HISTORICAL CHANGES IN SHORELINE POSITION ALONG THE MISSISSIPPI SOUND BARRIER ISLANDS

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ABSTRACT

A computer-based shoreline mapping methodology, within the framework of a geographic information system, was used to compile and analyze changes in historical shoreline position and island area between 1847/49 and 1986 for the Mississippi Sound barrier island system. The data base consisted of three to four cartographic shorelines and one to two air photo interpreted shorelines. The dominant direction of movement for Dauphin, Petit Bois, Horn, and Ship islands is to the west, whereas cross-shore change in shoreline position is the primary mechanism by which the beaches on Cat Island respond to incident processes. Average shoreline change for the study area was about -1.7 m/yr; however, Horn Island illustrated no net shoreline change for the period of record and the western halves of Petit Bois and Ship islands were net progradational. Although spatial variability in shoreline movement was common, associated land loss was relatively consistent, ranging from -1.6 to -2.5 ha/yr.

The magnitude of lateral island migration is generally an order of magnitude greater than cross-shore movements. East of Dog Keys Pass, the islands are moving to the west by updrift erosion and downdrift accretion at rates exceeding 30 m/yr. The eastern end of Petit Bois Island illustrates the greatest lateral movement, averaging 89.9 m/yr between 1848 and 1986. Long-term changes recorded for the ends of Ship Island are significantly smaller, mainly due to dredging at the Biloxi navigation channel and distance from sand source, limiting the quantity of sand available for natural bypassing to the west. Short-term lateral migration trends illustrate a similar response at Horn Island Pass.

INTRODUCTION

Surveys of historical shoreline position have been recognized as a primary data source for investigating the evolution of the land-water interface in response to incident coastal processes (Morton, 1979; Penland and Boyd, 1981; Everts *et al.*, 1983; Leatherman, 1984; Byrnes *et al.*, 1989; Anders *et al.*, 1990; McBride *et al.*, 1991). Coastal scientists, engineers, and planners often use this information for estimating the magnitude and direction of sediment transport as related to zones of erosion and accretion (Headland *et al.*, 1987), monitoring engineering modifications to a beach (Dean, 1989), examining geomorphic variations in the coastal zone (Hosier and Cleary, 1977), establishing coastal erosion set-back lines (Shows, 1978), and verifying numerical shoreline change models (Kraus, 1989). Although natural and anthropogenic processes have produced significant changes along the barrier island and mainland shorelines of Mississippi Sound, quantitative documentation of historical shoreline change for the Gulf shoreline has received limited attention. Waller and Malbrough (1976), Otvos (1979), and Shabica *et al.* (1984) provide previous descriptions of shoreline change for the Mississippi barrier coastline based on cartographic data sources and aerial photography. The objective of this study is to accurately document historical changes in shoreline position and island area for the barrier islands in coastal Mississippi using a new, integrated computer mapping approach within the framework of a geographic information system.

GEOLOGIC SETTING

The Gulf beaches fronting Mississippi Sound are part of a chain of barrier islands and tidal passes that total about 100 km in length; the five islands located approximately 15 to

20 km seaward of the mainland shoreline of Mississippi Sound provide the primary line of defense against normal and storm processes of the Gulf of Mexico and include Dauphin, Petit Bois, Horn, Ship, and Cat (Fig. 1). Dauphin, Petit Bois, Horn, and Ship Islands are elongate east to west, whereas Cat Island has an east-west trending beach ridge complex on the sound side of the island and a northeast-southwest trending Gulf barrier beach. The islands consist of broad, well-developed beaches backed by dunes of variable height. Average elevations are between 3 and 6 m, and island widths are generally less than a mile (Waller and Malbrough, 1976). Beach texture and composition are predominantly well-sorted, fine quartz sand with some shell material and heavy minerals. Subaerial beach morphology varies from relatively wide and gently sloping profiles along the Gulf shoreline to narrow beaches with steep scarps along the Sound side of the barrier islands and at inlets. The interior of the islands illustrate a combination of broad, low sand flats and dunes, with marshes and shallow ponds, and extensive beach ridges vegetated by maritime pine forests that reach elevations of 10 m or more (Boone, 1973). Island area for the Mississippi barriers in 1986 was 537 ha (1 ha = 2.471 acres) for Petit Bois, 1325 ha for Horn, 374 ha for Ship, and 846 ha for Cat Island.

The Holocene geologic framework of the study area consists of sandy barrier island systems enclosing a back-barrier lagoon containing fine-grained bioturbated sediment transported into the lagoon through inlets or supplied by rivers draining the mainland. Barrier island environments include recurved spits at inlets, washover fans and flats, and dune systems. Fine-grained bioturbated deposits of Mississippi Sound vary in sediment texture based on proximity to the shoreline. Silt and clay deposits predominate in the central basin of the lagoon, whereas sand-sized sediment is associated with shallow-water shoals that exist in the Sound and marginal beach deposits. Median sand size for these areas ranges from about 0.2 to 0.6 mm (Knowles and Rosati, 1989). The immediate source of sand to island beaches appears to be from the east along the Alabama shoreline (Otvos, 1982). The Holocene sand platform on which the islands are perched averages approximately 12 m thick (Otvos, 1979).

PHYSICAL SETTING

The climate of the study area is humid subtropical with an average summer temperature of 81°F and an average winter temperature of 54°F (Eleuterius, 1974). Average annual rainfall is 1.49 m, with July being the peak month due primarily to the frequency of thunderstorms. Prevailing surface winds are mainly from the east and southeast during the spring and summer months, and from the east and northeast during fall and winter months (Eleuterius and Beaugez, 1979). Mississippi Sound is a relatively shallow, open-water lagoon where fetch- and depth-limited waves average less than 0.3 m in height (Jensen, 1983). However, during large storm events, when water level is elevated, wave height is increased significantly over ambient condi-

