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BENTHIC FORAMINIFERAL CENSUS DATA AND RADIOCARBON DATES FROM THE GULF OF MEXICO (MATAGORDA 1A CORE)

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Introduction

Development of oxygen-poor bottom water conditions (hypoxia) along the Louisiana and Texas coasts has become an important economic and environmental issue. The development of hypoxia is considered to be mostly related to increased nutrient loading due to agriculture practices in the Mississippi Basin (e.g. Malakoff, 1998; Rabalais and others, 1994, 1996). Analyses of benthic foraminifer assemblages in shallow marine cores near the Mississippi Delta suggest seasonal development of low-oxygen bottom water conditions has increased over the last 200 years with the most prominent increase occurring in the last 50 years (Sen Gupta and others, 1996). However we are not aware of attempts to identify variations in bottom waters oxygen conditions in prehistoric intervals from other regions of the Gulf of Mexico

This report contains data and initial interpretations from a pilot study testing the use of benthic foraminifers to identify changes in bottom water oxygen levels in pre-historic shallow marine sediments near Matagorda Island in the Gulf of Mexico (Fig. 1).

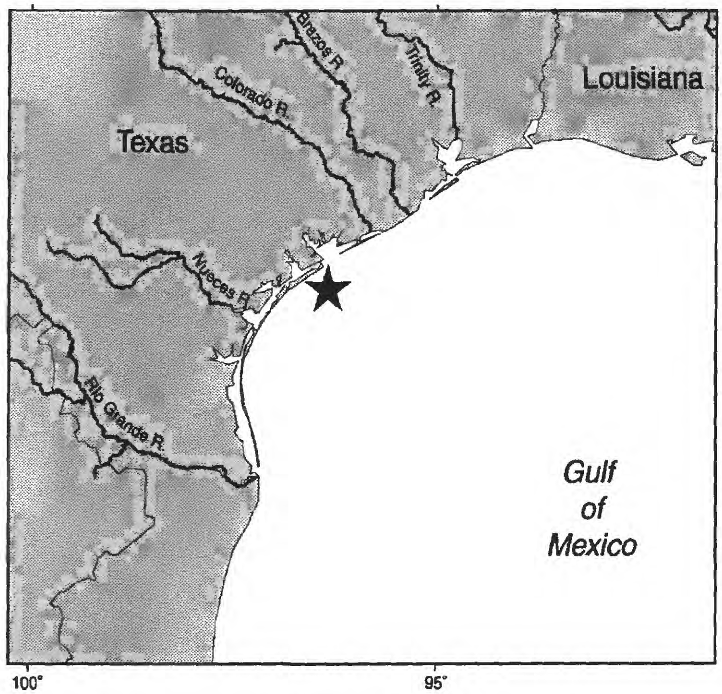

Figure 1: Location of Matagorda 1A Core

Methods and Materials

Matagorda 1A is one of eleven gravity cores collected by John Chance and Associates along a transect through Outer Continental Shelf Blocks (OCS) 622-669 off Matagorda Island, northeast of Corpus Christi, Texas. Water depth in this region of the shelf is between 84-100 meters, but the exact depth of the location was not measured. We obtained continuous 2 cm samples from Matagorda 1A for analysis of foraminifers and ^{14}C dating. The samples were soaked in a dilute calgon solution and agitated for 30 minutes to assist in disagregation, then wet sieved at 63μm. The washed residue was oven dried at $\leq 50°$ C, then dry sieved at 125 μm.

Faunal analysis

All samples contained abundant benthic foraminifera and a representative subsample of approximately 300 specimens was obtained for faunal analysis with a microsplitter. Benthic foraminifers were hand picked from the >125μm faunal split and then placed on standard 60 square micropaleontological slides to be sorted by species. Identification of the benthic foraminifer species was made using standard literature. The taxonomy of Loeblich and Tappan (1988, 1994) was followed. Additional taxonomic references included Poag (1981), Anderson (1961), and Phlegar and Parker (1951).

