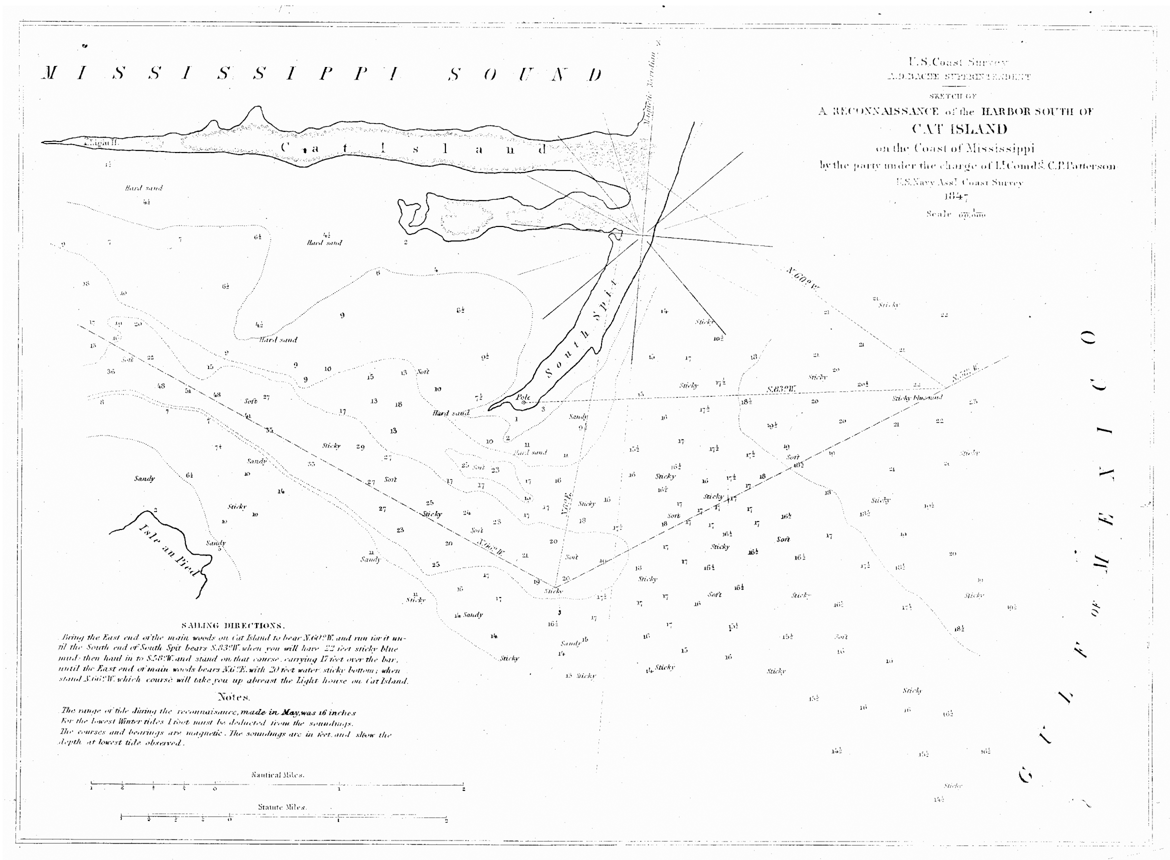
Cat Island Evolution, Morphology, and Hurricane Response – 1995 to 2000

By Keil Schmid



Mississippi Department of Environmental Quality

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S. Cragin Knox

State Geologist

Coastal Section

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Cover: Chart and sailing directions for Cat Island, 1847. Chart courtesy of Office of Coast Survey, National Ocean Service, NOAA

Table of Contents

Introduction

Changes in barrier island position, elevations, and morphology typically happen at irregular and exaggerated rates (Byrnes et al., 1989). The Mississippi barrier islands are no exception, with average shoreline position changes in some areas as high as 90 meters/year (McBride et al., 1995). These high rates make simple Global Positioning System (GPS) shoreline surveys with accuracies of better than five meters a viable way to document island evolution at yearly to semi-yearly scales. This is an important milestone in the study of hurricane change along the Mississippi Barrier Islands; at no time before could shoreline evolution be as densely and completely quantified prior to and following a hurricane's passage without incurring high costs. Previous studies have shown short temporal changes; however, they have been mainly qualitative (Byrnes et al., 1989). Temporally dense data help highlight small trends and their causes that together drive island morphology and evolution. Moreover, the availability of Light Detection and Ranging (LIDAR) data to researchers has brought highly accurate elevation data sets to the greater research community. LIDAR has been successfully used in documenting seasonal change in coastal California as well as the Atlantic Coast (Morgan et al., 1999; Sallenger et al., 1998). This report focuses on Cat Island and is part of a series covering recent change on the Mississippi Barrier Islands.

