Progress Report on Sediment Analyses at Selected Faunal Monitoring Sites in North-central and Northeastern Florida Bay

by

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ABSTRACT

Florida Bay is a shallow, subtropical lagoon at the southern tip of the Florida peninsula. The 2200 square kilometer, triangular-shaped area is the site of modern carbonate sediment formation and deposition. The intricate ecosystem of the bay has undergone significant changes as the result of natural influences and human intervention. The purpose of this study is to investigate carbonate sediment characteristics and distribution in conjunction with faunal and floral to determine the substrate preferences of associated fauna and flora. The modern data provide the proxy data for down-core analyses of sediments, fauna and flora in order to document ecosystem changes in the bay.

Selected sediment samples collected during 1996 from 18 sites in the northeastern and central bay were analyzed for insoluble residues, organic content, total carbonate, and percent of silt and clay sized particles. Insoluble residues range from 0.8% of the sediment in a shell lag to 11.5% with an average of 5.1%. Organic content ranged from a minimum of 1.43% of the sediment to 18.05% with an average of 7.6%. The total carbonate content ranged from 72.56% to 97.81%, averaging 87.98%. The percent silt and clay sized particles ranged from 13.75% to 63.62% for the samples analyzed. The insoluble residue content shows a general trend of decreasing insoluble residues from the northeastern bay toward the southwest. Organic content is variable throughout the bay and does not show a regional trend. Several sites show a trend of higher organic content in the samples collected in February as compared to those collected in July.

Lithologic examination indicated that, in addition to the carbonate mud (less than 63μm), sample components included whole and fragmented mollusks, foraminifers, bryozoans, ostracods, and organic matter. The insoluble residues consisted of quartz sand and silt, clays and siliceous fossils. A component of the insoluble residues may be dust derived from Africa and transported to southern Florida by the prevailing winds.

INTRODUCTION

The south Florida ecosystem is a complex interplay of physical, chemical and biological components. Recent negative trends in the biological components of the system, such as declining numbers of wading birds, decreases in the shell fish populations, and seagrass dieoffs, have caused a great deal of scientific attention to be focused on the region. The emphasis, however, has been on examining the biological trends over the last ten to forty years. Attempts to restore the ecosystem to its natural state, as mandated by the Everglades Forever Act, passed in 1994, should be based on a knowledge of the history of the system, and how the physical, chemical and biological components interacted prior to significant human intervention in the region.

The U. S. Geological Survey (USGS) and the Florida Geological Survey (FGS), in cooperation with the National Oceanic and Atmospheric Administration (NOAA), the National Park Service (NPS), the Army Corps of Engineers (ACOE), and the South Florida Water Management District (SFWMD), among others, are conducting research to provide data on the historical trends in the physical, chemical and biological components of the ecosystem. The time scales examined are the last 150-200 years and the last few millennia. The primary goal of this work is to understand what are the natural patterns of change in the ecosystem, and to what extent has human alteration of the environment overprinted these natural patterns. In order to understand the natural variation in the biological components of the system, we must understand how the organisms interact with the physical and chemical parameters of their environment.

Florida Bay is an integral part of the Everglades ecosystem, constituting 2200 km^2 of shallow water, and providing habitat for birds, and a nursery for many forms of marine life. It has been profoundly affected by alteration of the natural flow of water across the terrestrial Everglades environment, and by the alteration of the Florida Keys. The sediments of Florida Bay preserve a record of the physical, chemical and biological changes that have occurred in the environment. Sediments, fauna, and flora preserved in shallow cores from the Bay are used to interpret the changes that have occurred in the environment over the last 150-200 years (Wingard et al., 1995; Ishman et al., 1996; Brewster-Wingard et al., 1997). In order to interpret the significance of the down-core changes more accurately, it is important to understand the distribution of sediments, fauna and flora in the present-day Florida Bay, and it is essential to determine the substrate and salinity preferences and tolerances of the living fauna and flora (Brewster-Wingard et al., 1996). Thus, we have established 26 monitoring sites within Florida Bay that are sampled twice per year, in February and July, to examine the modern distribution, and the frequency of change on a seasonal scale. This report includes data from 18 sites, sampled in 1996, in the north-central and northeastern Florida Bay (Figure 1; Table 1).

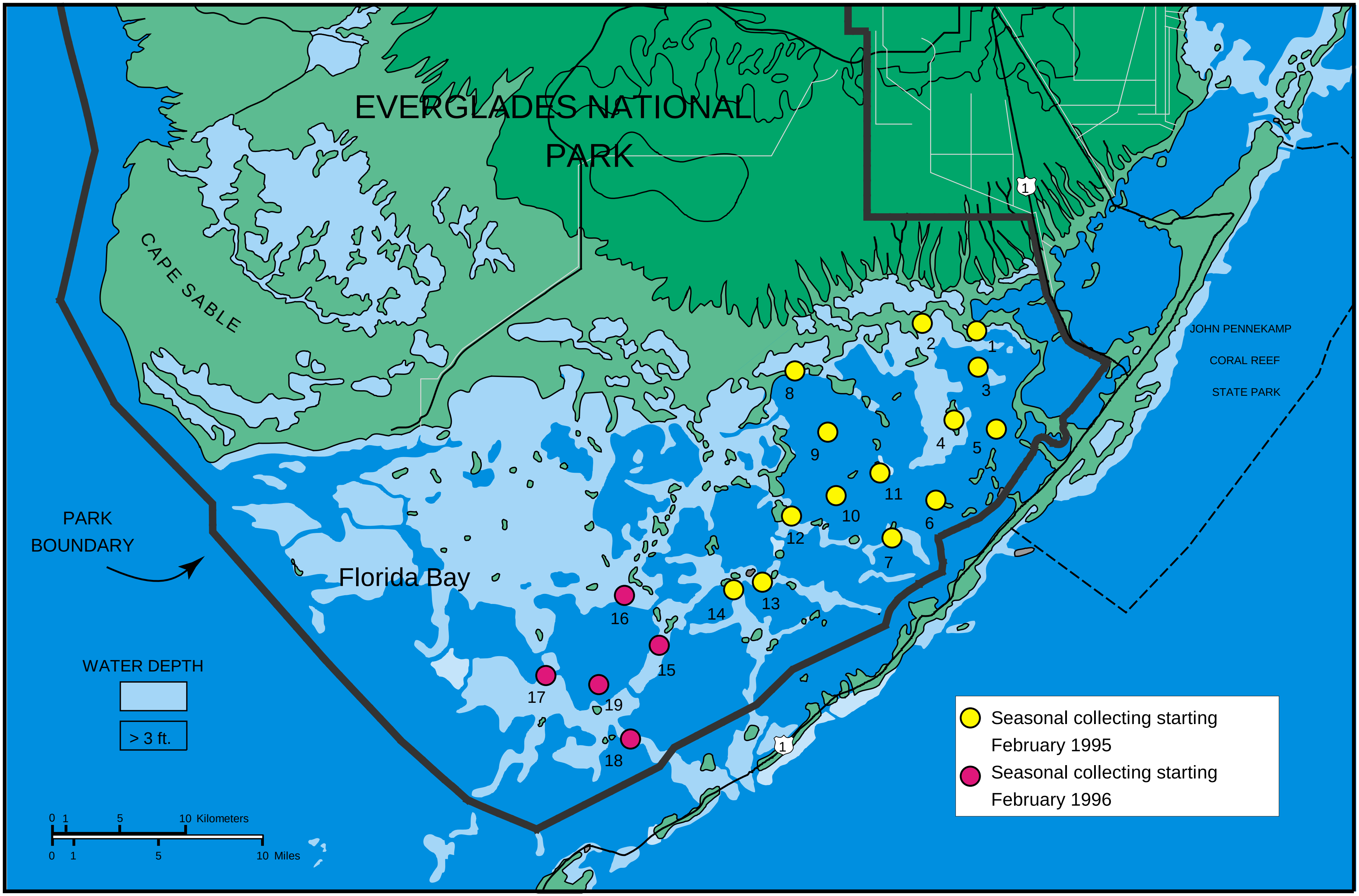

Figure 1: Map of Florida Bay showing location of 19 monitoring sites sampled in 1996. Note: no samples were processed from site 19, so this site is not discussed within the body of the report. Sites 1-14 were also collected in 1995 (Brewster-Wingard and others 1996).

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data: Longitude	GPS Data: Latitude	GPS Error ± I	Salinity (ppt) Top	Salinity (ppt) Bot-tom	Temperature (C) Top	Temperature (C) Bot-tom	Conductivity (MS) Top	Conductivity (MS) Bot-tom	Specific Concuctance (ms) Top	Specific Concuctance (ms) Bot-tom	Depth (ft.)	Bottom Conditions	General Area Description
1	Shell creek - mouth	Feb	A - SW channel	W 80 29.200'	N 25 12.426'	± 168'	18.4	18.3	19.1	19	26.37	26.28	26.69	29.41	2 '	Thalassia, Halodule, algae on firm mud.	Mouth of creek flowing from Long Sound; surrounded by Mangroves.
1	Shell creek - mouth	Feb	B - channe	W 80 29.200'	N 25 12.426'	± 168'	18.4	18.3	19.1	19	26.37	26.28	26.69	29.41	3'	Shell lag deposit.	Mouth of creek flowing from Long Sound; surrounded by Mangroves.
1	Shell creek - mouth	Feb	C - NE channel	W 80 29.200'	N 25 12.426'	± 168'	18.4	18.3	19.1	19	26.37	26.28	26.69	29.41	2'	Mix of Thalassia and Halodule. Soft, soupy, mud bottom. Patchy.	Mouth of creek flowing from Long Sound; surrounded by Mangroves.
1	Shell creek - mouth	July	A - SW of Channel	W 80 28.78'	N 25 11.17'	N/A	10.1	14.1	29.8	30.4	17.03	23.54	18.75	25.99	2.5'	Soft mud, ~ 80% Thalassia cover.	Mouth of creek flowing from Long Sound; surrounded by Mangroves.
1	Shell creek - mouth	July	B -channel	W 80 28.78'	N 25 11.17'	N/A	10.1	14.1	29.8	30.4	17.03	23.54	18.75	25.99	3.5	Shell lag.	Mouth of creek flowing from Long Sound; surrounded by Mangroves.
1	Shell creek - mouth	July	C - NE of channel	W 80 28.78'	N 25 11.17'	N/A	10.1	14.1	29.8	30.4	17.03	23.54	18.75	25.99	2.5	~ 90% Thalassia cover, ~ 5% Halodule grass. Halodule grass patch noted in past is gone, replaced by Thalassia.	Mouth of creek flowing from Long Sound; surrounded by Mangroves.
2	Trout creek H2O station	Feb	A - 10 yrds offshore	W 80 32.018'	N 25 12.742'	± 391'	12.8	13	19.7	19.7	19.1	21.1	21.24	23.8	2.5	Soft mud, sparse Halodule grass; scattered Ruppia?.	Off mangrove island near mouth of Trout Creek at water monitoring station.
2	Trout creek H2O station	Feb	B - 2 yrds offshore	W 80 32.018'	N 25 12.742'	± 391'	12.8	13	19.7	19.7	19.1	21.1	21.24	23.8	1	Firm mud with coarse organics (Oyster and wood); Halodule present. No Thalassia seen	Off mangrove island near mouth of Trout Creek at water monitoring station.
2	Trout Creek H2O station	July	A - 10 yards off island	W 80 31.62'	N 25 11.43'	N/A	2.6	2.7	30.8	30.8	4.94	5.05	5.48	5.6	2'	~ 2 - 3' mud over limestone. Mud is fairly soft. Little Thalassia; ~ 10%; Halodule cover.	Off mangrove island near mouth of Trout Creek at water monitoring station.

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data			Salinity (ppt)		Temperature (C)		Conductivity (MS)		Specific Concuctance (ms)		Depth (ft.)	Bottom Conditions	General Area Description
				Longitude	Latitude	GPS Error ± l	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom			
2	Trout Creek H2O station	July	B - 1 yrd. off island	W 80 31.62'	N 25 11.43'	N/A	2.6	2.7	30.8	30.8	4.94	5.05	5.48	5.6	2'	~ 2 - 3' mud over limestone. Mud is fairly soft. Little Thalassia; ~ 10%; Halodule cover.	Off mangrove island near mouth of Trout Creek at water monitoring station.
3	Duck key H2O station, S side of island	Feb	A - offshore	W 80 29.363'	N 25 10.784'	± 493'	18.5	18.5	17.2	17.2	25.38	25.42	29.79	29.84	2.5 '	Very sparse grass, patches of Thalassia, some algae. Substrate fairly firm.	Southern end of mangrove island in center of basin away from any mud banks or other islands.
3	Duck key H2O station, S side of island	Feb	B - inlet	W 80 29.363'	N 25 10.784'	± 493'	18.5	18.5	17.2	17.2	25.38	25.42	29.79	29.84	0.5'	Substrate firm mud. No vegetative cover.	Southern end of mangrove island in center of basin away from any mud banks or other islands.
3	Duck Key H2O station	July	A - offshore	W 80 28.97'	N 25 09.61'	N/A	19.3	19.6	31	31.4	31.12	31.66	34.71	35.54	2.5'	Mud with high shell content ~ 75% algae, and some Thalassia.	Southern end of mangrove island in center of basin away from any mud banks or other islands.
3	Duck Key H2O station	July	B - inlet	W 80 28.97'	N 25 09.61'	N/A	19.3	19.6	31	31.4	31.12	31.66	34.71	35.54	1'	Very fine-grained mix of crushed shell and firm mud, sparse Halodule grass.	Southern end of mangrove island in center of basin away from any mud banks or other islands.
4	Northern Nest key	Feb	B - side of bank, grass	W 80 30.561'	N 25 08.692'	± 92'	17.7	17.5	21.1	19.8	26.21	25.48	28.5	28.31	2'	Soft sediment. Sparse, patchy coverage (70-80%) of Thalassia and algae in deeper H2O.	Mud Bank at southern end of northern mangrove island in center of basin.
4	Northern Nest key	Feb	C - top of bank, grasses	W 80 30.561'	N 25 08.692'	± 92'	17.7	17.5	21.1	19.8	26.21	25.48	28.5	28.31	0.5'	Soft sediment; mix of Thalassia and Halodule grass.	Mud Bank at southern end of northern mangrove island in center of basin.
4	Northern Nest Key	July	A - top of Bank	W 80 30.558'	N 25 08.679'	± 89'	13.8	17.4	30.6	31.2	23.28	29.14	25.82	32.58	1'	Very soft soupy mud. ~80-90% Thalassia. Scattered algae .	Mud Bank at southern end of northern mangrove island in center of basin.
4	Northern Nest Key	July	B - side of bank	W 80 30.558'	N 25 08.679'	± 89'	13.8	17.4	30.6	31.2	23.28	29.14	25.82	32.58	2'	Very soft soupy mud. Thalassia, patchy. Scattered algae .	Mud Bank at southern end of northern mangrove island in center of basin.

