GEOGRAPHIC ANALYSIS OF SHORELINE RECESSION, COASTAL EAST TEXAS

by

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Foreword

Man always has an immediate benefit in mind when he dredges channels, builds jetties, or diverts the waters of a river. He may achieve his benefits, but often the costs turn out to be greater than he reckoned. Dredging, jetty-building, and water diversion can cause serious shoreline changes by interfering with normal processes of beach replenishment.

In this Note, Dr. Jaworski describes a very clear example of shoreline changes indirectly effected by some of man's activities along the East Texas coast. From reading this paper, one gains a feeling for the dynamic system of wave action, sediment transport, and land subsidence along the Texas coast, a system man needs to know well before he messes with it.

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Earl Cook

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TABLE OF CONTENTS

ILLUSTRATIONS

GEOGRAPHIC ANALYSIS OF SHORELINE RECESSION, COASTAL EAST TEXAS

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Abstract

Shoreline recession along the East Texas coast is occurring at a rate of approximately 5 feet per year. Field observations and map study reveal that the coast consists of two small regressive sections and a large transgressive section. Although the most rapid recession of the transgressive section is caused by hurricane washover and storm surge processes, other marine processes and the tectonic setting of the coast are also important. Human interference with the beach system is aggravating the sediment deficiency of the transgressive beach. Because beach environments of the Gulf Coast have great recreational and other land use value, the artificial nourishment of the beach system with available sediment supplies is recommended for the attainment of shoreline equilibrium.

Introduction

Several sections of the Texas coastline are receding. Of the 373 miles of Texas shoreline, approximately 27 percent, or 101 miles, show evidence of recession by marine processes (U.S. Army C.E., 1970, p. 3); the largest area of shoreline recession is along the East Texas coast.

A field survey and map study were made of coastal East Texas. Several geomorphic aspects were investigated, including the rate of shoreline recession and the processes responsible for the erosion. The objective of this study was to (1) determine the changes in shoreline morphology, and (2) to relate the shoreline changes to specific coastal processes. Emphasis was placed on the natural processes of erosion, but the impact of man-made changes also was investigated. As land use of our coastal environments increases, it will become necessary to initiate management programs which will integrate our knowledge of both the natural and the man-induced coastal processes.

Description of the coast

The East Texas coast, 62 miles long, lies between the entrance to Galveston Bay and Sabine Pass (Fig. 1). It formed during Recent time after the rise in sea level that followed the Late Wisconsin glacial stage (Nelson and Bray, 1970, p. 72). Multiple beach ridges (cheniers) near Sabine Pass and dune ridges on Bolivar Peninsula indicate extensive Recent coastal progradation. Along the central portion of this coast, as near High Island, there is only a single beach ridge. Behind the beach ridge is coastal marsh. Farther inland appears the Beaumont surface, a coastal Pleistocene terrace that dips seaward under the Recent marsh and beach deposits (Houston Geol. Soc., 1959, p. 56).

The East Texas shoreline consists of a large transgressive section and two small regressive sections. Regression is occurring along a 12-mile strip east of the Galveston Bay jetty and also along a 6-mile strip west of the Sabine Pass jetties. In the 44 miles between these regressive sections, the coast is transgressive. West of the High Island dome the modern beach is transgressing over the coastal marsh (LeBlanc and Hodgson, 1959, p. 218).

The coastal morphology of transgressive beaches is distinct from that of regressive beaches. A transgressive beach does not prograde, rather the beach transgresses over the existing inshore environments. Sediments of a transgressive beach characteristically are thin and the

