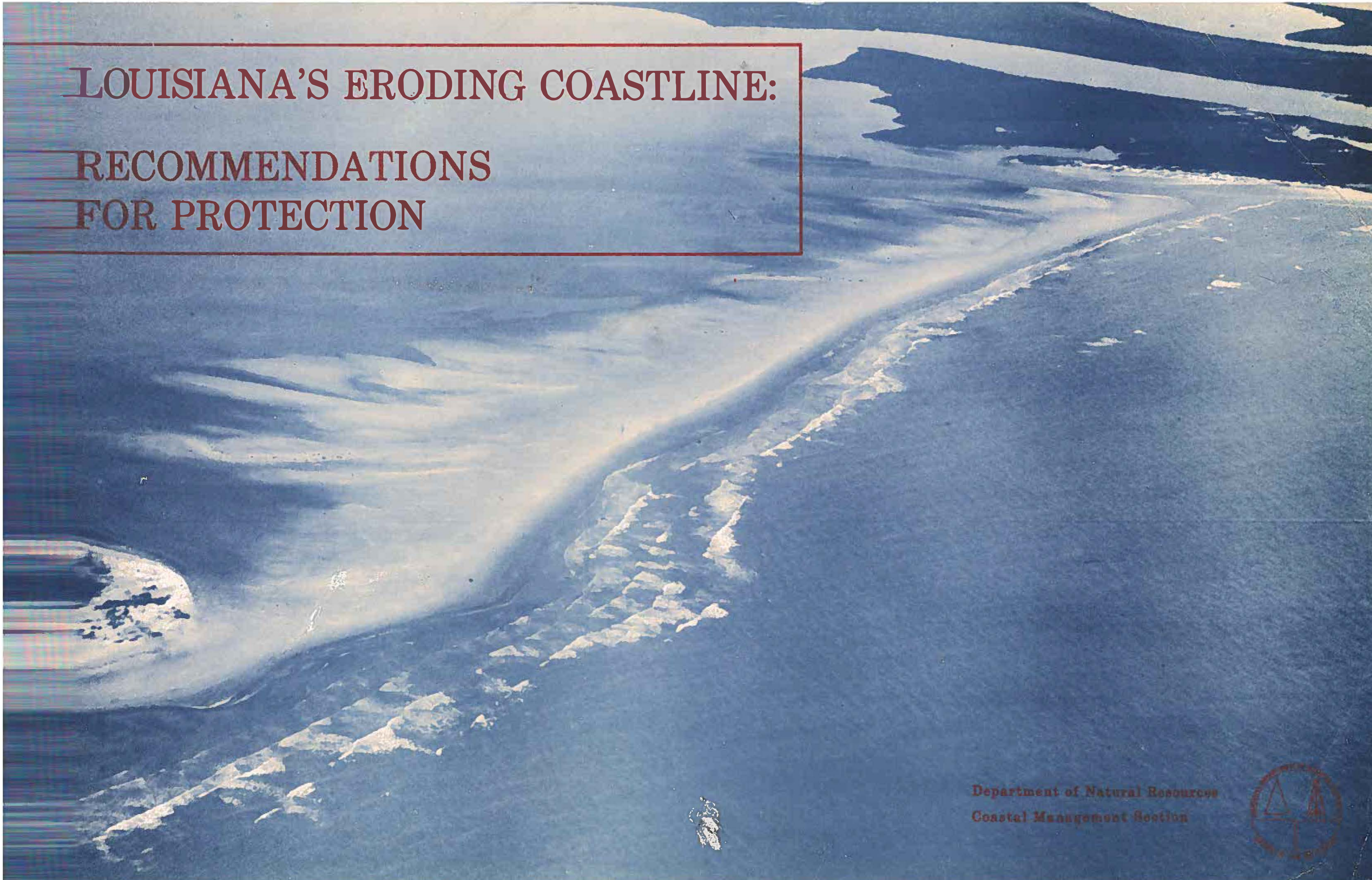
LOUISIANA'S ERODING COASTLINE:

RECOMMENDATIONS FOR PROTECTION



Department of Natural Resources
Coastal Management Section

Louisiana's Eroding Coastline: Recommendations for Protection

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Simultaneous with the present study, a report was prepared for the Terrebonne Parish Police Jury concerning that parish's barrier system. Accordingly some results as set forth in the present report are based in part on jointly developed approaches. We wish to acknowledge this commitment of the Policy Jury and its Barrier Island Committee to a joined effort of state and local government in dealing with Louisiana's coastal problem.

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Chapter I
Introduction

This report is the result of a study directed at assisting the State of Louisiana in development of a plan for the protection and management of its first line of coastal defense. That is the natural system of barrier islands, barrier beaches, and associated wetlands facing the Gulf of Mexico. The need for such action is becoming increasingly urgent as wetland losses and saltwater intrusion accelerate, water levels rise, and an ever greater number of people is affected by these changes. The present study represents one of a number of responses by the State Legislature and Governor David C. Treen to the urgent nature of Louisiana's coastal problems.

Authorization for the present study resulted from enactment in 1979 of subsection G, Section 213.10, of Title 49 which directed development of a critical coastline and barrier islands indexing system under the State and Local Coastal Resources Management Act. More recently, in November 1981 this was followed by passage of Act 41 by the State Legislature creating the Coastal Environmental Protection Trust Fund, and by the appointment of the Governor's Task Force on coastal erosion. Through these joint efforts implementation of coastal erosion control measures is presently being realized in a number of demonstration projects.

To assist the State in these considerations of coastal erosion problems and in program development, major aspects of the present report were advanced through the Coastal Management Section of DNR. These advance recommendations included presentations to the Secretaries of the Department of Natural Resources and Department of Wildlife and Fisheries, to representatives of the Governor's Office, and to the Joint Legislative Committee on Natural Resources. Accordingly, this report restates earlier recommendations while placing them in a broader perspective.

Example of deteriorating barrier island characterized by extensive washover development.

To arrive at recommendations for protection and management of Louisiana's Gulf shore, the report first considers active processes, natural and man-induced, to which documented changes of the shoreline and coastal wetlands can be related. In this manner the coast is divided into a number of process-based units as a requirement for functional design.

A second element in the development of a protection plan is the benefits to be derived from protective measures. While many intangibles are involved in this regard, a direct approach is to consider land uses in the immediate vicinity of the shoreline. Local and economic impacts of coastal erosion and associated wetland deterioration on present land uses are therefore evaluated and weighed as elements in recommending specific protection measures.

On the basis of the combined information concerning perceived causes, trends and rates of change, and anticipated impacts, recommendations are made for each of the coastal units in the form of measures considered most feasible for protection and management. These recommendations are further detailed in the form of three projects that demonstrate the proposed approaches.

Chapter II

Processes of Shoreline Erosion and Wetland Deterioration

Background

The barrier islands and barrier shorelines of Louisiana originated in the deltaic system of the Mississippi River. During the last 6000 years, five major delta complexes containing sixteen separate delta lobes have built the vast Deltaic Plain of south-central and southeast Louisiana (Frazier 1967), as well as the Chenier Plain of southwest Louisiana (Byrne et al. 1959).

In the Deltaic Plain, each delta lobe experiences phases of aggradation and degradation. The former represents the growth phase, when fluvial input and sedimentation rates are at their maximum. In time, favorable gradient advantages trigger diversion at some upstream point on the river. This delta-switching mechanism initiates the gradual abandonment of a particular river channel and the onset of the phase of degradation within the associated delta lobe. As the introduction of sediments slowly decreases (due to increasing fluvial discharges being directed to the new locus), active sedimentation cannot keep pace with the compaction and settlement of the recently deposited land mass. Even the large expanses of marshgrass, which first colonized the deposited sediments and assisted the aggradation phase by the production of organic matter and entrapment of fine sediments carried in suspension by tidal forces, cannot maintain a surface above sea level when subsidence becomes a dominant factor in the delta cycle. Marine processes become more important within the abandoned delta lobe, as an intricate tidal channel network develops and wave action affects the outer edge, or deltaic headland. The waves rework the outer deltaic sediments, winnowing out the fine material and concentrating the coarser material in a landward and longshore-migrating ridge, or dune. Elevations within this outer deltaic rim are higher than in more inland marsh zones because of the wave and wind processes. The combined processes of subsidence and marine forces reworking the outer rim lead to a gradual disappearance of the seaward marshes and a formation of a barrier rim. This landward-migrating barrier rim may occur as a continuous sand chain, a series of barrier islands, or a mainland-fringing barrier beach, depending upon an interplay of factors which include sand supply, wave climate, tidal-exchange forces, and stage of the delta cycle. A conceptual model of barrier evolution has been formulated by researchers at Louisiana State University (Penland and Boyd 1981; Penland et al. 1981).

The Chenier Plain of southwest Louisiana, downdrift of the Deltaic Plain, was created by alternating processes of progradation and transgression related to proximity of the active Mississippi River delta. During periods of a relatively close active delta, deltaic clays and fine silts carried in suspension by westerly coastal currents become welded to the shoreline and thus account for a net seaward progradation of the land mass. When the delta-switching mechanism redirects the locus of active sedimentation to a more distant location (the eastern sections of the Deltaic Plain, for example), wave action reworks the shoreline sediments into a barrier beach ridge within a cycle of marine transgression. (When sufficient elevations are attained, the beach ridges become colonized by live oak trees [Quercus virginiana], or chênes in French, thereby leading to the use of the term chenier in describing these ridges.) The sequence of delta systems has thus led to the present physiography of the Chenier Plain, characterized by a series of inland-stranded, east-west-trending cheniers within a vast marsh plain. As the active delta has occupied a position 200 mi (320 km) east of the Chenier Plain since historic times, the shoreline is generally eroding and can be characterized as an active barrier.

With the exceptions of the Atchafalaya Bay/Côte Blanche Bay area and the present birdsfoot delta of the Mississippi River, the entire Gulf-fronting shoreline of Louisiana consists of barrier islands or barrier beaches. These areas comprise the focus of study of this report.

Louisiana's modern-day barrier shoreline can be roughly divided into three components: the Chandeleur system, the Terrebonne-Barataria system, and the Chenier Plain system (Figure 1). The Chandeleur system, including Breton Island, is a barrier island chain, separated by 25 mi (40 km) from the mainland by Chandeleur and Breton Sounds, which represents the outer rim of the St. Bernard delta complex. The Terrebonne-Barataria system extends from Point au Fer to Sandy Point and is comprised of a series of small barrier island chains which developed following erosion of the Caillou and Caminada-Moreau deltaic headlands, and transgression of flanking barrier shores. This system is associated mainly with various deltaic lobes of the Lafourche delta system. The Chenier Plain system consists of a long, continuous barrier beach backed by marsh or beach ridges. (Marsh Island, while deltaic in origin, exhibits shore characteristics similar to those further west and is thus generalized as an appendage of the Chenier Plain system.) The shoreline is primarily sandy, with stretches of finer silts and clays near river mouths and accreting mudflats associated with pro-delta clays

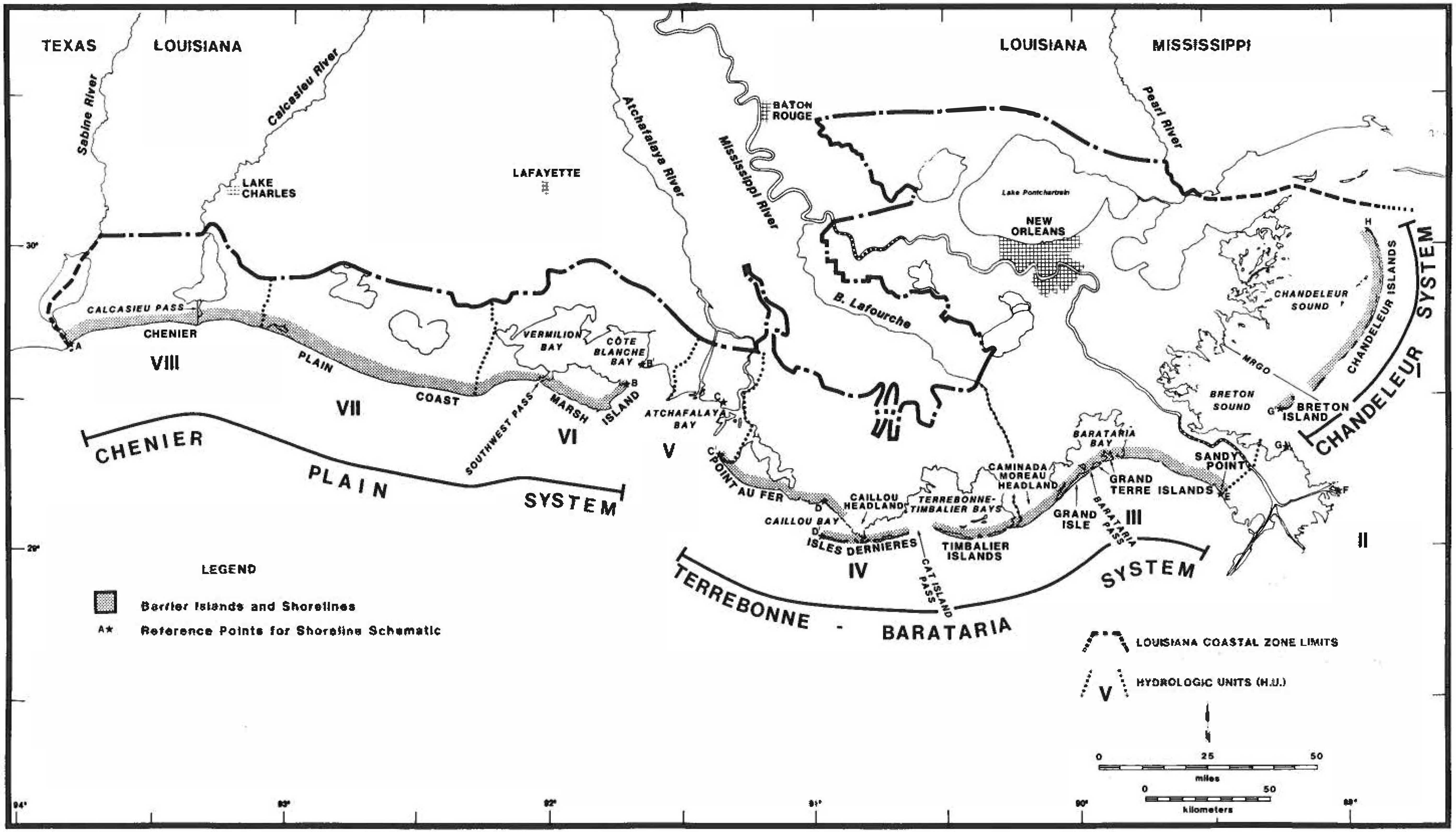


Figure 1. Louisiana's Barrier Shoreline.

of the Atchafalaya River delta. (Additional characteristics of Louisiana's shoreline are presented on Figure 2a and 2b in schematic form.)