Hypoxia Index

Sen Gupta and others (1996) used a relative dominance index of *Ammonia parkensoniana* and *Elphidium excavatum* to identify a historic increase in anoxic episodes off the Mississippi River Delta. *Ammonia parkensoniana* and *E. excavatum* are common shallow water benthic foraminifers throughout the Gulf of Mexico. The A-E Index as defined by Sen Gupta and others (1996) is given as:

$$\left[N_A/(N_A+N_E)\right]*100$$

(where N_A and N_E are the numbers of *A. parkensoniana* and *E. excavatum* respectively in a sample). High values of the A-E Index presently occur in regions with high total organic Carbon (TOC).

Table 1 contains the benthic foraminifer census data for Matagorda 1A. Figure 2 illustrates the percentage data for the five most common benthic foraminifer species, and figure 3 shows the values obtained applying the A-E Index of Sen Gupta and others (1996) to the Matagorda 1A census data.

Depth (cm) in core	Other Agglutinated	Ammobaculites sp.	Milliamina horrida	Pseudoclavulina humilis	Saccammina difflugiformis	Siphotextularia rolshauseni	Textularia mayori	Troccamina sp.	Ammonia parkensoniana	Astacolus sp.	Bolivina sp.	Bolivina pulchella	Brizalina sp.	Bucella hanni	Bulimina marginata	Bulimina tenuis	Cancris auriculus	Cassidulina reniforme	Elphidium crispum	Elphidium discoidale	Elphidium translucens	Elphidium excavatum	Elphidium poeyanum	Epistomiella vitrea	Eponides antillarum	Fursenkoina pauciloculata	Guttulina pulchella	Hanzawai grossepunctata	Ioanella tumidulus	Miliolinella fichteliana	Nodosaria	Nonionella basiloba	Other Calcareous	Planulina floridana	Pseudononion atlanticus	Pyrgo nasutus	Quinqueloculina sp	Quinqueloculina bicarinata	Quinqueloculina lamarckiana	Rectobolivina advena	Reussella spinulosa	Rosalina floridana	Rosalina subaraucan	Trifarina sp.	Uvigerina sp	Total Calc. & Agglut.	Total Agglutinated
2	1	6		6	38	13	4		86			5	1	4	2		2	1	3	109	18		3		1	12		42						1	39	1		1		3	9	1	5	1	1	419	68
4	2	8		22	42		12	2	148			4		8	2	1	2		7	179	54		2	1	1	9		74							45			4	2	2	25	1	16			675	88
8		11		15	34	14	8	1	111				1	5	3	1	4		6	118	7	1	3	1	1	9		50					1		26			9		1	16	1	4		1	463	83
12	1	11		15	82	13	11		153	1	2	2		9		4	5		3	216	26	2	5	4	1	3		60			1		1	5	35			4	2		19	1	13			710	133
16		19		26	70	3	7		154			5		8			9		5	193	23	6	9	3	2	12		89				1		2	67			6	3	3	36		11			772	125
20		2		15	42	6	16	4	140		1	7		5	2		5		1	167	10	6	2	1		5	2	63		2	2			3	39	1		14	7	1	19	1	5			596	85
24		4		5	33	4	16		99		2	3		5	3		1		4	133	8	6		3	1	4		63		1				1	26		1	7		3	7		2			445	62
26		8		7	12	7	17		191		52	6	2	7	11		2			107	50	9	17	29		58		55		2	6		3	3	53			4	2	2	28		7	2		759	51
28		3		12	20	15	21	1	99		1	5		3	4	1	2		3	53	11	4	2	7		7	1	57	3	1	1			4	53			24		3	18		2		1	442	72
