CHAPTER 67

FACTORS CONTROLLING CHANGES TO AN OPEN COAST BEACH

William N. Seelig[1]
and
Robert M. Sorensen[2]

ABSTRACT

A study of historical information and field measurements in Sargent Beach, Texas, reveal that the shoreline is retreating with historic rates increasing from -10 feet per year in the late 1800's to -31 feet per year (-9.8 m/year) in the early 1970's. The cause of this erosion is the lack of an adequate sand supply to the beach zone. This sand deficiency is due to: a) reduced updrift sand input to the coast by the Brazos River beginning in 1945 and caused by decreased sediment transport capability of the river, b) increased sand storage in the Brazos Delta encouraged by jetties and vegetation, and c) possible offshore losses of sand due to hurricane wave energy focusing on the Brazos Delta in conjunction with river jetting during peak river flows.

INTRODUCTION.

Sargent Beach, Texas is located on the western coast of the Gulf of Mexico adjacent to Caney Creek, 70 miles (115 km) southwest of Houston, Texas on a straight section of coastline (Figure 1). The purpose of this study is to investigate medium to long term beach changes and the factors causing these changes. Therefore, this study included 26 miles (41 km) of coast updrift from Sargent Beach and 6 miles (9 km) downdrift of Sargent so that the overall pattern of coastal change could be examined. The coast updrift of Sargent Beach is of particular interest since it includes the Brazos River, which has the highest sediment load of all Texas rivers, the Brazos Delta, which stores a large volume of sediment at the mouth of the river, and the Freeport Jetties at the former mouth of the Brazos River (Figure 1).

A more thorough discussion of many aspects of this work may be found in Seelig and Sorensen (1973b), and studies on the Brazos

---

[1]Civil Engineer, Special Projects Branch, Coastal Engineering Research Center, Ft. Belvoir, Virginia (formerly Research Assistant, Civil Engineering Department, Texas A&M University, College Station, Texas).

[2]Chief, Special Projects Branch, Coastal Engineering Research Center, Ft. Belvoir, Virginia (formerly Associate Professor, Civil Engineering Department, Texas A&M University, College Station, Texas).