Created by marine forces, the overall role of the barriers is to cushion the impact of the sea upon more fragile marsh deposits. And since the initial settlement of the coastal zone, the barriers have played no small role in buffering damaging storms and hurricanes and "absorbing" much of the wave energy expended upon Louisiana's shores. Barrier islands and tidal inlets until now have been important regulators both of water exchange between the Gulf and the bays and of transfer of wave energy from the Gulf into the bays. As barrier islands erode and tidal inlets widen, the impact of the sea upon the bay areas and lower marshes increases.

The entire barrier shoreline of Louisiana is characterized by erosion and shoreline retreat as well as naturally high subsidence rates. Prior to the twentieth century, erosion and retreat rates were partially offset by renewed sediment input. Annual overtopping of the Mississippi River natural levees during spring flooding provided sediments necessary to maintain interdistributary wetlands. Tidal forces aided in distributing these sediments within the gulfward marshes. Numerous distributaries received freshwater input during the spring floods, and valuable coarse sediments were funnelled to and distributed along the shoreline. Bayou Lafourche, for example, was an important conduit for river sediments until early in this century. Today, the Mississippi River is totally contained by artificial levees throughout the Deltaic Plain. Fluvial sediments are not only no longer being introduced into the interdistributary swamps and marshes, but are lost to the steep slopes of the Outer Continental Shelf by way of the passes of the active delta. (The sole exception to this is the regulated Atchafalaya River, which is presently building a delta in Atchafalaya Bay and contributing to mudflat accretion on the Chenier Plain shoreline. Nonetheless, land accretion is still minor in comparison to the overall erosion.) The result of this modern cutoff of sediments has been increased shoreline erosion and severe land loss presently amounting to over 40 sq mi/yr (100 km^2/yr) per year within the coastal marshes of the Deltaic Plain alone (Gagliano et al. 1981).

Subsidence

A dominant process contributing to shoreline erosion and land loss in coastal Louisiana is the downward movement of the land surface in relation to sea level. This is caused by a variety of factors, which include sea level rise, tectonic processes such as crustal downwarping, folding, and faulting, and compaction of sediments due to overlying weight, extraction of water and hydrocarbons from the subsurface strata, and wetland reclamation (Adams et al. 1976).

For the sedimentary environment present in the Deltaic Plain, the factor of crustal downwarping is considered very important. Estimates of long-term subsidence rates, based upon radiocarbon dating of buried peat deposits, have ranged from averages of 0.35 ft/century (0.1 cm/yr) assuming steady sea level (Frazier 1967; Gagliano and van Beek 1970) to 0.78 ft/century (0.2 cm/yr) for the Lake Pontchartrain area (Kolb and van Lopik 1958), the latter incorporating an assumed sea level rise rate of 0.32 ft/century (0.1 cm/yr). (Considerable variability in subsidence rates is found across the Deltaic Plain, and these two estimates represent averages.) A refined estimate of 0.1 ft/century (0.035 cm/yr) for the sea level rise component of relative subsidence was derived by sedimentary analysis of the geologically stable Cape Sable region of south Florida (Scholl et al. 1969).

Short-term trends, as observed by analysis of tide gauge records, indicate much higher relative subsidence rates. Swanson and Thurlow (1973), after subtracting out 0.035 cm/yr (0.1 ft/century) for estimated eustatic sea level rise, examined subsidence patterns along the Gulf Coast for the 1948-1971 period and noted a significant change in rates occurring about 1959. At Bayou Rigaud, for example, subsidence rates were calculated at 0.27 cm/yr (0.9 ft/century) for 1948-1959 and 1.29 cm/yr (4.2 ft/century) for 1959-1971 (Swanson and Thurlow 1973). Updating of the 1973 study and inclusion of the eustatic component led to a calculation of a subsidence/sea level rise rate of 1.30 cm/yr (4.3 ft/century) for 1954-1979 at Bayou Rigaud (Baumann 1980). Comparable rates (over 4 ft/century [1.2 cm/yr]) were derived for Bayou Chevreuil in upper Barataria Basin and Calcasieu Pass near Cameron (Baumann 1981, personal communication). (For the east end of the Galveston, Texas seawall, relative subsidence rates of 2.6 ft/century [0.79 cm/yr] were derived [Price and Parker 1979].)

Since the Mississippi River has been harnessed effectively by protection levees, and overbank flow and crevassing have been virtually eliminated, the lack of newly introduced sediments has resulted in an "accretion deficit." Sedimentation is now limited to the reworking of bottom sediments by tidal forces, and the rate of marsh build-up is no longer keeping pace with the subsidence rate. Recent sedimentation studies in lower Barataria Basin indicate vertical accretion rates of 1.35 cm/yr (4.4 ft/century) in streamside marshes and 0.75 cm/yr (2.5 ft/century) for marshes 45 m (147 ft) from streamside (Delaune et al. 1978). In other words, only the natural levees of the tidal channel are barely keeping pace with the subsidence rate, whereas slightly more distant marshes show an accretion deficit. It is in these latter regions that marsh breakup and land loss will tend to dominate. This pattern is quite common in the littoral zone, as well as in more inland marshes (see Appendix, Plate 26 for example).

The combined factors of subsidence and sea level rise have a direct effect upon shoreline erosion (Figure 3). Formulas have been developed to theoretically arrive at shoreline retreat rates (Bruun 1962; Weggel 1979). A rough estimate of Louisiana conditions can be made by using a formula modified from Bruun (1962),

$$\left(x = \frac{ab}{h+d}\right)$$

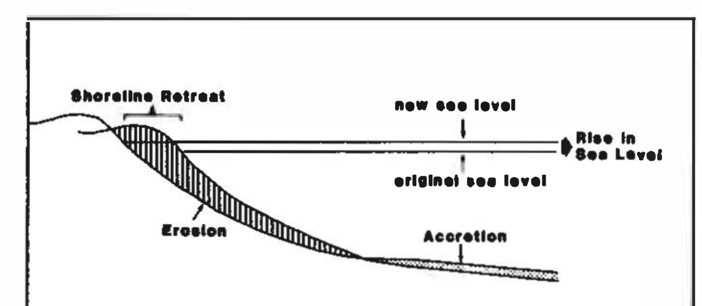


Figure 3. Impact of Sea Level Rise Upon Shorelines (after Bruun 1962).

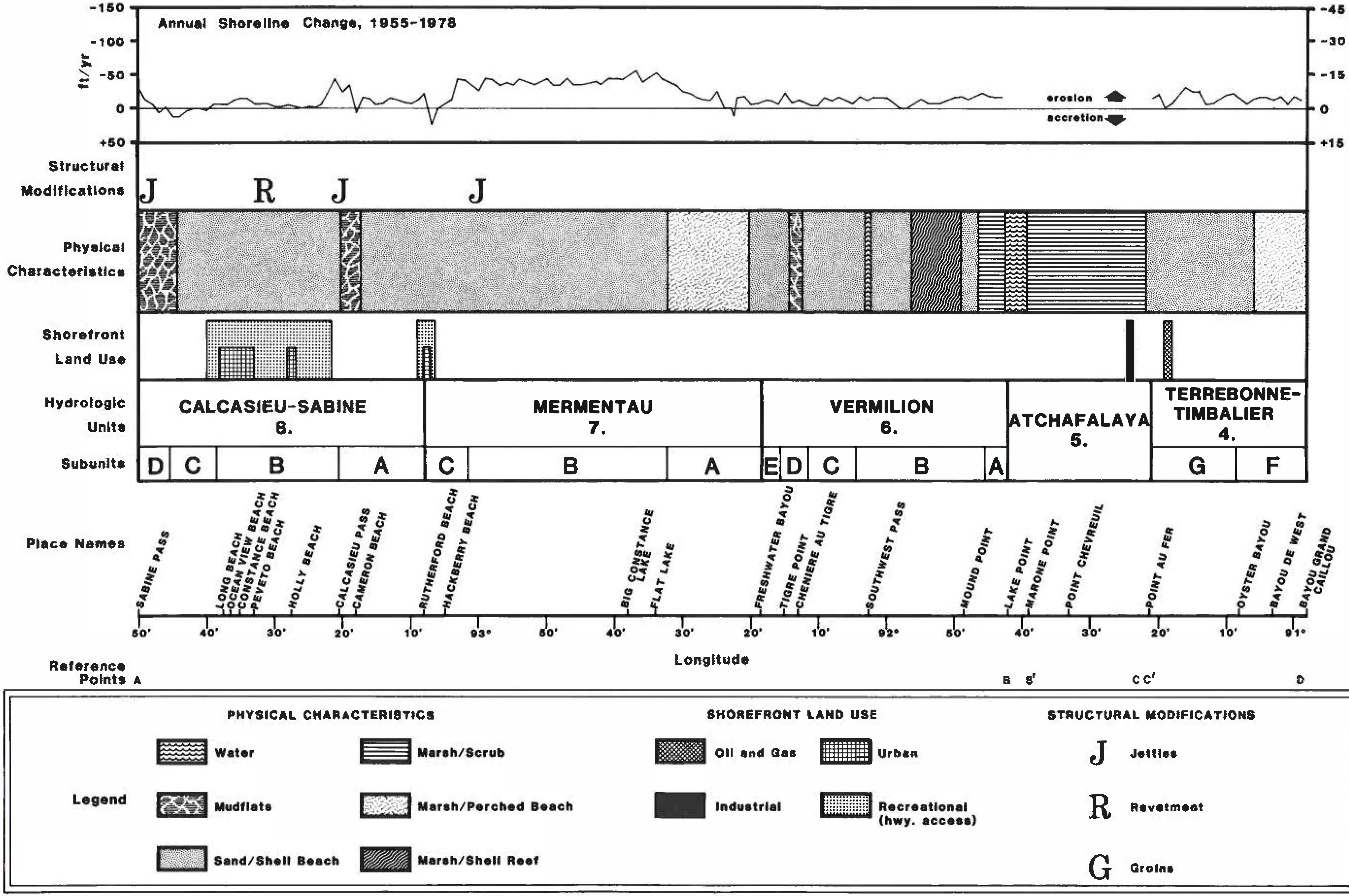


Figure 2a. *Louisiana Shoreline Schematic.*

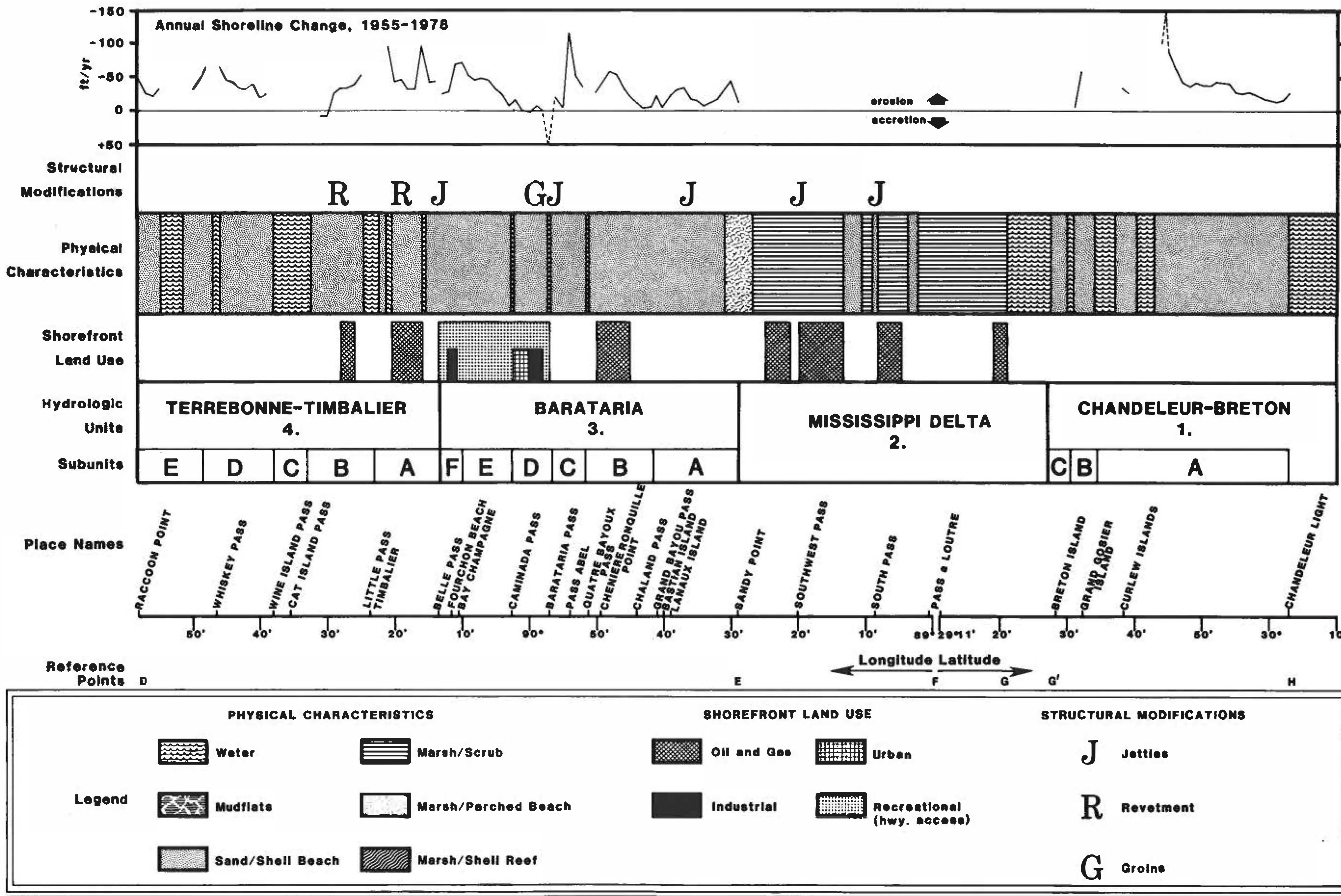


Figure 2b. Louisiana Shoreline Schematic.

whereby x is the amount of recession, a is the vertical displacement of sea level relative to land, b is the distance from shore to the first depth contour, d, the distance beyond which little sediment transport takes place, and h is the dune height on the shore. For the Terrebonne-Timbalier shoreline, the equation becomes

$$x = \frac{4 \text{ ft/century} \times 8000 \text{ ft}}{(4 + 18) \text{ feet}}$$

or 1455 ft/century (446 m/century). That is, the combined processes of subsidence and sea level rise (estimated at over 1.2 cm/yr or 4 ft/century) are calculated to account for 15 ft (4.5 m) of the annual shoreline erosion. Wave action contributes to the actual higher retreat rates, but subsidence/sea level rise is a very significant factor in shoreline erosion.