Study Site

Coastal Mississippi stretches from Louisiana in the west to Alabama in the east (Figure 1) and contains five nearly shore-parallel barrier islands. The Mississippi Barrier Islands are an elongate east – west chain, located 15 to 20 kilometers from the mainland coast. From east to west the islands are Petit Bois, Horn, East Ship, West Ship and Cat (Figure 2). Petit Bois, Horn, East Ship, and West Ship are presently part of the Gulf Islands National Seashore and Cat is in the stages of being acquired. The eastern islands appear to exhibit a shoal to island geology (Otvos, 1970a, b) with the main source of sediment from the Alabama mainland coast (Otvos, 1985). Their early formation into islands has been placed in the Mid-Holocene (about 3-4 thousand years ago). Historically, within the last 300 years, the eastern islands (Petit Bois and Horn) have had a dominantly translational – longshore drift movement, such that they are not moving landward but rather along the coast. Cat Island, the westernmost island, has had very little translational movement and is instead eroding in place. The two Ship Islands are in the middle of the spectrum.

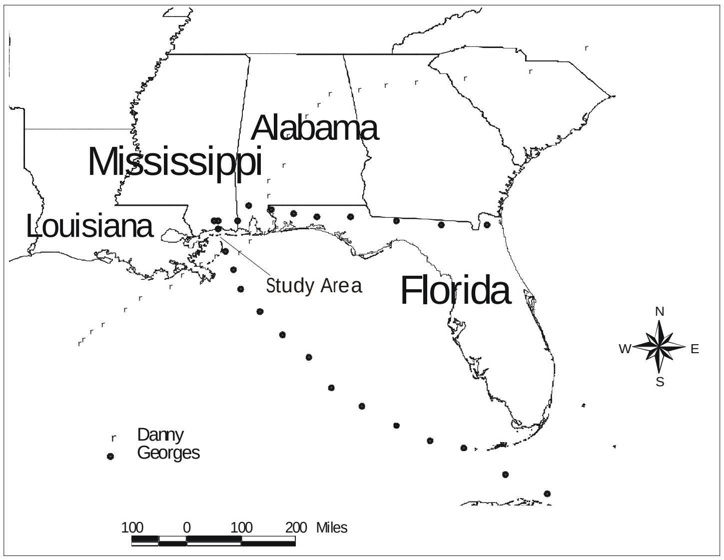

Figure 1. General Study site in Southeastern United States.

The eye of Hurricane Georges entered and passed through the Mississippi Sound between East Ship and Horn Islands on September 28, 1998 (Figure 1 and 2). It was a category 2 storm before making landfall near Biloxi, Mississippi. Although Hurricane Georges was only a category 2 storm when impacting the Mississippi Gulf Coast, its slow forward motion of about 5 mph (Otvos, 1999) caused significant damage to barrier islands in the area. Island changes in Louisiana from Georges have been compared to those caused by Hurricane Camille, a category 5 storm (Penland et al., 1999). The only other tropical storm of note to pass fairly close to Mississippi during the study period was Hurricane Danny in 1997 (Figure 1); however, it only glanced the area and was substantially weaker.

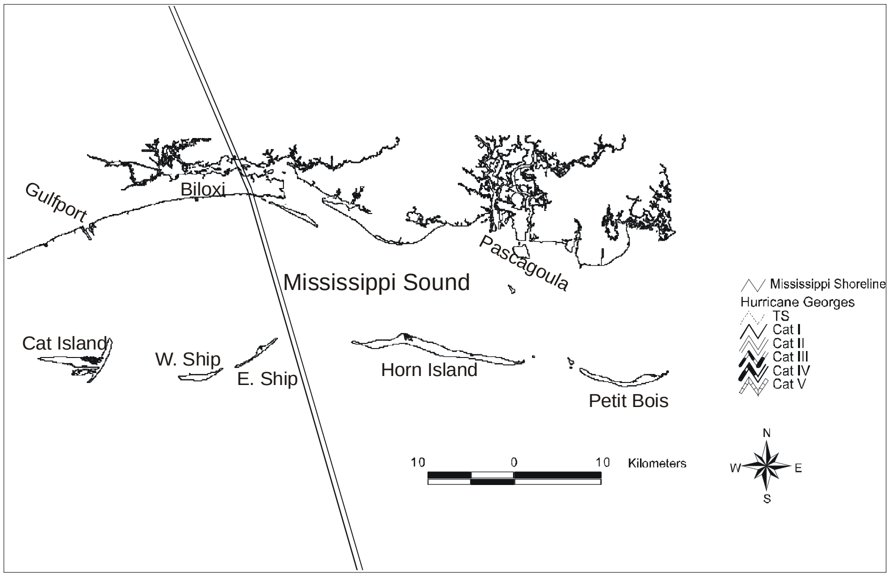

Figure 2. Study area with Hurricane Georges track.