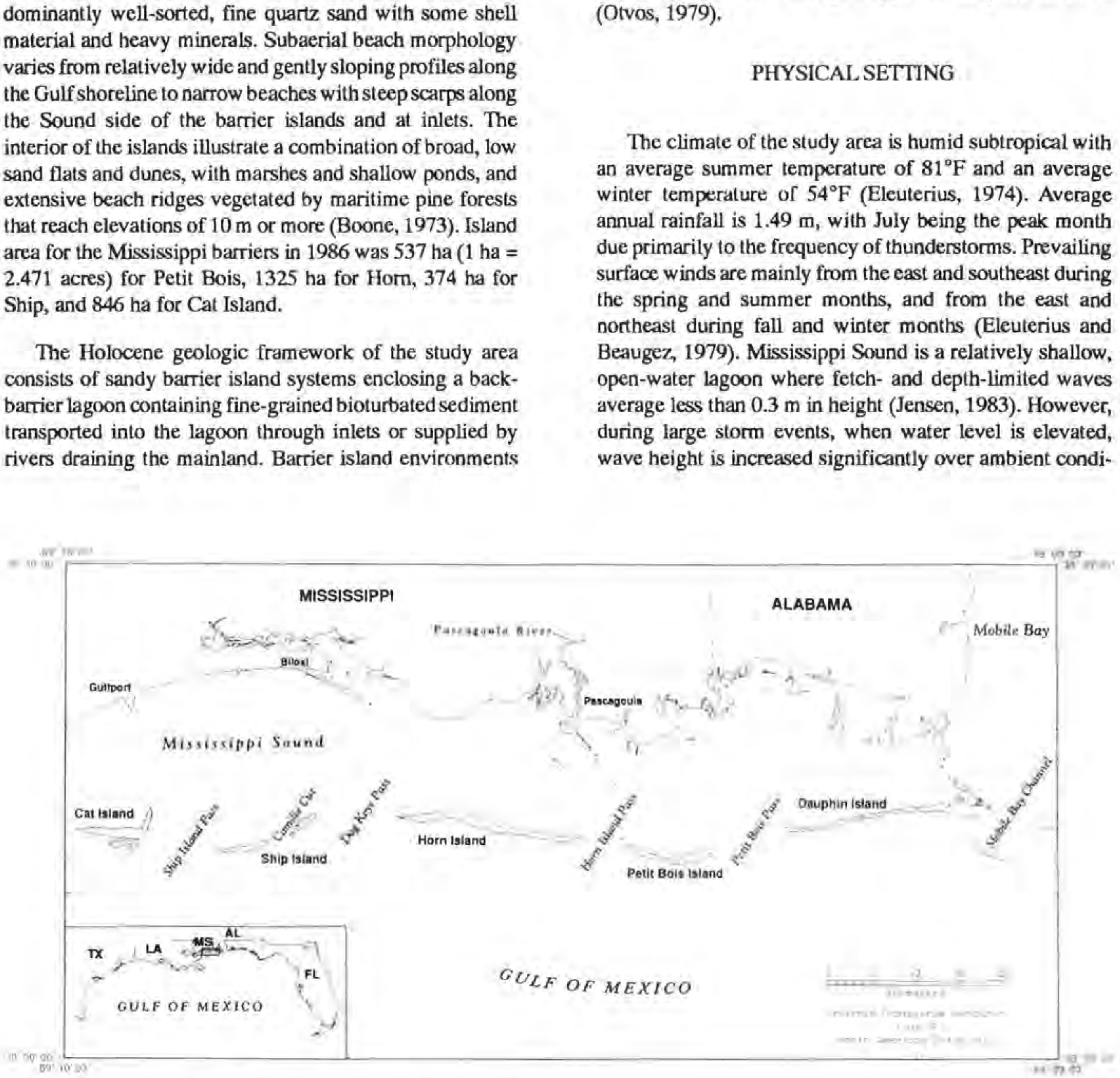

Figure 1. Index map of the Mississippi Sound barrier islands.

ions, increasing sediment transport. Average significant wave height at the US Army Corps of Engineers Wave Information Study (WIS) station 26 (seaward of Ship Island in 25 m water depth) is 1.0 m. The most frequent direction of wave propagation is from the southeast (Hubertz and Brooks, 1989). This results from prevailing southeasterly winds that produce a westward-flowing longshore current (0.5 to 1.5 m/sec) along the barrier islands (Boone, 1973). Updrift erosion and downdrift deposition associated with wind-driven currents are characteristic processes along the barrier islands, but episodic hurricane events appear to be equally important in affecting significant shoreline changes (Otvos, 1979). These high-energy, short-duration events are particularly devastating in the northern Gulf of Mexico where storm frequency is high and ground elevation is low (US Army Corps of Engineers, 1970; Penland *et al.*, 1980; Penland *et al.*, 1985). Accurate records of hurricanes impacting the Mississippi coast are incomplete prior to 1871, when official data collection was initiated by the US Weather Bureau (Neumann *et al.*, 1985). However, for the period of shoreline record pre-dating this time (1848 to 1871), records on tropical cyclone impacts document four hurricane events that probably represent the most severe storms for that time period having a direct effect on shoreline change. Between 1848 and 1986, a total of 74 recorded tropical cyclones affected the study area; however, it is likely that the hurricanes of 1852, 1893, 1909, 1915, 1947, 1965, and 1969 caused the greatest amount of change (Waller and Malbrough, 1976; Otvos, 1979).

Tide gauge data for the period 1895 to 1983 indicate that relative sea level has risen about 0.2 cm/yr in the study area (US Army Corps of Engineers, 1973; Penland *et al.*, 1989), suggesting limited significance of sea level changes on island morphodynamics compared with other areas of the northern Gulf of Mexico that exhibit much higher rates of rise (Penland and Ramsey, 1989). Even though tide is diurnal, with an average range of only 0.45 m, the large estuarine area and very shallow nearshore region result in a large tidal prism. Tidal currents generated by the movement of this volume of water create current speeds ranging between 0.5 to 1.0 m/sec on the flood tide and 1.8 to 3.5 m/sec on ebb at tidal passes between the islands (Foxworth *et al.*, 1962). Historically, these inlets have evolved considerably in depth and width, and associated shoal morphology suggests a mixed to tide-dominated environment.

PREVIOUS STUDIES

To date, only three studies have attempted to quantify shoreline change for the barrier islands of Mississippi Sound. Waller and Malbrough (1976) provided the first quantitative summary of Sound and Gulf shoreline changes using maps and aerial photography for the period 1848 to 1973. Otvos (1979) established a qualitative history of shoreline evolution for the barrier islands using mid-18th century maps and written accounts and the historical data of Waller and Malbrough (1976). More recently, Shabica *et al.* (1984) documented relatively short-term changes in shoreline position for the Mississippi Sound barrier islands (1957 to 1980) using aerial photography.

Waller and Malbrough (1976) used United States Geological Survey (USGS) 7.5-minute quadrangle maps as base maps for their study; all T-sheets and aerial photographs were either enlarged or reduced to the precise scale of the USGS topographic maps for comparison of shoreline position. Rates of change were calculated at 305-m longshore intervals and shoreline change measurements were made to ±15 m (this does not refer to data source and measurement accuracy). Long-term rates of Gulf shoreline movement for Petit Bois Island were calculated to be 1.8 m/yr along the western half of the island and -3.5 m/yr for the eastern shoreline. Horn Island showed an average retreat of about -0.6 m/yr for the 124-yr time interval, while Ship Island averaged about -3.0 m/yr but showed considerable variability in magnitude and direction. Magnitudes of shoreline change along the Gulf side of Cat Island were more consistent than those recorded for Ship Island and averaged -2.4 m/yr between 1848 and 1973. Major morphologic changes occurred along southwestern Cat Island where the large sand spit extending to the southwest of the beach ridge complex deteriorated at a rate of 19.1 m/yr. Recognizing the importance of lateral island migration in response to westward-directed longshore transport, Waller and Malbrough (1976) also tabulated net average rates of erosion and accretion on the east and west ends of the island systems: Petit Bois Island – 98.1 m/yr (east), 35.9 m/yr (west); Horn Island – 36.3 m/yr (east), 38.1 m/yr (west); Ship Island – 13.4 m/yr (east), 11.7 m/yr (west). Knowles (1989) illustrates the same trend for western Ship Island where net average longshore sand transport to the west has resulted in spit progradation at a rate of about 11.6 m/yr between 1848 and 1986.

Shabica *et al.* (1984) documented short-term shoreline change for the Mississippi barrier islands using near-vertical aerial photographs. Prior to annotating high-water shoreline position, 1:5,000 scale base maps were produced by photo-enlarging USGS 7.5-minute quadrangles. Aerial photographs were then enlarged (but not rectified) to the scale of the base map, and measurements of shoreline position change were made; a 200- to 300-m sampling interval was used. They calculated an average retreat rate for Petit Bois Island of -0.8 m/yr and showed a net shoreline advance of 0.3 m/yr for Horn Island for the period 1957 to 1980. Because Ship Island presently exists as west and east segments, two average retreat rates were calculated for the barrier island complex. West Ship Island exhibited net progradation (0.6 m/yr) whereas eastern Ship Island retrograded an average -6.4 m/yr. Rates of shoreline retreat along

Cat Island for the period 1932 to 1978 averaged 2.5 m/yr, a much lower rate of change than recorded for eastern Ship Island. Shabica *et al.* (1984) list 1922 as the initial shoreline for Cat Island; however, only a 1932 data source exists. In addition, the 1932 survey was the first NOS photo-interpreted shoreline in the historical data base and significant errors in shoreline placement were identified in the present study.

METHODOLOGY

Prior to widespread use of computer-based routines for capturing and analyzing changes in shoreline position, manual and semi-automated techniques were applied for assessing shoreline evolution in coastal areas (Stafford, 1971; Morton, 1977; Dolan *et al.*, 1978). Currently, accurate quantitative documentation of coastal change depends on electronic digitizers and computer processing that integrate computer-aided design and drafting (CADD), computer cartography, and geographic information system (GIS) software designed for workstations and personal computers. A shoreline change mapping strategy within the framework of a GIS has been developed at the Louisiana Geological Survey to document changes in shoreline position from cartographic and near-vertical aerial photographic data sources (Byrnes *et al.*, 1991a,b; McBride *et al.*, 1991). For the present study, US Coast and Geodetic Survey (now National Ocean Service) topographic sheets (NOS T-sheets) provided the cartographic data base of historical surveys, and aerial photography from the US Army Corps of Engineers was used to create photomaps (Table 1). A Bausch and Lomb Zoom Transfer Scope was used to rectify aerial photography to common stable ground points on the most recent NOS T-sheets (1:10,000 scale). The high-water shoreline was interpreted according to the location of the wet- and dry-beach contact or the high-water debris line. A series of six shoreline data sets was used to quantify movements in position of the high-water line.