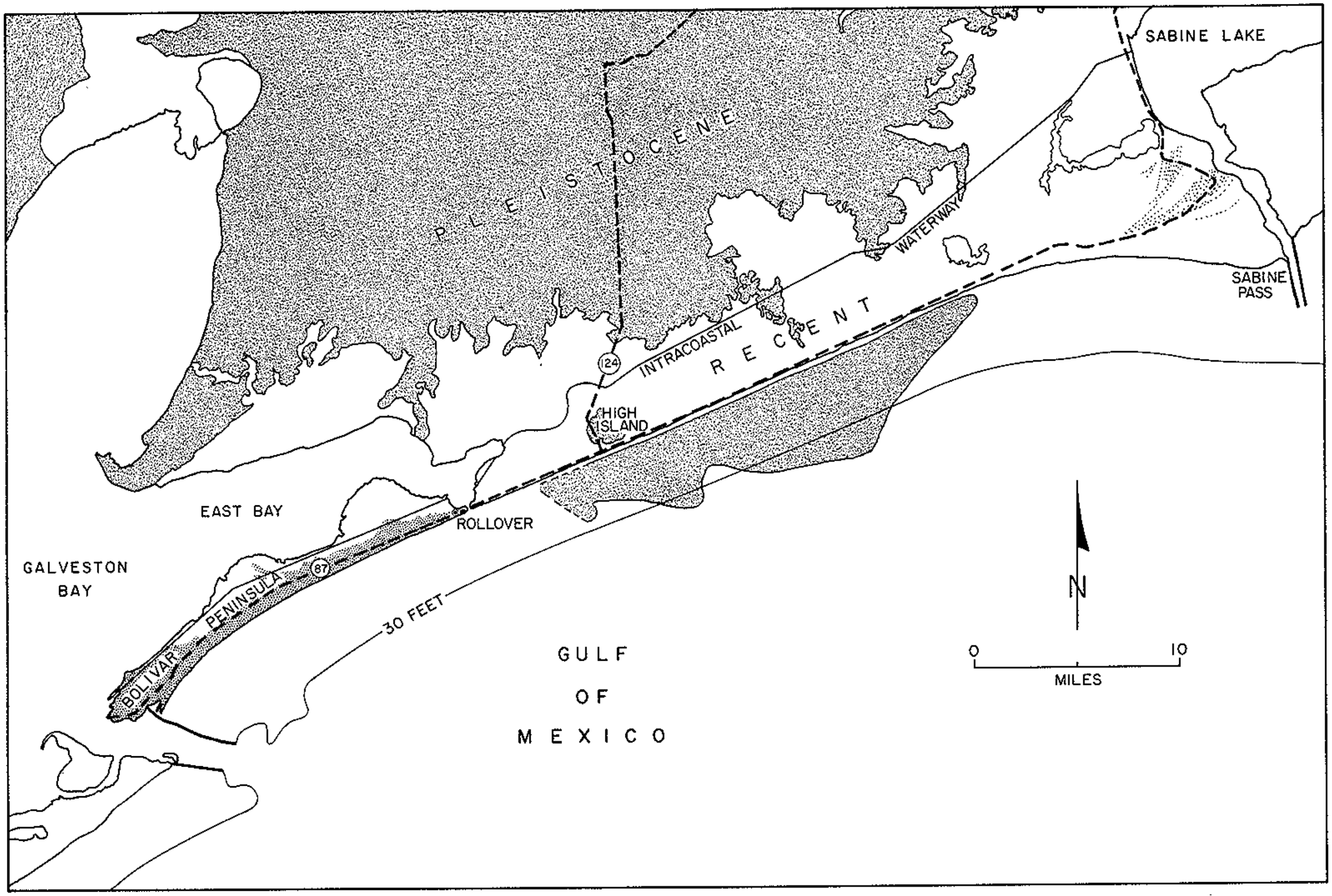

Fig. 1. The study region, the East Texas Coast.

beach zone is narrow (Pl. 1). Foredunes on the beach ridge are either absent or incipient, and multiple beach ridges do not occur as on regressive beaches. A low sediment supply and a dominance of marine processes result in the reworking of the beach and a continual retreat of the shoreline.

Shoreline recession

Interest in the problem of shoreline recession developed from a study of the relocation of Highway 87 which follows the transgressive beach ridge (Pl. 2), because the coastal marsh prohibits the construction of a stable roadbed farther inland. The first hard-surfaced highway here was built in 1936, following a hurricane in 1934. In 1945 and 1962 the highway was again relocated because of extensive shoreline recession (Young, 1970, personal communication). With each relocation the highway centerline was re-established 50 to 60 feet farther landward.

From several lines of evidence, the rate of shoreline recession was determined to be approximately 5 feet per year. East of High Island the rate of retreat was inferred from the highway relocations. Residents at High Island reported that 200 feet of the nearby coast had eroded away since 1939. West of High Island the Corps of Engineers (1958, p. 14) has estimated the erosion rate to be about 5 feet per year. A comparison of U.S. Coast and Geodetic Survey maps published in 1894 with 1969 editions revealed parallel recession of the shoreline.

Plate 1. Transgressive beach, ten miles west of High Island. Note cusps on upper beach and marsh exposed in swash zone.

Plate 2. Remnants of a former roadbed of Highway 87. Trend of present highway is indicated by telephone poles in left background.

Natural processes of coastal erosion

The tectonic setting of the coast exerts a powerful control over the coastal processes. The Sabine Arch trends north-south between the High Island salt dome and Sabine Pass (Graf, 1966, p. 20-22). The arch acts as a drainage divide, resulting in an absence of coastal rivers in the transgressive beach area. In addition, the Sabine Arch is associated with the exposure of the Pleistocene Beaumont surface in the near-shore zone (Nelson and Bray, 1970: Pl. 1). The dominance of marine processes over fluvial processes in the transgressive beach area probably is due, at least in part, to the influence of the arch.

The stratigraphy of the transgressive beach ridge also helps explain why marine processes exert a dominant influence on the transgressive beach zone. From several bore holes through the transgressive beach, a cross section was obtained (Fig. 2). The beach deposits are thin, commonly less than a foot thick. Beneath the beach are dark gray to black-colored clayey marsh sediments which range from 4 to 8 feet thick. Under the marsh sediments, at depths of 4 (Houston Geol. Soc., 1959, p. 56) to 10 feet below sea level, Pleistocene materials were encountered. Because Pleistocene fragments are common in the beach sediments, the Beaumont Terrace must be exposed to wave activity in the surf zone. Both the Recent marsh and the Pleistocene materials are being eroded by surf and swash processes.

