Quick Response Report #84

IMPACT OF HURRICANE OPAL ON THE FLORIDA/ALABAMA COAST

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1996

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This material is based upon work supported by the National Science Foundation under Grant No. CMS-9632458. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

INTRODUCTION

Hurricane Opal passed over the Florida panhandle between the cities of Pensacola and Fort Walton Beach on the night of October 4, 1995. Although the storm weakened in the hours prior to landfall from a strong Category 4 to barely a Category 3 hurricane, major beach erosion, storm surge flooding, and overwash occurred along a stretch of shoreline extending from Gulf Shores, Alabama, to Mexico Beach, Florida, a distance of over 150 miles. By and large, wave damage was restricted to the first row of buildings and it was severe in a stretch from Pensacola to Fort Walton Beach. Overwash was over one meter thick in many places and pervasive from Gulf Shores to Fort Walton Beach. The character of the shoreline helped control damage as did development patterns. To classify Opal in a few words, it was a "water storm," meaning most of the damage caused by the storm was in the form of storm surge, wave attack, and overwash. Contrast this to Hurricane Andrew in 1992, which was a more intense (though compact) storm and whose principal agent of destruction was wind. Wind impacts from Opal were, however, felt to a minor degree in some areas along the coast.

The coastal impacts from Opal were generally the result of wave action and flooding rather than wind. A discussion of the wind impacts of Opal can be found in Chiu (1996), but the gist of it is that there was very little wind damage caused by Hurricane Opal to areas right at the coastline. However, the damage caused by waves and storm surge was extreme, ranking Opal as the ninth costliest storm to strike the coast of the United States (damage totals corrected to 1994 dollars), causing an estimated 2.9 million dollars worth of damage (Hebert et al., 1996). Much can be learned on how to mitigate future damage from a survey of the damage patterns using a geological perspective.

Field Work. The shoreline of Florida and eastern Alabama was visited by David Bush on October 6-8 1996 under the auspices of the Natural Hazards Center. Also collaborating in the quick response phase of this study with support from their respective institutions were: Craig Webb, geology graduate student at Duke University, and Robert Young, Assistant Professor of Geology, University of Vermont. Bryan Johnson, West Georgia College student revisited some of the sites in the Pensacola area on January 13-15, 1996. Graham Bates, geology graduate student of Robert Young's, University of Vermont, will be studying the Opal impacted area during the summer of 1996 as part of an ongoing risk-mapping project funded by the Federal Emergency Management Agency. This quick response study provided an invaluable service in adding to our database of storm impacts and as it allowed a reconnaissance look at the coast upon which to base further studies.

It was impossible to visit all sites along the shoreline due to access problems and time restraints. Specifically, the highly publicized and severely damaged community of Navarre Beach had to, sadly, be omitted because of fading daylight and curfews.

Pre-Storm Conditions. The area studied, specifically the panhandle coast of Florida, is predominately microtidal, with a tidal range of less than 0.5 m. The coastline struck by Hurricane Opal is dominated by long, narrow, sandy barrier islands. A good example is Santa Rosa Island, upon which are located several of the communities that were severely damaged during Opal, including Pensacola Beach and Navarre Beach. Santa Rosa Island is approximately 45 miles long (72 km), and at its widest point is only 0.5 miles wide (0.8 km). For the most part these islands are sparsely vegetated and have low elevations, making them vulnerable to storm surge and wave damage. Much of the area does have large, healthy dune fields, however, with dune heights often reaching 16 feet (5 m). The presence of these dunes can help to absorb wave energy and buffer the areas behind them from the brunt of the storm, thereby reducing the damage, as shown by a study of the geomorphic impacts of Hurricane Hugo along the South Carolina coast (Thieler and Young, 1991).

ACKNOWLEDGEMENTS

The primary funding for this study was provided by the Natural Hazards Center with the follow-up work supported by the Federal Emergency Management Agency. The authors also wish to acknowledge the superb assistance of several agencies during the field inspection: Florida County Sheriff Departments, especially in Bay, Okaloosa, and Escambia Counties for their help with access; the National Guard, especially Spc. Gary Be,gi of the Florida Army National Guard Public Affairs Office for a guided tour of Fort Walton Beach and a detailed description of the damage in Navarre Beach; and Michael Simmons and Brandon Richberg, 4-wheel drive volunteers, who provided safe transportation and their insights of the storm damage on Pensacola Beach.