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data			Salinity (ppt)		Temperature (C)		Conductivity (MS)		Specific Concuctance (ms)		Depth (ft.)	Bottom Conditions	General Area Description
				Longitude	Latitude	GPS Error ±	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom			
4	Northern Nest Key	July	C - beach	W 80 30.558'	N 25 08.679'	± 89'	13.8	17.4	30.6	31.2	23.28	29.14	25.82	32.58	0	Shell lag from beach off main island, east side.	Mud Bank at southern end of northern mangrove island in center of basin.
5	Porjoe key - S mud bank	Feb	A - edge of bank	W 80 28.342'	N 25 08.084'	N/A	20.3	20.3	16.6	16.5	27.28	27.22	32.45	32.45	2'	Patchy - Thalassia, abundant algae, sparse Halodule. Variable firmness of substrate.	To west of Little Buttonwood Sound on eastern edge of basin. Well developed mud bank on southern end of keys.
5	Porjoe key - S mud bank	Feb	B - side of bank	W 80 28.342'	N 25 08.084'	N/A	20.3	20.3	16.6	16.5	27.28	27.22	32.45	32.45	1'	Patchy - abundant algae, Halodule grass increasing in density on bank. Variable firmness of substrate.	To west of Little Buttonwood Sound on eastern edge of basin. Well developed mud bank on southern end of keys.
5	Porjoe key - S mud bank	Feb	C - top of bank	W 80 28.342'	N 25 08.084'	N/A	20.3	20.3	16.6	16.5	27.28	27.22	32.45	32.45	0.5'	Patchy - Halodule dominant grass type, mangroves 1-2 high. Variable firmness of substrate.	To west of Little Buttonwood Sound on eastern edge of basin. Well developed mud bank on southern end of keys.
5	Porjoe key - S mud bank	July	A - edge of bank	W 80 27.87'	N 45 06.81'	N/A	21.8	21.8	31.5	31.6	34.9	34.98	39.26	39.41	3.5'	Thalassia density variable but very healthy. Deeper water off bank: 80 - 90% Thalassia, scattered Halodule, disk algae, halimeda and penicillus present. Abundant live molluscs.	To west of Little Buttonwood Sound on eastern edge of basin. Well developed mud bank on southern end of keys.
5	Porjoe key - S mud bank	July	B - side of bank	W 80 27.87'	N 45 06.81'	N/A	21.8	21.8	31.5	31.6	34.9	34.98	39.26	39.41	1'	Decreasing amount of Thalassia compared to deeper water.	To west of Little Buttonwood Sound on eastern edge of basin. Well developed mud bank on southern end of keys.

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				Longitude	Latitude	GPS Error ± f	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom			
5	Porjoe key - S mud bank	July	C - top of bank	W 80 27.87'	N 45 06.81'	N/A	21.8	21.8	31.5	31.6	34.9	34.98	39.26	39.41	0.5'	Halodule predominant grass type.	To west of Little Buttonwood Sound on eastern edge of basin. Well developed mud bank on southern end of keys.
6	Butternut key H2O station	Feb	A - nearshore	W 80 31.132'	N 25 05.200'	N/A	18.6	18.5	20.4	19.7	27.3	26.9	30	29.89	0.5'	Sandy shell deposit and shell lag just below water line at beach.	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.
6	Butternut key H2O station	Feb	B - offshore ~ 10m	W 80 31.132'	N 25 05.200'	N/A	18.6	18.5	20.4	19.7	27.3	26.9	30	29.89	2'	Peat deposits overlain with $CaCO_3$ sand. Very sparse Thalassia (<5%)	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.
6	Butternut key H2O station	Feb	C - beach	W 80 31.132'	N 25 05.200'	N/A	18.6	18.5	20.4	19.7	27.3	26.9	30	29.89	0'	Shell lag on beach, above water.	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.
6	Butternut key H2O station	July	A - nearshore	W 80 31.15'	N 25 05.212'	± 98'	26.5	26.6	29.7	29.6	41.48	41.65	45.17	45.31	0.5'	Very firm coarse substrate, with a few patches of Thalassia. Surface covered with live *Batillaria* , and shell debris.	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.

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6	Butternut key H2O station	July	B - offshore ~ 10m	W 80 31.15'	N 25 05.212'	± 98'	26.5	26.6	29.7	29.6	41.48	41.65	45.17	45.31	3.5'	Firm substrate; peats with very thin layer of coarse calcareous material overlying the peats. 10-15% Thalassia.	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.
6	Butternut Key	July	C - beach	W 80 31.15'	N 25 05.212'	± 98'	26.5	26.6	29.7	29.6	41.48	41.65	45.17	45.31	0'	Shell lag on beach.	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.
6	Butternut Key	July	D - onshore	W 80 31.15'	N 25 05.212'	± 98'	26.5	26.6	29.7	29.6	41.48	41.65	45.17	45.31	0'	Large blocky calcareous mud/marl eroded out of island, sitting on peat above water level.	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.
6	Butternut Key	July	E - onshore	W 80 31.15'	N 25 05.212'	± 98'	26.5	26.6	29.7	29.6	41.48	41.65	45.17	45.31	0"	Shell lag trapped in mangrove roots above water level.	Mangrove island; samples from ne side of western tip of island on east side of basin. A long mud bank is present to the east of the island.
7	Bottle Key: SE mud banks	Feb	A - top of bank	W 80 33.519'	N 25 03.686'	N/A	21.7	22.1	21.5	19.4	32.1	31.35	34..48	35.1	0.5'	Very soft mud. Dense mix of Thalassia, Halodule and algae (~ 70%).	String of mangrove islands. Very shallow flats with lots of juvenile mangroves.
7	Bottle Key: SE mud banks	Feb	B - side of bank	W 80 33.519'	N 25 03.686'	N/A	21.7	22.1	21.5	19.4	32.1	31.35	34..48	35.1	2'	Very soft mud. Mostly Thalassia.	String of mangrove islands. Very shallow flats with lots of juvenile mangroves.

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7	Bottle Key: SE mud banks	July	A - top of bank	W 80 33.044'	N 25 03.901'	± 99'	28.3	26.4	31.2	30.8	44.2	41.43	49,39	46.02	0.5'	Very soft, soupy mud with 10 - 30% unhealthy Halodule.	String of mangrove islands. Very shallow flats with lots of juvenile mangroves.
7	Bottle Key: SE mud banks	July	B - side of bank	W 80 33.044'	N 25 03.901'	± 99'	28.3	26.4	31.2	30.8	44.2	41.43	49,39	46.02	1.5'	Thalassia bed, firm mud with lots of shell material.	String of mangrove islands. Very shallow flats with lots of juvenile mangroves.
7	Bottle Key: SE mud banks	July	C - off bank	W 80 33.044'	N 25 03.901'	± 99'	28.3	26.4	31.2	30.8	44.2	41.43	49,39	46.02	3.5'	Very soft gelatinous mud; no vegetation.	String of mangrove islands. Very shallow flats with lots of juvenile mangroves.
7	Bottle Key: SE mud banks	July	D - Beach	W 80 33.044'	N 25 03.901'	± 99'	28.3	26.4	31.2	30.8	44.2	41.43	49,39	46.02	0'	Coarse shell lag collected on beach of main island.	String of mangrove islands. Very shallow flats with lots of juvenile mangroves.
8	Little Madeira Bay mouth	Feb	A - N side of bar	W 80 37.913'	N 25 10.564'	± 97'	15.7	15.8	19.7	19.2	23.08	22.98	25.65	25.76	1'	Soft mud; ~ 70% Thalassia.	Mouth of Bay which Taylor Creek feeds into. 2 small mangrove islands on either side of mouth.
8	Little Madeira Bay mouth	Feb	B - S side of bar	W 80 37.913'	N 25 10.564'	± 97'	15.7	15.8	19.7	19.2	23.08	22.98	25.65	25.76	2.5'	Firm mud; ~ 35% Thalassia and algae.	Mouth of Bay which Taylor Creek feeds into. 2 small mangrove islands on either side of mouth.
8	Little Madeira Bay mouth	July	A - N side of bar	W 80 37.889'	N 25 10.546'	± 123'	8.3	10.2	31.2	31.3	14.49	14.6	16.22	16.28	1'	Soft mud with shell material, forams and mollusks abundant. Sparse but healthy Thalassia.	Mouth of Bay which Taylor Creek feeds into. 2 small mangrove islands on either side of mouth.
8	Little Madeira Bay mouth	July	B - S side of bar	W 80 37.889'	N 25 10.546'	± 123'	8.3	10.2	31.2	31.3	14.49	14.6	16.22	16.28	2.5'	Soft mud and lots of shell material, ~ 15% Thalassia.	Mouth of Bay which Taylor Creek feeds into. 2 small mangrove islands on either side of mouth.
9	Middle of basin s. of Little Madeira Bay	Feb		W 80 37.048'	N 25 08.436'	± 142'	16.9	18.1	19.3	17.9	24.45	25.18	27.4	29.17	5'	Cover of 3 - 6" of sediment over hard rock substrate. Substrate exposed in some places. <2% coverage of Halodule grass. Burrows present.	Center of basin; fair distance from any islands.

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SITE #	Location	Month Sampled	Sample	GPS Data Longitude	Latitude	GPS Error ± f	Salinity (ppt) Top	Bot-tom	Temperature (C) Top	Bot-tom	Conductivity (MS) Top	Bot-tom	Specific Concuctance (ms) Top	Bot-tom	Depth (ft.)	Bottom Conditions	General Area Description
9	Middle of basin S of Little Madeira Bay	July		W 80 37.088'	N 25 08.460'	± 103'	21.2	21.1	30.8	31	34.02	33.9	37.8	37.7	5'	Sparse sediment cover ove hard rock. Scattered Thalassia, Halodule, Acetabularia. Green sponges, black sponges, and burrows present	Center of basin; fair distance from any islands.
10	Middle of basin between Park and Russell	Feb		W 80 36.017'	N 25 05.817'	N/A	17.6	18.1	19.6	17.5	25.4	25.03	28.46	29.2	5'	Varied from exposed rocks to holes with ~ 4" of sediment. Plant material present (0 visibility prevented identification).	Center of basin between Park Key and Russell Key fair distance from any islands; deeper water with little sediment cover.
10	Center of basin between Park and Russell Key	July		W 80 34.991'	N 25 05.842'	± 100'	24.6	24.6	31.4	31.4	43.69	43.76	38.95	38.97	5'	Hard bottom with little substrate. Some algae and burrows.	Center of basin between Park Key and Russell Key fair distance from any islands; deeper water with little sediment cover.
11	Park Key SW bank	Feb	A - top of bank	W 80 34.010'	N 25 06.274'	N/A	18.9	18.7	22.1	19.8	28.2	27.05	30.56	30	0.5'	Soft gelatinous mud. Sparse Halodule.	Samples on mud bank 100 yrds to SW of key to south of Park Key. Key is sparsely developed mangrove island
11	Park Key SW bank	Feb	B - side of bank	W 80 34.010'	N 25 06.274'	N/A	18.9	18.7	22.1	19.8	28.2	27.05	30.56	30	1'	Thalassia present but not healthy. Soft mud.	Samples on mud bank 100 yrds to SW of key to south of Park Key. Key is sparsely developed mangrove island
11	Park Key SW bank	Feb	C - side of bank, deeper water	W 80 34.010'	N 25 06.274'	N/A	18.9	18.7	22.1	19.8	28.2	27.05	30.56	30	2'	Firm mud with dense Thalassia cover.	Samples on mud bank 100 yrds to SW of key to south of Park Key. Key is sparsely developed mangrove island

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SITE #	Location	Month Sampled	Sample	GPS Data Longitude	GPS Data Latitude	GPS Error ± l	Salinity (ppt) Top	Salinity (ppt) Bot-tom	Temperature (C) Top	Temperature (C) Bot-tom	Conductivity (MS) Top	Conductivity (MS) Bot-tom	Specific Concuctance (ms) Top	Specific Concuctance (ms) Bot-tom	Depth (ft.)	Bottom Conditions	General Area Description
11	Park Key SW bank	July	A - top of bank	W 80 34.134'	N 25 06.485'	± 92'	24.1	24	30.6	30.5	42.15	41.85	38.06	37.96	0.5'	Thalassia, soft, gelatinous mud.	Samples on mud bank 100 yrds to SW of key to south of Park Key. Key is sparsely developed mangrove island
11	Park Key SW bank	July	B - side of bank	W 80 34.134'	N 25 06.485'	± 92'	24.1	24	30.6	30.5	42.15	41.85	38.06	37.96	2'	Firm mud, with shell lag below. Thalassia present.	Samples on mud bank 100 yrds to SW of key to south of Park Key. Key is sparsely developed mangrove island
11	Park Key SW bank	July	C - side of bank, deeper water	W 80 34.134'	N 25 06.485'	± 92'	24.1	24	30.6	30.5	42.15	41.85	38.06	37.96	3.5'	Sparse Thalassia, soft mud.	Samples on mud bank 100 yrds to SW of key to south of Park Key. Key is sparsely developed mangrove island
11	Park Key SW bank	July	D - Very top of bank	W 80 34.134'	N 25 06.485'	± 92'	24.1	24	30.6	30.5	42.15	41.85	38.06	37.96	0.5-0"	Firm mud cap (algal mat?), burrowed with flat laminae, mud cracks where exposed.	Samples on mud bank 100 yrds to SW of key to south of Park Key. Key is sparsely developed mangrove island
12	Russell Key SE bank	Feb	A - top of bank	W 80 37.782'	N 25 04.044'	N/A	19	18.9	18.7	18.5	27.02	26.6	30.7	30.25	0.5'	Very soft mud with dense unhealthy Thalassia.	Taken about 200 yrds off Mangrove Island on top of mud bank and erosional side of bank.
12	Russell Key SE bank	Feb	B - sides of bank	W 80 37.782'	N 25 04.044'	N/A	19	18.9	18.7	18.5	27.02	26.6	30.7	30.25	1'	Firm shelly substrate; ~ 70% Thalassia.	Taken about 200 yrds off Mangrove Island on top of mud bank and erosional side of bank.
12	Russell Key SE bank	Feb	C - side of bank, deeper water	W 80 37.782'	N 25 04.044'	N/A	19	18.9	18.7	18.5	27.02	26.6	30.7	30.25	2.5'	Firm sticky mud with moderate Thalassia cover.	Taken about 200 yrds off Mangrove Island on top of mud bank and erosional side of bank.

