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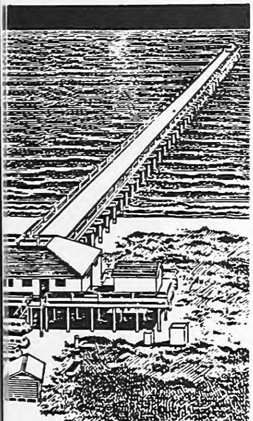

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MIGRATION OF ISLES DERNIERES: PAST AND FUTURE

by

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Isles Dernieres comprise a barrier island complex located in the southwestern portion of the Mississippi River deltaic plain. The islands formed from reworking of the Early Lafourche deltaic headland deposited from approximately 1,000-300 years B.P. Isles Dernieres have been experiencing a high rate of land loss due to wave attack and rapid subsidence, recently prompting local officials to consider ways of preventing any further deterioration of the coastline.

The migration of Isles Dernieres is controlled mainly by overwash, tidal currents, longshore drift, and subsidence. Using historic topographic maps, bathymetric surveys, and aerial photographs, quantitative values were placed on each of the factors influencing migration. By comparing the data pertaining to each of the four factors controlling migration, the trend of these factors through time was determined. The analysis indicates

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that Isles Dernieres are making the transition from a wave-dominated regime to one of mixed energy, probably resulting in future change in the observed pattern of migration and decreased rates of migration.

PREFACE

This report was prepared and published by the US Army Engineer Waterways Experiment Station (WES) with funds provided by the Office, Chief of Engineers (OCE), through the Barrier Island Sedimentation Studies Research Work Unit of the Shore Protection and Restoration research program.

Mr. Louis D. Britsch, Physical Scientist, prepared the report under direct supervision of Dr. Suzette M. Kimball, Principal Investigator, Barrier Island Study Unit, and under general supervision of Mr. H. Lee Butler, Chief, Research Division, and Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Chief and Assistant Chief, Coastal Engineering Research Center, respectively.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

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PART I: INTRODUCTION

1. Isles Dernieres are a group of islands located approximately 48 km south of Houma, Louisiana, in the southwestern part of the Mississippi River Deltaic Plain. The island complex is approximately 32 km long and has the characteristic arcuate shape and orientation of islands formed from the reworking of delta margins (Figure 1). Island widths are variable, ranging from 0.1 to 1 km. Isles Dernieres roughly parallel the mainland coast, acting as a valuable storm buffer cushioning the impact of wave attack on the Terrebonne Parish coastline. The islands also serve as habitat for many animals and as a base for commercial and recreational fishing.

2. The original island, Isle Dernieres, has been broken through in several places by channels resulting from overwash during storms, hence the

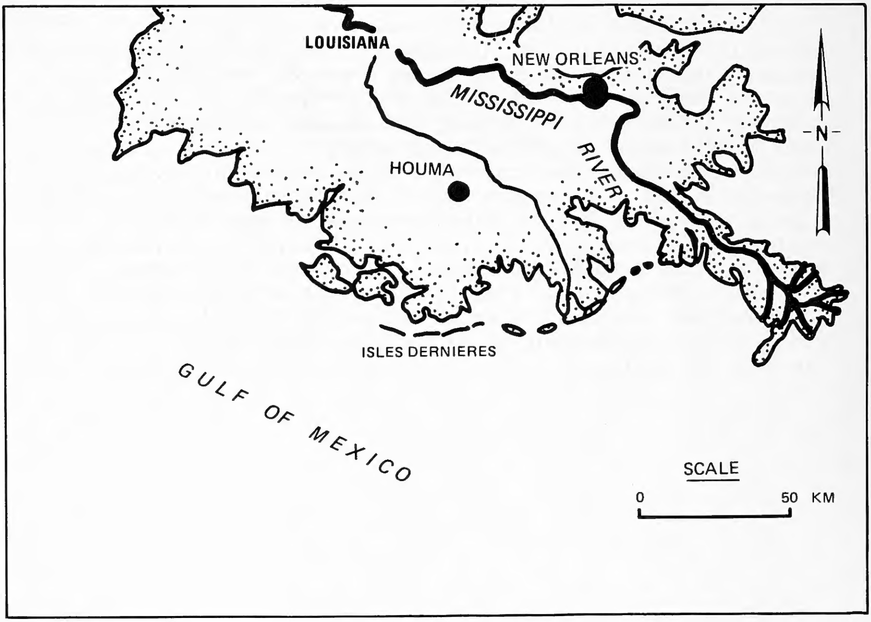

Figure 1. Generalized map of south Louisiana showing location of Isles Dernieres

pluralization of the name. The islands consist of marsh areas along most of the mainland side and sand beaches on the Gulf of Mexico side. These beaches average approximately 30 m in width and are rarely backed by dunes. Peyronnin (1962) and Penland and Suter (1983) have conducted extensive coring projects on Isles Dernieres and found that the beach-ridge deposits range from 1.8 to 6 m in thickness and are underlain predominantly by bay deposits (Figure 2). The backshore slopes down into low marshy areas or open water. A large bay (Lake Pelto) is situated between the mainland and Isles Dernieres. This bay has increased in size dramatically due to increased erosion and subsidence of the mainland marshes flanking the island (Figure 3).

3. The origin of Isles Dernieres is attributed to reworking of the abondoned Lafourche Delta and subsequent barrier spit accretion on both ends of the island. As the deltaic headland is attacked by waves, finer sediments are winnowed out and carried offshore while coarser sediments remain behind. These coarser sediments become reworked landward and laterally, creating a barrier beach. Mechanical analysis of the sediments revealed that the beaches

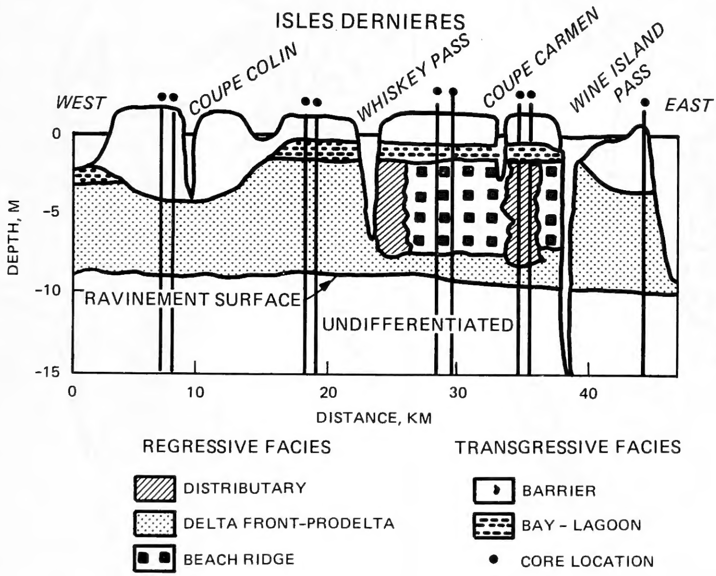

Figure 2. Stratigraphic strike section depicting the facies relationships through the Isles Dernieres (after Penland and Suter 1983)