30		8	2	26	16		6	1	142		41	6	2	5	6			2	1	134	41	8	22	26		55	1	59		1	7			1	74	1		8	1	2	34	4	13			756	59
32		1	1	11	19	3	8	1	144		3	7	1	5	2		1		3	154	16	2	3		1	54		63		8	1				49		1	7		4	21	1	9			604	44
34		8		23	10		14		147		17	5		8	3		1		9	144	29	6	9	14	2	22	3	76			3		1	2	29			8		2	29		13			637	55
36		3		16	4	6	11		100			5		1	1	1			6	79	23	1	1			8		45	2		1				13			10		5	10		3			355	40
38		4		14	7	6	11		165		64	2		1	15				1	124	36	2	12	65		42	1	48	2	1				2	39			12	2	3	9		3			693	42
40		2		4	11	4	19	1	101			1	1	2		1			6	71	25	1	2	1		12		44							22			7	2	2	9		1			352	41
42		3		1	12	9	6		117		37			3	9				1	83	26	4	8	12		20		32			2				19		1	3	2	1	9		5			425	31
44		5		7	19	7	13	1	76		2	2	2		4		1		5	99	19	2		1		9		29					2		14	2		4		1	12	1	1			340	52
46		7		6	9		11		144		28	1	1		4			1	2	97	34	4	10	11		17		37			2				18	3		9	2	2	8		2			470	33
48		2	1	13	5	1	9	4	131		2		2	3	3				5	117	12	4	1	4	1	10	1	57			1			3	13	1		6		4	10		2			428	35
50		8		9	3	3	11	2	190		37	6	2	7	12		1		6	157	47	6	19	14		32		64				2	2	1	40	1		14	4	8	18	3	5			734	36
52		3	1	19	14	7	23		117					7	4		2		6	181	24	8	6	1	3	6	1	77							32			14	3	2	15		6			582	67
54		3	3	12	6	19	12	1	140		1	4		4	2				3	151	43	7	7	4		7		62		2	3				41			8	1	2	29	1	3			581	56
56	1	1	3	18	5	19	18	2	101				1	1	11				4	94	21	8	6		1	4		45							38			11	3	1	15	2	4	1	1	440	67
58		3		18	1	6	9	4	151		13	1	1	9	5		1		9	200	32	7	13	13		13	2	44							51	1		3	1		30	2	4			647	41
61		3		5		6	9		91		13	2		3	5				3	126	20	5	14	11		10		36			1		1		23	2		8	4		21		11			433	23
62				6	2	3	4		78					3	3				11	136	29	4	5	1		6		55		2					30			6	1	1	13		6			405	15
66		1	2	4		2	6		101		1	2		5					17	131	25	11	5	1	1	5		49						1	36			2	1	1	14	1	12			437	15
70				12		5	6		146			7		5	2				11	156	70	19	5			5		61						3	66	2		3	2		45	2	19	1		653	23
74		2	5	10		8	8	1	110			1		10			1	1	16	154	47	11	4		1	9	1	65		1				1	45			3	4		32		12			563	34
78			1	15		6	3		102		2	3		4	1		2		11	134	52	6	7		1	7		63		2	2		1	2	35	1		5	4	3	26	3	10			514	25
82			2	6		5	5		83			9		8		1	9		24	166	32	23	29			8	2	70		1			1	3	82			10		1	41	2	15			638	18
86				10		12	14		113		3	5	2	7	2	2	2		8	155	53	11	14	1		15	1	81		3			1	3	60	3	1	4		8	36	1	9	1		641	36
88			1	23		12	8	2	117	1		4		5	2	1	1		12	200	42	8	19		2	8	2	74						2	39	3		6			32	1	10			637	46
90				10	2	8	9		134			5	1	5	3	1	1		6	140	64	13	18	1		16		37		2	2		1	1	43			1	1	3	41		13			582	29
94			1	18		2	10		95			7	1	2	3		4		7	117	51	8	17			1	1	49		3	1			2	30			17		1	28		6			482	31
98			1	19		4	13		89		1	6	2	6		1	3		12	135	38	4	19		1	2	1	78			1			2	45			5	6	1	25	1	10			531	37
102			3	14		5	12		106		2	5		2					11	140	16	6	10		1	16	3	46		2	1			5	35			9		3	37	1	3		1	495	34
106		1	4	23	3	3	12		83	1		2		1			3		8	109	8	10	1	2		1		44						1	34			7		3	15	1	8			388	46

