SEDIMENTARY EVIDENCE OF COASTAL RESPONSE TO HOLOCENE SEA-LEVEL CHANGE, BLACKWATER BAY, SOUTHWEST FLORIDA

LILY E. LOWERY
University of the South
Sponsors: Donald B. Potter, University of the South
Lenore P. Tedesco, Indiana/Purdue University at Indianapolis

INTRODUCTION

Studies of Holocene coastal sedimentary sequences in southwest Florida have provided important clues in determining coastal response to sea-level changes (Parkinson, 1989; Wanless et al., 1994). Much of the southwest Florida coast is a mangrove-dominated estuarine system with chains of mangrove-capped oyster bars that provide a barrier between the bay and open marine influences. This low energy, low relief system provides an ideal environment for the deposition and preservation of sedimentary sequences that record relative sea-level fluctuations. The mangrove fringe is a major control on shoreline facies, as reported by Davis (1940) and summarized by Parkinson (1989), sometimes resulting in local shoreline changes in opposition to regional trends. In an early study of the southwest Florida coastal system, Davis (1940) described the sedimentation processes specific to mangrove dominated systems: the trapping of sediment results in rapid aggradation of peat, progradation of the shoreline, and local marine regression in a rising regional system (Parkinson, 1989). Conversely, mangrove control in these systems can actually allow the opposite effect, when the destruction of the vegetation in a storm or period of storm events causes shoreline retreat and a punctuated rise in relative sea level (Wanless et al., 1994).

Initial studies of sedimentary sequences in southwest Florida (Davis, 1940) documented coastal submergence during relative sea-level rise. Later studies (Scholl et al., 1967, 1969) created a submergence curve for southwest Florida for the last 7000 years that delineated continual, but decelerating rise in sea level,

SOUTH FLORIDA SEA-LEVEL HISTORY

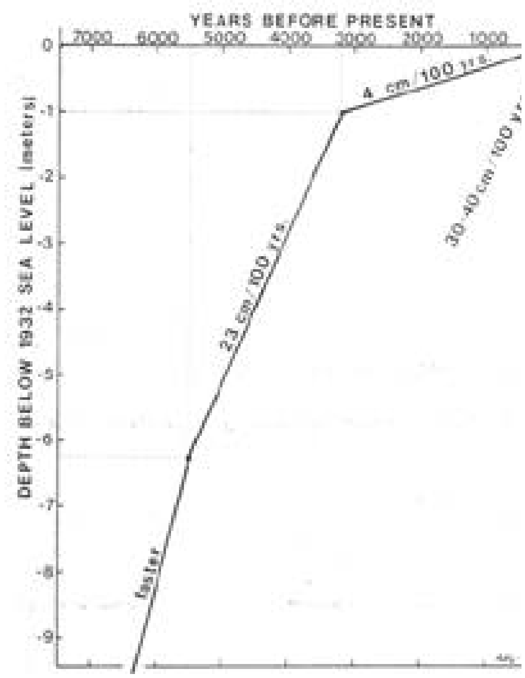

Figure 1: Holocene sea-level rise curve illustrating deceleration of rate of rise and present rapid rise from tide-gauge records. (from Wanless et al., 1994).

which was later modified (Wanless et al., 1994) to assign specific rates of rise and dates of changes in rate (Figure 1). More recent work in the Everglades and Ten Thousand Islands regions presents a two-phase relative sea-level model within the decelerating eustatic system, consisting of (1) transgression with rapid eustatic rise, followed by (2) regression beginning at approximately 3200 y.b.p. as sea-level rise slowed and biogenic sedimentation kept pace with or outpaced eustatic rise (Parkinson,1987,1989).

During June, 2001, a northeast/southwest transect of four sediment cores was taken, roughly perpendicular to the shoreline across Blackwater Bay (Figure 2) using a vibracore

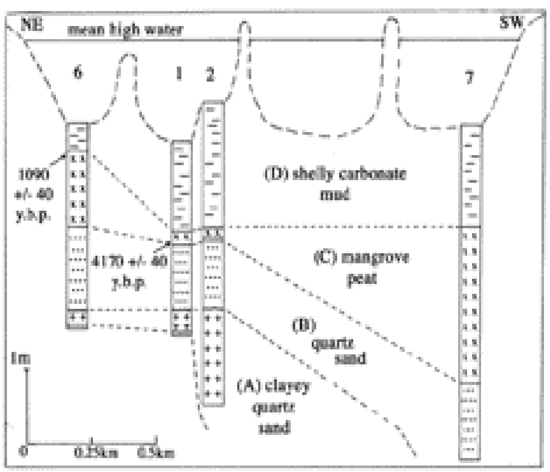

Figure 3: Core transect across Blackwater Bay showing correlated stratigraphy. Note 525 times vertical exaggeration: slope of all actual contacts is less than 0.15°. Radiocarbon dates for peats in cores 6 and 1 are shown by arrows.

mounted on a pontoon boat. Coring recovered the entire Holocene sequence (units B, C, D in Figure 3), in addition to upper Pleistocene sediments (unit A), with negligible loss and little compaction. Preliminary descriptive analysis was performed with open cores during the summer, and subsequent lab analysis determined percent carbonate, organic content, and grain size.

Based on these cores from Blackwater Bay, we believe that this portion of the southwest Florida shoreline has experienced three major phases of relative sea-level change during the Holocene eustatic rise: (1) transgression, (2) regression with accumulation of thick peat sequences, and (3) a return to transgression.

