Holocene and late Pleistocene sedimentary facies of a sand-rich continental shelf: A standard section for the northeastern Gulf of Mexico

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Holocene and Late Pleistocene Sedimentary Facies of a Sand-Rich Continental Shelf: A Standard Section for the Northeastern Gulf of Mexico

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Abstract

A standard section is proposed for late-Pleistocene and Holocene deposits of the northeastern Gulf of Mexico shelf based on vibracores, grain-size analysis, and mollusk and foraminifera identifications. The standard section is characterized by four facies and two erosional unconformities. These preserved facies and regional surfaces reflect the stratigraphic signature of the last major fall and rise of eustatic sea level. At the base, *Facies 1* is a yellowish-burnt-orange and grey, massive to highly bioturbated, oxidized clayey quartz sand (Pleistocene soil horizon) that is capped by a distinct erosional unconformity (bay ravinement). The unconformity is overlain by *Facies 2*, a tan clayey, sandy silt to silty fine quartz sand with subtle bioturbation and characterized by an estuarine foraminiferal assemblage. Incorporated at the base of *Facies 2* are well-developed, yellowish-burnt-orange and grey rip-up clasts. *Facies 2* is truncated by a second distinct erosional unconformity (shoreface ravinement).

Facies 3 is a well-developed shell bed containing a primarily shallow-marine molluscan assemblage. The shell bed is 0.88 m thick with a fine quartz sand matrix. In addition, the shell bed is graded with large bioclasts crudely stratified at the base, and fines upward into horizontally- laminated to massive, shelly, fine sand. As shell content decreases upward, *Facies 3* grades into *Facies 4*, which is a tan, massive to horizontally-laminated, fine quartz sand (MAFLA sand sheet) containing open-marine foraminifera and scattered shell fragments. *Facies 4* fines upward and is 2.7 m thick.

Introduction

Over the past eleven years, numerous investigations have focused on the geologic framework and sedimentary processes associated with modern and ancient continental shelves (Tillman et al., 1985; Knight and McLean, 1986; Moslow and Rhodes, 1986; Nummedal et al., 1987; Swift et al., 1991; Fletcher and Wehmiller, 1992; Walker and Plint, 1992; Dalrymple et al., 1994; Tortora, 1996). Although the Holocene geology of the northwestern and north-central Gulf of Mexico shelf is well known (e.g., Berryhill et al., 1986; Suter et al., 1987; Coleman and Roberts, 1988a, 1988b; Penland et al., 1989; Anderson et al., 1992; Siringan and Anderson, 1994; Brooks et al., 1995), the counterpart in the northeastern Gulf (east of the State of Mississippi) is relatively unexplored. Based on 106 vibracores collected in the northeast Gulf of Mexico, we propose a standard section for the transgressed shelf that describes the Mississippi-Alabama-Florida (MAFLA) sand sheet and the underlying Holocene and Late Pleistocene geology. The purpose of this paper is to delineate the primary sedimentary facies and surfaces associated with the last rise of eustatic sea level.

Study Area

The southwestern Alabama/western Florida Panhandle shelf is located in the northeastern Gulf of Mexico between the Mississippi and Apalachicola River Deltas. The continental shelf between these two fluvial systems narrows to about 25 km and widens from this point in both directions to about 110 km. The 25-km wide section of shelf corresponds to the most northerly extent of the DeSoto Canyon (Fig. 1). The entire shelf surface in this area is covered by an extensive sand layer known as the MAFLA sand sheet (Doyle and Sparks, 1980; McBride and Byrnes, 1995). The shelf and upper slope offshore Alabama and the western Florida Panhandle can be divided into three shore-parallel geomorphic zones (McBride and Byrnes, 1995). Zone 1 ranges from 0 to 20 m water depth and is dominated by shore-oblique shelf and shoreface sand ridges (Fig. 1). Zone 2 encompasses most of the middle to outer continental shelf region between 20 and 50 m water depth. The seafloor in this area is dominated by two long, linear shoals (North and South Perdido shoals) that are >5 m in relief and oriented parallel to the shelf break. Zone 3 extends from 50 to 150 m water depth and is dominated by 10 to 25 km wide, shelf edge lobes. A standard-section core (ALA-91-16), located on the western end of South Perdido Shoal in 35 m water depth (Fig. 1), is used to describe characteristic facies found in all 106 cores.

Methods

Vibracores were collected between 1990 and 1993 aboard the R/V *Kit Jones*, a 20-meter-long research vessel operated by the Marine Minerals Technology Center. Six-meter-long aluminum irrigation tubing (7.5-cm diameter) was used to collect cores, with a pneumatic vibrator attached to a submersible seven-meter-high steel tripod. The tripod was lowered to the seafloor, and core tubes were vibrated the full six meters or until refusal. Once retrieved, the vibracores were transported to the laboratory, logged, photographed, sampled, and archived.

