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The Post-Storm Hurricane Hugo Recovery of the Undeveloped Beaches Along the South Carolina Coast, "Capers Island to the Santee Delta"

Walter J. Sexton

Athena Technologies, Inc.
3700 Rosewood Drive
Columbia, SC 29205

ABSTRACT

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Hurricane Hugo made final landfall on the South Carolina coastline on September 21/22, 1989 with storm surges of 6 to 7 m and winds estimated at 140 mph. Numerous field excursions have been made to the study area since the storm's landfall in 1989. During these field trips, data collection included low altitude aerial overflights, beach profile data, and general ground observations. From the analysis of this data, the beaches and tidal inlets within the study area have essentially recovered. Capers Island has had the slowest recovery of any of the regressive barrier islands. The delta front beaches on the Santee Delta (Cedar Island) are now sandy beaches, whereas before the hurricane, the beaches were mixed sand and mud. The transgressive barrier island beaches of Cape Romain have resumed their landward retreat completely eroding the hurricane washover deposit. The hurricane tidal inlet that formed along Cape Island (Cape Romain) has matured, first forming a flood-tidal delta then reducing its cross-sectional area and forming an ebb-tidal delta. It appears that it is now in the process of closing off. Post-storm washover fan deposition was observed on Capers Island. This process was active for two years following the storm and continued until the top of the beach built vertically to a point where it was not overtopped by high tides. The regressive barrier islands have recovered to their previous morphodynamic patterns. Bull Island's beaches have experienced full recovery, whereas Capers Island's beaches are unstable in that the beaches are somewhat sediment starved with persistent erosional zones.

ADDITIONAL INDEX WORDS: *Beach profile, tidal inlets, delta front beaches, barrier island, delta, washover deposit.*

INTRODUCTION

The post-storm recovery of beaches along the undeveloped coastline of South Carolina between Capers Island and the Santee Delta has been monitored since the landfall of Hurricane Hugo in September 1989. The focus of this paper is to present a summary of the significant shoreline changes that have occurred since Hurricane Hugo impacted the study area. This section of the South Carolina coast has a variety of morphological features including the Santee Delta, both regressive and transgressive barrier islands, several tidal inlets with well developed ebb-tidal deltas, extensive salt marshes, and tidal flat complexes.

The duration of the study was 3 years, 5 months and includes a 50 km portion of the South Carolina coast from Capers Island, located approximately 20 km north of Charleston, to the Santee Delta (Figure 1). This section of the South Carolina coastline experienced the full force of Hurricane Hugo. This paper presents the findings of a long-term post-storm recovery from a severe storm along an undeveloped coastline. Other studies on the effects of severe storms along similar coastlines in natural settings (TANNER, 1961; EL-ASHRAY and WANLESS, 1965; HAYES, 1967; SCOTT *et al.*, 1969; DOLAN and GODFREY, 1973; SEXTON and MOSLOW, 1981) have all focused on the storm's impact with some short-term recovery reported. With a study of this length, it is important to realize that although the coast is recovering from the storm, other high energy events begin to complicate the one event recovery process.

PHYSICAL SETTING

The climate along the South Carolina coast is subtropical to temperate. Mean yearly temperatures average 16 °C. Annual rainfall averages around 122 cm, with predominant seasonal winds from the north during the winter and south during the summer. Winds are typically light except during storm events (LANDERS, 1970). The study area

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has a semidiurnal tide and spring tides range from 1.8 to 2 m (BROWN, 1977).

Net longshore transport rates on the beaches in the study area have been measured at 130 to 150,000 m^3/yr (KANA and KNOTH, 1977), from the northeast toward the southwest.

The beach sediments in the study area are predominantly well sorted, fine grained (mean diameter 0.125 mm), quartz-rich sand. The beach sediments on the Cape are coarser (medium sand) and more poorly sorted. They are also rich in shell content.