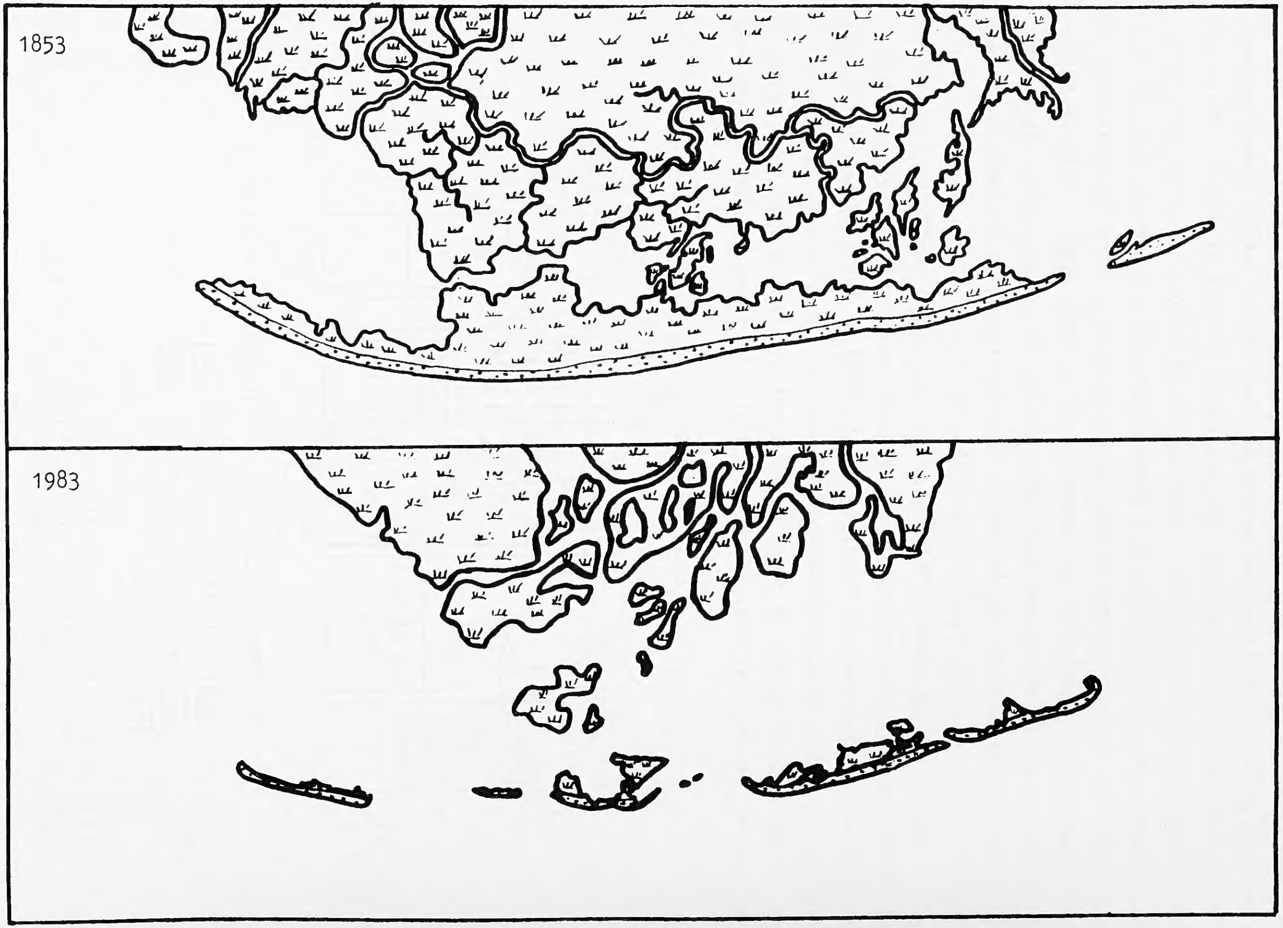

Figure 3. Historical shoreline changes in the Isles Dernieres barrier island arc between 1853 and 1983

are composed of well-rounded, well-sorted, fine-grained sand.

4. Because Isles Dernieres are so important to the residents of Terrebonne Parish as a protective front, their rapid decrease in size has become a major concern in recent years. Increased erosion, due to this size-decrease, is responsible for the destruction of commercial and residential property on the mainland as well as the loss of coastal wetlands. The land loss on Isles Dernieres has been well documented by Peyronnin (1962) and Meyer-Arendt and Wicker (1982), but the dispersal of the eroded material has not been studied in detail, especially as it relates to migration. This investigation analyzes trends in the factors controlling migration from 1887 until 1980 and any changes that may have occurred within those trends.

5. The migration of Isles Dernieres is controlled mainly by overwash, longshore drift, tidal inlet formation, and subsidence. Wind action plays a very minor role and therefore was not evaluated. The purpose of this study is to define the migration of Isles Dernieres since 1887 by quantitatively evaluating the various processes controlling migration and to document how these processes have changed through time. To accomplish this, recent and historic topographic maps and hydrographic charts were used to place quantitative values on the erosion and deposition related to each factor affecting the migration of Isles Dernieres. These values can be used to explain the evolution of the island group, speculate about its early history, and make some predictions about its future.

6. The Isles Dernieres belong to a small, well-defined unit known as the Mississippi River Deltaic Plain. The coast of Louisiana is fringed by a band of marshland 16 to 130 km in width. The western band of marsh is more narrow and is characterized by stranded beach ridges, or cheniers, surrounded by marsh. This area of the southwest Louisiana coast is known as the Chenier Plain. The eastern band of marshes contains gulfward-projecting natural levee ridges bordering active and abandoned courses of the Mississippi River. This eastern region, which spans almost 320 km of coastal Louisiana from Vermilion Bay to the Chandeleur Islands, comprises the deltaic plain of the Mississippi River (Figure 4). This plain encompasses the active and abandoned deltas of

Figure 4. Location map of the Mississippi River Deltaic Plain

the Mississippi River and forms a distinct physiographic unit bounded on the west by the Chenier Plain, on the east and south by the Gulf of Mexico, and on the north by a distinct contact with older, gulfward-dipping Pleistocene deposits (Kolb and Van Lopik 1966).

7. Progradation of the present and former Mississippi River deltas is responsible for creating the recent deltaic plain of southwestern Louisiana. Each time the Mississippi River has built a major delta lobe seaward, it has subsequently been abandoned in favor of a shorter more direct route to the sea. These course changes and accompanying shifts in centers of deposition have resulted in the distribution of deltaic sediments along the coast of southwest Louisiana. As soon as a delta lobe is abandoned, marine transgression caused by compaction of deltaic sediments begins.

8. The geologic history of Louisiana's deltaic plain has been determined from more than 30,000 borings and hundreds of radiocarbon age determinations. These data indicate that over the past several thousand years marked changes have occurred in the Louisiana coastline. The evolution of Isles Dernieres and similar delta-margin islands is closely related to these changes in coastline. Because the Mississippi River has changed its course so often in the last 8,000 years, the Louisiana coast offers an extremely dynamic area in which to observe the various aspects of coastal sedimentation. Important contributions to the understanding of the history of the Louisiana deltaic plain have been made by Fisk (1955), Fisk and McFarlan (1955), McFarlan (1961), Kolb and Van Lopik (1966), and Frazier (1967).

9. During the last glacial advance, the Late Wisconsin Stage, continental ice accumulation caused sea level to be lowered some 90 m below its present level (Dillon and Oldale 1978). As a result, the Louisiana shoreline was as far as 160 km south of its present position (Kolb and Van Lopik 1958.) Lowered sea level led to the entrenchment of gulfward-flowing streams and their tributaries into the newly exposed deposits of the Pleistocene Prairie Formation. The Prairie Formation is recognized in the subsurface by its erosional contact, its light-colored-oxidized surface resulting from subaerial exposure during lowered sea level and low water content. At that time, the ancestral Mississippi River trended southeasterly across the coastal area approximately 25 km west of Houma, Louisiana, and formed a valley approximately 16 to 40 km wide (Kolb and Van Lopik 1966).

10. Between 17,000 and 20,000 years B.P., sea level began to rise as a

result of glacial melting and regional subsidence of the coast (Kolb and Van Lopik 1966; Nummedal 1983). Streams alluviated their entrenched valleys to adjust to the rise in base level. When deposition could not keep pace with the rise in sea level, the sandy deltas were forced farther upvalley depositing estuarine-marine sediments over coarse basal fluvial sediments as the shoreline transgressed northward. As sea level continued to rise, both the quantity and grain size of detritus supplied to the streams decreased, and the site of sand deposition shifted rapidly upvalley leaving only fine sands, silts, and clays for deltaic deposition (Kolb and Van Lopik 1966).

11. Four to seven thousand years ago a standstill of sea level occurred at approximately the present level. The Mississippi River began building a series of lobate deltas in a gulfward direction displacing the gulf waters that had extended up the Mississippi River alluvial valley to the latitude of Baton Rouge, Louisiana (Kolb and Van Lopik 1966). The location of the Mississippi River and its associated deltas shifted frequently during this gulfward growth of land.

12. The Mississippi River Deltaic Plain is composed of various active and inactive deltaic complexes that extend 288 km across southwest Louisiana. Several major deltaic complexes, which formed during the last 8,000 years, have been identified in coastal Louisiana. These complexes reflect changes in the course of the Mississippi River in recent time. From oldest to youngest, the deltaic complexes are the Maringouin, Teche, St. Bernard, Lafourche, Plaquemines, and the present Balize (Figure 5). The relative ages of these complexes are well established, but the absolute ages are less accurate. Ages were derived from Carbon 14 data and archeological evidence.