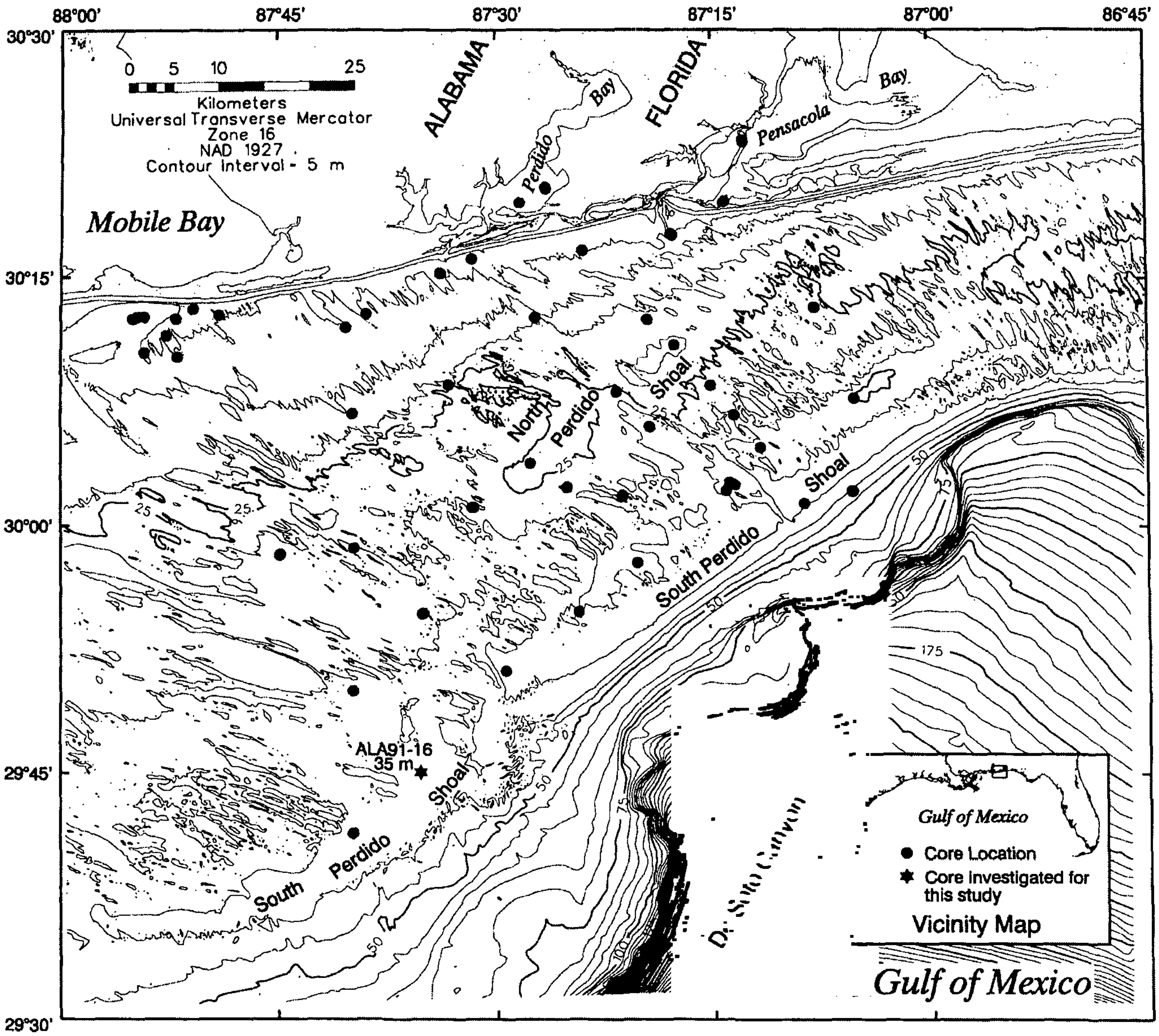

Figure 1. Study area in the northeastern Gulf of Mexico showing bathymetry at 5-m contour intervals (from McBride and Byrnes, 1995). The standard-section core (ALA-91-16) is located on the western end of South Perdido Shoal in 35 m water depth.

Grain Size Analysis

Sediment samples for ALA-91-16 were collected at 25 cm intervals between 0 and 300 cm and at approximately 5 cm intervals between 318 and 358 cm. The percent of sand, silt, and clay were calculated for sediments between 358 and 400 cm (@ 374 and 393 cm). In accordance with Folk (1980), grain-size analysis was performed using a Gilson sonic sifter, and size statistics (moment measures) were computed using a PC-based computer program.

Mollusk Analysis

The shell bed in ALA-91-16 was divided into consecutive 5 cm samples and sieved using a 1.4 mm (-0.5 phi) screen with the >1.4 mm fraction reserved for examination. Whole shells and valves, as well as fragments containing the hinge in bivalves or the spire in gastropods, were identified to species and counted. For each species, the following information was recorded: 1) number of bioclasts (shells, valves, tests, colonies), 2) taphonomic grade, 3) measurement of the largest bioclast, and 4) pertinent environmental information reported in the literature (see Anderson and McBride, 1996). Species relative abundance, preservation, and environmental preferences were used in paleoenvironmental interpretations.

Foraminifera Analysis

The paleoecology of benthic foraminifera was investigated based on the quantitative analysis of 12 samples (~2 cm thick). The samples were selected based on lithology and stratigraphic variability. Samples were washed through a 63-micron sieve and floated in bromoform to recover relatively clean foraminiferal residues. All specimens of benthic foraminifera (>63 microns) were identified in suitable aliquots of the samples. Species percentages were computed and stratigraphic variations of dominant species determined.

Shelf-Sedimentary Facies

Detailed core data about the Holocene geology of the northeastern Gulf of Mexico shelf has been lacking. Based on recently collected data, a standard section is proposed for the transgressed shelf. A standard section is a reference section that shows, as completely as possible, a sequence of all the strata in a certain area, in their correct order, thus affording a standard for correlation (Bates and Jackson, 1987). Vibracore ALA-91-16 serves as a standard section and consists of four sedimentary facies (Figs. 2 and 3). A sedimentary facies is defined as any areally restricted part of a designated stratigraphic unit that exhibits characteristics significantly different from those of other parts of the unit (Moore, 1949). Selley (1970) further explains the term facies as having five defining parameters: geometry, lithology, paleontology, sedimentary structures, and paleocurrent pattern. Selley (1988) recommends that a genetic connotation be avoided when delineating sedimentary facies; terms such as deltaic or barrier facies should not be used. In this paper, facies is used as a descriptive term to characterize sedimentary deposits. Below is a detailed description of the four sedimentary facies from bottom to top.