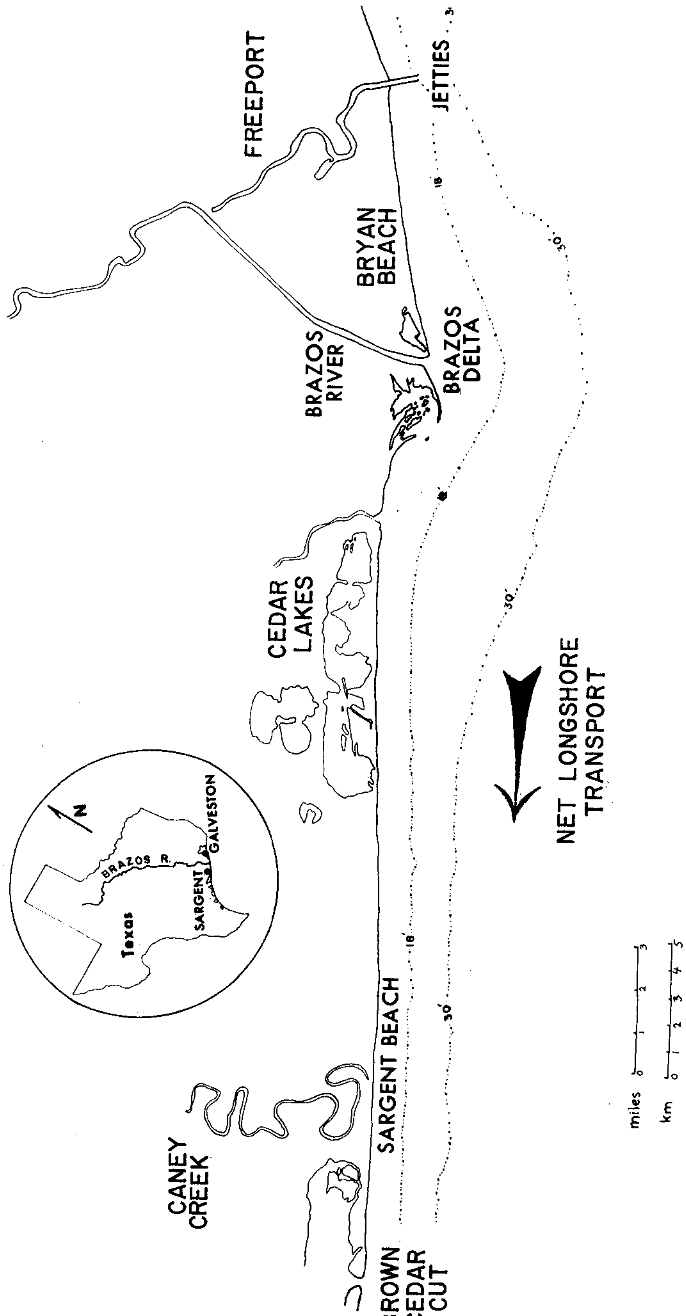


FIGURE 1. SARGENT BEACH AND VICINITY

Delta by Sealy (1974), and Odem (1953). An investigation of Brown Cedar Cut, an inlet to the southwest of Sargent, is available in Mason and Sorensen (1971).

HISTORICAL BACKGROUND.

The study area, as illustrated in Figure 1, has undergone a variety of large scale changes since the first surveys were made of the coastal zone in 1852. While the net shoreline change for the section of coast adjacent to and including Sargent Beach has undergone large net shoreline retreat, the area adjacent to the Brazos River has shown a more complex series of change.

In the 1850's the Brazos River mouth in the old location had a small delta with a straight coastline to either side (Figure 2). Due to shoaling and navigation problems at the river mouth, jetties were built and completed in 1899 which caused shoreline advances downdrift of the jetties. By the 1930's this Brazos Delta had reached the seaward end of the jetties (Figure 2). Due to continued navigation problems in Freeport Harbor, a decision was made in 1929-1930 to reroute the Brazos River mouth 6 miles (10 km) to the west. This change caused a new delta to be built at the present location of the river mouth with an associated erosion of the old delta. The new delta reached its maximum length in 1948, then retreated while migrating westward to the 1971 location (Figure 2).