The morphology of the transgressive beach ridge provides evidence as to the processes of coastal erosion. Washover fans, extending from

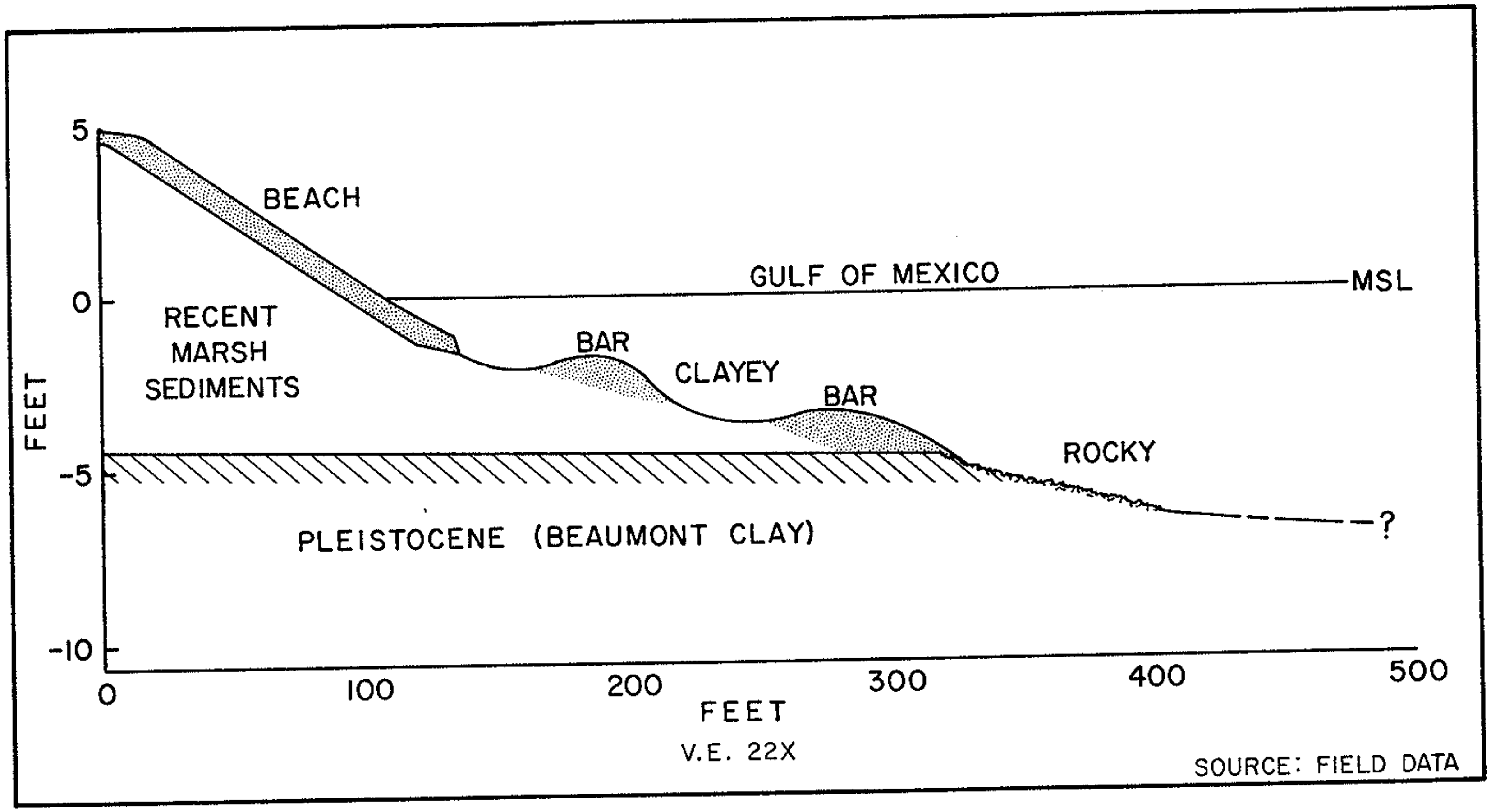

Fig. 2. Cross section of the transgressive beach, 4 miles east of High Island.

the beach ridge into the coastal marsh, are conspicuous landforms. Washover fans are subaerial, fan-shaped features built out into the marsh by strong, wind-driven waves and storm-surge processes (Andrews, 1970, p. 17). The soils on the washover fans have been mapped by the Soil Survey (Crout et al., 1965, p. 8) as poorly sorted, sandy deposits washed over the beach into the marsh by hurricanes and storms. Because the washover features are slightly higher than the surrounding salt marsh, cattle are grazed on them.

