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Holocene sedimentary fill in Weeks Bay, Alabama: a 6000 year record of human- and storm-impacted deposition in a United States Gulf Coast estuary

DOUGLAS W. HAYWICK[1], MIRIAM L. FEARN[1], JOHN P. KEMPTON[1], & LEE YOKEL[1]
[1]*Department of Earth Sciences, University of South Alabama, Mobile, AL 36688, USA*
(E-mail:dhaywick@jaguar1.usouthal.edu)

INTRODUCTION

Weeks Bay is a small (c. 7 km^2) embayment attached to the eastern side of Mobile Bay in south-western Alabama, USA (Fig. 1). It has two major inputs of freshwater (Fish River in the north and Magnolia River in the east), and one input of brackish water at a southern inlet into Mobile Bay. Overall, Weeks Bay is considered brackish, but there is significant variation in salinity depending upon proximity to the rivers and inlet, tidal cycles and season (e.g., rainfall intensity). Our study was originally designed as an undergraduate research project that would produce a detailed GIS map of bottom sediment in a typical United States Gulf Coast estuary [1]. Weeks Bay was selected because its relative small size permitted high resolution sampling by undergraduate students within a reasonable time frame (one semester). The results of this study yielded unexpected data concerning storm and event sedimentation in Weeks Bay [2] and consequently, we extended the surface sediment study for two more years. We also initiated a comprehensive piston coring program in order to investigate human and event impacts during Holocene sedimentation in Weeks Bay.

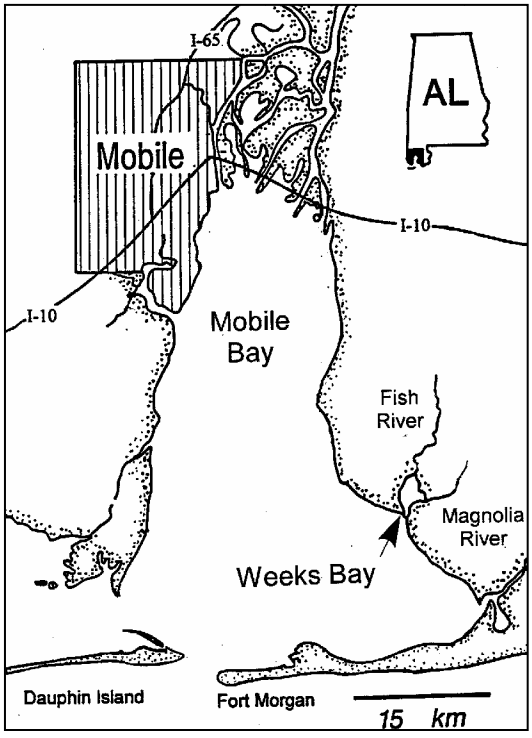

Fig. 1. Location map of Weeks Bay in south-western Alabama, USA

METHODS EMPLOYED

Bottom Samples

Bottom sediment samples were collected using a Ponar grab sampler deployed from small boat. The upper 2 cm of each sample was extracted for grain size analysis using the pipette and sieve method [3,4]. The location of each sample was determined using a GPS receiver equipped with a differential antenna. Our first phase of sampling (January, 1998) produced 401 grab samples and was conducted about six months after the passage of Hurricane Danny, a category 1 storm that made landfall at Weeks Bay in July, 1997. The second round of bottom sediment collection (666 grab samples) was completed in early 1999 approximately 5 months after category 2-3 Hurricane Georges made land fall 120 km west of Weeks Bay. Both storms impacted Weeks Bay albeit in different ways. Hurricane Danny was a "rain-maker." It produced more than 75 cm of rain during its crossing and caused unprecedented flooding in the Fish River watershed. Hurricane Georges generated exceptionally high tides and flooded many lower portions of the Gulf Coast. Weeks Bay recorded a 6.5 foot storm surge at its inlet to Mobile Bay.

Our third phase of sampling (813 samples; January, 2000) followed a relatively quiet year when no major events affected the study area. Year three data therefore reflect fair-weather sedimentation in Weeks Bay.

Core samples

We employed a simple piston coring device to collect 17 cores up to 4.5 m in length from Weeks Bay during field sessions in 1999, 2000 and 2001. The cores were collected along one north-south (7 cores) transect and two east-west (10 cores) transects. After extraction, each core was examined for variations in stratigraphy, mineralogy, grain size and when possible, faunal content. Samples were collected from grain size analysis at either a 1 cm or a 3 cm-scale in all 17 cores. Two representative cores were also examined for pollen content, and Cs^{137} isotopic markers. Bottom dates were obtained for all cores using conventional C^{14} dating.