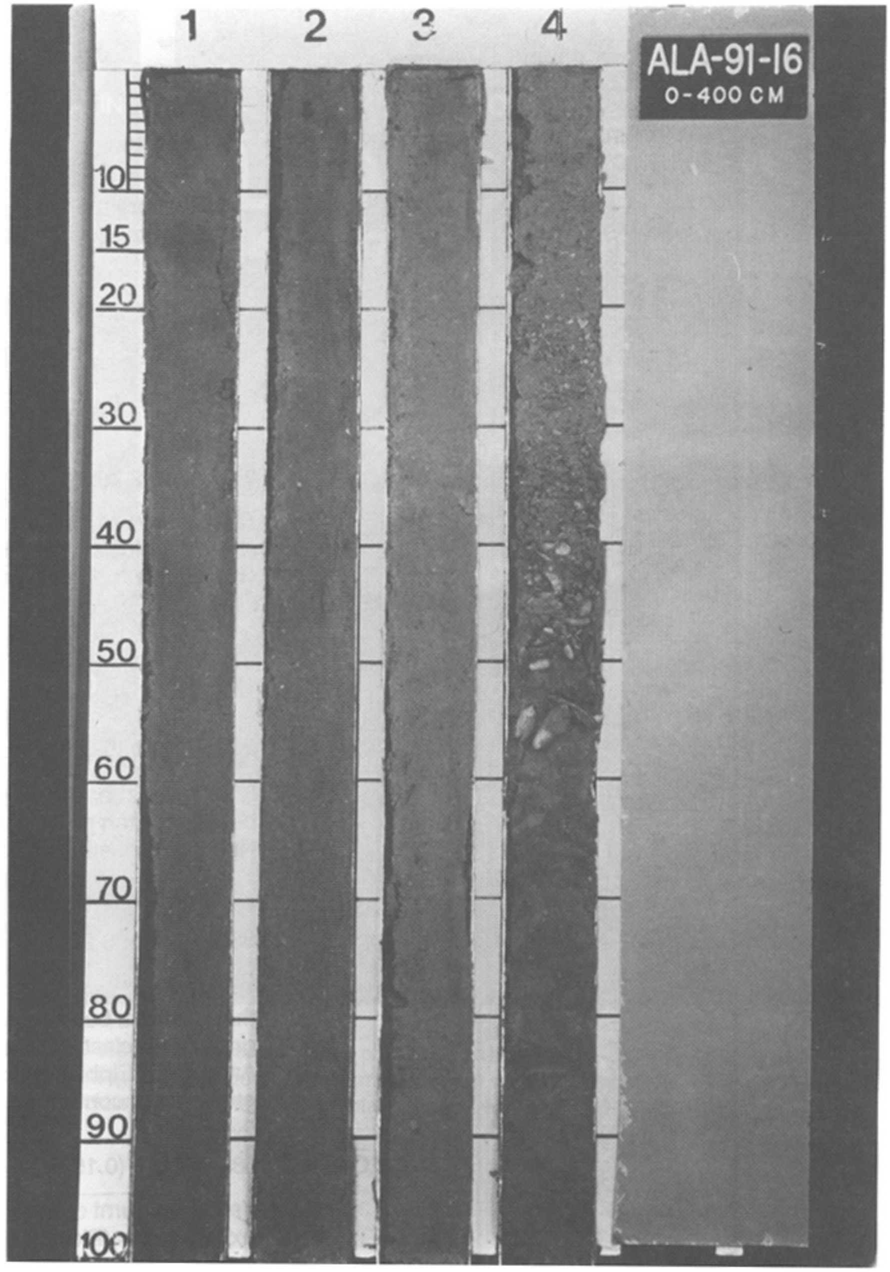

Figure 2. Photograph of standard-section core (ALA-91-16) showing four primary sedimentary facies. Core top is upper left and core bottom is bottom right. Scale in centimeters.

Facies 1

Facies 1 extends from 400 to 385 cm and is characterized by a yellowish-burnt-orange and grey, massive to highly bioturbated, dense, mottled clayey quartz sand (Figs. 2, 3, and 4). Oxidized sediments dominate indicating continuous or fluctuating subaerial exposure. Macrolocomotion bioturbation and possible root traces are present. Thickness of *Facies 1* is 0.15 m, and macro- and microfossils are absent. The unit is truncated by an erosional unconformity, and a distinct decrease in bulk density exists with overlying facies.

Facies 2

Facies 2 occurs from 385 to 358 cm and overlies the lower erosional unconformity (Figs. 2, 3, and 4). *Facies 2* is a tan, clayey silt to silty fine quartz sand with subtle bioturbation throughout. Incorporated within the lower portion of *Facies 2* are well-developed, yellowish-burnt-orange and grey rip-up clasts (3 x 6 cm; Fig. 4). The dominant benthic foraminifera identified in this unit are *Ammonia parkinsoniana* and the genus *Elphidium* (i.e., *Elphidium poeyanum*, *Elphidium* spp.). A few small shell fragments are scattered throughout the unit. The thickness of this facies is 0.27 m. *Facies 2* is truncated by another distinct erosional unconformity (Fig. 5).

Facies 3

Facies 3 extends from 358 to 270 cm and is a well-developed shell bed containing a primarily shallow-marine

