4.1.2 Chandeleur Islands, Louisiana

The Chandeleur Islands form the eastern flank of Louisiana and have historically eroded landward at an average of about 9 m/yr (Penland and others, 2003). Past hurricanes, such as Camille in 1969, have breached the islands in many places. After each storm, the islands have recovered, at least to some extent, and many of the breaches have closed. During Hurricane Katrina (August 29, 2005), however, the island lost 85 percent of its surface area in a few hours and has struggled afterwards to rebuild naturally. In the 3 years since the storm, over 50 percent of the shore has continued to erode, though some recovery is evident (figs. 13-14). Hurricane Gustav (September 1, 2008) appears to have set back any recovery of the islands even further, by waves overwashing sand landward and attacking the marsh platforms on which the beach and dunes of the Chandeleurs are built (figs. 13-15).

Figure 13. Oblique aerial photography of the central Chandeleur Islands, Louisiana, from July 17, 2001 (top left); August 31, 2005, 2 days after the landfall of Hurricane Katrina (top right); June 24, 2008 (bottom left); and September 4, 2008, 3 days after the landfall of Hurricane Gustav (bottom right). Yellow cross-hairs indicate a common reference location within the images. Sand was eroded from the beach face and transported landward by waves.

Figure 14. Oblique aerial photography of the northern Chandeleur Islands, Louisiana, from July 17, 2001 (top left); August 31, 2005, 2 days after the landfall of Hurricane Katrina (top right); June 24, 2008 (bottom left); and September 4, 2008, 3 days after the landfall of Hurricane Gustav (bottom right). Yellow cross-hairs indicate a common reference location within the images. Sand was eroded from the beach face and transported landward by waves, resulting in an increasingly smaller and more fragmented island.