Methods

Several different methods were used to document island evolution prior to, in response to, and following Hurricane Georges. Kinematic GPS surveying techniques were used to highlight shoreline changes in time periods prior to Hurricane Georges (1995-1997), encompassed by Hurricane Georges (1997-1998), and following Hurricane Georges (1998-2000). To further document island changes, morphology from LIDAR elevation data sets was analyzed in relation to hurricane-driven shoreline change. At representative locations, cross shore profiles generated from LIDAR elevations taken following Hurricane Georges were compared with profiles measured with conventional survey procedures in 2000/2001 to highlight morphology changes during the two-year period.

Yearly GPS shoreline surveys of the Mississippi Barrier Islands have been performed since 1993 by the Mississippi Office of Geology and semi-annually by the National Park Service since 1998. In each survey the high tide shoreline was mapped using kinematic GPS techniques. All data were post processed, yielding accuracies on the order of ± 2-5 meters (Hutchins and Oivanki, 1994). The high tide line, denoted by either a wet-to-dry line or debris wrack line, has been chosen as a repeatable datum and represents the state-owned boundary. Errors in interpreting the high-tide line and from differences in tide range exist, although effort has been taken to insure a level of consistency between mapping parties.

Locations of shoreline retreat and advance beyond chosen levels were computed using buffers on GPS shorelines. The buffer width was chosen to highlight areas of significant change within the confines of the survey accuracy. Any portions of the compared (later) shoreline landward of the negative buffers of the base (earlier) shoreline were highlighted as retreat; portions seaward of the positive buffers were highlighted as advance.

Buffer widths varied from island to island based on historic levels of shoreline change reported in Byrnes et al. (1991). Cat Island has an average shoreline change of roughly 2.5 m/yr and a high of 3.5 m/yr, which was rounded up to 4.0 m/yr for the purpose of analysis. These values were used to construct buffers of average change (years x 2.5) and high change (years x 4.0) during the ambient and recovery periods. The high change buffer was doubled for the hurricane period to highlight major changes; the average value was not used for the hurricane period analysis. Buffers help highlight areas of targeted change levels; they do not represent all areas of change, which would, in most cases, highlight the entire shoreline.

Total island changes in acres were also computed using GPS shorelines. A buffer method was used to approximate the acreage change because the GPS'ed shorelines did not include the entire island. Only surveyed shoreline segments common in each compared year could be used; thus the acreage change is not representative of the entire island, but does provide comparison between the time periods because each had similar GPS shoreline segments.

Shoreline configurations prior to 1993 were taken from National Ocean Service (NOS) T-sheets and aerial photography (Byrnes et al., 1991). These data are less accurate than GPS surveys; they are used only to document broad historic trends spanning several tens of years.

General analysis of morphology was preformed using LIDAR data flown in November 1998 (U.S. Geological Survey et al., 1998). Horizontal accuracies are on the order of 1 meter; vertical accuracies are ±15 to 20 centimeters. For general analysis of morphology, a 10 x 10 meter grid was used; the minimum value within each grid was used. The minimum value in the grid was specifically chosen to minimize the effects of vegetation. Elevation values were imported into AUTOCAD MAP (AutoDesk, 1998) and 10 x 10 meter gridded surface was generated using QUICKSURF (Schreiber Instruments, 1998). A triangulated grid method was chosen based on the normal spacing of data points (Schreiber Instruments, 1998).

Areas with representative morphology and shoreline change were further analyzed with a higher density of LIDAR elevation points; for these areas 2 x 2 meter grids and surfaces were chosen. The high-density data were used to produce cross-shore profiles. These LIDAR profiles were then compared to conventional profile surveys taken with a total station in 2000/2001. Survey benchmark locations were GPS'ed and elevations taken from the 2 x 2 meter LIDAR grid. In some locations the benchmark elevation taken from the 1998 LIDAR survey was not completely accurate for 2000/2001. In these cases, the benchmark elevations were adjusted slightly so that measured beach face morphology was consistent with respect to its elevation. LIDAR elevations over the subaqueous portions of the profiles (below sea level) are suspect in some cases so interpretation of the bathymetry changes is tenuous.