RESULTS

Using the textural composition classification of Perlmutter (1982), we found the cores revealed a consistent stratigraphy across the entire bay (Figure 3). Pliocene limestone bedrock (Parkinson, 1987, 1989), at the base of cores 6 and 1, is overlain oldest to youngest by units A to D. These units were classified (Table 1) as sediment type A (quartz packstone or a clayey quartz sand), sediment type B (quartz grainstone), sediment type C (*Rhizophora*, red mangrove, peat), and sediment type D (shelly quartz packstone to wackestone). The base of the peat in core 1 was dated at 4170 ± 40 y.b.p. using radiocarbon techniques, and the upper surface of the peat in core 6 was dated at 1090 ± 40 y.b.p. (Figure 3).

DISCUSSION

Vertical and lateral relationships of units A to D in the four cores suggest that Blackwater Bay has undergone three phases of local sea-level change during the eustatic Holocene transgression. Each sedimentary sequence represents a time transgressive unit, as changes in sea level caused migration of depositional environment. Sediment types A and B formed during the early transgressive phase, as interpreted by Parkinson (1987, 1989), as shoreline approached the study site. The thick peat sequences represent the shoreline intersection with the site, then a relative shallowing or at least a temporary stabilization of shoreline. The facies change to sediment type D at a uniform elevation indicates a return to deepening.

Transgression

Parkinson (1987, 1989) suggests that Pliocene limestone was exposed, eroded, and then unconformably overlain by the Pleistocene aged clayey sand of unit A, as the terrestrial environment evolved to a salt water marsh. The small grain size and low carbonate percentage of this unit (Table 1) indicates that the finer grains are terriginous clays. Unit A is sharply and unconformably overlain by the clean quartz sands of unit B, which we interpret as fluvial deposits of the ancestral Blackwater River.

Stabilization/Regression

The base of the peat, unit C, represents the initiation of an intertidal regime as sea level reached that elevation, and the coastal mangroves continued to migrate landward with the shoreline. The base of the peat in the most seaward core (7) is 462 cm below Mean High Water (MHW), an elevation that corresponds to a 4750 y.b.p. shoreline on the Wanless et al. (1994) curve, (Figure 1). Growth in the three most landward cores began shortly before the 4170 ± 40 y.b.p. basal peat radiocarbon date, in good agreement with a 4100 y.b.p. intersection on the South Florida sea-level curve, Figure 1 (Wanless et al., 1994).

During the first stage of peat accumulation prior to 3200 y.b.p., the mangrove aggradation may have been in a precarious equilibrium with rapid sea-level rise of 23 cm/100 yr. At 3200 y.b.p., as sea-level rise decelerated to 4 cm/100 yr, peat accumulation rates may have slowed in response, resulting in a temporarily stabilized shoreline. If peat aggradation continued at a pace comparable to the more rapid rate of rise, a relative regression may have occurred.

Transgression

The upper contact of unit C, where peat is sharply overlain by the shelly carbonate muds of D, indicates a relatively sudden inundation of the mangroves and destruction of the mangrove dominated system across the 1.5 km length of this transect at 1090 ± 40 y.b.p., as shown by the radiocarbon date from core 2. It is unlikely that the slow eustatic rise was sufficient to inundate the coastal mangroves, or result in the modern submerged condition of Blackwater Bay.

Table 1: Averaged grain size and compositional characteristics of sedimentary units.

Sediment Type	Description	% Mud	Quartz Mean Φ	Quartz Mode Φ	% Carbonate
A	Clayey quartz sand	6.76	2.1	2.1	7.63
B	Quartz grainstone	1.47	2.2	2.2	2.11
C	Mangrove peat	-----	-----	-----	-----
D	Shelly quartz pack/wackestone	15.37	2.0	2.9	50.55

Previous work (Boettner, 2000) has documented an upstream carbonate mud levee in the Blackwater River, containing marine faunal fragments 1069 ± 99 y.b.p. to 990 ± 84 y.b.p. in age. One possible interpretation of this levee involves landward transport of marine sediment and fauna during a violent storm event or a period of high storm frequency. These dates coincide with the submergence of the mangroves in Blackwater Bay at 1090 ± 40 y.b.p. (the radiocarbon date of upper peats in core 2), suggesting that the same events may have inundated the coastal mangroves, resulting in destabilization of the mangrove system and subsequent transgression.

Sediment type D, which forms the modern sediment surface, exhibits a deepening phase followed by a shallowing phase (Kitchen, 2002, this volume): oysters, indicative of intertidal conditions, overlie finer muds of a deeper depositional environment. Cores taken in previous studies contain sequences of mangrove-capped oyster bars over these muds (Parkinson, 1987, 1989). When the mangrove system was first inundated, waterflow and sedimentation processes may not have been ideal for oyster habitation, but a slight increase in depth may have allowed initiation of oyster colonization and sediment aggradation.

Tide gauge records for the past 60 years in South Florida (Wanless et al., 1994) and studies of worldwide sea level over the past century (Barnett, 1990) indicate an increase in sea-level rise rates ranging from 10 to 40 cm/100 yrs. We expect that this acceleration would contribute further to the deepening represented by unit D.

CONCLUSIONS

The four units sampled in our cores from Blackwater Bay document that the area experienced an early Holocene transgression, followed by a stabilization and possible regression of the shoreline at approximately 4100 y.b.p. with the accumulation of thick peat sequences. At approximately 1000-1090 y.b.p., a significant event, possibly a storm or series of storms, inundated the mangroves in all cores, reinitiating a relative sea-level rise that eventually brought Blackwater Bay to approximately its current size and depth. If the acceleration of sea-level rise recorded in the last century in South Florida (Wanless et al., 1994) and worldwide (Barnett, 1990) continues, the transgressive phase of the past 1000 years will be accentuated in the study area: intertidal mangroves will be slowly inundated as the shoreline moves landward and Blackwater Bay deepens.

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