DETERMINATION OF HOLOCENE SEA LEVEL CHANGE BY ANALYSIS OF MOLLUSKS, BLACKWATER BAY, SOUTHWEST FLORIDA

CHRIS KITCHEN
Keck Geology, Whitman College
Sponsor: Bob Carson

INTRODUCTION

Estuaries are the most productive ecosystems on earth and the fastest diminishing ones too. These two facts make protection and restoration of estuaries a top priority. One of the potentially most destructive forces to estuaries is rapid sea level rise, which is currently being accelerated by global warming. The Environmental Protection Agency (EPA) forecasts a sea level rise of 55-335cm (average150-210cm) by the year 2100 (Wanless et al. 1994). This rise will have serious environmental impacts on Florida's estuaries and urban centers, most of which are not more than a meter above sea level.

In this paper I will describe the effects of Holocene sea level rise on Florida's estuary environments. I will focus on the relationship between Holocene sea level rise and the effects it has on mollusk fauna of the time.

SEA LEVEL HISTORY

During the Pleistocene period in southwest Florida limestone platforms were submerged and subaerially exposed due to glacial and interglacial periods (Tedesco 2001; Parkinson 1987; Wanless et al. 1994). About 120,000 years before the present (ybp), sea level was 100m-150m below today's level. Approximately 20,000ybp sea level began to rise inundating the limestone platforms and causing landward migration of coastal features. Relative sea level rise is a competition between the rate of sedimentological and biological processes versus the rate of sea level rise. If the rate of sedimentation and biological accumulation is greater than that of sea level rise, relative sea level drops (regression) and vise versa. From 7,500ybp to 5,500ybp sea level was rising at a very fast rate of 50cm/100yrs and from 5,500ybp to approximately 3,200ybp sea level rise was 23cm/100yrs (Tedesco 2001;

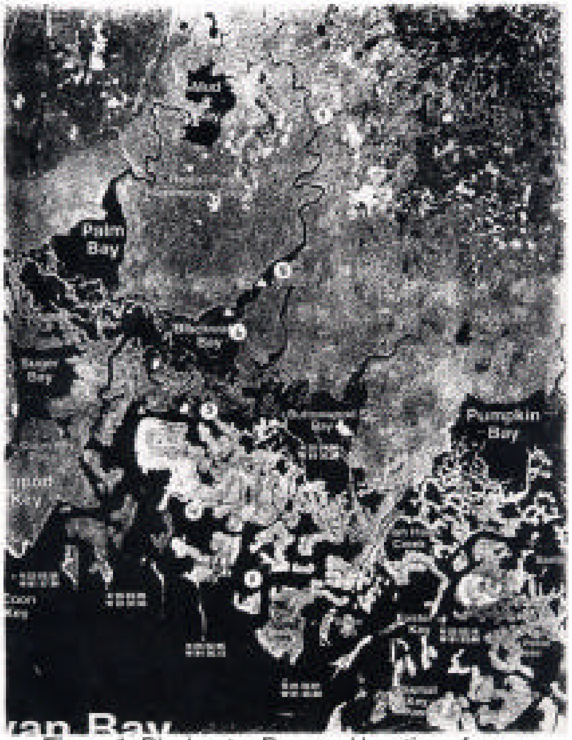
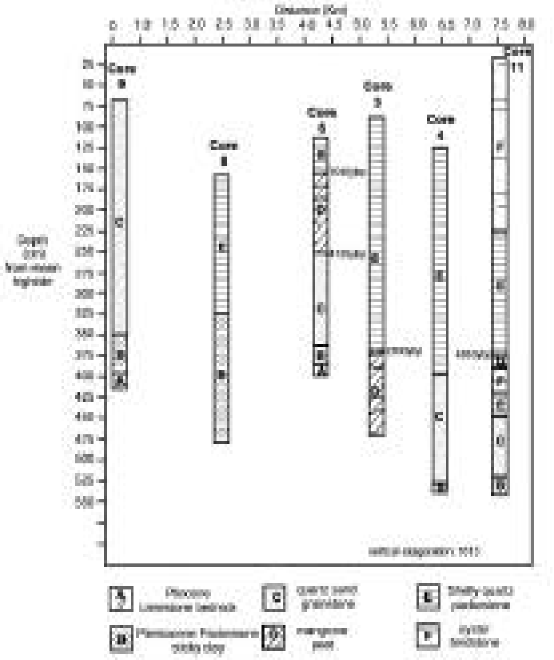


Figure1: Blackwater Bay and location of cores

Parkinson 1987; Wanless et al.1994). This rapid sea level rise was sufficient to cause shoreline retreat, flooding and deepening of bays. At approximately 3,200ybp this rate slowed to 4cm/100yrs, which allowed coastlines to stabilize, marine environments to shallow, and oyster and mangrove colonization to proceed seaward. There is disagreement as to when exactly the rate slowed and many believe that the rate was decreasing before 3,200ybp.