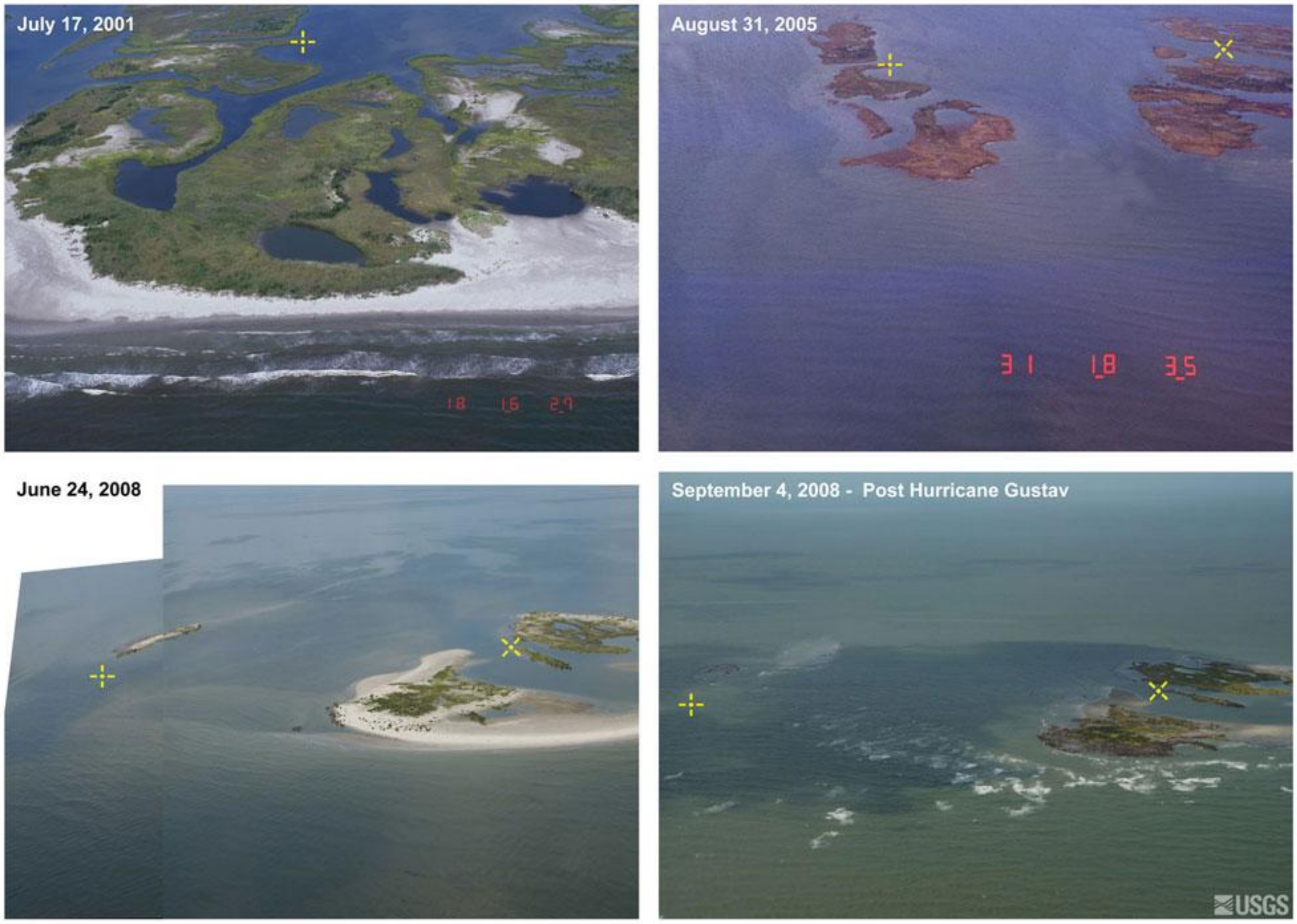

Figure 15. Oblique aerial photography of the northern tip of the Chandeleur Islands, Louisiana, from July 17, 2001 (top left); August 31, 2005, 2 days after the landfall of Hurricane Katrina (top right); June 24, 2008 (bottom left); and September 4, 2008, 3 days after the landfall of Hurricane Gustav (bottom right). Yellow cross-hairs indicate a common reference location within the images. The sand that had deposited since Hurricane Katrina was removed from the island, leaving only a small marsh platform.

4.2 Quantitative Topographic-Change Analysis

Post-storm lidar topographic data were compared to pre-storm surveys of beach topography to quantify morphologic changes due to Hurricane Gustav. Because of the large spatial extent of the post-storm lidar survey, several different survey dates had to be used for the pre-storm topography. The survey date and spatial coverage for each pre-storm survey are detailed in table 3. For morphologic analysis, last-return lidar data were optimized for identifying shorelines and dune height. The analysis required interpolation to a gridded domain that was rotated parallel to the shoreline and had a resolution of 10 m in the longshore direction and 2.5 m in the cross-shore direction. The interpolation method applies spatial filtering with a Hanning window that is twice as wide as the grid resolution (Plant and others, 2002). Grids of pre- and post-storm lidar topography differenced over the entire overlapping survey area provide a quick visual of coastal change. For example, in Dauphin Island, Alabama, difference grids reveal erosion of the shoreline and reduction of dune elevations (fig. 16). The emergency berm built after Hurricane Katrina (fig. 16) has been completely eroded by the waves and surge generated by Hurricane Gustav.

For a more quantitative analysis, gridded last-return lidar data were used to measure changes in elevation and position of the frontal sand dune or berm system, shoreline change, and volume change. The cross-shore location of the peak elevation of the seaward-most sand dune is extracted from gridded pre-storm topography (Stockdon and others, in press). The difference between the pre- and post-storm topography at this location defines hurricane-induced dune or berm-elevation change (figs. 17A-20A).

To calculate the shoreline position, the cross-shore position of the elevation at the shoreline (defined in regard to a vertical datum) was extracted from each row of the shore-parallel-oriented grids of beach topography (Stockdon and others, 2002). The shoreline vertical datum was set at mean high water from tidal records (Weber and others, 2005) and is approximately 0.37 m above mean sea level for Isles Dernieres to Venice, Louisiana, and approximately 0.23 m above mean sea level from the Chandeleur Islands, Louisiana to Fort Walton Beach, Florida. Shoreline change was calculated as the difference between the pre-storm shoreline and the post-storm horizontal shoreline position (figs. 17B-20B). Typical errors in shoreline position are on the order of 1 to 2 m (Stockdon and others, 2002); however uncertainty in position will vary due to data noise and beach slope.

Volume-change calculations were performed by contouring the topography at a fixed vertical datum, which was set at mean high water from tidal records (Weber and others, 2005). The volume is calculated between the cross-shore location of the pre-storm dune base and the pre-storm shoreline. This eliminates complications from structures and vegetation, which generally are located landward of the dune base. Beach volume change was calculated as the difference between the pre-storm and September 2008 surveys (figs. 17C-20C).

Table 3. Details of the pre-storm lidar data used for coastal-change analysis.

Survey Date	Instrument	Spatial Coverage
June 27-29, 2007	EAARL	Ship Island, Mississippi, to Petit Bois Island, Mississippi
March 9, 2008	EAARL	Isles Dernieres, Louisiana, to Venice, Louisiana
June 24-26, 2008	EAARL	Dauphin Island, Alabama, to Ft. Walton Beach, Florida, and Chandeleur Islands, Louisiana