13. The earliest deltaic lobes (the Maringouin and the Teche) were deposited mainly to the north and west of Isles Dernieres from approximately 8,000-3,500 years B.P. The Teche Delta complex once covered much of the area now occupied by Isles Dernieres, and it has been proposed that reworked deposits of this complex may be present in the sediments of Isles Dernieres (Peyronnin 1962). After progradation of the Teche system, the Mississippi River shifted far to the east and started building the St. Bernard Delta. The Chandeleur Islands are composed of reworked sediments of the St. Bernard Delta complex. Approximately 2,000 years B.P., the St. Bernard Delta was abandoned, and the Mississippi River was diverted westward where it started building the Lafourche Delta lobe. Frazier (1967), using data from 500 borings and

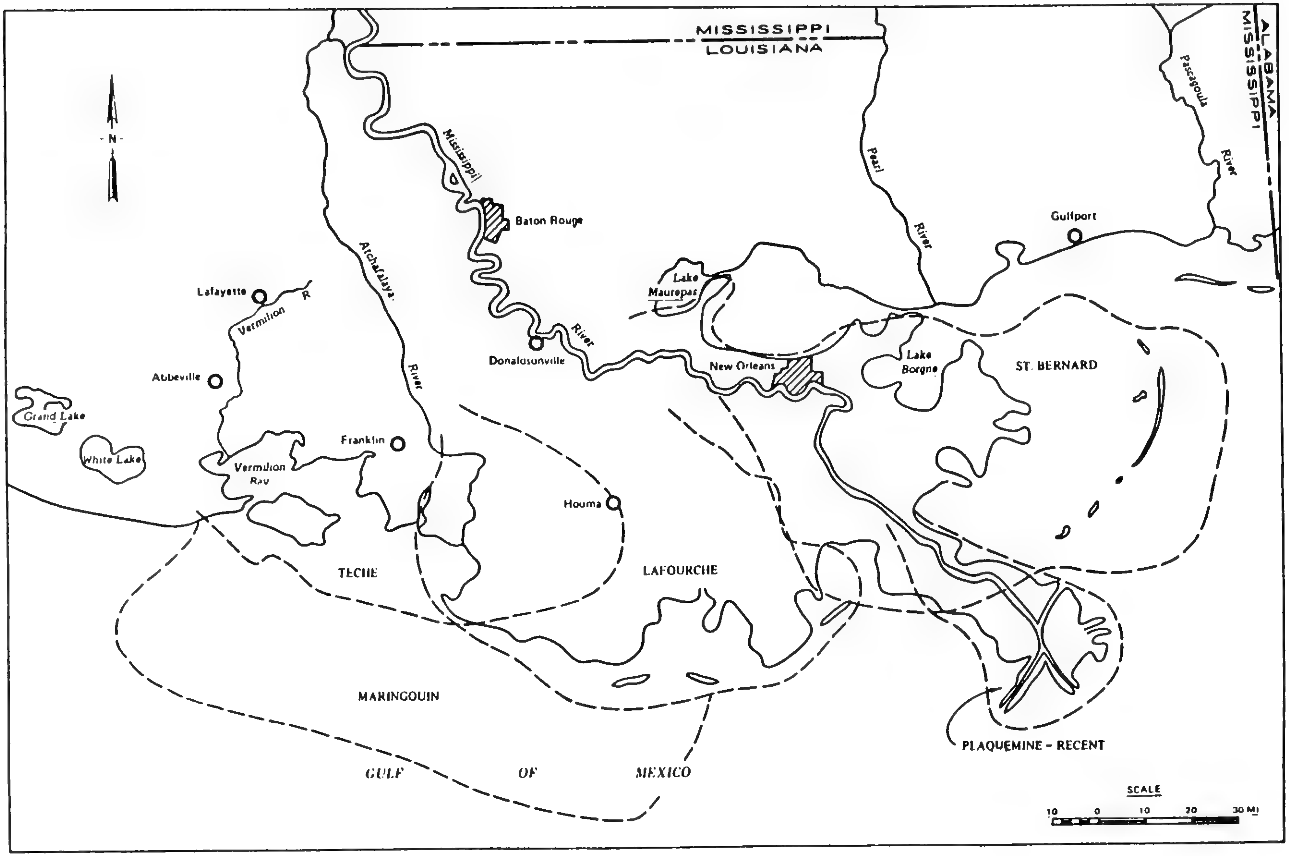

Figure 5. Recent deltaic lobes of the Mississippi River (after Smith, Britsch, and Dunbar 1985)

numerous radiocarbon dates, has divided the major deltaic lobes into 16 smaller units into which major flow of the Mississippi once occurred. The Lafourche Delta, whose reworked sediments comprise Isles Dernieres, has been subdivided into five smaller units by Frazier. Of these five units, the fourth one, which was active approximately 1,200-400 years B.P., is responsible for bringing most of the sediment to the Isles Dernieres area (Frazier 1967). This delta is the most extensive of the five and (like the other lobes) was deposited by several distributaries. When the Mississippi changed its course from the overly extended one of the Lafourche Delta in favor of a shorter, more direct route to the sea, it began construction of the Plaquemines lobe to the east. Wave action and subsidence became the dominant forces on the abandoned Lafourche Delta, and the gulfward margin was reworked landward. Isle Dernieres, an arcuate sandy beach consisting of reworked distributary front deposits, was formed as a result. Timbalier Island and Grand Isle, located to the east of the Isles Dernieres, are parts of another delta margin barrier complex formed from reworked sediments deposited by a slightly younger one of the five Lafourche deltas.

14. The Balize Delta of the present Mississippi is very different in size, shape, and distributary characteristics from the earlier complexes. These complexes had a roughly triangular outline, whereas the Balize Delta resembles a bird's foot. The earlier deltas had a much larger area than the modern Balize, which has an area of 768 km^2. The St. Bernard Delta comprised an area of 7,680 km^2, the Lafourche 5,888 km^2, and the Teche 5,120 km^2. The major distributaries of the ancient deltas were more numerous, deeper, and narrower, but the modern ones tend to be wide and shallow. The biggest difference in the Balize Delta, as compared with the ancient deltas, is a result of differences in the depth of water into which each prograded. The Balize has developed near the edge of the continental shelf in water originally reaching depths of greater than 90 m. Borings in the Lafourche and St. Bernard complexes indicate that progradation occurred in water ranging from 9 to 45 m deep (Kolb and Van Lopik 1966).

PART III: PREVIOUS WORK

15. The history of the Louisiana deltaic plain has been studied by Fisk (1955), Fisk and McFarlan (1955), Frazier (1967), McFarlan (1961), and Kolb and Van Lopik (1966). Through the use of borings and radiocarbon dating, they have been able to define the many units comprising the deltaic plain. From a review of their findings, it is apparent that the Mississippi River has changed its course several times over the past 8,000 years, and that the configuration and areal extent of the Louisiana coastline has been directly controlled by the flow of the Mississippi River. There has been some disagreement over the exact dates of the changes in the course of the Mississippi River, but most authors generally agree on a range of dates in which these changes have occurred.

16. The US Army Corps of Engineers has conducted several studies concerning erosion of Louisiana's barrier islands and ways to inhibit this erosion (Woodhouse 1978,1979; Knutson and Inskeep 1981). These studies, while providing valuable information, are done from an engineering standpoint and provide little geomorphological interpretation or prediction. Peyronnin directed a survey conducted in 1962 by the US Army Corps of Engineers that provided an historical review of Isles Dernieres, as well as some sedimentologic data. Several suggestions as to how erosion might be controlled were offered but never implemented.

17. Penland and Boyd (1981) have documented the severe erosion along the Louisiana coastline using digitization of individual island areas, as well as providing a model for deltaic barrier evolution. Penland and Boyd have discussed the importance of washover in the development of deltaic barriers on the Louisiana coast.

18. The Coastal Studies Institute at Louisiana State University is involved in ongoing research of Louisiana's barrier islands and beaches. Studies dealing with barrier islands of the Louisiana coast have examined shoreline erosion (Adams et al. 1978) and barrier island development (Kwon 1969). Coleman (1966, 1981) has described the sedimentation in and around the Mississippi Delta and the depositional environments related to this sedimentation.

19. Coastal Environments Incorporated, a private company in Baton Rouge, has done several studies for the Terrebonne Parish Police Jury. These

studies were concerned with the restoration potential of the Terrebonne Parish barrier islands. At the present time several of these proposed projects are being initiated (Meyer-Arendt and Wicker 1982).

20. Models for the development of barrier islands have been proposed by Hoyt (1967, 1970), Fisher (1968), and Otvos (1970). Using characteristics of the barriers of the Atlantic as typified by those of the Georgia coast, Hoyt (1967) proposed that barrier islands are initiated when wind or water-deposited sediments are built into a ridge immediately landward of the shoreline. Slow submergence, as during the late Holocene, floods the area behind the ridge producing the barrier island (Hoyt 1970).