Energy Input

Waves

Under the prevalent condition of subsidence and a limited sand supply, the reworking of sedimentary deposits is the main process by which Louisiana's barrier system is maintained. Waves are a controlling factor in this process by providing much of the energy necessary to entrain and move the sediments and by determining sediment retention. Movement of sediments as a result of wave action generally is considered in two directions: onshore-offshore and longshore.

Onshore-offshore movement is often reflected by rapid changes, such as erosion and washover, during a storm and the subsequent return of sediment to the beach after a storm. These changes are controlled primarily by wave steepness and the extent to which water levels are elevated by storm-surge. Offshore-onshore movement is important for at least two reasons. One is that major storms such as hurricanes may cause offshore movement of sediments to depths from which they will not be returned by subsequent fair weather conditions. The second reason is that onshore-offshore components of wave action are the dominant control over sorting and retention of sediments placed on the beach as nourishment.

Longshore movement of sediment becomes apparent in the migration of the barrier islands, in the lateral movement of inlets, and in shoreline erosion and accretion where the beach zone is interrupted by structures such as groins and jetties. Longshore transport by waves results where sediment is placed in suspension by the shoaling and breaking waves and moved as a result of the longshore component of water motion associated with the wave or the longshore current generated by the waves. This transport may be augmented or opposed by tidal- and wind-generated current, in particular near the tidal passes. The extent and direction of longshore transport are controlled largely by the breaker height and direction of wave approach.

Most of the sediment transport takes place in the surfzone involving the interactive processes between shoaling and breaking waves, tidal currents, and surfzone topography. Longshore bars play a major role in this regard as a storage mechanism and as avenues for longshore transport. These interactions have not been very well defined along the Louisiana coast, and a general lack of information exists concerning average nearshore wave conditions or wave climate.

Because the major economic interests in Louisiana affected by waves are offshore oil and gas development and navigation, most data collection efforts have focused on offshore conditions and are proprietary. Some efforts have been made to define the offshore wave climate on the basis of wave conditions hindcasted from weather observations and by using ship and platform data. These summaries show a dominance of southeasterly waves from 2 to 6 ft (0.5 to 1.5 m) high (Becker 1972; Glenn and Associates 1972; Suhayda 1976). As expected, most of the highest waves occur during the fall and winter and are associated with hurricanes and fronts. Only general conclusions can be drawn directly from offshore wave data relative to beach change. As waves travel shoreward, significant changes occur as a result of bottom topography and sediments. Changes in height and direction of travel take place as waves are increasingly affected by the shelf bottom. Consequently, considerable variation in surfzone conditions exists along Louisiana's coast because of differences in shelf topography, sediment characteristics, and angle between the shoreline and approaching waves.

Using linear wave theory, shelf bathymetry, and bottom sediment conditions (BLM 1979), a general estimate can be made as to wave conditions along Louisiana's shoreline. This was done by Becker (1972) on the basis of hindcasted data and in this study on the basis of offshore observations (Suhayda 1982, personal communication). Our estimates indicate that most of the total annual wave energy is provided by offshore waves having a significant height (H_S) of 10-15 ft (3.1-4.6 m) and approaching from the southeast. Resulting from shelf conditions, wave energy associated with these waves is highest along the modern delta and the Fourchon area. Lowest energy conditions are found in the area of the Atchafalaya delta. Energy levels along the Chandeleurs are higher than those along the Chenier Plain.

A second consideration is the direction of wave propagation. For the above wave spectrum, longshore energy flux (as a measure of longshore transport) was smallest in the Atchafalaya Bay area (because of the low wave energy) and highest along the Chenier coast. Of further interest were the comparatively low values found in the area of Fourchon, Grand Isle, and Grand Terre, indicating that offshore movement of sediment is the more important element in the shoreline erosion in at least that area.

Hurricane Effects

Hurricane and major storm surges play a significant role in the erosion of barrier islands and shorelines. Striking the Louisiana coast approximately once every three years (Neumann et al. 1978), hurricanes account for as much as 90% of shoreline retreat. The impacts of hurricanes upon the Chenier Plain coast have been documented for the Chenier Plain coast (Morgan et al. 1958), the Caminada-Moreau headland and adjacent islands (Adams 1970; Penland and Ritchie 1979), and the Chandeleur Islands (Boyd and Penland 1981; Kahn 1980; Nummedal et al. 1980; Wright et al. 1970).

A considerable proportion of shoreline retreat is attributed directly to hurricanes. Based upon analysis of historic maps and storm records, hurricanes were found to account for 50-90% of total shoreline retreat in the Chandeleurs (Kahn 1980). Hurricanes Camille (1969) and Frederic (1979) each caused 130-260 feet (40-80 m) of shoreline erosion (Kahn 1980). Hurricane Audrey (1957) accounted for dune crest setbacks of 50-300 ft (15-90 m) along the Chenier Plain coastline (Morgan et al. 1958). Inspection of pre-and post-Audrey aerial photographs of Holly Beach indicates both dune crest setback and shoreline retreat of 100-120 ft (30-36 m).

In southwest Louisiana, beach profiles surveyed before and after Hurricane Audrey in 1957 provided insights into storm-related morphologic changes (Morgan et al. 1958), as illustrated in schematic form on Figure 4. At Holly Beach, for example, a gulf-fronting, sandy barrier beach ridge abuts a thin (3-6 ft or 1-2 m) layer of organic marsh deposits overlying gulf bottom silts and clays (Fisk 1955). During hurricanes, water levels completely inundate all surface features, and the beach dune crest becomes eroded (in a dominantly inland direction) and flattened. Following the return of water levels to mean sea level, the dune crest, lower in elevation, has shifted landward and the beach is very wide. As a new equilibrium profile develops, the shoreline retreats to a position roughly approximating the pre-hurricane profile. While some of the beach sand becomes lost to the offshore, much is carried onto the "new" dune by wave action until a dune height comparable to the pre-hurricane height is attained (Morgan et al. 1958).

Hurricane effects upon the barrier islands are usually more detrimental than upon barrier shorelines such as in southwest Louisiana. While similar mechanisms of dune and shoreline retreat are at play, the barrier islands lack the extensive marsh backing. As a result the potential for breaching and accelerated erosion because of tidal scouring becomes more significant. In areas where island widths are precariously narrow, high shoreline setback following a major storm may induce breaching. On island chains such as the Isles Dernieres where available sand supply is insufficient to reseal breaches, permanent tidal inlets develop. In addition to disrupting the sand transport system, inlet development induces increased tidal scouring and island erosion. On the central Chandeleur Islands, however, washovers that become ephemeral tidal inlets following hurricanes tend to gradually reseal themselves (Boyd and Penland 1981). This is attributed to a more abundant sand supply in this area. The islands which comprise the southern Chandeleurs are much lower in elevation and subject to higher erosion during storms (Kahn 1980). Many of these islands (such as the Curlews) disappeared completely following Hurricane Camille (Wright et al. 1970).

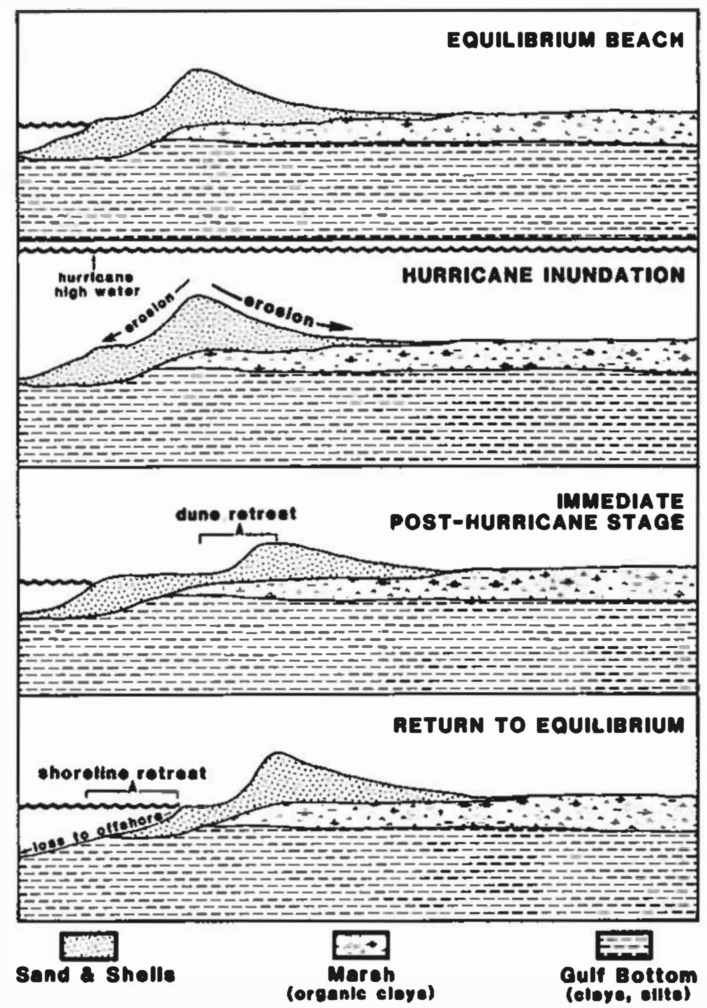


Figure 4. Hurricane Effects Upon Chenier Plain Shoreline (after Fisk 1955; Morgan et al. 1958).

Sediment Supply and Transport

Louisiana's barrier islands were formed by depositional and erosional processes characteristic of the degradational phase of the delta cycle. Following abandonment of a delta lobe by the main flow of the Mississippi River, marine forces begin to dominate, particularly at the outer rim of the delta lobe. Via transgressive erosion of the deltaic headlands, finer sediments are winnowed out and carried offshore, while coarser sands remain to be redistributed as dunes and beach ridges by wave action. Longshore currents in the nearshore zone redistribute some of these sands laterally, in the form of flanking barrier spits. So, in addition to a gradual inland migration of the active beach ridge (as a combined result of subsidence/sea level rise and wave attack), longshore drift of sediment accounts for lateral growth of the barrier beach. As tidal exchange forces lead to breaching and development of tidal inlets, the barrier spits are severed and become flanking barrier islands. (The Timbalier Islands and Grand Isle represent flanking barrier islands of the Caminada-Moreau headland, for example.)

Sandy barrier beaches, characteristic of the Caminada-Moreau deltaic headland and most of the Chenier Plain coast, are maintained by erosion of cheniers and beach ridges and reworking of in situ sands. Dominant nearshore currents account for longshore transport of reworked sands, the direction of which is dictated by a combination of prevailing winds and waves and angle of shoreline orientation. As a generalization, shorelines oriented counter-clockwise of ENE-WSW (azimuth of less than about 67°) will exhibit dominantly eastward drift patterns, while more east-west or southeast-northwest-trending shorelines display westward drift patterns. In the Chenier Plain, overall drift patterns are dominantly westward, and the distribution of sand beaches generally reflects the erosion of updrift beach ridges and cheniers. Sediments eroded from the Caminada-Moreau headland are transported to both flanks and historically nourished both the Timbaliers and Grand Isle. (The highest shoreline retreat rates and the point of bifurcation of sediment transport occur near the present site of Port Fourchon.) The physical processes base map (Figure 5) displays directions of net sediment drift across the state.

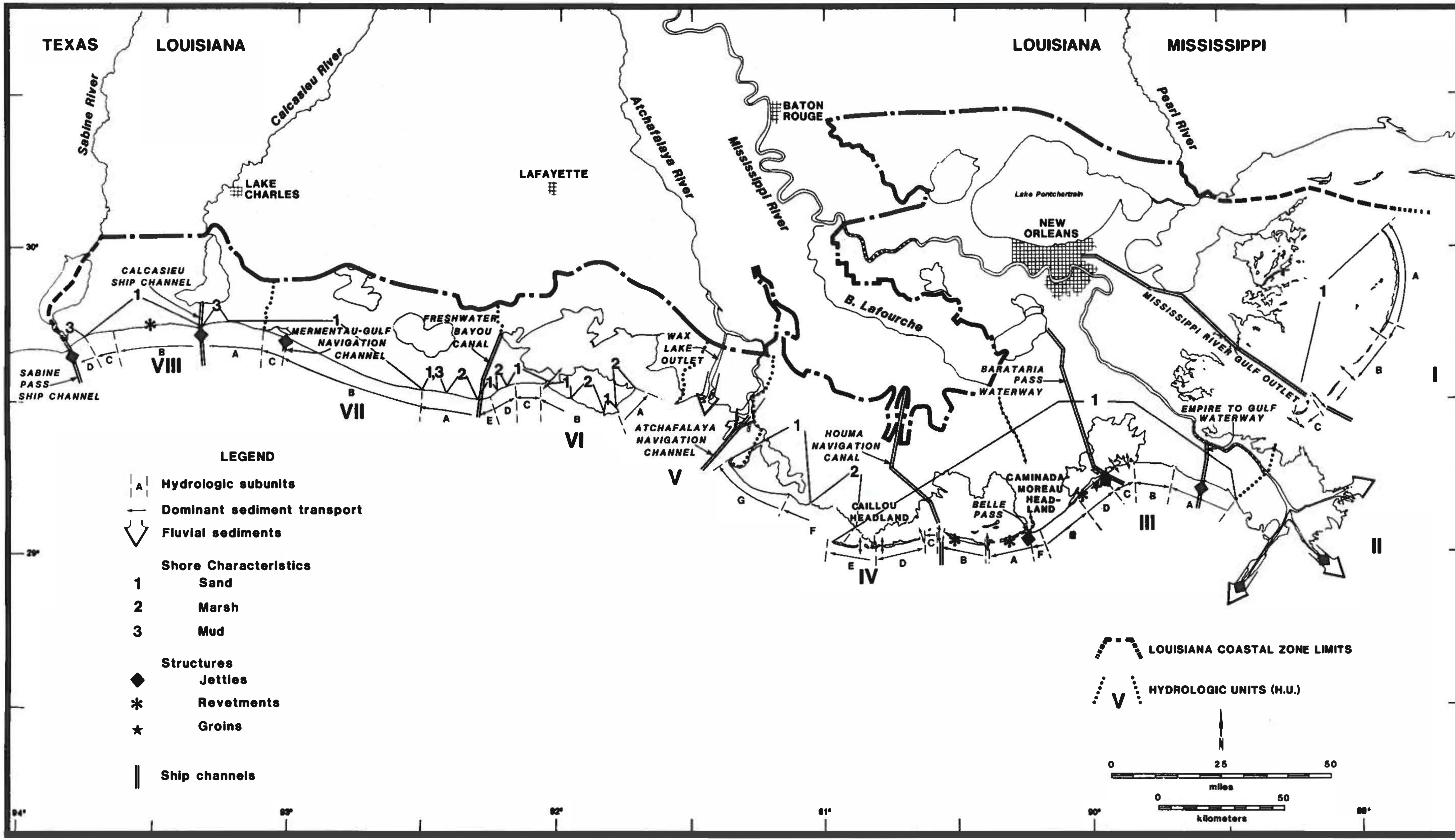


Figure 5. Physical Processes Along the Louisiana Shoreline.