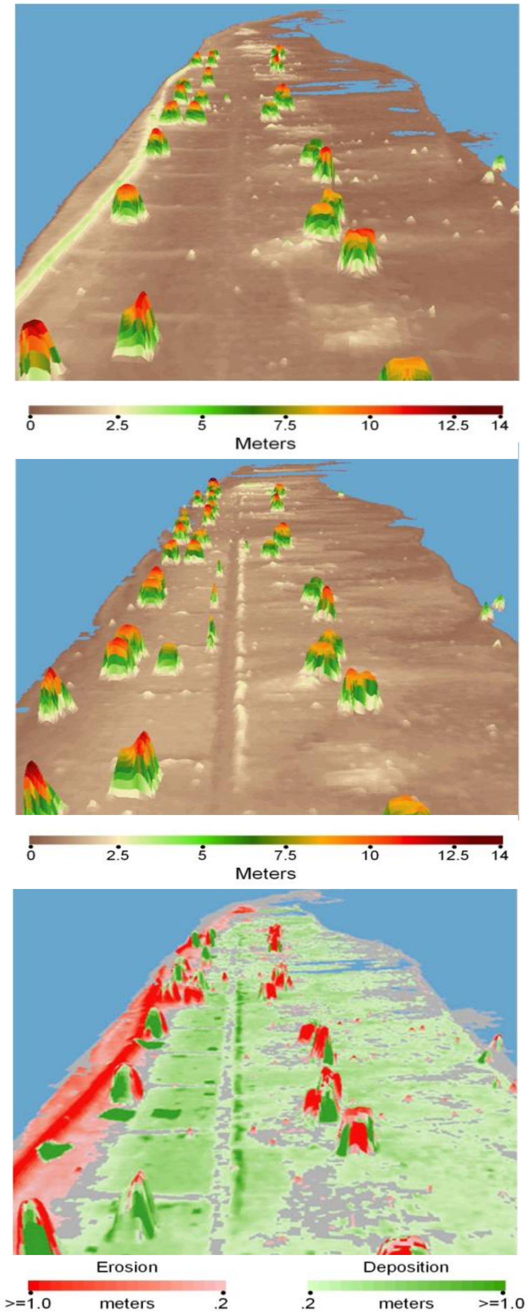

Figure 16. Three-dimensional view of Dauphin Island, Alabama, lidar-based topography measured in June 2007 (top) and September 8, 2008 (middle). Blue represents elevations below mean high water. Lower elevations are represented by brown shades; higher elevations are greens and reds. The view is looking west along the island with the Gulf of Mexico to left. A 3.5-m emergency berm that was built after Hurricane Katrina (2005), seen in green on the Gulf-side of the island in 2007 (top), is conspicuously absent post-Gustav (middle). The bottom image shows changes in elevation with areas of erosion in red and deposition in green. Sand eroded from the beach was deposited inland. Overwash along the road was cleared prior to the lidar flight. Piles of cleared sand are seen in green along the north side of the road. The patches of red and green on the houses are an artifact of data processing. Large green rectangles on the ground are locations of houses built since Hurricane Katrina.

4.2.1 Barrier Island Coast of Central Louisiana

Dune-height changes ranging from 1 to 2 m were observed in the Isles Dernieres, where Gustav made landfall. Similar dune-height changes were observed at Grand Isle, Louisiana, about 60 km from landfall and in the right-front quadrant of the storm impact area (fig. 17A). Mean shoreline erosion of 40 m was observed on the central Louisiana coast from Trinity Island to Grand Isle, Louisiana (fig. 17B). On the eastern and western ends of Timbalier Island, more extreme shoreline erosion of 100 to 200 m was observed. Volume losses follow the same pattern as the shoreline changes for the central Louisiana barrier islands (fig. 17C), implying that sediment lost due to erosion was transported seaward and not deposited higher on the beach face.