Several investigators (Hayes, 1967; Andrews, 1970; and McGowen et al., 1970) have documented the effect of hurricanes and tropical storms on coastal erosion along the Texas coast. Hurricanes and tropical storms create large waves and storm surges which lead to the erosion of the beach and the deposition of washover fans (Fig. 3). As storms approach the beach ridge, which is about 5 feet in height, water levels are increased from 4 to 15 feet above normal tide (U.S. Army C.E., 1958, Appendix II). The higher-than-normal waves and storm surges wash over and cut channels through the beach ridge (Texas Highway Dept., 1961, Sheet 17). Sediment is transported through the washover channels into the marsh where it accumulates as a washover fan. Some sediment is also transported seaward as the water drains from the marsh (Hayes, 1967, p. 48; Houston Geol. Soc., 1959, p. 56). Following a hurricane, the transgressive beach is swept clean of beach sediments and the shoreline has the appearance of a mudflat (Bridges, 1959, p. 71).

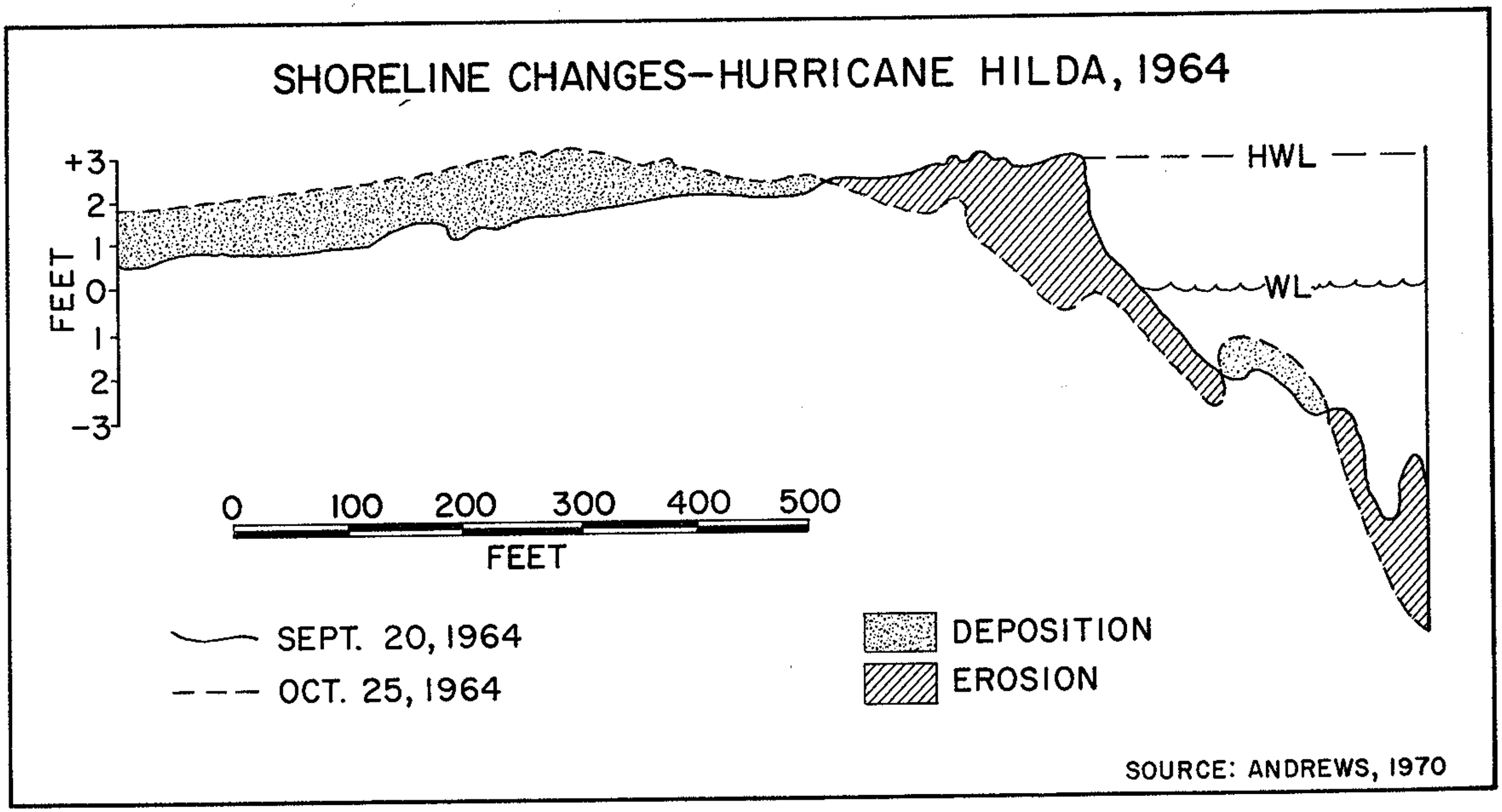

Fig. 3. Shoreline changes associated with hurricanes and tropical storms.

