>	<i>Ammobaculites</i>	<i>Miliammina</i>	Total
0.5	2	102	12	3	119
2.5		109	7	2	118
4.5		90	12	2	104
6.5	1	101	3		105
8.5	14	72	20	3	109
10.5	32	15	50	6	103
12.5	32	15	56	1	104
14.5	12	3	93	1	109
16.5	14	3	82	2	101

Depth (cm)	<i>Elphidium</i>	<i>Ammonia</i>	<i>Ammobaculites</i>	Total
0.5		86	2	88
2.5		54		54
4.5		15		15
6.5		7		7
8.5		28		28
10.5		12	3	15
12.5		10	5	15
14.5	2	34	13	49
16.5	1	19	8	28
18.5	5	68	3	76
20.5	6	60	7	73
22.5	17	72	3	92
24.5	16	24	4	44

Depth (cm)	<i>Elphidium</i>	<i>Ammonia</i>	<i>Ammobaculites</i>	<i>Miliammina</i>	Total
0.5	24	3	1		28
2.5	44	9	5		58
4.5	8	19	31	1	59
6.5	3	42	15	2	62
8.5	4	35			39
10.5	3	80	14		97
12.5		62	21		83
14.5	8	86	3		97
18.5		36			36

Depth (cm)	<i>Elphidium</i> sp.	<i>Ammonia tepida</i>	<i>Ammotium salsum</i>	Total
0.5	1	1		2
2.5				0
4.5	1	2		3
6.5	19	10	6	35
8.5	93	21	2	116
10.5	129	11	1	141
12.5	127		2	129
14.5	139			139
16.5	142	2	5	149

Depth	<i>Elphidium</i>	<i>Ammonia</i>	<i>Ammobaculites</i>	Total
0.5				0
1.5				0
2.5			1	1
3.5			2	2
4.5				0
5.5				0
6.5	16	22		38
7.5	2	86	9	97
8.5		14	6	20
9.5			2	2
10.5				0
11.5	23	4	3	30
12.5	43		8	51
13.5	10		5	15
14.5			2	2
15.5				0
16.5	18			18
17.5	17	1	1	19
18.5	36	2	4	42
19.5			1	1
20.5	100			100
21.5	2			2

Depth (cm)	<i>Elphidium</i> sp.	<i>Ammonia tepida</i>	<i>Ammotium salsum</i>	Total
1.0	68	26	12	106
2.5	47	46		93
4.5	50	52		102
6.5	46	53		99
8.5	33	40	14	87
10.5	51	21		72
12.5	50		17	67
14.5	93			93
16.5	10	1	36	47
18.5	24	1	59	84
20.5	23		25	48
22.5	8	10	54	72

Depth (cm)	<i>Elphidium</i>	<i>Ammobaculites</i>	<i>Ammonia</i>	Total
0.5	58	4	39	101
1.5	15	55	7	77
2.5	17	50	33	100
3.5	18	39	42	99
4.5	2	61	29	92
5.5	1	67	34	102
6.5	4	83	7	94
7.5	48	47	6	101
8.5	7	90	1	98
9.5		100		100
10.5		100		100
11.5	4	96		100
12.5	28	69	3	100
13.5	31	69		100
14.5	10	87		97
15.5		100		100
16.5		100		100
17.5	5	95		100
18.5	7	93		100
19.5	1	99		100
20.5	4	101		105
21.5		82		82

Depth (cm)	<i>Elphidium</i> sp.	<i>Ammonia tepida</i>	<i>Miliammina fusca</i> (?)	<i>Ammotium salsum</i>	<i>Globigerinoides</i> spp.	<i>Textularia earlandi</i> (?)	Total
0.5		96	1	14			111
2.5		37	1	48			86
4.5		48	3	90			141
6.5		54	5	69		1	129
8.5	1	103	20	111			235
10.5		27	2	67			96
12.5		37	2	61			100
14.5	1	56	5	38			100
16.5	7	23	4	57		1	92
18.5	18	64	33	227	1		343
20.5	11	3		50			64

Depth (cm)	<i>Ammobaculites</i>	<i>Elphidium</i>	<i>Ammonia</i>	<i>Milimmina fusca</i> (?)	Total
0.5	71	0	4	4	79
1.5	84	0	11	12	107
2.5	92	0	4	8	104
3.5	77	0	4	10	91
4.5	100	0	23	0	123
5.5	89	0	0	4	93
6.5	72	0	0	5	77
7.5	106	0	6	7	119
8.5	101	0	3	2	106
9.5	86	0	1	2	89
10.5	97	0	0	2	99
11.5	90	0	1	1	92
12.5	100	0	0	0	100
13.5	105	0	0	2	107
14.5	100	0	0	0	100
15.5	101	0	0	3	104
16.5	93	0	0	3	96
17.5	99	0	0	3	102
18.5	93	0	0	4	97
19.5	100	0	0	4	104
20.5	88	3	6	5	102
21.5	98	0	0	3	101

Chesapeake Bay Diatoms

By Lisa M. Weimer

Diatoms are golden brown algae (Class Bacillariophyceae) whose cellular material is contained within a highly silicified cell wall called a frustule, which is often fossilized in marine, estuarine and lacustrine sediments. They are generally classified on the basis of symmetry of the frustule; those with radial symmetry are called centric diatoms and those with axial symmetry are called pennate diatoms. Upon death, the diatom cell walls become incorporated into the sediment where they comprise some of the most abundant microfossils, often achieving nearly 200 million diatoms per square centimeter of sediment.

Diatoms preserved in sediments can provide records of environmental change at time scales ranging from seasonal to millennial (Battarbee, 1986, 1991). Diatoms have been widely used to reconstruct past changes in pH (Gasse and Tekaia, 1983; Birks *et al.*, 1990), salinity (Kjemperud, 1981; Fritz, 1990), nutrients (Whitmore, 1989; Agbeti, 1992; Fritz *et al.*, 1993), and climatic changes (Haworth, 1977; Brugan, 1980; Dean *et al.*, 1984).

Previous studies and taxonomic lists of diatoms for the Chesapeake Bay have focused primarily on the phytoplankton component of the diatom flora (Wolfe *et al.*, 1926; Morse, 1947; Griffith, 1961; Mulford, 1962; Patten *et al.*, 1963; Marshall, 1984, 1986). More recently, Wilderman (1987) examined distribution patterns of both planktonic and benthic diatoms in the Severn River (a Chesapeake Bay tributary). In a series of papers, Cooper has documented the diatom community structure changes in relation to land-use changes over approximately the past 2,000 years (Cooper, 1993; Cooper, 1995a; Cooper, 1995b; Cooper and Brush, 1991; Cooper and Brush, 1993).

The present study is an effort to document both the modern distribution of diatoms in Chesapeake Bay sediments as well as reconstructing the communities that have been present over the past few millennia. By understanding the relationship between modern diatom community structure and environmental conditions, it may be possible to make reliable inferences about past events in the bay. Here in Plates 1-5, we illustrate diatom taxa from the past 1,000 years from the mesohaline region the Chesapeake Bay and some important diatom taxa found in mid-Bay sediments are listed in Table 3.

Table 3. Some Diatom Taxa found in Chesapeake Bay sediments

Actinocyclus octonarius Ehrenberg

Actinoptychus senarius Ehrenberg

Biddulphia spp.

Cocconeis pediculus Ehrenberg

Cocconeis placentula Hustedt

Coscinodiscus sp. Ehrenberg

Cyclotella spp.

Diploneis didyma Ehrenberg

Diploneis domblittensis (Grunow) Cleve

Diploneis weissflogii (A.S.) Cleve

Diploneis spp.

Endictya oceanica Ehrenberg

Melosira sp. Agardh

Rhaphoneis amphiceros Ehrenberg

Terpsinoe americana (Bail) Rolfs

Thalassiosira baltica (Grunow) Ostfeld

Thalassiosira sp.

Triceratium favus Ehrenberg

Campylodiscus spp.

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Plate 1

- 1) *Actinocyclus octonarius* Ehrenberg, PTMC 3-P-2 0-2 cm., x 2200.
- 2) *Actinocyclus octonarius* Ehrenberg, PTMC 3-P-2 46-48 cm., x 3600.
- 3) *Actinoptychus senarius* Ehrenberg, PTMC 3-P-2 422-424 cm., x 2000.
- 4) *Actinoptychus senarius* Ehrenberg, PTMC 3-P-2 48-50 cm., x 1800.
- 5) *Actinoptychus senarius* Ehrenberg, PTMC 3-P-2 364-366 cm., x 2200.

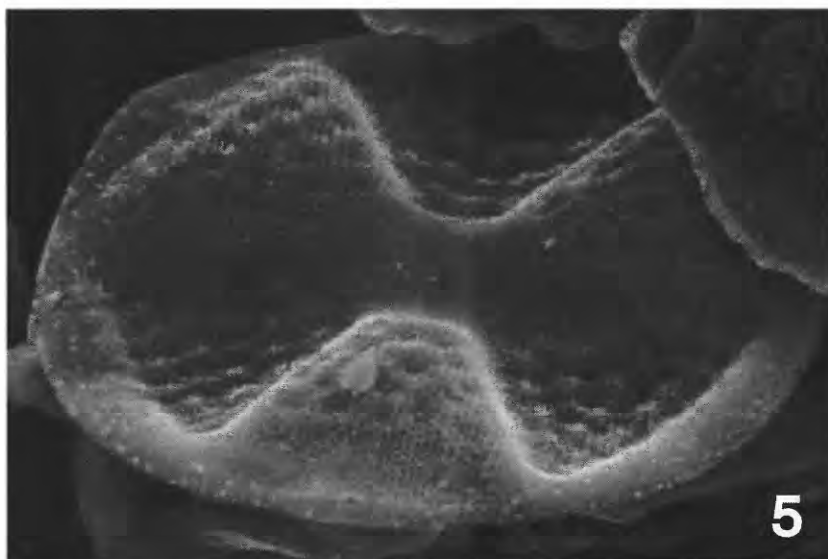
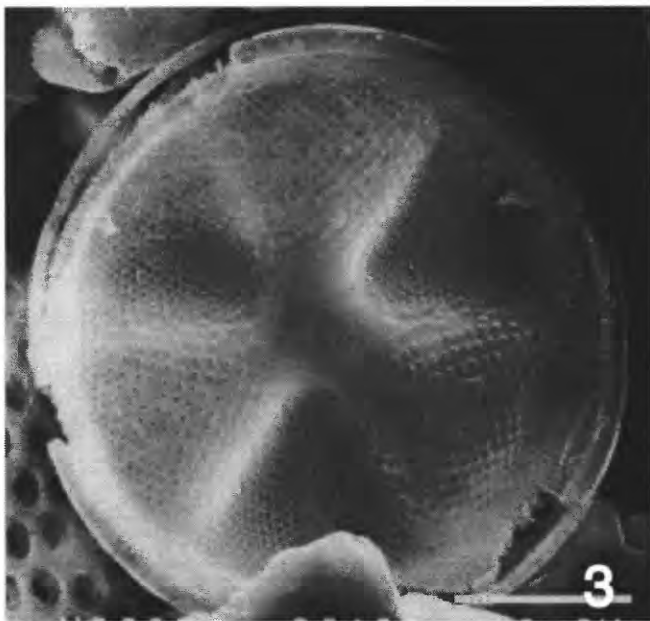
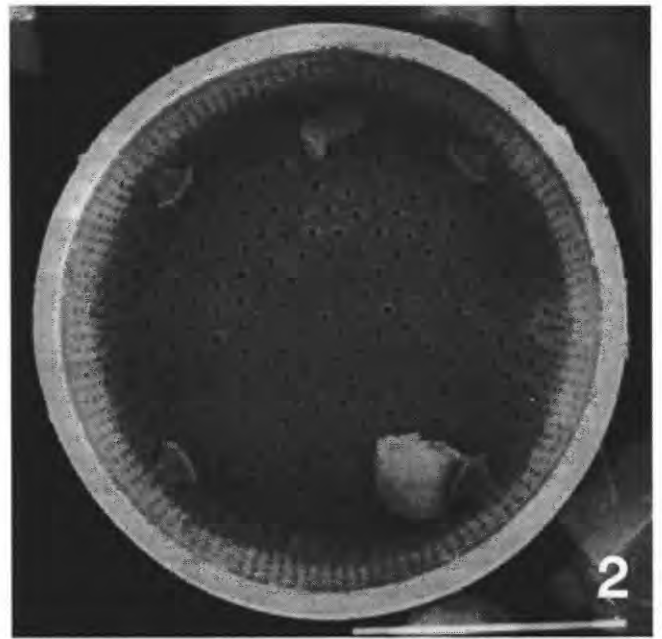
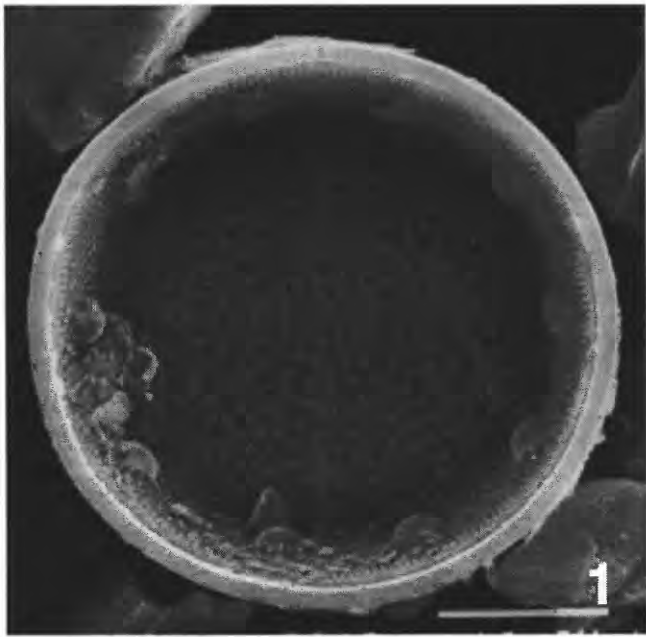


Plate 2

- 1) *Cyclotella* sp., PTMC 3-P-2 0-2 cm., x 3000.
- 2) *Cocconeis pediculus* Ehrenberg, PTMC 3-P-2 364-366 cm., x 4800.
- 3) *Cyclotella* sp., PTMC 3-P-2 364-366 cm., x 3600.
- 4) *Cocconeis placentula* Hustedt, PTXT 2-P-3 100-102 cm., x 6000.
- 5) *Cyclotella* sp., PTMC 3-P-2 0-2 cm., x 2600.
- 6) *Terpsinoe americana* (Bail.) Rolfs, PTMC 3-P-2 422-424 cm., x 2000.

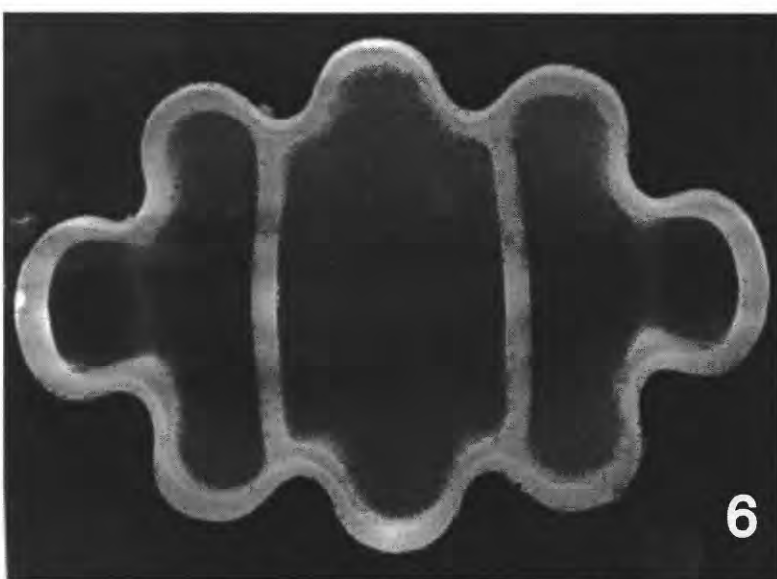
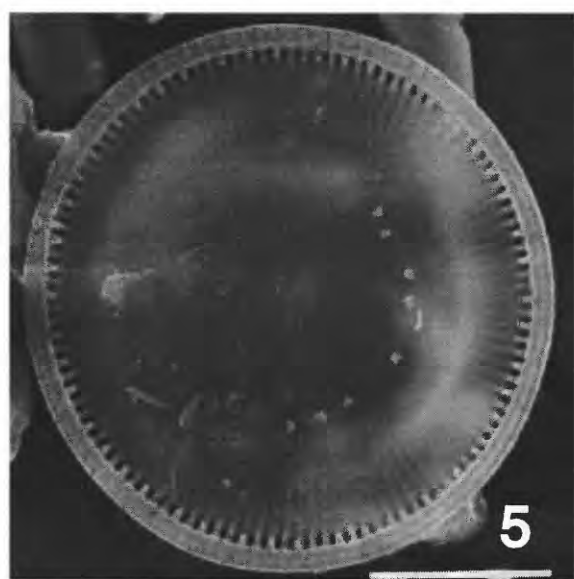
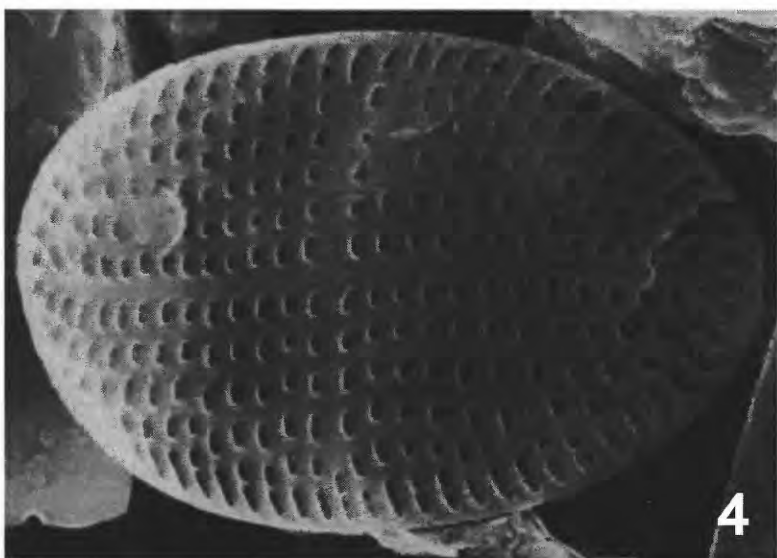
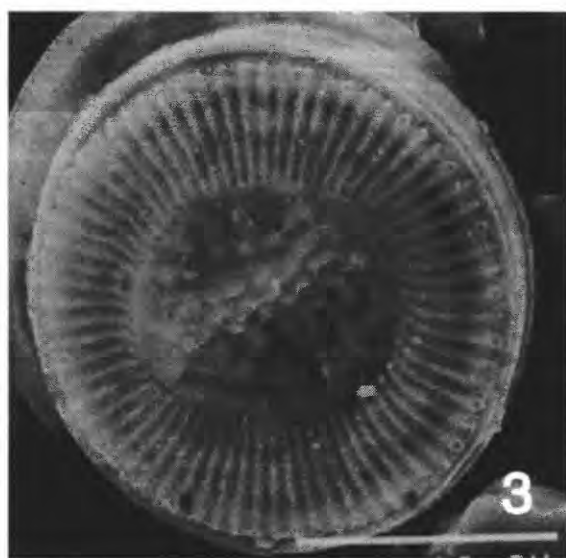
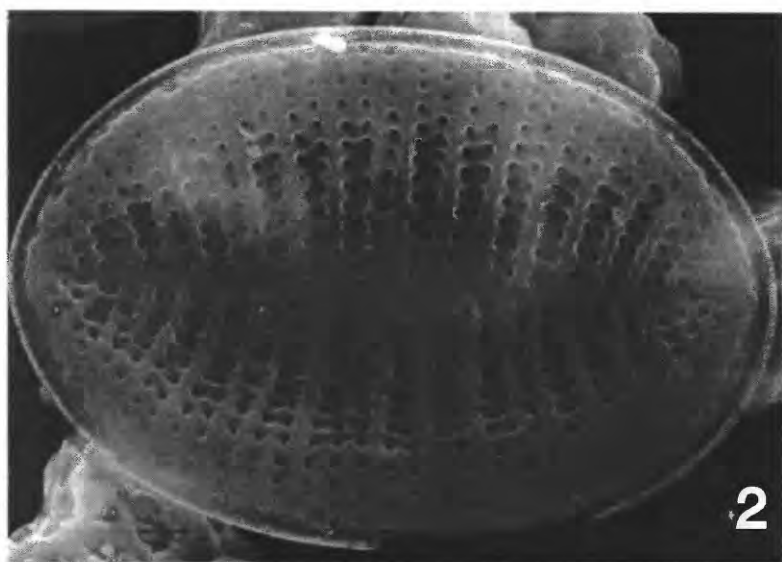
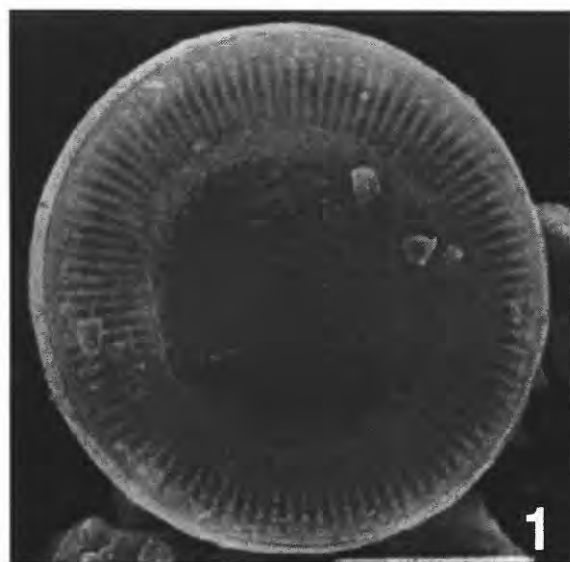


Plate 3

- 1) *Diploneis* sp., PTMC 3-P-2 80-82 cm., x 4400.
- 2) *Diploneis* sp., PTMC 3-P-2 364-366 cm., x 3600.
- 3) *Diploneis didyma* Ehrenberg, PTMC 3-P-2 222-224 cm., x 2200.
- 4) *Diploneis domblittensis* (Grunow) Cleve, PTMC 3-P-2 48-50 cm., x 2400.
- 5) *Diploneis weissflogii* (A.S.) Cleve, PTMC 3-P-2 364-366 cm., x 4000.
- 6) *Rhaphoneis ampiceros* Ehrenberg, PTMC 3-P-2 364-366 cm., x 2600.