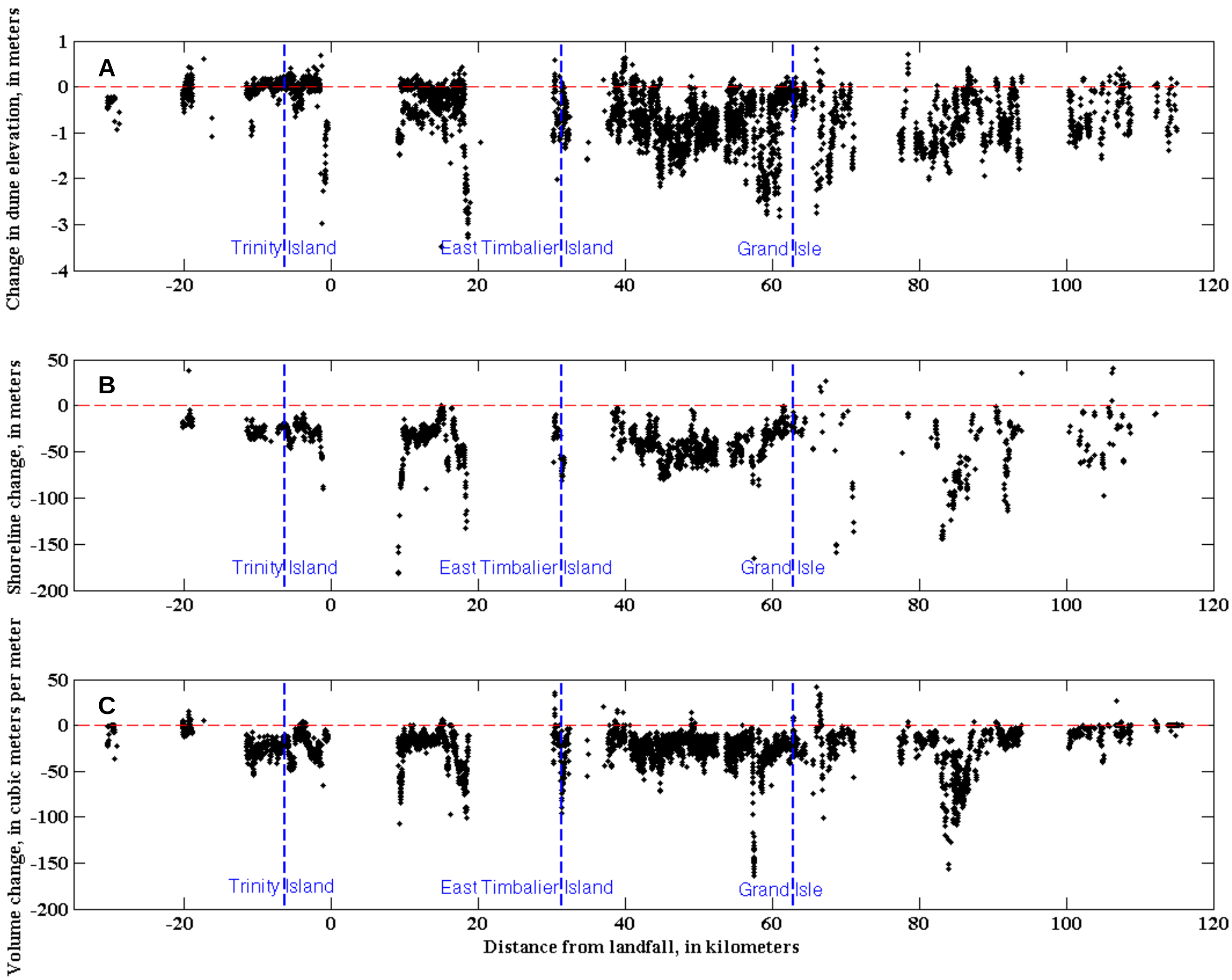

Figure 17. Hurricane Gustav dune-elevation change (A), shoreline change (B), and beach-volume change (C) between March and September 2008 for the central Louisiana barrier island coast. Vertical dashed lines indicate the center of Trinity Island (the easternmost of the three islands composing the Isles Dernieres), East Timbalier Island, and the town of Grand Isle, Louisiana.

4.2.2 Mississippi Barrier Island Coast

Along the Mississippi barrier island coast, 150 to 200 km to the east of landfall, mean dune-height changes were near zero (fig. 18A), with the exception of the ~1-m elevation change on the western end of Horn Island. Shoreline change was highly variable ranging from extreme erosion of 100 to 200 m on East Ship Island to accretion of ~100 m near the center of Horn Island , where there is an inflection point in the shoreline orientation (fig. 18B). Because the pre-storm survey is from June 2007, the shoreline changes seen here may be a combination of long-term and storm-induced change. Similar to the Louisiana sandy barriers, volume losses here follow the same pattern as shoreline changes (fig. 18C).