Shoreline data were captured at a 1:1 scale using a large-format, high-precision digitizer and cursor according to original projection, ellipsoid, and datum using Intergraph's computer mapping hardware and software (McBride *et al.*, 1991). Data quality assurance was monitored continually and a detailed analysis of inherent and operational errors was performed to gauge the significance of measured changes (Anders and Byrnes, 1991; Byrnes *et al.*, 1991b). Total root-mean-square error for individual time periods did not exceed ±10 m. Once accurate maps were compiled, shoreline change was quantified using the Automated Shoreline Analysis Program (ASAP) for a longshore measurement interval of 50 m at transects perpendicular to general shoreline orientation. A cubic spline interpolation routine was employed to organize temporal data for comparison at common longshore positions. Sequential and cumulative changes in shoreline position were calculated using digital shoreline coordinates (UTM projection) and tabulated for temporal and spatial comparisons.

Table 1. Cartographic and aerial photographic data sources.

Date	Survey Type	Cartographic Product	Scale
1847/1849	field	NOS t-sheet	1:20,000
1916/1917	field	NOS t-sheet	1:40,000
May 1950	air photo	NOS t-sheet	1:20,000
November 1957	air photo	NOS t-sheet	1:10,000
January 1966	air photo	NOS t-sheet	1:10,000
November 1976	air photo	LGS photomap	1:10,000
November 1986	air photo	LGS photomap	1:10,000

RESULTS AND DISCUSSION

The detailed analysis of changes in shoreline position for the Mississippi Sound barrier islands for the period 1847/49 to November 1986 showed that the islands migrated to the west and north at varying rates depending on incident wave conditions and sediment availability. The dominant direction of movement is controlled by wave-generated longshore currents that cause erosion on the eastern ends of the islands and accretion along the western termini. Consequently, historical shoreline evolution will be presented in a manner consistent with the dominant direction of sand transport (east-west). Although each island has distinct characteristics, the evolution of Cat Island is significantly different from the others due to shoreline orientation as influenced by development of the St. Bernard delta (Otvos, 1979; Rucker and Snowden, 1989, 1990). In this case, shoreline retreat caused by cross-shore processes dominates the system and the southwest-directed spit has been degrading continually throughout the historical record.

Western Dauphin Island/Petit Bois Island

Cumulative change in position of the high-water shoreline for western Dauphin Island and Petit Bois Island from 1848 to 1986 is illustrated in Figure 2. In 1848, the eastern end of Petit Bois Island was located off the Alabama coast, approximately 12.5 km to the east of its current position. In response to storm events and a strong longshore-directed movement of sand, both Dauphin and Petit Bois islands migrated to the west by erosion of updrift margins and downdrift spit accretion. The rate of landward-directed shoreline movement at Petit Bois is relatively insignificant compared with lateral changes. However, two distinct zones of change can be recognized in relation to shoreline movement; the western portion of the island shows net progradation relative to the 1848 shoreline (1.7 m/yr) whereas the eastern end exhibits net retreat (-3.3 m/yr). Table 2 provides a summary of cumulative and sequential changes in shore-

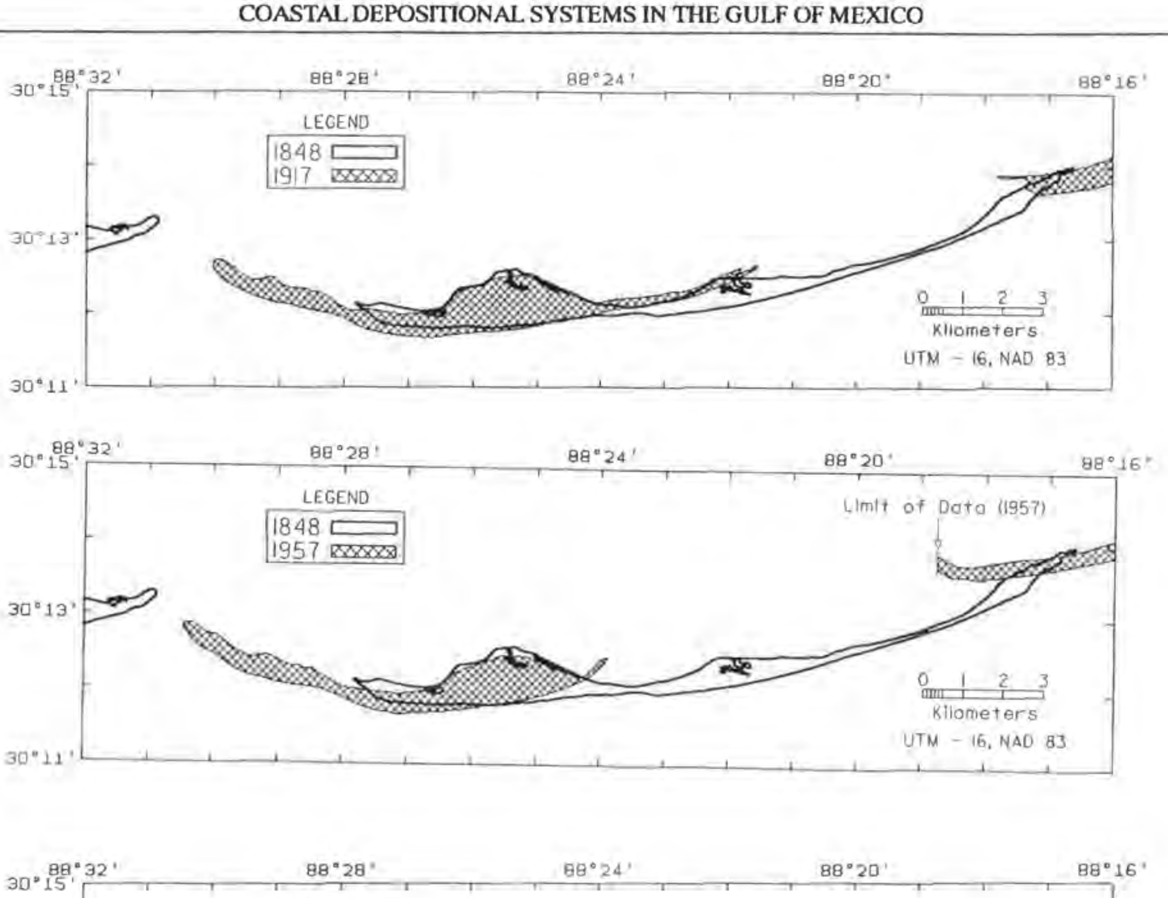

Figure 2. Cumulative changes in historical shoreline position between 1848 and 1986, Petit Bois Island, Mississippi.

line position. These numbers represent the average of individual change values calculated at 50-m longshore intervals for overlapping land area. Sequential changes through 1976 indicate consistent rates for the eastern half of Petit Bois Island; however, a significant increase in the rate of shoreline retreat is recorded between 1976 and 1986. For the

Table 2. Rates of change for island area (ha/yr) and shoreline position (m/yr) at Petit Bois Island, MS.