Table 1: Benthic Foraminifers, Matagorda 1A

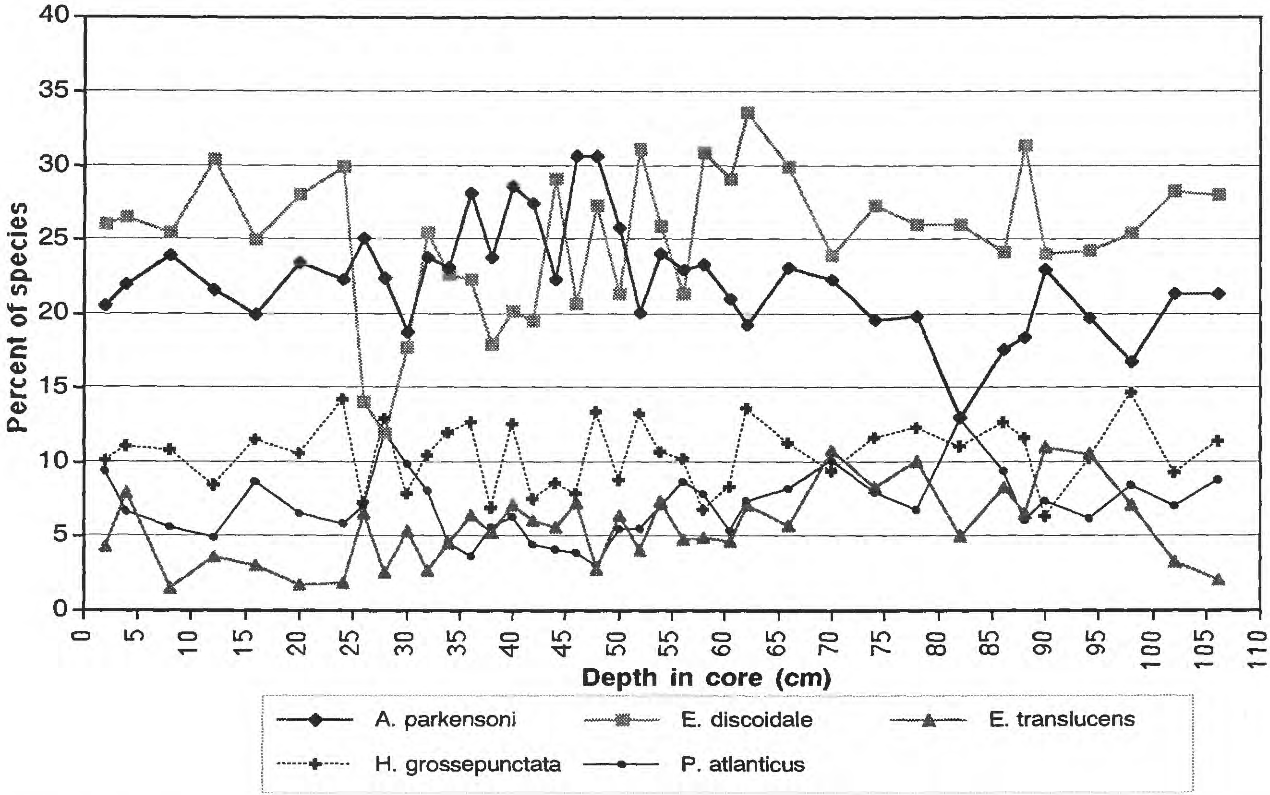

Figure 2. Percent of the five most abundant benthic foraminifer species in Matagorda 1A