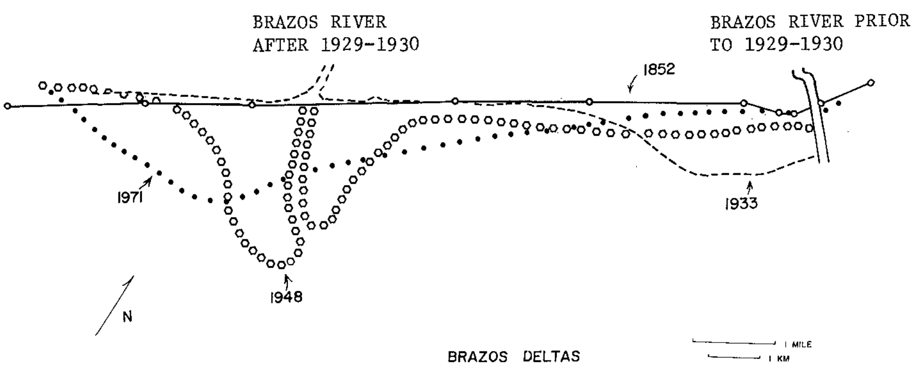


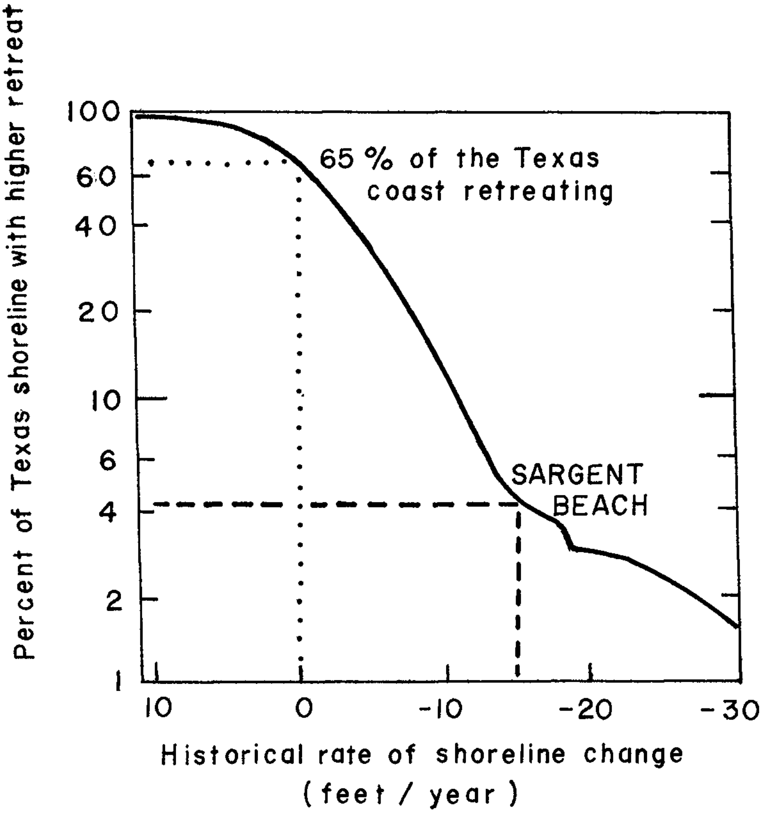
FIGURE 2

SARGENT BEACH CHANGES.

Sargent Beach displays many of the classical characteristics of an eroding beach. Sargent Beach is steeper and narrower than other beaches in the area (e.g. Bryan Beach) with a scarp typically higher than 3 feet (1 m) and a concave beach seaward of the scarp. Oyster reefs, clay outcrops and stumps are occasionally exposed on the beach face suggesting that Sargent has been eroding throughout recent geologic time (Figure 3).

FIGURE 3. SARGENT BEACH 23 NOVEMBER 1972

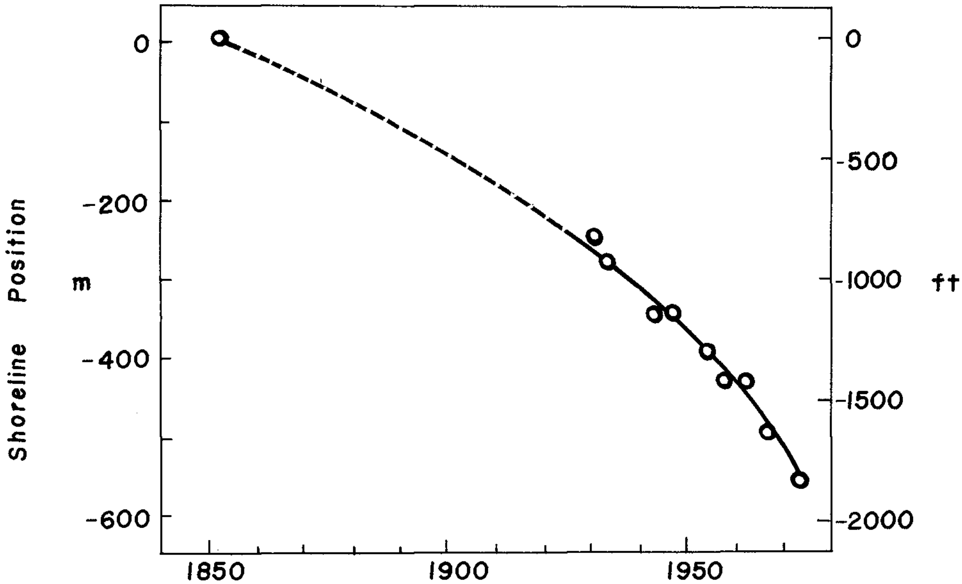
To determine historical shoreline changes for Sargent Beach surveys, maps and photographs for the period 1852 to 1972 were analyzed. They show the shoreline retreated 1800 feet (550 m) for this 120 year period to give a mean shoreline change rate of -15 feet per year (-4.5 m/year). A study of historical shoreline changes for the entire Texas coast shows Sargent Beach to be retreating faster than 96 percent of the Texas coast (Figure 4). Also note that 65 percent of the Texas shoreline has retreat rates greater than zero feet per year so that the Texas coast is predominantly erosive with Sargent Beach one of the hardest hit area. A more detailed discussion of Texas coastal changes is given in Seelig and Sorensen (1973a).