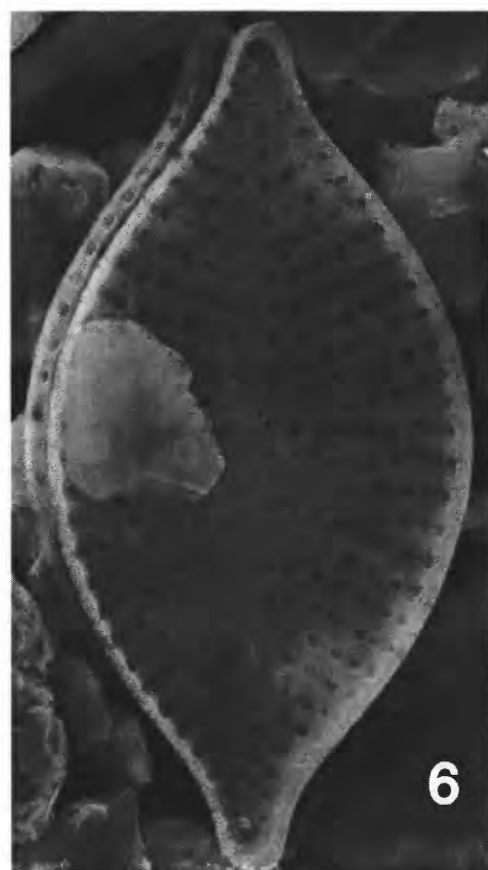
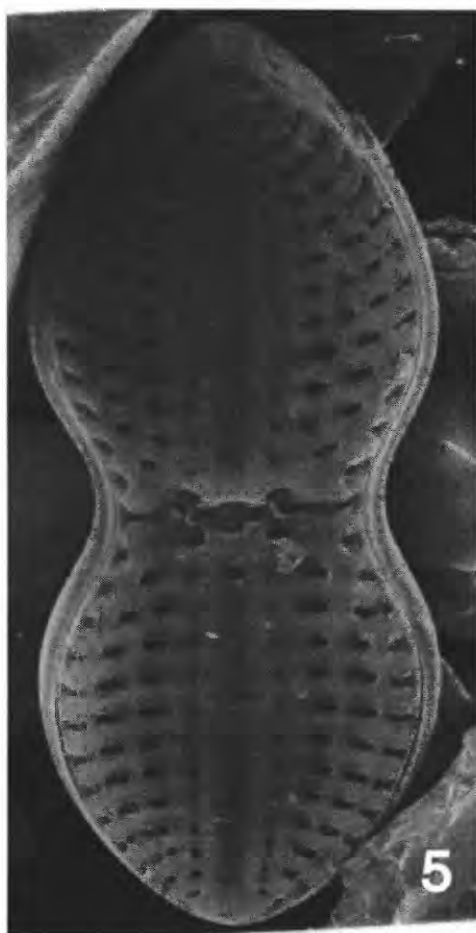
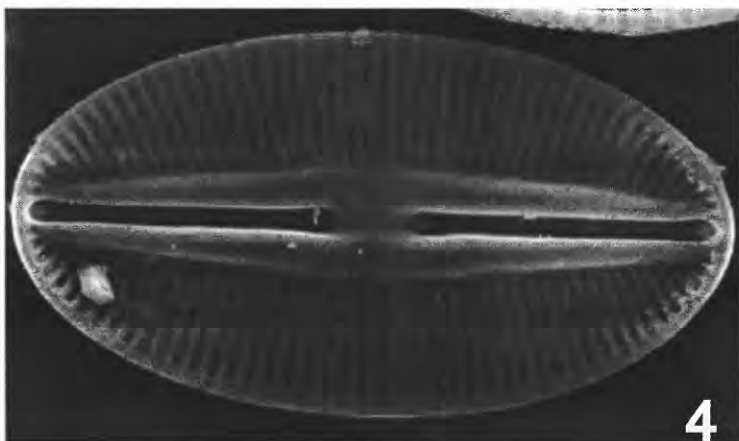
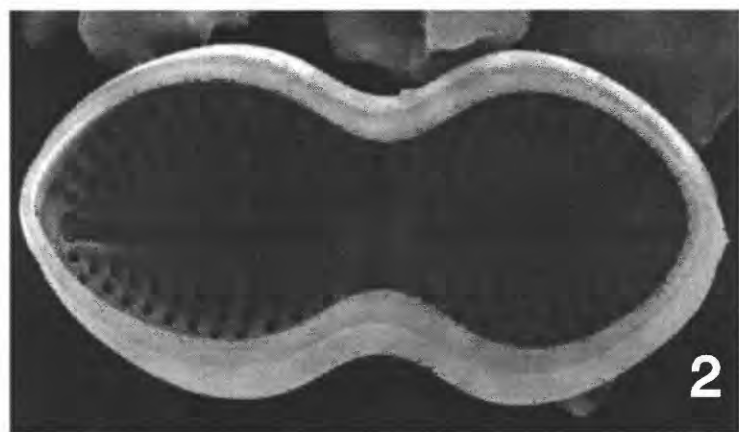
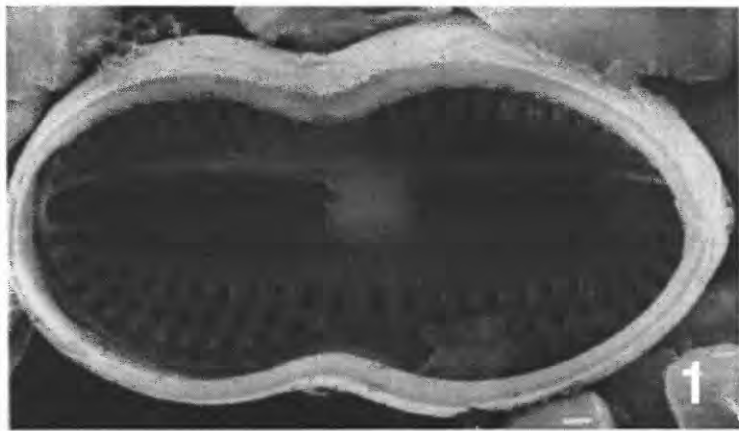


Plate 4

- 1) *Endictya oceanica* Ehrenberg 1845, PTMC 3-P-2 0-2 cm., x 6600.
- 2) *Thalassiosira baltica* (Grunow) Ostenfeld, PTMC 3-P-2 0-2 cm., x 3600.
- 3) *Thalassiosira baltica* (Grunow) Ostenfeld, PTMC 3-P-2 222-224 cm., x 2200.
- 4) *Thalassiosira* sp., PTMC 3-P-2 46-48 cm., x 2400.
- 5) *Triceratium favus* Ehrenberg, PTMC 3-P-2 422-424 cm., x 720.
- 6) *Triceratium favus* Ehrenberg, PTMC 3-P-2 422-424 cm., x 660.

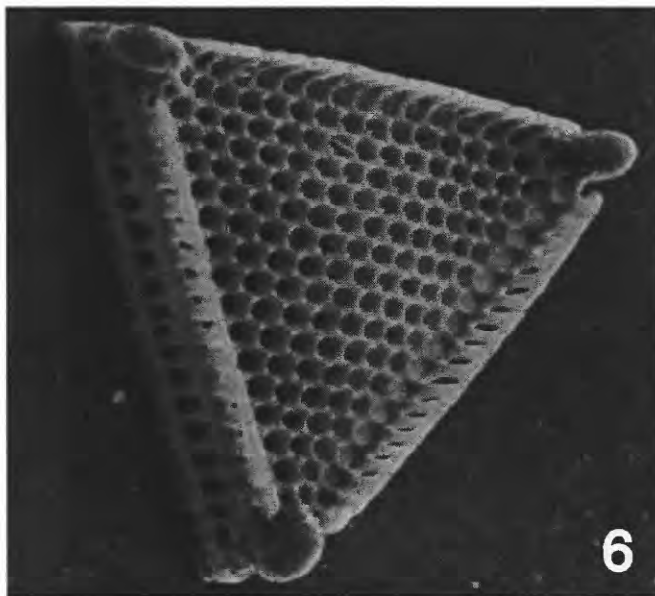
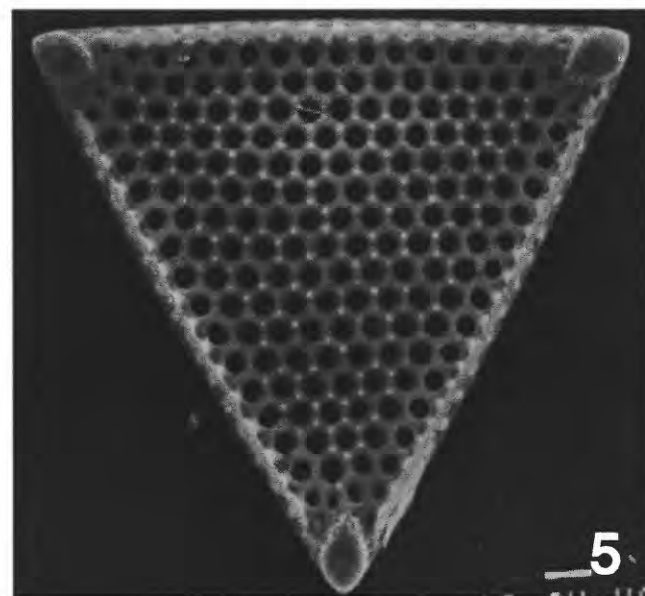
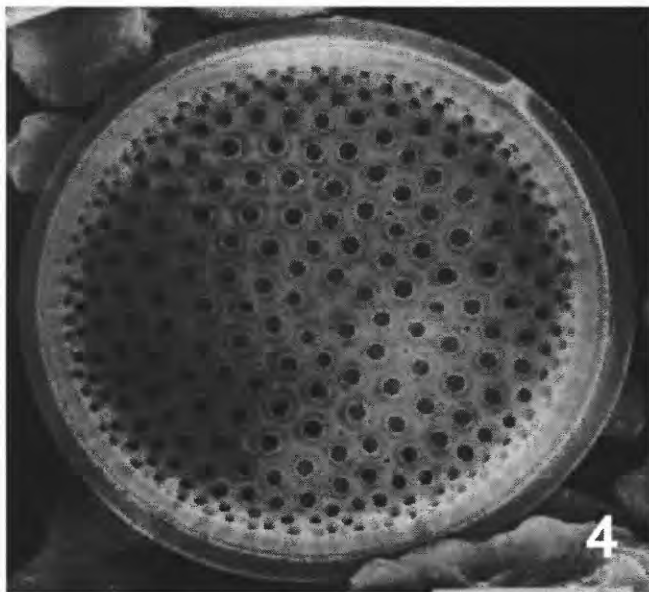
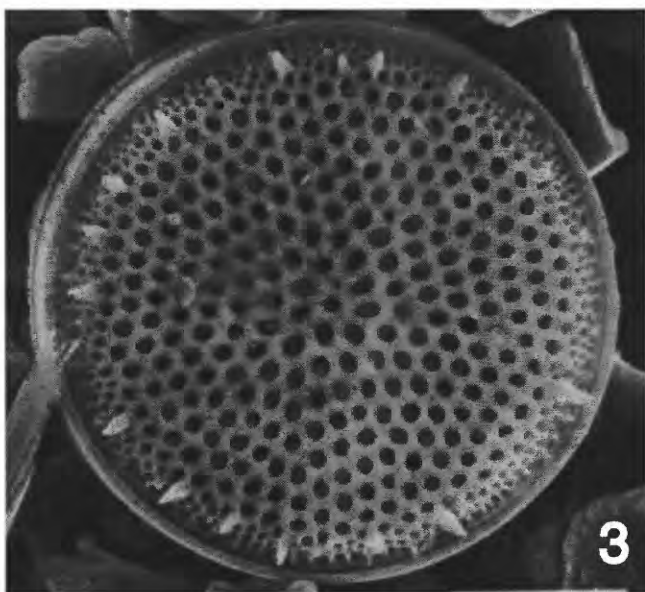
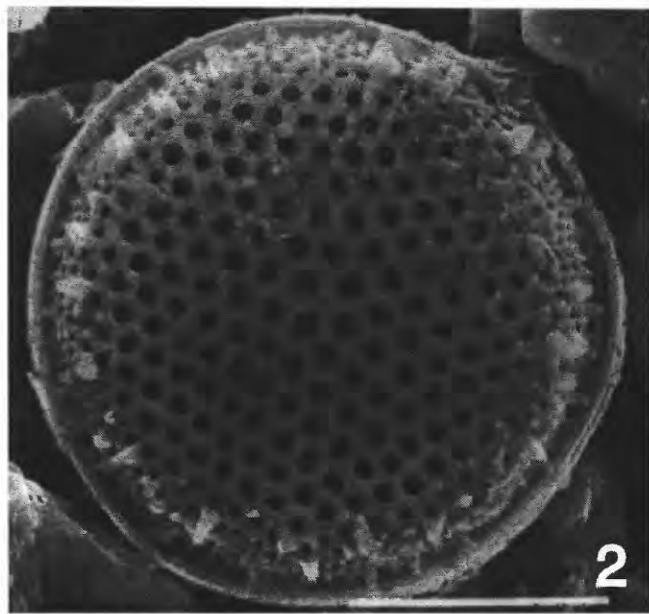
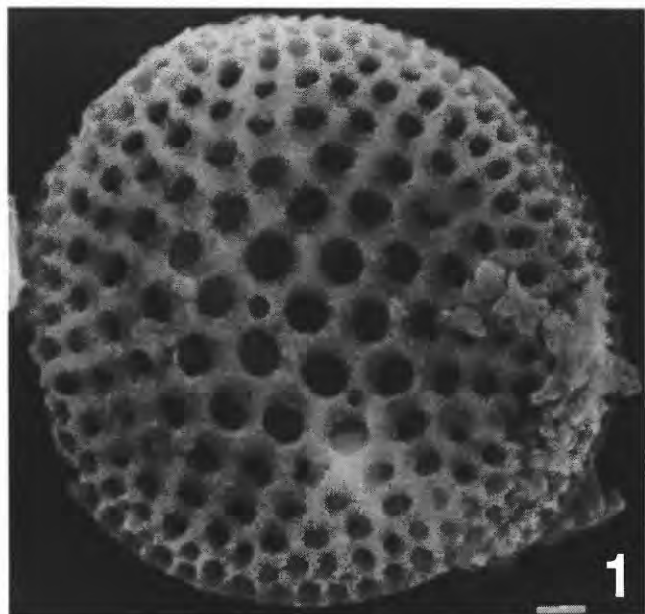
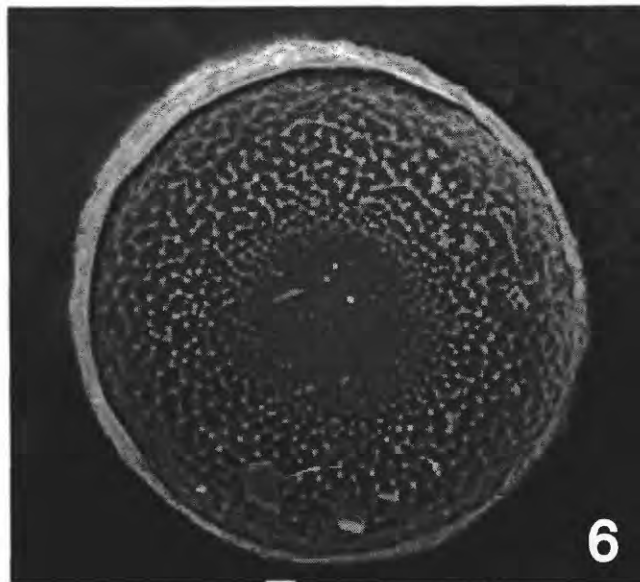
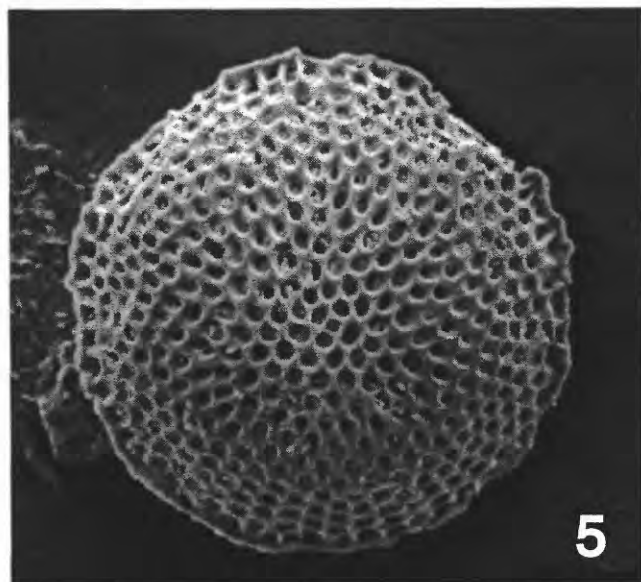
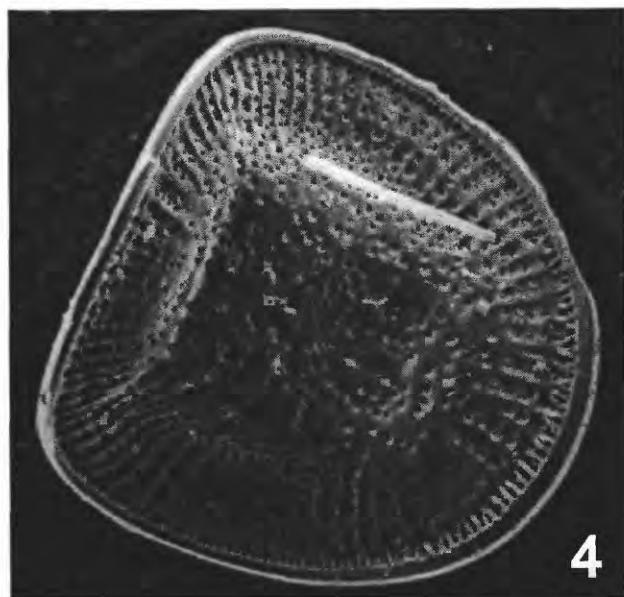
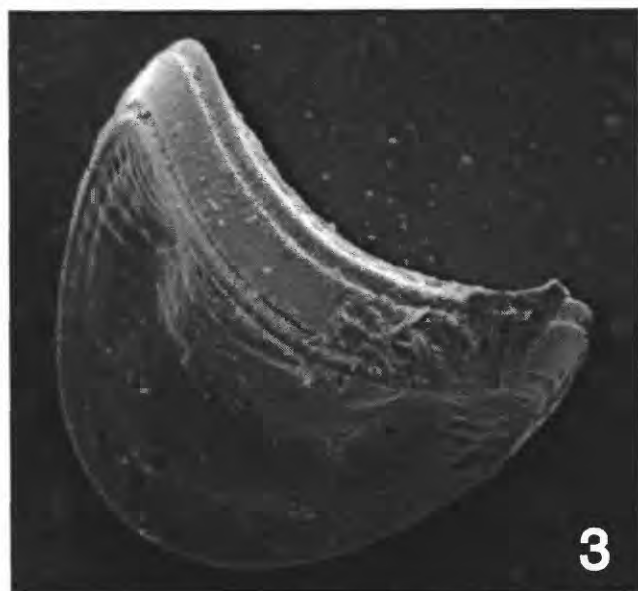
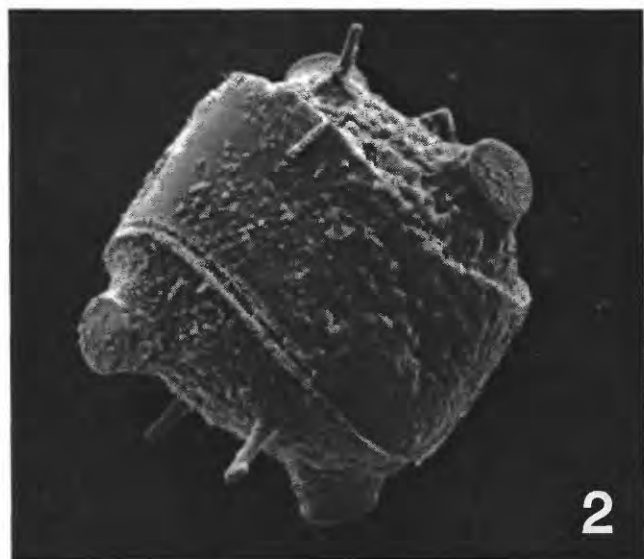


Plate 5

- 1) *Biddulphia* sp. Gray, PTXT 2-G-3, x 507.
- 2) *Biddulphia* sp. Gray 1821, PTXT 2-G-3, x 391.
- 3) *Campylodiscus* sp. Kutzing, PTXT 2-G-3, x 472.
- 4) *Campylodiscus* sp. Kutzing, PTXT 2-G-3, x 366.
- 5) *Coscinodiscus* sp. Ehrenberg, PTXT 2-G-3, x 432.
- 6) *Melosira* sp. Agardh, PTXT 2-G-3, x 792.



Depth (cm.)	<i>Thalassiosira eccentrica</i>	<i>Thalassiosira decipiens</i>	<i>Thalassiosira baltica</i>	<i>Thalassiosira</i> spp.	<i>Coscinodiscus marginatus</i>	<i>Cyclotella bodanica</i>	<i>Cyclotella striata</i>	<i>Cyclotella meneghiniana</i>	<i>Cyclotella pseudostelligera</i>	<i>Cyclotella stylorum</i>	<i>Cyclotella</i> spp.	<i>Paralia</i> sp.	<i>Actinophthycus senarius</i>	<i>Actinocyclus octonarius</i>	<i>Actinocyclus normanii</i>	<i>Hyalodiscus scoticus</i>	<i>Auliscus</i> sp.	<i>Cocconeis placentula</i>	<i>Cocconeis scutellum</i>	<i>Cocconeis disculus</i>	<i>Cocconeis clandestina</i>	<i>Delpheneis</i> sp.	<i>Melosira</i> sp.	<i>Raphoneis amphiceros</i>	<i>Raphoneis surirella</i>	<i>Gomphonema angustatum</i>	<i>Gomphonema parvulum</i>
0-2	11	22	3	7		2	5	3	2		143		1	1	4			2	3					2			1
20-22	11	70	3	5			21		1	3	67	5	2		2			4	1					1			
60-62	7	35		5			9		1	1	50	5	1					8	1		3						
80-82	11	24	1	7	4		12	4	2		38	12	4				4						1	1			
100-102	9	21	2	0			5	1	2	1	54	6	1	1	1		3		1								
120-122	7	15		1	1		9		1		58	9	1	4			8	1	1				1	1			
140-142	9	16		1			6		7		20	33	3		4	1	1	3	1			2	3	2	1		
160-162	11	17	2	4			14	2	17	2	29	22	2					9	5			3	1	1			
180-182	13	29	2	0			16		11	2	11	25	1	1	2			11	1	2		2	1	2			
198-200	22	23	1	4			20	2	38	2	41		1	1	5			18	4	2			12	3			1

[illegible]

Chesapeake Bay Dinoflagellates

By Stacey Verardo

The present report is part of a study to document modern dinoflagellate cysts in Chesapeake Bay sediments and temporal trends in cysts over the last few millennium from sediment cores of the middle Bay. Dinoflagellates, which are part of the division Dinoflagellata, are primarily organic-walled, single-celled organisms that often occur as motile cells, called theca, in marine, brackish, and freshwater environments. Living dinoflagellates may be autotrophs, heterotrophs or symbionts. Photosynthetic forms (autotrophs) account for approximately 50% of the dinoflagellate genera. Free living genera are a major component of marine phytoplankton and are important primary producers in the oceans. When dinoflagellates leave fossil remains, they usually consist of their nonmotile or cyst stage. Dinoflagellate cysts are produced within the motile dinoflagellate theca and are also made of organic material (Fensome *et al*, 1996).