	1917	1957	1976	1986
1848	***-1.1***[1]	***-1.9***	***-1.9***	***-2.0***
(e)	-4.2	-2.3	-2.8	-3.3â
(w)	2.5	2.2	1.9	1.7
1917	—	***-3.2***	***-2.8***	***-2.8***
(e)	—	-4.2	-4.7	-5.3â
(w)	—	1.8	1.5	1.6
1957	—	—	***-2.1***	***-2.4***
(e)	—	—	-4.2	-6.1
(w)	—	—	1.5	1.4
1976	—	—	—	***-2.8***
(e)	—	—	—	-8.2
(w)	—	—	—	1.3

[1] bold italicized numbers represent rates of area change;
1 hectare (ha) = 2.47 acres
(e) = eastern half of Petit Bois Island
(w) = western half of Petit Bois Island

entire time period, the western portion of the island shows a net decrease in the rate of shoreline advance. Changes in island area are recorded to evaluate the impact of shoreline movement on island erosion in response to sediment supply and nearshore processes. Between 1848 and 1986, island area decreased by about 2.0 ha/yr. Analysis of cumulative change relative to the 1986 shoreline shows a general increase in land loss associated with increasing rates of shoreline retreat for the eastern portion of Petit Bois Island and decreasing rates of shoreline progradation for western Petit Bois Island, implying a persistent increase in net erosion.

Tables 3 and 4 provide quantitative documentation of the direction and rate of lateral movements associated with Dauphin and Petit Bois islands. For the period of record, the western end of Dauphin Island migrated at a rate of 55.3 m/yr to the west while the eastern end of Petit Bois moved to the west at a rate of 89.9 m/yr, resulting in net expansion of Petit Bois Pass. In addition, the western end of Petit Bois Island migrated to the west at 31.3 m/yr, causing a net reduction in island area. Short-term rates of change illustrate a net decrease in lateral movement for both ends of Petit Bois Island and the western end of Dauphin Island.

Table 3. Lateral island migration rates (m/yr) at western Dauphin Island, AL.

	1917	1957	1976	1986
1847	+54.4	*	56.6	+55.3â
1917	—	*	59.2	+56.2
1957	—	—	*	*
1976	—	—	—	+37.8

\+ = migration to the west
\- = migration to the east
* shoreline position data for the eastern end of Dauphin Island not available

Table 4. Lateral island migration rates (m/yr) at Petit Bois Island, MS.

		1917	1957	1976	1986
1848	(e)	+120.5	+110.1	+95.9	+89.9
	(w)	+53.1	+40.0	+33.9	+31.3
1917	(e)	—	+92.5	+67.6	+59.7
	(w)	—	+17.7	+11.7	+9.7
1957	(e)	—	—	+14.2	+13.6
	(w)	—	—	-1.3	-1.7
1976	(e)	—	—	—	+12.4
	(w)	—	—	—	-2.4

(e) = eastern end of Petit Bois Island
(w) = western end of Petit Bois Island
\+ = migration to the west
\- = migration to the east

Horn Island

General shoreline movement at Horn Island is consistent with that documented for Petit Bois Island; however, the magnitude of change and historical trends are slightly different. Sequential changes in shoreline position between 1849 and 1986 exhibit steady lateral migration to the west with no significant island retreat along the Gulf or Sound shorelines (Fig. 3). Average rates of shoreline change show a relatively stable feature for the period of record (Table 5). Although net cumulative change was calculated at 0.0 m/yr, an associated standard deviation of ±2.1 m/yr indicates spatial variability in calculated rates of change for each 50-m interval. This apparent balance in the long-term rate of shoreline movement is the result of a continual decrease in shoreline retreat since 1849. In contrast, island area has

Table 5. Rates of change for island area (ha/yr) and shoreline position (m/yr) at Horn Island, MS.

	1917	1957	1976	1986
1849	***0.5***[1]	*	***-1.3***	***-1.7***
	-0.9	-0.2	-0.1	0.0
1917	—	*	***-3.4***	***-3.8***
	—	-0.3	-0.1	0.1
1957	—	—	*	*
	—	—	-1.3	-1.1
1976	—	—	—	***-6.4***
	—	—	—	-1.5

[1] bold italicized numbers represent rates of area change;
1 hectare (ha) = 2.47 acres
* shoreline position data for western end of Horn Island not available for making area calculation

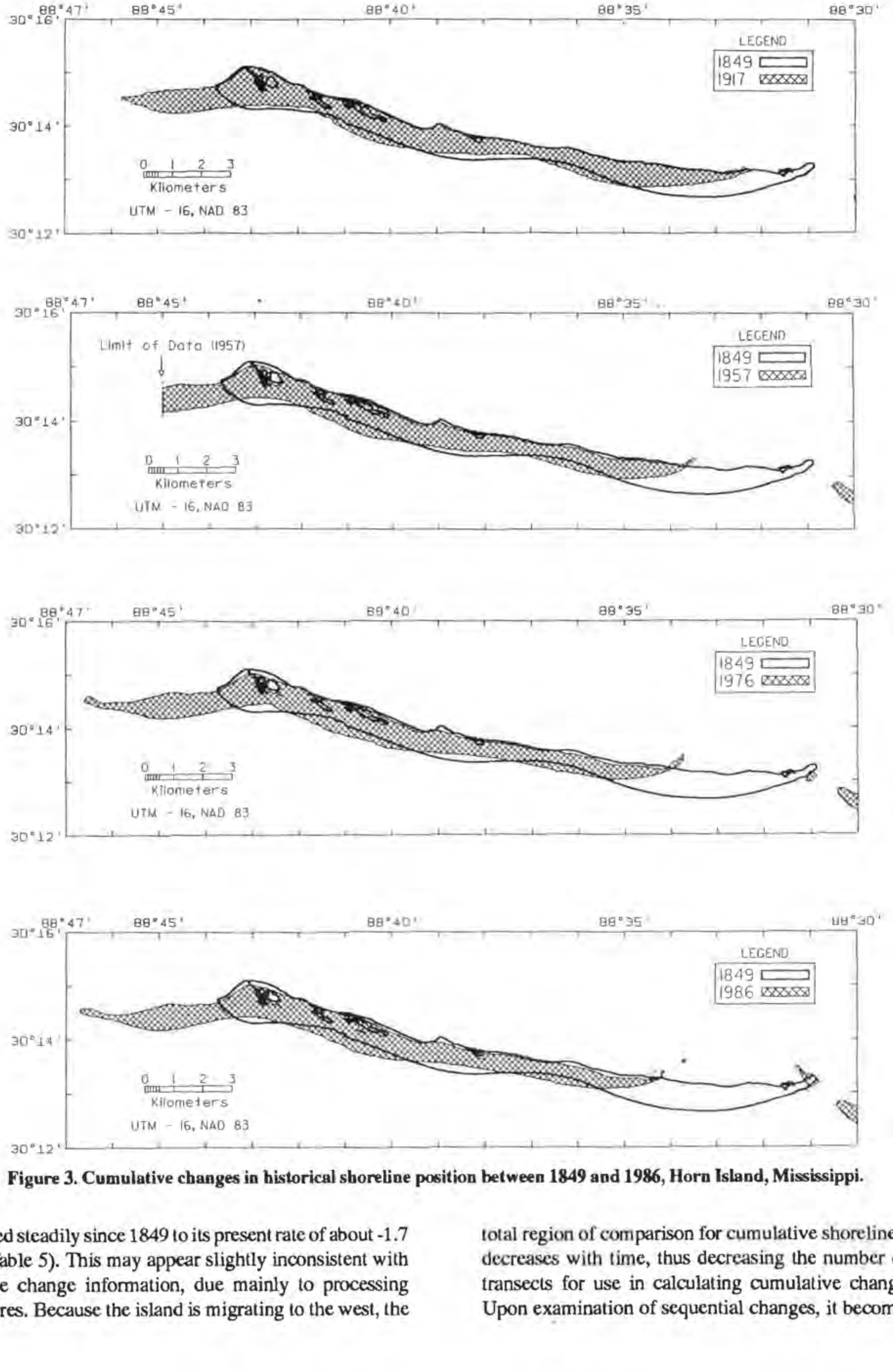

Figure 3. Cumulative changes in historical shoreline position between 1849 and 1986, Horn Island, Mississippi.

decreased steadily since 1849 to its present rate of about -1.7 ha/yr (Table 5). This may appear slightly inconsistent with shoreline change information, due mainly to processing procedures. Because the island is migrating to the west, the total region of comparison for cumulative shoreline change decreases with time, thus decreasing the number of 50-m transects for use in calculating cumulative change rates. Upon examination of sequential changes, it becomes clear that the rate of retreat generally increases with time, creating a slightly narrower island relative to its initial configuration (Fig. 3; Table 5).

