Biennial Report of Sand Beaches;

Harrison County, 1999

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Executive Summary

The Harrison County Beach has been maintained to a nearly uniform, but decreasing, beach width during the five-year period of this study. Volume changes, which more accurately portray beach change, indicate that sediment has moved from the "dry" beach to the submerged "wet" portion of the beach. Although there is an overall trend of erosion, rates are not severe for most of the beach. Erosion is mainly concentrated on the ends of the beach and locally occurring hot-spots. The effects of Hurricane Georges were minimal over a significant portion of the beach. The long length of the beach and regular nourishment have helped reduce sand loss. Flattening of the beach by maintenance, while maintaining a wider width, has in some cases lowered the beach elevation and restricted dune growth, which are both important for storm protection.

Introduction

The Beach in Harrison County is an extremely valuable resource to residents and visitors alike. Beaches are vital environmental, cultural, recreational, and economic resources. Beaches help maintain the health and productivity of the shoreline and coastal waters and provide for diverse cultural opportunities and recreational activities. Moreover, beaches in Mississippi are important in limiting infrastructure damage; and with an increase in development along the Mississippi Gulf Coast, the beaches are becoming an even more valuable asset. For these reasons, the Mississippi Office of Geology will continue to update local communities on the state of their sand beaches.

This interim report is meant to update coastal governments on the state of their beaches from a coastal geology perspective and highlight areas that may require more resource allocation. A more in-depth analysis, including subsurface geology and total-sand-volume calculations will soon be available. The data presented here include GPS shoreline surveys and beach profiles along the beach from Henderson Point to the end of the renourished beach in Biloxi and encompasses the years of 1994 to 1999. Changes in the past one to two years are used for analysis of impacts and trends associated with Hurricane Georges.

Methods

Two methods were used to map and describe the beach, both above and below sea level. Shoreline surveys of the normal high tide line were carried out using backpack style GPS (Global Positioning System) receivers with an accuracy, after being corrected for government scrambling, of 1-2 meters (3-6 ft.). The normal high tide line has been chosen as a repeatable datum for these shoreline surveys, which were done in the summer and spring months. The error in determining the high tide line is, based on comparison of multiple surveys of the same beach area, on the order of 1-3 meters (3-10 ft.). Thus, the overall accuracy of the method is generally about 2-5 meters (6-16 ft.). GPS surveys of the high tide position were carried out during June, 1999; previously shorelines were surveyed with GPS in 1993, 1994, and following Hurricane Georges in 1998.

To examine and map areas with shoreline significant change, an analysis was performed to highlight any portion of the shore with retreat or accretion of more than a predetermined value. A value of 5

meters (16 ft.) was chosen for the 1998 to 1999 comparison based on the accuracy of the method; for the longer range comparison (1994-1999), where the beach changes are high compared to the error, a value of 15 m (50 ft.) was used. The values used equate to yearly beach retreat of more than 3 m/yr. (10 ft./yr.). Sections of the beach that did not change at these levels have not been highlighted.

These GPS surveys and analysis techniques do not show the extent of storm-related or astronomical high tides. In many locations even a strong-wind tide will advance the shoreline several tens of meters (50+ ft.) beyond the mapped shoreline. In addition, beach maintenance and storm water runoff from the coastal roads are periodic events that can obscure local trends. Therefore, this method, though largely representative of erosion and accretion, is augmented by higher accuracy site surveys such as beach profiles.

Beach profiles are performed using survey grade instruments giving accuracies on the order of one inch. Unfortunately, beach profiles are time consuming and therefore only performed at set locations along the shore. Spacing between beach profiles is determined by the degree of change along the beach.

Beach profiles are aligned at right angles to the shoreline, beginning at the seawall, and ending at depths around –4 feet (up to chin of survey personnel), which typically corresponds to the sand/mud boundary. Elevations are based on benchmarks along the seawalls. This technique encompasses nearly the whole beach system, from seawall to the mudline, and is, thus, more accurate in describing any changes that take place. Beach profiles, while representing changes caused by beach maintenance, wind loss, storm runoff, and high tides, are not compromised because of them. In this report, beach profiles are used to calculate sand volume change from date to date, highlight areas of erosion and accretion, and document the evolution of sediment transport features. Unfortunately, there are some gaps in the survey dates, such that in some years certain profiles were not measured and others were. To correct for this a yearly change rate was computed. Values from the most recent surveys (1999 to 1996 depending on profile) were taken as a short-term indicator of change; longer-term rates were determined from comparison between 1999 and 1994 data. The 1994 surveys were a consistent data set for all but one (HR8) of the profile locations.