RESULTS

Surface Sediment

Weeks Bay is largely underlain by fine siliciclastic sediment (clayey-silt) which is typical of fair-weather sedimentation in all but shoreline areas of the bay. Shorelines, particularly in the east and south are dominated by fine to medium quartz sand.

Our three year record of bottom samples resolved subtle but intriguing changes in sediment distribution in Weeks Bay, primarily through the episodic action of storms and floods. Hurricane Danny produced a storm-flood sand tongue up to 2 cm thick from the mouth of the Fish River well into the middle of the bay. Hurricane Georges produced a substantial storm bed/sand bar into Weeks Bay from Mobile Bay during the storm surge. The longevity of these sediment pulses was variable. Within one year, the Hurricane Danny sand tongue was obliterated due to bioturbation; however, the Hurricane George storm bed was still present 3 years after the event.

Sand bars at the mouths of the Fish and Magnolia Rivers also changed substantially between 1998 and 2000. The Magnolia River bar expanded approximately 20% during fair-weather conditions. The most feasible explanation is that this sediment was derived from erosion at construction and agriculture sites up-river. Human-induced changes were also found in other parts of the bay.

Cores

Cores collected proximal to shorelines were dominated by sandy-silt and quartz sand and preserved a record of high energy, shoreface deposition. Two of the cores bottomed out at a peaty-limonitic clay that contained large quartz pebbles up to 2 cm in diameter. We interpret this interval as a transgressive lag formed during the final phase of Holocene sea level rise (c. 6000 years B.P.).

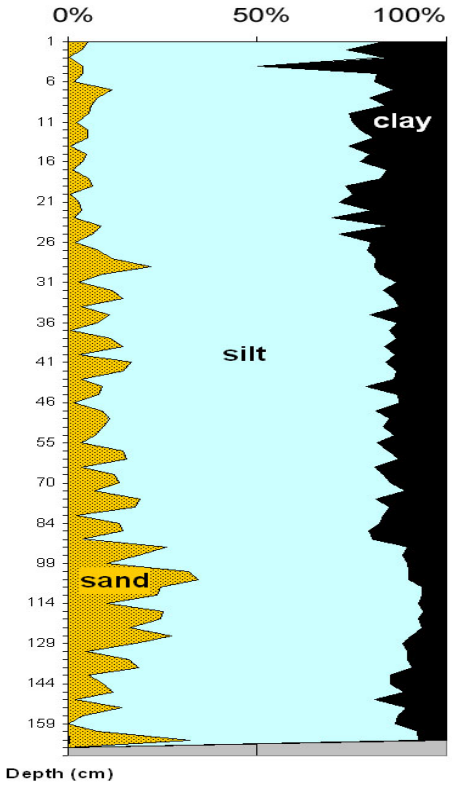

Fig. 2. Grain size variation in a 1.7 metre long core collected from the northern portion of Weeks Bay. The core has a basal C^{14} age of 4480 years B.P. and displays a fining-upward sequence due to progressive isolation of the site from the primary sediment input point (Fish River).

Cores collected from central portions of the bay consisted primarily of bioturbated, blue-grey, clayey-silt, the typical fair-weather sediment that is presently being deposited in low energy areas of Weeks Bay. Some of the cores displayed coarsening upward or fining-upward variations (e.g., Fig. 2), the results of predictable facies shifts. The majority of the central Weeks Bay cores also contained sporadic, thin layers (<1 cm) of fine to medium sand which we interpret as episodic storm or flood events.

Sandy intervals rarely contain any organic detritus, but finer grain sizes contain diatoms, shell fragments, pollen and abundant comminuted plant detritus. Foraminifera have not been observed in any of the cores collected in this study. Bottom C^{14} dates were variable with depth of penetration, but ranged between 2000 years B.P. and 6000 years B.P. These data in conjunction with additional radiocarbon dates derived from deeper boreholes (work in progress) are being used to establish the complete Holocene stratigraphy of the Weeks Bay area.

CONCLUSIONS

Sedimentation in estuaries is driven by fair-weather processes augmented by temporal events such as storms and floods. The sedimentary record of Weeks Bay demonstrates that event deposition was ubiquitous during the Holocene in this area of the United States Gulf Coast.

Human impact on Weeks Bay sedimentation is still being addressed in our study, but there are clear indications that in some areas of the bay, rates and/or grain size may have been influenced by human activity.

ACKNOWLEDGEMENTS

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