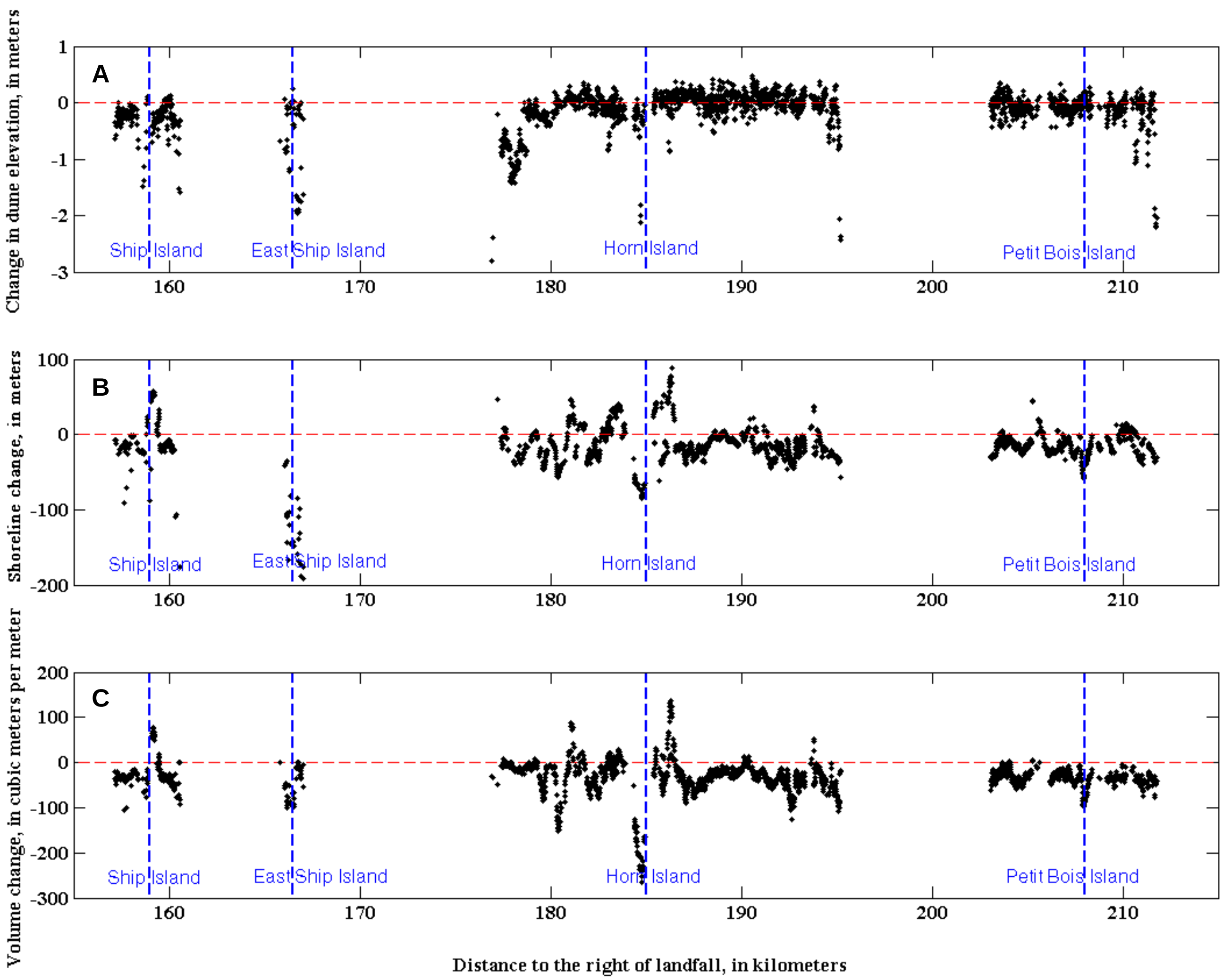

Figure 18. Hurricane Gustav dune-elevation change (*A*), shoreline change (*B*), and beach-volume change (*C*) between June 2007 and September 2008 for the Mississippi barrier island coast. Vertical dashed lines indicate the center of West Ship Island, East Ship Island, Horn Island, and Petit Bois Island.

4.2.3 Alabama Barrier Island Coast

On Dauphin Island, Alabama, 230 km to the east of landfall, mean dune-height changes were also near zero except for the 3-m elevation loss resulting from the destruction of the post-Katrina emergency berm, located between 230 and 240 km from landfall (fig. 19A). The native dunes on Dauphin Island are wider and more vegetated than the manmade emergency berm and resisted the severe erosion that impacted the manmade berm. Mean dune-height changes were near zero for the Alabama barrier island coast east of Dauphin Island (fig. 19A). Average shoreline erosion of 20 m was observed from Dauphin Island, Alabama, to Orange Beach, Alabama, with the exception of the areas of accretion on the spits of Dauphin Island (fig. 19B). Volume losses mirror the same pattern as the shoreline changes for the Alabama barrier island coast (fig. 19C).