Barrier islands and beaches are maintained by marine processes which rework the sediments bayward and alongshore. Where barrier islands are still flanking deltaic headlands (an early stage of delta lobe deterioration best displayed at the Caminada-Moreau headland), sediments eroded from the headland and transported alongshore contribute to the nourishment of those islands. In older delta lobes where the mainland has been detached from the barrier rim due to subsidence, the barrier islands are maintained only by the reworking of in situ coarse sediments. The Chenier Plain barrier beaches are also due to erosion and reworking of sediments in combination with longshore transport processes. (The zone of recent mudflat accretion near Freshwater Bayou, reflecting the recent development of the Atchafalaya delta, has been shifting westward, in part because of longshore processes [Wells and Kemp 1981].)

Fluvially-introduced sediments are presently contributing very little toward nourishment of the barrier islands and beaches. The major passes of the Mississippi River delta extend onto the slopes of the Outer Continental Shelf, and coarse sediments (that are not dredged) are lost to deep, offshore waters. The Atchafalaya River and Wax Lake Outlet have contributed coarse sediments to Atchafalaya Bay, and small deltas have developed since the early 1970s. While finer sediments are being transported to the Chenier Plain coast by longshore currents, the coarser material is remaining within the bay.

Tidal inlet during ebbing tide (Belle Pass in background).

The Role of Tidal Inlets

Tidal inlets, while serving as important conduits for water exchange between estuarine bay areas and the open Gulf, disrupt sediment transport patterns and contribute to the deterioration of barrier islands. Longshore migrating sediments entering a tidal inlet are picked up by the swift ebb or flood currents in the inlet throat and deposited in the form of fans, or ebb- and flood-tidal deltas, at the points where current velocities diminish. During flood tide, sediments are carried in suspension by landward flow and deposited on the inner bar, and during ebb tide, flow and sediment movement is toward the Gulf (Figure 6). For the Barataria Basin tidal inlets, ebb-tidal currents were found to be slightly higher in velocity than flood-tidal currents (Marmer 1948). Where the sediment supply is abundant or an inlet is in early stages of development, a considerable portion of the transported sediment is able to bypass the inlet (during ebb tide) in the form of offshore shoals migrating along the ebb-tidal delta and reattaching to the downdrift barrier island (Figure 7). One effect of ebb-tidal deltas is the refraction

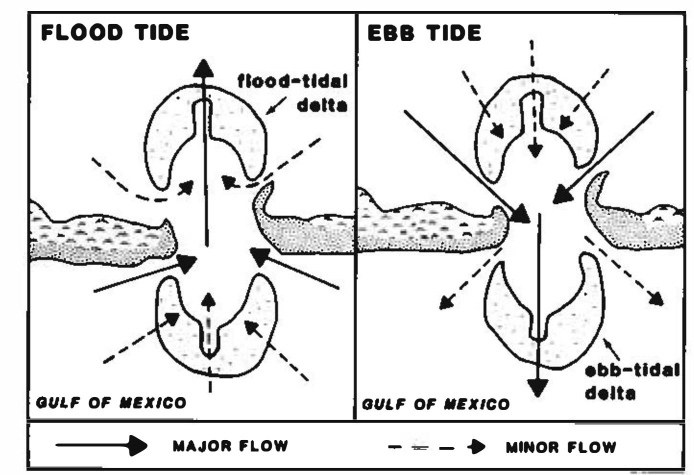


Figure 6. ***Currents Within Tidal Passes.***

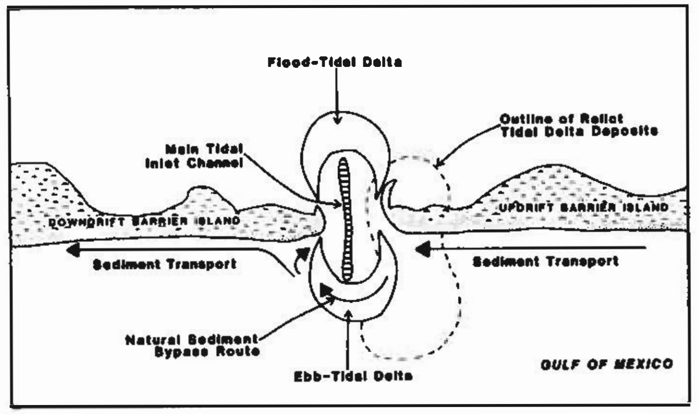


Figure 7. ***Role of Tidal Inlets in the Sediment Transport System.***

of waves, which tends to foster a reversal of dominant longshore transport at the adjacent spits of the downdrift barrier island (FitzGerald and Hayes 1980). This process accounts for accretionary trends at downdrift spits and the often bulbous outline of the updrift end of barrier islands (Hayes 1979). As the tidal inlets deepen and widen through time (due to factors of subsidence, sea level rise, shoreline erosion, and a resulting increase in the tidal prism), ever-decreasing amounts of sediment are able to bypass the inlet, and ever-increasing amounts become tied up in the tidal deltas. Thus, the erosion rate of the barrier islands is accelerated as less sediment remains available for replenishment.

In addition, if a tidal inlet migrates bayward because of shoreline retreat and/or laterally because of longshore processes, valuable sediments become tied up in relict tidal deltas and, thus, removed from active sedimentary processes. The tidal deltas may continue to absorb incoming wave energy and thus afford some measure of protection to proximate shoreline areas.

Two basic types of tidal inlets are recognized, migrating and stable (FitzGerald and Hayes 1980). Inlets generally migrate when longshore transport is dominant in one direction and subsurface sediments are largely unconsolidated sands. Deeper inlets, entrenched in organic and gulf bottom clays, are less likely to migrate. Examples of both inlets can be seen at Wine Island Pass and Cat Island Pass in Terrebonne Parish (Figure 8).

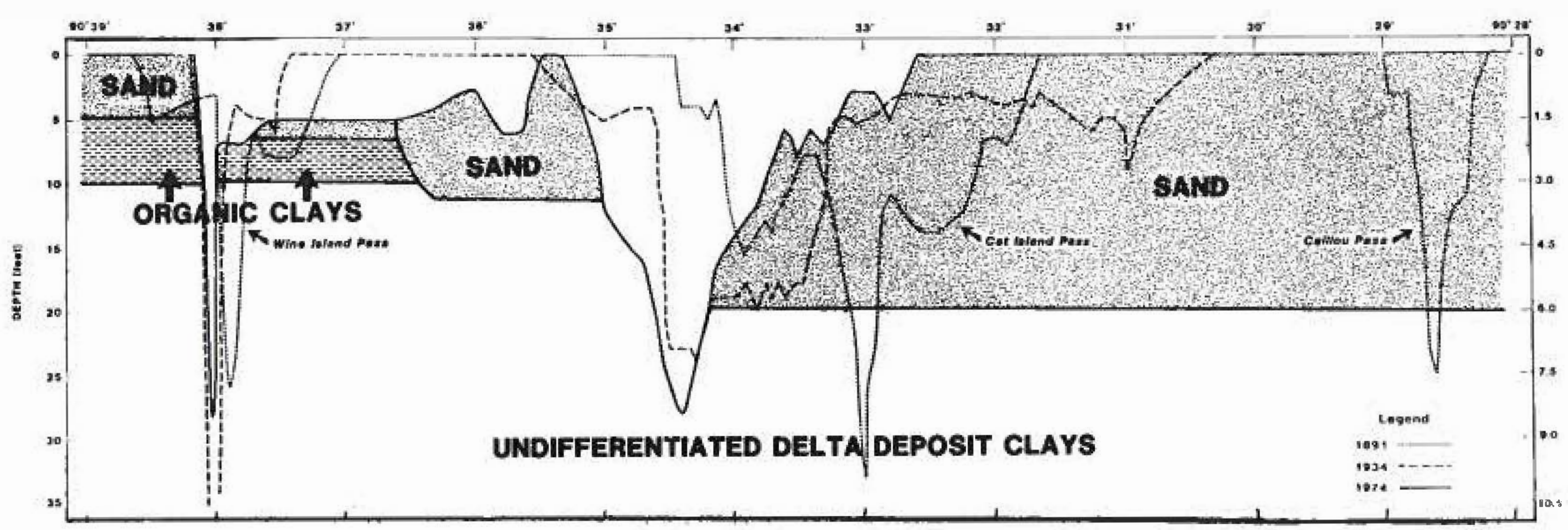


Figure 8. ***Geologic Cross Section, Wine Island Pass and Cat Island Pass (after USACE 1961).***

Man-Induced Effects

Shoreline erosion and wetland deterioration rates have accelerated greatly during the twentieth century (Gagliano et al. 1981), and a large proportion of this acceleration can be attributed to the influence of man. The largest impact upon the Deltaic Plain has been the harnessing of the Mississippi River for flood-control and navigation purposes, while additional impacts have resulted from the reclamation of wetlands, extraction of subsurface hydrocarbons, canal-dredging, and modification of the shoreline.

Pipeline canal bisecting island.

The harnessing of the Mississippi River and the clearing of log jams on its tributaries have effectively limited overland flow and associated sedimentation within the interdistributary basins of the Deltaic Plain. The construction of dikes along the river began with the first settlers, but it was not until after the 1927 flood that the present levee system was completed. With the exception of occasional levee breaks during flood stages, Mississippi River waters (and valuable delta-building sediments that are carried in them) are confined to the channel until the extreme lower reaches. The process of crevassing has been virtually eliminated, and formerly active distributaries such as Bayou Lafourche have been sealed off for flood control.

The only active distributary today is the Atchafalaya River, regulated to 30% of Mississippi River flow at its point of divergence, which is presently delivering sediments to Atchafalaya Bay. A subaerial delta has been building during the last decade (Meyer-Arendt and van Beek 1980), and pro-delta clays are actively accreting on the Chenier Plain coast (Kemp and Wells 1981).

Were it not for the regulation of Atchafalaya River flow at the Old River Control Structure near Simmesport, the Mississippi River may have been captured by the Atchafalaya. But, for economic reasons, the Mississippi channel is maintained, and consequently sediments important for delta-building are being funneled through the lower passes onto the slopes of the continental shelf. By keeping the Mississippi River in its present position, the high land-loss rates of former delta lobes cannot be offset by land gained in active deltas. Hydrologic Unit 5 (Atchafalaya Bay) is exhibiting some land gain, but because of the regulation of flow and maintenance dredging of the lower channel through the Atchafalaya delta, wetland growth is being hindered (van Beek and Meyer-Arendt 1981).

The reclamation of wetlands by man has seriously affected hydrologic and sedimentary processes. Reclamation projects undertaken to allow urban and agricultural expansion remove large tracts of wetlands from the natural system, thereby disrupting overland flow patterns and reducing available nutrient supply to valuable estuarine-dependent species (e.g., shrimp). Reclamation projects are often accompanied by construction of pumping stations and drainage canals. Canals tend to channelize outflow and remove water from upper portions of basins much faster than overland flow or meandering bayous would permit. The net effect of this forced drainage is increased flooding potential in middle and lower portions of interdistributary basins and increased summer drought potential in upper basin wetlands. Much brackish marsh in the western portion of the state has been leveed for wildlife management purposes. While water levels and salinities can be regulated to maintain an optimum habitat (such as for waterfowl), the lack of tidal exchange precludes the introduction of renewed sediments, as well as the export of important nutrients (Gosselink et al. 1980).

In addition to direct wetland loss due to displacement by water and spoil deposits, a major effect of canalization in wetlands is hydrologic modification. Canals trending perpendicular to the shoreline tend to accelerate water exchange, i.e., saline bay waters are able to penetrate further inland, and during low water periods fresher, upper basin waters are flushed bayward more rapidly. The saltwater intrusion process is the more serious impact as fresh marsh species, rooted and floating (flotant), cannot maintain themselves. The marsh tends to break up and turn to open water, although limited colonization of the remaining land by more salt-tolerant marsh species takes place. The process of marsh breakup via saltwater intrusion is accelerated by lineal waterbodies which act as conduits. Although most destruction is related to bigger and deeper conduits (natural bayous, dredged canals, or dredged bayous), even small, lineal scars through the marsh (trapping canals, or trainasses) contribute to saltwater intrusion and marsh breakup (Figure 9). Canals trending parallel to the shoreline orientation disrupt normal flow patterns in that the associated spoil banks create hydrologic impoundments. The consequent lack of renewed sediment introduction by tidal processes increases the land loss potential within the impounded area. In the barrier shoreline environment, normal-to-shore canals can develop into major tidal inlets, as has occurred between Belle Pass and East Timbalier Island (Figure 10). Canals dredged parallel to shore on the barrier island or beach (or directly behind it) tend to act as sand traps as the shoreline retreats bayward (Figure 11).