Volume change is initially determined in cubic yards per linear foot of beach width, such that a volume change of –1.0 cubic yards over a 700-foot stretch is equal to a deficit of 700 cubic yards of sand. Sand volumes include the dry beach (above 0.0 elevation) as well as the beach below sea level to about –3.0 to –4.0 feet. The values are then sorted into four categories representing the spectrum from high volume loss to high volume gain.

Harrison County Results

As the Harrison County Beach is significantly long, this report has been broken up into three sections: Western, Central, and Eastern Harrison County.

Western Harrison County (Henderson Point to Long Beach)

GPS shoreline surveys

Comparison of the 1998 and 1999 GPS erosion and accretion data highlights the changes following Hurricane Georges (Map 1). In the region from HR16 to HR10, the area to the west of profile location HR13 has experienced higher shoreline retreat than most of the entire Harrison County Beach; a significant amount of the retreat in the area from HR13 to HR14 is associated locally with culverts. The cause of the overall higher retreat in this area following Hurricane Georges may be related to low erosion (possible accretion) during the storm followed by redistribution (erosion) of the sand after the storm (following winter and spring). To the east of HR13, the beach shows little retreat and, in fact, the east side of Long Beach Harbor is accretionary during this period. Accretion on the east side of the harbor is an indicator of a northwest longshore current (flowing from southeast to northwest).

Looking at the slightly longer range, from 1994 to 1999 (Map 2), the only areas that have more than 3 m/yr. (15 m total, 50 ft. total) of beach retreat are areas downdrift of large structures including harbors (Long Beach and Pass Christian) and culverts/drainage structures. This pattern indicates that longshore drift is an important factor in the beach evolution here and should be considered when future development is undertaken.

Beach Profile Surveys: Volumes

Seven profile locations, HR16 to HR10, have been surveyed from 1992 to present along this stretch of beach. Short-term trends (Map 1) have been analyzed using data from 1996 to1999 depending on the availability. Profiles HR11 to HR14 were surveyed in 1996 and then again in 1999; profiles HR15 and HR16 were surveyed in January 1999 and then in July 1999. All values were corrected to a yearly change. Yearly changes in beach volume ranged from a loss of 18 cubic yards/foot (HR11) to a gain of 8 cubic yards/foot (HR12). In fact, the volume loss at HR11 was the highest short-term loss along the whole Harrison County shoreline. Overall, the profile changes show the effects of harbors on sediment movement (Long Beach Harbor) and the inescapable loss of sediment at the end of the beach. Large structures in a beach dominated by longshore currents impound sediment on the upcurrent side, robbing it from the downcurrent side. Loss of sand from the beach ends is a common problem on renourished beaches around the world. In contrast to the areas with a negative budget, the stability of the beach from HR14 to HR12 may be attributed to dune growth in some locations along this stretch (profile HR13).

Direct comparison of the volume change with shoreline retreat is hampered somewhat by the range of years used in computing the values. For example, the area near HR14 (Map 1) shows a modest gain in beach volume but a trend of beach retreat. This is attributed to the construction of dunes since 1996, which promote beach volume gain landward of the active shoreline, coupled with shoreline retreat during the past year.

Longer-term changes are reflected in the period of 1994 to 1999 (Map 2). This data set (Western Harrison) is the most complete of the five-year comparisons. All values have been computed to a yearly volume change (cubic yards/foot/year). The entire Harrison County Beach has a very modest change over the longer term, with values ranging from –2 to +3 cubic yards/foot/year compared to the recent changes of between –18 to +39 cubic yards/foot/year. In general, the western portion, from HR16 to HR10, has a slightly negative budget. The highest losses are on the downdrift sides of the two harbor structures and also at the end of the renourished beach; steady to slightly positive change takes place in the middle portion, HR12 and HR13.