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data			Salinity (ppt)		Temperature (C)		Conductivity (MS)		Specific Concuctance (ms)		Depth (ft.)	Bottom Conditions	General Area Description
				Longitude	Latitude	GPS Error ±	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom	Top	Bot-tom			
12	Russell Key SE bank	July	A - top of Bank	W 80 36.402'	N 25 03.309'	± 88'	26.9	23.4	31.4	31.5	42.1	37.21	47.19	41.89	0.5'	Shell lag with unhealthy Thalassia (~80% cover).	Taken about 200 yrds off Mangrove Island on top of mud bank and erosional side of bank.
12	Russell Key SE bank	July	B - side of Bank	W 80 36.402'	N 25 03.309'	± 88'	26.9	23.4	31.4	31.5	42.1	37.21	47.19	41.89	1.5'	Firm mud with large shell hash component; shell lag.	Taken about 200 yrds off Mangrove Island on top of mud bank and erosional side of bank.
12	Russell Key SE bank	July	C - side of bank, deeper water	W 80 36.402'	N 25 03.309'	± 88'	26.9	23.4	31.4	31.5	42.1	37.21	47.19	41.89	3.5'	Firm, gelatinous mud; some Thalassia present.	Taken about 200 yrds off Mangrove Island on top of mud bank and erosional side of bank.
12	Russell Key SE bank	July	D - top of the Bank	W 80 36.402'	N 25 03.309'	± 88'	26.9	23.4	31.4	31.5	42.1	37.21	47.19	41.89	0.5'	Shell lag deposit; sparse Halodule and live*Batillaria* present.	Taken about 200 yrds off Mangrove Island on top of mud bank and erosional side of bank.
13	Bob Allen mud bank	Feb	A - top of bank, grass	W 80 39.553'	N 25 01.390'	± 111'	26.8	27.2	25.2	19.8	42.18	37.9	41.9	42.15	0.5'	Soft mud with dense Thalassia. No transitional area between grass and mud areas.	~ 1/4 mile s. of Mangrove Island. Shallow mud flats & grassy areas extend out for quite some distance.
13	Bob Allen mud bank	Feb	B - side of bank, mud	W 80 39.553'	N 25 01.390'	± 111'	26.8	27.2	25.2	19.8	42.18	37.9	41.9	42.15	1'	Very soft gelatinous mud, no Thalassia. No transitional area between grass and mud areas.	~ 1/4 mile s. of Mangrove Island. Shallow mud flats & grassy areas extend out for quite some distance.
13	Bob Allen mud bank	Feb	C - side of bank, grass	W 80 39.553'	N 25 01.390'	± 111'	26.8	27.2	25.2	19.8	42.18	37.9	41.9	42.15	2.5'	Relatively firm mud with some shell debris and dense Thalassia.	~ 1/4 mile s. of Mangrove Island. Shallow mud flats & grassy areas extend out for quite some distance.
13	Bob Allen mud bank	July	A - top of bank, grass	W 80 39.398'	N 25 01.358'	± 184'	32.9	32.9	31.3	31.3	50.5	50.5	56.6	56.6	0.75'	Thalassia bed over soupy mud. Sharp patchiness as before - no transition between thick grass beds and gelatinous mud.	~ 1/4 mile s. of Mangrove Island. Shallow mud flats & grassy areas extend out for quite some distance.

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data Longitude	GPS Data Latitude	GPS Error ± l	Salinity (ppt) Top	Salinity (ppt) Bot-tom	Temperature (C) Top	Temperature (C) Bot-tom	Conductivity (MS) Top	Conductivity (MS) Bot-tom	Specific Concuctance (ms) Top	Specific Concuctance (ms) Bot-tom	Depth (ft.)	Bottom Conditions	General Area Description
13	Bob Allen mud bank	July	B - top of bank, mud	W 80 39.398'	N 25 01.358'	± 184'	32.9	32.9	31.3	31.3	50.5	50.5	56.6	56.6	0.75'	Gelatinous mud; 0.75' of mud covers old Thalassia bed. No lateral transition between thick grass beds and gelatinous mud.	~ 1/4 mile s. of Mangrove Island. Shallow mud flats & grassy areas extend out for quite some distance.
13	Bob Allen mud bank	July	C - side of bank, grass	W 80 39.398'	N 25 01.358'	± 184'	32.9	32.9	31.3	31.3	50.5	50.5	56.6	56.6	2.5'	Shelly soupy mud under dense Thalassia bed. No lateral transition between thick grass beds and gelatinous mud.	~ 1/4 mile s. of Mangrove Island. Shallow mud flats & grassy areas extend out for quite some distance.
13	Bob Allen mud bank	July	D - off bank	W 80 39.398'	N 25 01.358'	± 184'	32.9	32.9	31.3	31.3	50.5	50.5	56.6	56.6	3.5'	Gelatinous mud. No transition between thick grass beds and gelatinous mud.	~ 1/4 mile s. of Mangrove Island. Shallow mud flats & grassy areas extend out for quite some distance.
14	Bob Allen Key H2O mon. station	Feb	A - ~20m offshore	W 80 40.872'	N 25 01.577'	± 149'	28	28	19.9	19.4	39.1	38.72	43.37	43.43	1'	Soft sticky mud, Halodule predominant.	South side of Mangrove island near water monitoring station at western most Bob Allen Key.
14	Bob Allen Key H2O mon. station	Feb	B - ~ 40 m offshore	W 80 40.872'	N 25 01.577'	± 149'	28	28	19.9	19.4	39.1	38.72	43.37	43.43	3'	Very firm bottom with "crunchy" shell layer; ~ 20% Thalassia cover; abundant shell material present.	South side of Mangrove island near water monitoring station at western most Bob Allen Key.
14	Bob Allen Key H2O mon. station	July	A - ~20 m offshore	W 80 40.9'	N 25 01.59'	± 93'	33.5	33.4	31.3	31.3	51.2	51.1	57.4	57.2	1'	Very soft, soupy mud with ~ 30 % Halodule; surface covered with live *Batillaria* .	South side of Mangrove island near water monitoring station at western most Bob Allen Key.
14	Bob Allen Key H2O mon. station	July	B - ~40 m offshore	W 80 40.9'	N 25 01.59'	± 93'	33.5	33.4	31.3	31.3	51.2	51.1	57.4	57.2	2'	Firm mud with shell hash layer; scattered (~10-20%) Thalassia.	South side of Mangrove island near water monitoring station at western most Bob Allen Key.

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data Longitude	GPS Data Latitude	GPS Error ±	Salinity (ppt) Top	Salinity (ppt) Bot-tom	Temperature (C) Top	Temperature (C) Bot-tom	Conductivity (MS) Top	Conductivity (MS) Bot-tom	Specific Concuctance (ms) Top	Specific Concuctance (ms) Bot-tom	Depth (ft.)	Bottom Conditions	General Area Description
15	Gopher Pass - south side of channel cut	Feb	A - top of mudbank	W 80 43.630'	N 24 58.730'	± 88'	31.3	same	17.4	same	40.87	same	47.93	same	0.5'	Mud and shell lag on bank with unhealthy Thalassia covering surface.	Cut through n-s trending mud banks. Mangrove island just N ~ 200 yrds
15	Gopher Pass	Feb	B - top of bank, deeper water	W 80 43.630'	N 24 58.730'	± 88'	31.3	same	17.4	same	40.87	same	47.93	same	1'	Shelly substrate, with healthy Thalassia.	Cut through n-s trending mud banks. Mangrove island just N ~ 200 yrds
15	Gopher Pass	Feb	C - top of bank, next to channe	W 80 43.630'	N 24 58.730'	± 88'	31.3	same	17.4	same	40.87	same	47.93	same	2.5'	Firm shell lag.	Cut through n-s trending mud banks. Mangrove island just N ~ 200 yrds
15	Gopher Pass	July	A - top of bank, shell lag	W 80 44.212'	N 24 58.859'	N/A	37.1	same	28.8	same	N/A	N/A	N/A	N/A	1'	Shell lag on top of bank.	Cut through n-s trending mud banks. Mangrove island just N ~ 200 yrds
15	Gopher Pass	July	B - top of bank	W 80 44.212'	N 24 58.859'	N/A	37.1	same	28.8	same	N/A	N/A	N/A	N/A	1.5'	Dense Thalassia bed.	Cut through n-s trending mud banks. Mangrove island just N ~ 200 yrds
15	Gopher Pass	July	C - sides of bank	W 80 44.212'	N 24 58.859'	N/A	37.1	same	28.8	same	N/A	N/A	N/A	N/A	2.5	Thalassia overlying shell lag.	Cut through n-s trending mud banks. Mangrove island just N ~ 200 yrds
16	Mud Bank SW of Sid Key SE of Corinne Key	Feb	A - top of bank	W 80 45.889'	N 25 00.724'	± 115'	31.5	31.4	17.7	17.6	41.4	41.33	48.26	48.1	0.5'	Very soft, soupy mud. ~75% Thalassia coverage (unhealthy) with scattered Penicillus.	E-W trending mud bank, W of N-S trending islands and banks.
16	Mud Bank SW of Sid Key SE of Corinne Key	Feb	B - side of bank	W 80 45.889'	N 25 00.724'	± 115'	31.5	31.4	17.7	17.6	41.4	41.33	48.26	48.1	1.5'	Firm substrate, mud with shell lag. Thalassia unhealthy.	E-W trending mud bank, W of N-S trending islands and banks.
16	Mud Bank SW of Sid Key SE of Corinne Key	July	A - top of bank, grass	W 80 45.889'	N 25 00.75'	N/A	34.5	34.5	30.3	30.4	52.7	52.6	58	58	1'	~ 90% Thalassia beds on bank top covering soupy mud, w/ open areas of gelatinous mud.	E-W trending mud bank, W of N-S trending islands and banks.

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data Longitude	GPS Data Latitude	GPS Error ± l	Salinity (ppt) Top	Salinity (ppt) Bot-tom	Temperature (C) Top	Temperature (C) Bot-tom	Conductivity (MS) Top	Conductivity (MS) Bot-tom	Specific Concuctance (ms) Top	Specific Concuctance (ms) Bot-tom	Depth (ft.)	Bottom Conditions	General Area Description
16	Mud Bank SW of Sid Key SE of Corinne Key	July	B - side of bank	W 80 45.889'	N 25 00.75'	N/A	34.5	34.5	30.3	30.4	52.7	52.6	58	58	2.5'	Firm mud with shell debris and ~20% Thalassia. Bottom patchy with ~1m depressions with shell lag on bottom. No grass.	E-W trending mud bank, W of N-S trending islands and banks.
16	Mud Bank SW of Sid Key SE of Corinne Key	July	C - top of Bank, mud	W 80 45.889'	N 25 00.75'	N/A	34.5	34.5	30.3	30.4	52.7	52.6	58	58	1'	Open area of gelatinous mud over buried grass bed.	E-W trending mud bank, W of N-S trending islands and banks.
17	Rabbit Key H2O station	Feb	A - top of mudbank, shell lag	W 80 49.451'	N 44 58.895'	± 97'	30.7	same	17.6	same	40.4	same	47.05	same	1'	Shell lag from scour through Thalassia bed on top of mudbank.	Mud flats to east of mangrove island, separated from island by channel. Island used for overnight camping
17	Rabbit Key H2O station	July	A - top of bank, shell lag	W 80 49.535'	N 24 58.894'	± 91'	34.6	34.4	32.5	32.3	52.8	52.6	60.4	59.8	1'	Shell lag from scour through Thalassia bed on top of mudbank.	Mud flats to east of mangrove island, separated from island by channel. Island used for overnight camping
17	Rabbit Key H2O station	July	B - top of bank, grass	W 80 49.535'	N 24 58.894'	± 91'	34.6	34.4	32.5	32.3	52.8	52.6	60.4	59.8	1'	Soft sticky mud, with varying amounts of shell material; ~80% patchy Thalassia, some Halodule present where Thalassia sparse.	Mud flats to east of mangrove island, separated from island by channel. Island used for overnight camping.
17	Rabbit Key H2O station	July	C - Sides of bank	W 80 49.535'	N 24 58.894'	± 91'	34.6	34.4	32.5	32.3	52.8	52.6	60.4	59.8	3'	Soft marl with Thalassia.	Mud flats to east of mangrove island, separated from island by channel. Island used for overnight camping
18	Peterson Key H2O station	Feb	A - near island	W 80 44.829	N 24 55.100'	± 369'	31.3	same	17.7	same	41.31	same	48.1	same	0.5'	Soft mud with Halodule, sparse Thalassia; ~ 3m from mangrove roots.	NW side of mangrove island on mud flats just S of station. Channel separates mudflats from island.