Data

Cat Island

Cat Island is the westernmost barrier island in Mississippi. It has a unique shape (Figure 3) with the main island dominated by beach/dune ridges (Rucker and Snowden, 1989), middle spit dominated by marsh, and the eastern shoreline from South Spit to North Point dominated by active wave and wind features. Cat Island has recently received considerable attention as it is set to be purchased and incorporated into the Gulf Islands National Seashore. Cat Island also has a unique geologic evolution among the present islands in the National Seashore (Rucker and Snowden, 1990). Its complex history was influenced by the extension of the Saint Bernard subdelta just to the south of the island. The Saint Bernard subdelta complex was a major delta lobe of the Mississippi River from 4000 to 2000 years ago (Roberts, 1997). During this period, Cat Island was surrounded by marsh that shielded it from the typical northwest longshore drift. The eventual destruction of the Saint Bernard subdelta coupled with the southeastern wind regime has given Cat Island a distinctive T-bone shape. Several studies have attributed the N-S spit on the eastern end as a result of modified sediment transport patterns following decline of the Saint Bernard subdelta (Otvos, 1993; Rucker and Snowden, 1990). Yet, the curious shape and trend from 1850 to present (Figure 4), where the southern portion of the spit has changed drastically as compared to the rest of the island, leaves room for future analysis. Based on historical shoreline configurations the central point of Cat Island has moved only meters, while the other islands in the chain have moved kilometers (Schmid, 2000). These differences in Cat Island's evolution certainly make it unique among the five barrier islands. In addition, it is also the only barrier island in the chain with a significant fringing coastal marsh habitat.

Yearly wind patterns from 1995 to July 2000 show little change (Figure 5), although the period between August 1997 and November 1998 does have a slightly higher southwest component than the other periods. Average wind speeds during the 1995-2000 period are highest from the northeast to northwest (about 14 knots), and lowest from the south (about 10 knots).

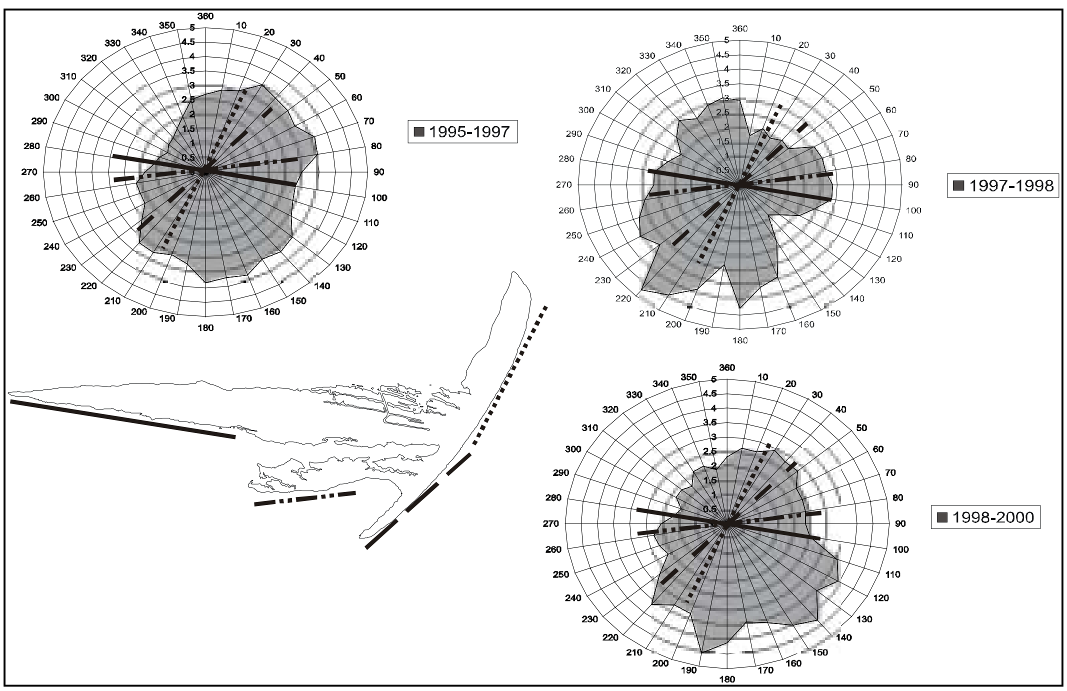

Figure 5. Wind data taken from National Data Buoy Center – buoy #42007, approximately 10 miles south of Cat Island. Shaded area is the percent of time the wind was from the specific direction.