CUMULATIVE CURVE OF TEXAS
HISTORICAL SHORELINE CHANGES

FIGURE 4

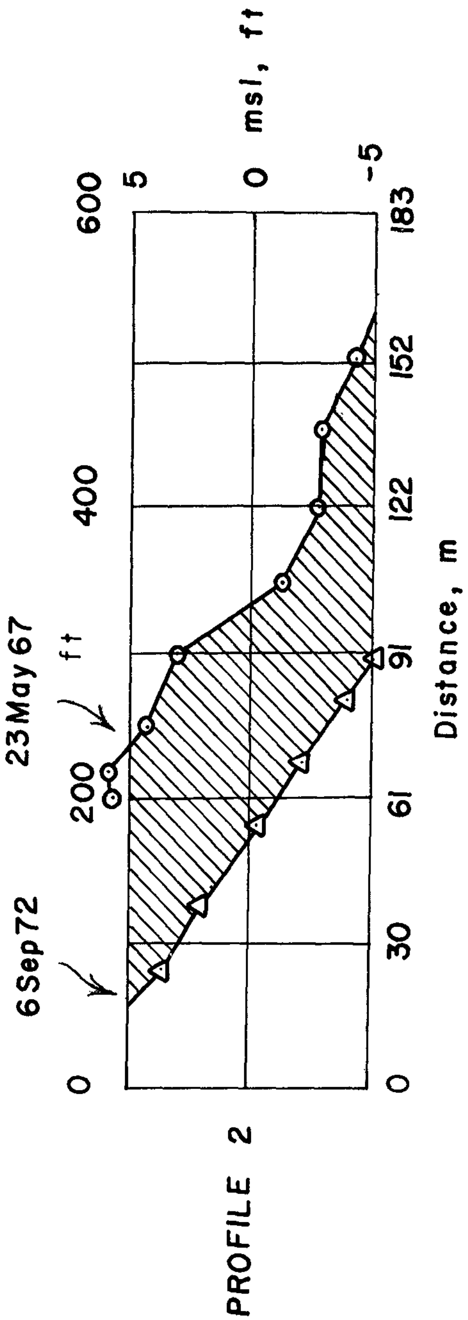
The most striking result of the Sargent shoreline change is shown in a chronological plot of shoreline position for the time period 1852 to 1972, which indicates a continual increase in the rate of shoreline retreat or acceleration of beach losses (Figure 5). For example, in the mid 1800's the shoreline retreat rate was approximately 10 feet per year (3 m/year) which grew to 31 feet per year (9.8 m/year) for 1967 to 1973.



SARGENT BEACH SHORELINE LOCATION

FIGURE 5.