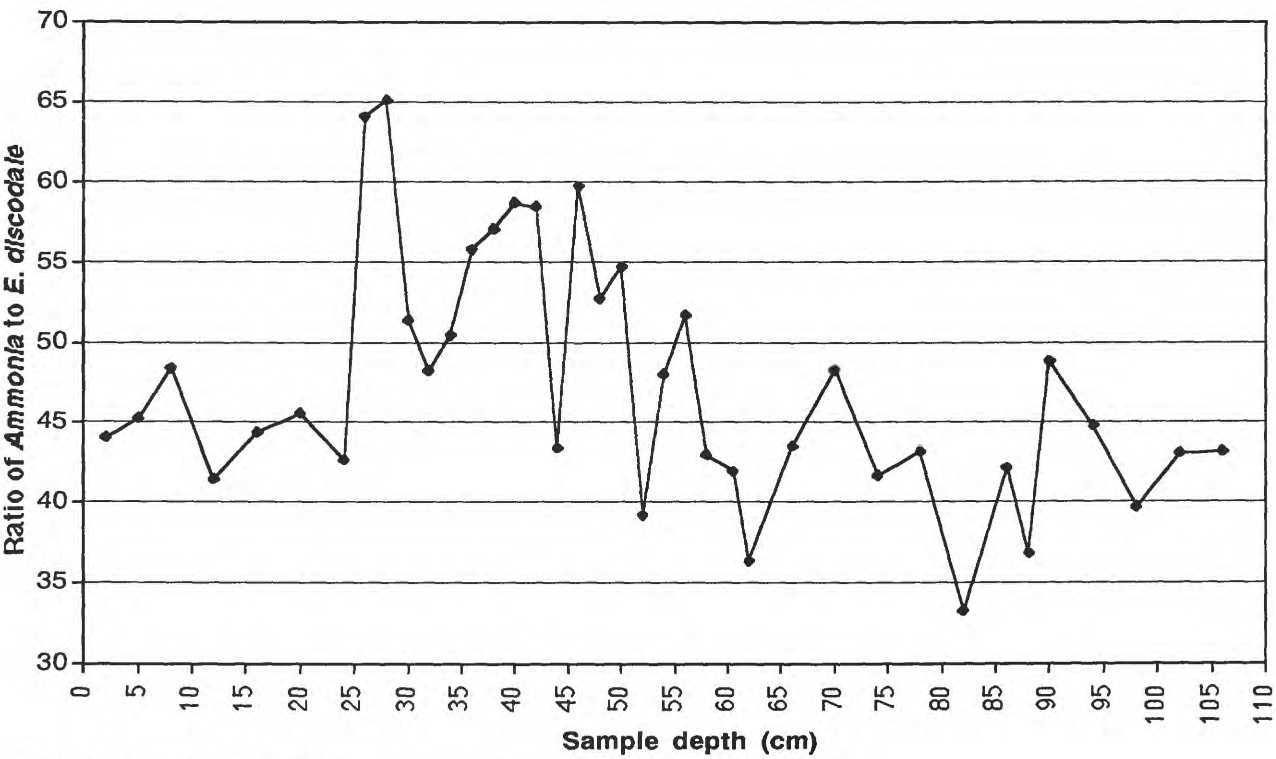

Figure 3. Hypoxia Index for Matagorda 1A

Chronology

We obtained five radiocarbon dates on mollusk fragments and mixed species of benthic foraminifers. Graphite targets were prepared at the U. S. Geological Survey and ^{14}C ages were determined at the Center for Accelerator Mass Spectrometry (CAMS) at Lawrence Livermore National Laboratory in Livermore CA. The radiocarbon dates (Table 2) are in stratigraphic order down to 90cm. The dates from samples below 90cm are out of sequence and suggest problems with reworking and unconformities in the lower part of the core. Therefore benthic foraminifers were only analyzed in the upper 106cm of the core.

Figure 4 shows our initial age model for the core. The negative values for the upper sample indicates the presence of "bomb" carbon and indicates a modern age. We are uncertain about the appropriate marine reservoir correction to apply in these shallow water deposits so we have reported the dates and constructed the age model in uncorrected radiocarbon years. The age model is sufficient to establish that the upper part of the core contains a record of the last few thousand years. The sediment accumulation rate is about 30 cm/1000 14C year.