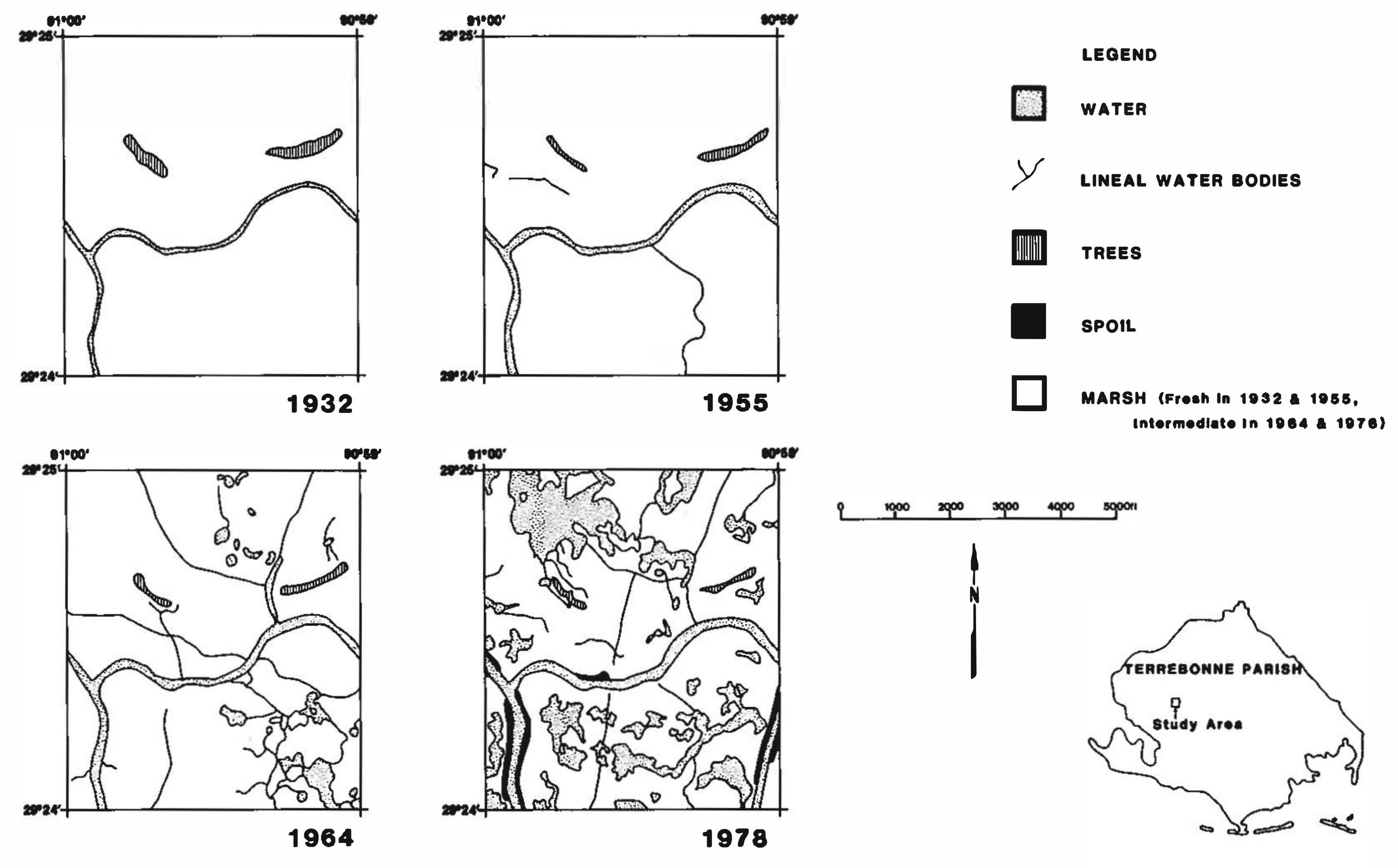


Figure 9. Impact of Canals Upon Wetland Deterioration.

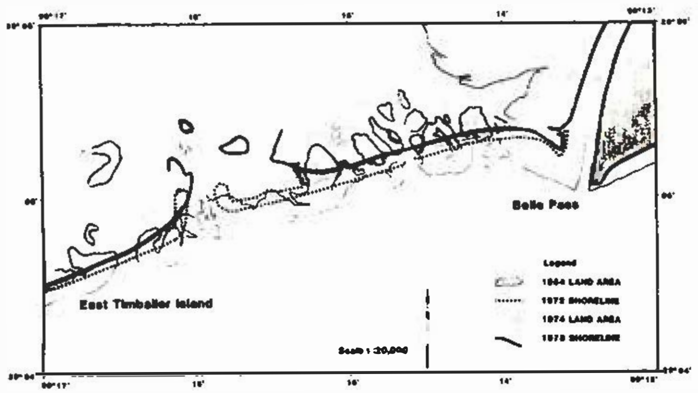


Figure 10. ***Impact of Canal Dredging Upon Tidal Inlet Development, East Timbalier Island.***

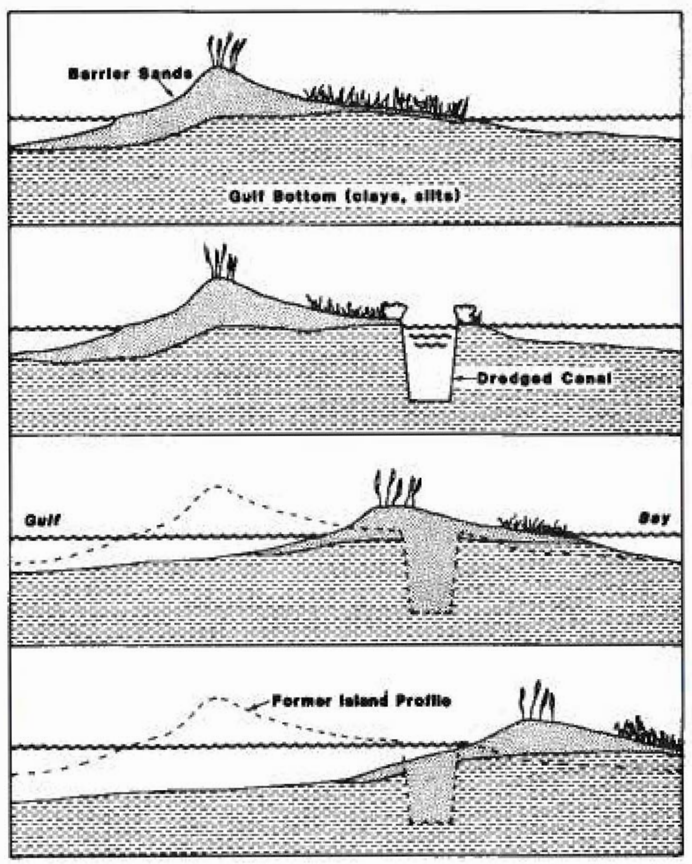


Figure 11. ***Effects of Shore-Parallel Canals Upon Barrier Islands.***

Extensive canal-dredging activity is usually directly related to extraction of subsurface hydrocarbons, a process which may account for increases in subsidence rates. While subsidence linked directly to oil and gas extraction is normally associated with shallow fields comprised largely of unconsolidated sands (Kreitler 1976), oil and gas extracted from depths as great as 8000 to 9500 ft (2400 to 2900 m) can influence surface subsidence rates (Erickson 1976; Schoonbeck 1976). Many of the wells drilled in coastal Louisiana tap fields at 18,000 to 25,000 below surface, and whether this deep-drilling affects subsidence rates has yet to be determined. A significant increase in the rate of landward migration of the salt-marsh zone has been attributed to the petroleum industry (Monte 1978).

Direct effects by man upon Louisiana's shoreline include canal construction, maintenance dredging, and shoreline protection construction. Twelve major navigation channels bisect the Gulf shoreline, and channel training jetties are in place at eight of them. Much sediment, valuable for the maintenance of barrier islands, beaches, and wetlands, is dredged annually from these channels to maintain sufficient water depths. At sites of coastal settlement or development (e.g., Grand Isle, Peveto Beach, East Timbalier), erosion control measures such as groin fields and rip-rap dikes have been constructed in attempts to stabilize the shoreline. Approximately 14 mi (22.5 km) of the state's 300 mi (480 km) of barrier shoreline have been modified via shore protection measures.

A significant impact of shoreline structures is the disruption of sediment transport processes. In cases where jetties have been constructed at the outlets of navigation channels to minimize shoaling, sediments accrete updrift of the jetty (or at least erode less rapidly), while the downdrift shoreline, starved of sediments, erodes more rapidly. This process is cartographically best illustrated at the mouth of the Gulf-Empire Waterway (Plate 26), and also at Belle Pass, where a prominent downdrift offset has developed (see Figure 10). Also, by disrupting the natural patterns of headland erosion and longshore sediment transport to downdrift-flanking barrier islands and spits, the sediment supply to the distal ends of the flanking barriers becomes cut off. A case in point is Timbalier Island in Terrebonne Parish. Originally a flanking barrier of the Caminada-Moreau headland, the island accreted westward over 4 mi (6.5 km) during the last century, as a result of renewed sediment nourishment and longshore littoral processes. Very little outside sediment now reaches the island because of: a) widening of tidal inlets (natural and man-induced), b) construction of sediment-trapping jetties at Belle Pass, and c) extensive dike construction on East Timbalier Island. Sand no longer is transported alongshore to Timbalier Island, and the island is not only eroding rapidly at its eastern end, but is reorienting itself in a more east-west alignment in response to prevailing waves (Penland and Boyd 1981). Shoreline modification at Grande Isle (groins and jetties), on the eastern flank of the Caminada-Moreau headland, occurs near the downdrift end of the sediment transport system, and disruptions in sediment transport have been less severe. (Shoreline erosion and modifications will be discussed in more detail in Chapter III.)

Summary of Causes

Each of the eight hydrologic units that comprise the Louisiana coastal zone is affected by some or all of the above described physical processes, natural or man-induced, in varying degrees of magnitude. While some processes, such as subsidence/sea level rise, may be relatively uniform across the coastal zone (with the exception of the active Mississippi River delta), others occur at varying intensities which are difficult to quantify. As a general rule, the greatest number of detrimental forces acting upon the shoreline occur in the degradation phase of Mississippi River delta lobes. These hydrologic units (1, 3, and 4) are characterized by a deficiency of sediment, tidal inlet widening, and barrier island deterioration. Table 1 presents shoreline erosion and land-loss statistics for each of the hydrologic units and outlines the physical parameters important within the respective shoreline areas. As an accurate quanti-

									PROCESSES IMPACTING THE SHORELINE								SEVERITY RANKING[6] (1 = most severe)					
							Probability of Hurricane Occurrence													Amount of Development[7]		
Hydrologic Unit	Name	Gulf Shore Description	Shoreline[6] Length (miles)	Shoreline[1] Retreat (ft/yr)	Land Loss Rate[2]	Last Hurricane[3]	winds >74 mph	winds >125 mph	Subsidence	Sediment Deficiency	Longshore Drift	Tidal Inlet Widening	Barrier Island Deterioration	Oil & Gas Activity[4]	Extensive Canali-zation[4]	Shore-line Modification	Land Loss[5]	Shore-line Erosion	Hurricane Probability	Within H.U.[5]	Within Littoral Zone	MEAN
I	Chandeleur-Breton	Barrier Islands	41	32.8	-3.5	1979	9%	4%	x	x	xx	xx	xx	--	--	--	3	2	2	3	6	3.2
II	Mississippi Delta	Active Delta	--	--	-13.3	1969	9%	4%	xx	x	--	--	--	xx	x	xx	--	--	--	--	--	--
III	Barataria	Barrier Islands & Beaches	52	27.2	-3.9	1974	13%	2%	x	xx	xx	xx	xx	xx	xx	xx	2	3	1	1	1	1.6
IV	Terrebonne-Timbalier	Barrier Islands & Beaches	72	35.7	-4.0	1974	9%	0%	x	xx	xx	xx	xx	xx	xx	xx	1	1	3	2	5	2.4
V	Atchafalaya	Active Delta	--	--	+0.5	1974	9%	0%	x	--	--	--	--	x	--	x	--	--	--	--	--	--
VI	Vermilion	Barrier Beach & Shell reefs	43	11.6	-1.6	1957	6%	0%	x	x	x	--	--	x	x	--	6	5	6	5	4	5.2
VII	Mermentau	Barrier Beach & Mudflats	54	30.3	n.a.	1957	6%	1%	x	x	xx	--	--	xx	xx	x	4	4	5	6	3	4.4
VIII	Calcasieu-Sabine	Barrier Beach & Mudflats	46	8.9	n.a.	1961	8%	4%	x	x	xx	--	--	x	x	xx	5	6	4	4	2	4.2

1 annual average rates 1955-1978
2 in ac/mi^2/yr, averaged over the hydrologic unit south of coastal defense line
3 minimum wind speed of 111 mph (179 kph) on Saffir-Simpson scale (Simpson and Riehl 1981)
4 within 2 miles of gulf shoreline
5 below coastal defense line
6 Barrier HUs only
7 in area

Table 1. Active Processes and Relative Severity of Louisiana's Hydrologic Units.

fication of the relative impacts of these processes would prove quite difficult, only relative importance (none, light, or heavy) is outlined on the matrix. The severity of overall land loss within the Louisiana coastal zone is best depicted cartographically (Figure 12).

Plates 1 through 31, contained in the Appendix, provide 1:50,000 scale coverage of the barrier island and shorelines (and adjacent littoral zones) discussed in this report. Each of the plates contains littoral habitats for 1955 and 1978, interpreted from 1955 black-and-white aerial photography and 1978 color-infrared aerial imagery (NASA 1978; PIC 1955-1956; Tobin 1955-1956). Areal measurements of the eleven delineated habitats are provided (for both periods) in bar graph form on each of the plates.

On the basis of the parameters outlined on Table 1 and additional processes and morphologic characteristics (shoreline orientation and dominant sediment drift patterns), the hydrologic units are divided into subunits (see Figure 5). The next chapter will present brief descriptions of the individual shoreline segments, examining dominant processes, rates of shoreline erosion, land use, and impacts of future barrier deterioration.

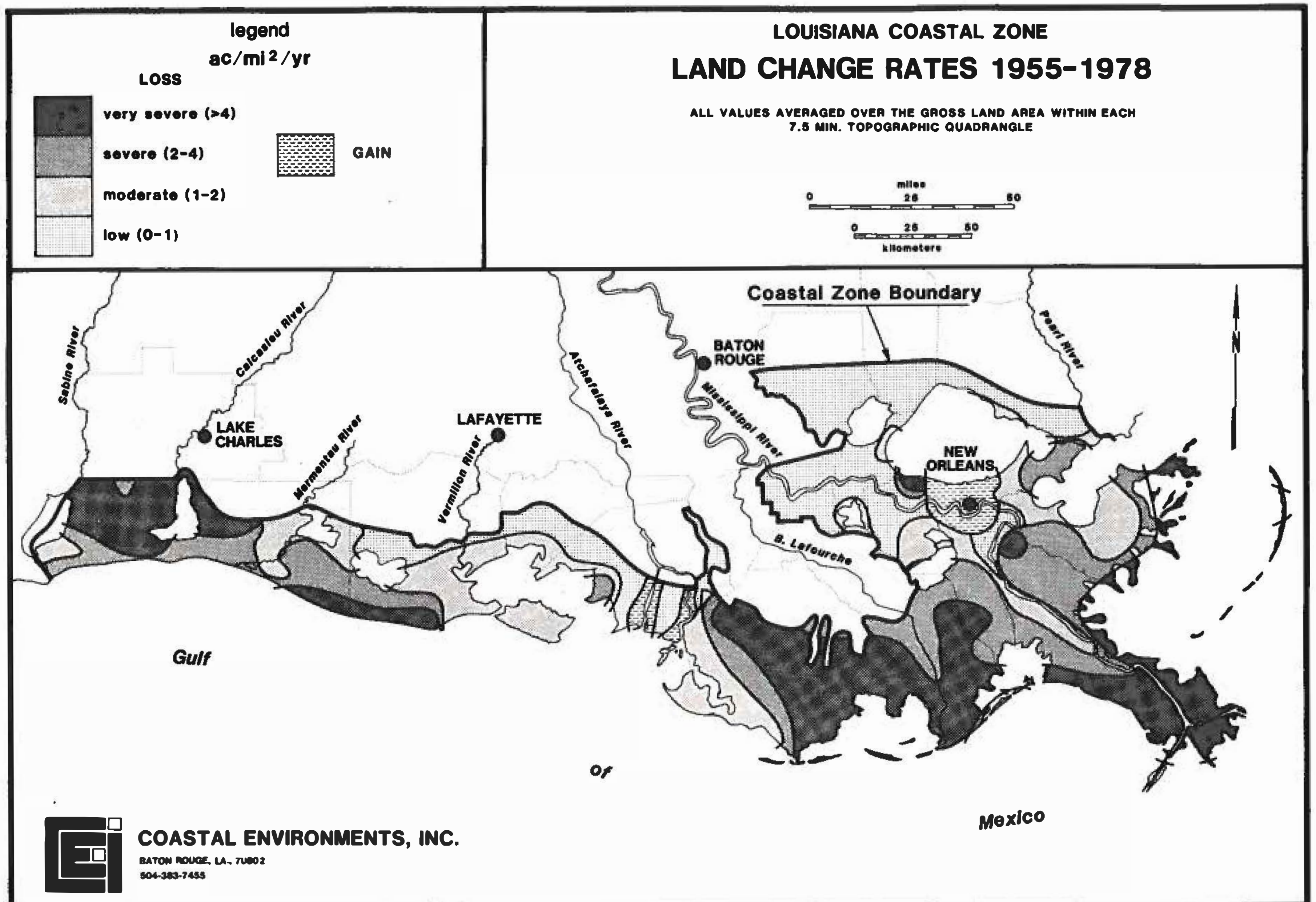


Figure 12. Land Loss in the Louisiana Coastal Zone.