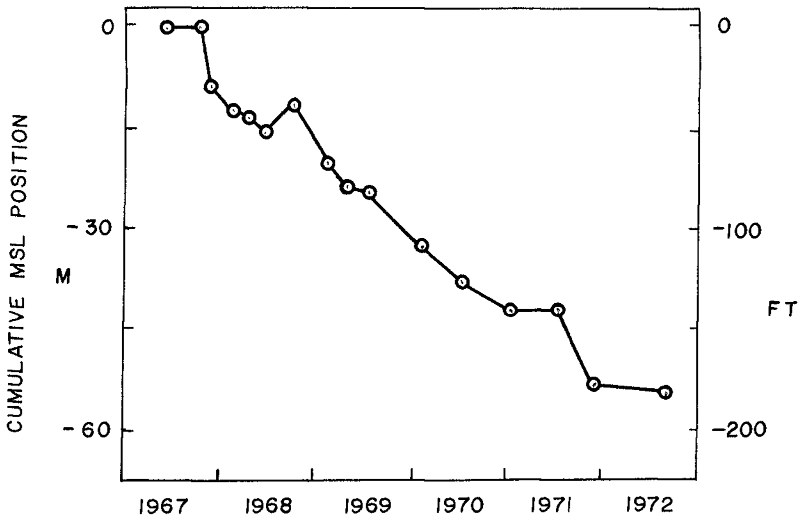
To investigate beach changes in greater detail, fifteen surveys were made of four profiles at 1000 feet spacing on Sargent Beach for the period 1967 to 1972 (surveys provided by Coastal Engineering Research Center, Ft. Belvoir, Va.). Analysis of these profiles includes location of the mean sea level intercept and determination of volume change of the beach between the +5 and -5 feet contours (Figure 6). The beach intercept retreated and the beach shape remained relatively constant, so that the beach volume changes are



SAMPLE SARGENT BEACH PROFILES

FIGURE 6.

proportional to the intercept changes. Therefore, the beach can be considered to be eroding continuously when using a three to six month sampling interval (Figure 7).



SARGENT SHORELINE CHANGES

FIGURE 7.

LONGSHORE TRANSPORT

The net longshore transport of sand for the study area is from east to west as determined from analyses of hindcast data for three years off Caplan, Texas, growth of the Brazos deltas, and changes to Brown Cedar Cut (Figure 1). Estimates of the transport rate vary between 10,000 and 90,000 cubic yards per year depending on the data and assumptions used (Mason and Sorensen, 1971, and Seelig and Sorensen, 1973b). The gross rate is estimated to be between 250,000 to 1,000,000 cubic yards per year.

SUBSIDENCE

Tide records indicate that much of the Texas coast is slowly subsiding at varying rates (Hicks, 1972, and Swanson and Thurlow, 1972). The recent subsidence rate for Freeport, the closest tide station to Sargent Beach, has averaged .037 feet per year (.01 m/year). Assuming a beach slope of 0.04, subsidence is estimated to cause approximately

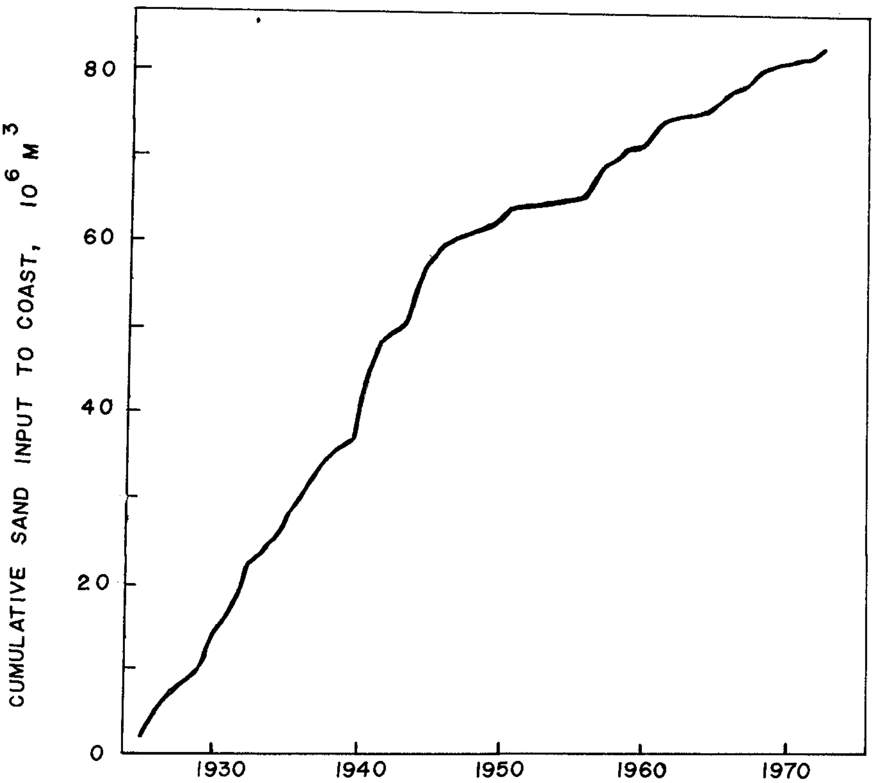
5 feet (2 m) of beach retreat at Sargent Beach for the 5.3 year survey period. This 5 feet of shoreline retreat, estimated as a first approximation of the shoreline change due to subsidence, compared with a total observed shoreline retreat of 160 feet, so subsidence is assumed to play a minor role in recent shoreline changes.