21. Fisher (1968) proposes that barrier islands form as complex chains of spits on a shoreline of submergence. This hypothesis has some merit because we see spit growth occurring today, but it probably is not the major cause of barrier island development. Otvos (1970) proposed that barrier islands form by the upward aggradation of submerged shoals. Recent studies by Schwartz (1973) and Swift (1975) have also focused on barrier island origin and development, but these works have generally reiterated the earlier views presented by Hoyt, Fisher, and Otvos. Field and Duane (1976) have presented an alternative model for the origin of barrier islands. They propose that a barrier coast is one that alternately erodes and progrades, but ultimately retreats in concert with a fluctuating (but steadily rising) Holocene sea. The shape and nature of both the surface and subsurface deposits of the inner shelf, orientation of shelf features, and association of continental shelf shoals with capes, inlets, and barrier spits on the east coast support the observation that barriers may originate on the shelf and retreat landward. The controversy over the origin of barrier islands remains largely unresolved, because most of the evidence pertaining to their origin has usually been destroyed by subsequent reworking. Most authors generally agree that barrier islands can be formed by several processes.

22. Isles Dernieres have been called barrier islands by previous authors, but it should be understood that the use of the term "barrier island" does not imply an origin similar to that of barrier islands found along other coasts. Although the processes controlling the migration of Isles Dernieres are similar to those proposed as causes for the origin of other barrier islands, these processes cannot be used to explain the origin of Isles Dernieres. The origin of Isles Dernieres has been best described by an evolutionary model

for deltaic barrier development proposed by Penland and Boyd (1981). This model suggests that there is an orderly sequence of events that takes place during the evolution of deltaic barrier islands, and the island's position within this sequence can be used to describe its history (Figure 6). The evolutionary sequence begins with an erosional headland whose sediments are deltaic in nature. Subsequent spit accretion on the flanks of this headland and detachment of the reworked headland from the mainland, due to subsidence, produces the barrier island.

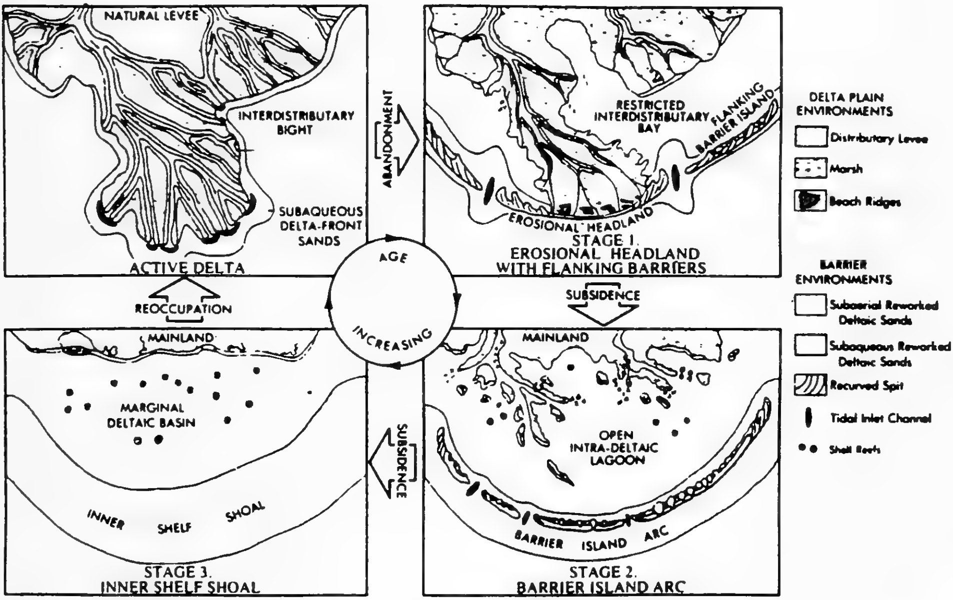

Figure 6. A three-stage model depicting the evolution of a barrier shoreline along abandoned Mississippi River deltas (after Penland and Boyd 1981)

PART IV: METHODS OF INVESTIGATION

23. In order to quantify the amount of beach erosion as measured from historic maps, a technique developed by the US Army Coastal Engineering Research Center (1973) was used. This technique recognizes that changes in area of beach can be used to estimate the volume of sediment eroded, if the average berm height and the offshore depth limit of effective wave base are considered. This same relationship was used to calculate the amount of material deposited in the back-barrier area by estimating the depth limit of sand penetration from historic hydrographic charts (Appendix A). Where marsh was present the marsh elevation was used as the depth limit. This relationship can be expressed as:

$$\Delta V = \Delta A(a - b)$$

where

ΔV = volume of sediment gained or lost

ΔA = change in area of beach or back barrier

a = average berm height

b = offshore (or bay depth) beyond which natural changes of sand bottom are insignificant

24. For Isles Dernieres, the values of a were variable along the islands' length, ranging from 0.36 to 0.59 m. The value of b for the offshore was determined to be 3.65 m by the US Army Corps of Engineers (1973) and was variable on the bayside. Using the values chosen for each time interval, a constant can be calculated using the above relationship for each period.

Example: Where a = 0.61 m and b = 3.65 m

$$\frac{\Delta V}{\Delta A} = \text{constant} = \frac{1\text{m}^3}{1\text{m}^3}\,[+0.61\text{ m} - (-3.65\text{ m})] = 4.26\,\frac{\text{m}^3}{\text{m}^2}$$

25. Therefore, for each square meter of beach change on Isles Dernieres, using these constants, 4.26 m^3 of sediment is lost or gained. Using this method, the value for square feet of beach surface gained or lost can be converted into cubic metres of sediment gained or lost.

26. The Ott Compensating Planimeter was used to calculate the area of sediment eroded and deposited during the intervals for which historic data

were available (1887-1906, 1906-1935, 1935-1953, and 1953-1980). The principal advantage in using this instrument is the ability to check the accuracy of every tracing by a compensating measurement, and of rectifying the result--if necessary. Before any measurements were taken, the scales of the topographic maps were adjusted to 1:24,000, and the maps were overlaid using latitude and longitude coordinates. Areas of beach front erosion were determined by tracing the change in beach front position from one map to the next. Similarly, the areas of deposition were determined by tracing the figure (representing the addition of material behind, as well as at the ends) of the island. This method will be used in the following sections to calculate the amount of sediment eroded, or deposited by overwash and longshore drift, on this delta-margin island.

27. Certain limitations are inherent in the data set and they should be noted at the outset. The US Geological Survey standard for horizontal accuracy states that at least 90 percent of the well-defined map points shall be plotted correctly within one-fiftieth of an inch on the published map. Any inaccuracies in the plotting will lead to small errors in the area calculations. Secondly, due to the lack of elevation data for Isles Dernieres prior to 1980, all constants used in the calculations for the pre-1980 intervals had to be estimated using the known data. In the case of inaccuracies in the quadrangles, the shoreline change is so great that the error involved is rather insignificant when looking at trends. Isles Dernieres have been an erosional headland for the entire study period, having the same sediment sources and wave climate so that estimation of variables for the period prior to 1980, while not desirable, provides acceptable values. When looked at in the context for which they are intended (to define the trends of processes controlling migration), the quantitative estimates of erosion and deposition made using the variables are very useful and yield results which are substantiated by geomorphic changes in the barrier complex.

PART V: PROCESSES CONTROLLING MIGRATION

Overwash

28. A washover occurs when sand, eroded from the beach and coastal dunes by overwash, is deposited on the backside of a barrier beach. The most important washover deposits are generated by hurricanes that strike the Louisiana Gulf Coast an average of once every 2.9 years (Neuman 1978). Hurricanes can elevate sea level up to 4 m for a period of 2 to 5 hr as a result of wind and low barometric pressure. A core taken in a known washover deposit on Isles Dernieres shows that these deposits are thin (less than 1 m) and are underlain by bay deposits. The main result of storm-generated overwash is the migration of Isles Dernieres landward. From 1887 to 1980, Isles Dernieres have migrated approximately 1.9 km landward due, primarily, to overwash processes. Figure 7 illustrates the landward migration of Isles Dernieres from 1887 to 1980. Note the location of Ship Shoal offshore of Isles Dernieres. Wind action plays a small role in the movement of sediment landward, as demonstrated by minor dune deposits. Compared to the process of overwash, however, it is insignificant and was not considered in this investigation.

29. Another important result of overwash is the formation of tidal inlets. Tidal inlets on Isles Dernieres most likely form as a result of ebb storm tides overtopping the beach ridge from the bayside (Pierce 1970). The absence of tidal flats behind Isles Dernieres aids inlet formation, because tidal flats limit the ability of storm tides to retreat through areas of low elevation on the barrier, thus creating new inlets.

30. To better understand the role overwash plays in the migration of Isles Dernieres, the following procedure was observed. Using overlays of topographic maps from the years 1887, 1906, 1935, 1953, and 1980, the total amount of frontal beach erosion and the total amount of backshore deposition was estimated for each interval using the planimeter (as described previously). By comparing the amount of sediment eroded versus the amount redeposited, a trend for washover deposition was determined. Table 1A lists the values for total erosion and total washover deposition for each time period.