Matagorda 1A		
Depth (cm)	Type	14 C Age
8-10	Molluscs	Modern
38-40	Molluscs	1710 +/- 60
38-40	Molluscs and mixed benthic foraminifers	1670 +/- 90
88-90	Mixed benthic foraminifers	3320 +/- 40
132-134	Molluscs	3110 +/- 50
132-134	Mixed benthic foraminifers	3310 +/- 90

Table 2: Radiocarbon dates for Matagorda 1A

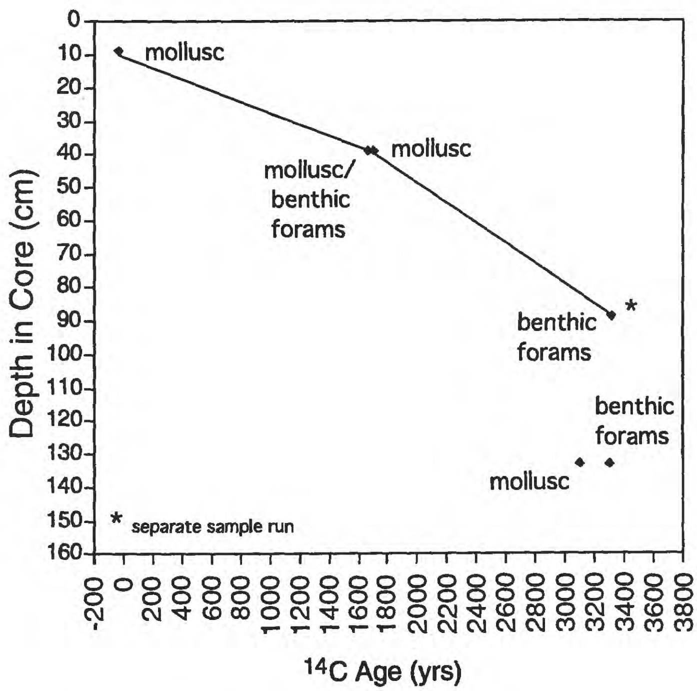

Figure 4: ^{14}C Age Model for Matagorda 1A

Results and Interpretation

The benthic foraminifer assemblages of Matagorda 1A are relatively diverse (Table 1). Most samples have more that 25 species. However, *Elphidium excavatum* and *Ammonia parkensoniana* and are consistently the first and second most abundant taxa and usually make up between 34 to 57% of the total assemblage (Fig. 2). In several samples between 26 and 56 cm the number of *Ammonia* is greater than the number of *Elphidium excavatum*. This results in high A-E Index values for this portion of the core (Fig. 3)

Inspection of the variation of the Hypoxia index (Fig. 3) suggests that the Matagorda 1A sequence can be divided into three intervals. The index in the upper part of the core shows little variation from a value of 45. However, between 26 cm and 56 cm core depth the index is higher and more variable. A maximum value of 65 is reached at 28 cm (Fig. 3). Below 56 cm variability continues to be high but the index values are lower with a minimum value of 33 at 82 cm.

This pilot study tests the usefulness of the A-E Index for identifying any evidence of changes in bottom water oxygen content in late Holocene continental shelf deposits of the Gulf of Mexico. The range of variation in the A-E Index in the Matagorda 1A core and the change in dominant species support an interpretation that the oxygen content of bottom waters has changed during the late Holocene. The radiocarbon dates and age model (Fig. 4) indicate that an interval of low-oxygen bottom water conditions occurred between ~1,000 to 2,000 ^{14}C years ago. However, the exact timing of the low-oxygen event and the details of the changes are still uncertain because of our low sampling density, limited radiocarbon dates, and potential mixing problems in the core.

The A-E Index values in Matagorda 1A are lower than the maximum values reported for the shallow cores in the historic anoxia zone reported by Sen Gupta and others (1996), but are similar to values reported by them for a core in deeper water (50m) at the southern fringe of the historic anoxia zone (Sen Gupta and others, 1996). Our data suggests that the A-E Index is a useful technique in detecting changes in the oxygen content of bottom waters along the Texas and Louisiana shelf. Although details are unclear, our initial results indicate changes in oxygen content of bottom waters during the Holocene and prior to Euro-American agricultural influences in the region.

Acknowledgments

Thanks to Melinda Tucker for providing the Matagorda 1A samples.

Figures and Tables

Figure 1. Location of Matagorda 1A.

Figure 2. Percent occurrences of the five most common benthic foraminifer species.

Figure 3. *Ammonia- Elphidium* Index value for Matagorda 1A.

Figure 4. Age model for Matagorda 1A.

