Effects of Hurricane Frederic on Dauphin Island, Alabama

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INTRODUCTION

Hurricane Frederic made landfall near Pascagoula, Mississippi at 00 00 CDT, September 13, 1979 (Fig. 1). Estimates of total property damage range as high as two billion dollars (Wall Street Journal, Nov. 23, 1979) indicating that it may be the costliest storm ever to have hit the United States. Hurricane Frederic is classified as a major storm, with highest sustained winds of 126 knots recorded at the bridge on the Dauphin Island causeway. An unofficial pressure of 943 mb was recorded at the Dauphin Island Sea Laboratory during storm passage.

The eye of the storm passed over the central part of Dauphin Island. Hurricane winds typically attain their maximum velocities along the eastern side of the storm track; storm surge elevations in the area of landfall support this (Fig 2). Hurricane precipitation ranged from 20-30 centimeters and the storm spawned numerous tornadoes along the coast (preliminary data, National Hurricane Center, Miami).

Storm passage caused severe property damage on Dauphin Island and significantly altered the morphology of this barrier island. To assess the effects of Hurricane Frederic, oblique aerial photographs obtained by the authors (Sept. 14, Sept. 22, and Oct. 25, 1979), vertical air photographs obtained through the courtesy of the Army Corps of Engineers, Mobile District (Oct. 1976 and Sept 22, 1979), and data from several ground surveys were analyzed to determine the morphologic changes that took place and the degree to which man's activities influenced these changes.

Fig. 1. Storm track of Hurricane Frederic 9/2/79 to 9/14/79. (Preliminary data from National Hurricane Center, Miami).

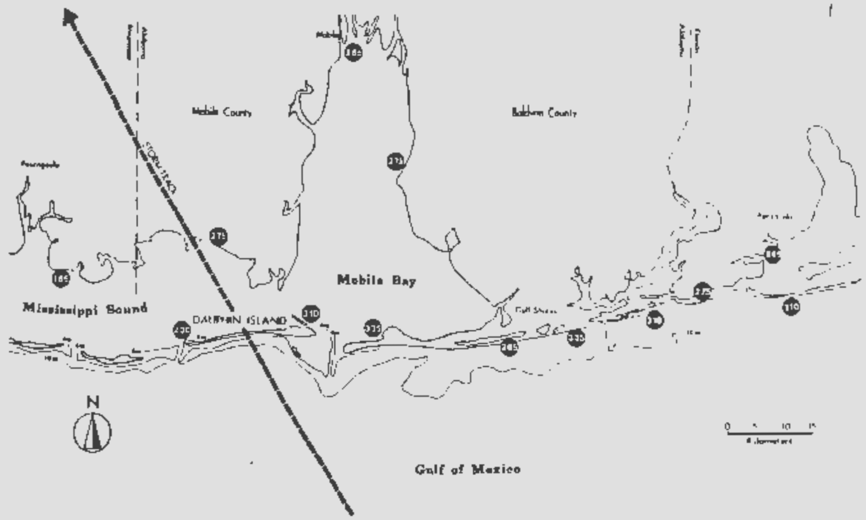

Fig. 2. Maximum storm tide elevations in coastal areas of Mississippi, Alabama, and western Florida during Hurricane Frederic Peak storm tide was recorded at Gulf Shores, Alabama. Storm tide elevations are given in centimeters.

DAUPHIN ISLAND

Dauphin Island is the easternmost member of a Gulf Coast barrier island chain that extends from Mobile Bay westward to the Mississippi-Louisiana border. This chain, except for Dauphin Island, is included in the Gulf Islands National Seashore and is restricted from development by law.