SEDIMENT INPUT TO THE COAST

The Brazos River has the highest sediment load of all Texas rivers discharging directly into the Gulf of Mexico. Measurements at the Richmond Bridge, 100 miles (160 km) from the coast, include the river cross-section, daily water discharge, suspended sediment measurements, and numerous size analyses of suspended and bed load samples. These measurements, in addition to work by Welborn (1973) and a Colby technique (1957), are used to estimate the total suspended and unmeasured river discharge of sand, where sand is defined as material greater than or equal to 0.062 mm in diameter.

Although the year-to-year river sand load may have a wide random variation, a large scale pattern of sand discharge is apparent when cumulative sand discharge for 1922 to 1972 is plotted (Figure 8). The slope of this cumulative curve represents the mean long-term rate of sand input to the coast. As can be seen in Figure 8, the slope (rate of sand discharge) for the period 1922 to 1945 is approximately three times greater than the sand discharge rate for 1945 to 1972. This drastic decrease in the sand load rate means that after 1945 only one-third as much sand reached the coast in any given long period of time as before 1945.

A combination of factors caused this decreased sand load to the coast after 1945. First,a dam on the Brazos River, completed in the mid 1940's, alters the river hydraulics, which directly effect the capability of the river to transport sand. Calculations of sand transport for the Brazos River show that 65 percent of the sand reaching the coast is transported during the highest 10 percent of water discharge periods, of flood type conditions. Similarly, 90 percent of the sand is moved in the highest 25 percent river discharges. Since a purpose of dams is to aid in flood control by reducing flood conditions, even a small reduction in peak river discharge causes a drop in the rate at which sand raches the coast. Sand is further inhibited from reaching the coast due to reservoir sedimentation.



BRAZOS RIVER SAND LOAD
(CUMULATIVE)

FIGURE 8.

A drought in the 1950's for the Brazos area further decreased river discharge and therefore sand transported by the Brazos River.

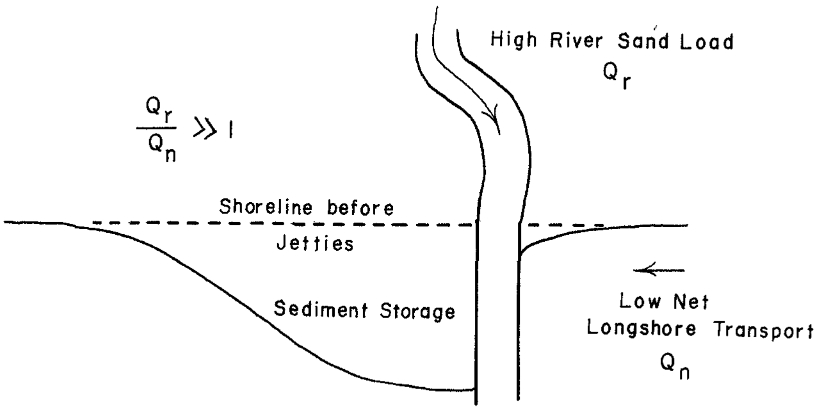
Changes in the agriculture of the Brazos River watershed associated with World War II may have also changed runoff characteristics and river hydraulics, thereby reducing the river sand load.