Chapter III

Characterization of the Barrier Shoreline

Hydrologic Unit 1: Chandeleur-Breton

The Chandeleur-Breton barrier is a transgressive barrier island arc approximately 41 mi (66 km) in length. Representing the outer rim of the former St. Bernard delta lobe, the islands are comprised primarily of sand and shell. It has been assumed that because of the age of the Chandeleurs (1800-3000 years - Frazier 1967) and a levelling of initial subsidence and compaction, a reduction of shoreline retreat rates on this island chain resulted (Morgan and Larimore 1957). Previously noted mechanisms of island maintenance include the landward migration of the islands across their own back-barrier mangroves (Russell 1936) and the washing up of nearshore relict deltaic deposits onto the islands by wave action (Kwon 1969). The 1955 and 1978 aerial imagery, however, indicates high erosion rates averaging 32.8 ft/yr (10 m/yr) (Plates 27-31). Except for isolated cases of washover fan development, there has been virtually no landward migration between 1955 and 1978. Coupled with the high shoreline retreat rates, it is apparent that erosion of the Chandeleurs is presently quite high. It has been estimated that 50-90% of shoreline erosion on the Chandeleurs is a direct result of hurricane activity (Kahn 1980), and the high erosion rates of recent decades may well be related to storms, especially Hurricane Camille which severely breached the islands in 1969.

Three distinct subunits can be identified along the Chandeleur-Breton shoreline: the northern and central Chandeleurs, the southern Chandeleurs (including Grand Gosier and the Curlew Islands), and Breton Island.

<u>North-Central Chandeleurs (Subunit A)</u>

Because of prevailing southeasterly winds and waves, sediment transport is to the north over most of Chandeleur Island. Receiving a greater relative input of sediments, Subunit A exhibits the highest dune crest elevations--up to 4 m (13 ft)--and the lowest shoreline retreat rates within the total hydrologic unit (Kahn 1980). While average retreat rates between 1955 and 1978 were 33 ft/yr (10 m/yr) over the whole subunit, rates of less than 16 ft/yr (5 m/yr) occurred at 30°00' N latitude (Figure 13). Shoreline erosion rates increase to the north and south from this point. The shoreline erosion graphs presented for each of the hydrologic units display average annual erosion rates for both the 1955-1978 and 1954-1969 periods. The former were developed specifically for this report, while the latter were adapted from work by Louisiana State University (LSU) researchers (Adams et al. 1978). Both sets of data are presented for comparative purposes.

The northernmost 3 mi (5 km) of Subunit A consist of a low, narrow, recurved spit subject to sheet overwash processes, while higher central and southern sections are subject to channel washover processes. Although erosion rates of about 40 ft/yr (12 m/yr) characterized the southern 9 mi (14 km) of the subunit, little back-barrier marsh has been created by overwash processes since 1955. The only land use in the area is a lighthouse and wharf near the northern tip of Chandeleur Island.

<u>South Chandeleurs (Subunit B)</u>

The southern portion of the Chandeleur Islands, which includes the south tip of Chandeleur Island, the Curlew Islands, and Grand Gosier Island, exhibits extremely high erosion and land loss rates (Plates 28 and 29). Much of this erosion is the result of Hurricane Camille in 1969, which created a large, shallow tidal inlet between Chandeleur Island and Grand Gosier Island. The former Boot Island and most of the Stake Islands have submerged into subaqueous shoals. Palos Island has become absorbed by the southern recurved spit of Chandeleur Island. This spit has shifted inland almost 1 mi (1.6 km) since 1955. A slight southwestward elongation of the spit indicates southward sediment transport, although this may relate to flood-tidal currents. The Curlew Islands (Plate 29) are composed primarily of beach and subaqueous sand shoal.

A recurved spit abuts the tidal inlet to the north, but even the central portion of the islands exhibits shoreline retreat rates of over 35 ft/yr (10 m/yr). A net sediment transport to the south is evidenced by the increase in land area at the

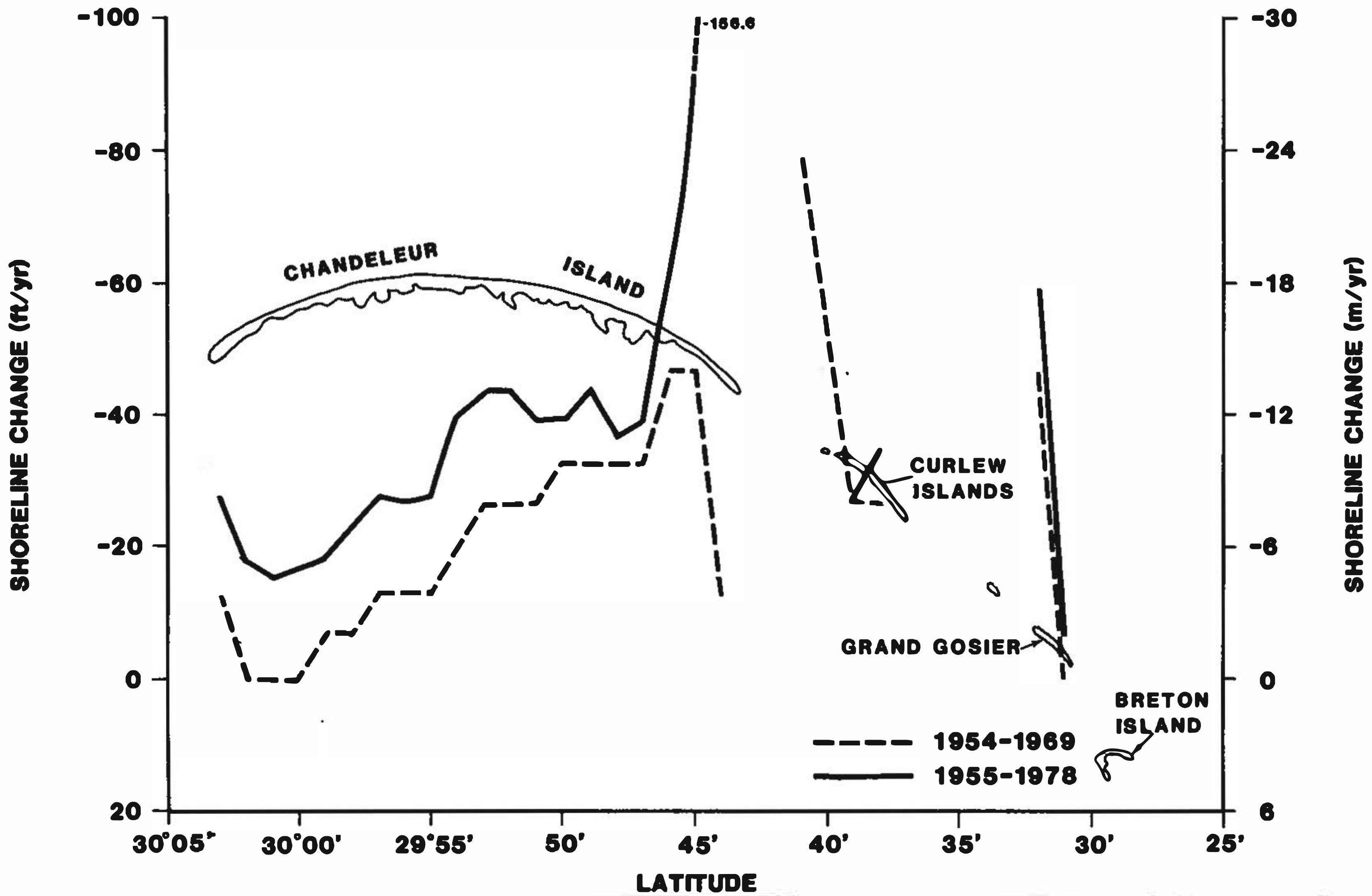


Figure 13. Shoreline Change, Hydrologic Unit 1.

southern spit. Grand Gosier Island (Plate 28), a narrow, low, but vegetated island in 1955, has been dissected by storm activity and now consists of two small island remnants. A small clump of mangrove remains on the stable northern island. The southern island is but a 1-mile (1.6 km) long subaerial shoal which has migrated bayward and accreted slightly at the southern tip (indicating net sediment transport from the north). Shoreline retreat rates, not counting the high rates associated with spit recurvature, average about 31.8 ft/yr (9.7 m/yr) in this subunit.

Breton Island (Subunit C)

Breton Island, containing a backbone of older beach ridges (indicating a possible origin due to distributary mouth accretion ridges), has been severed into two islands which are experiencing high erosion rates (Plate 27). The northern island has remained relatively fixed in position (except for shoreline erosion along the north-facing beach), while the southern island is experiencing truncation of its east-west-trending beach ridges by the dominant southeasterly waves. The back-barrier of the island is also eroding. Dominant sediment drift is to the south, as seen by the accreting south spit. A sediment deficiency is apparent, however, and the Mississippi River-Gulf Outlet (MRGO), which is dredged through the barrier chain immediately north of Breton Island, may be acting as a sediment trap and intercepting longshore sands migrating southward. A wharf and radio antenna are located on the northern island.

Hydrologic Unit 3: Barataria

The barrier shoreline of the Barataria Basin originated during various cycles of Mississippi River sedimentation, primarily associated with the Lafourche and Plaquemines-Modern delta complexes. At the western end, the barrier beach and downdrift-flanking islands (Grand Isle, Grand Terre) have formed by deposition and subsequent erosion of the Caminada-Moreau headland and numerous distributary mouth accretion ridges. Beaches at the eastern end originated by erosion of former Mississippi River distributaries and historic subdeltas.

The concave shape of the shoreline, in addition to a sheltering effect of the active Mississippi River delta, accounts for great variation in littoral transport patterns. Based largely upon sediment drift patterns, at least six major shoreline subunits are identified. Fourchon Beach (Subunit F) exhibits westward drift, while along the Caminada-Moreau beach and Grand Isle (Subunits E and D), sediment drift is well defined in an easterly direction. Along the rest of the hydrologic unit shoreline, bidirectional transport patterns are noted. A net westward drift characterizes Subunit A, while in B and C no directional dominance is apparent (see Figure 5).

Shoreline erosion rates averaged 27.2 ft/yr (8.3 m/yr) over the whole Barataria shoreline during the 1955-1978 period. The highest rates of erosion (over 100 ft/ yr or 30 m/yr) occur in the Grand Terre Islands and are attributed to tidal-exchange processes (Figure 14). The highest nontidal erosion rates exceed 70 ft/yr (21 m/yr) in the vicinity of Port Fourchon, while almost stable conditions occur immediately west of Grand Bayou Pass.

The Barataria shoreline is the site of one of two major road-accessible beaches in Louisiana. Over a thousand recreational camps are found at Grand Isle (Gary and Davis 1979), and dozens of new camps have been constructed in recent years around Port Fourchon.

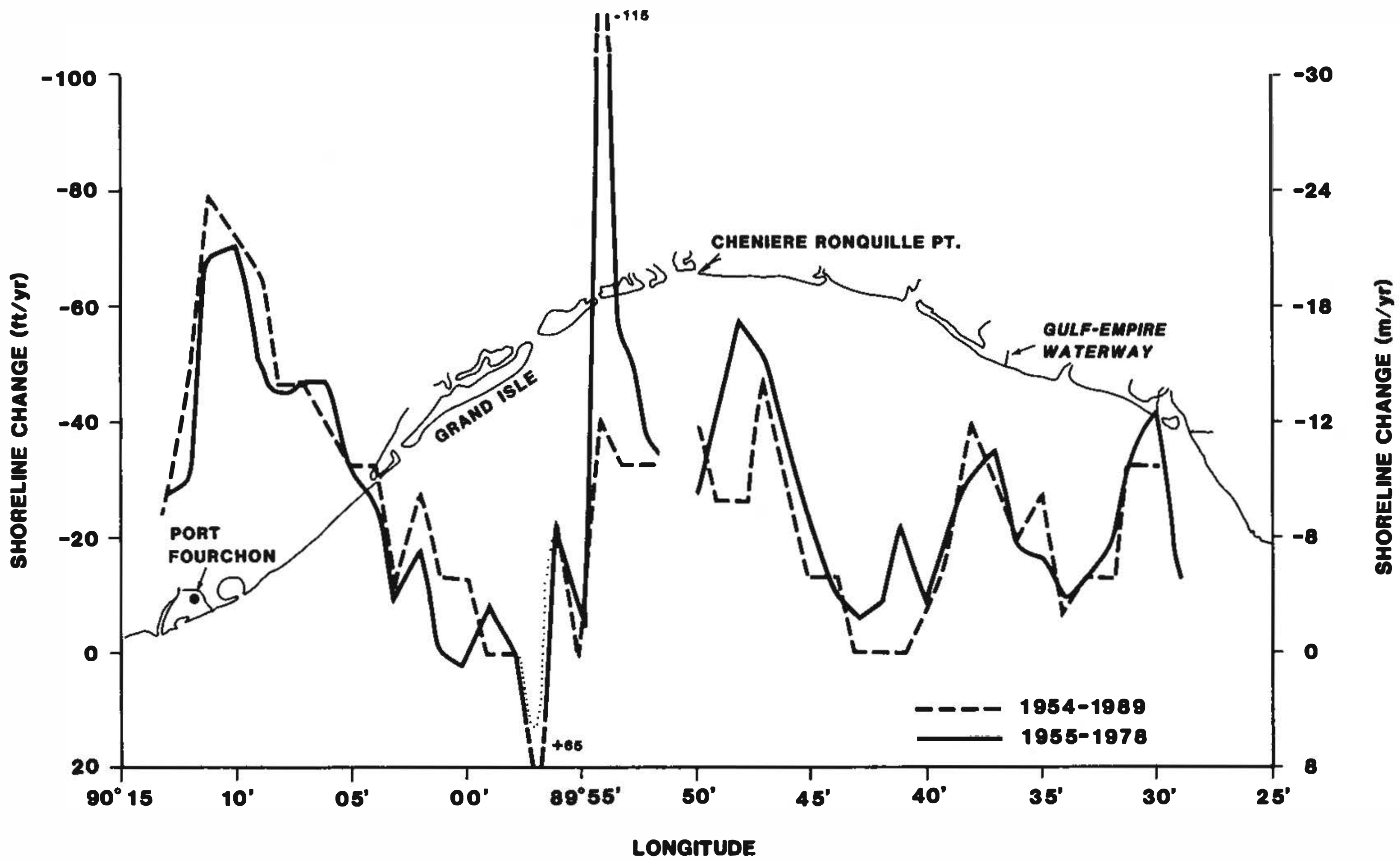


Figure 14. Shoreline Change, Hydrologic Unit 3.