Dauphin Island is 23 km in length. The eastern 5 km of the island has a Pleistocene core which is topographically high and is vegetated by a thick pine forest (Fig. 3). Sand dunes, which in places attain a height of 15 m, occur along the Gulf side. The remainder of the island consists of a low and narrow Holocene spit extending westward in the direction of the dominant longshore drift. Along this spit sand

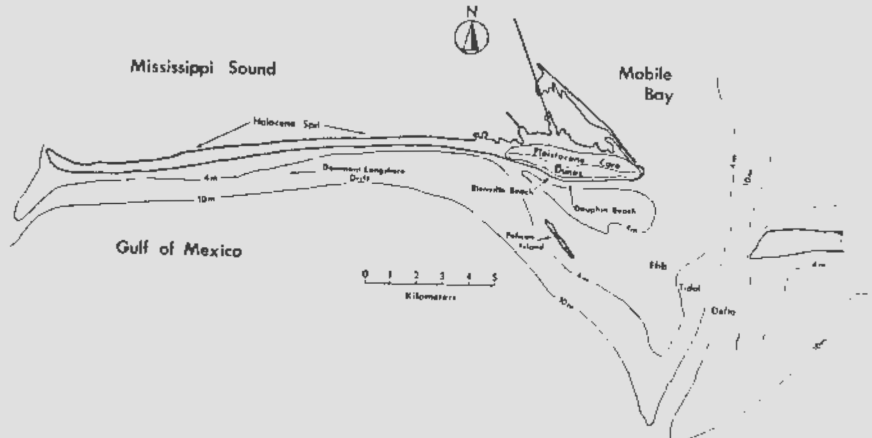

Fig. 3. Map of pre-storm morphology of Dauphin Island. The map is constructed from vertical air photos (courtesy of U.S. Army Engineers, Mobile District).

dunes are poorly developed, rarely reaching heights over 2 m, and are stabilized by various grasses and shrubs.

A small community has existed on the protected eastern end of Dauphin Island for some time. Residents occupied this area first because of the security provided by the extensive dunes. Rapid development of the island did not take place until 1954 when a bridge connecting the island to the mainland was completed. At first, development was confined to low-lying areas bordering the bayside of the eastern part of Dauphin Island. Through time, development expanded onto the low-lying spit extending towards the west, which is subject to washover during hurricanes.

STORM EFFECTS

The major effects of Hurricane Frederic on Dauphin Island were shoreline retreat on both the Gulf and Sound sides of the island, inundation of large areas, and overwash erosion and deposition along the western spit. The effects vary considerably because of local topography, nearshore bathymetry, and variations in storm surge levels along the length of the island.

Shoreline Erosion

The magnitude of shoreline retreat during the hurricane varied considerably from east to west along the Gulf side of Dauphin Island. The smallest amount of erosion occurred in the Dauphin and Bienville Beach areas near the eastern end of the island (Fig. 3). The reduced erosion is related to the proximity of these beaches to the ebb-tidal delta of the Mobile Bay entrance. The ebb-tidal delta is highly asymmetrical and extends westward, forming a shallow platform off the eastern part of Dauphin Island (Fig. 4). Incoming storm waves shoal and break over the shallow ebb-tidal delta platform, thus the waves expend most of their energy some distance offshore. As a result, the beach was relatively stable with some areas showing minor erosion and others minor accretion. Here, property damage was limited. Erosion increased both east and west of the Bienville and Dauphin Beach areas (Fig. 3). To the east, the increased erosion reflects an increase in distance and water depth between the shallow ebb-tidal delta margin and Dauphin Island (Fig 4). Immediately west of the ebb-tidal delta, shoreline erosion reached its maximum, probably because of wave focusing caused by refraction around the ebb-tidal delta. Maximum shoreline retreat was about 30 meters (Fig. 4).

On the western three-quarters of the island, beach erosion averaged 10-15 meters (Fig. 4). Shoreline retreat of 10-20 meters was experienced along the Mobile Bay side of Little Dauphin Island (Fig. 5). The reported shoreline retreat values were determined by the comparison of pre and post storm vertical aerial photographs. The average erosion rate over the period between photographic overflights has been subtracted from the total observed shoreline retreat and values given above reflect true storm erosion.