SEDIMENT STORAGE

The Brazos Delta, at the mouth of the Brazos River, updrift from Sargent Beach, had a small subaerial portion in 1852 suggesting that only a small volume of sediment was stored in that area (Figure 2). The Freeport Jetties completed in 1899, however, provided a shadow zone downdrift of the jetties which encouraged the high Brazos sediment load to be deposited in the lee of the jetties (Figure 9). This old Brazos Delta largely disappeared when the river sediment supply was cut off in 1929-1930, suggesting that the old Brazos Delta was largely composed of river material.

When the river was rerouted to the west in 1929-1930, a large percentage of the sediment stored at the jetties was moved westward under the action of the predominant waves from the southeast. This unusually large mass of sand moving westward was trapped at the new river location to form the new delta nucleus. Continued high river sediment discharge encouraged growth of the new Brazos Delta, which was quickly vegetated in the subtropical climate of the Texas coast. Aerial photography shows that this vegetation plays an important role in holding the delta together during hurricane periods.

The new Brazos Delta reached its maximum length in the mid 1940's, with retreat of the subaerial delta after the 1940's associated with the decreased river sand load. The symmetrical delta of 1948 also moved westward under the force of the westward longshore drift to the position shown in 1971 (Figure 2).



CONDITIONS FOR OLD BRAZOS DELTA FORMATION
FIGURE 9

Hydrographic surveys for 1930 and 1972 were compared to determine the total net volume of sediment stored for both the old and new Brazos Deltas. Sediment size analyses of delta and offshore sediments by Odem (1953) and Nieneber (1963) were applied to this volume change to estimate the volume of sand stored, which indicates that one third of all Brazos River sands reaching the coast between 1930 and 1972 were stored in the Brazos Delta in 1972.

OFFSHORE LOSSES.

Hayes (1967) reports that hurricanes, such as Carla in 1961, move significant volumes of sediment out of the active beach zone and into deeper water where the sediment is effectively no longer available to the beach. It is believed that this process is encouraged by the Brazos deltas since a) their delta shapes focused wave energy, b) stored sand is available to be moved, and c) the jetting action of the Brazos River during flood conditions, also associated with hurricanes, will carry sediment offshore. Through this mechanism the delta is essentially acting as a system to bypass river sands from reaching the beach.

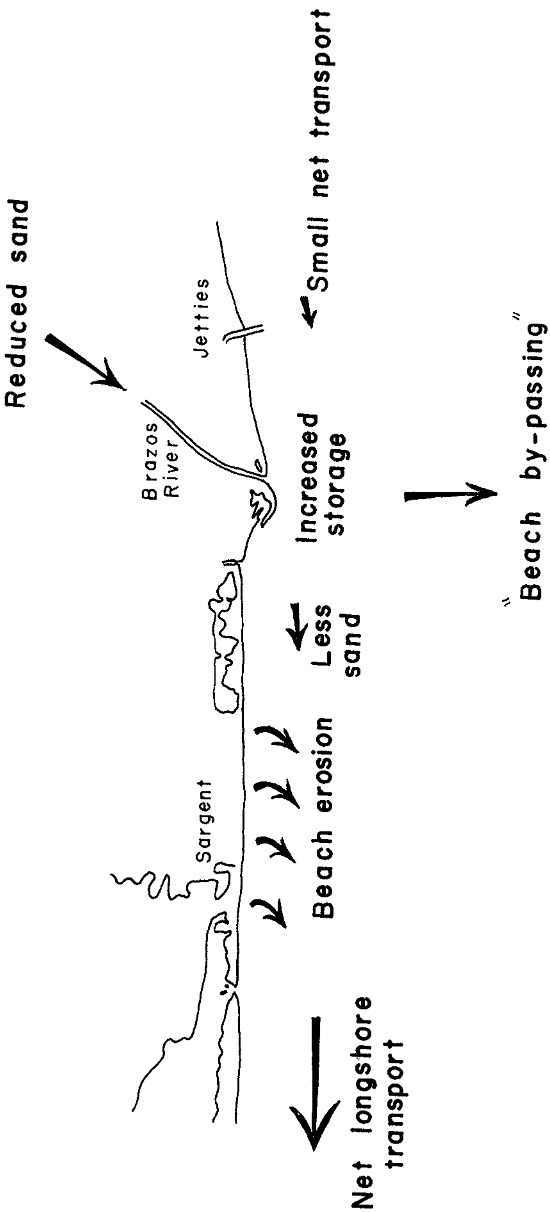
Surface sands found offshore of the Brazos Delta (Nienaber, 1963, Texas A&M Univ., Sea Dock Study, 1973) area are a sign that beach bypassing has taken place. Additional study of this mechanism is suggested.