Figure 3 1996 photo

figure 4 historical shorelines for cat

Shoreline Change

Historically, Cat Island is associated primarily with cross-shore changes (Figure 4) as opposed to translation (Byrnes et al., 1991; McBride et al., 1995). Cat Island has an average shoreline change of roughly 2.5 m/yr and a high of 3.5 m/yr (Byrnes et al., 1991), which was rounded up to 4.0 m/yr for the purpose of analysis. These values were used to construct buffers of average change (years x 2.5) and high change (years x 4.0) during the ambient and recovery periods. The high change buffer was doubled for the hurricane period to highlight major changes; the average value was not used for the hurricane period analysis. Shoreline surveys on the Mississippi Sound shoreline of Cat Island are difficult to perform because of overhanging trees and large root mats over the water's edge. Results from these areas, while surveyed on several occasions, are not used here because errors in locating the shoreline are high.

Table 1. Cat Island shoreline inventory

Shoreline	Buffers (high, ave)
July, 1995	Baseline
July, 1997	8 m, 5 m
November, 1998	8 m
June, 2000	7.5 m, 4 m

1995-1997 GPS

Comparison of the two GPS shorelines shows only a moderate degree of change during this period (Figure 6). Middle Spit, however, shows high shoreline retreat. The eastern shoreline of the island shows only localized high retreat on the southern half. Unfortunately, the southern spit was not surveyed in 1997 and could not be compared to earlier data. The northern half of the eastern shoreline is associated with accretion or little change during this period. Similarly, western Cat Island shows about equal shoreline retreat and advance.

Over the region GPS'ed in both 1995 and 1997, a total of 18.5 km, the island lost 7.2 acres during this period. This value is conservative as it does not include the Mississippi

Sound shoreline of the main island, Southern Spit, and most of the marsh dominated shoreline.

1997 –1998 Post Georges GPS

During this roughly one-year period only high change areas are highlighted. Once again Middle Spit is dominated by shoreline retreat (Figure 7). Also notable is the erosion on the western end of Cat Island, which was not dominated by erosion in the preceding period. The small area of shoreline advance is near the very tip where washover features are present (Picture 1). On the eastern portion of the island, which saw the highest wave energy from the storm, the southern half, including South Spit, is uniformly dominated by high shoreline retreat. In contrast, the northern half of the eastern shoreline has a large area of advance (Figure 7). Note that the 1995 shoreline was used to construct the buffer on the southern spit because of the lack of data for 1997.

An aerial photo taken after the hurricane (Picture 2) also depicts a series of ebb overwash fans at the intersection of the main island with the eastern shoreline. The distinct change in hurricane-driven change on the eastern shoreline is associated with the intersection of Cat Island proper. It is evident that the beach ridges making up the spine of the island are not only a sediment source, but also create a natural funnel for ebbing storm surge.

Over the region GPS'ed in both 1997 and 1998, a total of 17 km, the island lost 21 acres during this period. This value is also conservative as it does not include the Mississippi Sound shoreline of the main island, Southern Spit, and most of the marsh dominated shoreline. It does represent, however, about a 300% increase in erosion from the previous period.

Figure 6, 1995 –1997 data

1998 Post Georges – 2000 GPS

As in the preceding periods, Middle Spit is largely dominated by shoreline retreat (Figure 8). Shoreline retreat also continues on western Cat Island, but to a lesser degree. The major difference between this period (recovery) and the hurricane period (1997-1998) is on the eastern shoreline where patterns have switched. The northern half, which saw either subtle retreat or shoreline advance during Hurricane Georges, now shows a dominant retreat trend. In addition, the southern half shows only localized areas of retreat. This is a temporal change in pattern from both ambient and hurricane periods.

Over the common region GPS'ed in both 1998 and 2000, a total of 20 km, the island lost 4.6 acres during this period. Again, this is a conservative value; however, it is directly comparable to the other values and shows a major decrease in the area of erosion from the hurricane period (1997 – 1998) and is slightly lower than the initial period (1995 – 1997).

(Picture 1 and 2)

(Figure 7. 1997-1998)

Elevations and Profiles

<u>Eastern Shoreline</u>

LIDAR elevation data taken after Hurricane Georges passage show a nearly continuous dune ridge running parallel to the shoreline on the southern half of the eastern shoreline (Figure 9). Washover morphology exists immediately north of the intersection between relict dune ridges on Cat Island proper and the active eastern shoreline. It further suggests that this area was fully breached by the ebbing storm surge. The right angle configuration of the northern (Sound-side) shoreline appears to facilitate piling up of the ebb tide surge, creating a situation that causes ebbing flow over this section. In response to the seaward-directed washover, the shoreline in this area moved seaward following Hurricane Georges, and probably contributed to the general accretion north of this location following storm passage (prior to GPS shoreline survey). To the north of the breached section, there is a semi-continuous dune ridge with higher forested dunes at its most northern extent. This area has a higher elevation than most of the eastern shoreline, and is consistent with long-term stability (Figure 4).