The shoreline of Dauphin Island along Mississippi Sound eroded an average of 25 meters. It appears that this back barrier erosion was caused by a hydraulic jump where the overwash entered the waters of Mississippi Sound. The intense turbulence associated with the hydraulic jump scoured pools which range from 0.5 to 1.5 meters in depth and produced a serrated shoreline (Fig. 6) Large lobate sand shoals formed behind the scour pools in Mississippi Sound.

Overwash

The storm surge generated by Frederic inundated approximately 70% of Dauphin Island. Large bores

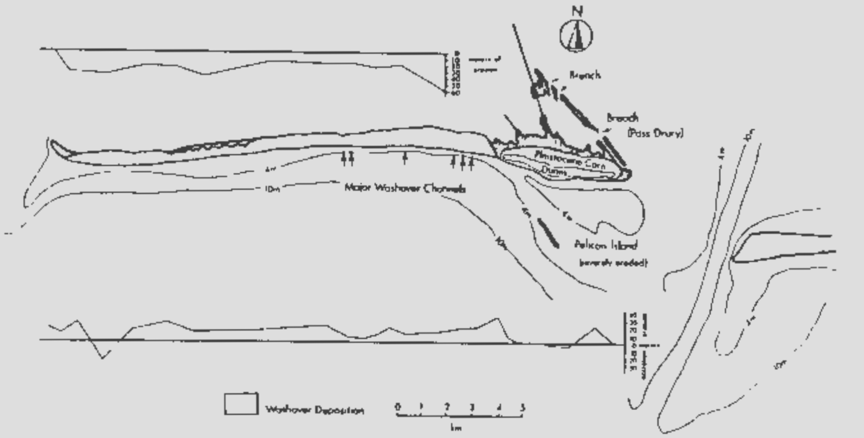

Fig. 4. Map of hurricane effects on Dauphin Island. Pleistocene core was not inundated by storm waters. Erosion measurements were made from vertical air photos taken in October 1976 and on September 22, 1979. (photos courtesy of U.S. Army Engineers, Mobile District).

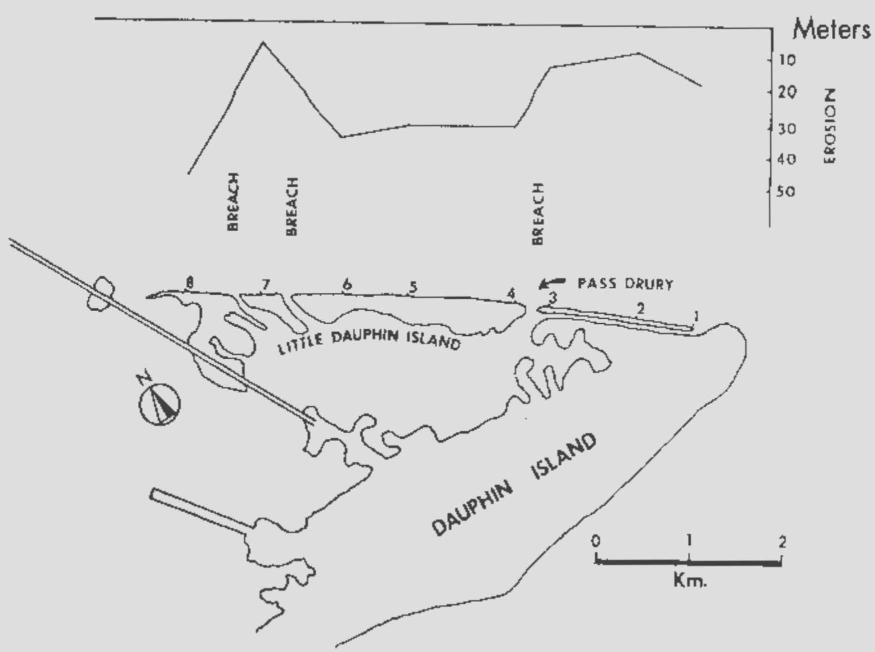

Fig. 5. Map of shoreline retreat along Little Dauphin Island; October 1976 to September 22, 1979

moving across the island scoured deep channels (1.5 m–2.0 m) through developed areas. In undeveloped areas overwash scour produced a number of small scour pits. A nearly continuous washover terrace was formed from Bienville Beach westward to the end of the island (Figs. 4, 7, and 8).