CONCLUSIONS.

The large scale beach losses at Sargent Beach, now resulting in a net shoreline retreat of 31 feet per year, are due to a change in the delicate balance between supply and demand of sand. The simultaneous decrease in the sand load of the Brazos River after 1945 with the increase in storage in the Brazos Delta and improved possibility of offshore losses since 1930 means that much less sand is available to Sargent Beach from updrift sources. At the same time wave forces and associated longshore currents continue to remove sediment from Sargent Beach to give a net retreat and erosion of the beach (Figure 10).

ACKNOWLEDGMENTS

This work was supported by the Texas A&M University Sea Grant Program, College Station, Texas. Beach profile data was provided by the U. S. Army Coastal Engineering Research Center, Fort Belvoir, Virginia.



THE SAND BUDGET 1930's - 1970's

FIGURE 10.

REFERENCES

Colby, B. R., "Relationship of Unmeasured Sediment Discharge to Mean Velocity," Transactions, American Geophysical Union, Vol. 35, No. 5, Oct., 1957, pp. 708-717.

Hayes, M. O., "Hurricanes as Geologic Agents: Case Studies of Hurricanes Carla, 1961, and Cindy, 1963," Bureau of Economic Geology, Report Inv. 61, Univ. of Texas, Austin, Texas, 1967.

Hicks, S. D., "On the Classification and Trends on Long Period Sea Level Series," Shore and Beach, April, 1972.

Mason, C., and Sorensen, R. M., "Properties and Stability of a Texas Barrier Beach Inlet," Sea Grant Publication No. TAMU-SG-71-217, Texas A&M University, College Station, Texas, Aug., 1971.

Nienaber, J. H., "Shallow Marine Sediments Offshore From the Brazos River, Texas," Institute of Marine Science, Vol. 9, 1963, pp. 311-372.

Odem, W. I., "Delta of the Diverted Brazos River of Texas," Thesis in Geology, Univ. of Kansas, 1953, pp. 1-112.

Sealy, J. E., "A Mathematical Model for River Delta Development and Its Application to the New Brazos Delta at Freeport, Texas," M. S. Thesis in Geology, Texas A&M University, College Station, Texas, May 1974.

Seelig, W. N., and Sorensen, R. M., "Historic Shoreline Changes in Texas," Sea Grant Report TAMU-SG-73-206, Texas A&M University, College Station, Texas, April, 1973(a).

Seelig, W. N. and Sorensen, R. M., "Investigation of Shoreline Changes at Sargent Beach, Texas," Sea Grant Report TAMU-SG-73-212, Texas A&M University, College Station, Texas, 1973(b).

Swanson, R. L., and Thurlow, C. I., "Recent Subsidence Rates Along the Texas and Louisiana Coasts as Determined From Tide Measurements," National Ocean Survey, NOAA, Rockville, Maryland, 1972.

Welborn, C. T., unpublished notes on the Colby method for computing the unmeasured sediment load of the Brazos River at Richmond, Texas, U. S. Geological Survey, Austin, Texas, received 1973.