PHYSICAL ASPECTS OF THE STORM

Hurricane Opal had a strange history, blowing up seemingly overnight and then weakening in the hours before landfall (Mayfield and Lawrence, 1996). There was quite a bit of confusion over where the storm was heading and what strength it would be when it hit. The general consensus seemed to be that the weakening of the storm as it approached land helped keep loss of life down. Also, many people said that the passage of Hurricanes Allison and Erin had helped prepare the people for another storm.

Opal hit at dead low tide, and although the tidal range in this area is small, this, in addition to the fact that the storm was weakening as it approached the coast, helped to keep inland penetration of storm surge and waves to a minimum.

This may account for the relative lack of sand completely washing over islands, even narrow portions, with the exception of Santa Rosa Island, which was almost entirely overwashed (Stone et al., 1996). Instead, most of the overwashed sand was deposited on the islands themselves. According to a study conducted by Stone et al. (1996), up to 95% of the sand eroded from the beach and dune area can be accounted for as overwash on the island itself and in fans overwashing into the bay side, rather than being moved offshore into a series of bars. In addition, Stone et al. noted that the shoreline did not retreat landward during the storm, as is often the case in large hurricanes, but remained in place.

Wind Damage. Hurricane Opal was definitely not a wind storm, at least not directly along the coast. Nowhere was there evidence of a great "swath" of fallen or snapped trees such as was present after Hurricane Hugo in South Carolina in 1989, nor the massive wind destruction caused by Hurricane Andrew in south Florida in 1992. There were numerous examples of delicate roof architecture (that is, many gables, angles, eaves) with little or no damage. Utility poles were left standing unless trees fell directly on the wires. Most of the trees that fell were not snapped but pushed over, meaning the weak soil and shallow root systems were contributing factors along with the wind. There were relatively few signs, awnings, or covers for gasoline station pumps blown down. Metal buildings remained standing. Opal did a great deal of damage, but wind was not the major culprit along the coast. Opal did cut a swath of extensive wind damage inland through eastern Alabama and western Georgia, but those impacts are beyond the coastal scope of this investigation.

Wave Damage. Wave damage from Opal was extensive and severe in places, especially to the waterfront areas stretching from Pensacola Beach to Destin. Damage was extensive to moderate from Gulf Shores, Alabama, to Pensacola Beach, and from Destin to Mexico Beach, Florida. In all cases, however, the wave damage was largely restricted to the first row of buildings. It was clear that those buildings that were elevated or located back from the beach suffered less damage than those built at grade or without reasonable setbacks.

Storm Surge. Storm surges were reported to have been in the 12-16 feet range (about 4-5 meters), but field inspection suggests that they were more in the maximum of 2-3 meter range. Debris lines on beaches and causeway landings, mud lines on buildings, and impact scars on pilings are some of the field observations made to estimate storm surge heights. Storm surge was certainly higher in the Pensacola Beach area than to the east or west. These observations were echoed by the detailed analysis of Jarvinen (1996) presented at the National Hurricane Conference April 2-5, 1996 in Orlando, Florida.

The very gentle slope of the continental shelf into the Gulf of Mexico, the gentle slope of the coastal plain, and the concave configuration of the shoreline work to maximize storm surge along this portion of the coast. The fact that storm surge was likely less than predicted may be accounted for by the rapid relative weakening of the storm as it was making landfall, plus the fact that Opal hit at low astronomical tide. There is enough variation in the offshore bathymetry along the coast to cause local variations in potential storm surge and storm wave height (Jarvinen, 1996).

Storm-Surge Ebb Scour. The rush of storm surge water back to the sea after passage of a hurricane is called storm-surge ebb. It can have quite dramatic consequences when the surge is high and the return flow is rapid, or when the reversal of winds by a coast-parallel storm helps blow the water back out to sea, increasing the water's flow velocity and scouring capabilities. Storm surge ebb is often funneled by shore-perpendicular roads and dune gaps, and is the primary agent in forming new inlets in barrier islands. None of these processes seemed to be very active during Opal. First, Opal was a coast-perpendicular storm, so there was no reversal of winds from onshore to offshore that would have aided in storm-surge ebb flow, as would be the case in a coast-parallel storm. Second, the storm surge was not all that high as discussed in the previous section. Finally, it appears from field inspection of sediment bedforms and other water flow indicators that the direction of flow of the last water draining off the islands, where there was some scour, was landward, toward the lagoons, not back toward the Gulf of Mexico. This would seem to corroborate the conclusion that storm surge was not excessive, and that perhaps the surge was somehow pushed forward as the storm weakened before landfall and the "surge wave" lost some of its forward momentum and simply "sloshed" over the islands and into the lagoons. It would also seem that the lagoons, then, were large enough to handle the excess water volume from Opal's surge, again corroborating the idea that storm surge was not as high as first predicted. Again, the lower storm surge effect would be aided somewhat by Opal's making landfall at low astronomical tide, even in this microtidal setting.