Breaches

Dauphin Island was not permanently breached by the hurricane. However, three breaches were formed on Little Dauphin Island. Each of these was open in the past but proved unstable, filling in relatively rapidly. After its opening by Hurricane Frederic the largest of these, Pass Drury, had a throat width of

Fig. 6. Oblique air photo of the Mississippi Sound side of Dauphin Island demonstrating the serrated shoreline, scour pools and lobate sand deposits. Width of photo is about 100 m.

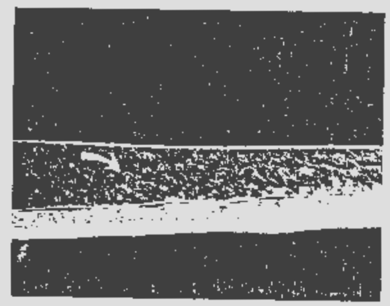

Fig. 7. Oblique view of central Dauphin Island in December 1978. Margin of old washovers is barely visible through the grass (arrow). Width of photo is about 400 m

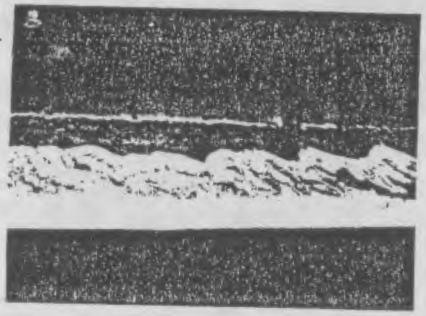

Fig. 8. Oblique view of the same area as Fig. 7, on September 22, 1979. (Photo courtesy of Rosemary Manty).

140 meters and a maximum depth of 1.4 meters. Pass Drury and the other breaches on Little Dauphin Island probably had a two-stage development. A north wind dominated during approach of the storm. In Mobile Bay a water level set-up and wave action, cut back dunes or washed over the island, producing "weak spots" in the barrier. Following passage of the eye of the storm, winds shifted to the WNW and a wind driven storm surge flowing across the barrier actually cut the channel. Several lines of evidence support this hypothesis. A large ebb-oriented sand body associated with Pass Drury was formed in Mobile Bay (Fig. 9). This ebb-tidal delta exists in spite of both current measurements and bedform morphology, which indicates that the inlet is flood-dominated under normal conditions. In addition, channel markers behind Pass Drury in Dauphin Island Bay were bent in the direction of an ebb current during the storm.

Effects of Man-Made Structures.

On the developed portion of the spit, streets and driveways which ran north-south across the island created topographically low areas that acted as pathways for the transport of water and sediment. Although topographic differences were minor, they were sufficient to cause these "weak" areas to be the first to be washed over during storm approach. This produced scour, making them more channel-like and increasing their capacity to handle flow. By the time the entire spit was awash, the "weak" areas had become the major overwash channels.

Canals within housing subdivisions and several drainage ditches which ran from midway across the spit to Mississippi Sound tended to concentrate flow, producing local increases in both amount of erosion and property damage (Figs. 10, 11, 12). Channels also developed behind beach front houses. The support pilings of these structures probably generated intense turbulence which initiated the channel scour (Figs. 13, 14).

The location of primary channels during overwash (in developed areas) was not determined naturally, but by the existence and position of streets, driveways, canals, and houses prior to the storm. Large overwash channels did not form in undeveloped parts of the spit, although in some places numerous scour pits coalesced to form small channel features. The bars, which mark the termini of the overwash fans, extend farthest into the back barrier waters behind the areas where man-made structures channelized overwash flow. The most severely damaged homes were those located within or immediately adjacent to the large overwash channels.