Beach Profile Surveys: Beach Geometry

As mentioned, beach profiles also describe the shape of the beach and how it is evolving. HR13 is a representative example of this stretch of beach (Figure 1) during the past several years. The most striking changes (highlighted by the thin solid line) are the construction of a dune, and a loss of sand from the dry beach to the submerged beach. Although this area shows shoreline retreat and a loss of 0.6 cubic yards/foot/year, dune construction (high point of dashed line) limits potential storm damage and sand blowing onto Highway 90. As a result, the present profile is a positive step for coastal protection.

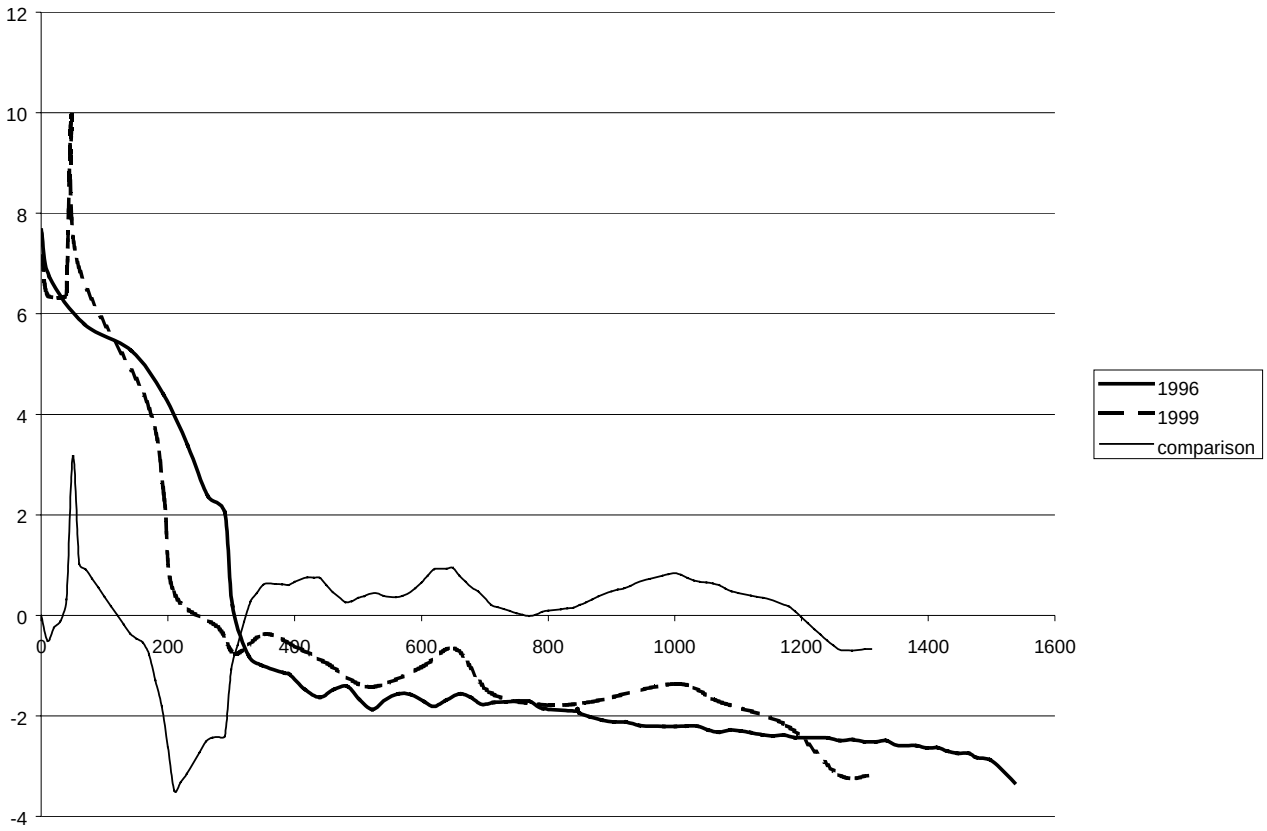

Figure 1. Beach profile at HR13; Y-axis is elevation in feet, X-axis is distance from seawall in feet.

Central Harrison County (Long Beach – Gulfport – Western Biloxi)

GPS shoreline surveys

This stretch of beach, HR9 to HR6, is typified by accretion during the period following Hurricane Georges (1998 to 1999) and may actually indicate that the area was more affected by the hurricane than Western Harrison County (Map 1). The high tide location in 1998 was, in many areas, landward of the 1999 location indicating that accretion dominates, which is opposite of the general trend. This suggests that the hurricane caused more beach retreat than to the west (moved the high tide line shoreward), and that following the storm (winter, spring) beach widening occurred by either natural recovery or, more likely, beach maintenance (moving the high tide line seaward). A one-mile stretch east of, and including, HR8 is the only area with a continuous retreat signature. There are numerous culverts and a pier (Courthouse Park and Pier) along the length that may, in combination with a slightly more SW-NE shoreline orientation, be increasing the amount of beach retreat.