31. From these data it is clear that the percentage of eroded sediment that was deposited by overwash has decreased with time. To further evaluate the role of overwash deposition in the migration of Isles Dernieres, the data

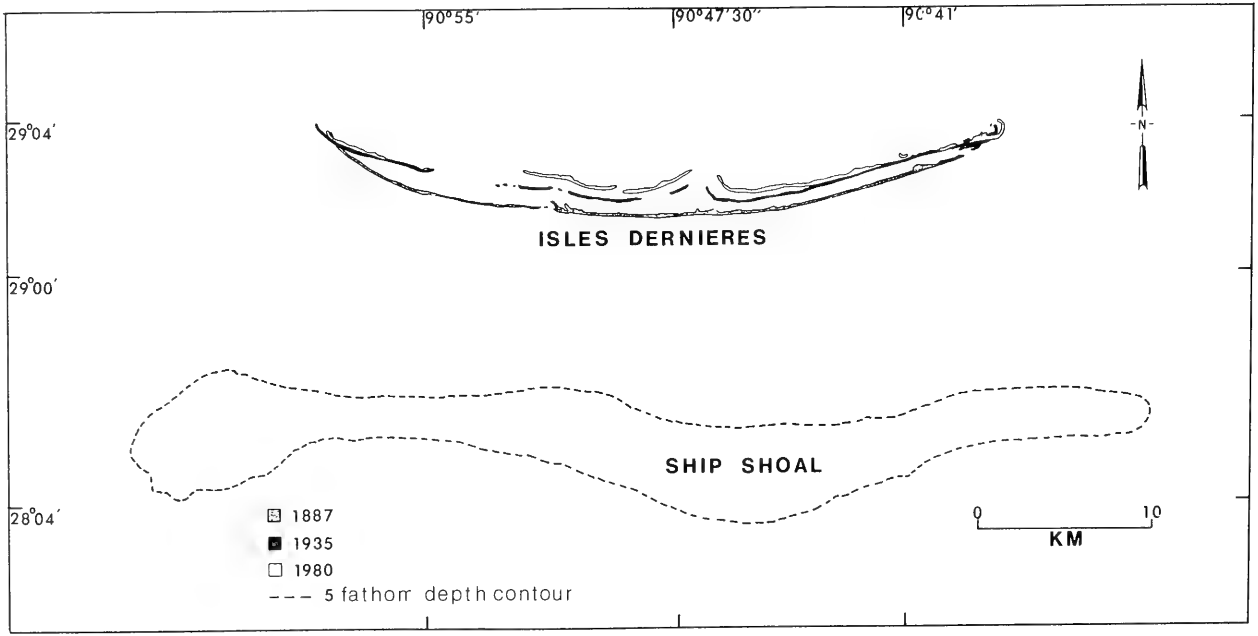

Figure 7. Landward migration of Isles Dernieres from 1887 to 1980

Table 1

Comparison of Total Erosion with Amount Redeposited by Overwash

A.

Time Interval	Total Amount of Eroded Sediment 10^6 m^3	Amount of Eroded Sediment Deposited by Overwash 10^6 m^3	Percent of Eroded Sediment Redeposited as Overwash
1887-1935	82.1	71.4	87
1935-1953	16.1	13.3	83
1953-1980	19.3	14.7	76

B.

	Amount of Sediment Eroded Annually 10^6 m^3	Amount of Eroded Sediment Deposited by Overwash Annually 10^6 m^3
1887-1935	1.71	1.49
1935-1953	0.89	0.74
1953-1980	0.71	0.54

in Table 1A were expressed as annual rates of erosion and deposition for each time interval. Table 1B shows that the annual rate of sediment eroded has decreased by 57 percent since 1887, and the annual rate of overwash deposition has decreased by a slightly larger amount of 67 percent in the same period. These figures reveal that there has been a change in overwash deposition, but its relationship (percent) to the total amount eroded has stayed approximately the same. This small change in overwash deposition results in a decrease in the relative importance of overwash with time, because the rates of other processes involved in island migration have changed significantly--relative to the change in overwash. The decrease in overwash importance is also reflected in the overall decrease in the rate of landward migration through time. In the central Isles Dernieres area, the rate of migration has decreased from 27 m/year between 1887 and 1906 to 17 m/year in the last 27 years. Several factors probably contribute to this decrease in landward migration:

a. There has been a large increase in the number of tidal inlets, i.e., from no tidal inlets in 1853 to three in 1980. Tidal inlets decrease the surge on the barrier front from overwash by allowing water to channel between (instead of over) the island, hence inhibiting landward migration.

b. A channel approximately 2.5 m deep has formed behind Isles Dernieres as a result of increased tidal exchange. This channel is capable of removing sediment from the bayside of the islands, hence decreasing the rate of landward migration.

c. The tidal currents behind Isles Dernieres allow removal of washover sediments from the bay to the tidal inlets. From there, strong ebb currents, especially those produced during storms, are capable of carrying sediments to depths too great to be returned by normal wave activity (greater than 3.7 m).

Subsidence

32. Much of the shoreline recession on Isles Dernieres can be attributed to subsidence. Some of the factors causing subsidence on Isles Dernieres include sea level rise, compaction, geologic downwarping, and extraction of hydrocarbons from subsurface strata (Meyer-Arendt and Wicker 1982). Although no absolute value for subsidence on Isles Dernieres has been determined, an approximate value of 1.2 m/100 years has been derived for this area of the Gulf Coast using tide gage data (Baumann 1980). Of this 1.2 m/100 years, only 0.12 m/100 years is related to eustatic sea level rise (Nummedal 1983). Subsidence exposes previously subaerial sediments to wave and current action while lowering the height of the island above sea level, making the island more susceptible to overwash. As relative sea level rises due to subsidence, Isles Dernieres are forced to retreat landward (Figure 8).

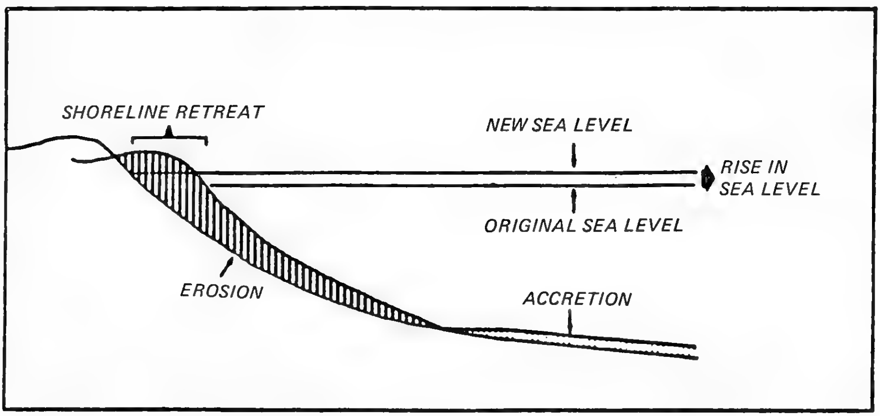

Figure 8. Shoreline response to relative sea level rise (after Bruun 1962)

33. Bruun (1962) has developed a mathematical relationship between relative sea level rise and shoreline recession:

$$\text{Shoreline recession} = \frac{(a)(b)}{(h + d)}$$

where

a = relative change in sea level

b = distance from shore to 18-m depth contour which represents the limit between nearshore and deep sea littoral drift phenomena

h = dune height

d = distance beyond which little sediment turbulence takes place (Meyer-Arendt and Wicker 1982)

Using a relative change in sea level of 1.2 m/100 years, the amount of shoreline recession resulting from relative sea level rise for Isles Dernieres can be calculated as follows:

$$\text{Shoreline recession} = \frac{1.2\ \text{m/century}\ (2{,}400\ \text{m})}{(0.9\ \text{m} + 3.7\ \text{m})} = 626\ \text{m/century}$$

The value of 18 m (which represents the limit between nearshore and deep sea littoral drift phenomena) was determined by Bruun (1962) by averaging data obtained along the Atlantic, Pacific, and Gulf Coasts. From this calculation, we find that subsidence accounts for 626 m/100 years (or approximately 6.26 m/year) of shoreline recession on Isles Dernieres. The value of 6.26 m/year accounted for 24 percent of the total recession for the central Isles Dernieres during the 1887 to 1906 time interval. Since that time, island migration due to overwash and longshore drift has decreased making the impact of subsidence much more significant. For the 1953 to 1980 time interval, the value of 6.26 m/year accounted for 36 percent of the total landward retreat for the central Isles Dernieres.