Table 1: Field data from 18 monitoring sites sampled in February and July 1996 and discussed within this report.

SITE #	Location	Month Sampled	Sample	GPS Data: Longitude	GPS Data: Latitude	GPS Error ± I	Salinity (ppt): Top	Salinity (ppt): Bot-tom	Temperature (C): Top	Temperature (C): Bot-tom	Conductivity (MS): Top	Conductivity (MS): Bot-tom	Specific Concuctance (ms): Top	Specific Concuctance (ms): Bot-tom	Depth (ft.)	Bottom Conditions	General Area Description
18	Peterson Key H2O station	Feb	B - top of grass flat	W 80 44.830	N 24 55.100'	± 369'	31.3	same	17.7	same	41.31	same	48.1	same	0.5'	Soft, sticky mud, fairly high shell content, with Thalassia (unhealthy) cover.	NW side of mangrove island on mud flats just S of station. Channel separates mudflats from island.
18	Peterson Key H2O station	July	A - near island	W 89 44.829'	N 24 55.117'	± 238'	35.7	35	32.5	32.5	54.3	53.5	62.1	61.2	1'	Soft, soupy mud with Halodule.	NW side of mangrove island on mud flats just S of station. Channel separates mudflats from island.
18	Peterson Key H2O station	July	B - top of grass flat	W 89 44.829'	N 24 55.117'	± 238'	35.7	35	32.5	32.5	54.3	53.5	62.1	61.2	1'	Soft soupy mud; ~ 90% Thalassia with Halimeda.	NW side of mangrove island on mud flats just S of station. Channel separates mudflats from island.
18	Peterson Key H2O station	July	C - off north end of bank	W 89 44.829'	N 24 55.117'	± 238'	35.7	35	32.5	32.5	54.3	53.5	62.1	61.2	3.5'	Soupy, gelatinous mud.	NW side of mangrove island on mud flats just S of station. Channel separates mudflats from island.

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Previous Investigations

Numerous investigators have focused their efforts on the Florida Bay ecosystem. Florida Bay sediments were first mentioned by Agassiz (1888) when he noted that carbonate sedimentation was occurring within the bay. Dall (1892) stated "...much of the limy deposit of the area behind the reefs and defended by them is probably the result of the deposition of lime originally held in solution and precipitated by chemical action rather than of mechanically transported sediment." Sanford (1909) briefly mentioned the "marls" in Florida Bay and referred to the development of the banks and islands. Vaughan (1910) provided the first descriptions of the carbonates of Florida Bay. Matson (1910) gave detailed descriptions of textural and microscopic examinations of these sediments including grain size and composition.

Trask (1932, 1939) discussed the occurrence of organic matter in the bay sediments and provided the first estimates of its abundance. Thorp (1935, 1939) investigated the organisms that contributed to the accumulation of bottom sediments. He cited coralline algae, mollusks and foraminifers as major sediment producers. A note authored by Parker Trask in Thorp (1939) briefly described the bay sediments and environmental conditions. Thorp (1939) believed that the quartz grains found in the bay sediments came from the weathering and erosion of the Pleistocene Miami Limestone.

Ginsburg (1956), in a pivotal investigation of southern Florida carbonate sediments, studied the effects of depositional environments on grain sizes and constituent particle composition in Florida Bay and the reef tract. Ginsburg (1957) observed the organic and physical processes affecting the carbonate sediments during early diagenesis. He determined the organic processes observed were mainly a result of the effects of marine organisms on the sediment, including aggregation, particle size reduction and bioturbation. The physical processes mentioned included compaction, desiccation shrinkage, and penecontemporaneous deformation. Ginsburg and Lowenstam (1958) investigated the role of marine flora and fauna on the depositional environment of southern Florida carbonate sediments.

Stehli and Hower (1961) determined the mineralogy of carbonate sediments from southern Florida. They state “Carbonate sediments produced in warm shallow water, either by biochemical activity or a combination of biochemical and physiochemical processes, show a well defined composition in which aragonite predominates and in which high-magnesium calcite is dominant over low-magnesium calcite. About 70 % of the average shallow water carbonate sediment consists of unstable forms of $CaCO_3$.”

Fleece (1962) studied the carbonate geochemistry and sedimentology of Florida Bay sediments from cores taken on and near keys off Islamorada and Tavernier. Fleece provides an excellent review of the pre-1962 literature on the bay sediments. Eighty-five percent of the samples he examined contained more than 70 percent silt and clay sized carbonate and approximately 70 percent of the finer-than-sand-sized sediment occurred in the medium silt size range. He discussed the tendency for increasing organic matter content with decreasing grain size. Organic content reached as high as 36 percent of the sediment.

Taft and Harbaugh (1964) recognized a bimodal distribution of sediment particle sizes within the carbonate sediments of Florida Bay. They attributed the size distribution to several causes including 1) inorganic precipitation of very fine particles, 2) secretion of finer particles by organisms or by the interaction of particles with organic matter, 3) breakdown of skeletal material. They found little size variation with depth in the sediment. Dolomite was not found in the eastern half of Florida Bay.

The origin of the fine carbonate muds in southern Florida was dealt with by Stockman et al. (1967). They determined that the major contributor of fine aragonite mud was *Penicillus*, a calcareous algae. Ginsburg (1972) presented a compilation of textural and compositional data of the Florida Bay sediments showing the silt-clay-sized component of the sediments ranged from 10-92 percent with an average of 6.2 percent organic matter. Multer (1977) also provided a compilation of data on the Florida Keys carbonate sediments.

Analyses of the sediments from Peterson Key Bank (Kick, 1981) provide an accurate picture of the sediments present in this portion of the bay. Sand accounted for 10-80 percent of the sediment with an average of 38 percent. Silt and clay comprised 20-80 percent of the sediment with the clay fraction usually making up less than 30 percent of the total. The banks are composed primarily of silt in the 31-5.9 μ range. An investigation of the sediments of Florida Bay’s grass-covered mud banks (Holmquist et al., 1989) indicated that for the entire bay the silt-clay content averaged 56.3 percent, sand content 36.6 percent and gravel content 7.1 percent. Organic content was determined to range from 5.8 percent to 11.1 percent in the combined northeastern and east central portions of the bay.

Holmquist et al. (1989) recognized distinct exposed and sheltered zones at most of the sampling stations as had other investigations (Ginsburg, 1956; Ginsburg and Lowenstam, 1958; Turney and Perkins, 1972; Enos, 1977; Enos and Perkins, 1979; Bosence, 1989a). Enos and Perkins (1979) and Bosence (1989a) suggested that the exposed sides of the banks (the northeast-facing sides) were most subject to winnowing and erosion with the finer sediments deposited on the lee side and a lag deposit remaining on the windward side. Wanless et al. (1994) discussed the Holocene environmental history of the carbonate mudbanks of Florida Bay. The evolution of the islands has been investigated by Enos and Perkins (1979) and Wanless and Tagett (1989). Enos (1977) produced a Florida Bay surface sediment facies map showing the distribution of skeletal grainstones and packstones and peloidal skeletal wackestones. Note that Enos (1977) utilized a 63 µm break between grains and mud rather than the 20 µm Dunham (1962) used and did not recognize significant areas of mudstone (>90 % mud).

Bosence (1989b) determined that carbonate sediments in Florida Bay were produced by, in decreasing importance, *Thalassia* epibionts, mollusks, *Penicillus,* soritid foraminfera and *Halimeda*. The banks produced twice as much skeletal carbonate per unit area as the basins. However, the basins cover much more area than the banks and generate approximately four times more sediment than the banks. The sediment textures on the banks vary from mud-pebble conglomerates, packstones and grainstones on the windward side to wackestones and mudstones with basin-floor packstones on the leeward side and basin (Bosence, 1989a). Bosence (1989a) and Wanless and Tagett (1989) modified Dunham's (1962) mudstone definition to include more coarser material.[1]

Steinen and Tennet (1990) examined the origin of the fine-grained sediments of Florida Bay, the reef tract and the Great Bahama Bank. They state that the Florida Bay muds were primarily composed of equant one micron grains with less than 20 percent aragonite needles. Three main processes were responsible for the sediment production: 1) disintegration of skeletal encrustations, mainly red algae and spirorbid worm tubes, on *Thalassia* grass blades; 2) postmortem desegregation of aragonite needles from calcareous green algae; and 3) direct precipitation of aragonite and Mg-calcite from supersaturated marine waters.

The role of epibionts living on *Thalassia* in carbonate production was determined by Nelson and Ginsburg (1986) and Frankovich and Zieman (1994). The distribution of calcifying epibionts and the distribution of epiphyte production in Florida Bay appear to reflect salinity variations (Frankovich and Zieman, 1994). The variability of carbonate production by epibionts is great across the bay and regional variation exceeds seasonal variations at most sites (Frankovich and Zieman, 1994).

The occurrence of siliciclastics in the Florida Bay sediments has been briefly mentioned in many papers but very few focused on this sediment component. The origin and distribution of clay-sized silicate minerals in Florida Bay was investigated by Manker

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[1] In Dunham's (1962) definition of a mudstone, material coarser than 20µm cannot exceed 10%.

(1969). His results indicated two clay mineral assemblages - 1) an eastern Florida Bay chlorite dominated assemblage, and 2) a western Florida Bay montmorillonite dominated assemblage. The distribution of the clay minerals was thought to be controlled by source area influences. The occurrence and abundance of quartz grains in the sediments is mentioned in many of the papers cited here. Ginsburg (1956) found that greater than 125 µm quartz grains constitute up to 20 percent of the sediment. Fleece (1962) found up to 4.3 weight percent clear, subrounded, 0.5 mm to 0.125 mm quartz grains. Layman (1977) reported an easterly decrease in the abundance of quartz grains from the Gulf of Mexico toward the inner portions of Florida Bay.

Peat deposits are often found interbedded with marine carbonate sediments. The occurrence of peats is mentioned in a number of the Florida Bay investigations, most notably Enos and Perkins (1979) and Quinn and Merriam (1988). The most complete description and discussion of the Florida Bay peats is presented by Davies (1980).

Recent investigations of the lithology and variability of the Florida Bay sediments have been conducted in relation to the south Florida ecosystem restoration efforts. The sediments have been studied as a means of documenting the link between the sediments, sea level and onshore water management practices (Halley et al., 1995), recognizing natural and anthropogenic changes (Nelsen et al., 1996), sediment transport (Prager et al., 1996, 1997) and the age of the sediments (Halley et al., 1997). Wanless et al. (1995) presented data on sedimentation styles found in Florida Bay.

Geologic Setting Of Florida Bay

Florida Bay, a shallow, subtropical lagoon, lies at the southern tip of the Florida peninsula, east of the axis of the Florida Platform. The bay, a generally triangular-shaped area, covers nearly 2200 square kilometers. It is bounded to the north by the Everglades, to the south and east by the Florida Keys (a Pleistocene reef, Key Largo Limestone), and to the west by the Gulf of Mexico (Figure 1). The western boundary with the Gulf of Mexico is arbitrarily placed at the westernmost mudbanks extending south from Cape Sable to the Florida Keys (Wanless and Tagett, 1989). The most striking feature of Florida Bay is the "anastomosing array of shallow mudbanks composed of shelly calcareous silts that cordon the bay into a lacework of interconnected shallow basins..."(Scholl, 1966). Water depths in this important estuary reach a maximum of approximately 3 meters immediately behind the Keys and along the southwestern margin of the bay (Enos and Perkins, 1979). While the mudbanks may be exposed at low tide, the average depth of the basins is about 1.5 meters (Scholl, 1966.) Scholl (1966) estimated that approximately 1.5 X 10^9 cubic meters of calcareous sediment have accumulated in the bay.

The Holocene sediments of Florida Bay lie disconformably upon the late Pleistocene Miami Limestone. The Pleistocene limestone surface is generally planar, gently dipping (approximately 0.1 meter per kilometer to the southwest [Enos and

Perkins, 1979]) and microkarstic. The Miami Limestone is closest to sea level under the northeastern portion of the bay where it lies 1.5 meters below mean sea level (msl) and dips southwestward to -3.7 meters msl at the southwestern edge of the bay (Davies, 1980; Wanless and Tagett, 1989). Subtle irregularities occur on the bedrock surface. These include 1) larger, subcircular depressions up to more than 1.6 kilometers in diameter and up to 2.1 meters below the surrounding limestone surface, common beneath the broader banks and islands of western Florida Bay; 2) long, narrow, anastomosing depressions, up to one meter below surrounding bedrock, criss-cross larger circular depressions and are commonly associated with narrower mudbanks in the central and eastern bay; 3) deeper channel depressions exist in the bay adjacent to and paralleling the exposed Florida Keys (Davies, 1980).

The Holocene calcareous sediments have been deposited in Florida Bay during the last 4,000 years as rising sea level encroached upon the southern tip of the peninsula. The sediments are thinnest under the basins where the Miami Limestone is often exposed or buried by only a few centimeters. The thickest accumulations occur under the banks. An average of one meter of sediment occurs beneath the banks (Enos and Perkins, 1979) but may exceed 1.5 meters in some areas. Scholl (1966) estimated that mudbanks covered approximately 32 percent of Florida Bay. The banks are not equally distributed across the bay. In the eastern portion of the bay, small, narrow, discontinuous banks cover about 13 percent of the area while the broad, irregularly shaped banks in western Florida Bay occupy nearly 75 percent of the area (Scholl, 1966). Islands, irregularly distributed in the bay, evolved from the mudbanks (Enos and Perkins, 1979; Enos, 1989). The islands are least numerous in the western bay (0.76% of area), most common in the central bay (2.89% of area) and intermediate in the northeastern bay (1.88% of area) (Enos, 1989).