Table 1. Benthic foraminifer census data- Matagorda 1A.

Table 2. Radiocarbon dates for Matagorda. 1A.

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Appendix I

Taxonomic List of GULF OF MEXICO FORAMINIFERS

AGGLUTINATED

Other Agglutinated= other unidentified species

Ammobaculites sp.= an unidentified species

Milliamina horrida (Cushman)= *Quinqueloculina horrida* Cushman

Pseudoclavulina humilis (Brady)= *Clavulina parisiensis* var. *humilis* Brady, 1884

Saccammina difflugiformis (Brady) = *Reophax difflugiformis* Brady, 1884

Siphotextularia rolshauseni Phleger and Parker, 1951

Textularia mayori Cushman

Troccamina sp.= an unidentified species

CALCAREOUS

Ammonia parkinsoniana (d'Orbigny) = *Rosalina parkensoniana* d'Orbigny

Astacolus sp.= an unidentified specie

Bolivina sp. = an unidentified species

Bolivina pulchella var. *primitiva* Cushman

Brizalina sp. = an unidentified species

Buccella hanni (Phleger and Parker) = *Eponides hanni* Phleger and Parker

Bulimina marginata d'Orbigny

Bulimina tenuis Phleger and Parker, 1951

Cancris auriculus (Fichtel and Moll) = *Nautilus auricula* var. β Fichtel and Moll

Cassidulina reniforme (Nørvang) = *Cassidulina crassa* d' Orbigny var. *reinforme* Nørvang, 1945

Elphidium crispum (Linné)= *Nautilus crispis* Linné

Elphidium discoidale (d'Orbigny) = *Polystomella discoidalis* d'Orbigny

Elphidium discoidale (d'Orbigny) formae *translucens* = *Elphidium translucens* Natland, NOTE: Similar to *E. discoidale* but slightly less inflated umbo.

Elphidium excavatum (Terquem) = *Polystomella excavata* Terquem, 1876

Elphidium poeyanum (d'Orbigny) = *Polystomella poeyana* d'Orbigny, NOTE: Characteristic semicircular openings along sutures.

Epistomilella vitrea Parker, in Parker, Phleger, and Peirson, 1953

Eponides antillarum d'Orbigny

Fursenkoina pauciloculata (Brady) = *Virgulina pauciloculata* Brady

Guttalina pulchella d'Orbigny

Hanzawai grossepunctata (Earland) = *Cibicides grossepuntatus* Earland, 1934, p. 184, pl. 8. Fig. 39-41. NOTE: ID based on Loeblich and Tappan, (1994) p.164, pl. 364, figs. 9-13 and pl. 365 fig. 1-13. This is *Hanzawaia concentrica* (Cushman) in Poag (1981) and *Cibicides concentricus* (Cushman) in Phleger and Parker (1951); This may not be correct as Cushman is 1918, which means that *H. concentrica* would be correct.

Ioanella tumidulus (Brady) = *Truncatulina tumidula* Brady, 1884

Milliolinella fichtelina (d'Orbigny) = *Triloculina fichteliana* d'Orbigny

Nodosaria = assorted Nodosariads

Nonionella basiloba Cushman and McCulloch, 1940, NOTE: Rare specimen with chamber overlapping the umbilicus.

Other Calcareous = unidentified calcareous

Planulina floridana (Cushman) = *Truncatulina floridana* Cushman

Pseudononion atlanticus (Cushman) = *Nonionella atlantica* Cushman

Pyrgo nasuta Cushman

Quingueloculina sp.= unidentified species

Quinqueloculina bicarinata d'Orbigny, 1826

Quinqueloculina lamarckiana d'Orbigny 1939

Rectobolivina advena (Cushman) = *Siphogenerina advena* Cushman

Reussella spinulosa (Reuss) = *Verneuilina spinulosa* Reuss

Rosalina floridana (Cushman)= *Discabis floridana* Cushman 1922

Rosalina subaraucan (Cushman) = *Discorbis subaraucan* Cushman

Trifarina sp. = unidentified species

Uvigerina sp. = unidentified species