MORPHOLOGICAL IMPACTS OF HURRICANE CAMILLE (1969) ON BARRIER ISLANDS OF MISSISSIPPI AND WESTERN ALABAMA

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Introduction

The Nation's rapidly growing population of coastal residents and their demand for reliable information regarding the vulnerability of coastal regions to storm impacts have created a need for evaluating and classifying storm hazard vulnerability. Government officials and resource managers responsible for dealing with natural hazards also need accurate assessments of potential storm impacts in order to make informed decisions both before and during major storm events. Mitigating damage to natural coastal resources and economic development depend on integrating models of storm parameters, hazard vulnerability, and expected coastal responses. Thus, storm hazard vulnerability assessments constitute one of the fundamental components of forecasting future storm impacts.

Each year at least 10-12 named hurricanes and tropical storms will be the focus of national attention. Of particular interest are the intense storms (category 3-5 of the Saffir-Simpson scale) that have the potential to cause substantial economic and environmental damage to the Atlantic and Gulf coasts of the United States. These coastal regions include some of the largest metropolitan areas in the country and they continue to experience rapid population growth. Judging from past news media reports, there is a general lack of knowledge regarding how different coastal segments will respond to future storm conditions.

An objective of the U.S. Geological Survey National Assessment of Coastal Change Project is to accurately characterize the morphological impacts of major historical storms that have affected the Atlantic and Gulf coasts of the United States. By knowing how extreme storms have impacted beaches and barriers in the past, we are better able to predict how they might impact similar coasts in the future. This map product, which focuses on the impacts of Hurricane Camille, is the first in a series of maps that will portray the changes caused by the most extreme storms in the southeast United States since the early 1960s.

Hurricane Camille was a category 5 storm that, according to the National Hurricane Center, ranks second in terms of intensity (high wind speed, low barometric pressure, high waves, and high storm surge). It formed in the Caribbean Sea and crossed the coast of Mississippi near Waveland and Bay St. Louis on August 17, 1969. The entire barrier island chain of Mississippi and 70 % of Dauphin Island in Alabama were inundated by the high storm surge of Camille (U.S. Army Corps of Engineers, 1970). Summaries of Camille's meteorological history, oceanographic processes, and storm-related deaths and destruction are presented in Simpson et al. (1970), U.S. Army Corps of Engineers (1970), and Earle (1975).

Mapping Methods

Low altitude (scale 1:10,000) vertical aerial photographs taken shortly after Hurricane Camille (October 1969) were obtained from the National Oceanic and Atmospheric Administration (NOAA), National Geodetic Information Center. These high-quality, color-contact prints (9"X9") provide the most accurate regional representation of ground conditions after the storm that can be used for mapping the storm impact area. Post-storm photographic coverage extends from eastern Dauphin Island to the western end of Cat Island and includes the adjacent mainland shore. Patterns of storm erosion and deposition and features that might influence those processes, such as hard structures (seawalls, groins, and jetties) were interpreted from the aerial photographs and classified. The shores of the impact area were divided into segments that display common storm responses or attributes. The classified shore segments were transferred to U.S. Geological Survey 1:100,000 paper maps to provide a preliminary basis for evaluating the storm impacts and for verifying the air photo interpretations. After verification, the classified shore segments were visually transferred to an electronic map of the shoreline provided by NOAA. The electronic map with associated impact attributes are a layer in an ArcInfo Geographic Information System (GIS). Representative aerial photographs were selected to illustrate the typical erosional and depositional storm impacts or other mapping units, such as engineering structures.

Explanation of the Classifications

The classifications used to characterize the morphological impacts of Hurricane Camille are dune/scarp erosion, washover terrace, perched fans, sheetwash, striations and local reworking, and channel incision. Morton (2002) presents technical explanations of the physical processes and topographic conditions that result in the different storm impacts.

Dune/scarp erosion Extensive beach and dune (or bluff) erosion is the most common morphological response reported for intense storms. Severe erosion of these features occurs when the combined storm surge and wave runup is substantially higher than the backbeach, but lower than the adjacent dunes or bluff. At some barrier locations, Camille deposited a washover terrace and eroded the dunes. Where two impact types occurred together, both classifications are shown.