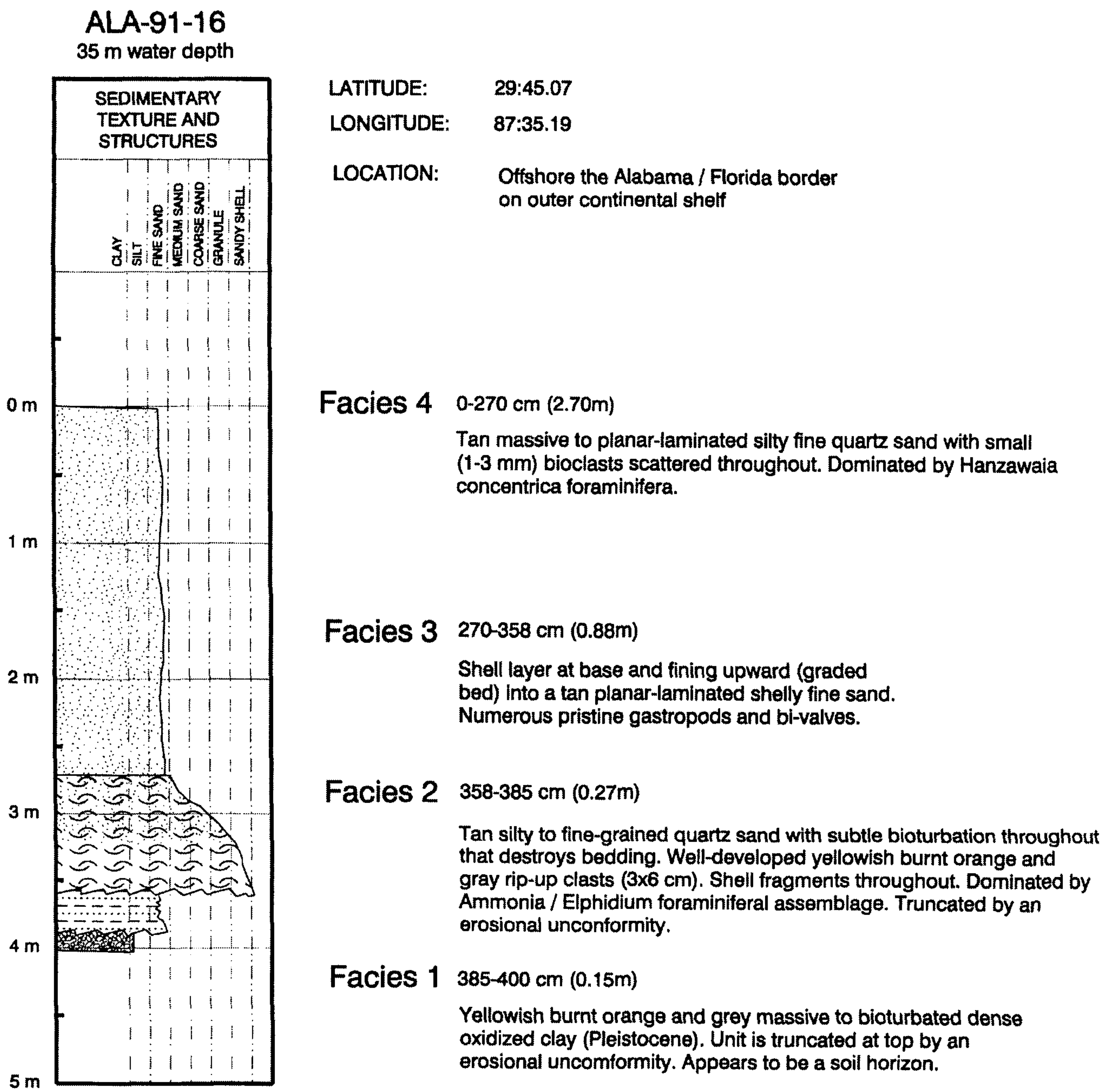

Figure 3. Description of standard-section core (ALA-91-16).

molluscan assemblage (Figs. 2, 3, and 6; Appendix A). The shell bed is 0.88 m thick with a fine quartz sand matrix and some quartz granules and pebbles found in the lower portion. In addition, the shell bed is graded with large (up to 6 cm) bioclasts crudely stratified at the base that fines upward into horizontally laminated to massive, shelly (<0.25 cm) fine quartz sand. The sand component of *Facies 3* is moderately well sorted, strongly coarse-skewed, and strongly leptokurtic (Table 1; Fig. 7). The dominant shell species are *Mulinia lateralis*, *Parvilucina multilineata*, *Macrocallista maculata*, *Ervilia nitens*, *Olivella floralia* (Anderson and McBride, 1996). Bioclasts are randomly oriented and size sorted. Minor preservational differences were observed between estuarine and marine mollusk species (Anderson and McBride, 1996). At the base of the unit (358 to 350 cm), the two most common benthic foraminifera are *Hanzawaia concentrica* and *Ammonia parkinsoniana.* However, *Hanzawaia concentrica* becomes dominant in the upper portion of the unit (350 to 270 cm).

Facies 4

The contact between *Facies 3* and *4* is gradational. *Facies 4* extends from 270 to 0 cm (2.70 m thick) and is a tan, massive to horizontally-laminated, fine quartz sand (0.19 to

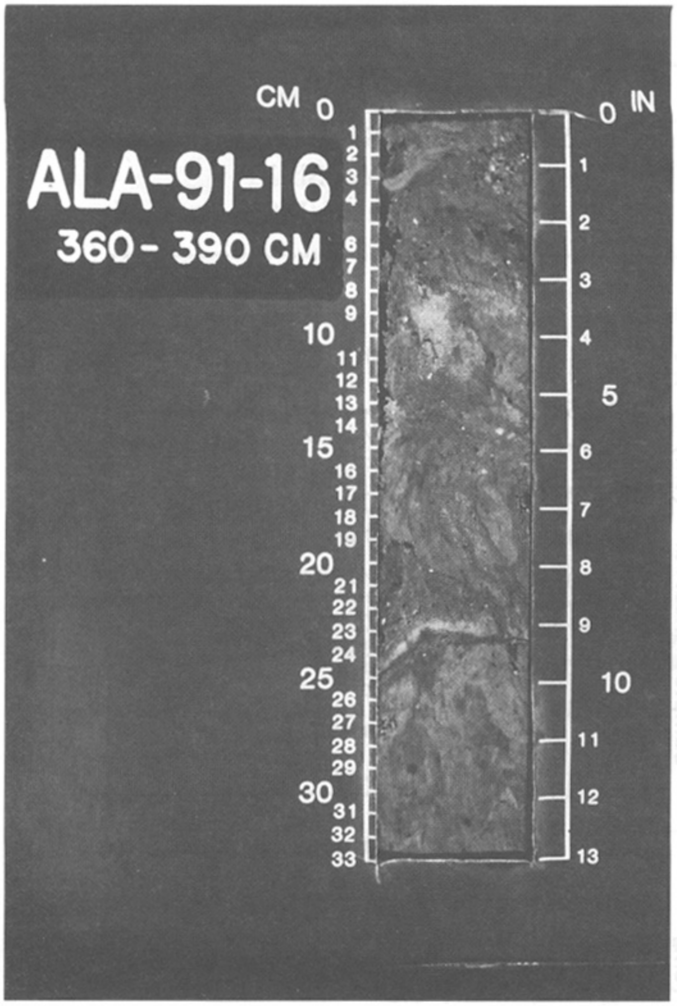

Figure 4. Core photo of ALA-91-16 (interval 360-390 cm) showing erosional unconformity (Pleistocene/Holocene contact) truncating *Facies 1* at 24 cm with overlying *Facies 2* depicting rip-up clast derived from *Facies 1* at 10 cm.