Most investigators conclude that the beaches of East Texas are supplied with sediment by westward beach drift and longshore currents. An onshore wind-vector diagram (Fig. 4) shows a strong resultant from the southeast which could produce westward beach drift and longshore currents. In response to the marine energy regime, the transgressive beach is straight and is oriented at an azimuth of 246°. Incipient blowout dunes on the forebeach trend at azimuths between 315 and 330°. Wave data (Bretschneider and Gaul, 1956, p. C-2) indicate that most of the waves approaching this coast are less than 4 feet high and come from the southeast (Table 1). As the wave trains approach the shoreline, there is considerable refraction, shoaling and frictional attenuation.

The impact of man on the coast

There are three areas along the East Texas shoreline where man appears to be aggravating the natural processes of shoreline recession. In the transgressive beach-ridge area sediments have been removed for road building. In many places along the transgressive beach and in the swash zone grooves, created by heavy-duty scrapers, can be seen in the top of the exposed marsh deposits. Removal of the thin beach deposits increases the sediment deficiency. In 1970 a bill was passed by the Texas Legislature which prohibits the removal of beach sediments for road building.

The second area where human activity has aggravated the natural processes of coastal erosion is adjacent to the Sabine Pass jetties

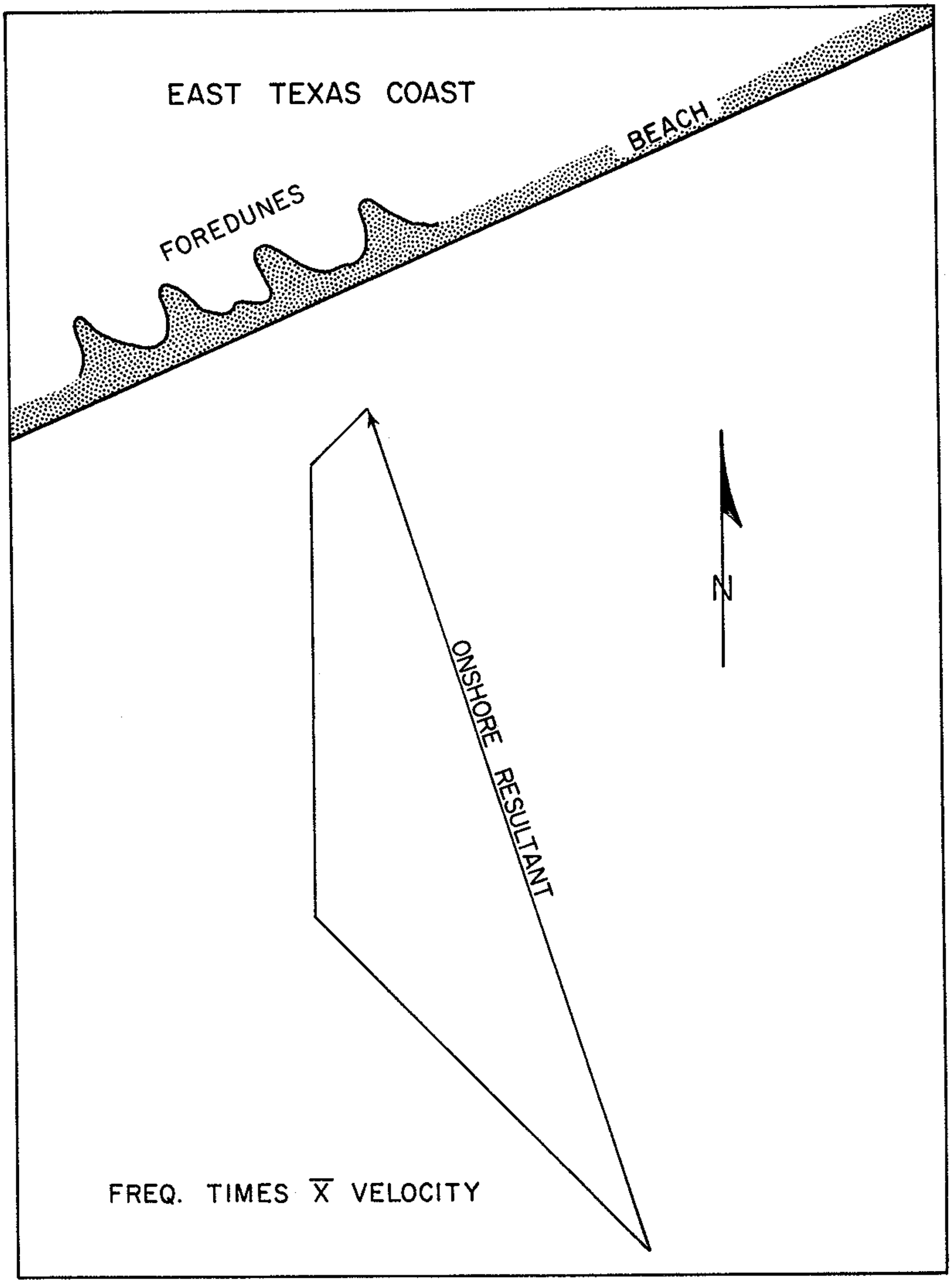

Fig. 4. Onshore wind vector diagram. The orientation of the transgressive beach and the trend of the dunes are also shown.