Sandy Point to Grand Bayou (Subunit A)

The easternmost zone of the Barataria barrier system, this stretch of shoreline is oriented WNW-ESE. Available sand supply diminishes to the southeast, and past Sandy Point only occasional "perched pocket beaches" are found along the active delta's marsh shoreline (Plate 26).

Shoreline retreat, under natural conditions, averages approximately 15 to 20 ft/yr (4.5 to 6 m/yr) in this subunit, but two major exceptions to this pattern are found: 1) the strip of marsh gulfward of Bay Coquette, abutting the tidal inlet leading to Sandy Point Bay, has been adversely affected by a shore-parallel, double-pipeline canal (acting as a sand trap), and shoreline retreat has averaged 35 ft/yr (10.5 m/yr); and 2) the jetties at the mouth of the Empire-to-Gulf Waterway have disrupted the normal sand transport system, resulting in retreat rates averaging 35 ft/yr (10.5 m/yr) immediately downdrift (west) of the jetties, and decreasing westward. In addition, the Lanaux Island spit has accreted westward and now shelters Bastian Island, previously exposed to the Gulf.

Judging by the pattern evident near the jetties, sediment transport is dominantly from the east, reflecting prevailing southerly winds. A slight erosional trend can be detected immediately east of the Empire-to-Gulf-Waterway jetties, indicating a small amount of sediment transport from the west. Net transport is from the east, however, and strong evidence for this is confirmed by the erosional trends to the west of the jetties and the westward accretion of the Lanaux Island spit.

Grand Bayou Pass to Quatre Bayoux Pass (Subunit B)

This shoreline reach, the inside of the concave Barataria barrier arc, represents a convergence zone of longshore currents and sediment drift. The eastern 3.5-mi (5.6 km) stretch, from Grand Bayou Pass to Chaland Pass, is oriented WNW-ENE and exhibits very stable conditions (Plate 25). Shoreline retreat has averaged only 7 ft/yr (2.1 m/yr) during 1955-1978, a rate attributable to a combination of the shoreline's orientation and its position within the barrier arc. The reach from Chaland Pass to Cheniere Ronquille Point exhibits shoreline erosion rates of 35 to 40 ft/yr (10.7 to 12.2m/yr). The highest erosion rates (58 ft/ yr or 17.7 m/yr) occur where open water (Bay la Mer) or a high pipeline canal density characterizes the back-barrier zone.

Empire-Gulf Waterway jetties.

A sediment deficit is apparent in this subunit. The only distinct evidence of sediment transport is seen by the slight eastward spit accretion at Chaland Pass. While this may indicate sediment transport to the east, the spit recurvature may represent tidal exchange processes. The marsh area immediately behind the barrier shoreline has been affected heavily by canalization, and shore-parallel canals near Cheniere Ronquille Point are causing accelerated shoreline retreat by acting as sand traps (see Figure 11).

Grand Terre Islands (Subunit C)

This shoreline segment, extending from Cheniere Ronquille Point to Barataria Pass, is subject to high erosion rates because of a large sediment deficiency coupled with tidal-exchange processes (Plate 24). Several major tidal inlets--Quatre Bayoux Pass, Pass Abel, and Barataria Pass--bisect the shoreline. These have deepened and widened through time (Adams et al. 1976; Howard 1982), and adjacent shoreline areas are subjected to increased erosion. This pattern is best displayed on Grand Terre, where shoreline retreat rates are moderate at the central portion of the island's gulf shoreline but increase toward both ends.

Located between two major tidal passes, backed by large waterbodies (Bay Melville, Bay Dispute), and criss-crossed by pipeline canals, the eastern Grand Terre Islands are characterized by considerable shoreline erosion and retreat. The westernmost portions of these islands consisted of sand spits and vegetated washover fans that have eroded greatly in recent decades. The tip of the western spit is retreating inland at a rate exceeding 115 ft/yr (35 m/yr), while average retreat rates are 40 to 50 ft/yr (12 to 15 m/yr) in this zone. A dominant sediment transport pattern is not readily apparent, and the small recurved spits appear to be more related to water exchange through the tidal passes.

The western end of Grand Terre, containing a Louisiana Wildlife and Fisheries field station and the historic Fort Livingston, is eroding due to tidal-exchange processes. Sediment drift is bi-directional, and it has been postulated that groin and jetty construction on Grand Isle has interrupted the longshore movement of sediments that is dominantly eastward during the fall and winter (Adams et al. 1978). The width of the beach in the vicinity of Fort Livingston, however, indicates accretion. Tidal exchange appears to be a more dominant factor than longshore sediment drift.

Grand Isle (Subunit D)

Grand Isle, the downdrift-flanking barrier island of the Caminada-Moreau headland, has developed into a major fishing and recreational center (population: 2400). In addition, many oil industry support service companies and a U.S. Coast Guard station are located on the island. Because the extensive development is threatened by shoreline erosion, numerous beach protection measures have been implemented, and existing plans call for additional beach nourishment (U.S. Army Corps of Engineers [USACE] 1980). In 1951, 14 timber groins were constructed by the Louisiana Department of Highways (Myers and Theis 1956). Erosion accelerated downdrift from the groin fields, however, and during 1954-1955, 1,150,000 yd^3 (880,000 m^3) of sand fill were pumped between several of the groins. One-third of this nourishment material was lost to offshore within one year, and the remainder was removed by Hurricane Flossy in 1956 (USACE 1972). In 1957, the Louisiana Department of Public Works built a 935-ft (287 m) jetty near the east end of Grand Isle, and 1,000,000 yd^3 (764,000 m^3) of sediment were trapped within a four-year period (USACE 1972). An immediate consequence of the jetty was the severing of the spit at the east end, but recent photographs indicate recovery and renewed spit accretion.

Critically eroding shoreline, Grand Isle.

Periodic destruction of the dune at Grand Isle by hurricanes has instigated several recent dune construction and beach nourishment and protection projects. The last severe storm was Hurricane Carmen in 1974, although lesser storms (e.g., Hurricane Bob in 1979) periodically remove valuable island-protecting sands to the offshore (USACE 1980). Several beach protection measures (e.g., sand-filled cloth tubes) were experimented with during the mid-1970s (Dement 1977), but success was limited. Present plans call for a comprehensive $14 million beach replenishment and dune construction project to be implemented in the early 1980s (USACE 1980).

Longshore sediment transport is from the west, and sand trapping by the east jetty has accounted for net accretion, averaged over the Grand Isle shoreline (Plate 23). Average shoreline change rates of +5.9 ft/yr (+1.8 m/yr) were calculated for the 1955-1978 period. Historically Grand Isle experienced erosion at the western end (adjacent to Caminada Pass) and accretion at the eastern end. The western spit was structurally stabilized in the early 1970s, and as a consequence, the immediate downdrift area was deprived of natural beach nourishment material. Average erosion rates of 31.6 ft/yr (9.6 m/yr) for 1955 to 1978 occurred in this zone. Another area of erosion is found near the central portion of the island, where erosion rates of 11.8 ft/yr (3.6 m/yr) were calculated. The large number of recreational camps directly on the Gulf shoreline makes Grand Isle quite vulnerable, in terms of potential property damage and loss of life, during hurricane events.

Caminada-Moreau Beach (Subunit E)

This 10.5-mi (17 km) stretch of shoreline, oriented northeast southwest, comprises the rapidly eroding shoreline of the Caminada-Moreau deltaic headland which supplies sediment for the downdrift barrier island of Grand Isle. While erosion rates averaged 41.1 ft/yr (12.5 m/yr), the western edge of the subunit, near Port Fourchon, is subjected to the highest nontidal shoreline retreat rates in the state (on the order of 70 ft/yr or 21 m/yr between 1955 and 1978) (see Plate 22 and Figure 13). Sediment drift is toward the east, and shoreline erosion rates decrease steadily eastward along the subunit.

The rapid erosion along the Caminada-Moreau coast is attributed to the headland's position at the apex of the offshore Mississippi Canyon, which tends to focus incoming waves and encourage sediment transport divergence. Processes of erosion include sheet washover and littoral drift. Dune crests are generally only 3 to 3.5 ft (1 m) high, and numerous washover locations occur. Gulf water level set-ups of only 2 ft (0.6 m) induce small-scale washovers (Penland and Ritchie 1979), although most of the shoreline erosion (over 70%) is attributed to tropical cyclones (Penland and Boyd 1981). Sheet washover and shoreline retreat are quite pronounced where large waterbodies (e.g., Bay Champagne) are directly behind the barrier beach. Based upon beach profiles surveyed over a three-year period, quantitative estimates of longshore sediment drift were made (Harper 1977). An estimated 660,000 yd^3/yr (530,000 m^3/yr) is eroded and transported out of the Caminada-Moreau system (Harper 1977). The USACE (1972) estimates that 300,000 yd^3/yr (230,000 m^3/yr) are trapped by the jetty at the east end of Grand Isle. The remaining 360,000 yd^3/yr (275,000 m^3/yr) are presumably intercepted by Caminada Pass and tied up in nearshore shoals or lost to the offshore (Harper 1977).

Fourchon Beach (Subunit F)

At a point approximately at the mouth of Pass Fourchon, longshore sediment drift diverges, east to nourish Grand Isle and west to nourish the Timbalier Islands. Shoreline erosion rates are highest at this point of diversion (70 ft/yr or 21 m/yr) and gradually decrease in both directions. The Fourchon Beach shoreline has experienced average retreat rates of over 42 ft/yr (13 m/yr) during 1955-78, although the extension of the Belle Pass jetties in the 1960s has reduced the rates somewhat. Sand that normally would have been carried westward to the Timbalier Islands is now intercepted by the jetties, and high erosion rates consequently have been reduced east of the jetties but substantially increased west of the jetties. Not all sediments are trapped by the jetties, as some natural sand bypassing occurs (Dantin et al. 1978).

Port Fourchon is presently booming as an industrial and recreational center. Considering the high shoreline erosion rates and potentially destructive hurricane impacts, this zone of development is in a precarious position. As the shoreline continues to retreat, Port Fouchon will gradually evolve into a peninsula (if not an island), and the adjacent shoreline areas will be deprived of their traditional source of sediment nourishment.

Industrial development at Port Fourchon.

Hydrologic Unit 4: Terrebonne-Timbalier

The Terrebonne-Timbalier hydrologic unit can be divided into three generalized shoreline segments (which can be further subdivided into a series of subunits): the Timbalier Islands, the Isles Dernieres, and the mainland coast from Caillou Bay to Point au Fer. The Timbalier Islands formed as a result of erosion of the Caminada-Moreau headland and westerly longshore drift-induced spit accretion. The Isles Dernieres represent the outer barrier rim of a complex delta lobe formed by a number of distributaries associated with the Lafourche delta complex (Frazier 1967). The Gulf coast of the Caillou headland and Point au Fer Island, characterized by broken barrier beaches and continuous barrier beach respectively, represents the outer rim of the delta lobe of Bayou Black and associated distributaries (Frazier 1967). Shoreline erosion rates are high on the barrier island segments and moderate on the mainland barrier shoreline (Figure 15a and b).

East Timbalier Island (Subunit A)

The entire Timbalier Island chain has been impacted severely by works of man in recent decades, and nowhere is this better displayed than on the East Timbalier shoreline segment (Plate 21). Historically a flanking barrier spit/island of the Caminada-Moreau headland, East Timbalier has been partially deprived of its sediment source following construction and subsequent extension of the Belle Pass jetties. Prior to jetty construction, even frequent hurricanes caused little reduction in island area (Penland and Boyd 1981). Today, a noticeable downdrift offset (indicating accelerated shoreline retreat) characterizes the coastline immediately west of Belle Pass. High erosion in this area has been accelerated additionally by extensive canalization. A shore-parallel pipeline canal has increased shoreline retreat rates just west of Belle Pass, and a normal-to-shore rig cut dredged into the back barrier has evolved into a major tidal inlet (see Figure 10). Average shoreline retreat rates of about 55 ft/yr (17 m/yr) for the 1955-1978 period are found in this subunit.

Another major interruption in the longshore sediment transport system has been the construction of rip-rap breakwaters along most of East Timbalier Island. To protect oil company interests, almost $11 million was spent between 1966 and 1980 on construction and maintenance of two parallel breakwaters--one on the beach and one in the back-barrier zone (Anonymous 1980).