An examination of cumulative lateral migration rates from 1849 indicates a near-balance between the rate of westward retreat along the eastern end of the island (39.3 m/yr) and spit progradation at the western end (34.5 m/yr). Table 6 illustrates that this trend is not consistent for all time intervals; in fact, the differential between downdrift retreat on the east end and progradation to the west gets progressively larger towards the most recent shoreline. Relative to the long-term average, the rate of change becomes greater along east Horn Island at Horn Island Pass and smaller along the western spit at Dog Keys Pass. Overall, Horn Island is the most stable barrier island fronting Mississippi Sound.

Ship Island

Ship Island exhibits the same general trend in lateral migration as the islands to the east; however, the rate of landward retreat along east Ship Island into Mississippi Sound is significantly greater than that recorded for Horn and Petit Bois (Fig. 4). In addition, the impact of major storm events is reflected by the presence of a breach midway along the island for three of the five time periods. The initial island breach recorded in 1950 was the result of a major hurricane impact in 1947. Between 1950 and 1966, the island became a continuous feature when the inlet filled with sand from updrift beaches. This was short-lived because Hurricane *Camille* breached the island in two places in 1969; one inlet, Camille Cut, remains open today.

Table 6. Lateral island migration rates (m/yr) at Horn Island, MS.

		1917	1957	1976	1986
1849	(e)	+31.9	+38.3	+36.4	+39.3
	(w)	+48.6	*	+36.1	+34.5
1917	(e)	—	+48.6	+41.2	+46.2
	(w)	—	*	+21.8	+20.8
1957	(e)	—	—	+26.1	+43.0
	(w)	—	—	*	*
1976	(e)	—	—	—	+76.2
	(w)	—	—	—	+15.0

(e) = eastern end of Horn Island
(w) = western end of Horn Island
\+ = migration to the west
\- = migration to the east
* shoreline position data for the western end of Horn Island not available

Table 7. Rates of change for island area (ha/yr) and shoreline position (m/yr) at Ship Island, MS.

	1917	1950	1966	1976	1986
1848	***-0.6***[1]	*	***-1.6***	***-1.7***	***-1.6***
(e)	-2.9	-3.0	-3.7	-4.0	-4.2
(w)	3.2	1.9	1.7	1.5	1.6
1917	—	*	***-2.9***	***-2.9***	***-2.6***
(e)	—	-4.7	-4.9	-5.0	-5.3
(w)	—	0.9	0.4	0.5	0.4
1950	—	—	*	*	*
(e)	—	—	-3.6	-5.3	-5.6
(w)	—	—	-0.5	-0.3	0.1
1966	—	—	—	***-2.8***	***-1.9***
(e)	—	—	—	-7.2	-6.5
(w)	—	—	—	0.2	0.5
1976	—	—	—	—	***-0.9***
(e)	—	—	—	—	-6.1
(w)	—	—	—	—	0.9

[1] bold italicized numbers represent rates of area change; 1 hectare (ha) = 2.47 acres
* shoreline position data for the eastern end of Ship Island not available for making area calculation
(e) = eastern half of Ship Island
(w) = western half of Ship Island

The two portions of the Ship Island barrier system respond quite differently to incident coastal processes. The eastern end of the system is eroding and the island segment is retreating. Conversely, west Ship Island is prograding to the west and south. Whereas the rate of lateral migration is relatively small compared with those of islands to the east, the rate of shoreline retreat for east Ship Island is more than double that associated with islands to the east (Table 7). Cumulative shoreline movements for east and west segments of Ship Island are -4.2 m/yr and 1.6 m/yr, respectively. Although this trend is relatively consistent for most time increments, there is a slight increase in shoreline retreat for both sections with increasing time. Cumulative change in island area (-1.6 ha/yr) is consistent with shoreline movements and island degradation associated with hurricane impacts. Sequential values fluctuated slightly but the overall magnitude was relatively consistent. Associated lateral island migration rates were close to balancing in the long-term; however, sequential variability was significant (Table 8). The magnitude of erosion on the east and accretion to the west was smaller than that associated with islands to the east. This trend is consistent with distance from the sand source and the direction of longshore transport. Because the source of sand to the barrier system is from the east, the magnitude of transport can be expected to decrease with increasing distance downdrift. In addition, erosion associated with the long-term rate of retreat on the eastern margin of the island (-7.5 m/yr) is slightly lower than the rate of downdrift progradation (9.6 m/yr). Maintenance dredging at the ship channel along the western flank of the island is certain to change the trend in the future (Knowles, 1989). In fact, incremental data between 1966 and 1986 illustrate this

Table 8. Lateral island migration rates (m/yr) at Ship Island, MS.

		1916	1950	1966	1976	1986
1848	(e)	+13.7	*	+7.5	+10.1	+7.5
	(w)	+12.3	+11.8	+12.1	+11.1	+9.6
1916	(e)	—	*	-1.1	+6.1	+1.4
	(w)	—	+10.8	+11.8	+9.7	+6.9
1950	(e)	—	—	*	*	*
	(w)	—	—	+14.0	+8.3	+3.3
1966	(e)	—	—	—	+38.5	+7.3
	(w)	—	—	—	0	-4.7
1976	(e)	—	—	—	—	-26.8
	(w)	—	—	—	—	-4.7

(e) = eastern end of Ship Island
(w) = western end of Ship Island
\+ = migration to the west
\- = migration to the east
* shoreline position data for the eastern end of Ship Island not available

impact where lateral island migration to the west effectively has ceased.

Cat Island

Cat Island responds differently to nearshore processes because its orientation is different from that of the other barrier islands (Otvos, 1979; Rucker and Snowden, 1989); the Gulf beach is aligned in a northeast-southwest direction instead of east-west. Landward retreat is the primary mechanism by which shoreline change occurs rather than lateral migration in response to longshore currents. Figure 5 shows a steady increase in the amount of shoreline retreat from northeast to southwest along the island. In addition, the elongate spit along the southern portion of the island deteriorates with time. The sequence of shoreline evolution shown in Figure 5 indicates significantly greater shoreline retreat along the southern half of the island system, includ-