There is a variety of shoreline types within the study area, including regressive and transgressive barrier islands, tidal inlets with large ebb-tidal deltas, long recurved spits, and a section of open coast at Bulls Bay. All of these coastal features have formed during the Holocene. The regressive barrier islands are typically 4 to 18 km long and 1 to 2 km wide. The transgressive barrier islands are not vegetated, are narrow (50 to 100 m wide), and vary in length. The transgressive barrier islands are composed of coarser sediments than the regressive barriers, containing a variety of sand sizes and abundant shell debris (MOSLOW, 1980; RUBY, 1981).

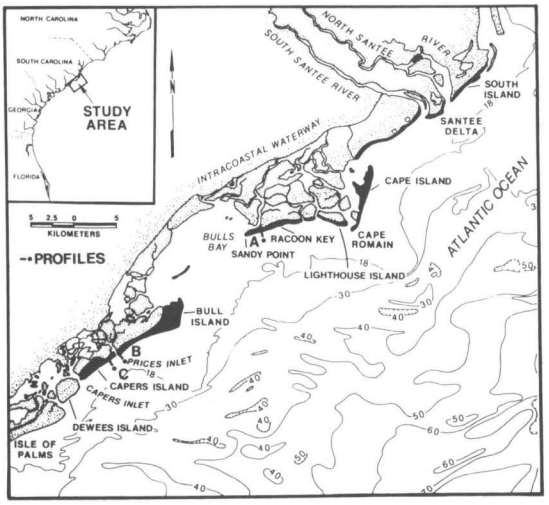

Figure 1. Location map of the study area which extends from Capers Island north to the Santee Delta. This section of the South Carolina coastline is undeveloped. Permanent beach profile stations are also shown (A, B, & C).

METHODS AND DATA BASE

Several beach profile stations were monitored within the study area during the post-storm beach recovery. The profiles were monitored using the EMERY (1961) method. Numerous trenches were dug throughout the study area to document the amount of post-storm recovery. The storm scour surface had truncated, older rooted and oxidized sediments which contrasted with the more recent sediments. The recent sediments are grey with no oxidation or rooting with abundant physical structures present.

Oblique aerial photography was used to examine shoreline recovery. The coastline was flown several times during the 3 year, 5 month study period. These aerial observations were complemented by numerous ground surveys between December 1989 and December 1992. During these field trips, observations were made and sequential ground photographs were taken.

POST HUGO BEACH RECOVERY— DECEMBER 1989 THROUGH FEBRUARY 1993

Hurricane Hugo was a Class 4 hurricane on the Saffir-Simpson scale with sustained winds of 140 mph. The geological impact of the hurricane along the shoreline of the study area was pronounced. Landward retreat (hurricane scarp) of the shoreline ranged from a high of 29 m at Capers Island to 20 m on Cape Island, a portion of Cape Romain (SEXTON and HAYES, 1991). Similar shoreline impact was reported from both north and south of the study area (KATUNA, 1991; NELSON, 1990). Numerous channels were formed along barrier islands during the hurricane ranging from return surge channels on the regressive barrier islands (typically only several meters wide) to island blowouts along the transgressive barrier island that were as wide as 1 km (SEXTON and HAYES, 1991).

Recovery of the beaches will be discussed from a framework of three geomorphic zones: (1) Santee Delta; (2) Cape Romain; and (3) Bull and Capers Islands and Price Inlet. This discussion moves from north to south through the study area (Figure 1).

Santee Delta

The beaches in the vicinity of the Santee Delta retreated an average of 18 to 21 m as a result of the landfall of the hurricane. The entrances to both the North and South Santee Rivers (Figure 1) widened due to the erosion of the ends of their associated recurved spits (SEXTON and HAYES,