Figure 3: Stratigraphic relationships between cores positioned relative to mean high tide. Radiocarbon dates indicated where known



METHODS

Cores were taken with 3in. diameter irrigation tubes (732cm in length) at the locations indicated (Figure 1). Using a vibrator head the cores were driven 2–5m into the sea floor and pulled out with an extensive winching system. All cores (Figure 2) were located in relation to mean high tide, which was determined by locating the sediment surface relative to the highest occurrence of barnacles or oysters. Where barnacles and oysters were not present, the lowest mangrove leaves, which were determined to be 20cm higher than the mean high tide mark, determined mean high tide. Compaction was determined from the distance from the surface of the water to the sediment surface inside the core minus the distance between the water surface and the sediment surface outside the core. Compaction was then assigned to individual layers, normally to the top sedimentary unit of each core. The cores were then cut open, and the stratigraphy was described. Five-centimeter thick samples were taken at intervals of 5cm-15cm from unit E (Figure 2) which is a shelly, muddy quartz packstone. Each sample was sieved through 2mm and 1mm sieve, leaving only the molluskan assemblage, which was then sonically cleaned. Next all the fauna was identified, and unit E was broken up into shallowing (regressive) and deepening (transgressive) phases (Figure 4). Fauna was assigned to a depositional environment based on habitat preference including brackish, intertidal and subtidal marine from Andrews (1994), Abbot (1974) and Morris (1973). Some of the key species and their habitat that were used to assign fauna assemblages to depositional environments can be seen in figure 3. It was not practical to base these depositional environments on the presence of individual mollusks because there was a large variety of fauna and associated habitats in each 5cm unit. Instead I compared the faunal assemblage with the habitat reflected by the bulk of the fauna in that unit to assign the core interval to a habitat.

Figure 3: A list of species and their habitat used to determine the transgressive and regressive phases in unit E

Marine Brackish
Chione cancellata
Pseudocryrena floridian

Marine Intertidal
Urosalpinx perugata
Urosalpinx tampaenis
Tellina simillis
Mitella lunata

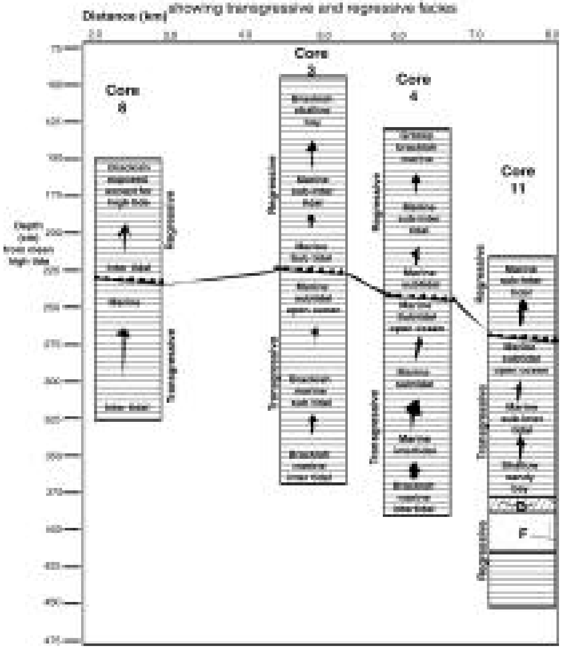
Marine Subtital
Nucula proxima
Epitonium (family)
Tangelus
Corbulla swiftiana
Nuculana acuta
Lucina nassula

CORE DESCRIPTIONS

Six different sediment packages were identified (A-F). Unit A is limestone bedrock from the Pliocene and it is covered by a Pleistocene sticky clay packstone (unit B) (Parkinson 1987). The fact that Pleistocene sediments are present in most cores indicates two things: one, that our cores contain the entire Holocene sediment record; and, two, that initial coastlines were widespread and uniform (Parkinson 1987). Unit C is a quartz sand grainstone that gradationaly changes from a clean quartz sand near the contact with unit B to a dirty sand which contains mud, peat remnants and mollusks as it grade upward to its contact with Unit E or D. Unit C is believed to be a nonmarine deposit. Unit D is a mangrove peat. Unit E is a shelly quartz packstone, rich in mollusks. This unit is clearly a lagoonal/ bay deposit. The faunal analysis of unit E indicates that it can be broken into a lower deepening phase and an upper shallowing phase (Figure4). Unit F is an oyster bindstone, which is essentially an old oyster reef.

All the cores in figure 2 show at least one full regressive /transgressive/ regressive sequence, whether it is in the major units or confined in the shelly quartz packstone (E) unit, with the exception of core 9 which is fluvial in nature (Figure 1). The first regressive cycle allowed for peat to form. From the radiocarbon dates it can be determined that the peat began to form before 4850ybp. This indicates that the first regressive phase probably began 5000-6000ybp. These dates coincide with the decreasing sea level, rise that occurred about the same time. The second transgressive/ regressive phase can bee seen in unit E in all the cores (Figure 4).