The dominant dinoflagellate cyst genus in modern Chesapeake Bay sediments is *Spiniferites* (see Lewis & Rochon, 1998 for discussion on *Spiniferites*). In the Bay, this taxonomic complex includes several morphotypes, but primarily representatives of the species *Spiniferites ramosus* (Harland, 1977). Today, *Spiniferites ramosus* cysts occur mainly in oceanic environments along the southeastern United States as well as within the Caribbean. It is generally considered a warm surface water species (Wall *et al*, 1977; Harland, 1983). In Recent Bay sediments, *Spiniferites* spp. comprises ~80% of the total dinoflagellate population. In samples from the 16th-17th century, *Spiniferites* spp. comprises approximately 50% of the total population. Another species, *Spiniferites mirabilis*, also increases in abundance over the past few centuries (from 1% in the 16th century to ~20% in modern sediments). The increase in *Spiniferites mirabilis* may be

related to increased nutrient concentrations of phosphate, and nitrate, lower salinities, and warm surface waters (Harland, 1983; Turon, 1984).

Operculodinium centrocarpum is the second most abundant dinoflagellate cyst type occurring in Chesapeake Bay sediments. Its modern distribution shows that it is often associated with the North Atlantic current and estuarine and coastal waters in mild to cool-temperate regions (Harland, 1977, 1983; Brenner, 1998). During the past 1000 years, the abundance of this species has decreased in the Chesapeake Bay.

Other species found in lower abundances in Chesapeake Bay sediments, are *Polysphaeridium zoharyi* (an indicator of polyhaline waters), *Lingulodinium machaerophorum*, *Nematosphaeropsis labyrinthica*, *Tuberculodinium vancampoae* and *Multispinula quanta* (Wall *et al*, 1977; Harland, 1983; Edwards & Anderle, 1992). These cyst species decreased in abundance during the past 1000 years and signify an overall long term decrease in cyst species diversity. Natural and anthropogenic factors in the Bay region, including natural climate and land use practices may be a cause of decreasing dinocyst diversity.

The two sections given below are three plates of scanning electron micrographs illustrating nine dinoflagellate species found in the mesohaline parts of the Bay, and species census data in Appendix 3. Dinoflagellate taxa are listed in Table 4.

Table 4. Some Dinoflagellate cysts from Chesapeake Bay sediments

Achomosphaera sp.

Impagidinium sp.

Lingulodinium machaerophorum Wall 1967

Multispinula quanta Bradford 1975

Nematosphaeropsis labyrinthica (Ostenfeld) Reid 1974

Operculodinium centrocarpum (Deflandre and Cookson) Wall 1967

Polysphaeridium zoharyi Bujak *et al.* 1980

Spiniferites mirabilis Sarjeant 1970

Spiniferites ramosus (Ehrenberg) Loeblich and Loeblich 1966

Spiniferites sp.

Tectatodinium sp.

Tuberculodinium vancampoe (Rossignol) Wall 1967

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- Wall, D., B. Dale, G. Lohmann and W. Smith, 1977. The environmental and climatic distribution of dinoflagellate cysts in modern marine sediments from regions in the North and South Atlantic Oceans and adjacent seas. *Marine Micropaleontology*, 2: 121-200.

Plate 1

- 1) *Spiniferites ramosus*, (Ehrenberg) Loeblich and Loeblich 1966, PRCK 1-P-2 90-92 cm., x 2000.
- 2) *Spiniferites* sp., PTMC 3-P-2 106-108 cm., x 1800.
- 3) *Spiniferites* sp., PTMC 3-P-2 446-448 cm., x 1800.
- 4) *Spiniferites mirabilis* Sarjeant 1970, PTMC 3-P-2 106-108 cm., x 1300.
- 5) *Spiniferites mirabilis* Sarjeant 1970, PTMC 3-P-2 106-108 cm., x 1500.
- 6) *Lingulodinium machaerophorum* Wall 1967, PTMC 3-P-2 200-202 cm., x 1300.

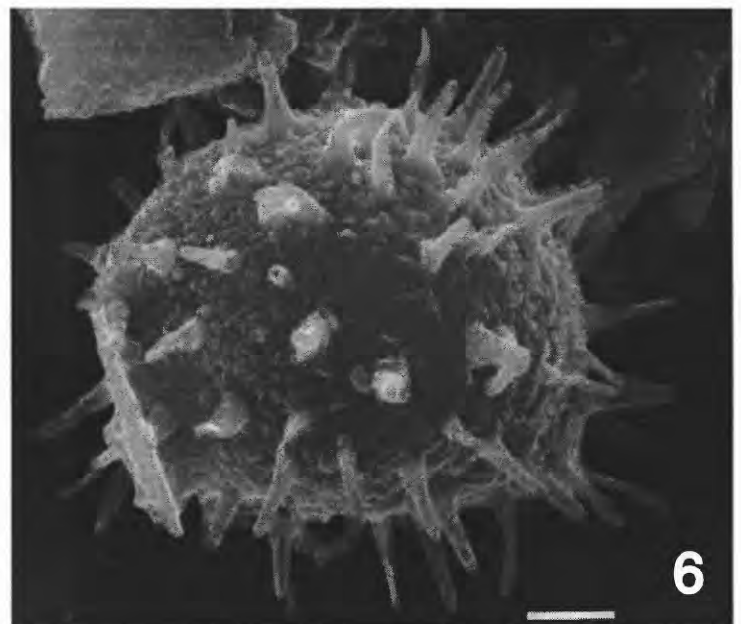
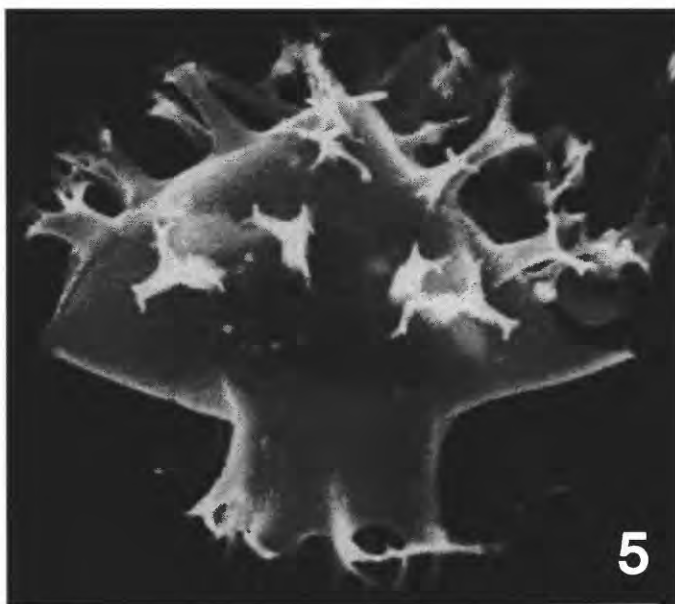
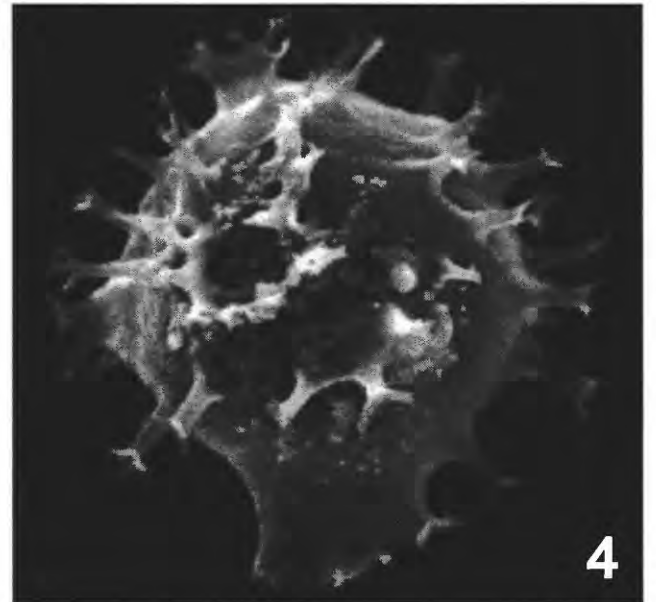
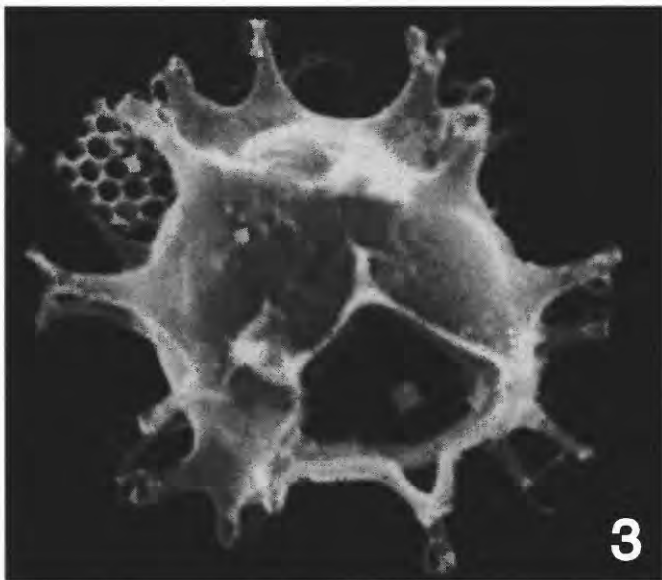
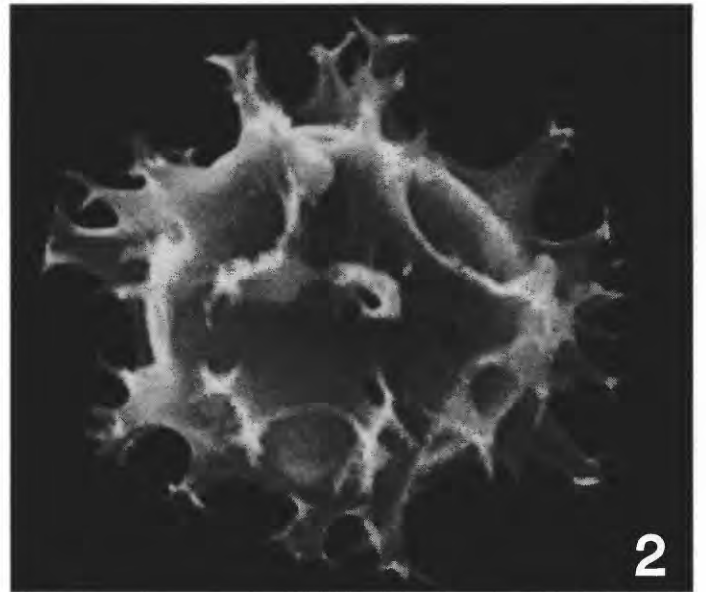
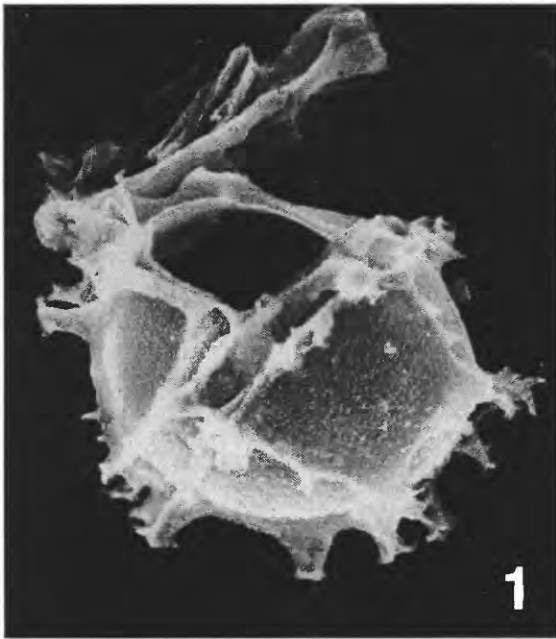


Plate 2

- 1) *Spiniferites mirabilis* Sarjeant 1970, PTMC 3-P-2 446-448 cm., x 1300.
- 2) *Spiniferites mirabilis* and *Spiniferites* sp. PTMC 3-P-2 190-192 cm., x 1300.
- 3) *Operculodinium centrocarpum* (Deflandre and Cookson) Wall 1967, PRCK 1-P-2 90-92 cm., x 1200.
- 4) *Operculodinium* sp., PTMC 3-P-2 106-108 cm., x 1600.
- 5) *Nematosphaeropsis labyrinthea* (Ostenfeld) Reid 1974, PTMC 3-P-2 446-448 cm., x 1300.
- 6) *Nematosphaeropsis labyrinthea* (Ostenfeld) Reid 1974, PTMC 3-P-2 446-448 cm., x 1200.

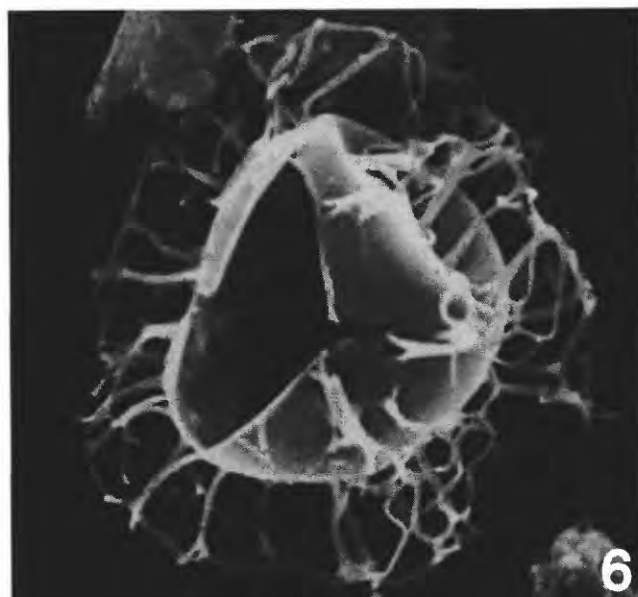
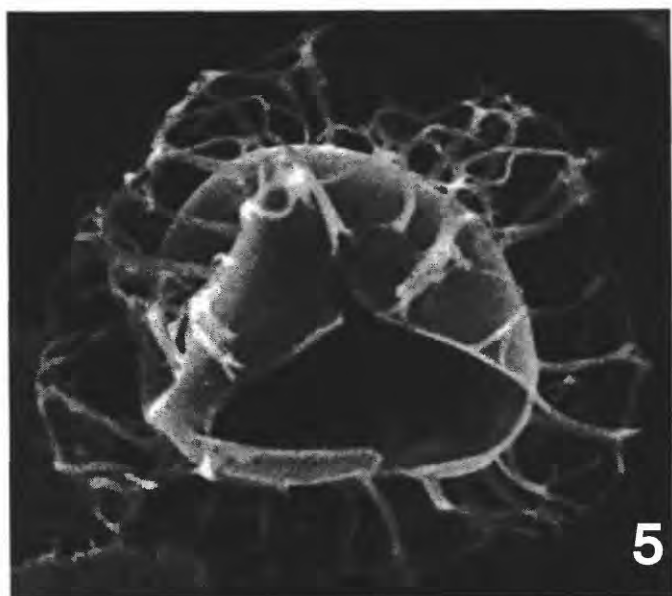
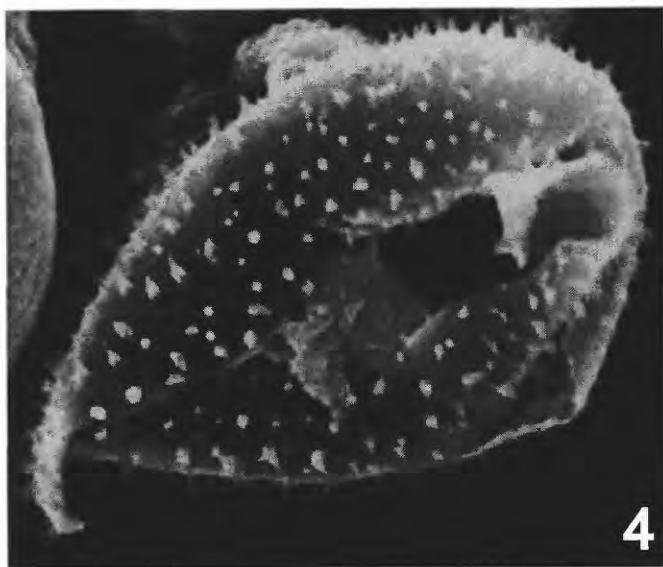
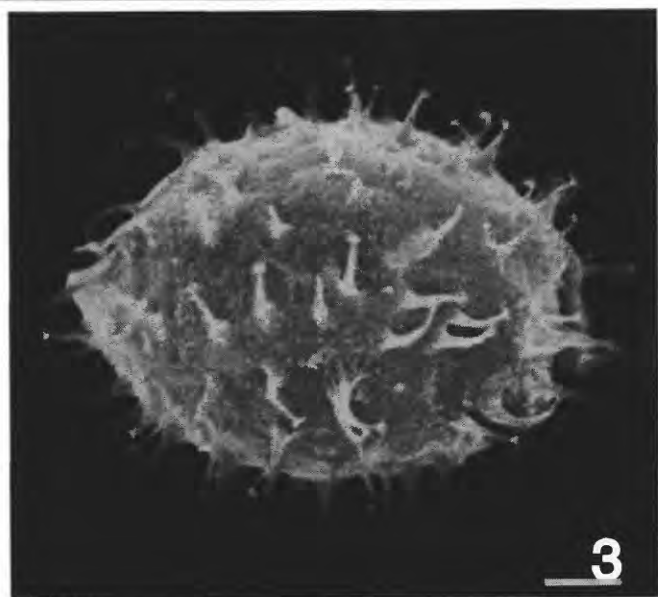
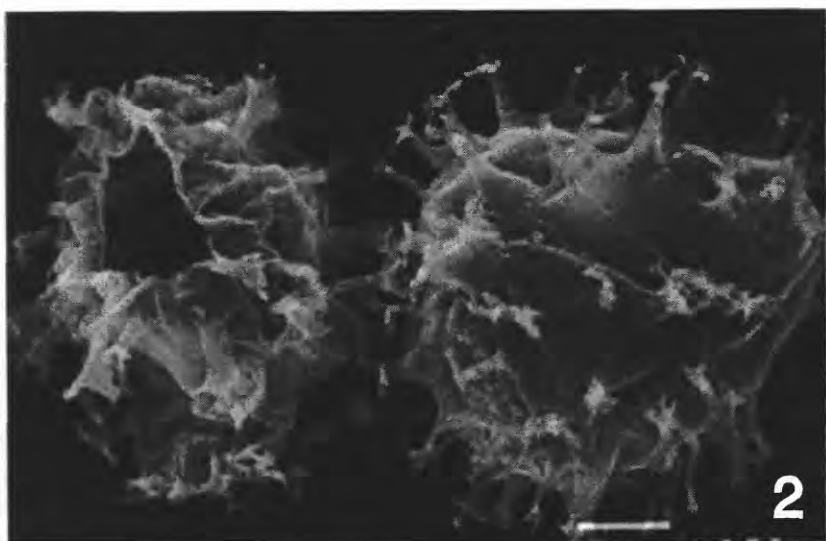
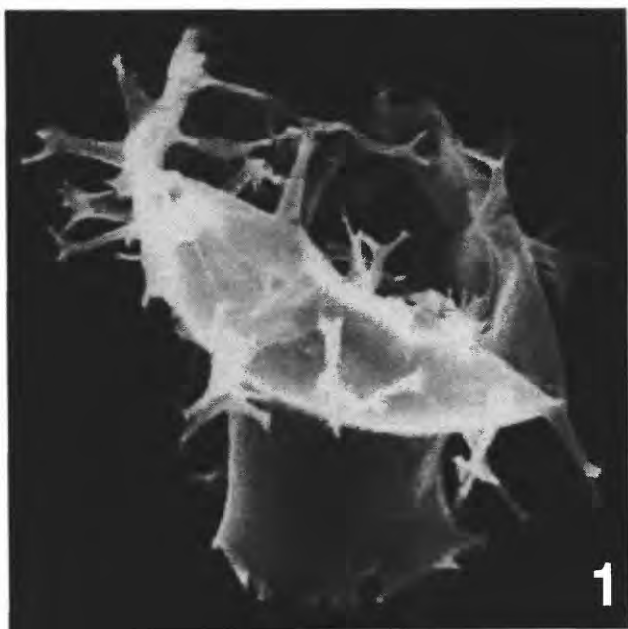
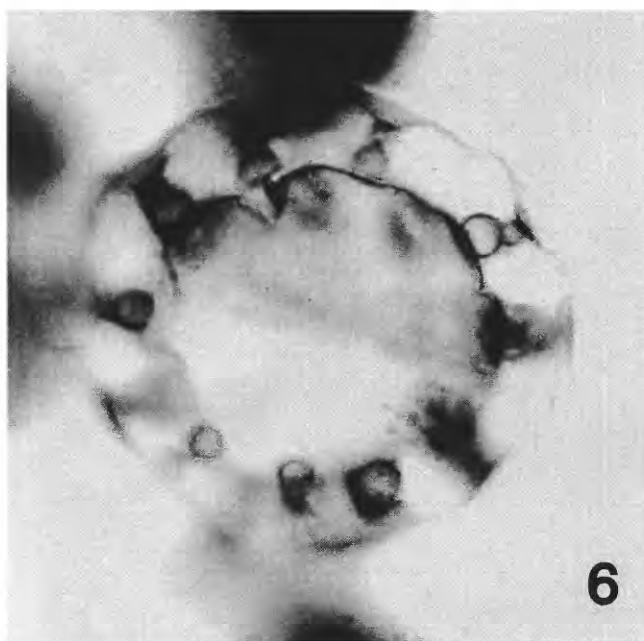
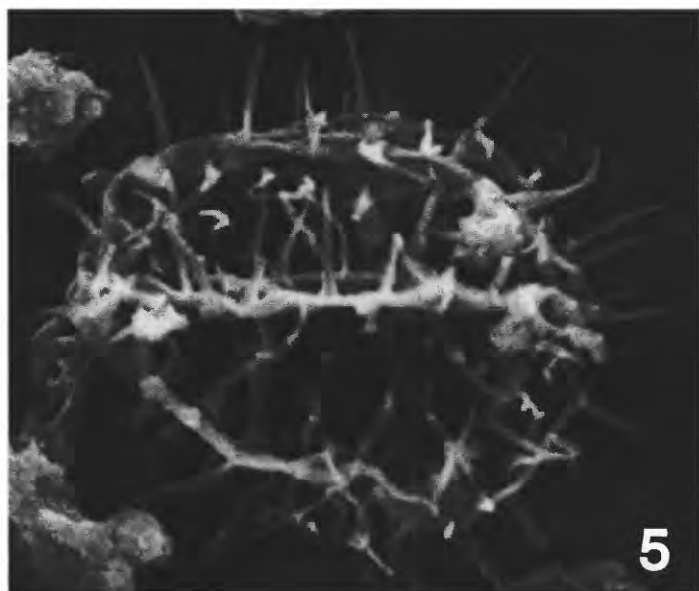
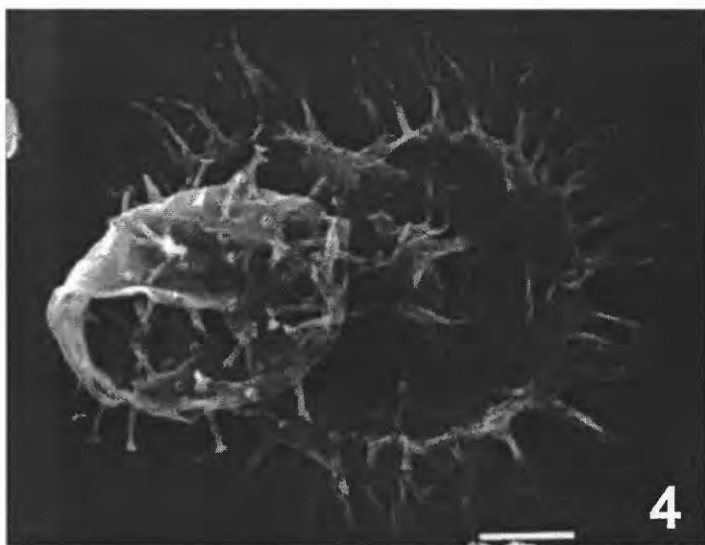
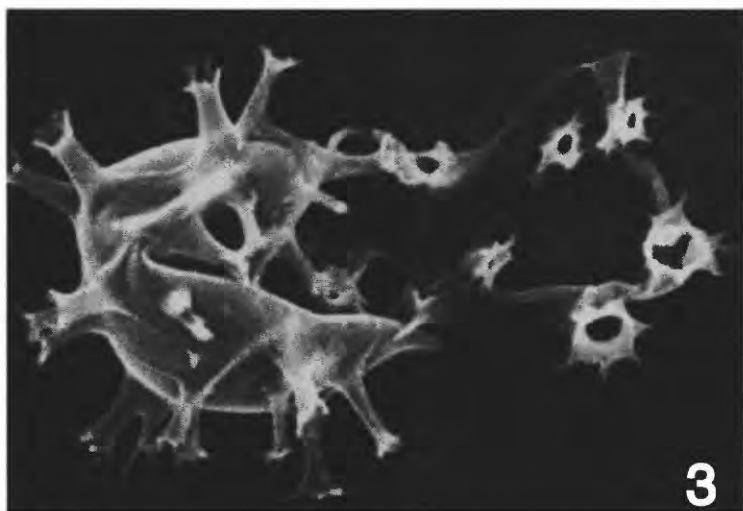
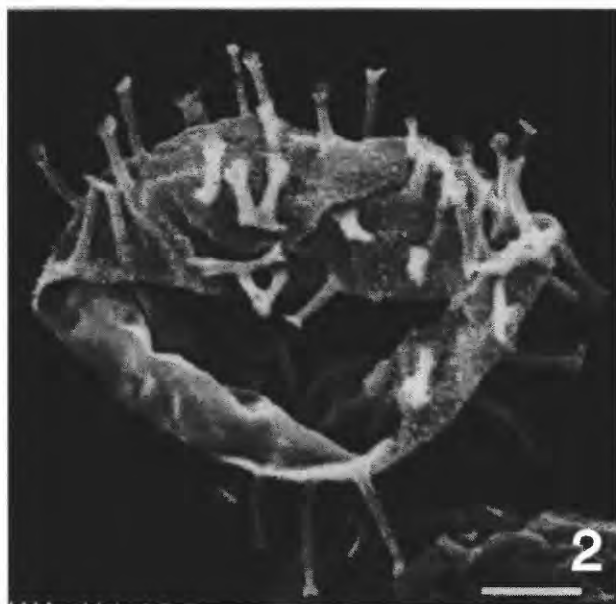
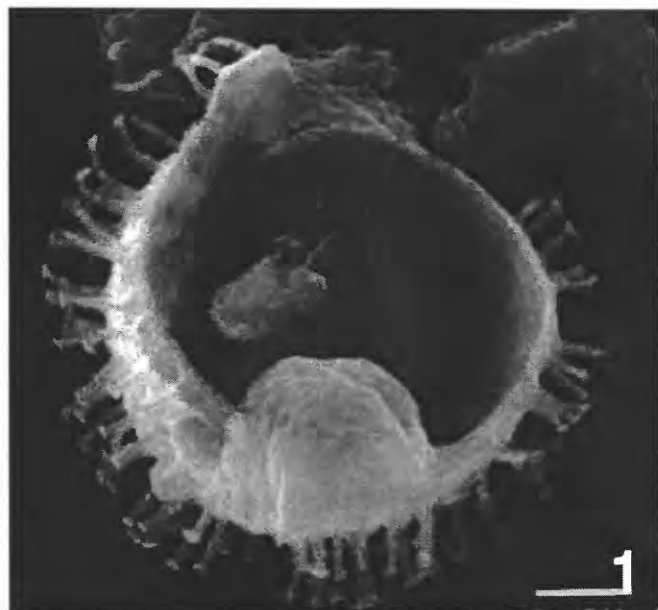