In the five-year period from 1994 to 1999, the same retreat signature to the east of HR8 is evident (Map 2). Other than this pervasive erosional stretch, shoreline retreat of more than 3 m/yr. (15 meters total) is spotty and mainly related to erosion on the downdrift sides of culverts.

Beach Profile Surveys: Volumes

Beach volume change from 1996 to 1999 over this stretch of beach ranges from –1 to –5 cubic yards/foot/year (Map 1). The beach east of Gulfport Harbor has the lowest volume loss (HR8); conversely, the beach west of Gulfport Harbor (HR9) has the highest rate of volume loss. The lower loss of sand at HR8 may be an artifact of profile location; it is just updrift of a large drainage structure that traps sand as it moves alongshore. This loss at HR9 is created by Gulfport Harbor; it blocks the pervasive northwest trending longshore drift. Spacing between profile locations in this area limits higher accuracy observations; however, it is evident that Gulfport Harbor is locally affecting erosion rates.

In contrast to the more recent beach changes (1996 to 1999), the five year (1994 to 1999) trend is for

increasing volume (Map 2) at two profile locations (HR9 and HR6); unfortunately the data for HR8 are suspect and therefore not used. Beyond the inherent positive volume trend, the lack of closely spaced data makes further interpretation difficult and speculatory.

Beach Profile Surveys: Beach Geometry

HR6 (Figure 2) illustrates the general lack of change in the longer term along the better part of this stretch of beach. It stands in contrast to problem areas such as the beach just east of the Veterans Administration Hospital. The increase in beach volume out to the 3.25-ft depth shown is a sign that sediment is being deposited here. This stretch of beach is typified by a series of culverts and the actual profile location is slightly updrift (east) of a large culvert, which is probably responsible for the stable response. It is likely that a profile downdrift of the culvert would show an overall decrease in volume.