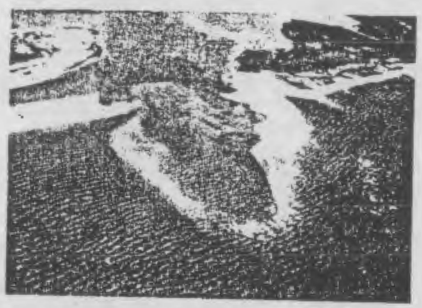

Fig. 9. Oblique view to the west of Pass Drury on October 25, 1979. The inlet gorge is 125 m wide.

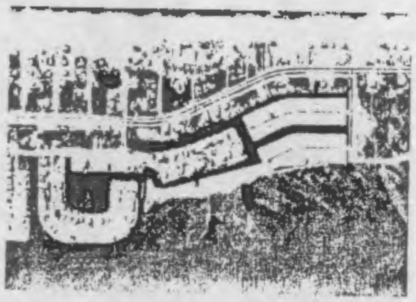

Fig. 10. Vertical air photo of the development west of Bienville Beach in October 1976. Gulf of Mexico on top of the photo.

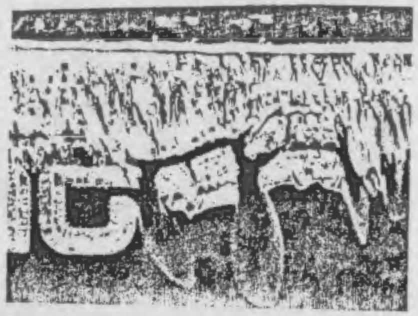

Fig. 11. Vertical air photo of the same development as Fig. 10 on September 22, 179.

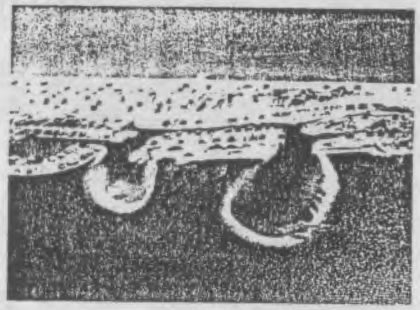

Fig. 12. Oblique aerial view of the same development as Fig. 10 on September 22, 1979.

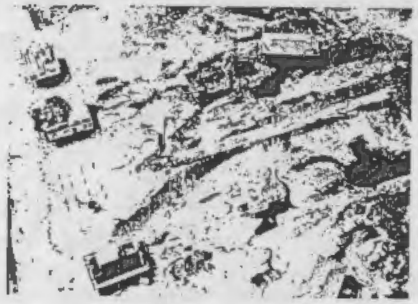

Fig. 13. Oblique aerial photo of hurricane-generated channels leading towards the back-barrier (to the right) from a beach-front housing development. (Photo courtesy of Perry Howard).

Fig. 14. Ground photo of damaged beach front home and the channel scoured underneath.

CONCLUSIONS

Erosion and property damage on Dauphin Island, Alabama during Hurricane Frederic were controlled, in a predictable way, by the following features:

- The large ebb-tidal delta (outer shoal) at the entrance to Mobile Bay broke storm waves, dissipating their energy far offshore. Shoreline retreat was at a minimum where ebb-delta protection was most effective. Shoreline retreat was at a maximum immediately west of the tidal delta platform, probably as a result of wave energy concentration by refraction around the margin of the tidal delta.
- The western three-quarters of Dauphin Island is a low spit which was completely inundated by the maximum hurricane surge. In this region, the most intense channel erosion occurred along driveways and back-barrier marina entrances. These man-made features acted as channel-ways focusing the currents during overwash.
- Support-pilings under beach front cottages also helped initiate channel scour, probably because of increased turbulence down current of these "obstacles."

ACKNOWLEDGMENTS

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