Plate 3

- 1) *Polysphaeridium zoharyi* Bujak *et al.* 1980, PTXT 2-P-3 110-112 cm., x 1300.
- 2) *Polysphaeridium zoharyi* Bujak *et al.* 1980, PRCK 1-P-2 90-92 cm., x 1400.
- 3) *Polysphaeridium zoharyi* Bujak *et al.* 1980, PTMC 3-P-2 106-108 cm., x 1500.
- 4) *Polysphaeridium zoharyi* Bujak *et al.* 1980 and *Multispinula quanta* Bradford 1975, PTXT 2-P-3 110-112 cm., x 1500.
- 5) *Multispinula quanta* Bradford 1975, PTMC 3-P-2 106-108 cm., x 1100.
- 6) *Tuberculodinium vancampoe* (Rossignol) Wall 1967, PTMC 3-P-2 106-108 cm., light microscope.



reworked dinoflagellate

Depth (cm)	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> spp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrinthica</i>	<i>Tuberculodinium vancamptopae</i>	<i>Achomosphaera</i> sp.	<i>Impagidinium</i> sp.	forma b	theca	unidentified	Total*
1	10	123	13	17	2	2	1	6	1			3		1	179
5	11	77	12	13	1	3		2	1						120
9	7	201	54	31		18	2	12	4						329
15	8	235	64	21		4	2	4							338
21	12	183	74	13		2	6	2	6			3		1	296
27	9	225	40	41		8	6	10	4					3	346
31	7	229	38	55		8	6	2	6						351
35	4	207	10	123	2	4	12	12	6						380
39	5	207	12	183	2	10	4	6	4						431
43	16	189	14	55	2	6	6	2	2			2	1	1	296
53	3	96	44	34		16	2	4	10					1	210
57	3	50	12	26			6	2	2						95
69	1	134	48	38		12	6	2	20			6		1	262
77	4	19	10	19	2	8	4	2	4			1		10	87
83	2	19	2	17			2						1		42
97	5	127	14	69	2	4	4		6			3	1		235
107	16	209	29	37	6	12	14		22			5	2	1	353
117	10	42	12	24		2			22						112
129	15	155	42	34	2	14	8	4	16	8		9			307
139	7	188	62	54		6	6	8	6			5		1	338
151	7	133	4	147	10		10	2	6						314
157	5	189	44	37		20	10	16	10			7	2		331
161	12	117		89	6	21	12	8	8				3		284
165	5	93	6	81		6	4	6	2			9	2		206
171	10	165	2	107	12	36	12	14	8				2		377
175	5	177	26	77	2	18	6	8	16				4		339
181	5	131	16	83	2	14	14	12	16				7		300
185	5	91	6	57		8	4	2	2		2		1		178
191	2	131	4	83	14	34	16	18	6			8	1	1	318
195	5	135	6	75		18	12	12	18			9	4		285
201	8	89		53	8	46	11		10	6			10	7	257
205	5	65		65	4	14	10	4	16				8	3	194
211	9	59	4	60	10	12	10	8	8		6	4	12		202
215	5	95	4	73		12	10	2	8				2	3	214
219		25		25			2							1	53
221	5	21		23		10			4						63
225		25		14	3	4	1	2				1	1		51

*Total does not include reworked dinoflagellates

reworked dinoflagellate

Depth (cm)	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> sp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrinthica</i>	<i>Tuberculodinium vancampoe</i>	<i>Achomosphæra</i> sp.	<i>Impagidinium</i> sp.	forma b	theca	unidentified	Total*	<i>Wetzeliiella</i> sp.
227	2	21	2	23	6	8	4		2			2			66	
229	10	53		45	8	14	4						2		136	
233	5	25		17		6	2		4	4			2		65	
237	2	100	2	59	6	32	12	4	6	15		10	6	6	260	
259	5	111		87		16	10	4	10						243	
261	7	157	8	57	4	54	10	2	8	8		12	16	4	347	
263	5	81		71	2	20	2	4	6	10					201	
271		36	2	26		4	4	4	1						77	1
283	13	39	2	39	1	18	8	2	12	1		8	8		151	
287	3	162	2	98		28	10	12	2				3		320	1
291	3	170	20	84		18	6	12	14						327	
293		12		6			2		4						24	
297	2	32	6	8		2			42						92	
299	1	10		2		2									15	
307	8	35	2	25		20	10	4		10	2	10	2	4	132	
319	2	56		26		12	2	2	8						98	
321		196	14	90		12	2	8	14				2		338	
323		196	14	90		12	2	8	14				2		338	
343	3	172	16	90		14	12	22	2		1				332	
335	6	11		7		6	6	4	4		2	4		4	54	
351															0	1
353		8		4		4									16	
357	10	77	14	57		26	6	6	8	10		8	3		225	
365		8		4											12	
369		16	4												20	
381		122	10	54		12	16	14	8						236	
395	10	43	4	13	2	26	6		12		4	14	4	1	139	2
399		2		2											4	
409	3	142	14	86		18	16	8	6				1		294	
419	4	48	2	13	2	12	2	10	2			12	2	5	114	
423	3	88	6	30		18	6	14					4		169	
427	3	142	8	50		34	12	14	12						275	
431		6		4											10	
435		160	4	80	6	28	10	18	8						314	
437		78	8	60	2	4	2	20	2				1		177	
443		128	10	108	2	8	12	22	4				1		295	
447	10	109	20	131		32	16	28	12	14		12	1	1	386	

*Total does not include reworked dinoflagellates

reworked dinoflagellates

Depth (cm)	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> spp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrintha</i>	<i>Tuberculodinium vancamptoeae</i>	<i>Achomosphaera</i> sp.	<i>Impagidinium</i> sp.	formB	theca	unidentified	Total*	<i>Meliosphaeridium choanophorum</i>	<i>Hystriochokolpoma</i> sp.	<i>Wetzelia</i> sp.	<i>Wilsonidium tabulatum</i>	<i>Labyrinthodinium</i> sp.	<i>Spiniferites pseudo</i>	<i>Homotryblum</i> sp.
51		176	24	52		20	18	4	14	8	2	1		1	318	2			3			
61		214	44	56		18	10	4	4	6	2		2	1	358						1	2
71	5	180	26	42		24	20	6	6		4	2		1	313							
81	2	208	68	38		6	10	4	4	2	2	1	1	1	344	1	2					
91	1	202	60	74		16	16		20	8		1	2	1	397	2						
101	2	40		8	2	5	4		2		2	1		1	65			1				
111	4	208	16	72	2	26	12	12	8	8	4	1		5	372	6			2	1		
121	3	72	2	12		2	8	4	6	4	1	2	1	1	114	2	2				2	
131	1	106	2	40		8	6	4	4	4		3	1	2	175	1			1			
141	3	86	8	38		8	10	2	8	1			1	2	164							
151		128	8	56		14	10	4	6	8	2		1	1	236							
161	4	112	4	68	2	18	20	12	2	8	2	4			252							
171	2	82	14	34		16	22		10	4	2				186							
181		60	4	30	2	6	16		4	2	2	3		1	126							
191	4	192	14	44		24	26	6	8	6	2	6		1	326							
201		110	10	42	4	14	24	4	14	16	10	2	1		248							

84

*Total does not include reworked dinoflagellates

reworked dinoflagellates

Depth (cm)	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> spp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrinthica</i>	<i>Tuberculodinium vancampoeae</i>	<i>Achomosphaera</i> sp.	<i>Impagidinium</i> sp.	forma B	theca	unidentified	Total*	<i>Melissasphaeridium choanophorum</i>	<i>Wetzeliella</i> sp.	<i>Homotryblum</i> sp.
1			8	58	2		8	2						1	163			
11	1	84	4	54		2									145			
21	2	44	6	30											84			
31		28	4	28	2	2									64			
41	2	68	2	24	2	2									100			
51	2	50	4	20	2	2			2			1			81	1		
61	2	62	6	34	2			2			4	4			116			
71	2	50	2	14	2	2			2			1	2		76		2	
81		48	14	16	2			4				4	4		89			
91	5	140	24	78	2	2	2	4	4			4	8	1	266			
101	4	110	14	40	4		6	10	8			3			207			
111	1	22		22				4				3	7		59			
121	3	70		32	6			2	4			1	4		128			
131	2	120	4	16		6	6	8				2	2		166			
141		22	4	20		6	2	4	10			2			68		1	
151	4	46	4	24	2	2	8		24			2	3		113			
161		24		6		2			2						34			
171		12	2	4									1		19			
181		4											1		5			
191		8		8			4								20			
201		4	4												8			1

*Total does not include reworked dinoflagellates

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Depth (cm)	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> spp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrinthica</i>	<i>Tuberculodinium vancampoeae</i>	<i>Achomosphaera</i> sp.	<i>Impagidinium</i> sp.	forma B	theca	unidentified	Total*	reworked dinoflagellates		
21	3	198	36	36		16	2	16	4						311			
31	2	186	20	28		8	4	14	10						272			
61	2	88	6	14	2	2		6							120			
71		154	20	46	2	10	12	10	10						264			
81		208	20	46		4	6	10	22						316			1
91	1	176	50	34		12	8	14	30						325			
111	5	164	46	40		4	12	4	8				1		284			
131		164	42	74		8	4	8	12				1		313			
141	2	170	44	50		6	8	12	26				1		318			
161		8		2					2						13			

*Total does not include reworked dinoflagellates

reworked dinoflagellates

Depth (cm)	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> sp.	<i>Spiniferites merabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrintha</i>	<i>Tuberculodinium vancampoeae</i>	<i>Achomosphaera</i> sp.	unidentified	Total*	<i>Wetzelii</i> sp.
0	3	48		4								55	2
5		217	10	26	4				1		2	260	
12	12	122	8	3	1	2			1		2	151	
16	21	155	1	8	3	3		1			3	195	
20	18	70	4	4	6	4					3	109	
24	12	138	7	20	7	9	1	1	1		2	198	

*Total does not include reworked dinoflagellates

reworked dinoflagellates

Site & Date	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> spp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrintha</i>	<i>Tuberculodinium vancampoe</i>	<i>Impagidinium</i> sp.	theca	unidentified	Total*	<i>Weizellia</i> sp.	<i>Hystriohokolpoma</i> sp.
BRIS 6/1/1996		2											2		
BRIS 7/1/1996		190	2	24		8		1	1				226		
BRIS 8/1/1996		264	18	18	6	6	8	2	2				324		
BRIS 9/1/1996		46	2	12	2			2	2				66		
BRIS 6/1/1997		256	16	14		2	4		2				294		
BRIS 6/1/1998		140	6	20		4	2						172		
BUVA 6/1/1996	1	4											5		
BUVA 7/1/1996		2											2		
BUVA 8/1/1996		6	2	4									12		
BUVA 9/1/1996		2	2	2									6		
BUVA 6/1/1997		1											1		
BUVA 6/1/1998		8		2									10	1	
HNPT 7/1/1996		2											2		
HNPT 8/1/1996		110	4										114		
HNPT 9/1/1996		36		2		2							40		
HNPT 6/1/1997													0		
MRPT 6/1/1996		28	2	12									42		
MRPT 7/1/1996	1	48		10	2								61		
MRPT 8/1/1996		60		10			4						74		
MRPT 9/1/1996		52		2	8			2				2	66		
MRPT 6/1/1997		22											22		
MRPT 6/1/1998	2	140	10	10	0	4	4	2					172		
PNPT 6/1/1996	2	84	12	16		6	2	2	2		1		127		

Box Core Tops (0-1cm)

Appendix 3: Dinoflagellates

reworked dinoflagellates

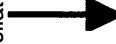
Site & Date	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> spp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrintha</i>	<i>Tuberculodinium vancamptoeae</i>	<i>Impagidinium</i> sp.	theca	unidentified	Total*	<i>Weizeliella</i> sp.	<i>Hystriohokolpoma</i> sp.
PNPT 7/1/1996	1	84	4	54	2	10	2	8	4		3		145		
PNPT 8/1/1996	3	206	36	42		2	2	2	4				314		
PNPT 6/1/1997		250	46	20		2	2	2	12				334		
R-64 6/1/1996	10	60	2	48	2	4	4	2	6				138		
R-64 7/1/1996	9	168	2	14	2	2		4	1		3		205		
R-64 8/1/1996	4	212		68	6						1		291		
R-64 6/1/1996	2	110	6	16		6	4	2	2				148		
RGPT 6/1/1996		58	6	4	1								69		
RGPT 7/1/1996	2	138	16	36	2		4	4	4		5		211	1	
RGPT 8/1/1996	1	232	52	24		18	2	2	2				333		
RGPT 9/1/1996		170	26	18		6	4	2	2				228	1	
STLC 6/1/1996		72	2	12	2		2	2	4				96		
STLC 7/1/1996		126	12	6		2			4				150		
STLC 8/1/1996	1	112	16	12		16	4	4	6			2	173		1
STLC 6/1/1998		184	6	16		4	2	4	6				222		2
STPD 7/1/1996		6											6		
STPD 8/1/1996		4											4		
PRCK 1- 6/1/1998		142	2	16			2						162		
PRCK 3-6/1/1998	4	124	16	4		2	4		2		2		158		
PTMC 1-2--6/1/1997		240	44	12				4	4				304		
PTMC 2-2--6/1/1997		250	54	26		6	4	10	6				356		

*Total does not include reworked dinoflagellates

Chesapeake Bay Microfossils

Site & Date	<i>Tectatodinium</i> sp.	<i>Spiniferites</i> spp.	<i>Spiniferites mirabilis</i>	<i>Operculodinium centrocarpum</i>	<i>Multispinula quanta</i>	<i>Polysphaeridium zoharyi</i>	<i>Lingulodinium machaerophorum</i>	<i>Nematosphaeropsis labyrintha</i>	<i>Tuberculodinium vancampoeae</i>	<i>Impagidinium</i> sp.	theca	unidentified	Total*
PTMC 3-2--6/1/1996		232	30	21		6	6	10	8				313
PTXT 2-6/1/1998	9	104	8	12		2	4	2	8			1	150
PTXT 2-3--6/1/1997		260	38	18			6	6	2				330
PTXT 3-6/1/1998	3	240	34	22	2	4	6	2	16		1		330

reworked dinoflagellates



Wetzellia sp.

Hystriehokolpoma sp.

96

*Total does not include reworked dinoflagellates

Chesapeake Bay Ostracodes

By Thomas M. Cronin and Deena Grinbaum

Ostracodes are bivalved Crustacea whose shells are often fossilized and used to reconstruct environmental trends in lakes, estuaries and coastal bays, and in the world's oceans. Ostracode species live in virtually all aquatic environments, including fresh, brackish, and marine waters. Most species have well-defined salinity and temperature tolerances (Hazel, 1970) such that changes in the relative frequencies of species in sedimentary sequences make them ideally suited for quantitative estimation of paleosalinity (Cronin, 1977) and paleotemperature trends (Valentine, 1971; Cronin and Dowsett, 1990).

Modern ostracodes from coastal environments of eastern North American and the Gulf of Mexico have been intensely studied for decades. Many species are geographically widespread, inhabiting many bays, lagoons, sounds and estuaries in eastern North America. The most comprehensive publications documenting and reviewing the taxonomy and ecology of the species that inhabit Chesapeake Bay include papers by Morales (1966), King and Kornicker (1970), Garbett and Maddocks (1979), and Cronin (1987) on faunas from Texas and Mexican Bays, and those by Cronin (1979), Schweitzer and Lohmann (1990), Grigg and Siddiqui (1993) on assemblages from the Atlantic coast.

The most important study of ostracodes from Chesapeake Bay itself is the classic ecological study by Tressler and Smith (1948) who, in a 2-year sampling program lasting from June, 1940 until June, 1942, determined the seasonal ecology of ostracode species living off Solomons, Maryland. Tressler and Smith's study also provided a benchmark faunal assessment of a major benthic group prior to recent nutrient application in the watershed against which the ostracode database presented here can be compared. Other

early studies include the paper by Sohn (1965) who reported on the genus *Cyprideis* from South River, Maryland, and Elliott *et al.* (1966) who documented the ecology of ostracodes living in the Rappahannock River estuary. Sandberg and Plusquellec (1974) reported *Cyprideis mexicana* Sandberg 1964 from the Patuxent River area and re-classified the *Cyprideis* described by Sohn (1965) from the South River as *Cyprideis americana* Sharpe (1909).