Five profiles were surveyed on the eastern shoreline in October 2000 and compared to LIDAR generated profiles following Hurricane Georges (Figure 8). These locations were chosen based on morphology and shoreline change. The two northern profiles (Figures 8 and 10; NE 1 and NE 2) show little change in shoreline location as is indicated by GPS surveys 1998-2000, but a positive volume change above zero elevation (Table 2). The northernmost profile (NE 1) displays vertical growth of two dune sets (Picture 3) and the highest positive normalized cross-shore volume change of all profile locations.

Table 2. Cat Island profile attributes. Volume change is in cubic yards per linear foot of the shoreline, normalized volume change is volume change/profile length. Zero Elevation change represents shoreward (-) or seaward (+) change of the 0 elevation contour.

Profile	Length (ft)	Volume Change (cyd/ft)	Normalized Volume Change (cyd/ft/ft)	Zero Elevation Change (ft)
NE 1	482	11.8	0.025	7.1
NE 2	381	2.5	0.006	0.5
Cntrl N	431	8.0	0.019	-50.7
Cntrl S	364	-11.8	-0.030	-5.1
SW	519	2.5	0.005	-1.0
Midwest	186	-2.5	-0.014	-5.57
West	107	-2.2	-0.021	-23.7

In the central section, the two profiles show very different topography in spite of their close proximity. The northern one, Cntrl N, (Figure 10) has modest vertical relief, high positive volume change, and a substantial shoreline retreat since 1998 (Table 3). There has been net vertical accretion on the shoreface and establishment of one dune set. Increased elevation and high shoreline retreat are indicative of recovery in a region generally typified by ebb overwash during Hurricane Georges. Scour marks are still present after nearly two years (Picture 4).

Figure 8 1998 to 2000

(Figure 9. LIDAR elevation grid on eastern shoreline)

The morphology of the southern profile, Cntrl S (Figure 10), located at the intersection of the older ridge sets with the eastern shoreline, has changed little since Georges' passage. This profile is typified by a large dune, reflecting the abundant source of sediment in the exposed relict beach ridges. There is, however, overall deflation along the profile with the highest negative normalized volume change. A lengthy deflation history is evident in the many dead trees and elevated stumps on the beach and nearshore platform (Picture 5). The differences in these two closely spaced profiles highlight the varied influence of older ridges on present shoreline dynamics.

One of the more interesting profiles is on the southern spit, not because there is marked change, but because there has been very little. On a section of the island that would seem to be the most responsive to changing conditions and has been in the past (Figure 4), there has been little volume or shoreline change since 1998. A general increase in dune height is the only notable change.

Middle Spit to West Point Shoreline

The western shoreline morphology is dominated by subdued beach berms (Figure 11) perched on an old marsh surface and backed by an active marsh. Non-exposed shorelines (between Middle Spit and Cat Island) are typically composed of marsh banks, with small sections of pocket beaches where older beach ridges are exposed. On Middle Spit, elevations scarcely reach one meter. Near West Point where slightly greater wave energies are present, berm elevations are somewhat higher, but here again are mainly less than 1 meter. Two profiles were surveyed on the western shoreline (Figure 8); both are in areas experiencing recent (1998 to 2000) retreat.

Figure 10 - profiles

The profile on Middle Spit (Figure 12 - Midwest) is a good example of the morphology found along this marsh dominated shoreline and highlights some shortfalls of the LIDAR data. The 2000 profile has a broad gently sloping (1/100) mud platform that abruptly drops off at zero elevation (Picture 6). On this mud platform there are small remnant clumps of marsh grass (*S. alternaflora, J. roemerianus*). The slight perturbations in the LIDAR profile along the mud platform represent berm crests and possibly some wrack and debris. Sand berms are perched on top of the mud platform. Note the differences in the offshore portions of this profile. Here there is a change of –4.5 c.yds/ft on only a small segment (100 ft) of the profile. This may represent limitations of LIDAR to map below the water surface where water turbidity is high, as is the case in this region from constant erosion of the mud platform. Likewise, there is dense marsh behind the most landward beach berm that the LIDAR appears to have sensed as ground elevation.