Figure 4: Stratigraphic relationships in Unit E showing transgressive and regressive facies



In core 8 transgression began in the E unit (Figure 4) for the first 90cm of deposition resulting in a change from an intertidal to marine environment. A regressive phase occurs in the top 85cm going from marine intertidal to a brackish, somewhat intertidal environment. In core 6 a peat forms, starting at approximately 4120ybp (dated wood fragment found at base of peat), indicating that a regressive phase had began sometime before then. At 1040ybp, (dated Macoma shell found just above the peat), the peat was inundated by bay deposits indicating that a transgressive phase had begun. No faunal samples were taken from this core because the E unit is less than 40cm thick; however it is assumed that this unit would show a regressive phase in the upper portion like all the other cores. The first regressive phase in core 3 ends about 2300ybp (dated angel wing shell just above the peat). A transgressive phase in the bottom 141cm of unit E results in brackish intertidal to open marine conditions. About 140cm from the top of the core a regressive phase causes a change from a marine subtidal environment to its present shallow brackish water bay (Figure 4).

In core 4 a transgressive phase occurs at the top of unit C to allow for the deposition of the lagoonal muds of unit E. In unit E a transgressive phase occurs in the bottom 142cm. This section of unit E appears to oscillate between intertidal and subtidal environments. This could be due to the difficult nature of determining mollusk environments from sediment packages or could indicate high frequency sea level oscillations. Gelsanliter and Wanless (1995) (in Tedesco 2001) found evidence for high frequency sea level oscillations between 3200ybp and 2400ybp. The upper 122cm of core 4 shows a regressive phase from marine subtidal to a shallow sea grass brackish environment of today. Core 11 shows the two transgressive / regressive cycles most completely. The first transgression occurs as unit C is covered by unit E. A regressive phase occurs in unit E and continues through unit F, oysterbindstone, and unit D, a peat. The top of this peat layer is dated at 4850ybp. The second transgression began about this time, which can be seen in the bottom 122cm of the second unit E. The top 40cm of unit E shows a regressive phase up through the oysterbindstone (unit F) above it.

DISCUSSION

The slowing sea level rise that occurred at 5,500ybp allowed sedimentary and biological processes to dominate over erosional ocean processes creating the regressional features of barrier islands, oyster bars and mangrove forests. Evidence of transgression appears at 4850ybp in core 11, 2300ybp in core 3 and 1040ybp in core 6. The difference in transgression ages is due to time transgressive phenomena. This transgressive phase is present in the lower section of unit E. The regressive phase that occurred in unit E is rather abrupt and appears to occur at about the same time in all the cores in figure 4. This indicates that, unlike the previous regressive/transgressive phase that occurred as sea level rise rate decreased gradually, this one was abrupt. This is due to a major decrease in the rate of sea level rise from23cm/100yrs to 4cm/100yrs. This was probably a rapid change unlike the gradual rate change that occurred 5,500ybp.

IMPLICATONS

Although sea level has been rising during the Holocene, relative sea level has been oscillating due to different rates of rise and sedimentological and biological processes. It can be seen that once sediment and biological processes gain a foot on sea level rise it takes a long time to overcome these processes. Of particular concern today is the fact that sea level has been rising extremely fast again since 1930 (Wanless et al. 1994). It has increased to a rate of 23cm/100yrs, which is the same rate that caused the last major transgression from 4800ybp to 1000ybp that inundated the mangrove forests and cause massive landward retreat of all coastal features. The EPA's prediction of a 55cm-355cm sea level rise by 2100 due to global warming far exceeds the rate that caused that last major transgression. This rise will cause major retreat of coastal features and could inundate Florida's lowlands and fresh water complexes. This would be devastating for Florida's fragile fresh water environments and fresh water sources for human needs. A rise of this magnitude will not only damage natural environments but also human population centers most of which are less than a meter above sea level. Small changes in faunal assemblages (i.e. disappearance or appearance of species) and depositional environments along with retreating coastal features could be an early indicator and warning of a rapid transgression and the effects of global warming. The information in figures 2, 3, and 4 can be used as a reference for the possible future effects of global warming and sea level rise on Florida's estuarine environments. It is my hope that this study will help bring to light the serious effects of global warming and a major sea level rise.

REFERENCES CITED

Abbott, Tucker 1974, American Seashells: Van Nostrand Reinhold Company, New York.

Andrews, Jean 1994, A Field Guide to the Shells of the Florida Coast: Gulf Publishing Company, Houston, Texas.

Michaels, Brian 2001, Holocene Stratigraphy and Geomorphic Evolution of the Cape Sable Region, Southwest Florida: Evidence for Late Holocene Sea Level Dynamics: University of Miami

Morris, Percy 1973. A Field Guide to the Shells of the Atlantic and Gulf Coasts: Houghton Mifflin Company, Boston.

Parkinson, Randall 1987. Holocene Sedimentation and Coastal Response to Rising Sea Level Along a Subtropical, Low Energy Coast, Ten Thousand Islands, Florida: Dissertation, University of Miami.

Tedesco, Lenore 2001. An Introduction to Southwest Florida's Natural Environment IUPUI Department of Geology and Center for Earth Environmental Studies.

Wanless, Harold, Parkinson, Randall and Tedesco, Lenore.1994. Sea Level Control on Stability of Everglades Wetlands: Everglades, the Ecosystem and Its Restoration: St. Luci Press, Delray Beach, Florida.