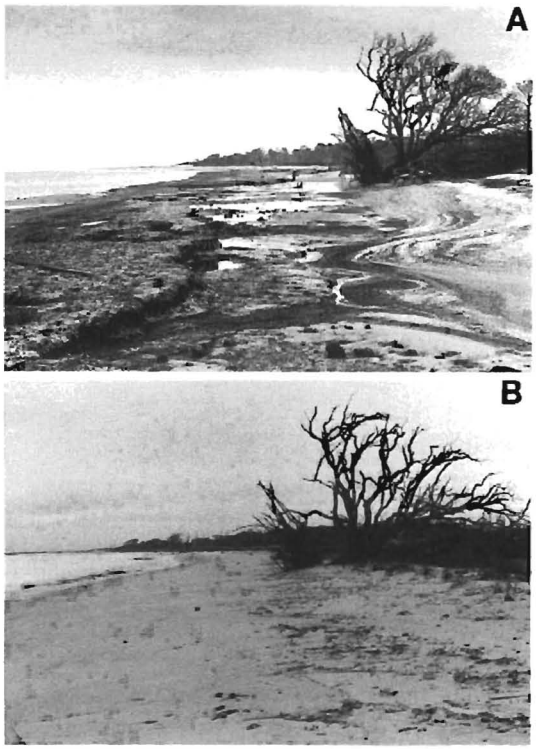

Figure 2. Comparison photos of the north facing ocean beach on Cedar Island located on the Santee Delta. Cedar Island separates the North and South Santee Rivers (Figure 1). Photo A taken in May 1990: Note that nearly all of the intertidal beach is composed of mud, exposed lower delta plain sediments. Photo B taken in December 1993: A sand beach was deposited over the mud scour surface formed during the hurricane.

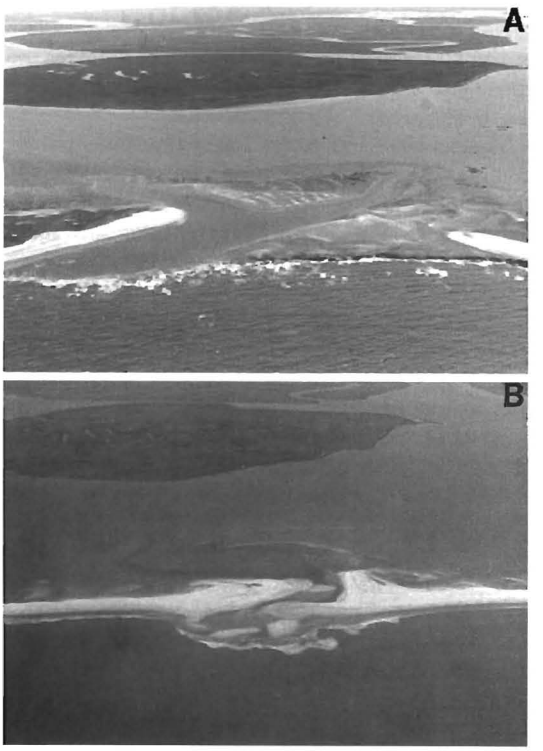

Figure 3. Hurricane inlet located along Cape Island, a portion of Cape Romain. Photo A taken in April 1990: Cape Island blow-out in the process of forming an inlet with a flood-tidal delta. Photo B taken in February 1993: The inlet matured continuing to narrow its cross-sectional area forming an ebb-tidal delta.

1991). Post-storm beach recovery began shortly after the landfall of Hurricane Hugo and was observed as numerous ridges of sand present on the beaches. One of the more pronounced zones of recovery was observed along the north facing beach at Cedar Island. Cedar Island separates the North and South Santee Rivers at their entrances (Figure 1). Figure 2 is a sequence of two photographs taken at the same beach location along Cedar Island. Photo A was taken in May during the spring of 1990, eight months after the storm. Note that some sand had been deposited along the upper beachface by this time. The remainder of the beach was composed of lower delta plain sediments (silt and clay mixed with rafted peat). These lower delta plain sediments were exposed/eroded during the hurricane. Photo B was taken in December 1992 and demonstrates the level of recovery the beach area experienced during this 2.5 year time period. This level of recovery is pronounced but not uncommon throughout the study area. It should be noted that in this beach area, although adjacent to a tidal inlet, no bar-bypass was observed during the recovery period.