TABLE 1

On-shore shallow-water wave-height statistics

Frequency of occurrence in hours per average year, for Caplen, Texas.

Wave Height	SW	S	SE	E
Depth - 12 Feet				
1.5	180	290	400	380
2.5	100	850	420	
3.5		340	952	
4.5		20	15	
5.5				
Depth - 24 Feet				
1.5	60	220	304	156
2.5	90	640	446	184
3.5	130	320	650	190
4.5		240	320	
5.5		56	47	
6.5		16	20	
7.5		12	13	
8-10		3		
Depth - 36 Feet				
1.5	50	220	304	156
2.5	80	430	396	84
3.5	74	450	600	120
4.5	46	260	370	85
5.5	30	90	76	45
6.5		34	22	
7.5		13	13	
8-10			17	
Depth - 48 Feet				
1.5	40	220	304	156
2.5	90	330	346	84
3.5	56	450	550	140
4.5	44	300	400	78
5.5	26	225	130	47
6.5	14	35	30	25
7.5	10	19	14	8
8-10			17	
10-12			8	

Source: Bretschneider & Gaul, 1956, p. C-2.

(Fig. 5). The Sabine jetties were built during the 1880's and were extended in the 1920's (U.S. Army C.E., 1963, p. 2). Before construction of the jetties the entire Sabine Pass beach-ridge area was regressive, whereas today erosion is occurring within 6 miles west of the pass. The jetties have disrupted the normal westward transportation of sediments by increasing deposition close to the pass. Sabine Pass is a source of local beach sediments (Kwon, 1969, p. 16). The pass must be dredged continually to maintain an adequate navigation channel; the dredged sediments are dumped offshore near the west jetty. The dredged sediments, or spoil, are associated with the nearshore shoaling and the coastal progradation west of the Sabine jetties. The beach sediments of this regressive section of coast are clayey, and marsh grasses grow down to the shoreline.

The third area where man has influenced the natural coastal processes is along Bolivar Peninsula (Fig. 6). Since the completion of the Galveston Bay jetties in 1893 (U.S. Army C.E., 1964, p. 2), progradation has taken place along western Bolivar Peninsula. The north jetty of the Galveston Bay entrance traps sediment which is slowly transported westward by beach drift and longshore currents (U.S. Army C.E., 1959, p. 16; Bridges, 1959, p. 17-18). Spoil from continuous dredging of the Galveston Bay entrance is dumped west of the south jetty.

The fish pass at Rollover was dug in 1955 (U.S. Army C.E., 1959, p. 9). It has been estimated by the U.S. Army Corps of Engineers (1959, p. 17) that the shoreline between Rollover and High Island has