The mudbanks of Florida Bay have been classified in to four categories: 1) inner destructional zone in the eastern bay; 2) central migrational zone in the central part of the bay; 3) western constructional zone in western Florida Bay; and 4) outer destructional zone along the exposed western margin (Wanless and Tagett, 1989). Sampling for this report occurred in zones one and two. Zone one consists of smaller, more discontinuous, erosional mudbanks while zone two is a maze of narrow, more continuous mudbanks (Wanless and Tagett, 1989).

METHODS

Sample Collection:

Sediment samples were collected from 18 sites in Florida Bay during February and July 1996 (Figure 1; Table 1). Samples were collected by wading and snorkeling in water depths ranging from a few centimeters to two meters. Sampling via this method allowed us to make detailed observations of the substrate, the condition of flora and fauna, and microhabitats that existed at each site. Representative samples were obtained from the subenvironments recognized at each location. For each location, the environmental conditions including surface and bottom salinity and temperature, water depth, and substrate were recorded (Table 1). Salinity, temperature, and conductivity measurements were taken with a YSI Model 30 hand-held instrument.

At each site, at least one push core (4 cm diameter clear plastic tube) and one bag sample (approximately four liters) were collected. When a number of subenvironments occurred at a site, each subenvironment was sampled. Push cores were obtained by pushing the plastic tubing into the substrate as deep as possible. The tubes were capped to maintain a vacuum and extracted from the substrate. Push cores were cut at the sediment-water interface and sealed to prevent sediment disruption. Bag samples were taken by scooping the upper ten centimeters of sediment into a one gallon plastic bag. The samples analyzed and discussed in this report represent a subset of the total number of samples taken.

Sediment Analyses:

The sediment samples analyzed for this investigation were taken from the one gallon bag samples collected at each site. Samples taken in both February and July were analyzed. Analyses performed on the samples include visual examination under a binocular microscope, wet sieving, acid dissolution of the carbonate fraction and organic matter digestion.

Samples examined visually utilizing a binocular microscope were classified based upon Dunham (1962) and subsequent modifications by Enos (1977) and others. The break between grains and mud in Dunham's (1962) classification was at 20 µm; Enos (1977) used a 63 µm break. Bosence (1989a) used mudstone to denote sediments with greater than 50 % sediment finer than 63 µm. In this analysis, we used the 63 µm break between grains and mud and a sample was referred to as a mudstone if it contained more than 90 % mud by visual estimate.

Subsamples of sediments collected at selected sites were prepared for grain size analysis utilizing a modification of Ginsburg's (1956) method. Approximately 50 grams of dried sediment were weighed on a Metler Toledo PG 803 balance and placed in a ten percent H_2O_2 solution for up to 48 hours. Some samples dissaggregated completely under this treatment. However, other samples did not thoroughly disaggregate, resulting in an abundance of sediment clumps. Sediments that did not disaggregate completely were placed in a Calgon solution and submerged in an ultrasonic bath for 10 minutes to one hour. Despite these efforts, a number of samples continued to contain varying amounts of sediment clumps. As a result, the recorded percentage of sediment finer than 63 µm from these samples can be considered as a minimum only. Efforts are continuing to develop a method to totally disaggregate the sediments.

Prepared samples were wet sieved at .5 phi intervals from -1.0 to 4.0 phi (2.0 mm to 63 µm). The sediments retained on each screen were dried, weighed and visually examined for grain-type identification. A grain-size distribution was determined for the selected samples.

Approximately 20 grams of sediment were taken from each sample for acid dissolution and organic digestion to examine the amount and types of insoluble residues. Samples were weighed on a Metler Toledo PG 803 balance and submerged in a 10 percent HCl solution. Each sample remained in the HCl until the sediment no longer reacted to a fresh HCl solution. The acid-insoluble residue was washed to remove residual HCl, dried and weighed to determine percent total insoluble plus organics.

Following acidulation, the acid-insoluble residues were treated with an approximately 20 to 30 percent warm H_2O_2 solution to remove organics. The samples remained in the H_2O_2until all evidence of the reaction ceased. The remaining sediment was washed to remove residual H_2O_2, dried and weighed to determine total insoluble content and calculate the organic content. The remaining sediment was visually examined.

DISCUSSION OF RESULTS

Lithology

The lithologies of the sediments collected from the 18 sites in Florida Bay during 1996 ranged from mudstones (gelatinous muds) to grainstones (lag deposits) (Figures 2 to 8). Most commonly, the sediments were wackestones to packstones containing varying percentages of mollusks, foraminifers, ostracodes, bryozoans, other faunal elements and organic matter, usually seagrass. Quartz grains were coated with carbonate and were not recognizable upon examination of the bulk sediment.

The condition of the mollusks contained in the sediment varied from well preserved to having a leached, weathered appearance. In general, the mollusks were well preserved at the majority of sites. Weathered shell was most common at Site 1 in a shell lag found in the channel.

There was little evidence of seasonal variation in the samples analyzed from these sites. A possible seasonally-controlled variation in organic content was observed in a comparison of February and July samples from a few sites. This limited data suggested a higher organic component in the February samples.

Figure 2: Photograph of grainstone from site 6 (Feb C) (dried unprocessed sample). This sample is from a lag deposit above the water line on the beach. The high-spired gastropod *Batillaria* is the predominiant mollusc present. Also present is *Diodora* sp. and a serpulid worm tube.

Figure 3: Photograph of packstone/wackestone from site 6 (Feb A) (dried unprocessed sample). This sample is from a coarse grained deposit just below water level at the beach. The unfragmented molluscs present include *Chione cancellata* and *Batillaria*.

Figure 4: Photograph of packstone/wackestone from site 12 (Feb B) (dried unprocessed sample). This sample is from a Thalassia bed overlying a firm shelly substrate in 1 foot of water on the sides of the bank at site 12. Most molluscs present are fragmented.

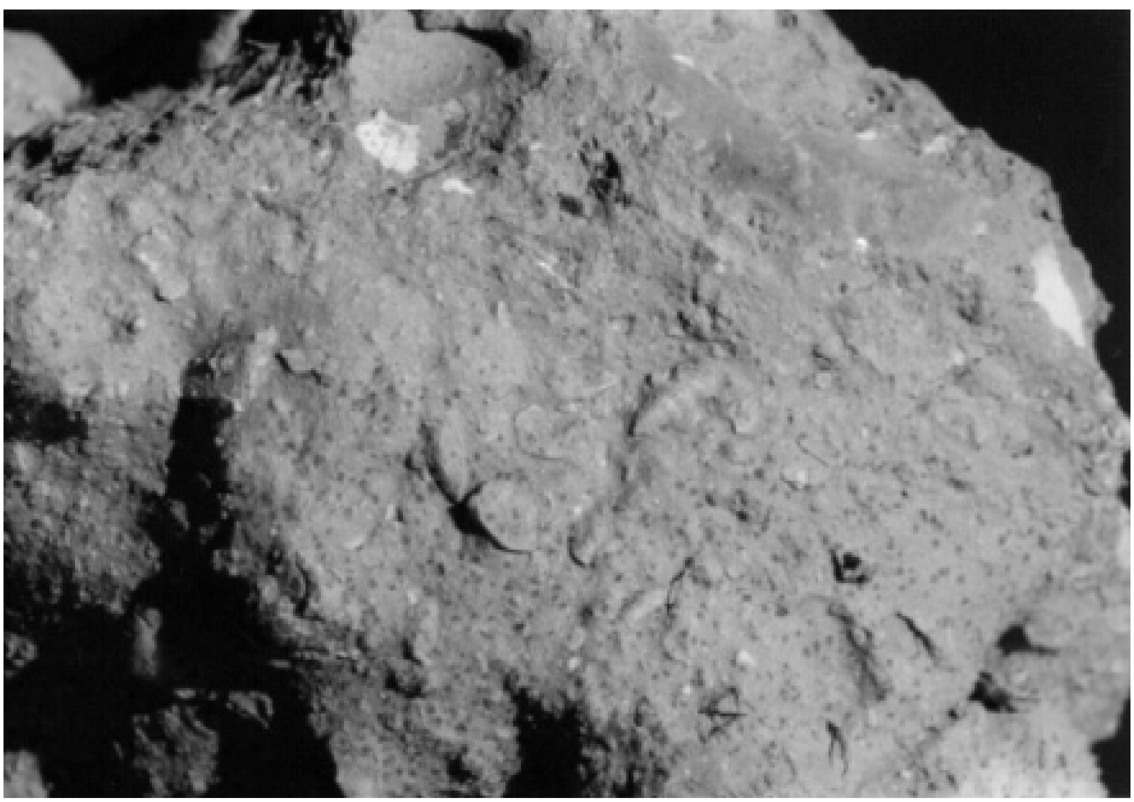


Figure 5: Photograph of packstone/wackestone from site 12 (Feb C) (dried unprocessed sample). This sample is from the sides of the bank at site 12 in 2.5 feet of water. Note the decreased amount of visible shell material compared to Fig. 4 (site 6 Feb B).

Figure 6: Photograph of packstone/wackestone from site 3 (July B) (dried unprocessed sample). This sample is a mix of finely crushed shell and mud, forming a firm substrate in a small inlet at site 3, in 1 foot of water.

Figure 7: Photograph of packstone/wackestone from site 10 (July) (dried unprocessed sample). This sample is from the center of the basin south of Little Madeira Bay in 5 feet of water. Little sediment is present in the center of the basins.

Figure 8: Photograph of mudstone from site 13 (July D) (dried unprocessed sample). This sample is from 3.5 feet of water off the bank at site 13 in a clear mud area with no vegetation present. This site has very distinct areas of clear mud, which border vegetated areas, with virtually no transition zone between the two substrates.

Insoluble Residues

Samples from all 18 sites collected during 1996 were analyzed for insoluble residues. At selected sites, samples from the top and side of the mudbank were analyzed while only a single sample from the remaining sites was treated. Percent insolubles ranged from a minimum of 0.8 % in a shell lag at Site 6 (July E) (see Table 2 and Figures 9 - 11) to a maximum of 11.5 % at Site 5 (Feb B) averaging 5.1 %. These results fall within the range of percentage insoluble cited by Ginsburg (1956) and Fleece (1962).

Visual examination of the insoluble residues revealed the presence of rounded to subangular quartz grains in the medium sand to silt size range (350 to 31 μm). Clay minerals appeared to be present in all samples. Visual comparison indicated a high degree of variability in the concentration of clay-sized insoluble components. Siliceous spicules and diatom frustules were present in widely varying amounts in virtually all samples.

A trend in the proportions of the insoluble constituents moving from the northeast to the southwest was recognized during the visual examination. There was more quartz sand and silt in the samples from the northernmost portion of the bay closer to the mainland than in the southwest portion. The clay sized proportion increased in comparison to the silt and sand sized component toward the southwest. Grains of coarse and medium sand-sized quartz occurred in samples from Site 1 (July A, C). In most samples, the first appearance of quartz grains occurred in the fine to very fine grain size.

A component of Florida Bay's insoluble residues may be dust particles originating in Africa and transported into this area by the prevailing winds (Shinn, personal communication, 1997). Shinn (personal communication, 1997) hypothesized that the influx of African dust may play an important role in ecosystem changes, and may explain some of the negative trends seen in recent years. Further analyses may document the presence of the dust incorporated in the carbonate sediments of Florida Bay.

Organic Content

Sediments from all 18 sites collected during 1996 were analyzed for percent organic matter. Organic matter present in the samples ranged from 1.43 % at Site 9 (July) to 18.05 % at Site 13 (Feb B) with an average of 7.6 % for the entire area sampled (Table 2 and Figures 9-11). The two sites with the lowest percentage of organic matter in the sediments occurred in the middle of basins, Site 9 (July) in Little Maderia Bay and Site 10 (Feb) in the middle of the basin south of Little Maderia Bay.

Peat was encountered at a few sites sampled for this investigation. These organic sediments are reddish brown, presumably mangrove peats.

Table 2: Sediment analysis data for Florida Bay samples collected in February and July 1996.

Site number (Sample)	Percent organics	Percent insolubles	Percent carbonate	Percent total sediment finer than sand	Description of the insoluble residues.[1]
1 (Feb A)	5.52	7.63	86.85		
1 (Feb C)	7.37	8.78	83.85		Sand, silt, clay, spicules.
1 (July A)	9.94	7.89	82.17	37.6	Abundant fine-medium sand, some silt, clay, spicules.
1 (July C)				43.5	
2 (Feb A)	4.89	7.54	87.57		Mostly silt; clay, sand rounded to sub-angular, spicules, charcoal.
2 (Feb B)	11.31	8.33	80.36	30.6	Silt and clay, sand, spicules.
2 (July A)	8.04	7.51	84.45	30.1	Mostly clay; silt, vf sand, spicules.
2 (July B)	14.21	4.89	80.9		Abundant silt, vf sand, clay, spicules abundant.
3 (Feb A)	11.13	7.8	81.07		Abundant fine-medium sand, silt clay, spicules.
3 (July A)	10.33	6.96	82.71		
3 (July B)	2.15	6.93	90.92		
4 (Feb B)	9.63	5.25	85.12		Silt, sand, clay, spicules.
4 (Feb C)	8.89	6.7	84.41		Silt, sand, clay, spicules.
4 (July A)	2.9	4.06	93.04		
5 (Feb A)	9.51	5.63	84.86		Abundant silt, sand, clay, abundant spicules.
5 (Feb B)	15.94	11.5	72.56		Abundant silt, sand, clay, abundant spicules.
5 (July B)	3.2	3.03	93.77		
6 (Feb B)				13.8	Clay, very little silt and sand.
6 (July A)	0.6	1.59	97.81	16.5	
6 (July E)	7.78	0.8	91.42		
7 (Feb A)	7.35	3.96	88.69		Silt, clay, sand, spicules.
7 (Feb B)	6.33	3.87	89.8		Silt, clay, sand, spicules.
7 (July A)	3.13	2.77	94.1		
7 (July B)	8.53	1.47	90		
8 (Feb A)	3.15	4.62	92.23	26.9	Abundant clay and silt, some sand, spicules, fish scales.
8 (Feb B)	4.32	8.95	86.73		Gray clay, little silt/sand, spicules.
8 (July A)	2.44	2.67	94.89		Clay, silt, some vf sand, few spicules.
8 (July B)	1.72	5.99	92.29		Abundant clay, silt, some vf sand, few spicules.
9 (Feb)	6.6	4.37	89.03	20.6	
9 (July)	1.43	4.31	94.26		Abundant silt to vf sand, some clay, few spicules.
10 (Feb)	2.46	4.54	93	17.8	Clay, lot of sand, silt, few spicules.