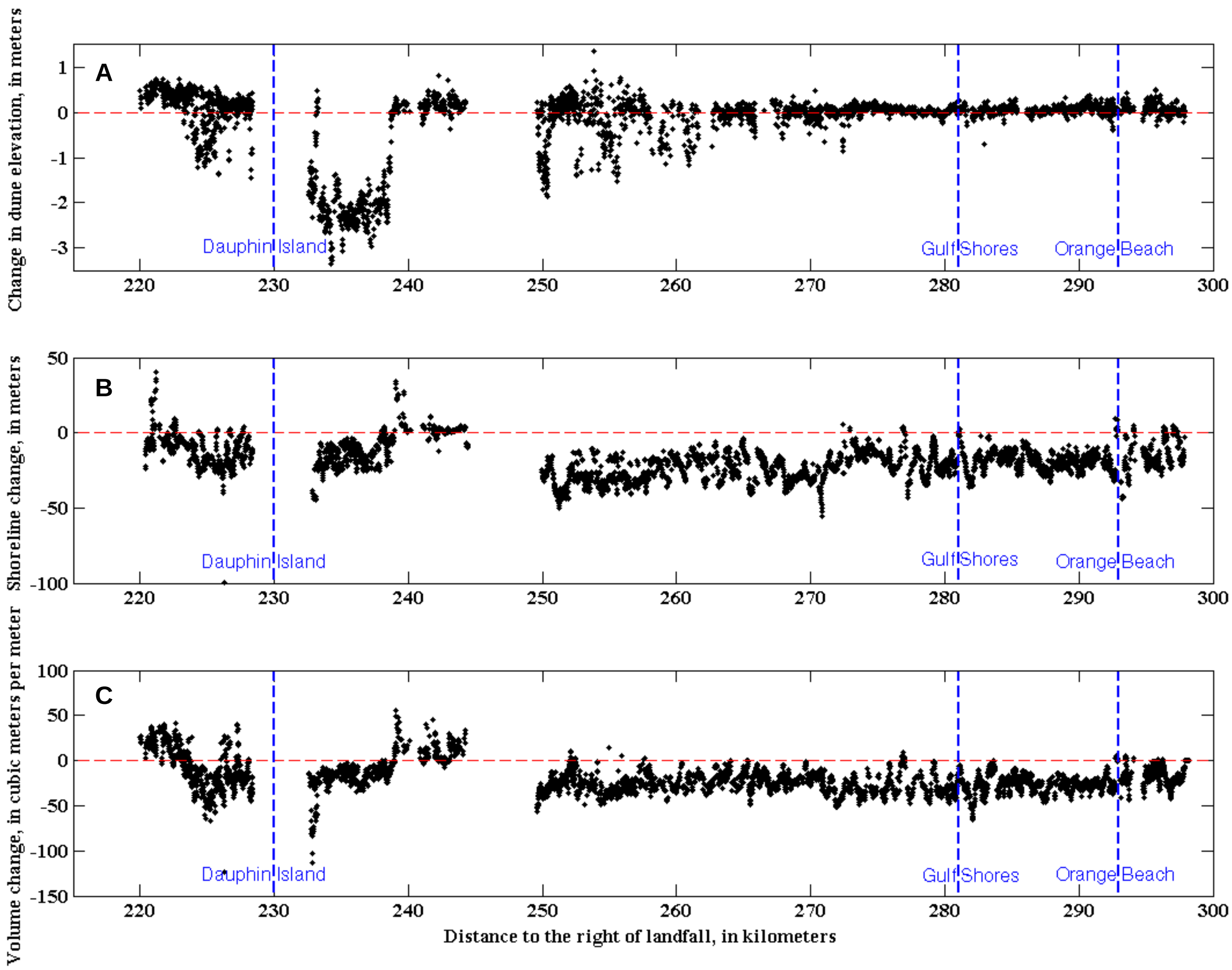

Figure 19. Hurricane Gustav dune-elevation change (*A*), shoreline change (*B*), and beach-volume change (*C*) between June and September 2008 for the Alabama barrier island coast. Vertical dashed lines indicate the center of Dauphin Island, and the towns of Gulf Shores and Orange Beach, Alabama.

4.2.4 Florida Barrier Island Coast

Dune-height changes were near zero for the barrier island coast of the Florida Panhandle (fig. 20A). Shoreline erosion ranged from 20 m on Perdido Key, Florida, to 0 m east of Gulf Breeze, Florida (fig. 20B). From the western end of Santa Rosa Island (fig. 20B, distance = 320 km), to Gulf Breeze, Florida, shoreline erosion of 50 to 60 m was observed. Volume losses were small but indicate that some sand was eroded even though the shoreline position and dune height changes were near zero (fig. 20C).