Washover terraces are elongate deposits that have their long axis oriented parallel to the shore. Terraces form where land elevations are (1) lower than the maximum storm surge and wave runup elevations, and (2) relatively uniform alongshore. Terraces were the most common morphological storm impact observed after Hurricane Camille. Washover terraces typically are deposited near an erosional scarp or berm crest. They may form a uniformly wide band along the shore, or their landward margins may be highly irregular, depending on the interaction between breaking waves and currents during washover deposition.

Perched fans are elongate washover deposits that have their long axis oriented perpendicular to the shoreline trend. The fans can be either individual isolated features, or regularly spaced features that are repeated alongshore. Isolated fans are constructed when the peak runup superimposed on the peak storm surge exceeds the lowest dune elevations, but elsewhere alongshore the surge is blocked by higher dune elevations. Spacing between the pre-storm dune gaps or storm-eroded breaches in the dunes controls the spacing of the isolated perched fans. Regularly spaced perched fans that are not controlled by alongshore variations in dune crest elevations may be products of wave interference patterns (Morton, 2002). Morpho logical criteria that favor construction of regularly spaced fans include a narrow barrier island, low dunes, and minor alongshore elevation differences between dune gaps and dune crests.

Sheetwash refers to unconfined flow where onshore sediment transport is continuous across the barrier island or coastal plain. Morphological responses to sheetwash can be either deposition of sediment eroded from the adjacent beach/dune system or redistribution of sand eroded locally from the ground surface. Washover deposits form sand sheets extending across the barrier island that bury the coastal vegetation.

Striations and local reworking occur where the washover current velocities are high enough to transport sand, but the volume of sand available from beach erosion is less than the capacity of the currents. Post-storm observations indicate that the striations and local reworking are products of processes where the current velocities are augmented by the high wind velocities of the storm. Under those conditions, the currents simultaneously erode sand and deposit it in narrow ribbons adjacent to the scour troughs. These morphological responses are commonly found on low-lying barrier islands that lack significant foredunes.

Channel Incision Excavation of new channels is the most destructive storm impact on a barrier.
One common type of response is excavation of a series of narrow, elongate channels that are relatively closely spaced and are eroded < 2 m below low water. These morphological responses are commonly found on low-lying barrier islands that lack high continuous foredunes. The closely spaced scour troughs are enlarged versions of the features classified as striations and local sediment reworking. Oblique low-altitude aerial photographs presented by Wright et al. (1970) show that Hurricane Camille cut the central part of the Chandeleur Islands, LA in several places by channel incision.

Another type of channel incision response is barrier breaching and opening of a new tidal inlet or reoccupation of a closed inlet. This channel incision response commonly occurs where narrow spits or peninsulas attach to headlands, and where inlet migration produces a low barrier segment. These new inlets may remain open indefinitely or they may remain open for decades before closing as a result of shoaling. An example of barrier breaching by Hurricane Camille is Camille Cut that bisected Ship Island, MS. Long, narrow microtidal barrier island segments that have low dunes and elevations less than 2 m are the most susceptible to breaching and new inlet construction during extreme storm inundation. This is because fast moving hurricanes tracking near the coast produce storm surges that exceed the dune heights, and also exceed the adjacent lagoon level, creating a hydraulic head that drives flows and incises channels across the narrow barrier (Morton, 2002).

Seawalls, **riprap**, **jettys**, and other engineering structures are intended to protect coastal property or navigation channels, and consequently they alter coastal processes during a storm. Both seawalls and riprap are positioned in the backbeach, parallel to the shore so they will help deflect the storm waves and currents. Seawalls are typically constructed of reinforced concrete, whereas riprap is commonly constructed of blocks of rock (limestone, granite) or concrete. The mainland shore of Mississippi is protected by a seawall that is located between the beach and the coastal highway, U.S. 90. Jettys are constructed of blocks of rock or concrete oriented perpendicular to the shore at tidal inlets and harbor entrances. Their purpose is to block the flow of sand alongshore and to reduce shoaling of the channel.

Storm surge elevations and **Sediment transport distances** are also provided on the map. The storm surge category represents maximum water levels produced by Hurricane Camille. The water levels were derived from maps prepared by the U.S. Geological Survey (Wilson and Hudson, 1969). The sediment transport distances are a measure of how far sand was moved inland during the storm. It is an indirect measure of the strength of the storm. Sediment transport distances were determined by taking the scale of the aerial photograph and calibrating a variable ruler so that it measured directly on the photograph in meters. Sediment transport distances were measured perpendicular to the shore and from the beach to the landward limit of sand transport, which is defined as the landward limit of the washover deposits.

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