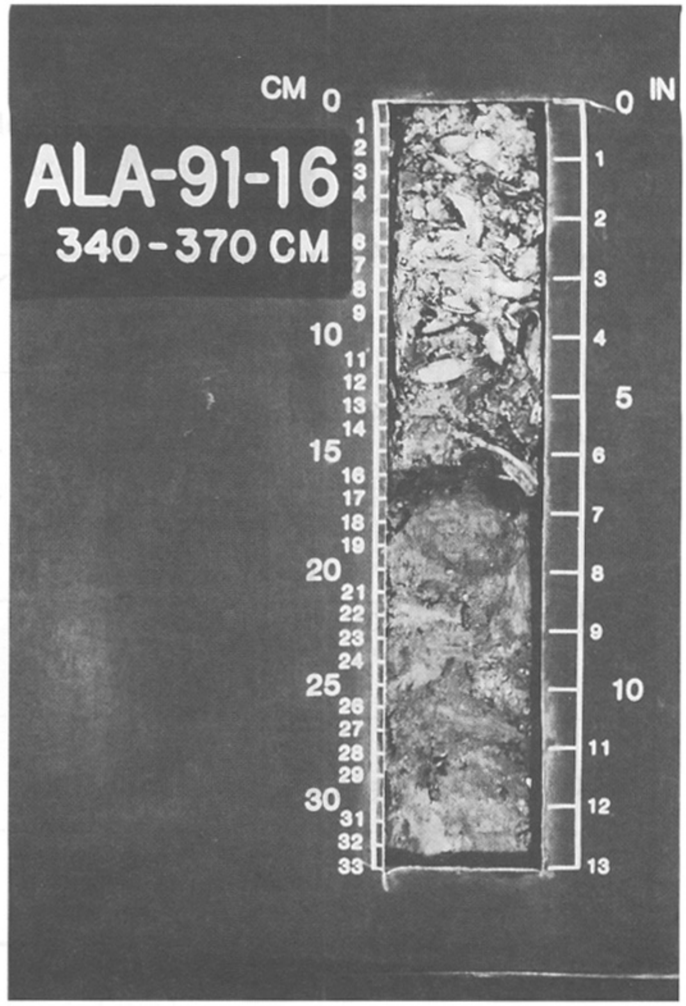

Figure 5. Core photo of ALA-91-16 showing the erosional unconformity forming the sharp contact between *Facies 2* and *Facies 3*. The shell bioclasts have been trimmed back to allow a more detailed view of the erosional contact (compare to Fig. 6).

0.21 mm) with widely scattered bioclasts (Figs. 2 and 3). *Facies 4* fines slightly upward and the sand is well sorted, strongly fine-skewed, and extremely leptokurtic (Table 1; Fig. 7). When compared with sand of *Facies 3*, *Facies 4* is better sorted and has positive skewness (strongly fine-skewed). The benthic foraminifera assemblage is dominated by the hyaline species *Hanzawaia concentrica* and *Asterigerina carinata*, but large, well-preserved porcelaneous species such as *Archaias angulatus*, *Parasorites orbitolitoides*, and *Peneroplis proteus* are also common.

Discussion

During the last full glaciation approximately 18,000 yrs. B.P., eustatic sea level in the Gulf of Mexico and Caribbean Sea fell at least 90 m and possibly as much as 121 m below present day levels (Curray, 1965; Fairbanks, 1989). In response to the glacio-eustatic sea-level fall, fluvial channels incised as the shoreline migrated seaward to the edge of the continental shelf (Fisk and McFarlan, 1955). Consequently, most of the shelf surface was subaerially exposed producing a well-developed soil horizon and an erosional unconformity. *Facies 1* is interpreted as a Pleistocene soil horizon.

The amount of Pleistocene section removed above *Facies 1* is unknown, but the erosional unconformity was further reworked by the ensuing transgression that occurred in response to the last deglaciation. This transgressive surface of erosion (bay ravinement) formed at the leading edge of the transgression as the bay-mainland shoreline moved landward. Therefore, the erosional unconformity between *Facies 1* and *2* is a combination of subaerial exposure during sea-level lowstand and the bay-ravinement process during subsequent sea-level rise. *Facies 2* is interpreted to represent estuarine deposits based on stratigraphic context and the *Ammonia-Elphidium* foraminiferal assemblage. Rip-up clasts incorporated within *Facies 2* were derived from *Facies 1*. These rip-up clasts most likely formed as the mainland shoreline eroded and Pleistocene deposits (*Facies 1*) slumped into the bay and were reworked by waves during the passage