HURRICANE OPAL LESSONS LEARNED

One of the main emphases of studies by this investigator and colleagues over the years has been to extract "Lessons Learned" for coastal management from each storm. Post-storm investigations in many different geologic settings and after different strength storms helps to clearly illustrate these lessons. For further information on general principles the reader is refered to Bush et al. (1996). For specifics about western Florida, please see Doyle et al. (1984), Webb et al. (submitted), and Bush et al. (in preparation). The lessons learned from Hurricane Opal are briefly outlined below.

Building Above Grade. The importance of building above grade is shown by four nearby single family houses in Mexico Beach. Two were built at grade and were completely destroyed, while two were elevated on pilings and suffered no observable structural damage. In another instance, Hollywood beach houses too close to the water were completely destroyed, even though they had protective seawalls. The seawalls did keep the structures from being undermined, but did little to prevent the floors from being damaged. One condominium complex built about 3 meters above pre-storm grade and set back farther from the water suffered only minor damage to the first floor. Building on pilings or (preferably) at higher elevations does not guarantee that no damage will be incurred, but it was observed that during this storm, those houses with more elevation, even just the several meters offered by pilings, can be saved. It is important to note, though, that if your house is on pilings and none of your neighbors' are, you are still at risk, as those houses may very well be floated off their foundations and into your house.

Removing Dunes. All along the impact area dunes were destroyed. In some cases, however, where dunes had been removed before the storm for building sites or beach view, damage was greater. For example, along Inlet Beach several houses were set back over 60 meters from the sea and were slightly elevated. Dunes had been removed before the storm and the houses suffered structural damage. Had the houses been built behind the dune, the damage likely would have been minimal.

Setback. Setback from the beach, that is, building a certain distance away from the surf zone, was seen to be a good way to avoid damage. Setbacks of as little as 50 to 100 ft, when combined with higher elevations, can help to minimize the damage to the structure. However, it is important to note that this does not guarantee safety, especially if dunes between the structure and the sea are removed. As mentioned above, buildings set back and elevated were still damaged, as the protective dunes in front of them were removed.

Mitigation Capabilities of Seawalls. Seawalls saved many structures from significant damage. However, failure of seawalls was not uncommon, indicating they may not be the best or most assured method of reducing damage. Three main types of failures were observed: (1) end-around failures resulting from erosive "flanking" of the seawall; (2) seaward toppling of the seawall by overloading from behind by rain water, wave washover, and insufficient drainage leading to failure of the tiebacks; and (3) undermining by erosive scouring at the base of the seawall, which removes material from behind the wall resulting in the characteristic landward fall of the wall. While these walls in many cases prevented damage from undermining, they did little to prevent the structure from being ravaged by waves and storm surge, which overtopped the wall. Apparently the value of the seawalls is not as great as people think, and it would seem that all they really provide is a false sense of security to those living directly on the beach. Hurricanes Gilbert (Yucatan, Mexico, 1988) and Hugo (South Carolina, 1989) illustrated that low seawalls are often overtopped (flooded by storm surge) and offer no protection against storm waves.

Beach Shape and Property Damage Potential. Hurricane Opal created a classic storm beach profile, that is, a wide and flat post-storm beach. Many of the flattened beaches were overwashed, leaving up to 1 meter of sand in some places. Where the initial beach was wide and backed by tall dunes, damage to structures were lessened. Areas with buildings set back far from the sea, where overwash sand is reintroduced to the beach/dune system, and where dune growth is encouraged with sand fencing and vegetation will help to mitigate against future storm damage.

The wide, flat beach formed in Panama City Beach and in many other areas along the coast leaves all structures at a higher risk of damage by future storms. Another storm of this magnitude, or even a smaller storm, would cause quite a bit more damage, as the protective dunes require some time to recover. Recovery will commence naturally but can be aided artificially by replenishment, dune building by trucking in new sand, or encouraging dunes by sand fencing and vegetation. Mitigating some future damage to several of the single family houses in the area could be as simple as constructing an artificial dune.