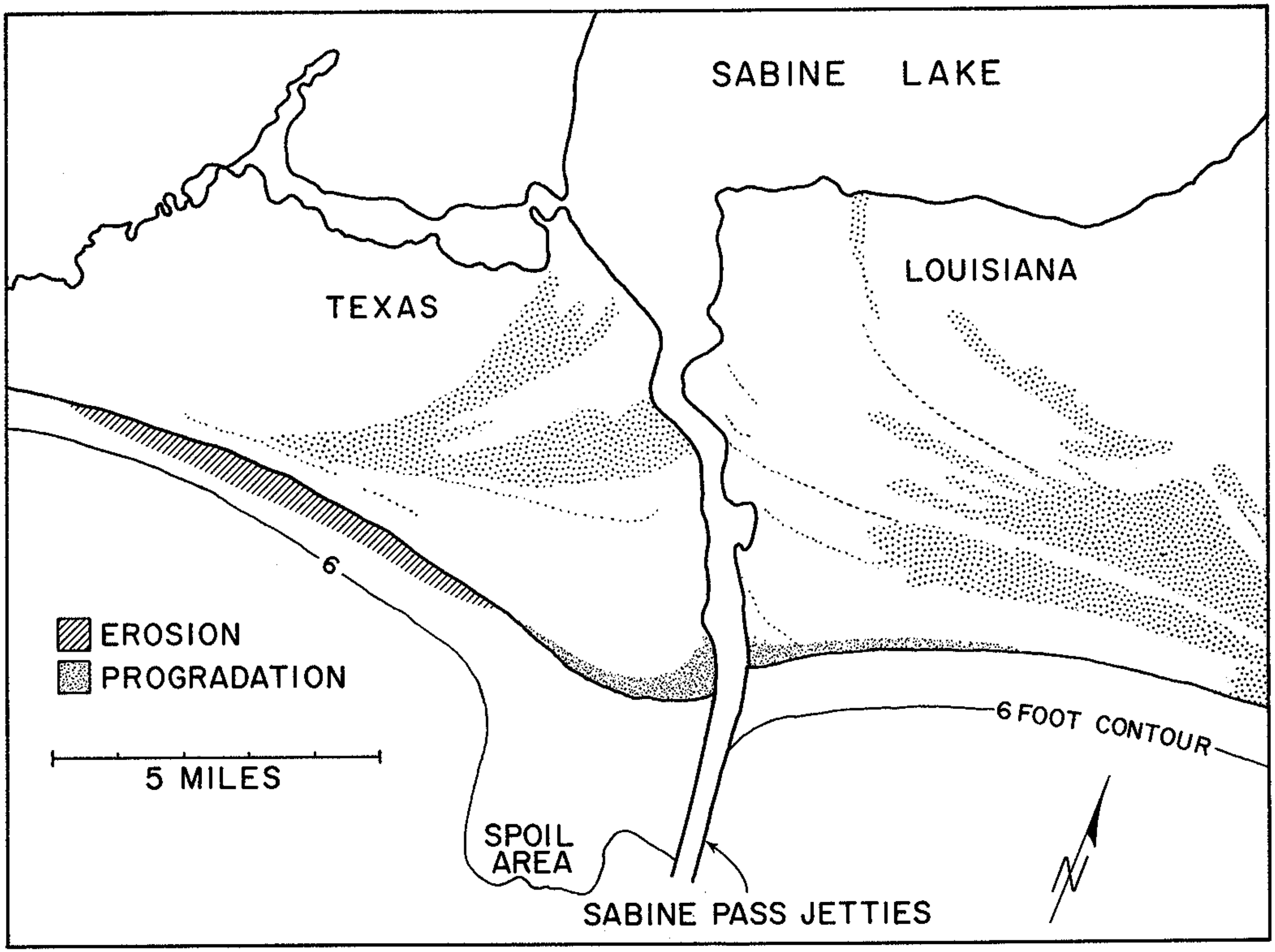

Fig. 5. Changes in shoreline morphology near Sabine Pass since 1900.