Cape Romain

The entire cuspate-foreland was inundated by the 6 to 7 m peak storm surge of Hurricane Hugo. The hurricane produced large washover fans throughout this area with the removal (blow-outs) of large sections (1,064 and 661 m) of the narrower transgressive barrier islands. Shoreline retreat varied along the Cape from 27 to 9 m but generally was less than along the regressive barrier islands (SEXTON and HAYES, 1991). During the recovery of the beaches on Cape Romain all of the large

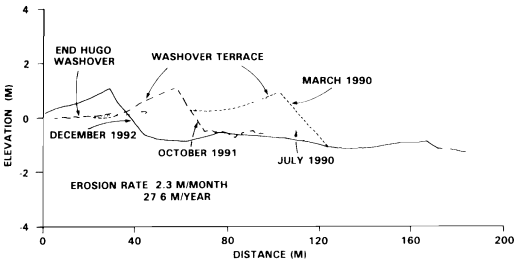

Figure 4. Beach profile plot comparisons of the southernmost beach area on Cape Romain (March 1990–December 1992). This highly erosional coastal setting retreated landward 71.3 m during the study period.

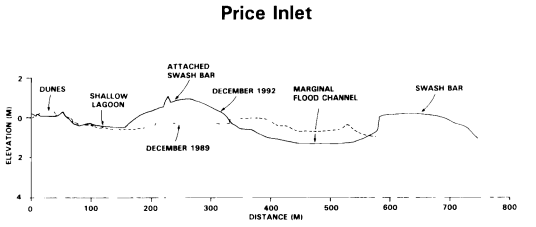

Figure 5. Beach profile plot comparisons of the north side of Price Inlet (December 1989–December 1992). The inlet has regained its pre-hurricane morphology with active swashbars and marginal flood channels.

hurricane channels that formed during the hurricane closed off within several months following the storm except one located on the central portion of Cape Island (Figure 1). This large opening, 1,064 m wide, narrowed until a small tidal inlet was formed. Figure 3, Photo A shows the inlet in April 1990, seven months after the hurricane. At this time the inlet had a well developed flood-tidal delta but no ebb-tidal delta. Over the next two years the inlet continued to close and began developing an ebb-tidal delta. Photo B, Figure 3, taken in February 1993, shows the small inlet nearly closed off with its ebb-tidal delta. It is felt that the inlet will probably close off within the next several months. This is the last remaining hurricane channel within the study area.

On the southwest side of Cape Romain, the beaches of Raccoon Key (Figure 1) have resumed their post-storm pattern of extensive beach erosion. Figure 4 is a time series beach profile plot for Profile Station A—Raccoon Key/Cape Romain (Figure 1). This plot compares survey data from March 1990 through October 1992. The total erosion of the shoreline during this time period was 71.3 m (2.3 m/month) measured from the crest of the washover. The transgressive barrier has retreated landward to a point where the entire Hurricane Hugo deposit has been either eroded or is buried by the present washover terrace.

Bull and Capers Islands and Price Inlet

This is the southernmost portion of the study area (Figure 1). Bull Island experienced 24 m of shoreline erosion along the front ocean facing beaches as a result of the landfall of Hurricane Hugo. Numerous return surge channels were formed across the back beach and active beach face, but no channels cut completely through the island. Within six months following the storm, all the return surge channels had infilled with sand. Observations made in February 1993 indicate that the beaches along the island have recovered, and new back beach dunes have been deposited with dune grasses vegetating these dune deposits. During our aerial reconnaissance in February 1993, the hurricane scarp was difficult to observe due to the extent of beach recovery and revegetation.

At Price Inlet (Figure 1), the inlet has regained its more typical morphological configuration. The profile plot comparison shown in Figure 5 is data collected from the north side of Price Inlet on Bull Island (Figure 1, Profile B). The beach profile plot summarizes the recovery at the inlet with the formation of a new marginal flood channel and the active deposition of sand in the form of swash bars. The remainder of the inlet has shown similar recovery.