There are also numerous publications describing and illustrating the fossil ostracodes from Neogene sediments from the Chesapeake Bay area. These include Ulrich and Bassler (1904), Malkin (1953), Forester (1980), Valentine (1971), Hazel (1971, 1985), Cronin (1979), Cronin and Dowsett (1990). The paleontological data contained in these papers are especially useful because they demonstrate that many ostracode species living in Chesapeake over the past millennium have been living in the mid-Atlantic region from hundreds of thousands to millions of years.

The present study is an effort to document both the living ostracodes of Chesapeake Bay and the temporal trends in ostracodes that have taken place over approximately the past millennium, by documenting fossil assemblages in sediment cores. Following the format used for other microfossil groups, there are two sections given here. These include a section containing six plates of scanning electron photomicrographs illustrating 26 ostracode species found in the mesohaline parts of the bay (Table 5), and a section containing the species census data for ostracodes obtained from the box, piston, and gravity cores described in the introduction (Appendix 4). The species illustrated in the plates include most ostracode species now living, or having lived in the middle regions of Chesapeake Bay over the past millennium.

Table 5. Some Ostracode Species from Chesapeake Bay

<i>Actinocythereis captionis</i>	Hazel 1983
<i>Cyprideis cf. americana</i>	Sharp 1908
<i>Cyprideis mexicana</i>	Sandberg 1964
<i>Cyprideis salebrosa</i>	van den Bold 1963
<i>Cyprideis</i> sp.	
<i>Cytheromorpha curta</i>	Edwards 1944
<i>Cytheromorpha fuscata</i>	(Brady 1869)
<i>Cytheromorpha newportensis</i>	Williams 1966
<i>Cytherura cf. forulata</i>	Edwards 1944
<i>Cytherura</i> sp.	D of Valentine 1971
<i>Hemicytherura</i> sp.	
<i>Hulingsina rugipustulosa</i>	(Edwards 1944)
<i>Leptocythere nikraveshae</i>	Morales 1966
<i>Loxoconcha matagordensis</i>	Swain 1955
<i>Loxoconcha</i> aff. <i>granulata</i>	Sars 1865
<i>Malzella floridana</i>	Benson and Colman 1963
<i>Neolophocythere subquadrata</i>	Grossman 1967
<i>Paracytheridea altila</i>	Edwards 1944
<i>Paracytheroma repexa</i>	Garbett and Maddocks 1979
<i>Paradoxostoma</i> sp.	
<i>Pellucistoma magniventra</i>	Edwards 1944
<i>Perissocytheridea brachyforma</i>	Swain 1955
<i>Perissocytheridea</i> sp. A	of Grigg and Siddiqui 1993
<i>Pontocythere</i> sp.	
<i>Proteoconcha nelsonensis</i>	(Grossman 1967)
<i>Protocytheretta cf. sahnia</i>	(Puri 1952)

References

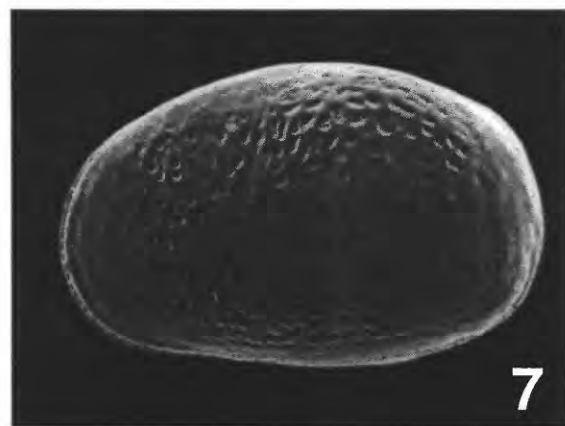
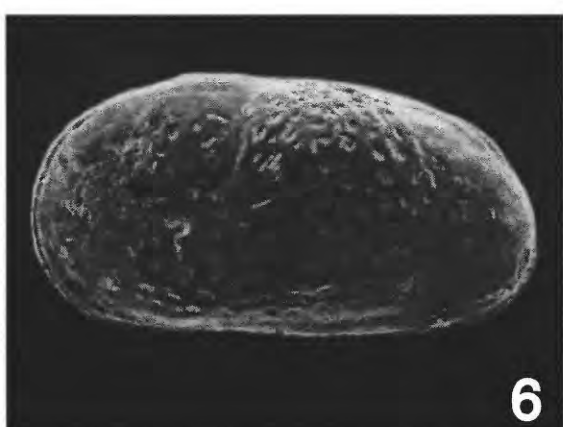
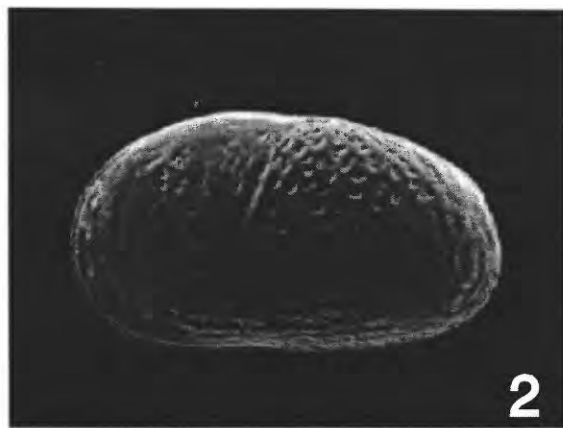
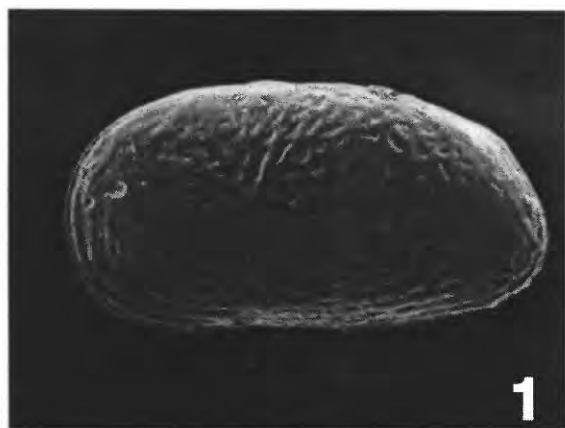
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Chesapeake Bay Ostracodes. *Cyprideis*

Plate 1

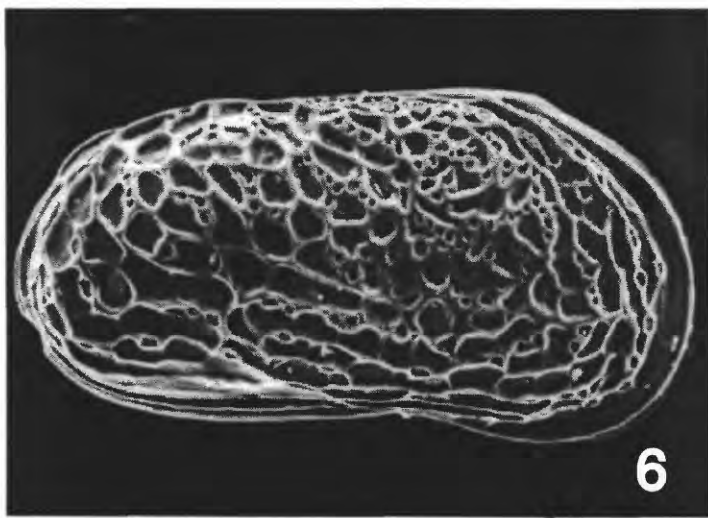
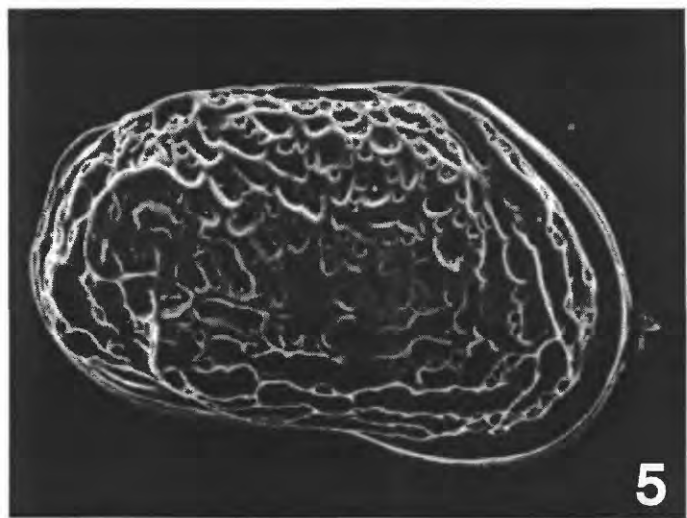
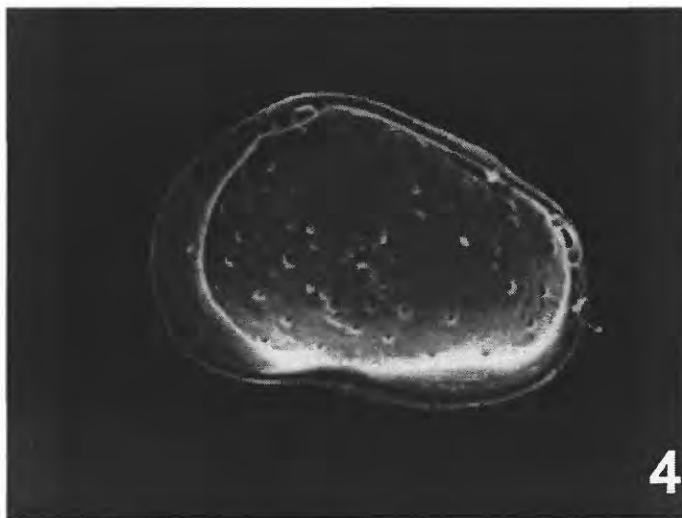
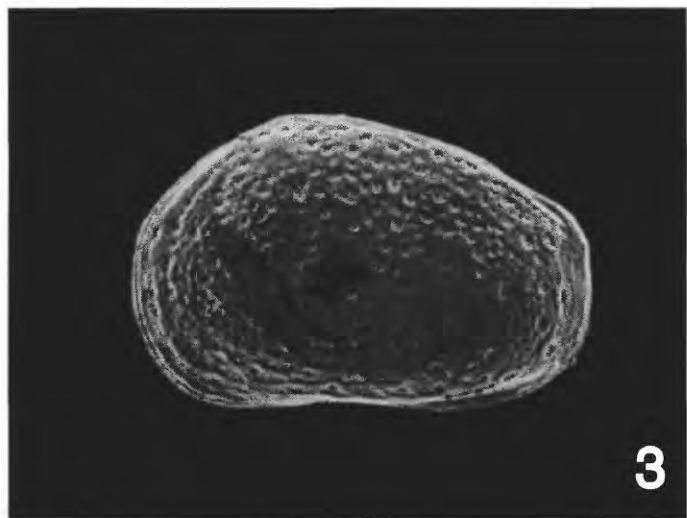
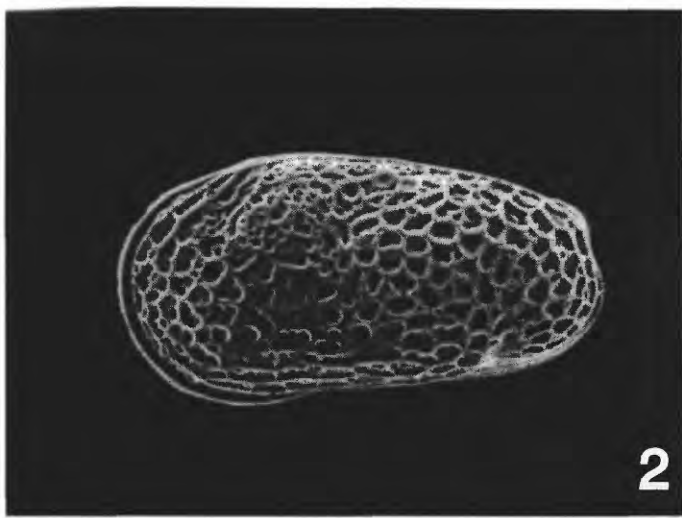
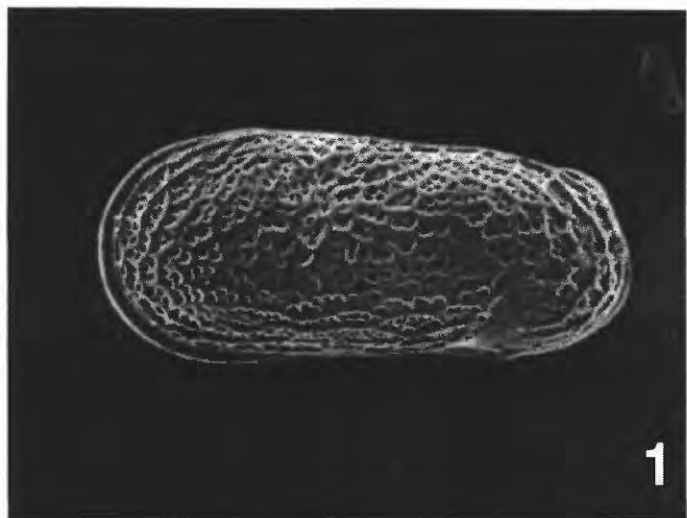
- 1) *Cyprideis mexicana* Sandberg 1964, left valve, male, PTXT 2-G-3 90-92 cm., x 100.
- 2) *Cyprideis mexicana* Sandberg 1964, left valve, female, PTXT 2-G-3 60-62 cm., x100.
- 3) *Cyprideis cf. americana* Sharp 1908, left valve, male, Hog Island-4, 7/96, x 86.
- 4) *Cyprideis* species, external, right valve, female, Hog Island-4, 7/96, x 86.
- 5) *Cyprideis* species, internal, right valve, male, Hog Island-4, 7/96, x 86.
- 6) *Cyprideis* species, left valve, male, weakly noded form, Hog Island-4, 7/96, x 86.
- 7) *Cyprideis salebrosa* van den Bold 1963, left valve, female, Hog Island-4, 7/96, x 86.
- 8) *Cyprideis salebrosa* van den Bold 1963, left valve, male, Hog Island-4, 7/96, x 86.



Chesapeake Bay *Cytheromorpha*

Plate 2

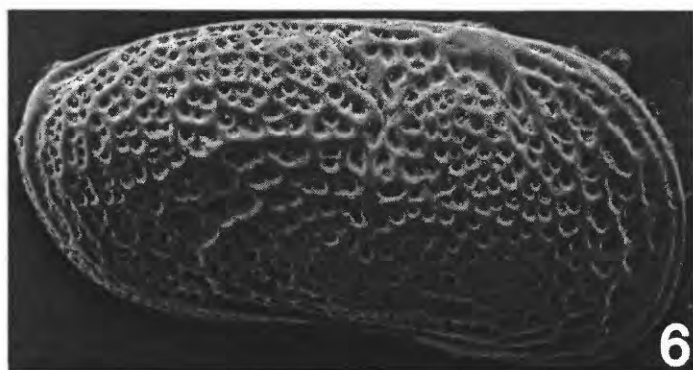
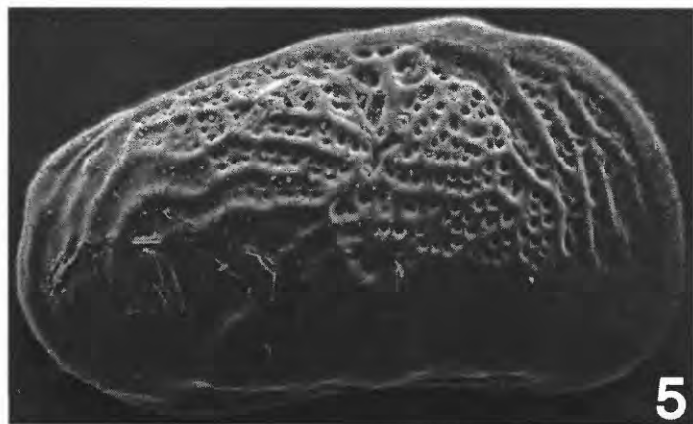
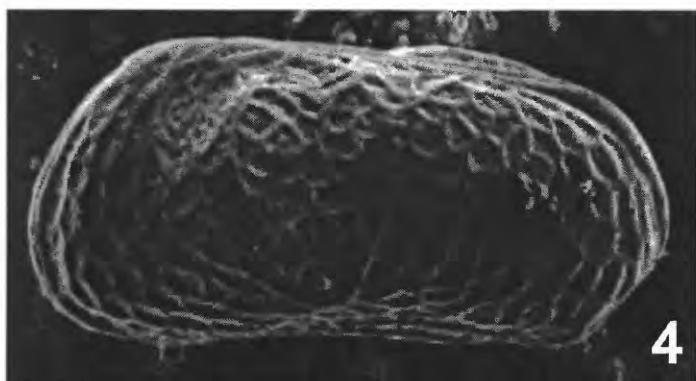
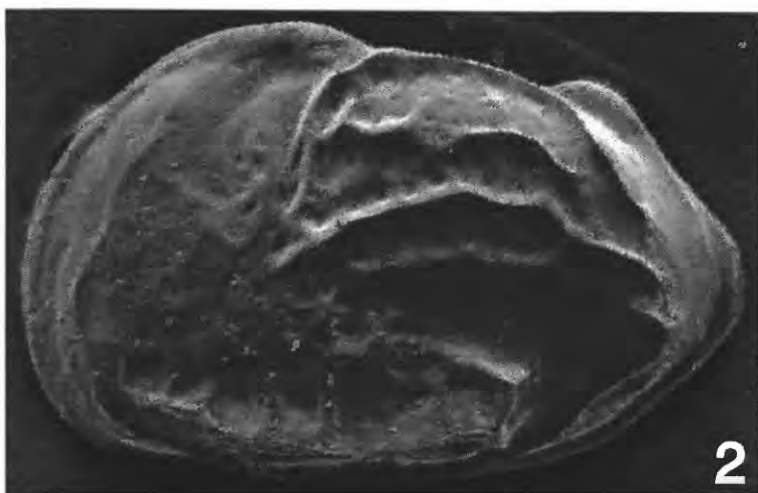
- 1) *Cytheromorpha newportensis* Williams 1966, left valve, male, PTXT 2-P-5 204-206 cm., x 160.
- 2) *Cytheromorpha newportensis* Williams 1966, left valve, female, PTXT 2-P-5 204-206 cm., x 160.
- 3) *Cytheromorpha curta* Edwards 1944, left valve, female, PTXT-2 0-1 cm., 6/98, x 160.
- 4) *Cytheromorpha curta* Edwards 1944, internal, right valve, female, PTXT-2 0-1 cm., 6/98, x 160.
- 5) *Cytheromorpha fuscata* (Brady 1869), right valve, female, PTXT-2-P-5 110-112 cm., x 160.
- 6) *Cytheromorpha fuscata* (Brady 1869), right valve, male, PTXT-2-P-5 204-206 cm., x 160.



Chesapeake Bay Mesohaline Ostracodes

Plate 3

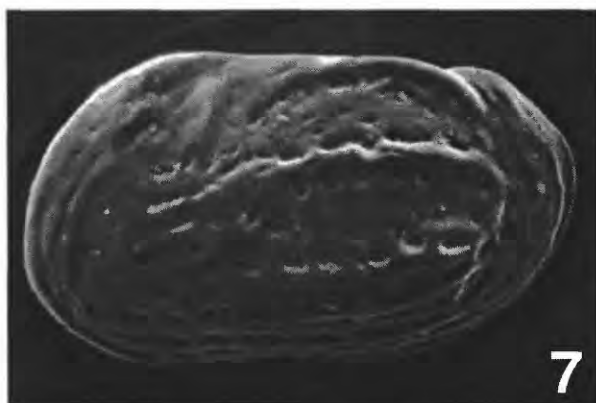
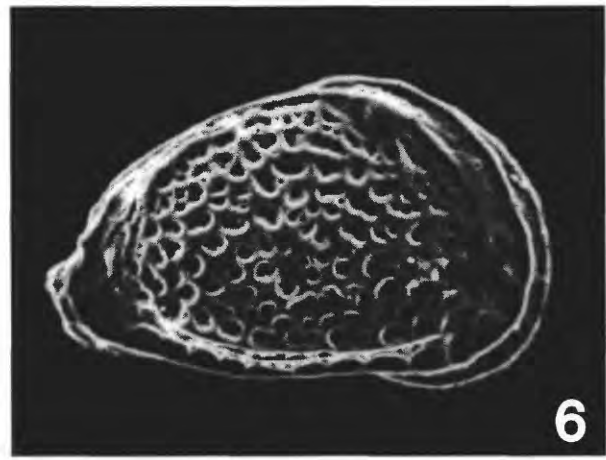
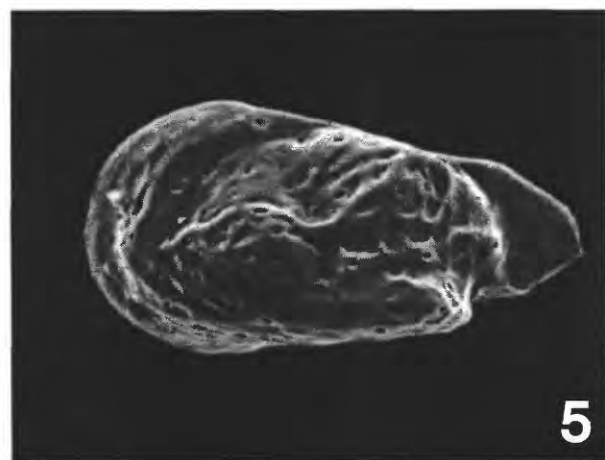
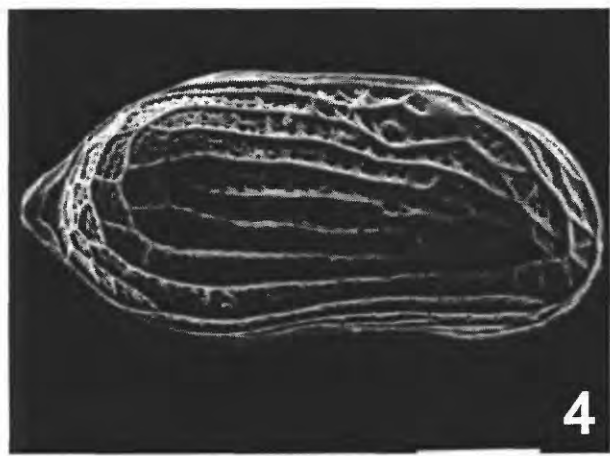
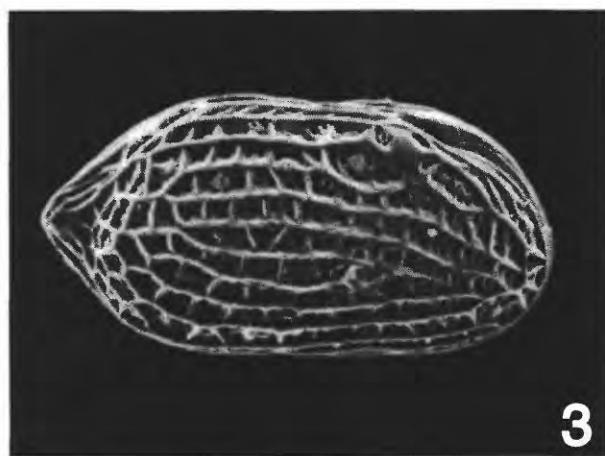
- 1) *Perissocytheridea brachyforma* Swain 1955, PTXT 2-3-G 96-98 cm., x 143.
- 2) *Perissocytheridea brachyforma* Swain 1955, PTXT 2-3-G 96-98 cm., x 143
- 3) *Neolophocythere subquadrata* Grossman 1967, left valve, male, Hog Island-2 6/18/96,
x 147.
- 4) *Neolophocythere subquadrata* Grossman 1967, left valve, female, Hog Island-2
6/18/96, x 133.
- 5) *Leptocythere nikraveshae* Morales 1966, PTXT 2-3-G 96-98 cm., x 172.
- 6) *Leptocythere nikraveshae* Morales 1966, PTXT 2-3-G 96-98 cm., x 200.