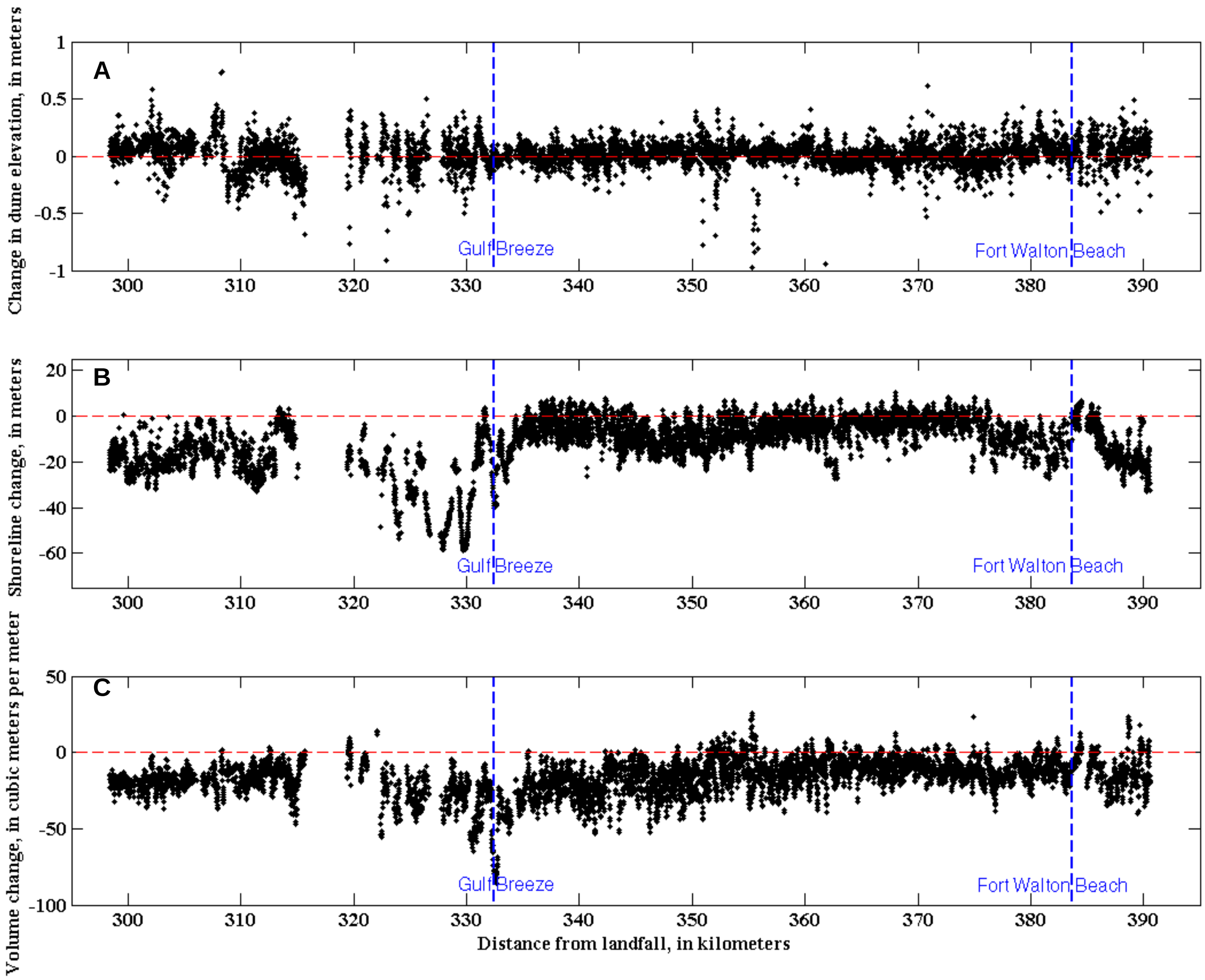

Figure 20. Hurricane Gustav dune-elevation change (*A*), shoreline change (*B*), and beach-volume change (*C*) between June and September 2008 for the Florida panhandle barrier island coast. Vertical dashed lines indicate the center of the towns of Gulf Breeze and Fort Walton Beach, Florida.

4.2.5 Chandeleur Islands, Louisiana

Because the Chandeleur Islands are low-lying marsh platforms fronted by transient sandy beaches, different methodologies were used to quantify storm-induced topographic change. Instead of measuring dune-elevation change, the maximum elevation was computed within a 5-m-wide swath oriented south to north and covering the width of the island (fig. 21). The maximum elevation change observed between June and September 2008 was on the order of 0.5 m to 1 m of erosion. Island area above the mean high water line is computed in ArcGIS using contours at 0.23 m. Between June and September 2008 the islands lost 23 percent of the existing land area (fig. 22). The islands have migrated westward and become increasingly fragmented as a result of the large waves and surge of Hurricane Gustav.

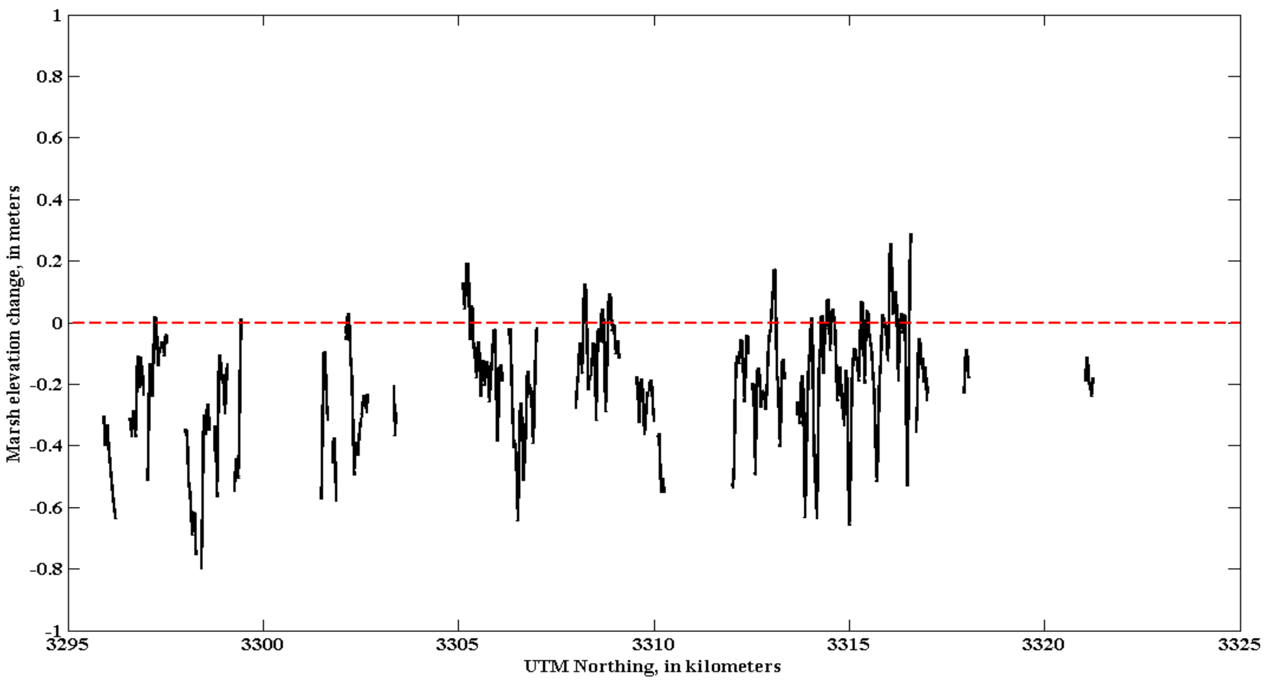

Figure 21. Chandeleur Islands change in maximum elevation between June and September 2008.