The most westerly profile (Figure 12 - West) highlights, like Cat Cntrl N on the eastern shoreline, the process of ebb flooding process and subsequent recovery. Aerial pictures following hurricane passage (Picture 1) show the large ebb overwash morphology in this area, and especially to the west of the profile. Likewise, the LIDAR profile depicts a wider beach than at present (2000). At this location, sandy beach deposits are perched on top of a mud unit that is exposed below sea level (Picture 7). Comparison of LIDAR and total station surveys would suggest that the mud step has been eroded about 20 ft in two years.

(Pictures 3 to 5)

(Pictures 6 and 7)

(Figure 11. LIDAR elevation grid for the western portion of Cat Island)

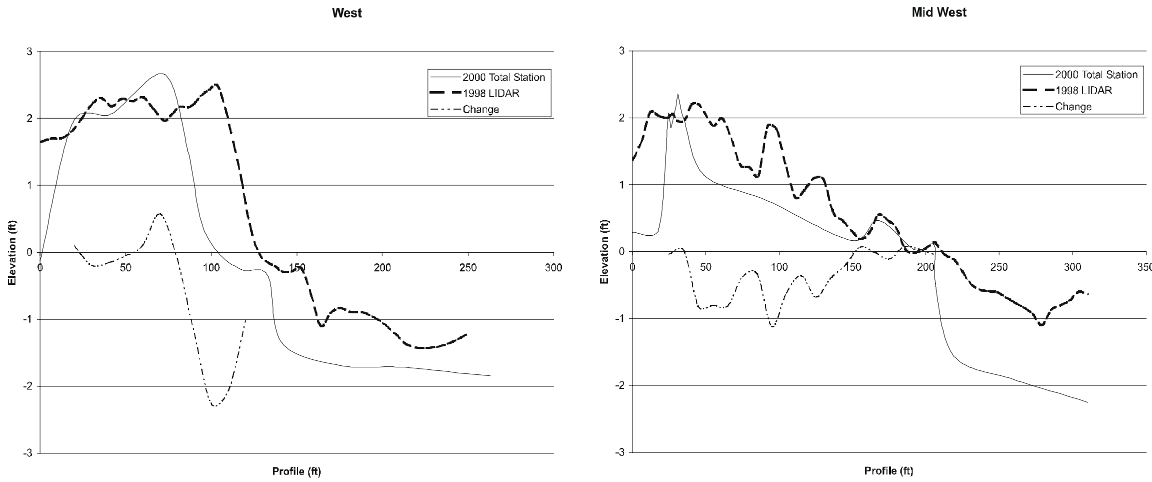

Figure 12. Profiles on western portion of island.

Discussion

During the 5 year period of investigation Cat Island lost more than 32 acres of land, most of which occurred during the Hurricane Georges period (1997-1998) (Table 3). There are three major areas on Cat Island associated with prevalent shoreline change at a level distinguishable in the short term: Middle Spit, the western end of Cat Island, and the entire eastern shoreline. More generally, there are two separate shoreline types: mud-platform dominated shorelines and sand dominated shorelines.

Table 3. Island area change along surveyed shorelines.

Year period	Measured shoreline distance (km)	Acres lost
1995-1997	18.5	7.2
1997-1998	17.0	21
1998-2000	20.0	4

<u>Mud Dominated Shorelines</u>

Middle Spit shows the most dominant retreat trend with little shoreline advance (Table 4). Shoreline retreat did not change significantly between any period; shoreline advance was minimal in all three periods. The only area of shoreline advance was the progradation of a small cuspate spit on the western end. High levels of retreat may partially be the result of a decrease in size of South Spit since 1850. In 1850 Southern Spit extended 1.8 kilometers (Figure 4) to the south of its present tip and protected much of Middle Spit from the dominant southeastern wind direction (Figure 5).

Table 4. Cat Island shoreline change

Middle Spit				
Years	Shoreline retreat %		Shoreline advance %	
	High	Ave	High	Ave
95-97	45	58	6	6
97-98	37	-	0	-
98-00	24	38	0	1
Cat Island – West Point				
Years	Shoreline retreat %		Shoreline advance %	
	High	Ave	High	Ave
95-97	4	12	7	19
97-98	60	-	1	-
98-00	15	30	2	7
East Shoreline				
Years	Shoreline retreat %		Shoreline advance %	
	High	Ave	High	Ave
95-97	7	15	7	18
97-98	38	-	28	-
98-00	21	34	18	26

Middle Spit's shoreline has little elevation; sand that is present forms a perched beach on top of relict marsh mud so there is a limited amount of local coarse sediment available. Nearly all of the sand-sized sediment is from longshore drift; onshore sand movement and fair weather beach aggradation is precluded by the nearly vertical mud step.