Table 2: Sediment analysis data for Florida Bay samples collected in February and July 1996.

Site number (Sample)	Percent organics	Percent insolubles	Percent carbonate	Percent total sediment finer than sand	Description of the insoluble residues.[1]
10 (July)	0.85	3.18	95.97		
11 (Feb A)	4.32	6.68	89		Abundant clay, silt, some vf sand, few spicules.
11 (Feb B)	5.91	5.57	88.52		Abundant clay, silt, some vf sand, few spicules.
11 (Feb C)	5.5	6.69	87.81		Abundant clay, silt, fine-medium sand, abundant spicules.
11 (July A)	5.28	5.89	88.83		
11 (July A)	2.2	6.14	91.66		
11 (July B)	5.09	3.25	91.66		
12 (Feb A)	11.88	6.45	81.67	33.8	Abundant clay, silt to vf sand, few spicules.
12 (Feb C)	13.66	6.2	80.14		Abundant clay, silt to vf sand, spicules.
12 (July A)	3.26	2.04	94.7		Silt and clay, little sand, spicules.
12 (July B)	2.54	3.19	94.27		Abundant medium-fine sand, silt, clay, spicules.
12 (July C)	4.45	4.81	90.74		Clay, silt, sand, spicules.
12 (July D)	7.31	2.47	90.22		Clay, silt, sand, spicules.
13 (Feb A)	8.61	4.75	86.64		
13 (Feb B)	18.05	6.13	75.82		
13 (Feb C)	11.6	5.17	83.23		
14 (Feb A)	12.07	4.99	82.94		
14 (Feb B)	3.07	1.81	95.12		Sand, silt, clay.
15 (Feb A)	6.09	4.51	89.4		Clay, silt, and little sand, spicules.
16 (Feb A)	7.11	4.69	88.2		
16 (Feb B)	5.72	3.51	90.77		Gray clay, silt, minor sand, spicules.
17 (Feb A)	11.81	4.77	83.42		Abundant clay, silty, little sand, few spicules.
17 (July B)				37.2	
17 (July C)				37.5	
18 (Feb B)	9.99	4.74	85.27		

[1] Description based on cursory examination of residue samples under binocular microscope

Figure 9: Percent by weight of non-carbonate sediment component (organics and insolubles) from the northeast basin of Florida Bay (sites 1-6).

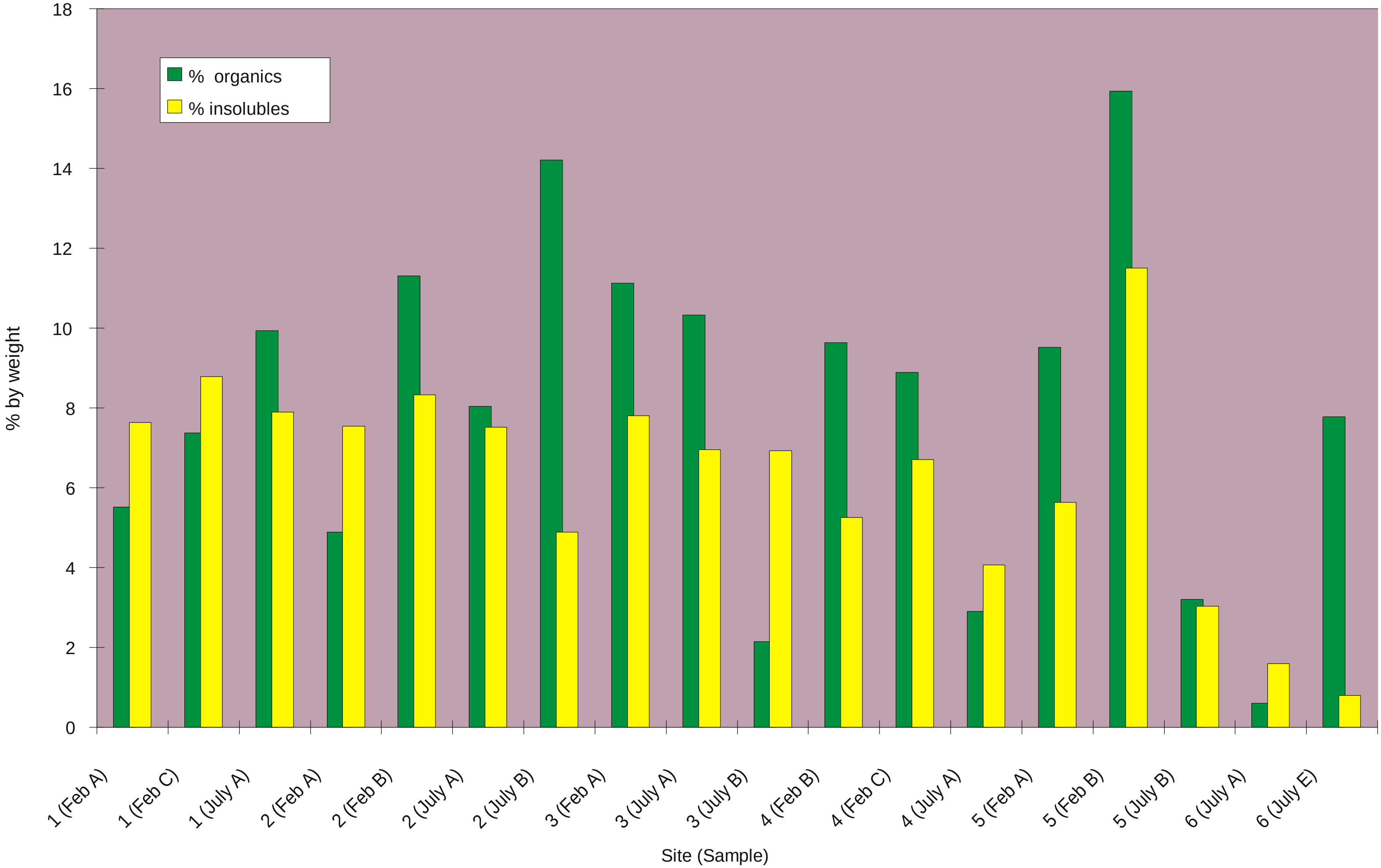


Figure 10: Percent by weight of non-carbonate sediment component (organics and insolubles) from the basin south of Little Madeira Bay, in Florida Bay (sites 8-12).

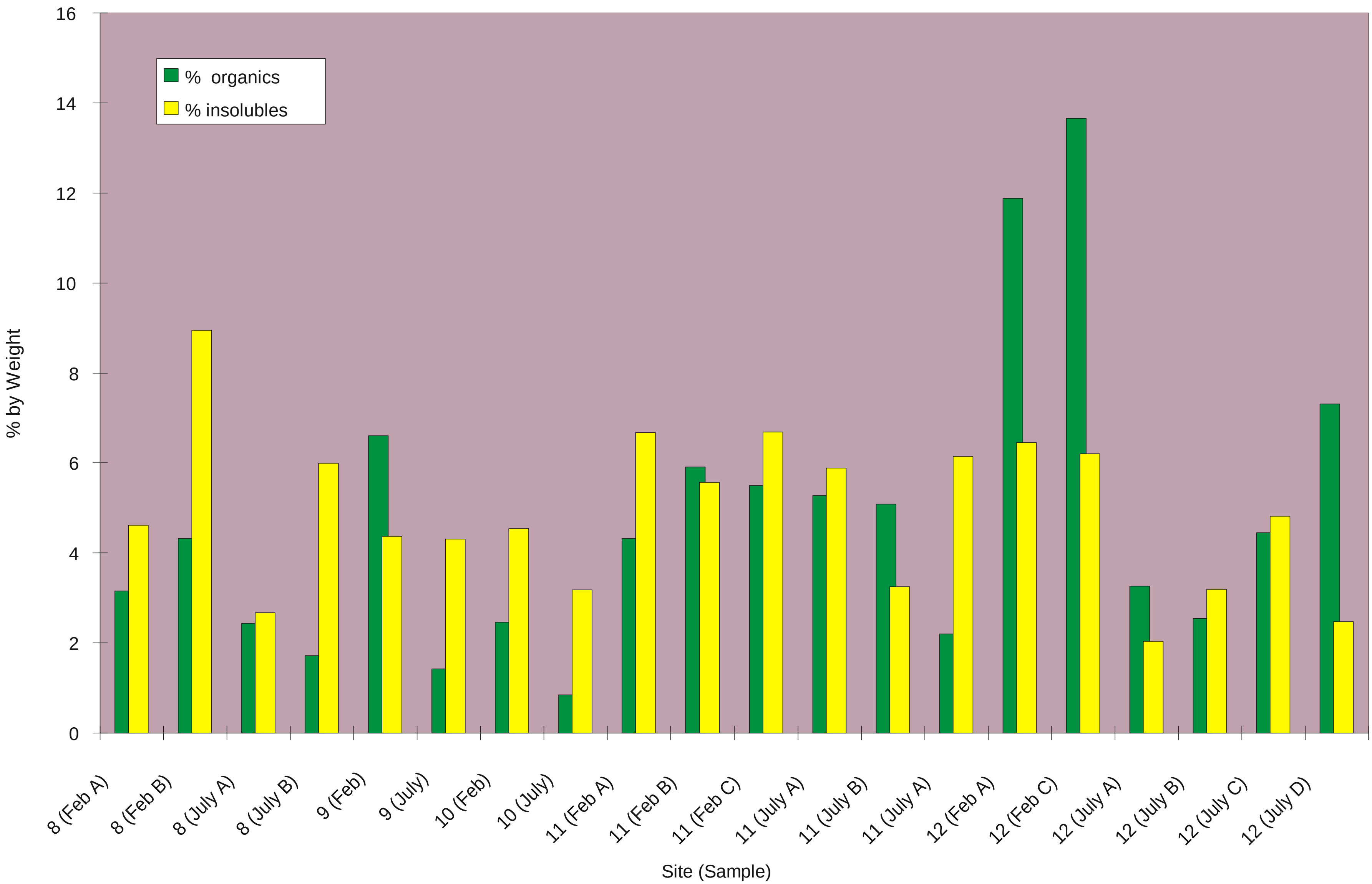
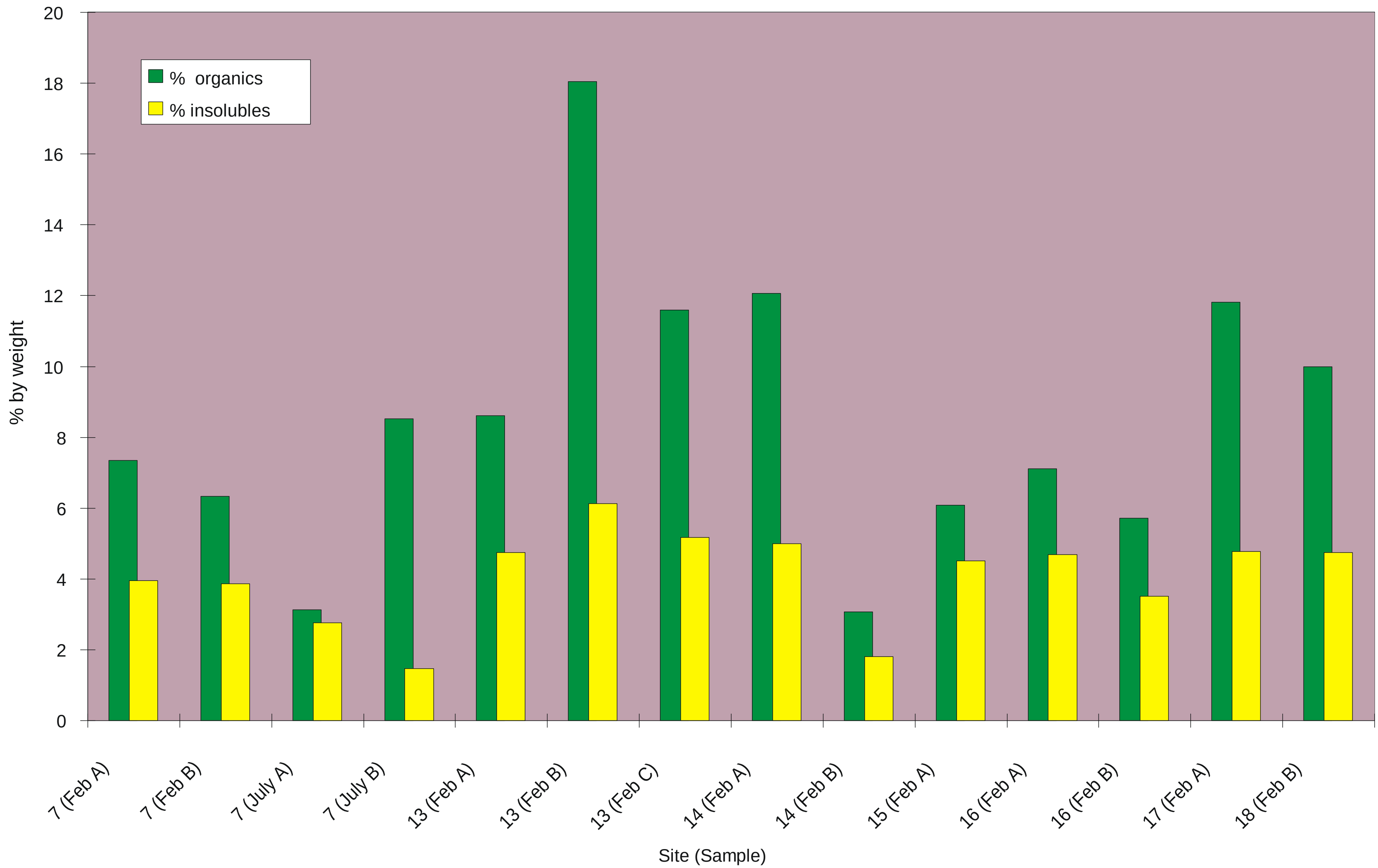


Figure 11: Percent by weight of non-carbonate sediment component (organics and insolubles) from the southern portion of study area in Florida Bay (sites 7, 13-18).