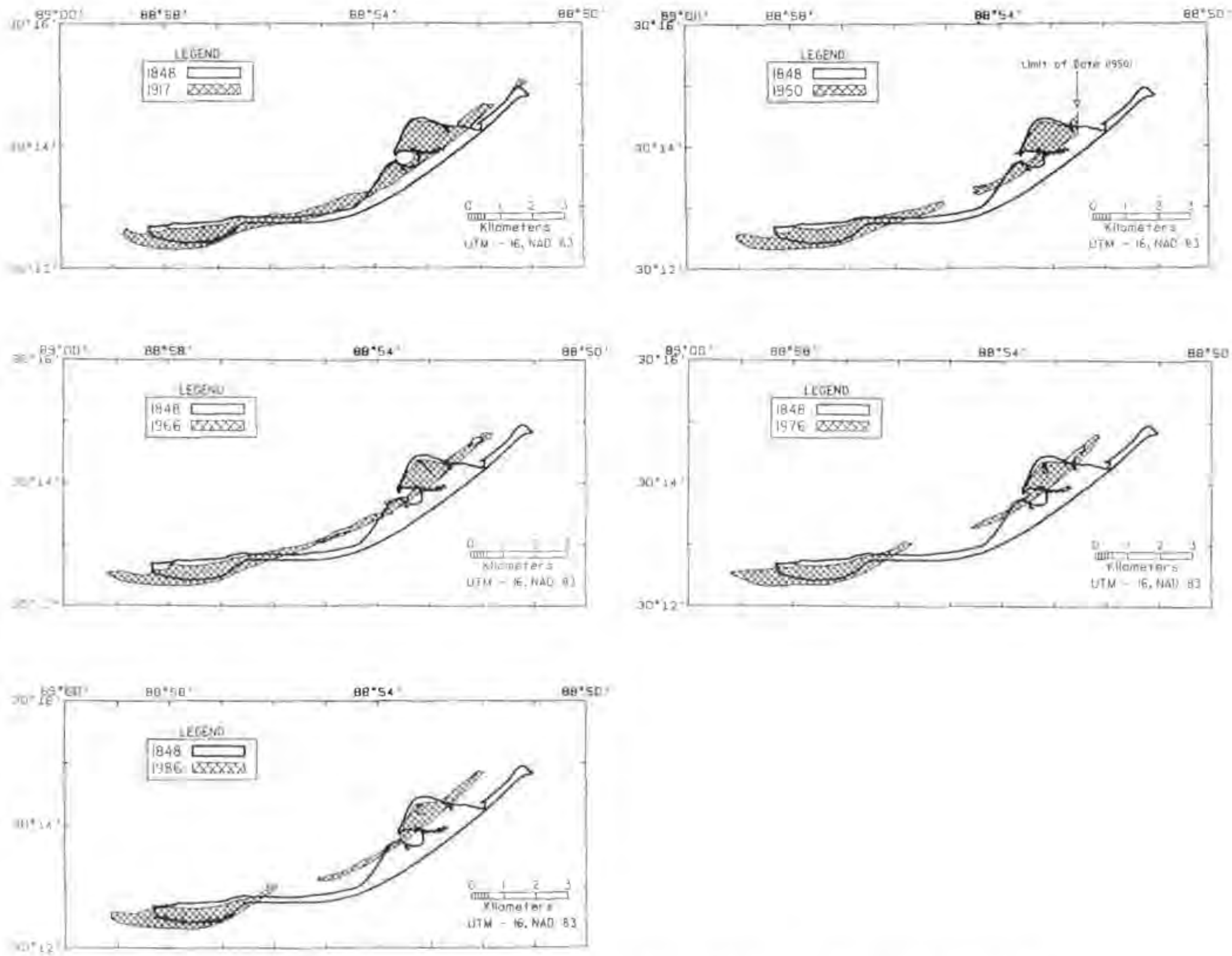

Figure 4. Cumulative changes in historical shoreline position between 1848 and 1986, Ship Island, Mississippi.

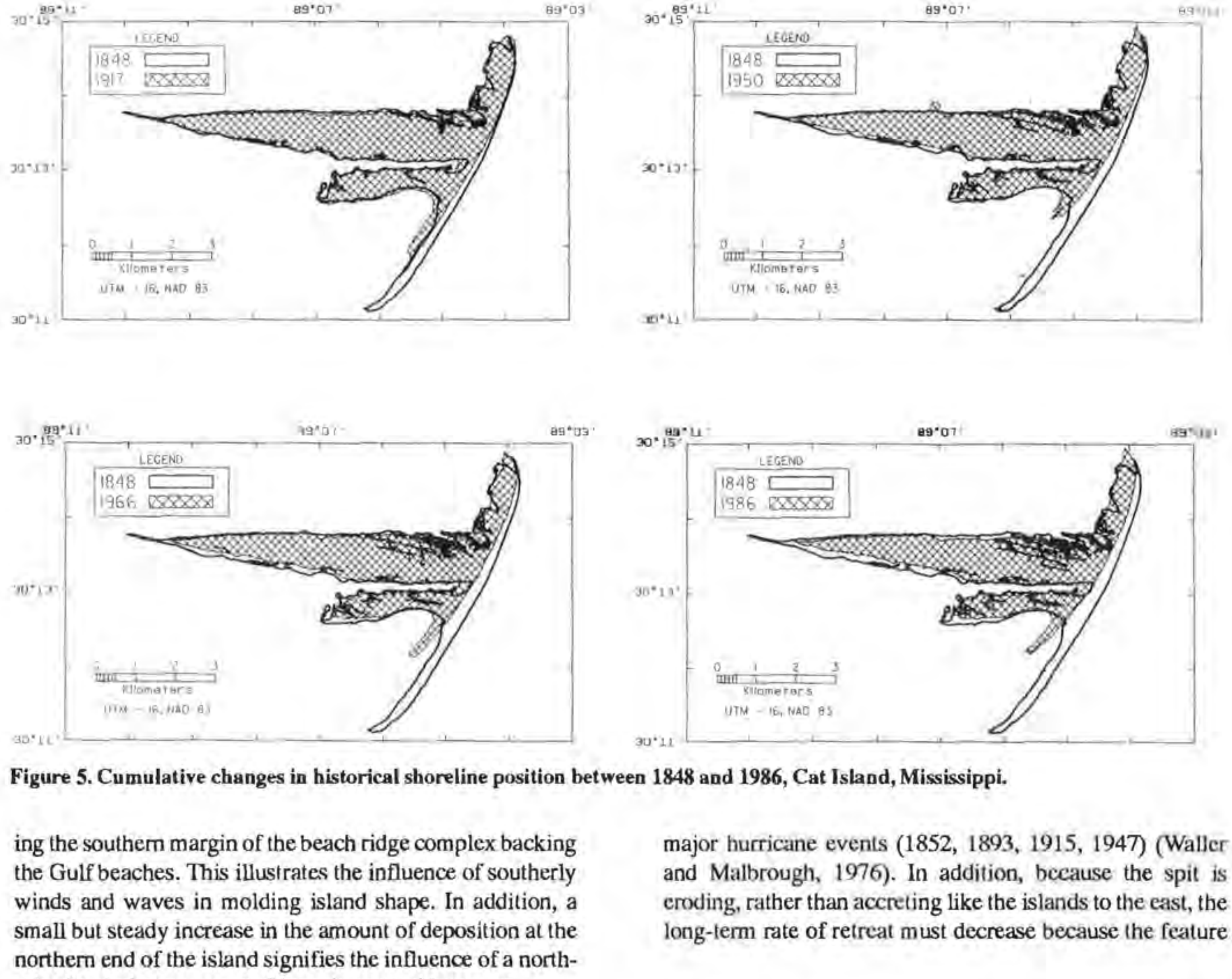

Figure 5. Cumulative changes in historical shoreline position between 1848 and 1986, Cat Island, Mississippi.

ing the southern margin of the beach ridge complex backing the Gulf beaches. This illustrates the influence of southerly winds and waves in molding island shape. In addition, a small but steady increase in the amount of deposition at the northern end of the island signifies the influence of a northerly directed component of longshore sand transport.

Table 9 lists the cumulative and sequential rates of change in island area, shoreline retreat, and spit deterioration from 1848 to 1986. The average amount of shoreline retreat for the 138-year record is -2.4 m/yr. This value is generally consistent for all time intervals relative to 1848, although the magnitude of change increases slightly with time. Sequential changes show the same general trend of increasing retreat rates with time. Because the shoreline along the southern spit of Cat Island is the most dynamic portion of the system (Fig. 5), individual rates of retreat for this area would reflect greater net movement. Change in island area has been increasing with time and measures about -2.5 ha/yr for the period 1848 to 1986. The large increase in area change between 1917 and 1950 reflects the loss of significant amounts of land associated with the old southern spit complex. Cumulative change in deterioration of the sand spit along south Cat Island shows a long-term retreat rate of 16.1 m/yr. This magnitude of change was greater prior to 1950, reflecting the influence of several major hurricane events (1852, 1893, 1915, 1947) (Waller and Malbrough, 1976). In addition, because the spit is eroding, rather than accreting like the islands to the east, the long-term rate of retreat must decrease because the feature

Table 9. Rates of change for island area (ha/yr), shoreline position (m/yr), and spit deterioration (m/yr) at Cat Island, MS.

	1917	1950	1966	1986
1848	***-0.9***[1]	***-2.2***	***-2.6***	***-2.5***
	-1.7	-1.8	-2.3	-2.4
(s)	25.3	26.8	18.4	16.1
1917	—	***-4.9***	***-4.9***	***-4.1***
	—	-2.6	-3.3	-3.2
(s)	—	30.0	8.9	7.2
1950	—	—	***-4.8***	***-3.3***
	—	—	-3.0	-2.9
(s)	—	—	-36.5	-13.9
1966	—	—	—	***-2.2***
	—	—	—	-3.2
(s)	—	—	—	3.2

[1] bold italicized numbers represent rates of area change; 1 hectare (ha) = 2.47 acres

(s) = spit deterioration; negative sign in this category signifies spit growth is of finite length. With a lack of sand supply to the system, it is doubtful that the feature will recover to its 1848 configuration.