Chesapeake Bay Polyhaline/Euhaline Taxa

Plate 4

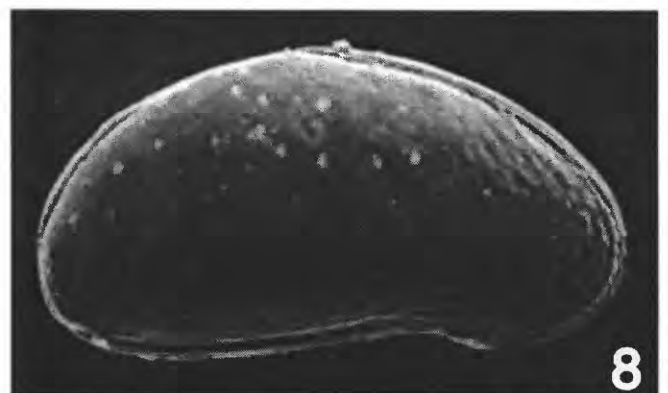
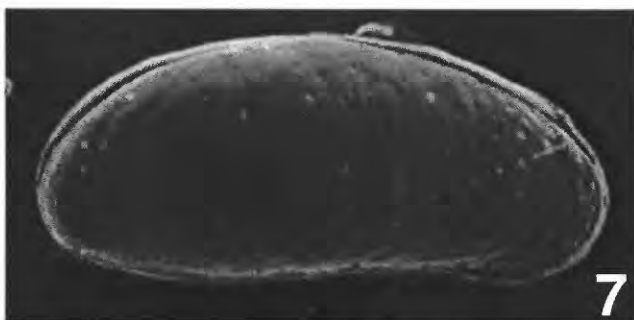
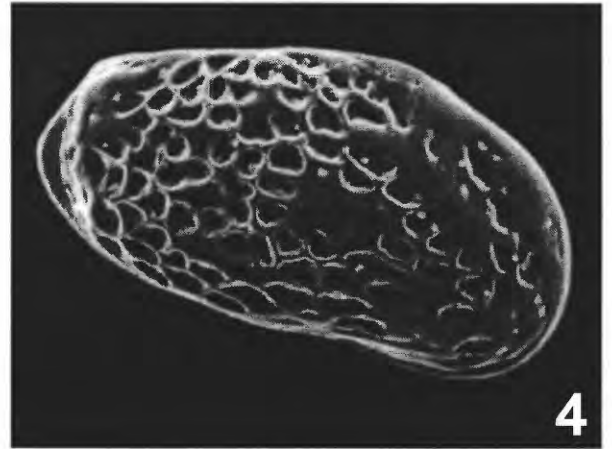
- 1) *Actinocythereis captionis* Hazel 1983, left valve, male, PTXT 2-P-5 378-380 cm.,
x 130.
- 2) *Actinocythereis captionis* Hazel 1983, left valve, female, PTXT 2-P-5 374-376 cm.,
x 130.
- 3) *Cytherura* sp. D of Valentine 1971, right valve, female, PTXT 2-G-3 74-76 cm., x 200.
- 4) *Cytherura* sp. D of Valentine 1971, right valve, male, PTXT 2-P-5 196-198 cm., x 200.
- 5) *Paracytheridea altila* Edwards 1944, juvenile, left valve, female, PTXT 2-P-5 180-182
cm., x 260.
- 6) *Malzella floridana* Benson and Colman 1963, juvenile, right valve, female, PTXT 2-P-5
180-182 cm., x 240.
- 7) *Protocytheretta* cf. *sahnia* (Puri 1952), left valve, female, PTMC 3-P-2 222-224 cm.,
x 102.



Chesapeake Bay Polyhaline/Euhaline Ostracodes

Plate 5

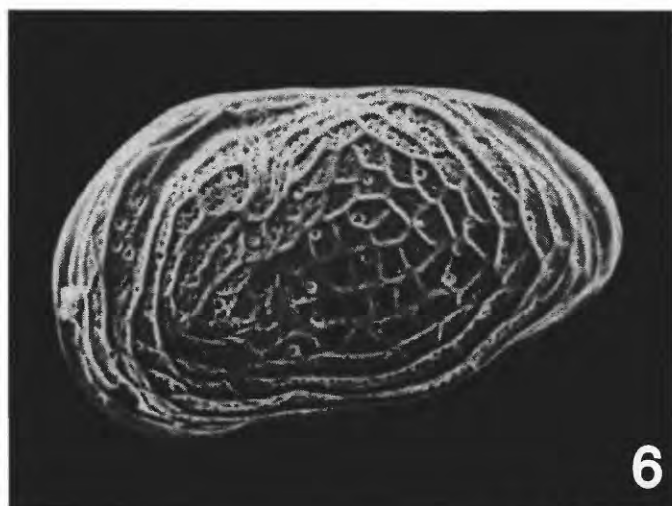
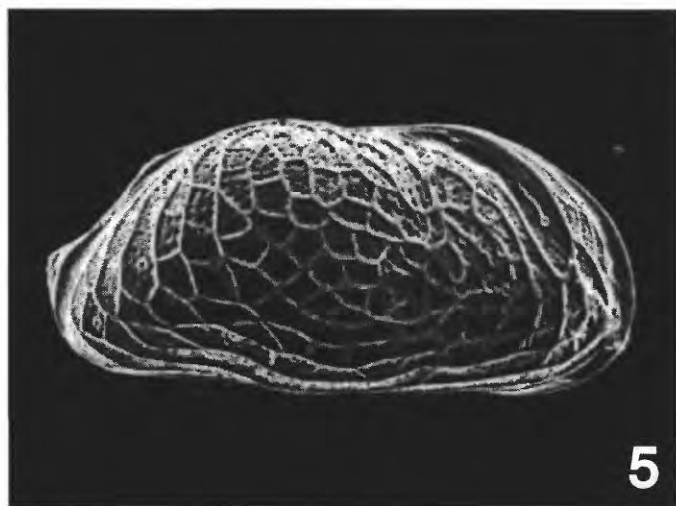
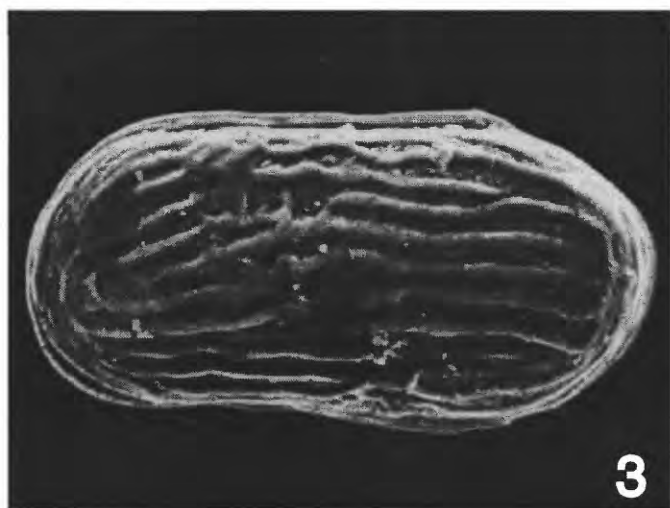
- 1) *Pellucistoma magniventra* Edwards 1944, external, left valve, female?, PTXT-2-P-5
204-206 cm., x 160.
- 2) *Pellucistoma magniventra* Edwards 1944, internal, left valve, female, PTXT 2-P-5
196-198 cm., x 160
- 3) *Hemicytherura* sp., right valve, female, PTXT 2-P-5 116-118 cm., x 220.
- 4) *Proteoconcha nelsonensis* (Grossman 1967), right valve, female, PTXT 2-G-3 72-74
cm., x 180.
- 5) *Hulingsina rugipustulosa* (Edwards 1944), left valve, male, PTXT 2-P-5 180-182 cm.,
x 130.
- 6) *Paradoxostoma* sp., internal, right valve, female, PTXT 2-P-5 180-182 cm., x 150.
- 7) *Pontocythere*, right valve, male, Hog Island-2 6/18/96, x 112.
- 8) *Pontocythere*, right valve, female, Hog Island-2 6/18/96, x 141.



Chesapeake Bay Epiphytal (*Loxoconcha*) and other Ostracodes

Plate 6

- 1) *Loxoconcha matagordensis* Swain 1955, left valve, female, Dameron Marsh #11, 6/98, x 150.
- 2) *Loxoconcha* aff. *granulata* Sars 1865, left valve, male, PTMC 3-2 228-230 cm., x 258.
- 3) *Paracytheroma repexa* Garbett and Maddocks 1979, left valve, female, York River, TF4.2, x 200
- 4) *Cytherura* cf. *forulata* Edwards 1944, juvenile, left valve, female, PTXT 2-P-5 110-112 cm., x 240.
- 5) *Perissocytheridea* sp. A of Grigg and Siddiqui 1993, right valve, female, PTXT 2-P-5 184-186 cm., x 110.
- 6) *Perissocytheridea* sp. A of Grigg and Siddiqui 1993, left valve, female, PTXT 2-P-5 112-114 cm., x 130.



Depth (cm)	<i>Loxococoncha</i> sp.	Total
1		
6		
11		
16		
21		
26		
31		
36		
41		
46		
51	4	4
56		
61		
66		
71		
76	1	1
81		
86		
91		
96		
101		
106		
111		
116		
121		

Depth (cm)	<i>A. captonis</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Cytheretta</i>	<i>Eucythere</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>Loxococoncha</i> sp.	Total
1									
3									
5									
7									
9									
11									
13									
15									
17								1	1
19								1	1
21								1	1
23								3	3
25								1	1
27									
29								2	2
31									
33									
35			1					18	19
37			1					53	54
39									
41									
43									
45								1	1
47									
49								1	1
51								1	1
53		1						6	7
55			1				1	4	6
57								2	2
59									
61								5	5
63			2				1	13	16
65								31	31
67								27	27
69								10	10
71		1						2	3
73			1					10	11
75								17	17
77								3	3
79								1	1
81								10	10
83								6	6
85								5	5
87			2					11	13
89								3	3
91								2	2
93									
95									
97								3	3
99							1	11	12
101			1					4	5
103								2	2

Depth(cm)	<i>A. captonis</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Cytheretta</i>	<i>Eucythere</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>Loxococoncha</i> sp.	Total
105								3	3
107								10	10
109									
111								1	1
113								1	1
115							1	23	24
117			1					64	65
119								13	13
121								4	4
123								4	4
125			1					9	10
127								14	14
129								1	1
131								3	3
133								8	8
135								2	2
137								3	3
139								4	4
141									
143								1	1
145								2	2
147								2	2
149									
151									
153									
155									
157								1	1
159									
161									
163									
165									
167									
169									
171									
173									
175									
177									
179									
181									
183				1					1
185									
187									
189									
191									
193									
195	1								1
197									
199									
201									
203									
205									
207									
209									
211									
213									
215									
217									
219								20	20
221			1	2				81	84

Depth (cm)	<i>A. captionis</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Cytheretta</i>	<i>Eucythere</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. williamsi</i>	Total
223			4	2			2	130	138
225	1		6			1	6	151	165
227			4			1	1	81	87
229			8	1			5	206	220
231								3	3
233								7	7
235								3	3
237	1		3		2	1	5	199	211
239									
241									
243									
245									
247									
249								4	4
251									
253									
255									
257									
259									
261	1		3					7	11
263									
265									
267									
269									
271									
273									
275									
277									
279									
281									
283								1	1
285									
287									
289									
291									
293									
295									
297									
299									
301									
303									
305									
307									
309									
311									
313									
315									
317									
319									
321									
323									
325									
327									
329									
331									
333									
335									
337									
339									

Depth(cm)	<i>A. captionis</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Cytheretta</i>	<i>Eucythere</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. williamsi</i>	Total
341									
343									
345									
347									
349									
351									
353									
355									
357								1	1
359									
361									
363									
365									
367								17	17
369									
371									
373									
375									
377									
379								1	1
381									
383									
385									
387									
389									
391									
393									
395									
397									
399									
401									
403									
405									
407									
409									
411									
413									
415									
417									
419									
421									
423									
425									
427									
429									
431									
433									
435									
437									
439									
441									
443									
445									
447									
449									

Depth (cm)	<i>C. curta</i>	<i>Loxococoncha</i> sp.	Other	Total
1				
6				
11				
16				
21		8		8
26				
31			2	2
36	1			1
41				
46				
51		2		2
56		4		4
61				
66				
71				
76				
81		1		1
86				
91				
96		1		1
101		16		16
106				
111		2		2
116				

Depth (cm)	<i>Cyprideis</i>	Total
1		
6		
11		
16		
21		
26		
31		
36		
41		
46		
51		
56		
61		
66	1	1
71		
76		
81		
86		
91		
96		
101		
106		
111		
116		
121		

Depth (cm)	<i>A. captonis</i>	<i>Cyprideis</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Cytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>Loxococoncha</i> sp.	<i>N. subquadrata</i>	<i>Pellucistoma magniventra</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	Other	Total
1														
6														
11														
16														
21			3					1			1			5
26			3								1			4
31			3	1	1		2				5			12
36			1	1							4			6
41														
46				1	2		6				6			15
51			5	2			1				7			15
56		1	4			2	1				5			13
61		17	6	2				9			6	1		41
66		1	2					1						4
71		1	1								1			3
76			3					3			5	1		12
81		1	1					1						3
86	2		3	6				4		1	2			18
91	2	1	2	5				1						11
96	7	2	4	13		2	1	1	1	1	6	2		40
101	1			2			2	5		2				12
106	2		3			2	1	2			3			13
111	3	4	5	10	2	5	8	4		7	30			78

115

Depth (cm)	<i>A. capitonis</i>	<i>Cypideis mexicana</i>	<i>C. curta</i>	<i>C. fuscata</i>	<i>C. newportensis</i>	<i>Cytherura</i> sp. B	<i>C. forulata</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. matagordensis</i>	<i>Loxconcha</i> sp.	<i>M. floridana</i>	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paracytheridea altilia</i>	<i>Paradoxostoma</i>	<i>Pellucistoma magniventra</i>	<i>Peratocytheridea</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	<i>Protoocytherella edwardsi</i>	<i>Loxconcha tetracytherura</i>	Other	Total
1																									1
3																									2
5			1																						1
7																									8
9			1																						2
11			2																						2
13			6																						6
15			8																						8
17			5																						5
19			5																						5
21			4						1																3
23			3																						3
25			8																	1					9
27			9																						9
29			3																	1					3
31			2																						3
33																									2
35			2																						2
37																									7
39			3							1											1				2
41			1							1										3					2
43			2							2										4					9
45			1							1										1					3
47			1									1								8					13
49			1						2											9					21
51			4							1										7					10
53			1													1				1					6
55										1										2					3
57		1	3																						3
59	1	1	4																	7					12
61			1					2		1		1								6					14
63	1	1	1							3		2								1					3
65										2		1								2					11
67			3																	2					8
69			2							2										2					15
71	1	1				1														10					5
73			1																	2					5
75			1																	3					1
77	1	1	1		6					3		5								4					20

9"

Depth (cm)	<i>A. captonis</i>	<i>Cypridis mexicana</i>	<i>C. curta</i>	<i>C. fuscata</i>	<i>C. newportensis</i>	<i>Cytherura</i> sp. B	<i>C. forulata</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. malagordensis</i>	<i>Loxconcha</i> sp.	<i>M. floridana</i>	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paracytheridea allia</i>	<i>Paradoxostoma</i>	<i>Pellucistoma magniventra</i>	<i>Peratocytheridea</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	<i>Protocytherella edwardsi</i>	<i>Loxconcha tetracytherura</i>	Other	Total
79			1		6					1		1							1	8				18	
81					1					3		3								9				16	
83		1	3									2								1				7	
85		3			3							4								5				15	
87		13	1		6	1					22	22							7	7				50	
89		27			3						19	19							6	6				57	
91		6			8				1	3	6	6							7	7				31	
93		23	3		4					9	10	10							2	2				51	
95		14	2		3				1	9	4	4							1	1				36	
97		2	2	2	3	2			1	9	3	3								11				34	
99		3		1	1					4	2	2			1					1				13	
101		3			5					3	1	1								3				15	
103		6	8	2	4				3	11	9	9			1					6				50	
105		10	4		1				2	1	5	5								4				22	
107		20	6	2	14	1				11		5			2					16				79	
109		13	8	1	13					17	14	14								8				74	
111		3	15	2	16	1	1		3	20	19	19			2				37	13				119	
113		4	17		17	1				16	7	7								3				78	
115		3	14		8					6	22	22								3				58	
117			3	1	2			1		4	14	14			2					5			1	33	
119		1	1		1						3	3			2					14					
121	2	1	3	1	6				1	1	5	5			2					2				24	
123			4							2										1				7	
125	3	2	15		11					4	5	5		1	1					3	1			46	
127	4	1	4		7					5	4	4			2					1				28	
129	2	2	3		11					4	4	4						1		3				30	
131	4		1		9					1	1	1								7				23	
133	2	4			6					2	5	5			1					3				23	
135	3		1		8					1	10	10								1	3			27	
137											7	7												7	
139	2				5					3										1				11	
141			1		5															1				7	
143	8									1	2	2								10				21	
145	13		4		11				5		8	8						1		4				46	
147	21	1	8		4		1		4		6	6								3				48	
149	19	2	1		26				8		13	13						2		22				93	
151	17	1	3		32			2	2	7	9	9								25				97	

L11

Depth (cm)	<i>A. caplioni</i>	<i>Cypriideis mexicana</i>	<i>C. curta</i>	<i>C. fuscata</i>	<i>C. newportensis</i>	<i>Cytherura</i> sp. B	<i>C. forulata</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. matagordensis</i>	<i>Loxconcha</i> sp.	<i>M. floridana</i>	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paracytheridea atila</i>	<i>Paradoxostoma</i>	<i>Pellucistoma magniventra</i>	<i>Peratocytheridea</i>	<i>P. brachyotoma</i>	<i>Perissocytheridea</i>	<i>Protocytheretia edwardsi</i>	<i>Loxconcha tetracytherura</i>	Other	Total
153	7		2		39	2				3		9						1		14					77
155	2	1	3		19	2			2	1		8				1				47					87
157	1	1	3		28					1	2	3								50					89
159	1	3	4		26							3								24					61
161	1		4		15					2		7								12	4				45
163	2				8							2								2					14
165			1		2				1	2										5					11
167				1	6													1		4					12
169	1	2	2	2	17				5	8		4								32					73
171	8		3	1	31				3	6		4						1		20					77
173	3	5			8		1			1								2		54					74
175	3	3	1		6	1			5	3		2								55	1				80
177	25	13	4		8	1	1		9	13		4			1			4		58	1				138
179	9		4		17	1			1	3		12	1				1			16					66
181	8	5	1		38	1			3	1		4			1	1		5		34	1			2	106
183	8	9		1	41				13	9		4			1			6		67	1				160
185	9	6	12	1	68			1	5	5		8						5		83	1				203
187	4	5	4		27				4	6		3			1			3		17	1				75
189	1				4	2			1	1		3								19				1	31
191	1	8			9													3		17					39
193	1	5	8		30				3	3		1						4		32					87
195	3	31	1		36	4				8		14						7		54					158
197	1	9	2		28	7			1	8		2						2		43					103
199	1	2			19					11		1								8					42
201		2			1					2										4	1				10
203					14				2	2		4								19					41
205		1	2	4	13													6		19					45
207	1	4	3		11					3		2								8					32
209		3	2		12															5					23
211		3	1	1	7							4								4					20
213	2	4	1		16					3		8								5					39
215	2	3	1		10					3		3								12					34
217	1	15	2		48	1			4	5		5						1							82
219		3	3		9				4									2							21
221			2		1				1			6													10
223		2	3		3																				8
225					3				1			2													6
227					5																				5

Depth (cm)	<i>A. captonis</i>	<i>Cyprideis mexicana</i>	<i>C. curta</i>	<i>C. fuscata</i>	<i>C. newportensis</i>	<i>Cytherura</i> sp. B	<i>C. forulata</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. matagordensis</i>	<i>Loxocncha</i> sp.	<i>M. floridana</i>	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paracytheridea altila</i>	<i>Paradoxostoma</i>	<i>Pellucistoma magniventra</i>	<i>Peratocytheridea</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	<i>Protocytherella edwardsi</i>	<i>Loxocncha tetracytherura</i>	Other	Total
229			2		11										2										15
231					1																				1
233																									
235	4									5		15								1					5
237	13				14		1		2									1						1	50
239	4				3					1		2													12
241	1				2							2													6
243			1		1				1			2													5
245					2							2													4
247																									
249	3	1			2	1			1																8
251	1											2													3
253	3											3												1	7
255			1		3					1															5
257			1		15				4			4													24
259	1	1	2		21				1			2													28
261		3	1		22				1			4						2							34
263	2	1	3		5				1	2		5						1		1					20
265												2												1	4
267	1		1		7							4													13
269		2										2													4
271					2																				2
273																									
275		1	1									1												1	4
277	4		4		1							1													6
279			2		1					2															5
281			1																						1
283																									
285																									
287																									
289																									
291	1				4													1			1				7
293																									
295					4																				4
297	1	5	2		4				2	3		2						1							20
299					8				3	2		4						4							21
301			9		11				2	4		2													28
303	10	1	16	2	36	1				2		10						9							87