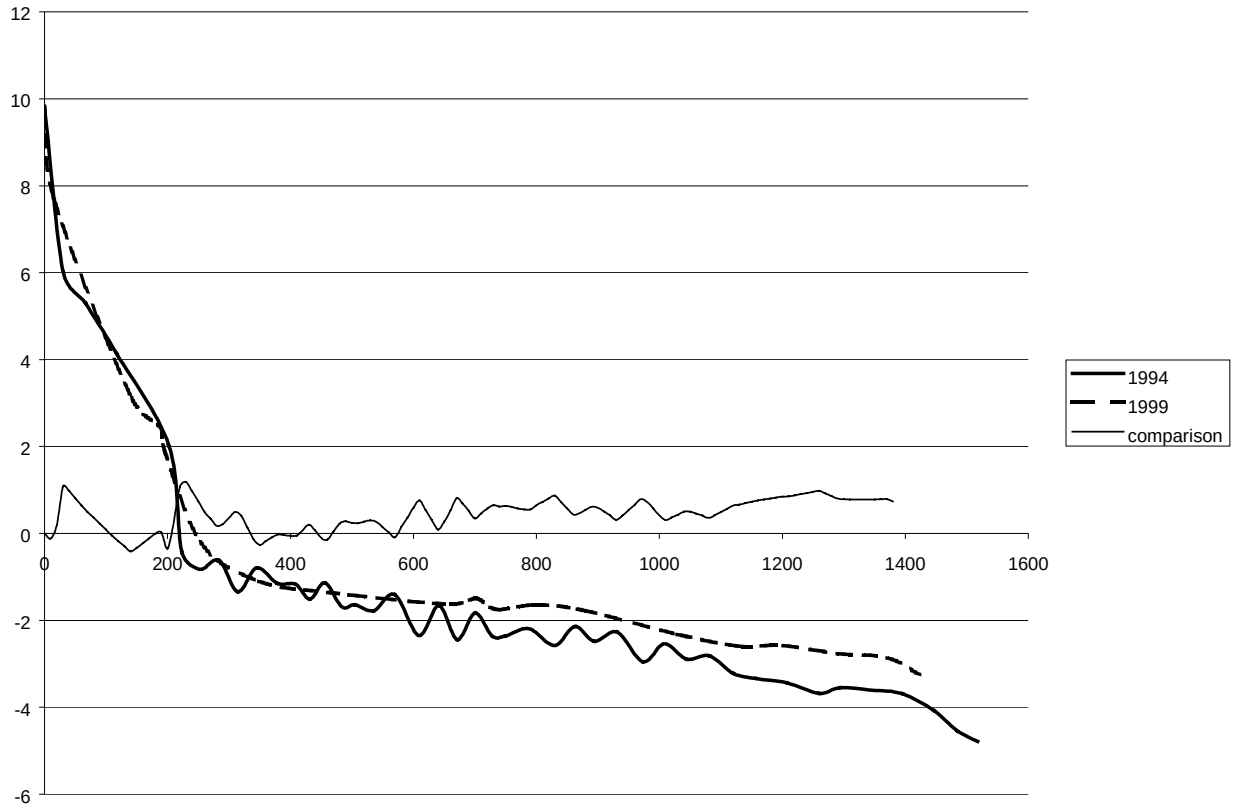

Figure 2. Beach profile at HR6; Y-axis is elevation in feet, X-axis is distance from seawall in feet.

Eastern Harrison County (Biloxi)

GPS shoreline surveys

Shoreline position change from 1998 to 1999 in the area from HR5 to the small beach along Casino Row indicates that for the most part the beach has accreted during this period (Map 1). The pervasive accretion may be a function of sample dates and post storm recovery, like the Central Harrison County section. The 1998 shoreline survey was conducted just after the passage of Hurricane Georges, which appears to have caused more beach retreat on the eastern end of Harrison County than on the western end. Following Hurricane Georges, beach maintenance and grading probably hastened the beach width recovery process. Therefore, the short-term shoreline survey in this area is a better indicator of storm erosion and subsequent human modifications than natural beach processes.

Longer term, 1994 to 1999, trends show very little shoreline retreat above 3 m/yr. (10 ft/yr.) (Map 2). The few locations where retreat reaches more than 15 meters (50 feet) since 1994 are dominantly downdrift of drainage culverts. In general, however, it appears that a constant beach width has been maintained by the Harrison County Sand Beach Commission.

Beach Profile Surveys: Volumes

In this highly modified section of the Harrison County Beach, beach volume change is a better indication of shoreline trends. Profile volumes are less influenced by beach maintenance and artificial shoreline accretion. It is for this reason that, although there was little shoreline retreat over the past year, shoreline volume changes are mainly negative (Map 1). For short-term comparison, all profiles along this stretch of beach were surveyed in 1998 following Hurricane Georges and then again in July 1999, thus providing a consistent set of data. The large positive value at HR5 (just west of Broadwater Marina) is an interesting anomaly. This location has the highest positive gain of the entire Harrison County Beach in the short term; much of this can be attributed to a high loss during Hurricane Georges followed by recovery to nearly the same pre-hurricane volume. It is apparent by the shape of the beach profile change from 1998 to 1999 that the recovery is more a

function of beach maintenance than natural recovery.

The five-year data set for this stretch of beach is complete except for HR3, which has been designated a zero value (Map 2). The overall trend indicates a negative budget east of the Broadwater Marina (HR5) and a positive budget to the west. It is unclear whether this is a function of specific profile location or a real effect created by the harbor structure. Otherwise, like the whole Harrison County Beach, this stretch appears to be eroding slowly, with only a minor amount of average yearly volume change.

Beach Profile Surveys: Beach Geometry

HR2 (Figure 3) represents the short-term change over a one-year period following Hurricane Georges. The profile change is typical of a highly modified shoreline, such that sand has been moved mechanically from the upper to the lower beach to maintain a constant width. Notice that the beach berm formed by waves during Hurricane Georges (solid dark line) was at about 5.6 ft above sea level, and that at present (dashed dark line) this may have reached the base of the seawall. When waves reach seawalls the amount of sediment moved offshore from waves increases and beach loss is hastened. Flattening of the beach works against its natural protection in storm events.