Longshore Drift

34. The growth of spits was used as a measure to document the effectiveness of longshore drift in controlling migration. On Isles Dernieres, spits are found on both ends of the island group as a result of longshore transport and tidal exchange forces. Because of its orientation perpendicular to the dominant south and southeast winds, the Isles Dernieres group has

experienced high rates of erosion at its central-most point. Longshore drift has been westward on the western part of the island and eastward on the eastern end of the island (Peyronnin 1962). Similar transport patterns have been documented by Penland and Boyd (1981) on the Timbalier Islands--Caminada/Moreau Coast--Grand Isle complex, and the Chandeleur Islands. Figure 9 illustrates the orientation of Isles Dernieres and the directions of longshore transport. The main source of sediment for spit growth is from the rapidly eroding central portion of Isles Dernieres and exposed distributary sediments. Beach-front erosion rates of up to 26 m/year have been calculated for this area. Much of the sediment potentially available for spit growth never reaches the location of spit deposition. Rather, it is removed from the shoreface by tidal currents at the inlets to a depth below effective wave base. But, enough sediment is carried along a series of offshore bars to provide for some spit growth (Meyer-Arendt and Wicker 1982). The eastern spit is highly recurved indicating that strong tidal exchange forces are present. This spit has been kept relatively stable by Wine Island Pass, which is approximately 18 m deep and is directly adjacent to the spit (Figure 10). On the western end of the island an elongated spit has accreted, but, recently, it has started to retreat, presumably due to a decrease in sediment supply (Figure 11). Although sediment is being supplied to the western end of Isles Dernieres, it is not enough to overcome the effects of tidal current erosion

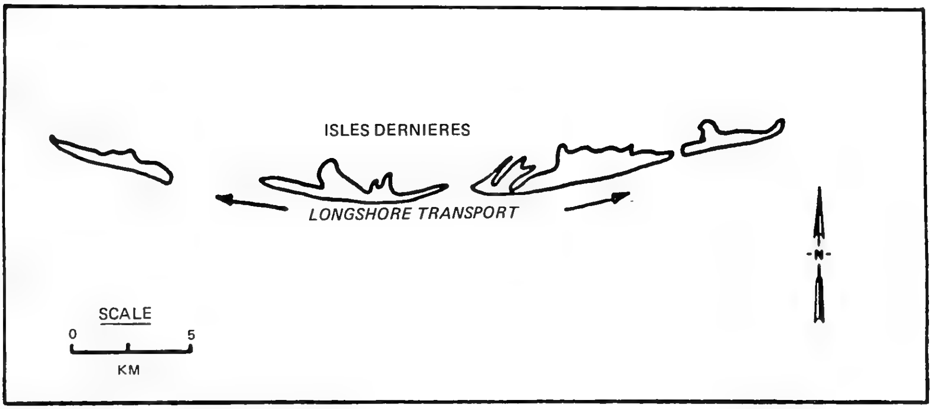

Figure 9. Sketch of Isles Dernieres showing the islands' orientation and directions of longshore transport

Figure 10. Recurved spit at the eastern end of Isles Dernieres

Figure 11. Elongated spit at the western end of Isles Dernieres

and subsidence and build a subaerial deposit. Enough sdeiment is available offshore so thtat increased wave energy could possibly build this material above sea level in the future.

35. By determining the total amount of sediment added or subtracted to the eastern and western spits (using the planimeter), the importance of longshore drift to the migration of Isles Dernieres can be ascertained (Table 2A). From comparison of the values found for the percentage of sediment deposited by longshore drift at the spits, it is apparent that through time a decreasing amount of sediment was able to bypass the tidal inlets and be deposited at the spits. The annual rates of erosion and deposition for each time interval (Table 2B) show that sediment erosion and spit deposition has decreased since 1887 (from 57 to 93 percent, respectively). These figures, like those calculated for overwash, demonstrate that the role longshore drift plays in island migration has decreased significantly in the past 93 years (1887-1980) relative to the other processes. The decrease in longshore drift as an effective factor in island migration is probably directly related to the increase in the effect of tidal inlets. As the inlets increase in number, widen, and especially deepen the amount of sediment able to bypass the inlet channel will

Table 2

Comparison of Total Erosion with Amount Deposited at Spits

A.

Time Interval	Total Amount of Eroded Sediment 10^6 m^3	Amount of Eroded Sediment Deposited at Spits 10^6 m^3	Percent of Total Deposited at Spits
1887-1935	82.1	1.64	2
1935-1953	16.1	0.16	1
1953-1980	19.3	0.08	0.4

B.

	Amount of Sediment Eroded Annually 10^6 m^3	Annual Amount of Sediment Deposited at Spits 10^6 m^3
1887-1935	1.71	0.03
1935-1953	0.89	0.009
1953-1980	0.71	0.003

decrease and more sediment will be lost to the tidal deltas associated with these inlets. Another factor adding to the decrease in longshore transport is straightening of the coastline. In 1887, the curvature of Isles Dernieres was greater and erosion was concentrated at the central-most point. As the island migrates landward the curvature decreases and the concentration of erosion at the central area diminishes, resulting in a decrease of sediment available for longshore transport. Straightening of the coast reduces the angle of wave impact causing waves to strike the shoreline more directly, thus reducing the strength of the current parallel to the shore and as a result decreasing longshore drift.

Tidal Inlets

36. Tidal inlets are channels between two adjacent barrier beaches connecting the open ocean to the lagoon or bay area located behind the barrier (Price 1962). On the Gulf Coast the term "tide" is used to describe the twice-daily astronomical tides as well as sea-level change associated with storms. The average range of astronomical tides for the Isles Dernieres is 0.4 m. Storm tides up to 7 m have been documented on the Gulf Coast (Hayes 1978). Tidal inlets on Isles Dernieres are most likely a result of ebb storm tides overtopping the beach ridge from the bayside because the barrier is narrow and no extensive tidal flats are present on the bayside of the island (Pierce 1970). Once an inlet is formed by storm tides, the normal astronomical tides are able to maintain and enlarge the inlet channel. The theory of inlet formation proposed by Pierce is supported by Coupe Carmen, a tidal inlet on the eastern end of Isles Dernieres. In 1974, Hurricane Carmen struck the Louisiana coastline and produced this inlet. Since that time the inlet has deepened and migrated westward due to tidal exchange and longshore transport. Once the tidal inlets on Isles Dernieres have been formed, they rarely fill back in with time; instead, they become wider and deeper. The main reason for their enlargement seems to be the drastic increase in the volume of water stored behind the island. The bay behind Isles Dernieres was approximately 2.4 km wide in 1853 and is now over 8 km wide and much deeper. As the volume of water increases, the tidal flux, as compared to wave energy, becomes much more significant in controlling island migration. The increase in tidal exchange has also caused the development of a channel which runs behind Isles

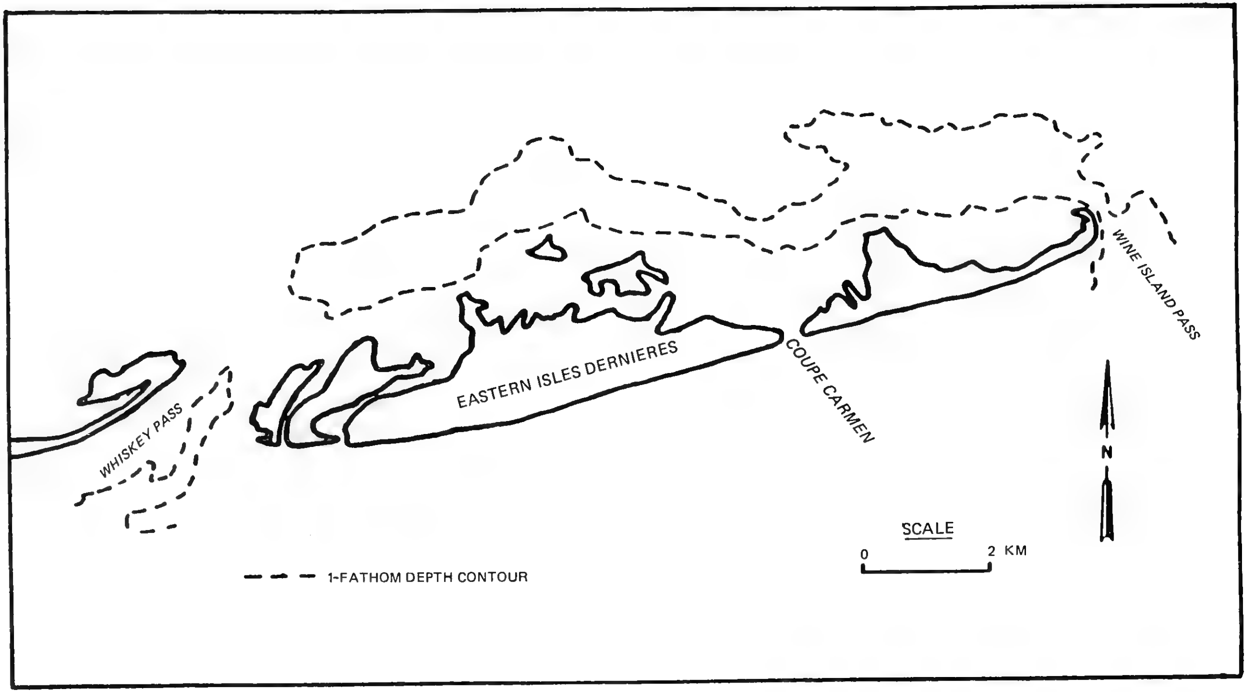

Figure 12. Location of channel behind Isles Dernieres as seen from hydrographic data

Dernieres from Wine Island Pass to Whiskey Pass. Figure 12 depicts this tidal channel as seen from hydrographic data. The channel limits effective landward migration of the barrier and contributes to the net loss of sediment by tidal flux.