Grain-Size Analysis

Twelve samples from 1996 were analyzed for grain-size distribution. Despite difficulties in completely disaggregating some samples, valid results were obtained for selected sites. The results of wet sieving samples are presented in Table 2. Since the percentage of mud (<63 µm, 4.0 phi) is important in the determination of the sediment texture, particular attention was given to obtaining completely disaggregated sediment for this analysis. In the analyzed samples, the percentage of mud ranged from 13.75 % on the side of the bank at Site 6 (Feb B) to 63.62% on top of the bank at Site 17 (July B) (Table 2 and Figure 12).

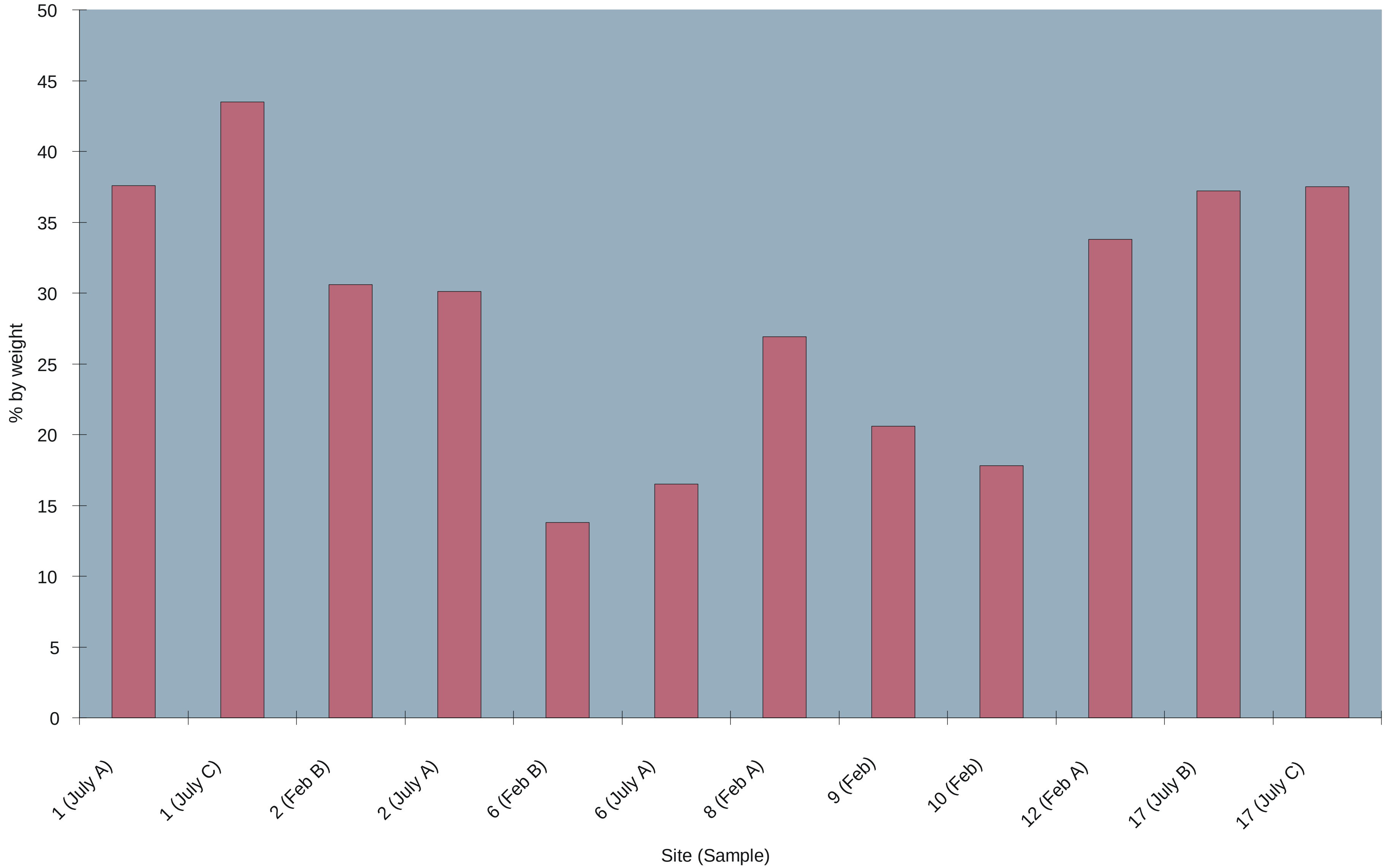
Selected disaggregated samples were wet sieved at 0.5 phi intervals to examine the types of grains in each size fraction. Whole and large fragments of mollusks occurred in the 2 mm to 0.5 mm range with the percentage of whole shells decreasing rapidly. In samples finer than 0.5 mm, most mollusks were fragmented. Large soritid foraminifers were common in the coarser than 0.5 mm fraction. Smaller miliolid, rotaliid, and elphidiid foraminifers (Lidz and Rose, 1989) were very common in the 0.71 mm and finer size range. Micro-gastropods (*Caecum* sp.) and ostracods are common in the 0.5 mm to 0.0625 mm samples. Spicules and worm tubes were present in many samples.

SUMMARY

Florida Bay's intricate ecosystem has undergone significant changes due to natural influences and human intervention. Modern sediment samples have been collected on a semi-annual basis in order to determine the distribution and characteristics of the sediments and the associated fauna and flora, and to determine the frequency of change on a seasonal scale. The distribution of modern fauna and flora collected from 14 sites collected in 1995 were presented by Brewster-Wingard et al. (1996); a report on the fauna and flora from the 1996 sites is planned.

Carbonate sediments from 18 sites in Florida Bay were analyzed for lithology, organic content, insoluble residues, percent of sediment finer than 63m, and percent total carbonate. The carbonate sediments of Florida Bay vary from mudstones to grainstones with the majority of the sediments being wackestones to packstones. The sediments contain mollusks, foraminifers, bryozoans, and other faunal components in varying concentrations. Organic material occurs as seagrass blades and roots and disseminated organic matter. The organic content ranges from 1.43% to 18.05% with an average of 5.1%. Insoluble residues consist of quartz sand and silt, clay-sized particles and siliceous microfossils. The insoluble residue content of the carbonate sediments ranges from 0.8% to 11.5%, averaging 7.6%. The total carbonate content of the sediments varied from 72.56% to 97.81%. The percentage of the sediment finer than 63µm ranges from 13.75% to 63.62%.

Figure 12: Percent by weight of sediment finer than sand based on grain-size analysis.



Additional data gathering and a comparison of our data to that of Prager (Prager et al. 1996, 1997) and Halley (Halley et al., 1997) will be necessary to determine if any trends in sediment distribution exist. The data presented here, however, suggest a northeast to southwest trend of decreasing insoluble residue content and a possible seasonal trend in organic matter. Samples from several sites had higher organic content in the February samples and lower organic content in the July samples. No geographical trend in organic matter was recognized.

Analyses of the sediments collected during the semi-annual monitoring and field collection in Florida Bay are continuing. Beginning in February 1997, the sediment sampling procedures were altered. Sediment samples are collected in five centimeter clear plastic tubes pushed into the sediment. For the 1997 samples, push cores from selected sites will be analyzed. Analyses of push cores will include overall lithology, sediment grain size distribution and texture, and sediment structures. These data will be linked to faunal and floral analyses in order to develop an understanding of the links between the physical and biological components of the Florida Bay ecosystem.

REFERENCES CITED

Agassiz, A., 1888, Three cruises of the United States Coast and Geodetic Survey Steamer "Blake": Bulletin, Museum Comparative Zoology, Harvard, v. 14, p. 286-287.

Bosence, D., 1989a, Surface sublittoral sediments of Florida Bay: Bulletin of Marine Sciences, v.44, no.1, p. 434-453.

__________, 1989b, Biogenic carbonate production in Florida Bay: Bulletin of Marine Science, v. 44, no. 1, p. 419-433.

Brewster-Wingard, G.L., Ishman, S.E., Edwards, L.E., and Willard, D.A., 1996, Preliminary report on the distribution of modern fauna and flora at selected sites in north-central and northeastern Florida Bay: US Geological Survey Open-file Report 96-732, 34p.

____________________, Ishman, S.E., Willard, D.A., Edwards, L.E., and Holmes, C.W., 1997, Preliminary paleontologic report on cores 19A and 19B, from Russell Bank, Everglades National Park, Florida Bay: US Geological Survey Open-file Report 97-460, 29p.

Dall, W.H., 1892, Correlation papers-Neocene: US Geological Survey Bulletin 84, 349 p.

Davies, T.D., 1980, Peat formation in interpreting the recent vegetational and geological history of the bay area: unpublished Ph.D. dissertation, Pennsylvania State University, 316 p.

Dunham, R.J., 1962, Classification of carbonate rocks according to depositional texture: *in* Ham, W.E., (editor), Classification of carbonate rocks: American Association of Petroleum Geologists, p. 182-191.

Enos, P., 1977, Holocene sediment accumulations of south Florida shelf margin: *in* Enos, P., and Perkins, R.D., (editors) Quaternary sedimentation in south Florida: Geological Society of America Memoir 147, p. 1-130.

_______, 1989, Islands in the bay- A key habitat of Florida Bay: Bulletin of Marine Science, v.44 no.1, p. 365-386.

_______, and Perkins, R.D., 1979, Evolution of Florida Bay from island stratigraphy: Bulletin of Geological Society of America, v. 90, p. 59-83.

Fleece, J.B., 1962, The carbonate geochemistry and sedimentology of Florida Bay: unpublished M.S. thesis, Florida State University, 112 p.

Frankovich, T.A., and Zieman, J.C., 1994, Total epiphyte and epiphytic carbonate production on Thalassia testudinum across Florida Bay: Bulletin of Marine Science, v. 54, no. 3, p. 679-695.

Ginsburg, R.N., 1956, Environmental relationships of grain size and constituent particles in some south Florida carbonate sediments: Bulletin American Association of Petroleum Geologists, v. 40, no. 10, p. 2384-2427.

_______________, 1957, Early diagenesis and lithification of shallow-water carbonate sediments in south Florida: *in* Le Blanc, R.J. and Breeding, J.G., (editors), 1957, Regional aspects of carbonate deposition: Society of Economic Paleontologists and Mineralogists, Special Publication 5, p. 80-100.

_____________, 1972, Texture and composition of Florida Bay sediments: *in* Ginsburg, R.N., (editor), South Florida carbonate sediments: Sedimenta II, Rosenstiel School of Marine and Atmospheric Science, University of Miami, p. 19-44.

_____________, and Lowenstam, 1958, The influence of marine bottom communities on the depositional environment of sediments: Journal of Geology, v. 66, p. 310-318.

Halley, R.B., Holmes, C., Robbins, J.A., Bothner, M.K., and Rudnick, D.T., 1995, Florida Bay salinity: Fragile links between sediments, sea level, and onshore water management (abstract): Florida Bay Science Conference, Abstracts and Program, October 17-18, 1995, Gainesville, FL., p. 106.

Halley, R.B., Holmes, C., and Prager, E.J., 1997, Florida Bay mudbanks: Relatively new piles of mostly old sediment (abstract): *in* U. S. Geological Survey program on the South Florida ecosystem - Proceedings of the technical symposium in Ft. Lauderdale, Florida, August 25-27, 1997: U. S. Geological Survey Open-file Report 97-385, p. 26-27.

Holmquist, J.G., Powell, G.v.N., and Sogard, S.M., 1989, Sediment, water level and water temperature characteristics of Florida Bay's grass-covered mud banks: Bulletin of Marine Sciences, v. 44, no. 1, p. 348-364.

Ishman, S.E., Brewster-Wingard, G.L., Willard, D.A., Cronin, T.M., Edwards, L.E., and Holmes, C.W., 1996 Preliminary paleontologic report on core T-24, Little Madeira Bay, Florida: US Geological Survey Open-file Report 96-543, 47p.

Kick, R.M., 1981, Carbonate sediments from Peterson Key Bank, Florida Bay: unpublished M.S. thesis, University of South Florida, 101 p.

Layman, J.W., 1977, Acid insoluble residues of the carbonate sediments of northwest Florida Bay, south Florida: unpublished M.S. thesis, University of Toledo, 78p.

Lidz, B.H., and Rose, P.R., 1989, Diagnostic foraminiferal assemblages of Florida Bay and adjacent shallow waters: A comparison: Bulletin of Marine Science, v. 44 no. 1, p. 399-418.

Manker, J.P., 1969, Origin and distribution of silicate minerals in a carbonate environment - Florida Bay: unpublished M.S. thesis, University of South Florida, 49 p.

Matson, G.C., 1910, Report on examination of material from the sea-bottom between Miami and Key West: *in* Vaughan, T.W., 1910, A contribution to the geologic history of the Floridian plateau: Carnegie Institute of Washington, Publication no. 133, Papers of the Tortugas Laboratory, v. 4, p. 120-125.

Multer, H.G., 1977, Field guide to some carbonate rock environments: Florida Keys and western Bahamas: Kendall/Hunt Publishing Co., Dubuque, Iowa, 415 p.

Nelsen, J.E., and Ginsburg, R.N., 1986, Calicum carbonate production by epibonts on Thalassia in Florida Bay: Journal of Sedimentary Petrology, v. 56, p. 622-628.