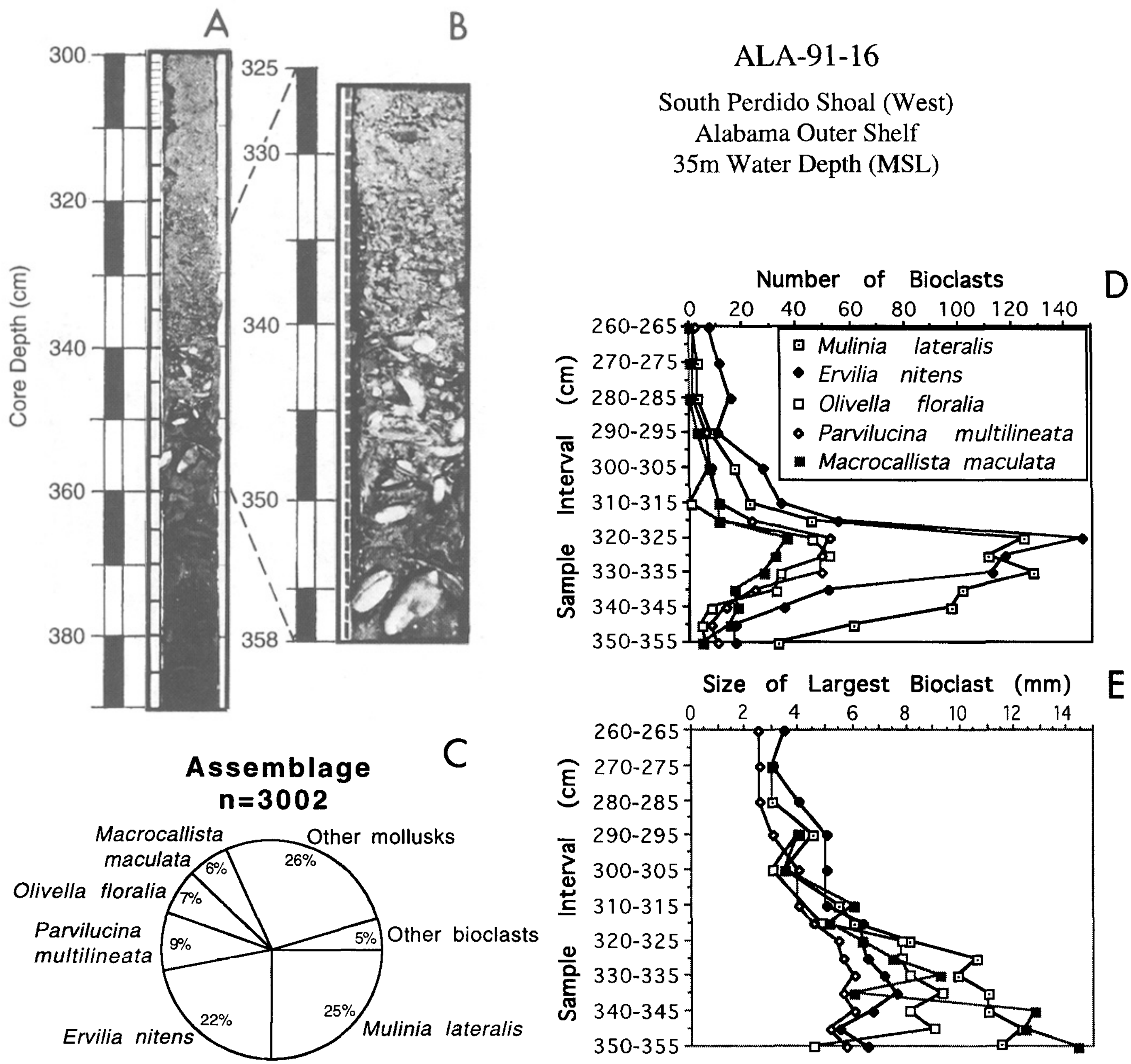

Figure 6. A) Core photograph of ALA-91-16 showing the shell bed *(Facies 3)*. B) Close-up core photograph of lower portion of *Facies 3*. C) Pie diagram showing proportions of dominant bioclasts. D) Number of bioclasts per sample with depth for common species. E) Size of largest bioclast per sample with depth for common species. (From Anderson and McBride, 1996).

of strong cold fronts and hurricanes, similar to modern mainland shoreline response in this area. As eustatic sea level continued to rise, the outer shoreline translated landward and upward through erosional shoreface retreat producing an erosional unconformity (shoreface ravinement surface). This unconformity lies at the base of the shell bed and represents the second transgressive surface of erosion. The molluscan assemblage of the graded shell bed (*Facies 3*) contains both characteristically estuarine (*Mulinia lateralis*, *Parvilucina multilineata*) and shoreface/shelf (*Macrocallista maculata*, *Ervilia nitens*, *Olivella floralia*) species in abundance (Anderson and McBride, 1996). Because preservation of estuarine and marine species is similar, estuarine species may have been concentrated three ways: 1) as a lag deposit from erosion of *Facies 2*, preserved by sand deposition on the shelf, 2) erosion of upper shoreface or inlet-influenced areas where environmental ranges of the common species overlap, or 3) combination of both processes. The shell bed most likely

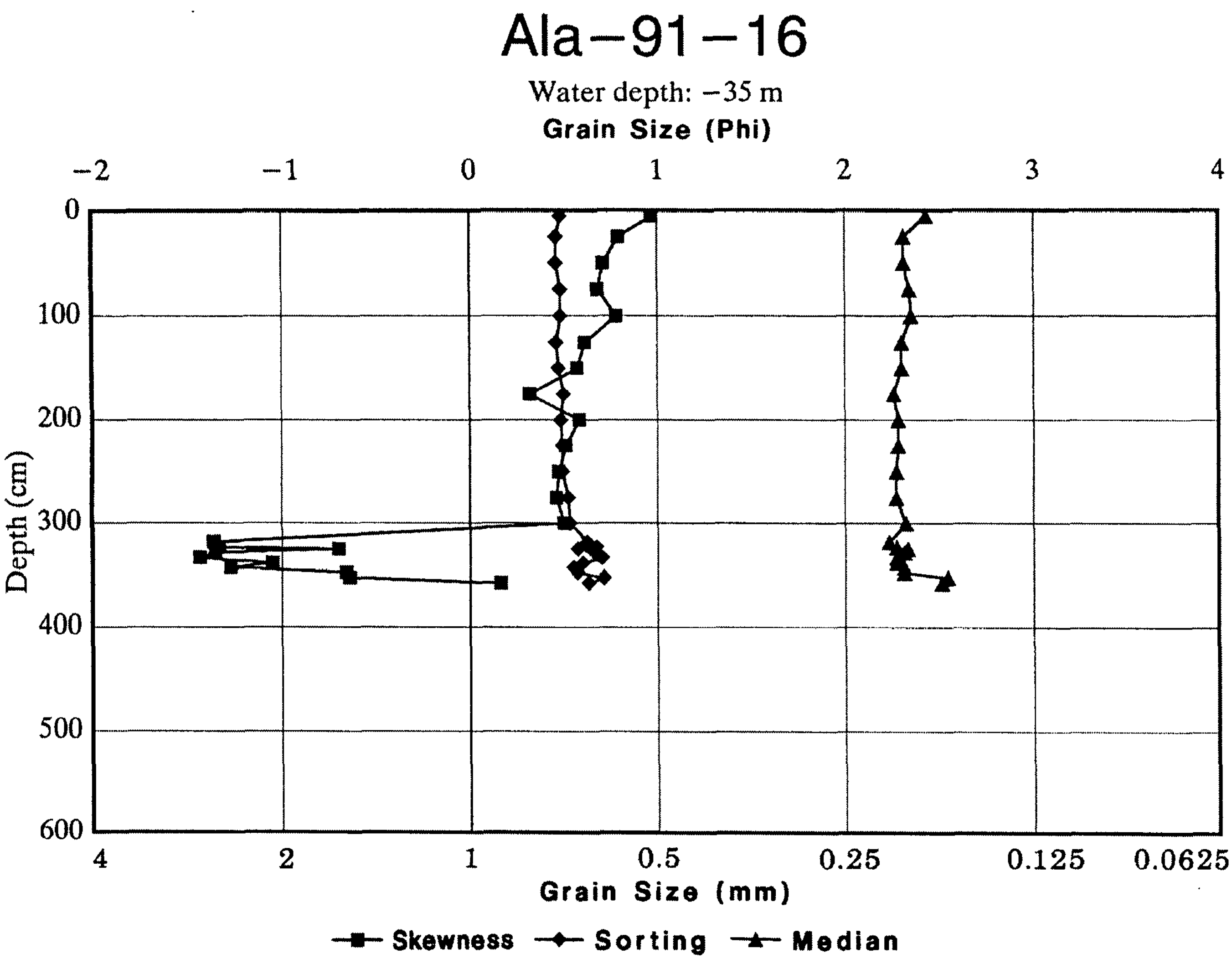

Figure 7. Trends in sediment characteristics for *Facies 3* and *4* of ALA-91-16 showing median grain size, sorting, and skewness.

formed at the base of the shoreface by high energy events (i.e., strong cold fronts, hurricanes, and the incursion of Loop Current water) and/or bedform migration on a dynamic shelf that concentrated, vertically mixed, and amalgamated bioclasts. The thick deposit of sand comprising *Facies 4* is the MAFLA sand sheet and is sourced from the eroding shoreface and transported offshore during high-energy events (see Swift et al., 1991).