611

Depth (cm)	<i>A. captonis</i>	<i>Cyprideis mexicana</i>	<i>C. curta</i>	<i>C. fuscata</i>	<i>C. newportensis</i>	<i>Cytherura</i> sp. B	<i>C. forulata</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. matagordensis</i>	<i>Loxconcha</i> sp.	<i>M. floridana</i>	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paracytheridea ahlia</i>	<i>Paradoxostoma</i>	<i>Pellucistoma magniventra</i>	<i>Peratocytheridea</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	<i>Protocytherella edwardsi</i>	<i>Loxconcha tetracytherura</i>	Other	Total
305	2		7		10		1		1	4		6						7							38
307	1		4		35				1	4		1						2					1		51
309	7	2	3		26				1	4								2							42
311	4		2		40					8		5													59
313					8					1		6													15
315	1		3		16	1			2	3	1	2													29
317	6				38			1		2		8						3							55
319	9				18					3		3						2							36
321	3				9					1		1						2					1		17
323	7		1		12	2				4		4						1							27
325	4	1	9		16				2	5		4						1							42
327	1		3		28					2		4				2		3					1		44
329	2	3	3		34	1				2		4						12							61
331		2	1		24	1				5		5						3				2			43
333	1	2	7		43				3	2								6							64
335	2	1	2		14				3									1							21
337		2	2		11				3	1		3													22
339		2	4		20	1			7	1		8													43
341	1	4	6		36				5	2		2						3							57
343	1	2	5		26				2	1		2						1							40
345		2			3	1				1		1													7
347			1		26				1	1		1													30
349	1		1		10		1																		13
351			1		4					1		3									2				11
353					3							2													5
355			1		1							2						4							8
357			9		5	1				1		2													16
359			4									1													5
361																									
363																									
365																									
367	1											2													3
369			3		1					1															5
371	3		1		11	1			2	1		2													21
373	18				9				1	5		14						4				3			54
375	17		4		7					2		4						3				3			40
377	17		4		9							5						1							36
379	15		2		26				1	2		5						1							52
381	14	1			26				1			5						6							53

20

Depth (cm)	<i>A. caplionis</i>	<i>Cypriideis mexicana</i>	<i>C. curta</i>	<i>C. fuscata</i>	<i>C. newportensis</i>	<i>Cytherura</i> sp. B	<i>C. forulata</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>L. matagordensis</i>	<i>Loxococoncha</i> sp.	<i>M. floridana</i>	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paracytheridea altila</i>	<i>Paradoxostoma</i>	<i>Pellucistoma magniventra</i>	<i>Peratocytheridea</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	<i>Protocytherella edwardsi</i>	<i>Loxococoncha tetracytherura</i>	Other	Total
383	2				4				2									1							9
385	2				4							1													7
387	12		1		13				1			6										4			37
389	7	2			4				1			4			1										19
391	4	5			4							4													17
393	1				1							1													3
395					2				2			1													5
397			1							2		3			1										7
399	1		1		2				1	3		2													10

Depth (cm)	<i>A. captionis</i>	<i>Cyprideis</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Cytherura</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>Loxococoncha</i> sp.	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paradoxostoma</i>	<i>Peratocytheridea</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	<i>Pontocythere</i>	<i>Proteococoncha</i>	Other	Total
1																			3
3																			10
5										2									2
7			1							10									5
9			2							1									3
11			1							1									6
13			6				1												2
15			1															1	1
17			1																3
19			1																2
21			1																1
23			2																3
25			5						1										2
27			4															2	11
29			15		1														5
31			29	13								1		4	1				27
33			11											25			1	1	78
35			9	3	1		1							8					24
37			3	2										19		1			36
39			7	5					1					4		3	1		17
41			6											10					23
43			1											8					14
45	2			1										2					6
47			3	5	2		1							3					11
49			4	4	1	1		5	4				2	19					38
51			7	3				2						14					22
53			19	5			2	6	3					24					43
55			14	4	2			7	3					16					52
57	1		2					6	1					13					40
								3	1					13					20

22

Depth (cm)	<i>A. captonis</i>	<i>Cypriids</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Cytherura</i>	<i>Hemicytherura</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>Loxconcha</i> sp.	<i>M. repexa</i>	<i>N. subquadrata</i>	<i>Paradoxostoma</i>	<i>Peratocytheridea</i>	<i>P. brachyforma</i>	<i>Perissocytheridea</i>	<i>Pontocythere</i>	<i>Proteconcha</i>	Other	Total
59		14	2	2					7					7					32
61		58	3	6			1	6	44					14					132
63		21	5	8				5	13					10					62
65		7	3	5	1			9	3					10					38
67			3	5				5	5					5					23
69		4	12	13			1	2	3					14	1			1	51
71		2	2	3					1					1					9
73		24	11	8				2	4					10		3			62
75		14	10	15	2	1		5	10					14					71
77		5	15	20				18	14		3		2	24					101
79		1	8	4				5	3		8			10				2	41
81			1	2				4	2					19		1		1	30
83			2	1				2	1					5		1			12
85		2	8	5			1	4	2					5					27
87		1	15	3				1	3					5			1		29
89	5	3	12	10			1		5					2	2				40
91	8	3	6	9				3	6					2	1				38
93	7	1		5			1	2	2					4					22
95	14	1	1	6				2	8					7					39
97	10	4	1	14			7		2					8					46
99	16	2	2	27			4	4	1					9					65

Depth (cm)	<i>A. captionis</i>	<i>Cyprideis</i>	<i>C. newportensis</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>Loxoconcha</i> sp.	<i>P. brachyforma</i>	Other	Total
100		11	9			12	2		34
111			1			2			3
121							5		5
131		1					2		3
141						2			2
151			1			2	1		4
161	1		1	3	1		4		10
191		2	1				1		4
201			3				6		9
211							1		1
221		2	2				16		20
231			3		1		13	1	18
241			2		2	3			7
251	1		1				2		4

Depth(cm)	<i>A. captionis</i>	<i>C. curta</i>	<i>H. rugipustulosa</i>	<i>L. nikraveshae</i>	<i>C. newportensis</i>	<i>Loxococoncha</i> sp.	<i>P. brachyforma</i>	Other	Total
1									
6									
11		3					2		5
16		1					1		2
21		2			1				3
26		2				4			6
31		1			2	13	1	1	18
36		2	2			1	2		7
41		1	4	1	7				13
46			5		6	1			12
51	20		4		2	3			29
56					1	2			3
61						2			2
66						1			1
71									
76									
81							1		1
86						4			4
91						1			1
96									
101									
106									
111									
116									
121									

Depth (cm)	<i>A. captionis/dawsoni</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>H. rugipustulosa</i>	<i>Loxconcha</i> sp.	<i>Paradoxostoma</i>	<i>Perissocytheridea</i>	<i>Protocytheretta edwardsi</i>	Total
1									
3									
5					5				5
7		1	3		14				18
9					14				14
11		5			13				18
13		2	2		27		1		32
15		2	1		30				33
17					41				41
19	2	1	4		63				70
21			2		17				19
23			1		14				15
25					9				9
27			3		22				25
29			2		8				10
31			1		10				11
33			7		10				17
35			3		11				14
37			1		8				9
39					2				2
41					2				2
43					4	1			5
45					1				1
47			5		21	1			27
49			1		4				5
51		1	2		5				8
53			1		23				24
55			2		10				12
57			1		15				16
59									
61									
63					3				3
65					1				1
67					6				6
69			1		2				3
71					9				9
73			1		8				9
75			1		8				9
77			2		22				24
79	2		1		8				11
81									

Depth (cm)	<i>A. captionis/dawsoni</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>H. rugipustulosa</i>	<i>Loxoconcha</i> sp.	<i>Paradoxostoma</i>	<i>Perissocytheridea</i>	<i>Protocytheretta edwardsi</i>	Total
83									
85									
87									
89									
91									
93									
95									
97									
99									
101									
103									
105									
107									
109									
111									
113									
115									
117									
119									
121					2				2
123									
125									
127									
129									
131									
133									
135									
137									
139					1				1
141					1				1
143					1				1
145									
147		1							1
149					1				1
151									
153					4				4
155					3				3
157					4				4
159					1				1
161					1				1
163									
165					1				1
167									
169									
171									
173									
175									
177									
179									

Depth (cm)	<i>A. captionis/dawsoni</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>H. rugipustulosa</i>	<i>Loxococoncha</i> sp.	<i>Paradoxostoma</i>	<i>Perissocytheridea</i>	<i>Protocytheretta edwardsi</i>	Total
181									
183									
185									
187									
189									
191									
193									
195									
197									
199									
201									
203									
205									
207					1				1
209									
211									
213									
215									
217									
219									
221									
223	1								1
225					1				1
227									
229									
231									
233									
235									
237	2				5				7
239									
241									
243									
245									
247									
249									
251									
253									
255									
257									
259									
261									
263									
265									
267									
269									
271									
273									
275									
277									

Depth (cm)	<i>A. captionis/dawsoni</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>H. rugipustulosa</i>	<i>Loxocochoa</i> sp.	<i>Paradoxostoma</i>	<i>Perissocytheridea</i>	<i>Protocytheretta edwardsi</i>	Total
279									
281									
283									
285									
287									
289									
291									
293									
295									
297				1	38				39
299									
301									
303									
305									
307									
309									
311									
313					3				3
315									
317	1		1		41				43
319					13				13
321					11				11
323									
325									
327					1				1
329					2				2
331									
333									
335									
337									
339									
341			1		2				3
343	2		5		28			3	38
345	2							1	3
347									
349									
351									
353									
355									
357									
359									
361									
363				1					1
365									
367	1								1
369									

Depth (cm)	<i>A. captionis</i>	<i>C. curta</i>	<i>C. newportensis</i>	<i>Hulingsina</i>	<i>L. nikraveshae</i>	<i>Loxococoncha</i> sp.	Total
0			1			1	2
5							
10							
15							
20							
25							
30							
35		1					1
40							
50							
55						1	1
60		1					1
62							
62.5							
63							
63.5							
70							
75							
80						1	1
85						1	1
90						8	8
100						5	5
110			2			7	9
120							
130			1			2	3
140			3		1	16	20
150			1				1
160							
161			1			6	7
162						2	2
163	2						2
170						4	4
180				2			2
190						1	1
200			2			26	28
210							
220							
230							
240							
250							

Depth (cm)	<i>M. repexa</i>	<i>C. curta</i>	Total
0.5			
2.5			
4.5			
6.5			
8.5	6	1	7
10.5	2	1	3
12.5			
14.5			
16.5			
18.5			
20.5			

Depth (cm)	<i>C. curta</i>	<i>Loxococoncha</i> sp.	Total
0.5			
2.5			
4.5			
6.5			
8.5			
10.5			
12.5	1		1
14.5	2	1	3
16.5	1		1
18.5			
21.5			

Depth (cm)	<i>C. curta</i>	Total
0.5	3	3
2.5		
4.5		
6.5		
8.5		
10.5		
12.5	2	2
14.5		
16.5	1	1
18.5	3	3
20.5	1	1
22.5	1	1
24.5		

Depth (cm)	<i>Cyprideis</i> (spp.)	<i>C. curta</i>	<i>L. nikraveshae</i>	Total
0.5	4			4
2.5			1	1
4.5				
6.5				
8.5				
10.5	1			1
12.0				
14.5				
16.5				
18.5	1	1		2
20.5				

Chesapeake Bay Pollen

By Debra A. Willard

Pollen is part of the life cycle of seed plants, the haploid male gametophyte, and pollen grains commonly are preserved as fossils. They are useful for reconstruction of past plant communities and, by extension, climatic and environmental trends from lacustrine, estuarine, and marine sediments. Plants have evolved a number of mechanisms to ensure successful reproduction, including pollination by wind, insects, and birds, among others. The type of pollination strategy used by a plant is a major control on the abundance and distribution of its pollen in sediments, with wind-pollinated plants the best represented in most sediments. Because virtually all pollen is transported some distance from the source plant, it is critical to correlate pollen abundance in surface samples with that of the source vegetation before interpreting past vegetational composition from fossil pollen assemblages. Such studies have been undertaken in lacustrine and wetland sediments from eastern North America by Davis (1963), Davis and Webb (1975), Delcourt, Delcourt, and Davidson (1983), Overpeck, Webb, and Prentice (1985), Webb and McAndrews (1976), and Willard and Weimer (1997). In an ongoing study, we are augmenting existing data by sampling annual pollen accumulation in both pollen traps and clay pads in forested wetlands as well as examining pollen from the surface centimeter of Chesapeake Bay sediment. These data are helping to establish how much variability is introduced by analysis of time-averaged surface samples as compared to analysis of annual samples.

Databases with abundance and distribution of modern pollen in offshore sediments have been compiled for quantitative paleoecological analysis of pollen assemblages from estuarine and marine systems. These include research by Mudie (1982) on the coastal and continental shelf areas off eastern Canada; Heusser (1983/84) on slope and rise sediments between Florida and Greenland; and Groot (1966) on sediments in the Delaware River

estuary. In the Chesapeake Bay region, extensive work by Brush and others has provided the groundwork for interpretation of vegetational patterns from pollen assemblages preserved in the Chesapeake Bay and its tributaries (see Brush and DeFries (1981) and DeFries (1986)). Pollen from major plant taxa in eastern North America has been illustrated in several publications, including McAndrews *et al.* (1973), Bassett *et al.* (1978), and Jones *et al.* (1995).

In this report, we illustrate several of the most common pollen types found in the Chesapeake Bay (Table 6) and provide pollen census data from box, piston, and gravity cores collected in the bay (Appendix 5). Ongoing research on pollen assemblages from the Chesapeake Bay region is documenting the distribution of pollen in the modern estuary and surrounding watershed and establishing temporal patterns in plant distribution in response to changes in both climate and land use over the last millennium.

Table 6. Pollen from the Chesapeake Bay

Scientific Name	Common Name
<i>Acer</i>	Maple
<i>Alnus</i>	Alder
<i>Ambrosia</i>	Ragweed
<i>Artemisia</i>	White Sage
Asteraceae	Aster family
<i>Betula</i>	Birch
<i>Carya</i>	Hickory
<i>Castanea</i>	Chestnut
<i>Celtis</i>	Hackberry
<i>Cephalanthus</i>	Buttonbush
Chenopodiaceae	Pigweed family
<i>Cornus</i>	Dogwood
<i>Corylus</i>	Hazelnut
Cyperaceae	Sedge family
Ericaceae	Heath family
Euphorbiaceae	Spurge family
Fabaceae	Legume family
<i>Fagus</i>	Beech
<i>Fraxinus</i>	Ash
<i>Ilex</i>	Holly
<i>Juglans</i>	Walnut
<i>Liquidambar</i>	Sweet-gum
<i>Liriodendron</i>	Tulip Poplar
<i>Myrica</i>	Wax Myrtle
<i>Nyssa</i>	Black Gum
<i>Ostrya/Carpinus</i>	Ironwood/Hornbeam
<i>Picea</i>	Spruce
<i>Pinus</i>	Pine
<i>Plantago</i>	Plantain
Poaceae	Grass family
<i>Polygonum</i>	Knotweed
<i>Quercus</i>	Oak
<i>Salix</i>	Willow
Taxodiaceae/Taxaceae/Cupressaceae	Cypress/Yew/Cedar families
<i>Tilia</i>	Basswood
<i>Tsuga</i>	Hemlock
<i>Typha</i>	Cattail
<i>Ulmus</i>	Elm

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Plate 1

- 1) *Juglans* Linnaeus (Walnut), PRCK 100-102 cm., x 2600.
- 2) *Liquidambar* Linnaeus (Sweet Gum), PTMC 3-2 106-108 cm., x 2800.
- 3) Chenopodiaceae Ventenat (Pigweed Family)/Amaranthaceae Jussieu (Goosefoot Family), PTXT 50-52 cm., x 2600.
- 4) *Quercus* Linnaeus (Oak), PRCK 100-102 cm., x 4800.
- 5) *Tsuga* Carrière (Hemlock), PRCK 100-102 cm., x 1300.

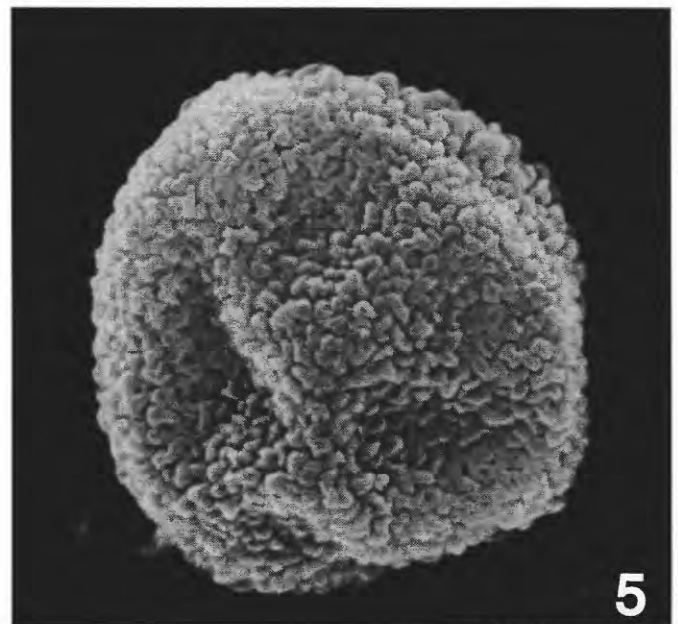
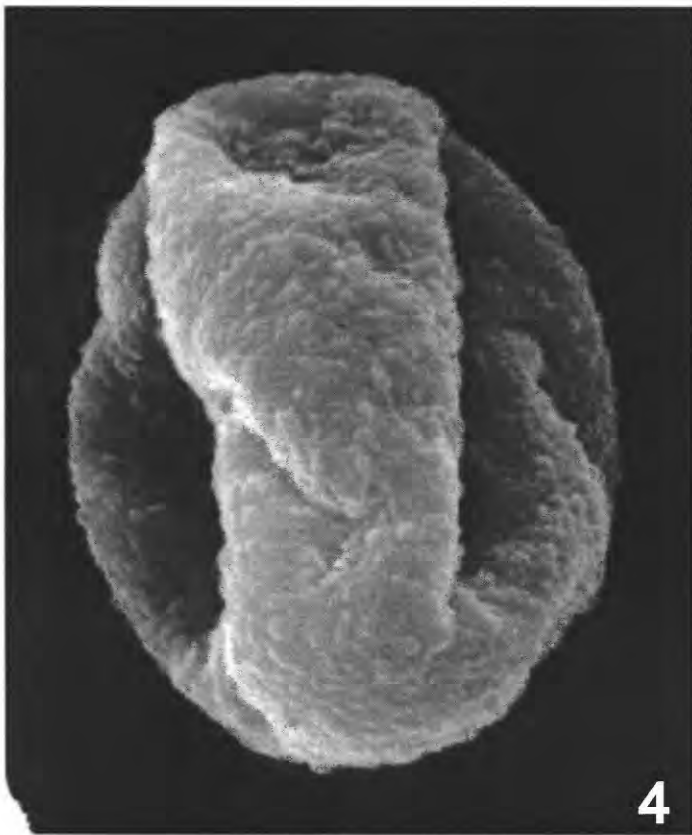
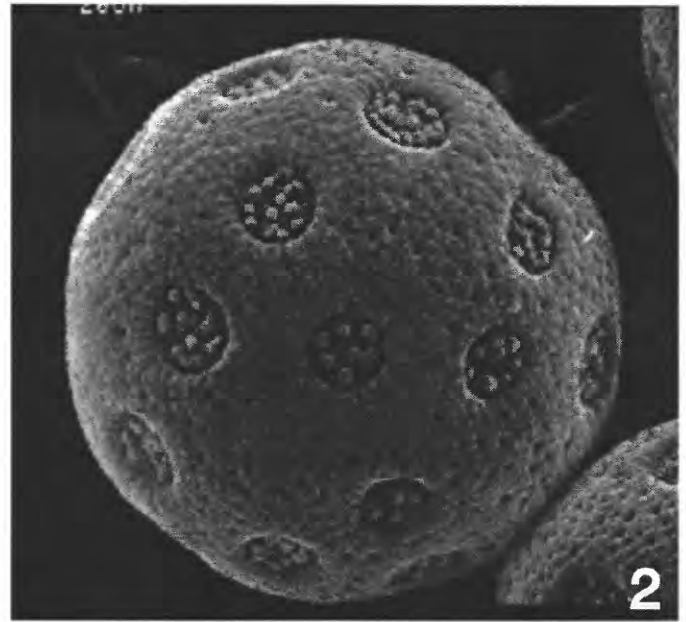
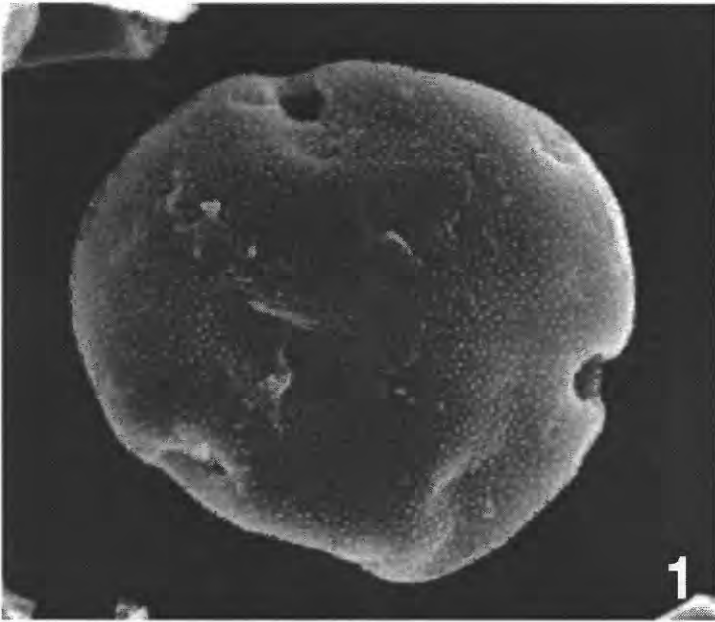
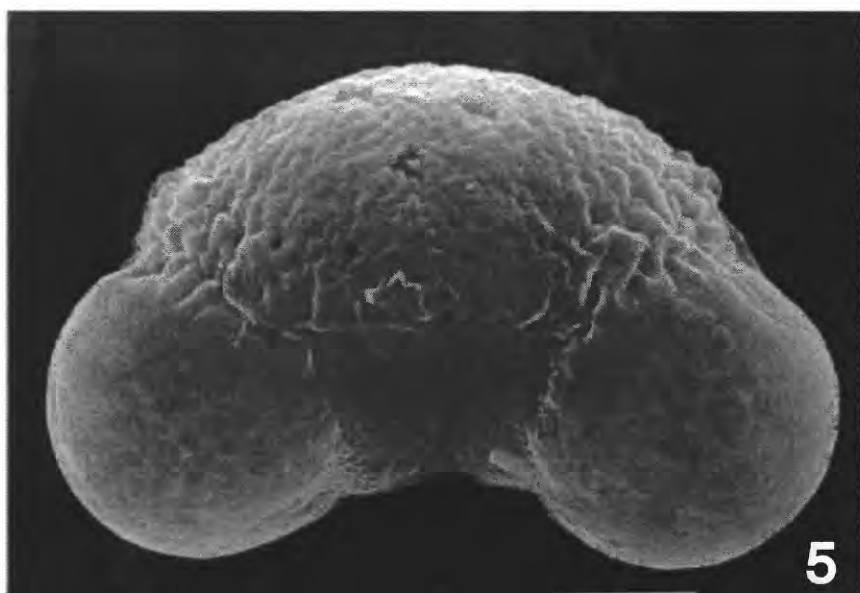
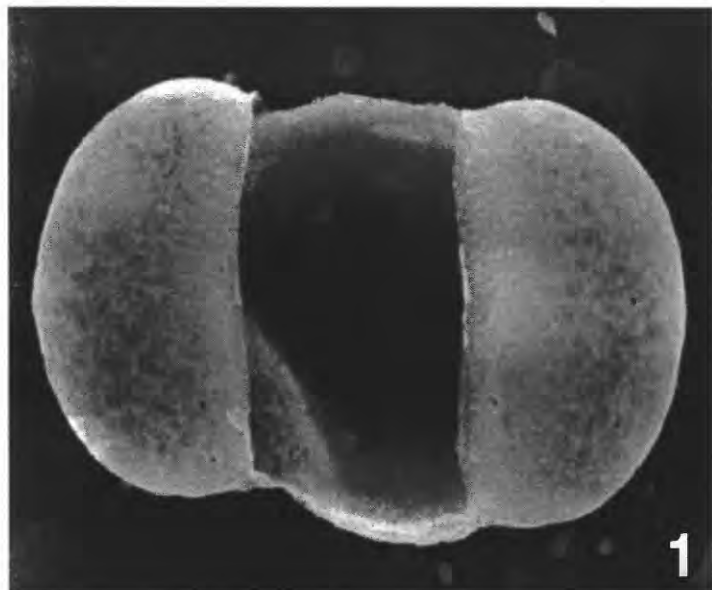


Plate 2

- 1) *Pinus* Linnaeus (Pine), PTMC 3-2 422-424 cm., x 1800.
- 2) *Ambrosia* Linnaeus (Ragweed), PTXT 50-52 cm., x 2600.
- 3) *Pinus* Linnaeus (pine grain with air bladder broken off), PRCK 100-102 cm., x 1800.
- 4) Poaceae Barnhart (Grass Family), PTXT 50-52 cm., x 1600.
- 5) *Pinus* Linnaeus (Pine), PTMC 3-2 422-424 cm., x 2000.