Nelsen, T.A., Zetwo, M., Wanless, H.R., Blackwelder, P., Swart, P., Hood, T., Alvarez-Zarikian, Trefry, J., Metz, S., Kang, W., Trocine, R., Tedesco, L., Capps, M.A., and O'Neal, M.A., 1996, The sediment record as a monitor of natural and anthropogenic changes in the lower Everglades/Florida Bay ecosystem: A high resolution study (abstract): 1996 Florida Bay Science Conference, December 10-12, 1996, Key Largo, Fl., p. 62-65.

Prager, E.J., Halley, R.B., and Hansen, M., 1996, Sediment transport processes and sea-floor mapping in Florida Bay (abstract): 1996 Florida Bay Science Conference, December 10-12, 1996, Key Largo, Fl., p. 68-69.

Prager, E.J., Halley, R.B., and Orton, P., 1997, Sediment resuspension, surface properties and seagrass in Florida Bay (abstract): *in* U. S. Geological Survey program on the South Florida ecosystem - Proceedings of the technical symposium in Ft. Lauderdale, Florida, August 25-27, 1997: U. S. Geological Survey Open-file Report 97-385, p. 69-70.

Quinn, T.M., and Merriam, D.F., 1988, Evolution of Florida Bay islands from a supratidal precursor: Evidence from westernmost Bob Allen Key and Sid Key: Journal of Geology, v. 96, p. 375-381.

Sanford, S., 1909, the topography and geology of southern Florida: Florida Geological Survey 2nd Annual Report, p. 178-231.

Scholl, D.W., 1966, Florida Bay: A modern site of limestone formation: *in* Fairbridge, R.W., (editor), The Encyclopedia of Oceanography: Reinholt Publishing Co., New York, p. 282-288.

Stehli, F.G., and Hower, J., 1961, Mineralogy and diagenesis of carbonate sediments: Journal of Sedimentary Petrology, v. 31, p. 358-371.

Steinin, R., and Tennet, P., 1990, Origin of fine-grained Holocene shallow marine carbonate sediment on the Florida-Bahama Platform (abstract): American Association of Petroleum Geologists, v. 74 no. 5, p. 771.

Stockman, K.W., Ginsburg, R.N., and Shinn, E.A., 1967, The production of lime mud by algae in south Florida: Journal of Sedimentary Petrology, v. 37, p. 633-648.

Taft, W.H., and Harbaugh, J.W., 1964, Modern carbonate sediments of southern Florida, Bahamas and Espiritu Santo Island, California: A comparison of their mineralogy and chemistry: Stanford University Publication of Geological Science, v. 8, no. 2, 133 p.

Thorp, E.M., 1935, Calcareous shallow-water marine deposits of Florida and the Bahamas: Carnegie Institute of Washington publication 452, p. 37-143.

__________,1939, Florida and Bahama marine calcareous deposits: *in* Trask, P.D. (editor), Recent Marine Sediments, American Association of Petroleum Geologists, p. 283-297.

Trask, P.D., 1932, Origin and environment of source sediments of petroleum: Houston Gulf Publishing Company, 323 p.

_________,1939, Organic content of Recent marine sediments: *in* Trask, P.D. (editor), Recent Marine Sediments, American Association of Petroleum Geologists, p. 428-453.

Turney, W.J., and Perkins, B.F., 1972, Molluscan distribution in Florida Bay: Sedimenta III, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, 37 p.

Vaughan, T.W., 1910, A contribution to the geologic history of the Florida Platform: Carnegie Institute of Washington Publication 133, p. 114-145.

Wanless, H.R., Nelsen, T.A., Tedesco, L.P., Trefry, J.H., Blackwelder, P.L., and Risi, J.A., 1995, Documenting the styles of sedimentation and contained historical sedimentary record in shallow marine environments in and adjacent to Florida Bay, south Florida (abstract): Florida Bay Science Conference, Abstracts and Program, October 17-18, 1995, Gainesville, FL., p. 114-117.

Wanless, H.R., and Tagett, M.G., 1989, Origin, growth and evolution of carbonate mudbanks in Florida Bay: Bulletin of Marine Science, v. 44 no. 1, p. 454-489.

Wanless, H.R., Tedesco, L.P., Cottrell, D., and Tagett, M.G., 1994, Holocene environmental history of carbonate banks in Florida Bay and Biscayne Bay, south Florida (abstract): Bulletin of Marine Science, v. 54, no. 3, p. 1087.

Wingard, G.L., Ishman, S.E., Cronin, T.M., Edwards, L.E., Willard, D.A., and Halley, R.B., 1995, Preliminary analysis of down-core biotic assemblages: Bob Allen Keys, Everglades National Park, Florida Bay: US Geological Survey Open-file Report 95-628, 35p.

APPENDIX

Qualitative Description of Sediment Greater than 63 mm

Following are the qualitative descriptions of sediment greater than 63 µm, retained on sieves during grain size analysis. Descriptions are listed by site and sample number, at half phi intervals. Samples were analyzed under a binocular microscope.

PHI SIZE	**Sample Description**
<u>Site 1 (July A):</u>	
-1	Whole and fragmented mollusks, organic matter, encrusting bryozoans, most shell in excellent shape.
-0.5	Whole and fragmented mollusks, less organic matter, few charcoal pieces, few large forams most shell in excellent shape.
0	Whole and fragmented mollusks, less organic matter, few large forams.
0.5	Mostly fragmented mollusk shell, some organic matter, few large forams, *Caecum* sp.
1.0	Mostly fragmented mollusk shell, ostracodes, few large foraminifer fragments, abundant fine organic matter, few quartz grains, bryozoan fragments, *Caecum* sp.
1.5	Mostly fragmented mollusk shell, abundant ostracodes, abundant organic fine matter, smaller forams, bryozoan fragments, *Caecum* sp.
2.0	Abundant smaller forams, organic matter, mollusk fragments with few whole gastropods, abundant ostracodes, few quartz grains.
2.5	as 2.0 with very few whole mollusks, fewer shell fragments, scattered quartz grains.
3.0	as 2.5 with no whole shell.
3.5	as 2.5 with spicules present.
4.0	smaller forams, shell fragments, minor organic matter, ostracodes, common quartz grains.

PHI SIZE	Sample Description
Site 1 (July C):	
-1.0	Whole and fragmented mollusks, some weathered shell, organic matter, encrusting bryozoans.
-0.5	as -1.0 with less coarse organic matter.
0	as -0.5
0.5	Fragmented and whole mollusks, *Caecum* sp., larger forams, organic matter, encrusting Bryozoans.
1.0	as 0.5 with abundant bryozoan fragments, smaller forams.
1.5	abundant smaller forams, abundant ostracodes, few whole mollusks, few *Caecum* sp., fine organic matter, few quartz grains.
2.0	abundant smaller forams, abundant ostracodes, mollusk fragments, abundant organic matter, Bryozoan pieces, quartz grains.
2.5	as 2.0, less organic matter, scattered quartz grains.
3.0	abundant smaller forams, fewer ostracodes, mollusk fragments, bryozoan fragments, less fine organic matter.
3.5	as 3.0
4.0	as 3.0
Site 2 (Feb B):	
-1.0	Whole and fragmented mollusks, pieces of wood, abundant organic matter.
-0.5	Whole and fragmented mollusks, larger forams, organic matter.
0	as -0.5 more common gastropods.
0.5	Whole and fragmented mollusks, *Caecum* sp., larger forams, organic matter.
1.0	as 0.5 with few large forams

PHI SIZE	Sample Description
1.5	Fragmented and whole mollusks, abundant smaller forams, ostracodes, few bryozoan pieces, organic matter.
2.0	as 1.5
2.5	few whole mollusks, abundant smaller forams and ostracodes, organic matter, few quartz grains.
3.0	Mollusk fragments, abundant forams, few ostracodes, little organic matter, scattered quartz grains.
3.5	Mollusk fragments, abundant forams, , little organic matter, scattered quartz grains, few spicules.
4.0	as 3.5.

Site 2 (July A):

-1.0	Whole and fragmented mollusks, few wood fragments, organic matter.
-0.5	Whole and fragmented mollusks, few larger forams, organic matter.
0	as -0.5 with abundant larger forams.
0.5	as 0
1.0	abundant whole and fragmented mollusks, abundant smaller forams, few larger forams, organic matter.
1.5	Mollusk fragments and few whole shells, abundant smaller forams, organic matter.
2.0	Mollusk fragments, abundant forams, abundant ostracodes, some organic matter.
2.5	Abundant smaller forams and ostracodes, mollusk fragments, some quartz, little organic matter
3.0	as 2.5 with fewer ostracodes

PHI SIZE	Sample Description
3.5	Abundant smaller forams, mollusk fragments, quartz grains, spicules, very little organic matter.
4.0	as 3.5.

Site 6 (Feb B):

PHI SIZE	Sample Description
-1.0	whole and fragmented mollusks, larger forams, organic matter.
-0.5	as -1.0
0	Whole and fragmented mollusks, common larger forams, *Caecum* sp., organic matter.
0.5	Fragmented mollusks, few whole shells, *Caecum* sp., worm tubes, organic matter.
1.0	Fragmented mollusks, few whole shells, *Caecum* sp., Larger and smaller forams, few ostracodes, organic matter.
1.5	as 1.0
2.0	as 1.0 with less organic matter.
2.5	as 2.0 with scattered quartz grains, no ostracodes.
3.0	as 2.5 with few spicules.
3.5	as 3.0
4.0	as 3.0

Site 6 (July A):

PHI SIZE	Sample Description
-1.0	Whole and fragmented mollusks, most in excellent shape, organic matter.
-0.5	Whole and fragmented mollusks, most in excellent shape, Larger forams, organic matter.
0	as -0.5

PHI SIZE	Sample Description
0.5	Fragmented mollusks with few whole shells, *Caecum* sp., worm tubes, larger forams, organic matter.
1.0	Mostly fragmented mollusks, worm tubes, ostracodes, smaller forams, organic matter.
1.5	as 1.0
2.0	as 1.0, most fragmented.
2.5	as 2.0 with few quartz grains.
3.0	as 2.5
3.5	as 2.5
4.0	as 2.5

Site 8 (Feb A):

-1.0	Whole and fragmented mollusks, larger forams, organic matter
-0.5	as -1.0, mostly larger forams.
0	as -0.5
0.5	Whole and fragmented mollusks, larger forams, some organic matter, *Caecum* sp., worm tubes.
1.0	Mostly fragmented mollusks, larger and smaller forams, pieces of worm tubes and *Caecum* sp.
1.5	Mollusk fragments, abundant smaller forams, ostracodes
2.0	as 1.5, mostly forams.
2.5	as 2.0
3.0	as 2.0 plus spicules.

PHI SIZE	Sample Description
3.5	as 3.0
4.0	as 3.5 with some quartz grains.

Site 9 (Feb):

-1.0	Whole and fragmented mollusks, larger forams, organic matter.
-0.5	Whole and fragmented mollusks some fresh and others leached, larger forams, little organic matter.
0	as -0.5
0.	fragmented mollusks, *Caecum* sp., worm tubes, few fragments of larger forams, few smaller forams, very little organic matter.
1.5	Mostly fragmented mollusks, *Caecum* sp., worm tubes, abundant smaller forams, few quartz grains.
2.0	as 1.5 with ostracodes and more quartz grains.
2.5	as 2.0 with more quartz.
3.0	as 2.5 with lots of quartz, some forams filled with pyrite.
3.5	as 3.0 with spicules and less quartz.
4.0	as 3.5

Site 10 (Feb):

-1.0	Whole and fragmented mollusks, organic matter.
-0.5	Whole and fragmented mollusks, few larger forams, less organic matter.
0	as -0.5, some blackened mollusks fragments.

PHI SIZE	Sample Description
0.5	Whole and fragmented mollusks, few larger forams, less organic matter, blackened shell and black grains, *Caecum* sp., few smaller forams.
1.0	as 0.5 mostly broken mollusks, some weathered shell.
1.5	fragmented mollusks, abundant smaller forams, ostracodes, quartz grains.
2.0	as 1.5
2.5	as 1.5
3.0	as 1.5, more quartz
3.5	as 3.0
4.0	as 3.0

Site 12 (Feb A):

-1.0	Whole and fragmented mollusks, abundant organic matter.
-0.5	Whole and fragmented mollusks, abundant organic matter, larger forams.
0	as -0.5
0.5	Mostly fragmented mollusks, *Caecum* sp., larger forams, worm tubes, organic matter.
1.0	as 0.5 with smaller forams.
1.5	as 1.0 with ostracodes.
2.0	as 1.5, quartz grains.
2.5	as 2.0 with more quartz grains.
3.0	as 2.5 with spicules.
3.5	as 2.5.
4.0	as 2.5.

PHI SIZE	Sample Description

Site 17 (July B):

-1.0	Whole and fragmented mollusks, organic matter.
-0.5	as -1.0.
0	as -0.5 with larger forams.
0.5	Whole and fragmented mollusks, *Caecum* sp., larger forams, smaller forams, worm tubes, quartz grains.
1.0	as 0.5.
1.5	as 1.0, ostracodes.
2.0	as 1.5, more abundant ostracodes.
2.5	as 2.0 with abundant forams.
3.0	as 2.5.
3.5	as 2.5.
4.0	as 2.5.

Site 17 (July C):

-1.0	Whole and fragmented mollusks, rock fragments, Bryozoans, organic matter.
-0.5	Mostly fragmented mollusks, bryozoan fragments, few larger forams, little organic.
0	as -0.5 with few worm tubes.
0.5	as 0 with few *Caecum* sp.
1.0	as 0.5 with smaller forams, ostracodes.

PHI SIZE	Sample Description
1.5	as 1.0
2.0	as 1.5 with a trace of quartz grains.
2.5	as 2.0 with more quartz.
3.0	as 2.5 with more abundant smaller forams.
3.5	as 3.0
4.0	as 3.0.