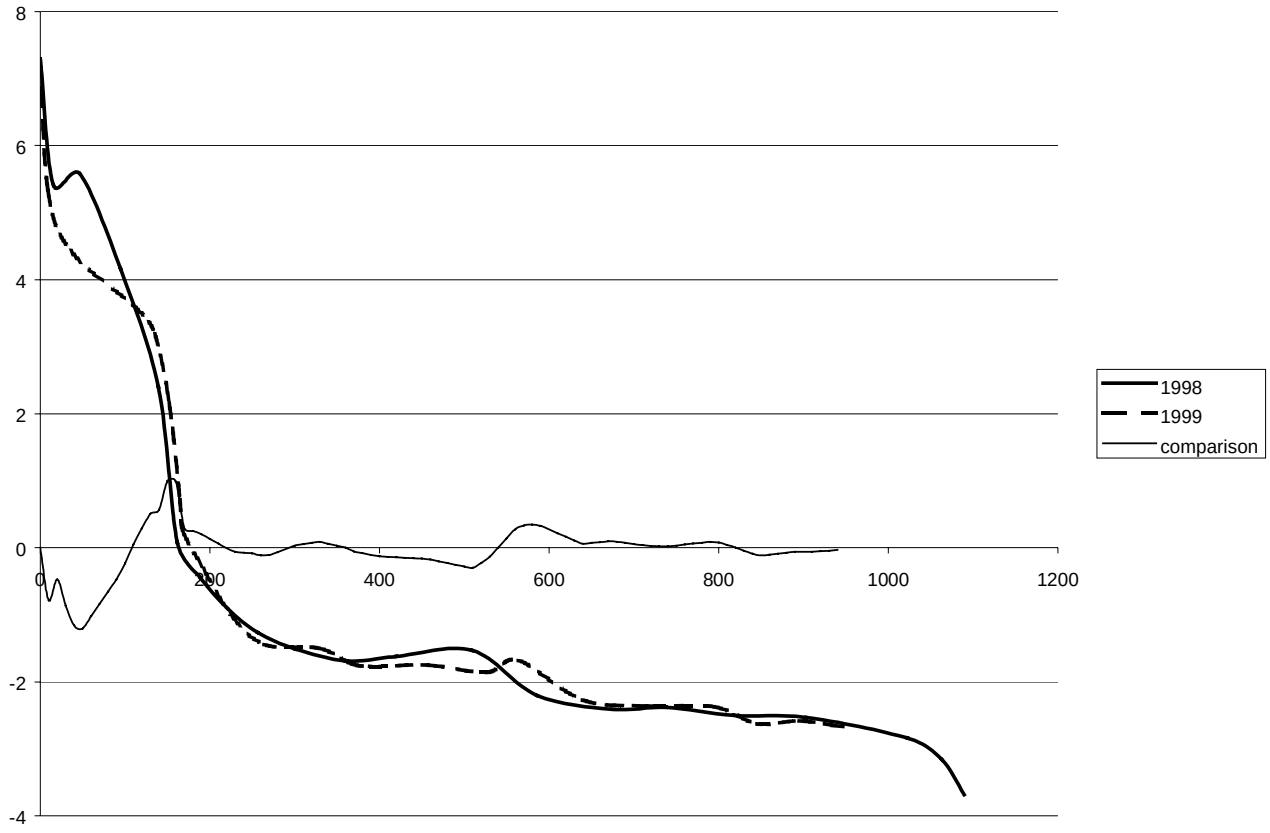

Figure 3. Beach profile at HR2, Y-axis is elevation in feet, X-axis is distance from seawall in feet.

Discussion

Based on the GPS and profile data, the Harrison County Beach shoreline position shows only moderate yearly retreat, especially in the long-term. However, mechanical maintenance of the shoreline position is coming at the expense, in most cases, of the beach volume above high tide (dry beach). Movement of sediment to re-establish the shoreline position invariably causes some sediment to move offshore where it resides on the wide shallow sub-aqueous portion of the beach (wet beach). Because the overall beach volume (out to about –4 ft.) was used in this report, this situation may not produce a net negative result, assuming no sand was lost through other causes. With this in mind, and although there are some notable exceptions, neither shoreline retreat nor volume change over the five-year period indicate any dramatic negative changes.

After the passage of Hurricane Georges, which created higher yearly changes, the shoreline returned to its pre-Georges position, mostly by mechanical means. The re-establishment of the shoreline did come at the expense of the overall "dry beach" volume; the profiles indicate a build-up of sediment below the high tide elevation, but loss above high tide. Beach volume loss was highest on the ends of the beach in the short term, which is to be expected.