Regional Trends

Although temporal and spatial variability in shoreline movement exist throughout the Mississippi Sound barrier island complex, regional trends in shoreline dynamics, as affected by incident wave processes and tropical cyclone impacts, can be identified. The most consistent trend is that associated with the direction of shoreline movement; longshore transport of sand to the west along Dauphin, Petit Bois, Horn, and Ship islands overwhelms cross-shore processes, resulting in rapid shoreline displacement along the ends of the islands (*e.g.*, Fig. 3, Tables 5 and 6). In addition, because the source of sand to the barrier islands is from the east, the rate of lateral migration decreases to the west (Tables 4, 6, and 8). Cat Island is an anomaly to this trend due to a difference in shoreline orientation as influenced by development of the St. Bernard delta complex; in this case, deterioration of the southern spit and shoreline retreat are documented historically. The response of these barrier islands is very different from systems to the west along the Louisiana outer coast where the dominant direction of shoreline change is cross-shore at rates in excess of -10 m/yr (McBride *et al.*, 1991).

Figure 6 provides a comparison of change in area with time for the four barrier islands in Mississippi. These trends emphasize the consistency of response throughout the barrier island complex as indicated in Tables 2, 5, 7, and 9. Even though trends are nearly identical, the cumulative percent change in area is significantly lower for Horn Island (15%) *versus* Petit Bois (34%), Ship (38%), and Cat (29%), suggesting a more stable feature. In addition, Horn Island has been affected the least by storm impacts, as indicated by historical records, whereas significant changes in island length and breaching at Petit Bois, Ship, and Cat islands related to hurricanes have altered shoreline configuration. Considering the magnitude of change in lateral island migration, the barrier complex shows relatively little change in area and only small changes in cross-shore shoreline movement, suggesting a near-balance in erosion and accretion in comparison with sand-starved, washover-dominated beaches in Louisiana.

Figure 6. Plot showing area change *versus* time for the Mississippi barrier islands between 1848 and 1986.

CONCLUSIONS

Changes in historical shoreline position for the Mississippi Sound barrier island complex were quantified using a computer-based, shoreline mapping methodology within the framework of a geographic information system. Regional shoreline response is controlled by longshore transport processes as indicated by the magnitude of island movement to the west compared with shoreline retreat at fixed longshore positions. Cumulative changes in shoreline position between 1848 and 1986 showed considerable spatial variability but long-term rates of change were relatively low at about -1.7 m/yr. Petit Bois and Ship islands illustrated similar trends in shoreline response where the eastern portions of the systems showed net retreat (-3.3 and -4.2 m/yr, respectively) and the western halves were characterized by progradation (1.7 and 1.6, respectively). Horn Island illustrated no net cross-shore change in shoreline position, whereas Cat Island retreated to the northwest at an average rate of -2.4 m/yr. Less variability was recorded for cumulative change in island area but overall, Horn and Ship islands illustrated the least amount of land loss (-1.7 and -1.6 ha/yr, respectively). The rate of land loss for Petit Bois Island was -2.0 ha/yr, and the greatest amount of change was recorded for Cat Island (-2.5 ha/yr) due to deterioration of its southern spit complex between 1848 and 1986. Although the changes recorded for the Mississippi barrier island system are significant, they are relatively minor compared with those of the Louisiana barrier islands where -15 m/yr of shoreline movement and -8 ha/yr of land loss are common (McBride *et al.*, 1991).

The greatest amount of shoreline movement for the barrier island system results from lateral migration. For the entire time period, the western end of Dauphin Island has migrated to the west at a rate of 55.3 m/yr. At the same time, eastern Petit Bois Island has been migrating in the same direction at 89.9 m/yr, creating an overall expansion of Petit Bois Pass. The western terminus of Petit Bois and both ends of Horn Island illustrate a relatively consistent rate of downdrift migration (31.3, 39.3, and 34.5 m/yr, respectively), although the magnitude of change has decreased relative to updrift change. Lateral movements to the west for the ends of Ship Island show a dramatic decrease to 7.5 m/yr along the eastern margin and 9.6 m/yr along the western terminus. This gradual decrease in the rate of lateral movement from east to west may be related to distance from the sand source to the east and dredging activities at the passes. This is particularly noticeable at Dog Keys Pass where dredging of the Biloxi navigation channel appears to have reduced the quantity of sand naturally bypassed to the west.

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COASTAL DEPOSITIONAL SYSTEMS IN THE GULF OF MEXICO

Quaternary Framework and Environmental Issues

Twelfth Annual Research Conference
Gulf Coast Section
Society of Economic Paleontologists and
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Program with Extended and Illustrated Abstracts

Adam's Mark Hotel
Houston, Texas
December 8-11, 1991

GULF COAST SECTION
SOCIETY OF ECONOMIC PALEONTOLOGISTS AND
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PROGRAM

COASTAL DEPOSITIONAL SYSTEMS IN THE GULF OF MEXICO

QUATERNARY FRAMEWORK AND ENVIRONMENTAL ISSUES

Adam's Mark Hotel
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The number in brackets following the paper title indicates the page in this volume on which the text or abstract of the paper begins.

SUNDAY, DECEMBER 8, 1991

4:00 - 6:00 p.m.	Registration — Salon Lobby
5:00 - 8:00 p.m.	Welcoming Reception and Poster — Exhibit Center

MONDAY, DECEMBER 9, 1991

7:00 - 8:00 a.m.	Cash Breakfast Bar — Salon Lobby
8:00 - 9:00 a.m.	Registration — Salon Lobby

SESSION I: QUATERNARY FRAMEWORK OF TEXAS AND LOUISIANA

Convenors: Robert A. Morton and Harry H. Roberts

8:15 - 8:30 a.m.	Opening Remarks
8:30 - 9:00 a.m.	CHARLES D. WINKER: Summary of the Quaternary Framework, Northern Gulf of Mexico [280]
9:00 - 9:30 a.m.	ROBERT A. MORTON: Response of Holocene Depositional Systems Tracts to Sediment Influx, Northern Gulf of Mexico [149]
9:30 - 10:00 a.m.	MARK A. THOMAS and JOHN B. ANDERSON: Late Pleistocene Sequence Stratigraphy of the Texas Continental Shelf: Relationship to $\delta^{18}O$ Curves [265]
10:00 - 10:30 a.m.	Coffee Break
10:30 - 11:00 a.m.	JOHN R. SUTER, RON BOYD and SHEA PENLAND: Late Quaternary Chronostratigraphic Framework, Northern Gulf of Mexico [263]
11:00 - 11:30 a.m.	HARRY H. ROBERTS: Quaternary Framework of the Eastern Louisiana Continental Shelf [215]
11:30 - 12:00 a.m.	SHEA PENLAND, RANDOLPH A. McBRIDE, JOHN R. SUTER, RON BOYD and S. JEFFRESS WILLIAMS: Holocene Development of Shelf-Phase Mississippi River Delta Plains [182]

12:00 - 1:30 p.m.	Lunch

SESSION II: QUATERNARY FRAMEWORK OF MISSISSIPPI, ALABAMA, AND FLORIDA

Convenors: Albert C. Hine and Eugene A. Shinn

1:30 - 2:00 p.m.	EUGENE A. SHINN, BARBARA H. LIDZ, AND ALBERT C. HINE: Coastal Evolution and Sea-Level History: Florida Keys [237]
2:00 - 2:30 p.m.	ALBERT C. HINE and LARRY J. DOYLE: Quaternary Geology of the West Florida Continental Shelf [93]
2:30 - 3:00 p.m.	JOSEPH F. DONOGHUE: Late Quaternary Deposition in the Apalachicola Embayment, Northwest Florida Coast [77]
3:00 - 3:30 p.m.	Coffee Break
3:30 - 4:00 p.m.	GREGORY W. STONE: Multiple Sediment Sources and a Cellular Longshore Drift System, Northwest Florida and Southeast Alabama Coast [255]
4:00 - 4:30 p.m.	ERVIN G. OTVOS: Late Quaternary Transgressive-Regressive Cycles and Stratigraphic Units, Gulf Coastal Plain — A Brief Review [171]
4:30 - 5:00 p.m.	JOHN A. LOPEZ: Origin of Lake Ponchartrain and the 1987 Irish Bayou Earthquake [103]
6:00 - 7:30 p.m.	Buffet Reception — Exhibit Center
7:30 - 9:00 p.m.	Poster Session — Exhibit Center Author present in booth 8:00 - 9:00 PM