Depth (cm)	Pinus	Carya	Quercus	Liquidambar	Tsuga	Picea	Betula	Corylus	Salix	Nyssa	Ulmus	Juglans	Ostrya/Carpinus	Fagus	Myrica	Alnus	Acer	Liriodendron	Celtis	Fraxinus	Castanea	Taxodiaceae/Taxaceae/Cupressaceae	Ilex	Tilia	Poaceae	Chenopodiaceae	Ambrosia
4	155	11	110	30	1	1	15			9	2	2	4	8	7	2	3	1					1		6	4	20
7	166	14	89	16	3	4	7			1	3	2		7			1						1		2	5	20
11	150	12	104	11	2	6	3				3	1	1	6											4	5	15
15	150	9	104	12	2	7	4	1			3			2	2	2	2								4	2	19
19	146	5	105	10	1	5	5				3			1	3	3						1			3	4	20
21	161	21	96	13	6	5	5			4	1	2	3	8	3		1							1	17	4	20
23	200	13	65	5	4	5	7				1	2		1											3	4	
27	213	15	55	5		7	1				1	1	1	3											5		3
31	202	19	66	11	2	4	1			4	1	1	1	7								1			6	3	2
35	217	18	71	11		6	1				1	1		5			1			1			1		4	1	6
39	201	25	79	7	1	7	2			4	2	2		8			1								3	2	5
43	116	10	46	9	3	7	3			6	3		3	6	8			1			1				3	3	20
77	175	22	73	8		4	6		1	7	3		2	4	13	3		1							6	2	61
107	186	10	44	8	4	5	5			7	1	1		4	4									1	2	2	13
129	194	17	40	5	7	4	7			3	2	1	2	3	1	1	1								7	2	10
151	230	11	90	6	2	6	1			1	5	1	1	2											1	1	12
157	143	9	99	7	6	4	8	2		2	1		1	10	5	4	1		1						7		40
161	192	16	108	2	3	2					1	1	1	1						1					1	3	3
165	170	20	174	7	2	2	3				2	1	1	1											1	1	4
167	148	17	142	5	2	2	1						1									1			1	4	2
171	201	17	105		4	7	1					1	3	4		2				1					1	1	1
175	150	18	141	3	1	3	1			1	1	2													2	1	1
181	170	23	119		3	3															4				5	1	9
185	149	21	128	3	2	5	3				1	1		12		3	2								5	1	1
191	199	19	146	4	2	5	2				1	1		1			3					1			1	1	1
195	175	25	102	3	1	6	1			1		1		3			1									3	3
201	144	15	124	2	2	3	4			1		2		3	1		1					2	1	1	9	1	
205	172	25	113	5	2	4	1					1		7								1			2		2
211	161	24	116	2	1	5	3			3				4			1								2		2
215	151	28	141	3	4	5	2				1	1		2											3	2	
237	141	15	120	6	5	2	4							3	1										3	2	
261	142	18	118	5	4	8	1			2		1		8	1					2					3	2	
307	133	17	147	2	5	3	6		2	2	1	1	1	4								7			4	4	1
335	148	19	121	5	5	2	6					2		15									3	1	5	3	1
357	189	31	136	7	6	3	8			6					1										4	2	
395	159	13	124	1	8	2	1						1												5	3	
419	194	23	126	2	3	3	4		1					2								2			2	2	3
447	181	23	95	4	4	3	4			1	1	1			1	1						1			2	2	2

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Depth (cm)	Asteraceae indet.	Fabaceae	Comus	Cyperaceae	Euphorbiaceae	Ericaceae	Typha	Plantago	Polygonum
4	3		1					1	
7	1			1			1		
11	2			2			1		
15	5			3			1		
19							1		
21	1			2					
23									
27				2			1		
31	1						1		
35	1								
39	1						1		
43	1						1	1	
77	1	1					1	6	
107	1						1		
129	1					1	2	1	
151	1								
157	3	2				1	3	2	
161	3								
165	4			2					
167	1								
171									
175	1			2					
181									
185	1			1			1		
191				2					
195				1					
201	1			4	1	1			
205	1			2					
211	1								
215									
237	3								
261	2	4		1			1		
307				4					
335		1		2					1
357	4	2		1	1	1			
395	1	2							
419		2		3					
447	1	1					1		

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Depth (cm)	Pinus	Carya	Quercus	Liquidambar	Tsuga	Picea	Betula	Corylus	Salix	Nyssa	Ulmus	Juglans	Ostrya/Carpinus	Fagus	Myrica	Alnus	Acer	Celtis	Fraxinus	Castanea	Taxodiaceae/Cupressaceae/Taxaceae
1	287	14	81	23	1	3	8	2			6	2	4	59	1	3	3				2
6	218	14	59	21		1	4			1	6	1		30	4	1	2		2	1	
11	149	12	69	21		1	4				2	2	4	35	4	2	2		1	1	1
16	145	15	68	25	1		5			1	3	1	2	35	4		1		3	1	
21	181	15	56	26		2	4			1	1	3	3	22	3	1			2		
26	169	16	52	10		1	1	1	1		9	1	3	24	3	1	6		1		
31	160	26	76	17		8	7		1		12	1	1	29	5	1	1		2	1	
36	160	23	64	17	1	7	6		1		8	1	2	22	7		1		2		
41	161	24	64	12	1	2	6				3	1	3	30	2	2	1		2		
46	172	4	75	8		10	1	1	1		1	1	2	14	1	1	1		1	1	
51	150	15	90	12	1	3	10				4	1	2	10	4	2	1			1	
56	185	12	58	14	2	5	7				1	1	1	22	4	2	2		2		
51	189	11	45	9	6	4	3			1	5		1	14	4	3	4		1		1
66	152	19	92	9		7	6			2		1	1	12	3	1	4		5		
71	148	22	65	8	1	5	7			3		1	3	20	3	3	1				
76	160	17	62	4	1	5	5	1		3	3	1	3	13	1	2	1		1	1	1
81	165	17	47	6	2	9	5	1	1	2	2	1	4	12	2	4	1	1	1	3	
86	168	18	39	8	2	7	3		1	3	3		2	19	5	7	4		1	1	
91	174	26	48	11	4	7	5			2	3	1	3	23	4	2	3			3	
96	125	16	42	8		6	11		1	2	2		3	34		9	3		2	2	
101	97	4	48	4	2	3	2	1		1	2			3	1	2	2		1	1	
106	140	11	41	5	5	3	9	1		1	2			58	2	3	1	1	5		1
111	237	19	41	9	5	5	5	1	2	3	1	5		58	2	3	2		3	1	2
116	153	5	46	7	5	4	3	2	3		2	6	1	50	2	7	1	1	1	2	1

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Depth (cm)	<i>Ilex</i>	<i>Tilia</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	Fabaceae	Cyperaceae	Euphorbiaceae	<i>Sagittaria</i>	<i>Typha</i>	<i>Polygonum</i>
1	1		7	2	9	6		2			1	
6			4	2	18	4						1
11			5	3	22	4					2	
16			8	2	25	2		1				
21				2	16							
26			10	1	34	3		1			1	
31			4	4	42			2				2
36			8	2	33	2		2			1	
41		1	7	4	28	1		3				
46			1	4	25			1				
51			3	7	31	1						
56			8	2	33	3		3				1
51			5	4	49	3						1
66			6	3	66	2		1		3		
71			9		52	3		5				
76			6	1	32	1		2				1
81	1		13	5	41	5		2		7	2	
86			8	11	47	2		3			1	
91			9	4	51	1				1	1	
96			10	4	42	3		1		6		
101	1		1	2	22		2					
106	1	1	7	1	43	2		1			1	
111		1	14	2	25	3	5	2	1		3	
116			12	2	37			3				

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Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Salix</i>	<i>Myrica</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	<i>Liriodendron</i>	<i>Celtis</i>	<i>Fraxinus</i>
1	199	17	84	14	4		2			2	2	3		3	2	1		1		
11	202	18	57	12	5	2	2					1		3			1		1	
21	220	20	85	9	4	3	2					2		3			1			
31	207	15	78	4	5	2	3				1	2		2						1
41	245	19	59	1	9	4						2		2	1					
51	168	15	83	4	2	3	1	1			2	3		4	2					1
56	210	28	52	4	10	4	1				1	2		1						1
61	159	11	161	5	3	2	7	1	1					1	1	1	1			1
71	208	14	53	2	7	7			1		1	1		1	1	3	1			
76	149	7	93		3		2	1		2				3	1					
81	198	11	76	1	10		1					3								
91	142	10	149	8	4	3	1	1			1			2	2					2
101	242	10	59	2	9	3								1						
106	287	18	92	3	7	1	1	1			1		1	1			3			
111	162	12	109	1	7	2	1		2		2			1	4					

Depth (cm)	<i>Castanea</i>	<i>Taxodiaceae/Taxacea</i> <i>e/Cupressaceae</i>	<i>Ilex</i>	<i>Tilia</i>	<i>Cephalanthus</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	<i>Artemisia</i>	Fabaceae	<i>Cornus</i>	Cyperaceae	Euphorbiaceae	Ericaceae	<i>Typha</i>	<i>Plantago</i>	<i>Polygonum</i>
1			2		1	4		4		1	1		2			3	1	
11			1			4	4	6					2					
21			2			1	3	3					1					
31		1					2	2			1					1	1	
41			2			3		2	1				1					
51						1	3	12	1		1		1	1		1		
56				1		1		7	1		1	1	1	1		1		
61	4		3	1		2	2	42			1		1		1			
71						2		4	1									1
76	3					2	2	21	1						1			
81			1			3	1	1										
91	3		2			3		6					1					
101			1			1	1											
106		2	1			1		1					2					
111		4	1					9					1	1				

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Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Alnus</i>	<i>Acer</i>	<i>Fraxinus</i>	<i>TCT</i>	<i>Tilia</i>	<i>Poaceae</i>	<i>Chenopods</i>	<i>Ambrosia</i>	<i>Asteraceae indet.</i>	<i>Cyperaceae</i>	<i>Typha</i>	<i>Polygonum</i>
101	197	16	61	8	5	3	6			4	1	14	1		1			5	1	24	7		3	
111	200	23	72	4	2	3	6		1	4		7	1					3	1	37	13	3	1	
121	261	18	36	3	9	4	2		1	2		3						5		7	1	1	1	
131	247	18	50	5	12	3	2				1					1					2	2	1	
141	224	14	68	4	6	3	4		1			3		1					1	10	4	1		
151	203	6	75	4	3	2	4			1		2						1		15	1	2	1	
161	225	22	36	7	6	7				3		5						1		1	1			
171	206	19	92	4	6	4	3			1		8	1	1				2		8	4	2		1
181	211	15	91	2	7	4	4		1	1	2	7		3						9	6	1	2	
191	206	21	75	1	5	6	1		2			4					1	2		2	1	3		
201	203	20	100	5	4		1	1	1	1	1	3	1					1		10	2	2		

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Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	Taxodiaceae/Taxaceae/ Cupressaceae	<i>Ilex</i>	<i>Tilia</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	Cyperaceae	<i>Typha</i>	<i>Polygonum</i>
11	210	21	81	6	5	8	4		1	2	1	8	3		1				3	1	21	1	3		
33	225	24	87	4	10	5	3			1	1	2			1		1	1	4		3	1	2	1	
77	205	25	114	8		10	2	1	2	1	3	1		1	1		1	1	1		3	1			
125	200	21	146	7	5	5	4					2		1	1	2			1	1			2	1	
171	200	18	120	9	4	7			2			1	2	1	1	1			4	1		1	1	1	
209	160	21	154	4	3	6	4		1			6	1		1				1	4			1		
249	159	29	154	9	6	5	1			1		2		1		1		1	1	2		2		2	
273	170	36	145	5	6	4	1		1	3	3	4						1	1	1	1	1		1	1
323	150	29	191	6	8	4	2			1	1	1	1		1			3	3	1	1	1	2		
337	133	31	246	7	8	5	1				2	5	1		4	1			3	4	2	1			
357	113	38	188	17	7	5	2	1			1	8					1		4	4	1				

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Depth (cm)	Pinus	Carya	Quercus	Liquidambar	Tsuga	Picea	Betula	Ulmus	Juglans	Ostrya/Carpinus	Fagus	Myrica	Alnus	Acer	Fraxinus	Taxodiaceae/Taxaceae/Cupressaceae	Ilex	Tilia	Poaceae	Chenopodiaceae	Ambrosia	Asteraceae Indet.
1	138	9	138	10			5	1	3	1									2	3	20	6
11	122	7	136	6		4	2	3	1	1	1				1					5	36	3
21	153	11	121	7		5	3	1	1	1		1	1		1	1			3	4	38	9
31	210	18	98	3	2	8	1	1	1			1					1	1	1		8	2
41	175	18	132		2	3	1		1			1			1	1			1		45	7
51	170	13	130	3	4	1			2	1	2		2	1				1	1		21	3
61	236	19	90	2	14	3		1	3									1		1		
71	245	21	43		6	9			1													
81	144	23	171		4	5	3		1	2	2		1		1	1	1			1	1	2
91	143	20	150	4	9	5	1		1		2		1							1	2	2
101	128	26	164	4	2		2	1	1	1			1								1	1
111	201	35	62	1	10	6	1	1			1			1								
121	178	35	86	4	7	2				1	1									2		1
131	144	29	167	2	4	4			1	1	3		3						1	3		2
141	216	32	88	2	11	4					1				1							
151	200	42	74	3	6	5		1			2											1
161	151	22	131	1	1	6				3				1			3			1		1
171	110	12	194	3	5	4	3	2		5	2		4			1			1	1	5	3
181	149	40	125	4	8	4			2	1								1	1	2	1	1
201	173	38	92	3	8	4			2		1						2	1	1	1		2

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Depth (cm)	Pinus	Carya	Quercus	Liquidambar	Tsuga	Picea	Betula	Corylus	Salix	Nyssa	Ulmus	Juglans	Ostrya/Carpinus	Fagus	Myrica	Alnus	Acer	Fraxinus	Castanea	Taxodiaceae/Cupressaceae/Taxaceae	Ilex
11	177	15	82	18		5	6			2	1	2		4			2			1	
16	200	17	86	15	4	8	2	1		2	2	2	1	3	1	1	2			1	
21	210	21	51	13	1	5	2				1		2	5			1			1	
26	199	22	96	11	4	5	10		1	1	6	1	6	6		2	2				
41	198	15	104	15	1	5	2			3	3	3		5	2		3				
51	164	16	99	10	3	6	2			4	4	2	2	3							
61	185	13	66	5	4	4	3	1			2	1	1	3	2	1			1		1
71	211	27	31	8	4	12	3				1	1	1	4	1				1		1
81	201	13	53	10	5	9	4		1	2		2		2	1			1			
91	150	18	77	2	4	10	3	1		1		2	1	1		5	2				
101	156	14	68	3	3	10	3			1	1		1	6							
111	208	17	83	4	5	15	2			2	2	1		2	1						
121	150	17	88	3	1	11	4					1	3	7	1	1			1		
131	175	10	84	2	3	3	5				1	1	2	1		2	1			1	
141	200	13	71	6	12	7	2			2		1		3			1				
151	244	10	38	3	6	12	3					1		3		1					1
161	180	16	69		10	2	1					2									
171	163	26	96	1	6	6	5				1	2		4		1	1			1	
181	200	14	57	4	11	14				1		1		4		1					
191	151	10	123	2	7	6	3				2	1		6		1	2	1			
201	216	11	59	3	9	11	1			1		1		2	1		1			1	
211	153	22	126	3	6	7	6				3	1		2		1					
221	152	23	134		5	7	2					1		2		3					
232	212	23	61	3	3	11	2					1		2		1					
242	200	23	73	2	3	14	2							1		1	1			1	
251	189	40	67	1	4	13	2					2		4							

Depth (cm)	<i>Tilia</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	Cyperaceae	<i>Typha</i>	<i>Polygonum</i>
11	1	4	4	9	1	1	1	
16		2	3	9		1	1	
21		2		10	1	1		
26		2	1	19	1		2	
41		3		10		2	2	1
51		4	5	11			1	
61		6	1	31		1	1	
71		1		10		1		
81		2	3	22	1	1		
91	1	6	3	59	5	2	1	
101		5	2	40	2	2		
111	2	5	1	24	3	3		
121		3	2	33	2			
131	1	4	2	38	3	1		
141		1	2	23				
151		2	2	6				
161		2	3	4			1	
171		2	1	6	1	1	3	
181		1		1				
191		4	2	2	3	2	2	
201			1	1	2			
211		3		3	1	1		
221			3	2		1		
232				1				
242		1	1	1	1		1	
251		1		1	1			

Depth (cm)	Pinus	Carya	Quercus	Liquidambar	Tsuga	Picea	Betula	Corylus	Salix	Nyssa	Ulmus	Juglans	Alnus	Acer	Liriodendron	Celtis	Fraxinus	Poaceae	Chenopodiaceae	Ambrosia	Asteraceae indet.	Fabaceae	Cornus	Nuphar
1.5	246	24	39	27	6	2	1	3	2	1	2	1						2	2	2		1		
5.5	347	29	30	31	6	4	1			5	1	1	1	2	3		5	2	2	2		1		
8.5	226	22	36	20	4	1		1		3	3	3				1	1	2	2	1	1	1	1	1
11.5	97	20	61	21	2	4	6	1	1	3	4	8	3	1		4	10	2	2	2	1	2	2	2
15.5	226	24	29	17	6	4	1	2			2	1		1			1	3	3	2		2	1	1

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Depth (cm)	Pinus	Carya	Quercus	Liquidambar	Tsuga	Picea	Betula	Corylus	Nyssa	Ulmus	Juglans	Ostrya/Carpinus	Fagus	Myrica	Alnus
0.5	216	9	35	18	3	1		1		3	10	1	1		
4.5	349	29	75	21	3	1									
8.5	200	23	56	10	7	2							4		
11.5	206	20	76	9	2	2				1	3		2		1
15.5	183	18	84	10	1	1	1			2	6		4	1	2
19.5	206	15	79	7		1			2	3	1		1		
23.5	212	12	90	7	6	2		3		1	3		12		

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Depth (cm)	Acer	Liriodendron	Fraxinus	Castanea	Poaceae	Chenopodiaceae	Ambrosia	Asteraceae indet.	Fabaceae	Cornus	Cyperaceae	Euphorbiaceae	Utricularia	Typha	Liguliflorae
0.5	1				4	1		1							
4.5			1		1	2	4	1			2	1	1		
8.5			1		1	8	4	1	1						
11.5	2	1			4	1	11	2		1				1	1
15.5		1	3	1	3	2	15							2	
19.5	1		1		3	3	6		1	2	1	1			
23.5	1		1	1	8	5	13	1	1		3				

Depth (cm)	Pinus	Carya	Quercus	Liquidambar	Tsuga	Picea	Betula	Corylus	Salix	Nyssa	Ulmus	Juglans	Ostrya/Carpinus	Fagus	Myrica	Alnus	Acer	Liriodendron	Cellis
0.5	254	14	73	32	3	11	2	2		2	3	3	2		1				
4.5	212	19	110	42	1	11	1	1		7	5	6	1	5	1				
9.5	184	21	78	23	3	12	6	2		4	2	3	1	3	3				
14.5	184	16	55	8	6	11	5		1	3		4						1	
20.5	262	25	40	9	2	24				1				5	1	1	1		

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Depth (cm)	<i>Fraxinus</i>	<i>Castanea</i>	<i>Poaceae</i>	<i>Chenopods</i>	<i>Ambrosia</i>	<i>Asteraceae</i> indet.	<i>Fabaceae</i>	<i>Comus</i>	<i>Cyperaceae</i>	<i>Nuphar</i>	<i>Eupphorbs</i>	<i>Utricularia</i>	<i>Typha</i>	<i>Myriophyllum</i>	<i>Ilex</i>	<i>Taxodiaceae/Cupressaceae/Taxaceae</i>	<i>Plantago</i>	<i>Liguliflorae</i>
0.5			3	1	11	2												
4.5			12		12		1		1				1	1	1			
9.5	1	1	5		24								2	1	1	2		
14.5	1		6	1	16								2	2				
20.5			1		12	1											2	

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