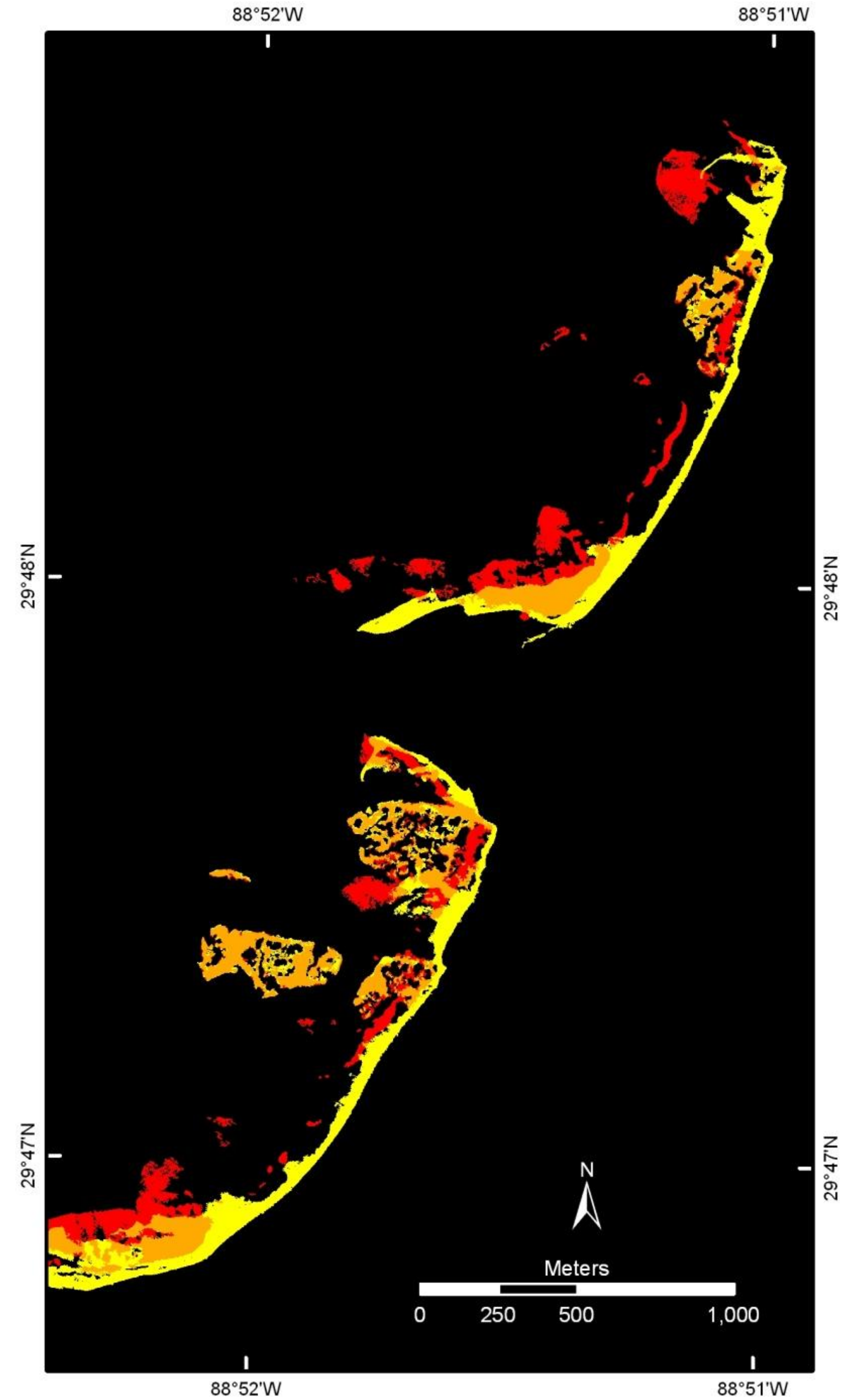

Figure 22. Chandeleur Islands area in June (yellow) and September 2008 (red) for the 4-km portion of the coast shown in figures 13 and 14. The orange color indicates area common to both dates, revealing patterns of erosion and deposition. The yellow areas were eroded and deposited landward in the red areas. These patterns are representative of area change observations for the entire Chandeleur Island chain.

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