Cat Island is characterized by several sets of relict beach/dune ridges (Figure 3) and, like Middle Spit, is open to southerly winds and waves on the western end. The amount of high retreat areas during the hurricane (1997-1998) period was significantly greater than during ambient (1995-1997) and recovery (1998-2000) periods (Table 3) even though there were large ebb washover areas. During the month and a half period between the hurricane and shoreline survey it is possible that the shoreline retreated landward. Moreover, exposure of the mud platform below mean water elevation suggests that transport dominates over deposition along this shoreline. Higher shoreline retreat during the recovery period as compared to the ambient may be a sign that significant sediment was made available (moved seaward) by the storm and subsequently lost to western longshore transport, which may help explain why the western tip of Cat Island has only lost 70 m since 1986. It is also possible that the storm caused higher erosion of the mud platform and thus left a smaller shelf for sediments to rest on. The percent of shoreline advance area is lower than retreat during the recovery period, whereas during the ambient period it was higher than retreat. This suggests that the shoreline had reached a semi-equilibrium, such that beach/dune ridges supply enough sand to stabilize the shoreline in ambient conditions. However, intense storms overpower the system causing increased levels of dune ridge erosion and, thus, a high short-term sediment supply followed by a deficit until equilibrium between dune erosion and longshore drift is re-established.

<u>Sand Dominated Shorelines</u>

Although change on the eastern shoreline since 1850 is quite dramatic, this shoreline has changed little since 1986, especially on the northern portion. It now appears to be very nearly balanced in terms of shoreline position. Retreat and advance are almost equal for all three periods (Table 4), despite the higher energy setting. In addition, the southern spit has actually grown since 1950 (Figure 4). An interesting pattern has developed such that the northern and southern portions of this shoreline retreat and advance out of phase. During ambient and hurricane periods, the northern portion was dominated by shoreline advance, the southern portion by retreat. Conversely, during the recovery period erosion was highest on the northern portion and the southern portion had higher levels of accretion than erosion (1200 m vs. 670 m). It is important to note that the ‘hinge point’ corresponds to the location of the intersection between the shoreline and Cat Island’s ridges.

It is clear that ebb overwash during the hurricane (Figure 13) and subsequent transport is one of the main causes of the advance-retreat cycle on the northern half; and that the islands antecedent morphology is controlling the overwash locations. The temporal regularity of ebb overwash, whether it occurs only in large storms (hurricanes) or as a more normal process, is uncertain. Subsequent growth of a dune ridge (Figure 10-Cntrl N) to the north of the hinge point in the years following Hurricane Georges suggests that ebb overwash is a limited process and does not account for shoreline advance during the ambient period (1995-1997). This is likely a result of a long-term northerly sediment transport.

Shoreline retreat on South Spit is to be expected given the dominant southerly winds (Figure 5). Shoreline advance during the recovery period is less intuitive. It is possible that the ebb overwash built-up the nearshore platform (Figure 10; Cntrl N, Cntrl S) and facilitated some onshore sediment transport in the following seasons; however, there are limited data to substantiate this. It remains an interesting point and may suggest that the present shoreline configuration is now aligned such that the rapid retreat from 1850 to 1986 (Figure 4), when the shoreline was more north-south oriented, is retarded.

(Figure 13. Cat Island in 1998- aerial photo)

Conclusions

Using high accuracy, simple, and cost effective GPS surveys and publicly available LIDAR elevation data combined with ground-based survey data has helped detail the differences and similarities of shoreline and morphology changes during the period from 1995 to 2000. During this time one major storm, Hurricane Georges, passed very near Cat Island. Shoreline and morphology changes were analyzed for the periods before the hurricane, in response to the hurricane, and during the recovery period. Several trends were recognized.

1) Mud platform shorelines show higher retreat/advance ratios for all periods.

2) Sand dominated shorelines are more dynamic and appear to be operating in semi-equilibrium, such that retreat and advance are nearly balanced.

3) Retreat/advance on the eastern shoreline is associated with its intersection with Cat Island’s beach/dune ridges. The shorelines north and south of the intersection appear to function as opposing systems, such that general shoreline change is opposite from one to the other. The ridges themselves provide sediment to the system and funnel ebb flow during large storms.

4) Profiles done with traditional survey equipment can be compared with profiles generated from LIDAR data to analyze morphology changes.

5) Dramatic changes seen on the eastern shoreline of Cat Island from 1850 to 1986 appear to be subdued from 1986 to 2000, despite the passage of Hurricane Georges. Changes on the mud-dominated shoreline (western shoreline) appear to be higher during the 1995-2000 period than during the 1850-1986 period. The cause for the deviations from the historical norm may be the slight re-alignment of the eastern shoreline.

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