TUESDAY, DECEMBER 10, 1991

7:00 - 8:00 a.m.	Cash Breakfast Bar — Salon Lobby

SESSION III: COASTAL DEPOSITIONAL SYSTEMS IN LOUISIANA

Convenors: R.J. LeBlanc and S. Penland

8:00 - 8:10 a.m.	Introduction
8:10 - 8:40 a.m.	JAMES M. COLEMAN and HARRY H. ROBERTS: Coastal Depositional Systems in the Northern Gulf of Mexico [62]
8:40 - 9:00 a.m.	RON BOYD, ROBERT DALRYMPLE and BRIAN ZAITLIN: Evolutionary Classification of Coastal Sediments [30]
9:00 - 9:20 a.m.	JOANN MOSSA: Temporal and Downstream Changes in Suspended Sediment Transport in the Atchafalaya and Mississippi Rivers, Louisiana [159]
9:20 - 9:40 a.m.	IVOR L. VAN HEERDEN, HARRY H. ROBERTS, SHEA PENLAND and ROB H. CUNNINGHAM: Subaerial Delta Development, Eastern Atchafalaya Bay, Louisiana [271]
9:40 - 10:10 a.m.	Coffee Break
10:10 - 10:30 a.m.	OSCAR K. HUH, LAWRENCE and HARRY H. ROBERTS: Impact of the Atchafalaya Bayhead Delta Complex on Downdrift Coasts [95]

10:30 - 10:50 a.m.	DAVID L. POPE, SHEA PENLAND, JOHN R. SUTER and RANDOLPH A. McBRIDE: Holocene Geologic Framework of Trinity Shoal Region, Louisiana Continental Shelf [191]
10:50 - 11:10 a.m.	STEPHEN P. MURRAY and CHARLES ADAMS: Sediment Transport in the Terrebonne Bay-Marsh Complex [164]
11:10 - 11:30 a.m.	DENISE J. REED: Sediment Deposition in Louisiana Coastal Wetlands [211]
11:30 - 11:50 a.m.	JOHN A. NYMAN and RONALD D. DeLAUNE: Mineral and Organic Matter Accumulation Rates in Deltaic Coastal Marshes and Their Importance to Landscape Stability [166]
12:00 - 1:30 p.m.	Lunch

SESSION IV: COASTAL DEPOSITIONAL SYSTEMS IN TEXAS, MISSISSIPPI, AND ALABAMA

Convenors: S. Jeffress Williams and John B. Anderson

1:30 - 1:50 p.m.	JACK L. KINDINGER, SHEA PENLAND, S. JEFFRESS WILLIAMS, JOHN R. SUTER, RANDOLPH A. McBRIDE, GREGG R. BROOKS and STAN LOCKER : Nearshore Holocene Stratigraphy, Northern Gulf of Mexico: Integration of Regional Geologic Studies [96]
1:50 - 2:10 p.m.	STEVEN J. PARKER and RICHARD L. HUMMELL : Holocene Stratigraphy of Mobile Bay, Alabama [177]
2:10 - 2:30 p.m.	RICHARD P. STUMPF and GUY GELFENBAUM: Fine-Sediment Transport in Mobile Bay, Alabama [256]
2:30 - 2:50 p.m.	MARK R. BYRNES, RANDOLPH A. McBRIDE, SHEA PENLAND, MATTESON W. HILAND and KAREN A. WESTPHAL: Historical Changes in Shoreline Position Along the Mississippi Sound Barrier Islands [43]
2:50 - 3:10 p.m.	RANDOLPH A. McBRIDE, MARK R. BYRNES, SHEA PENLAND, DAVID L. POPE and JACK L. KINDINGER: Geomorphic History, Geologic Framework, and Hard Mineral Resources of the Petit Bois Pass Area, Mississippi-Alabama [116]
3:10 - 3:40 p.m.	Coffee Break
3:40 - 4:00 p.m.	JOHN B. ANDERSON, FERNANDO P. SIRINGAN, WENDY C. SMYTH and MARK A. THOMAS: Episodic Nature of Holocene Sea Level Rise and the Evolution of Galveston Bay [8]
4:00 - 4:20 p.m.	WILLIAM A. WHITE and THOMAS R. CALNAN: Submergence of Vegetated Wetlands in Fluvial-Deltaic Areas, Texas Gulf Coast [278]
4:20 - 4:40 p.m.	DONALD K. STAUBLE, CHERYL E. BURKE and DOUGLAS R. LEVIN: Rapid Erosion of a Cohesive Shoreline, Sargent Beach, Texas [249]
4:40 - 5:00 p.m.	WILLIAM R. DUPRÉ, CLINT L. MARSHALL and CHRISTOPHER D. YOUNG: Seasonal Variations in Beach and Nearshore Morphology, Galveston-Freeport Area, Texas [83]

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SESSION V: ENVIRONMENTAL ISSUES

Convenors: Charles G. Groat and Denise Reed

8:00 - 8:30 a.m.	CHARLES G. GROAT and S. JEFFRESS WILLIAMS: Environmental Issues in the Gulf of Mexico: Stimulus for Research [91]
8:30 - 8:50 a.m.	LAWRENCE R. HANDLEY: Wetland Habitat Change in the Gulf of Mexico [92]
8:50 - 9:10 a.m.	DONALD W. DAVIS: The Mississippi Delta Plain's Levees, Crevasses, and Sediments [67]
9:10 - 9:30 a.m.	KAREN E. RAMSEY: Rates of Relative Sea Level Change in the Northern Gulf of Mexico [204]
9:30 - 10:00 a.m.	Break
10:00 - 10:20 a.m.	LOUIS D. BRITSCH and E. BURTON KEMP III: Land Loss Rates: Louisiana Coastal Plain [34]
10:20 - 10:40 a.m.	LYLE D. McGINNIS, DONALD O. JOHNSON, H. RONALD ISAACSON, R. ERIC ZIMMERMAN, SHEA PENLAND and PAUL F. CONNOR: Velocity Depression and Degasification Subsidence in Louisiana Wetlands [128]
10:40 - 11:00 a.m.	DONALD R. CAHOON: Management Implications of Sediment Dynamics in the Delta Marshes of Louisiana [56]
11:00 - 11:20 a.m.	KLAUS J. MEYER-ARENT: Human Impacts on Coastal and Estuarine Environments in Mississippi [141]
11:20 - 11:40 a.m.	ORRIN H. PILKEY and KATHIE DIXON: Beach Replenishment on Gulf of Mexico Shorelines [187]
11:40 - 12:00 p.m.	SHEA PENLAND and S. JEFFRESS WILLIAMS: Barrier Island Erosion Control Models Using Sediment and Vegetation [186]
12:00 Noon	Adjournment

ADDITIONAL PAPERS PRESENTED AS POSTERS

KENNETH C. ADBULAH and JOHN B. ANDERSON: Eustatic Controls on the Evolution of the Pleistocene Brazos-Colorado Deltas, Texas [1]

LOUIS R. BARTEK, JOHN B. ANDERSON and KENNETH C. ABDULAH: A Case Study of the Preservation Potential of the Coastal Lithosomes of Small Deltaic Systems: Examples from the Holocene of the Texas Continental Shelf [15]

D. G. BEBOUT, R.P. MAJOR, NOEL TAYLOR, P.M. HARRIS and CHARLES KERANS: Platform-Edge, Shallow-Marine, Ooid Grainstone Shoals, Joulters Cays, Bahamas: A Modern Analog of Carbonate Hydrocarbon Reservoirs [26]

GREGG R. BROOKS, JACK L. KINDINGER, SHEA PENLAND, S. JEFFRESS WILLIAMS, JOHN R. SUTER and RANDOLPH A. McBRIDE: Recent Geological Development of the Eastern Louisiana Continental Shelf [40]