Conclusions

1. A standard section is proposed for a sand-rich shelf that describes late-Pleistocene and Holocene deposits in the northeastern Gulf of Mexico. Four facies and two erosional unconformities were identified. *Facies 1* is a yellowish-burnt-orange and grey, oxidized clayey quartz sand (Pleistocene soil horizon). *Facies 2* is a bioturbated, tan clayey sandy silt to silty fine quartz sand (estuarine). *Facies 3* rests atop a distinct erosional unconformity and is a well-developed shell bed containing primarily shallow marine molluscs (lower shoreface). *Facies 4* is a 2.7-m thick massive to horizontally-laminated, fine quartz sand (open shelf).
2. The basal unconformity at the Pleistocene/Holocene boundary results from two processes: subaerial exposure during sea level lowstand and the bay ravinement during the ensuing transgression.
3. Shell-bed formation is a product of shelf dynamics associated with short-term, high-energy storm events and/or longer-term bedform migration. These processes concentrate bioclasts as lag deposits in the transport system.

Acknowledgements

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Table 1. Grain-size statistics (moment measures) with depth for Facies 3 and 4 of ALA-91-16.

Depth (cm)	Median (phi)	Median (mm)	Mean (phi)	Mean (mm)	Sorting (phi)	Skewness	Kurtosis
5	2.43	0.19	2.47	0.18	0.48	0.97	6.05
25	2.31	0.20	2.31	0.20	0.46	0.79	6.29
50	2.31	0.20	2.31	0.20	0.46	0.71	6.07
75	2.34	0.20	2.34	0.20	0.48	0.68	5.91
100	2.35	0.20	2.36	0.20	0.48	0.78	6.72
125	2.30	0.20	2.29	0.20	0.46	0.61	5.86
150	2.30	0.20	2.28	0.21	0.47	0.57	5.83
175	2.26	0.21	2.23	0.21	0.50	0.32	4.90
200	2.28	0.21	2.27	0.21	0.48	0.58	5.70
225	2.28	0.21	2.26	0.21	0.49	0.51	5.63
250	2.27	0.21	2.24	0.21	0.49	0.47	5.68
275	2.27	0.21	2.25	0.21	0.52	0.46	5.56
300	2.32	0.20	2.31	0.20	0.53	0.50	5.65
318	2.23	0.21	2.15	0.23	0.62	-1.36	6.82
323	2.27	0.21	2.16	0.22	0.67	-1.33	6.49
325	2.33	0.20	2.34	0.20	0.57	-0.70	6.06
328	2.31	0.20	2.23	0.21	0.66	-1.35	6.92
333	2.27	0.21	2.16	0.22	0.70	-1.43	6.33
338	2.27	0.20	2.30	0.20	0.60	-1.05	7.17
343	2.31	0.20	2.25	0.21	0.55	-1.27	7.54
348	2.31	0.20	2.29	0.20	0.57	-0.66	6.63
353	2.54	0.17	2.56	0.17	0.71	-0.64	5.80
358	2.51	0.18	2.57	0.17	0.63	0.16	4.94

APPENDIX A

Core ALA-91-16

Species abundance data for samples in ALA-91-16 (water depth 35 m). See Methods for description of how each taxonomic group was counted. Environmental categories and abbreviations are as follows: Er = river-influenced estuary (salinity 8-11‰; water depth 1-6m), Et = transitional estuary (salinity 10-25‰; water depth 1-9m), Em = marine-influenced estuary (salinity 25-38 ‰; water depth 1-9m), L = lagoon (salinity 20-40‰; water depth 1-4m), I = inlet-influenced area (includes inlet throat, flood and ebb tidal-deltas; salinity 30-35‰; water depth <17m), So = shoreface (salinity 36‰; water depth 0-15m), and Sh = shelf (salinity 36‰; water depth >15m). Substrate categories and abbreviations appear in parentheses ( ) and are as follows: M = mud, S = sand, and G = shell gravel or hard substrate.

Species	Sample depth (cm)														total	environmental
	260	270	280	290	300	310	315	320	325	330	335	340	345	350		range (substrate)
BIVALVIA																
Nucula proxima	0	0	0	0	0	0	0	1	2	2	1	0	0	0	6	I--Sh (M)
Nuculana acuta	0	0	2	1	1	3	2	9	4	7	5	3	0	1	38	Et--So (M)
Nuculana concentrica	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	Et--Sh (M)
Anadara transversa	1	1	1	0	1	5	7	16	11	4	4	5	3	0	59	Em--Sh (S)
Glycimeris sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	
Atrina sp.	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	
Ostrea equestris	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	Em--I (G)
Chlamys sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	
Argopecten gibbus	0	1	0	1	0	0	0	1	1	3	0	2	1	0	10	So--Sh (S)
Argopecten? sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	
Lyropecten sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	
Anomia simplex	0	0	0	0	0	0	1	3	0	4	3	6	1	0	18	Em--So (G)
Linga amiantus	0	0	0	0	0	0	0	0	0	2	0	1	0	0	3	Em--Sh (S)
L. pensylvanica	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	So--Sh
Parvilucina multilineata	2	1	1	6	8	11	23	52	49	49	24	13	8	10	257	Et--Sh (M)
Lucina nassula	0	0	0	0	0	0	1	1	1	0	4	0	1	0	8	Sh
L. radians	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	So--Sh
Lucina sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	
Divaricella quadrisulcata	0	0	0	0	0	0	0	0	0	1	0	1	1	0	3	Sh (S)
Thyasira gouldii	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2	
Codakia sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Diplodonta nucleiformis	0	0	0	0	0	2	0	1	1	2	3	2	0	0	11	Sh
Crassinella lunulata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	I--Sh (G)
Carditamera floridana	0	0	0	0	0	1	0	0	0	0	1	0	0	0	2	Em--So (S)
Carditamera sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
Pleuromeris tridentata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	So--Sh
Laevicardium pictum	0	0	0	0	0	0	0	2	3	4	4	11	1	0	25	Sh
Laevicardium sp.	0	0	0	0	0	0	0	0	4	2	0	0	0	0	6	
Dinocardium robustum	0	0	0	0	0	0	0	2	0	0	0	0	2	1	5	I--Sh (S)
Dinocardium sp.	0	0	0	1	1	0	0	1	1	0	0	2	12	9	6	
Mactra sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	
Mulinia lateralis	1	3	3	8	17	22	45	124	111	128	101	97	61	33	754	Et--So (M/S)
Ervilia concentrica	7	11	15	10	27	34	55	146	117	142	51	35	17	17	654	Em--So (S)
Tellina alternata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Em--Sh (S)
Tellina sp.	2	1	3	4	3	4	14	22	7	12	4	0	1	2	79	
Tellidora cristata	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	Em--I (S)
Strigilla miriabilis	0	0	0	0	1	4	2	10	4	8	10	10	5	2	56	So (S)
Tagelus cf. T. divisus	0	0	0	0	0	0	0	0	0	0	0	1	3	2	6	Em--So (S)