Capers Island is the barrier island located on the downdrift (southern) side of Price Inlet (Figure 1). Capers Island had an average shoreline retreat of 28 m resulting from the landfall of Hurricane Hugo (SEXTON and HAYES, 1991). Along the northern portion of the island there is a 1.5 km section of beach that has low relief and is backed by salt marsh. All the coastal dunes were removed during the hurricane, and a thin veneer of sand was deposited on top of the seaward fringe of the marsh surface. Photograph A, Figure 6 was taken one day after the hurricane along this section of Capers Island. During the next 1.5 years washover fans were deposited along this section of the island during the beach recovery process. Washover deposition continued until the top of

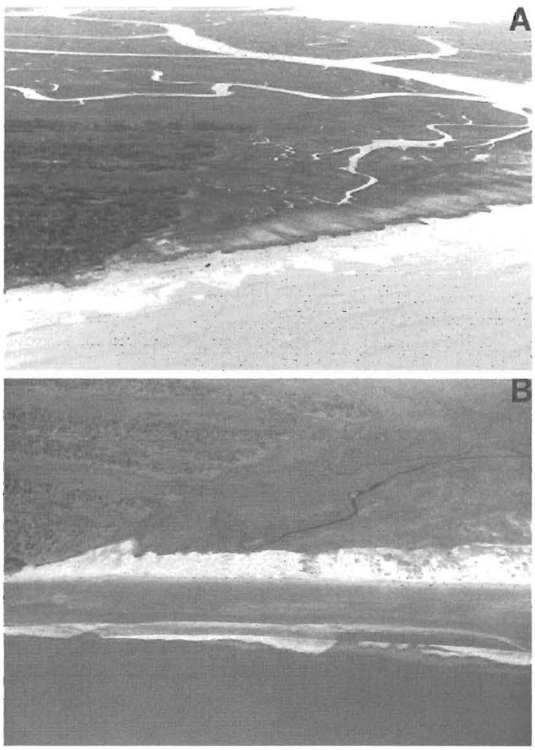

Figure 6. North section of beach located on Capers Island next to Price Inlet. Photo A taken in September 1989: One day after the landfall of Hurricane Hugo. The top of the beach is scarped back to the marsh with only a thin veneer of sand deposited landward of the active beach. Photo B taken in February 1993: Extensive washover deposition along this section of beach which occurred during post-storm beach recovery.

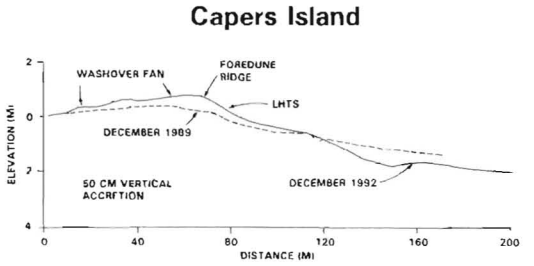

Figure 7. Beach profile plot (December 1989–December 1993) from Capers Island. Station is located along the section of the island that experienced post-hurricane washover deposition.

the beach reached an elevation from which high tides could not overtop the beach, activating the washover fans. Photograph B, Figure 6 was taken in February 1993 and documents the extensive washover fan deposit that occurred in this area during post-storm beach recovery. The beach profile plot comparison shown in Figure 7 summarizes the beach changes at this location (Profile C, Figure 1). This washover deposition first built a platform followed by berm deposition and then the formation of coastal dunes.

CONCLUSIONS

Hurricane Hugo, a Category 4 hurricane, profoundly affected a large portion of the South Carolina coastline. Immediately after the storm the beaches within the study area began to recover, and within one year after the hurricane the shoreline had experienced significant recovery. From the analysis of the data collected since the landfall of the storm, results are that the beaches and tidal inlets within the study area have essentially recovered. Some beach areas (Cedar Island and Santee Delta) have shown dramatic recovery with wide sandy beaches replacing scoured mud surfaces. The only tidal inlet that formed within the study area during the hurricane, along Cape Island, has matured and is probably in the process of closing. The transgressive shoreline segments, such as Raccoon Key on Cape Romain, have continued their rapid landward retreat eroding at a rate of 25 to 30 m/year. Price Inlet has regained its pre-storm ebb-tidal delta morphology with active swash bars and marginal flood channels. Of considerable interest was the post-storm development of washover fans monitored at Capers Island during the first 1.5 years following the storm. The washover fans were active until the top of the beach accreted to a critical height necessary to prevent overtopping by first neap then spring tides.

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