Robust dunes were heavily damaged during Hurricane Opal, but their demise offered a measure of protection to landward structures. Where dunes were completely destroyed by Hurricane Opal, structures were more seriously damaged. In cases where structures are located too close to the shore, or left too close by dune removal, there may not be enough room remaining in front of the structure to build dunes or encourage dune growth. In these cases, attempts at prevention of future damage may be impractical.

Storm-Surge Flood Scour. Storm surge flood scour occurred in many areas. By their nature, these areas are prone to repeat flooding and should be noted for future development restrictions. Where surge waters were channelized by development, scour and damage were greater. In some cases, notably near Fort Walton Beach, overwash scoured away Florida Route 98 and deposited overwash fans in the lagoon. As noted earlier in this report, scour from the return flow of surge to the sea (storm-surge ebb) was minimal during Opal.

General Remarks. It seems that after every hurricane we say that "this hurricane was different from all the rest," and that can certainly be said about Opal. Opal strengthened quickly to a strong Category 4 storm and started moving directly for the Florida panhandle. The geographic setting there allows for maximum storm surge elevation, some of the greatest anywhere in the U.S. This deadly combination did not bode well for residents of the area. The rapid weakening of the storm before landfall, and its striking at low tide certainly worked to lessen the impact of the storm. From a coastal geologic standpoint, massive amounts of sand washed onto the islands, but very little washed over the islands into the lagoons indicating that the effects from storm surge flooding were minimal in an areal and/or landward incursion of floodwaters sense.

Building code compliance, good setbacks, and selecting elevated building sites all helped to reduce the property damage from Hurricane Opal. Opal was just the size hurricane we make our coastal risk analysis for (Bush et al., 1996), so it was classic in that sense. The idea being there will be many more Category 3 and smaller storms than larger, and that when a true Category 4 or 5 hits, there is not a lot you can do in terms of property damage mitigation but keep your fingers crossed.

References

Bush D. M, Pilkey, O. H., and Neal, W.J.
1996. *Living By the Rules of the Sea*. Duke University Press, Durham, North Carolina.

Chiu, A.N.L.
1996. "A Preliminary Summary of the Effects of Hurricane Opal on the Florida Panhandle." Insurance Institute for Property Loss Reduction, Boston, Massachusetts.

Doyle, L.J., Sharma, D.C, Hine, A.C., Pilkey, O.H. Jr., Neal, W.J., Pilkey, O.H. Sr., Martin, D. and Belknap, D.F.
1984. *Living With the West Florida Shore*. Duke University Press, Durham, North Carolina.

Hebert P.J., Jarrell, J.D., and Mayfield, M.
1996. "The Deadliest, Costliest, and Most Intense United States Huricanes of This Century." In: Tait, Lawrence S. (compiler), *Hurricane Preparedness: Facing the Reality of More and Bigger Storms*. 18th Annual National Hurricane Conference, April 2-5, Orlando, Florida, p. 75-104.

Jarvinen, B.
1996. "Predicting Storm Surge." Presentation at the 1996 National Hurricane Conference, April 2-5, Orlando, Florida. Jarvinen is with the Tropical Prediction Center/National Hurricane Center, Miami, Florida.

Mayfield, M and Lawrence, M.

1996. "1996 Atlantic Hurricane Season Summary." In: Tait, Lawrence S. (compiler) *Hurricane Preparedness: Facing the Reality of More and Bigger Storms*. 18th Annual National Hurricane Conference, April 2-5, Orlando, Florida, p. 1-7.

Stone, G.W., Grymes, J.M., Armbruster, C.K., Xu, J.P., and Huh, O.K.
1996. "Researchers Study Impact of Hurricane Opal on Florida Coast." *Eos* 77 (19): 181, 184.

Thieler, E.R., and Young, R. S.
1991. "Quantitative evaluation of coastal geomorphic changes in South Carolina After Hurricane Hugo." In: Finkl, C.W. and Pilkey, O.H. (eds.), *Impacts of Hurricane Hugo: September 10-22, 1989, Journal of Coastal Research* Special Issue #8: 187-200.

Webb, Craig A., Bush, David M., and Young, Robert S.
Submitted. "Property Damage Mitigation Lessons from Hurricane Opal." *Journal of Coastal Research*.

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June 11, 1996

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