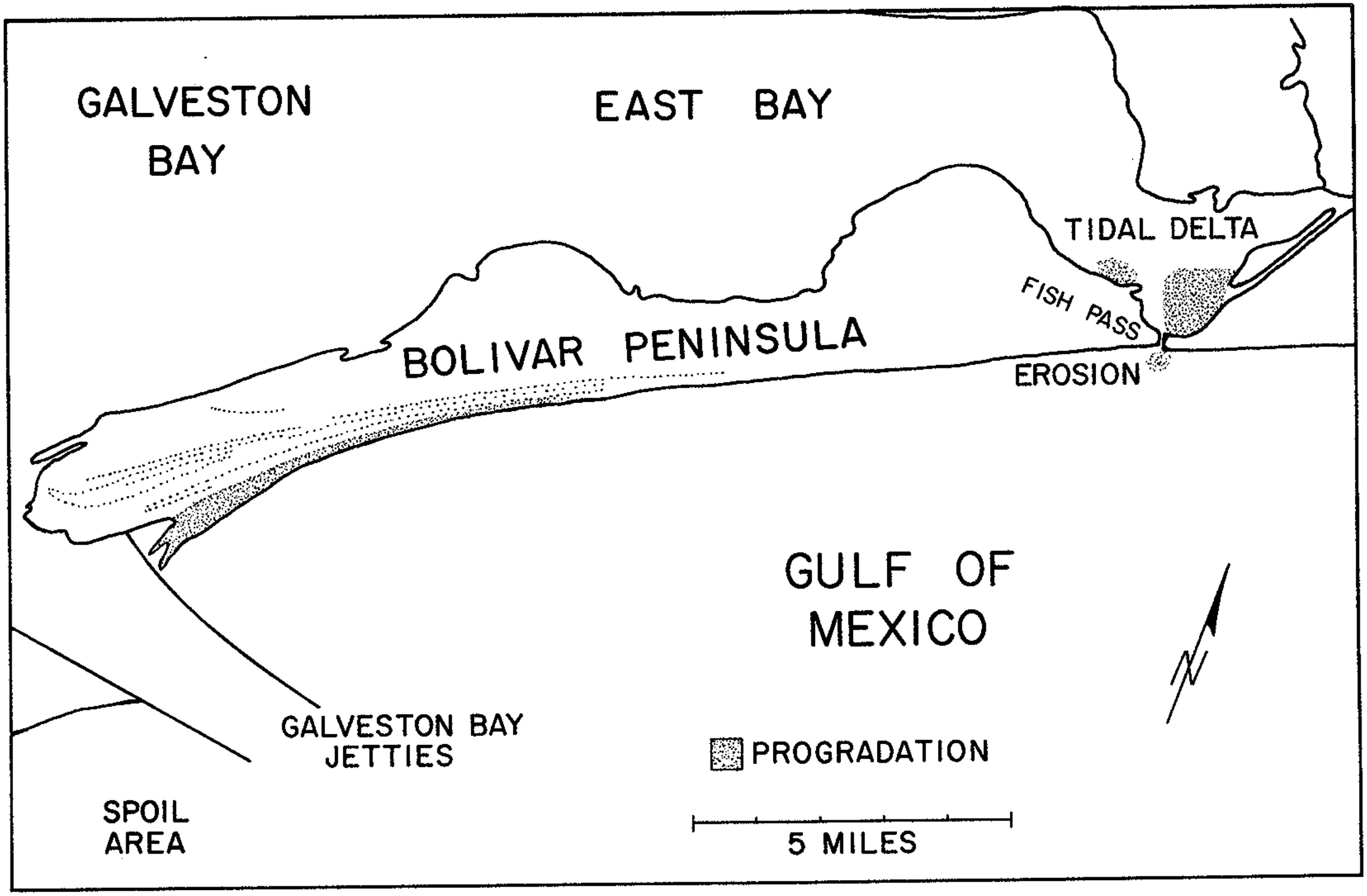

Fig. 6. Changes in shoreline morphology along Bolivar Peninsula since 1900.

an annual sediment deficiency of 200,000 cubic yards and that the fish pass would increase the annual deficiency by another 18,000 yards. The rapid development of a tidal delta in East Bay and accelerated erosion along the shoreline immediately west of the fish pass suggest that westward beach drift and longshore current transport are being affected. The tidal delta in East Bay has been built by strong tidal currents (U.S. Army C.E., 1959, p. 25) which transport sediments through the narrow pass into the bay. Moreover, field observations indicate that sand is being deposited in the nearshore area in front of the fish pass. Changes in the beach morphology are important along Bolivar Peninsula because of the recent recreational development of the area.

Source of transgressive beach sediments

Although there have been numerous general studies, no definitive research has been conducted on the source of beach sediments for the East Texas coast. Kwon (1969, p. 16) suggested that the sediments of Bolivar Peninsula come from erosion of the East Texas coast and from the Sabine River. From heavy-mineral analysis and roundness, Bridges (1959, p. 17, 81) concluded that the Sabine River sediments are present in the beach no farther than 11 miles west of Sabine Pass. Crocker (1963, p. 66) stated that all available data indicate that the East Texas rivers are not a major source of sands for the East Texas beaches.

None of the researchers has suggested that a major source of sediments for the thin transgressive beach may be the Pleistocene Beaumont Clay which is exposed in the nearshore zone (Fig. 1). Large angular fragments of calcareous nodules eroded from the Beaumont Clay are common in the transgressive beach, expecially in cusps on the upper beach (Pl. 1). Because the nodules are not durable, these fragments can serve as indicators of beach drift. Rounded nodules of gravel size are found east of Rollover, but eastward drift into the Sabine Pass beach-ridge area was not observed. Throughout the transgressive section and eastward, Pleistocene nodules and shell hash are abundant in the upper beach and in the swash zone. Some sands, perhaps exemplified by a local accumulation near High Island (Houston Geol. Soc., 1959, p. 56), also may be derived from erosion of the Recent marsh deposits.

An attempt to locate the exposed Pleistocene Beaumont Clay was made by probing in the surf zone. Four miles east of High Island the Pleistocene surface was encountered beyond the second offshore bar in a water depth of about 4.5 feet. Farther east the Beaumont Clay was not located out to depths of 6 feet. In the surf zone the Pleistocene materials appear as a lag of nodules encrusted by sessile shell organisms. Unconsolidated clays, silts and sands probably are winnowed out by wave action. Following a storm, the upper portion of the transgressive beach is covered with large Pleistocene-nodule fragments and shells, while the lower beach and offshore bars are composed largely of sands.

Conclusion

The East Texas shoreline consists of a complex beach system deficient in sediment supply. A large transgressive portion and two small regressive areas are recognized. With regard to natural processes, the most rapid recession of the shoreline is associated with hurricane washover and storm surge processes (U.S. Army C.E., 1970, p. 18). Surf and swash processes as well as westward beach drift and longshore current transport also are important. The large transgressive portion of the shoreline is associated with the Sabine Arch. In the transgressive area most of the beach deposits probably are derived from local erosion of the coast, in particular from the exposed Pleistocene Beaumont Clay.

Human interference with the beach system has affected the natural coastal processes in three areas of the shoreline. The construction of the Sabine Pass jetties, the dredging of the fish pass at Rollover, and the removal of beach sediments for road building have had an effect on the coastal processes. The most significant impact of man on the shoreline appears to be a reduction in the amount of sediment being transported westward by beach drift and longshore currents. In addition, there has been an increase in the length of the transgressive shoreline and a corresponding decrease in the length of the regressive shoreline. Because coastal erosion places constraints on the land use of the beach and beach-ridge, steps to reduce the shoreline recession may be justified. One possibility is to supply the transgressive beach with sediments from dredging as from Sabine Pass and from the tidal delta in East Bay near the Rollover fish pass.

Acknowledgments

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