37. The Isles Dernieres represent a once continuous island which has been fragmented into four smaller islands separated by tidal inlets (Figure 13). These inlets include from west to east--Coupe Colin, Whiskey Pass, Coupe Carmen, and Wine Island Pass, a tidal inlet separating eastern Isles Dernieres from the once subaerial Wine Island (earlier known as Vine Island). There is

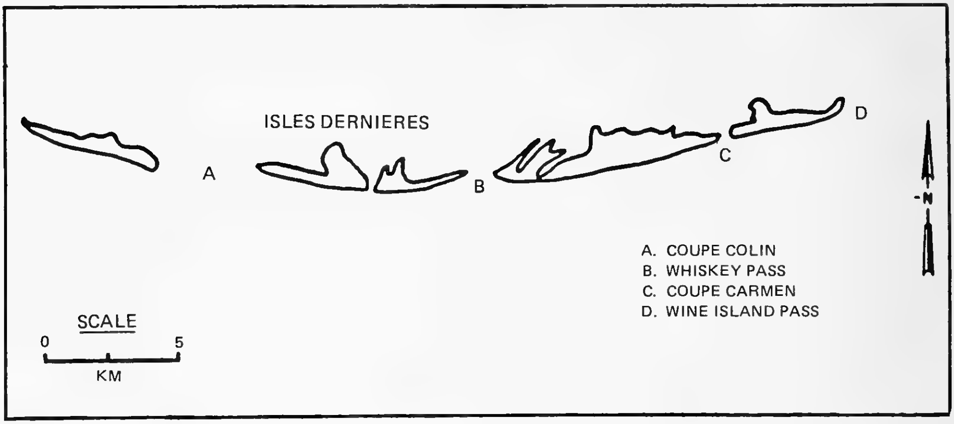

Figure 13. Sketch of Isles Dernieres showing location of tidal inlets

also a cut through the central Isles Dernieres which may represent an incipient inlet. These inlets are 300-1,200 m wide and range between 6 and 18 m deep. Ebb tidal deltas associated with these four tidal inlets are the principal sediment sinks for sand lost from the Isles Dernieres area (Penland and Suter 1983). Hurricanes are responsible for producing the strongest ebb currents, which are capable of transporting sediment from the bay to the ebb tidal deltas and beyond. Ebb currents produced during storms probably serve as the major mechanism by which sediment can be transported from the ebb tidal deltas to the shelf area and below effective wave depth. Therefore, hurricanes play an extremely important role in the removal of sediment from the Isles Dernieres, and as the number of tidal inlets increase so will the effect of hurricanes. To obtain values for the amount of sediment lost to the tidal deltas and the shallow shelf area, the following equation was used.

$$V_L = V_E - V_D$$

where

V_L = volume of sediment lost

V_E = volume of eroded sediment

V_D = volume of sediment deposited

38. The volumes of net sediment lost from Isles Dernieres are presented in Table 3A. These values demonstrate that the percentage of eroded sediment increased from 11 percent (between 1887 and 1935) to 24 percent (between 1953 and 1980)--reflecting an increase in the effects of tides on the migration of Isles Dernieres. The annual rates of erosion and sediment loss, shown in Table 3B, further support the data presented in Table 3A. The amount of eroded sediment lost from Isles Dernieres has remained about the same, but the amount of erosion has been greatly reduced. Thus, the importance of sediment lost by tidal activity has proportionately increased. This trend directly correlates with the evolution of tidal inlets on Isles Dernieres. In 1853, there were no tidal inlets over the entire length of Isles Dernieres; by 1980, there were three. Because these inlets are continuing to widen and deepen, it can be expected that an ever-increasing amount of sediment will be lost in the future.

39. By combining the data for the annual rates of eroded sediment redeposited by each of the three processes on a graph, the relative importance of these factors with respect to island migration can be illustrated (Figure 14).

Table 3

Comparison of Total Erosion to Amount of Sediment Lost

A.

Time Interval	Total Amount of Eroded Sediment 10^6 m^3	Amount of Eroded Sediment Lost From Isles Dernieres 10^6 m^3	Percentage of Total Lost from Isles Dernieres
1887-1935	82.1	9.1	11
1935-1953	16.1	2.6	16
1953-1980	19.3	4.5	23

B.

	Amount of Sediment Eroded Annually 10^6 m^3	Amount of Eroded Sediment Lost Annually 10^6 m^3
1887-1935	1.71	0.19
1935-1953	0.89	0.14
1953-1980	0.71	0.17

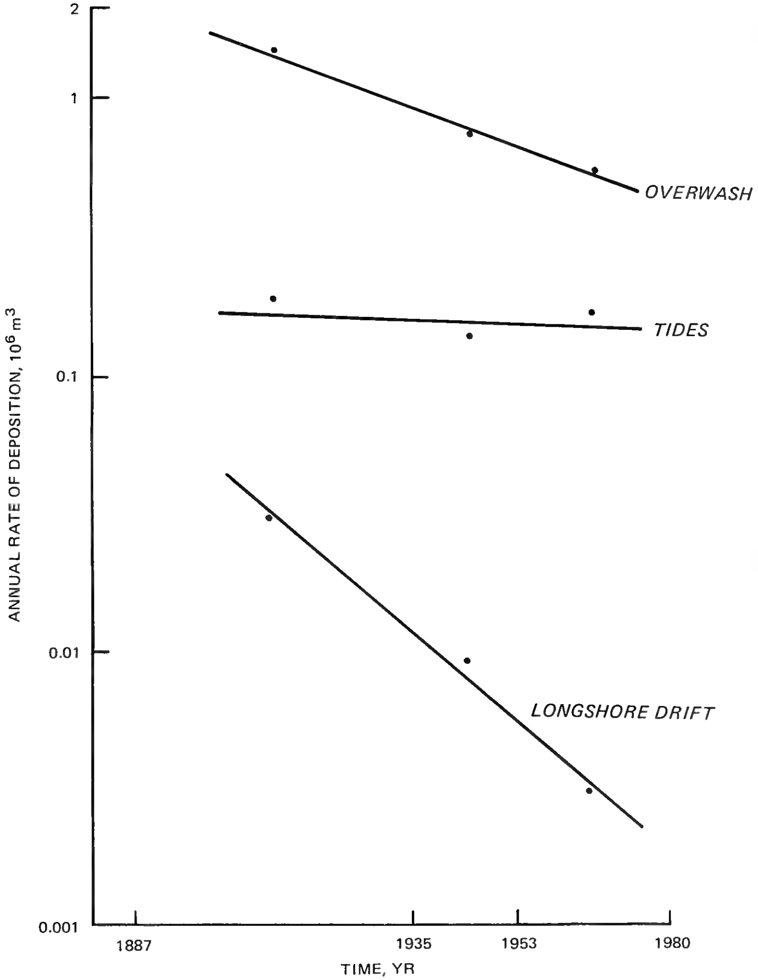

Figure 14. A schematic graph illustrating relationships of processes with respect to annual rates of sediment deposited

This graph shows that the rate of change of overwash and longshore drift from 1887 to 1980 has decreased steadily, but loss due to tidal inlets has remained relatively constant with time. This comparison reflects the change from a wave-dominated regime to one of greater tidal influence.