Species	Sample depth (cm)														total	environmental range (substrate)
	260	270	280	290	300	310	315	320	325	330	335	340	345	350		
Macrocallista nimbosa	0	0	0	0	0	0	4	4	6	6	8	15	8	1	52	I--So (S)
M. maculata	0	0	0	3	7	11	11	36	32	28	17	18	15	5	183	So--Sh (S)
Macrocallista sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
Chione cancellata	0	1	0	0	0	2	0	3	0	4	1	2	4	1	18	Em--Sh (S)
C. intapurpurea	0	0	0	0	0	0	0	1	2	1	2	2	4	1	13	So--Sh (S)
C. latilirata	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	Sh
C. grus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	I--Sh (S)
Chione sp.	2	0	1	0	0	0	0	0	0	0	0	0	0	0	3	
Dosinia elegens	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	So--Sh (M/S)
Dosinia sp.	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	
Parastarte triquenta	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	So S)
Corbula operculata	0	0	1	0	0	2	0	5	3	1	1	1	1	0	15	Sh (M)
C. caribaea	0	0	0	0	0	1	0	2	0	1	5	1	0	2	12	Em--Sh (M)
Lyonsia arenosa	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	So--Sh
GASTROPODA																
Smaragdia viridis	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2	Et--Em (S)
Turbonilla sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	
Strombus alatus	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	So--Sh (S)
Crepidula fornicata	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	Em--Sh (G)
C. convexa	0	0	0	0	2	0	1	1	4	1	0	0	0	0	9	Em--Sh (G)
C. plana	0	0	0	0	1	0	0	3	0	1	0	0	0	0	5	Et--Sh (G)
Polinices duplicatus	0	2	2	1	5	2	4	13	13	13	7	4	6	5	77	Em--Sh (S)
Niso aeglees	0	0	0	0	0	0	0	0	1	1	0	1	0	0	3	Em--Sh
Bailya intricata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	So--Sh
Anachis obesa	0	0	2	1	6	5	3	9	9	4	0	0	0	3	42	Er--So (S/G)
Anachis sp.	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
Nassarius albus	0	0	0	0	0	0	0	0	0	2	2	0	0	0	4	So--Sh
N. acutus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	Er--So (M/S)
Busycon sp.	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	
Oliva sayana	0	0	0	1	4	2	2	11	5	3	8	9	0	9	54	Em--Sh (S)
Olivella pusilla	0	0	0	0	0	5	0	0	0	0	0	3	7	0	15	So (S)
O. floralia	0	0	0	3	7	0	11	45	52	34	32	8	4	6	202	L--So (S)
O. minuta	0	0	2	0	1	0	0	0	0	8	5	7	0	0	23	I (S)
Olivella sp.	3	0	0	0	0	7	3	8	0	1	0	0	1	0	23	
Marginella aureocincta	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	So--Sh (S)
Cancellaria reticulata	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	So--Sh (S)
Conus stearnsi	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	So--Sh (S)
Conus sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
Cerodrillia clappi	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	So
Compsodrillia? sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
Monilispira leucocyma	0	0	0	0	0	1	0	3	2	1	0	0	0	3	10	So (S)
Cryoturris cerinella	0	1	0	1	1	0	0	0	0	0	0	0	0	0	3	L--Sh (S)
Terebra dislocata	0	0	0	0	0	0	0	0	1	2	2	1	2	0	8	So--Sh (M/S)
Turbonilla incisa	0	0	0	0	0	0	0	0	1	0	0	2	0	0	3	Em--So
Bulla cf. B. striata	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	L--I (S)
Acteocina canaliculata	0	0	0	0	0	0	0	1	1	0	1	0	1	0	4	Et--L (M/S)
SCAPHODPODA																
Dentalium eborium	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	So--Sh (S)
Cadulus cf. C. carolinensis	0	0	0	0	0	2	0	1	2	4	0	3	0	0	12	Em--Sh
Cadulus sp.	0	0	0	1	1	0	0	0	0	1	0	0	0	0	3	

Species	Sample depth (cm)														total	environmental range (substrate)
	260	270	280	290	300	310	315	320	325	330	335	340	345	350		
OTHER																
soritid foraminifera	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2	L--Sh (S)
<u>Oculina</u> <u>diffusa</u>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
cupularid bryozoan	0	0	0	0	0	0	2	11	0	8	0	0	3	0	24	I--Sh (S)
encrusting bryozoan	0	0	0	0	0	0	0	1	2	2	0	2	1	1	9	
<u>Mellita</u> sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
sand dollar fragment	0	0	0	0	0	0	2	6	0	6	1	0	0	0	15	
barnacle	0	0	0	0	0	0	0	4	7	9	6	2	2	0	30	
decapod fragment	0	0	0	0	0	0	0	3	2	4	5	2	0	1	17	
wood	0	0	0	0	0	0	1	4	6	4	11	10	3	2	41	