The two most notable exceptions to the slowly evolving erosive trend (HR8, HR11) are in areas that were targeted for experimental nourishment during the winter of 1999. In these locations, long-term shoreline retreat is prominent; also, highly negative volume change occurred at HR11. These areas are both in close proximity to harbor/promontories, which probably contribute to the problem by blocking longshore sediment drift. These specific cases are not, however, representative of all areas near or downdrift of harbors. Similar areas near the Gulfport Harbor and Broadwater Marina do not display the same dramatic loss. Their stability appears to be a result of beach maintenance and a significant sediment supply taken from adjacent stretches of the beach with little sediment loss or some sediment gain. The erosion "hot spot" areas (HR8, HR11) are probably a result of the structures and a generally declining downdrift sediment supply. These areas require further study to determine the nature of the problem, which will persist despite future renourishment.

The length of the beach and its history of replenishment are some of the factors that help it maintain relatively low erosion rates. The continued addition of sand since the initial renourishment in 1952-53 has built up a sizeable reservoir that acts to even out erosion through time. The sheer length of the renourished length also helps maintain stability. End points of a renourished beach act like one way valves that drain the system, especially when there is a significant degree of longshore drift. Therefore, the fewer end points over a certain length, the less loss will occur. Culverts, harbors and groins are special cases of end points that efficiently trap sand in the nearshore, but may, in some cases, also direct sand offshore to the wet beach where it is more likely to be lost from the system entirely.

Clearly, the evolution of the Harrison County Beach is tied to the regular maintenance practices. A constant, but slowly diminishing, beach width has been maintained in most areas, thereby mitigating the degree of shoreline recession. Beach volume calculations show a trend of sand loss above the

high tide line and in some cases a gain in the volume of the submerged portion of the beach. This is both a potential problem and a promising trend. On the positive side, it indicates that sand is staying in the whole beach system and will help form a base for any new renourishment. The negative implication is that the potential for the beach to protect against storm damage is reduced. Areas with stabilized dunes are better equipped to handle the potential damaging effects of storm overwash.

Conclusion

In summary, the renourished beach from Henderson Point to Biloxi shows only limited areas of critical erosion and in general is eroding at a consistent but relatively low level. If rating the beach over the five-year period on a grade scale (A for no net erosion, F for widespread erosion and sand loss), it would receive a B+. The fact that the yearly long term volume changes (wet + dry beach) are on the order of –1 cubic yard/foot suggests that much of the sand is staying within the system. This is encouraging and will surely reduce the cost of future renourishments. Given that there is a tendency to lose sand from the "dry" beach to the "wet" beach, the future renourishment should be used to build dunes (stabilized with vegetation) as well as extending the width of the beach. Sand invested in dunes is akin to a long-term savings account that will help lessen the blow of potentially expensive damage to infrastructure in the event of a large storm.

The following conclusions can be made based on the data presented:

1) Short-term trends in shoreline retreat/advance indicate that following Hurricane Georges the high tide position (beach-width) returned nearly to a pre-hurricane configuration. This appears to have been accomplished mainly with beach maintenance practices, not by natural processes.

2) In contrast to the shoreline position, short-term loss of beach volume is widespread, especially on the east and west ends of the beach and immediately west of Long Beach Harbor.

3) Small areas of heightened erosion occur downdrift of culverts and drains.

4) Over the five year period of this study there are only a few locations with more than 15 meters (50 feet; 10 feet/year) of beach retreat. These areas, roughly concentrated near Courthouse Pier

and Long Beach Harbor, should be monitored.

5) Longer-term (5 years) yearly beach volume change is much lower than the short-term changes. Values range from –2 to 3 cubic yards/foot/year. The areas with negative budgets are grouped on the east and west ends of the beach.

6) To quantify the total beach volume change occurring on the Harrison County Beach more profile locations, or newer survey techniques (Laser Mapping) are necessary. Laser mapping was done after Hurricane Georges, and the data are now available. Subsequent laser mapping surveys will help determine volume loss (on the dry beach only) with much higher accuracy.

Data

This report is meant to be an overview; more localized study and analysis can be done upon request. The data gathered from 1991 to present are also available.