PART VI: EVALUATION OF MIGRATION FROM 1853 TO 1980

40. The migration of Isles Dernieres is controlled mainly by overwash, longshore drift, tidal currents, and subsidence. Any change in one factor will ultimately affect the relative importance of the other three. By placing quantitative values on the processes affecting migration, the significance of these changes was determined. From the data presented in previous sections, the following conclusions are made:

- a. The Isles Dernieres are making the transition from a wave-dominated regime to that of a mixed-energy regime. This shift is evidenced by change in island morphology and the relative change in the processes controlling migration. In a wave-dominated regime the barriers are long, continuous (having few tidal inlets), and have a predominance of washover deposition. In 1853, the morphology of Isle Derniere was typical of barriers found in a wave-dominated regime. The island was not broken by tidal inlets along its entire length and wash-over deposition was the dominant process. In a mixed-energy regime the barriers are broken by several tidal inlets, wash-over deposition is of decreasing importance, and ebb tidal deltas are formed. In 1980, Isles Dernieres fit the description of a barrier in a mixed-energy regime. By 1980 Isles Dernieres were broken by three tidal inlets, washover deposition had decreased significantly, and ebb tidal deltas had formed at all tidal inlets indicating an increase in tidal influence on island morphology.
- b. Migration of Isles Dernieres has been slowed due to a decrease in washover deposition and longshore transport, and a corresponding increase in the number of tidal inlets.
- c. Overwash and resulting washover deposition is the principal cause of landward migration. Longshore transport controls the lateral growth of Isles Dernieres. Sediment transported by both astronomical and storm tides tends to be removed from the system decreasing the sediment available for overwash and longshore drift. By decreasing the migration of Isles Dernieres, the effects of subsidence have begun to play a more important role in the evolution of this island.
- d. Isles Dernieres are in a mature stage of delta barrier island development.

PART VII: FUTURE PROSPECTS FOR ISLES DERNIERES

41. In order to predict the future migration of Isles Dernieres, past migration must first be documented. To measure historic island migration, topographic maps from the years 1887, 1906, 1935, 1953, and 1980 were obtained. Before any measurements were taken, the scales of the maps were adjusted to 1:24,000 and the maps were overlaid by aligning selected points of latitude and longitude. The change in beach front position could then be measured directly from the maps. Three points of longitude were selected, along which landward migration was to be measured (90°41', 90°47'30", 90°55'). Eastward and westward accretion of the terminal spits was measured directly from the overlays. The values for island migration are found in Table 4.

Table 4

Landward and Lateral Migration of Isles Dernieres

90°41'	90°47'30"	90°55'
	Landward Migration	
1887-1906 = 318 m	1887-1906 = 480 m	1887-1935 = 942 m
1906-1935 = 360 m	1906-1935 = 630 m	1935-1953 = 30 m
1935-1953 = 60 m	1935-1953 = 330 m	1953-1980 = 162 m
1953-1980 = 180 m	1953-1980 = 450 m	
	Lateral Migration	
Eastern Spit		Western Spit
1887-1906 = 690 m		1887-1935 = 660 m
1906-1935 = 180 m		1935-1953 = -120 m
1935-1953 = 72 m		1953-1980 = -210 m
1953-1980 = 150 m		

42. Using the time interval and the migration within that interval the least squares regression formula was used to find a value for future migration (Y) as a linear function of X ($Y = m X + B$)

where

$$m = n\Sigma(x_i y_i) - \frac{\Sigma x_i y_i}{n\Sigma(x_i)^2} - (\Sigma x_i)^2$$

and

$$b = \frac{\Sigma y_i \Sigma x_i^2 - x\Sigma x_i y_i}{n\Sigma(x_i)^2 - (\Sigma x_i)^2}$$

These formulas enabled the extrapolation of the known migration to a point 100 years into the future (Table 5) to gain some insight into the future migration and orientation of Isles Dernieres (Figure 14). The area of the island was also reduced in accordance with previous rates of area loss calculated from topographic maps.

Table 5

Projected Migration of Isles Dernieres

Location	Migration for Past 93 Years (from formula), m	Projected Migration for Next 100 Years (from formula), m
90°41'	994	911
90°47'30"	1,955	1,909
90°55'	1,274	1,167
Eastern Spit	1,210	967
Western Spit	-212	-600

43. Figure 14 represents the best mathematical fit based on the limited data available from historical maps. The data derived in this investigation pertaining to individual processes controlling migration suggest that some modification of this extrapolation may be necessary. For example, tidal influx will probably increase considerably due to widening and deepening of the present channels and possible creation of new channels. The decrease in the importance of washover deposition and longshore drift relative to that of tidal activity will have the effect of restricting landward and lateral migration. By restricting the ability of the island to migrate, the effects of subsidence will be accelerated, causing sediments to sink below wave base and to be lost from the island. These trends will likely increase with time and Isles Dernieres will migrate much less in the future than it has since 1887. By reducing the effect of overwash and longshore drift on sediment transport and considering the limitations imposed by tidal channels and subsidence, Isles Dernieres will ultimately become a shoal. Therefore, the Isles Dernieres in the year 2080 (presented in Figure 15) may represent too large an area when considering the trend of the processes controlling island migration.

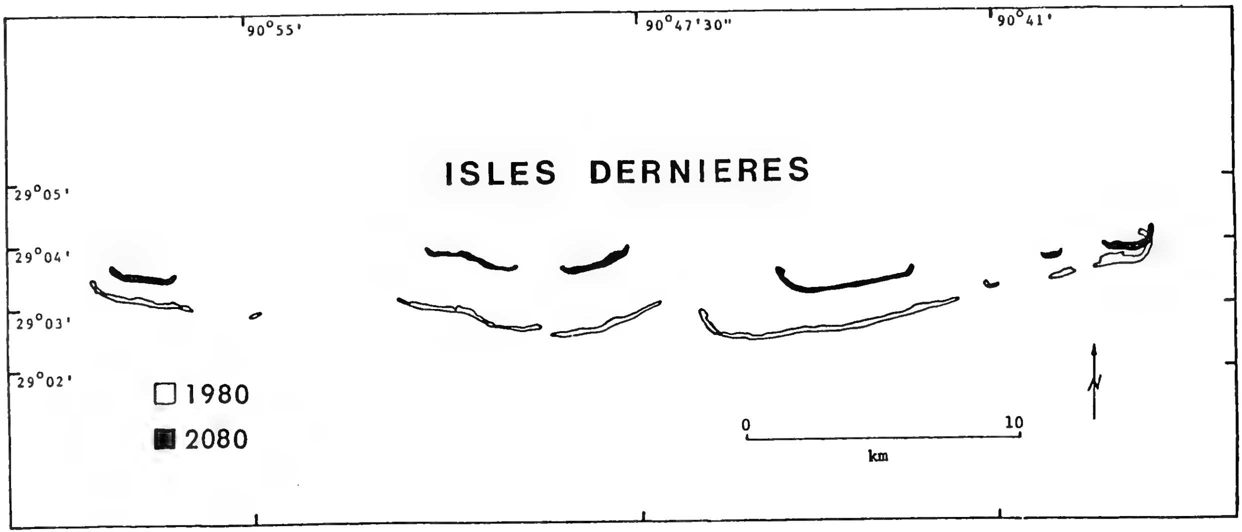

Figure 15. Prediction of landward migration for Isles Dernieres in next 100 years

PART VIII: CORRECTIVE MEASURES

44. The rapid deterioration of Isles Dernieres has been cited as one of the contributing factors in the loss of thousands of acres of coastal wetlands in south-central Louisiana. This loss has spurred local and state governments to spend large sums of money to investigate possible ways to alleviate further loss of the Louisiana shoreline. The Louisiana Department of Natural Resources and the Louisiana Geological Survey have proposed a 5-year plan for coastal protection beginning in 1985. Restoration of the Isles Dernieres barrier island complex is contained in Phase I of the program. A major part of this restoration involves dune building, back filling of the dunes, and revegetation. Information gained from the monitoring of these projects will aid in future management of the Louisiana coastal zone.

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APPENDIX A: HISTORIC HYDROGRAPHIC CHARTS

US Geological Survey Topographic Quadrangles

1887 - Topographic quadrangles at 1:63,500. Eastern Isles Dernieres, Western Isles Dernieres

1906 - Topographic quadrangle at 1:31,680. Western Isles Dernieres

1935 - Topographic quadrangles at 1:31,680. Eastern Isles Dernieres, Western Isles Dernieres

1953 - Topographic quadrangles at 1:24,000. Eastern Isles Dernieres, Central Isles Dernieres, Western Isles Dernieres

US Coast and Geodetic Survey Hydrographic Charts

11356 - Isles Dernieres to Point Au Fer, 1982. 1:80,000

11357 - Timbalier and Terrebonne Bays, 1982. 1:80,000

H - 442 - 1853 . 1:20,000

H - 360 - 1853 . 1:20,000

H - 2015 - 1889-90 . 1:20,000

H - 2016 - 1890 . 1:20,000

H - 2070 - 1891 . 1:20,000

H - 5479 - 1934 . 1:20,000

H - 5537 - 1934 . 1:20,000