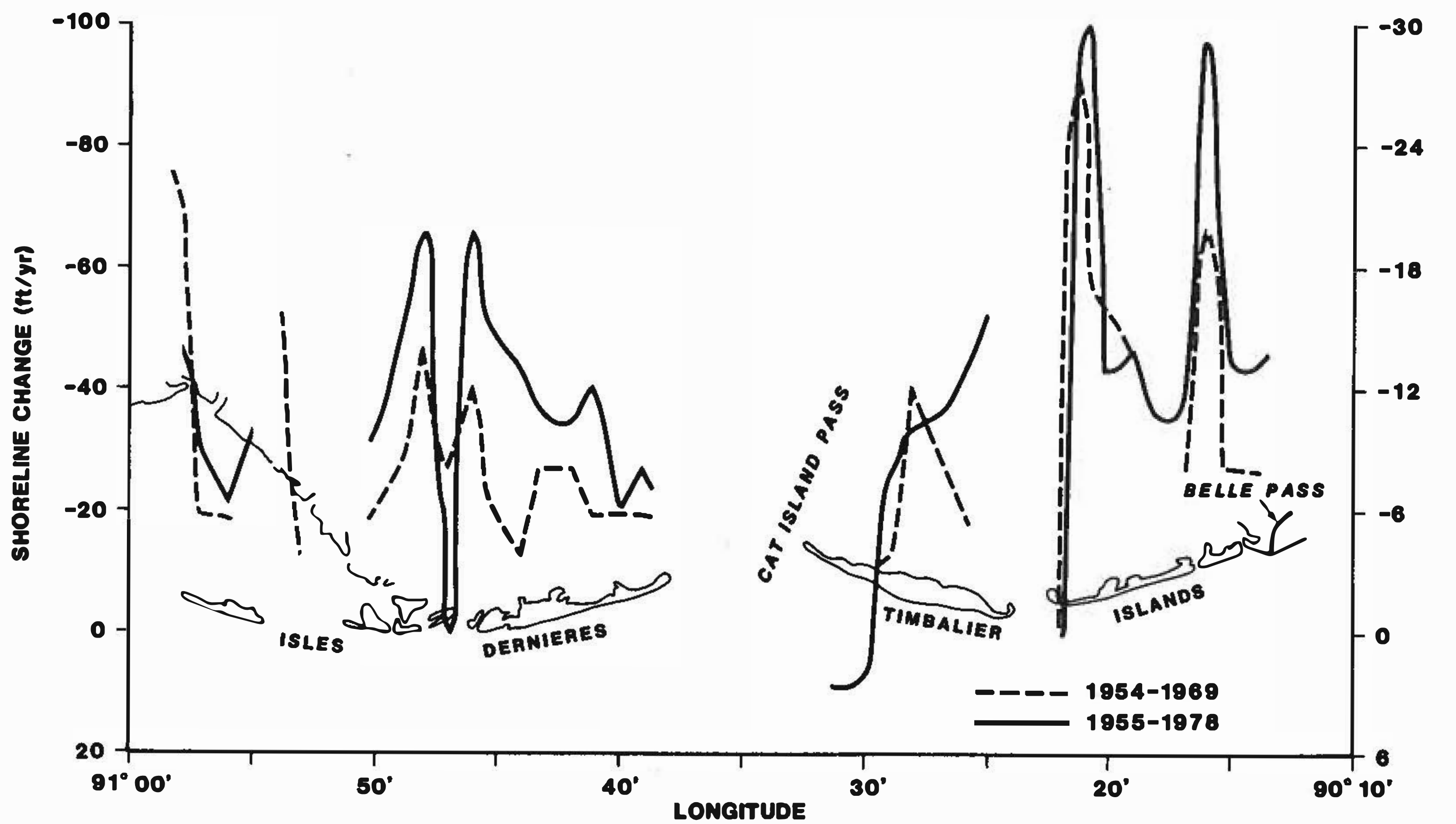


Figure 15a. Shoreline Change, Hydrologic Unit 4 (Barrier Islands).

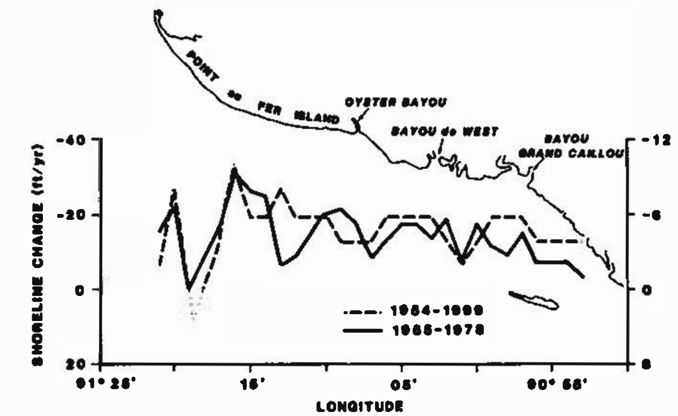


Figure 15b. Shoreline Change, Hydrologic Unit 4 (Mainland).

While the project is considered successful with regard to protection of oil company structures and perhaps even a minor reduction in shoreline erosion rates, the breakwaters are frequently breached during storm events. Little sand beach remains seaward of the outer dike, and along some reaches a lagoon and beach are found within the two dikes. Very little sand is presently migrating along the shoreface, the slope of which is believed to have steepened in recent years. The westernmost 2 mi (3 km) of the island have detached themselves from the reveted portion and now remain as migrating sand shoals in Little Pass Timbalier.

Timbalier Island (Subunit B)

Timbalier Island, the westernmost downdrift flanking barrier island associated with erosion of the Caminada-Moreau headland, is eroding rapidly at its eastern end and accreting at its western end (Plate 20). Historically, the island has accreted westward (4 mi [6.4 km] during the last century) in response to headland erosion, former Mississippi River sedimentation (via Bayou Lafourche), and strong longshore sediment transport (Meyer-Arendt and Wicker 1982). Numerous beach ridges are found on the eastern half of Timbalier Island, from which a chronology of accretion can be determined. These beach ridges are being truncated by wave action, and the inter-ridge swales are active washover sites. Since the interference by man of the natural sand transport system (Belle Pass jetties, canalization, and structural modification on East

Timbalier), less sand is reaching Timbalier Island. Its sediment supply diminished, the island is undergoing a phase of reorientation to prevailing waves. Although shoreline retreat rates averaged 24.5 ft/yr (7.5 m/yr) between 1955 and 1978, erosion rates as high as 52 ft/yr (16 m/yr) are found at the eastern spit, while accretion rates at the western spit approach 10 ft/yr (3 m/yr).

A small fishing village existed briefly on Timbalier Island at the turn of the century. Present land use consists of two clusters of recreational camps and several oil company storage tanks and well-heads. Numerous canals have been dredged in the central portion of the island, and several potential washover sites have developed. To minimize impacts of washover events on existing land use, two experimental shoreline protection measures have been installed. A 2000-ft (600 m) rip-rap breakwater was constructed by the Louisiana Office of Public Works in 1975, and in 1981 a sand fencing/vegetative stabilization project was begun by oil company interests in conjunction with LSU researchers and USDA Soil Conservation Service personnel. Both projects appear to have stabilized their respective shoreline segments, but the impacts of a hurricane or long-term erosion have yet to be measured. The rip-rap is presently slightly seaward of the adjacent natural shoreline, and its disruption of sediment transport processes can be seen readily by the accelerated erosion downdrift of the dike.

Barrier Island washover.

Westward growth of Timbalier Island has not occurred since 1955, and this is attributed to the diminished sediment supply and the proximity of Cat Island Pass, through which the Houma Navigation Channel is maintained. It has been estimated that about 650,000 yd^3 (500,000 m^3) of sediment are eroded from Timbalier Island each year (Meyer-Arendt and Wicker 1982). An average of 350,000 yd^3/yr (270,000 m^3/yr) was dredged for maintenance of the navigation channel between 1966 and 1980 (Broussard 1981), and calculations based on historic bathymetric charts (1891-1974) indicate a sediment load of at least 300,000 yd^3 (230,000 m^3) is being deposited annually on the outer bar (ebb-tidal delta) of Cat Island Pass. Even though Timbalier Island has not accreted westward in recent decades, the dominance of westerly drift can be seen in the westward shift of the 2-fathom depth contour and the 1982 realignment of the navigation channel (Figure 16).

Wine Island (Subunit C)

Wine Island, the easternmost extension of the historic Isles Dernieres, is situated between the major tidal inlets of Wine Island Pass and Cat Island Pass and has been subjected to such high erosion that just a small sand shoal remains today. In response to the westward-shifting Cat Island Pass, Wine Island has migrated 0.6 mi (1 km) to the west since 1955 (Plate 19). The island disappears periodically following storm events.

Eastern Isles Dernieres (Subunit D)

The Isles Dernieres barrier island chain, the outer rim of delta lobes associated with early phases of the Lafourche delta complex, is eroding and fragmenting at rapid rates. As recently as the late 1800s, Isles Dernieres was one continuous island with the exception of one small breach. The barrier has been maintained by a reworking of sediments and longshore drift processes, although the available sand supply is relatively small. Considerable breaching and tidal inlet development have occurred on the Isles Dernieres. Based largely upon sediment drift, the Isles Dernieres are subdivided into two subunits, the dividing line being the apex of the Caillou headland on the Central Isles Dernieres (approximately 90° 49' 00" W longitude). Sediment transport is dominantly westward over most of the Isles Dernieres, although eastward drift patterns are evident along Whiskey Island and along the easternmost section of Eastern Isles Dernieres. This reversal of dominant drift direction may relate to tidal exchange forces.

Eastern Isles Dernieres is the largest of the Dernieres barrier islands, and widths of almost 1 mi (1.6 km) characterize the western half (Plate 18). Shoreline erosion rates (see Figure 15a) decrease from 65 ft/yr (20 m/yr) at the western end to less than 20 ft/yr (6 m/yr) near the eastern end. The eastern spit, abutting Wine Island Pass, accreted seaward 200 ft (61 m) between 1955 and 1978; this is attributed to tidal dynamics (see Figure 7). The high shoreline retreat rates, coupled with the narrow island widths in the eastern half, have increased the potential for breaching and washover development. A permanent breach opened following the passage of Hurricane Carmen in 1974, and an active washover is located immediately west of the eastern spit.

The east-flanking barrier spit of the Central Isles Dernieres has retreated landward at rates of over 66 ft/yr (20 m/yr) and now has absorbed the formerly sheltered Whiskey Island. A 1981 overflight revealed that this island has now been severed from the Central Isles Dernieres and comprises a separate barrier island. (Because of its small size and isolated position, it is assumed that Whiskey Island, like Wine Island, will evolve into a sand shoal in the near future.)

Land use in this subunit is limited to isolated oil company activities and a recreational camp cluster (about 20 camps) along Trinity Bayou. As the shoreline continues to retreat, this settlement will be endangered and will require relocation. Near the eastern end of the island, a leveed oil company treatment pond is gradually filling in with sand as the shore retreats.

Western Isles Dernieres (Subunit E)

The Central and Western Isles Dernieres have experienced high erosion rates and the total disappearance of one island between 1955 and 1978 (Plate 17). The Central Isles Dernieres are deltaic marsh deposits being eroded by wave action. Longshore sediment drift has led to the building of low barrier spits, one of which has accreted westward a distance of 1.5 mi (2.4 km).

The westernmost island in the Dernieres chain, Last Island, represents a downdrift-flanking barrier island of the Caillou headland. Similar to Timbalier Island in morphologic characteristics, Last Island has eroded most at its eastern end. Although no westward accretion has occurred in recent decades, a 1981 overflight indicated substantial widening of the beach near Raccoon Point (west end). Last Island contained a fishing village in the early nineteenth century, and a pleasure resort flourished during the 1850s. Since an 1856 hurricane inundated the island and over 300 lives were lost, no further attempts to settle the islands were made (Peyronnin 1962; Sothern 1981).

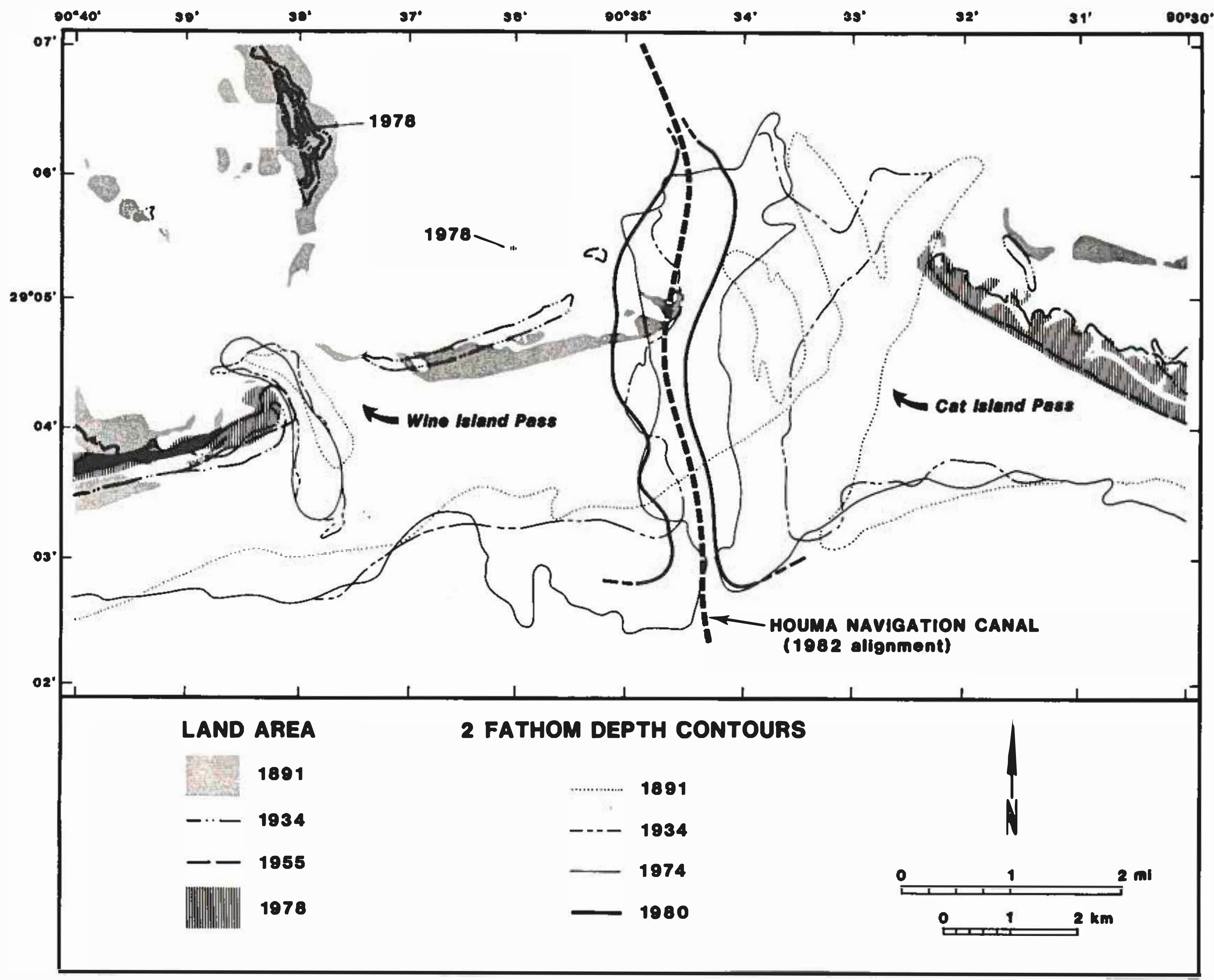


Figure 16. Bathymetric Changes, Cat Island Pass Area, 1891-1980 (1980 and 1982 data courtesy of Braussard 1981).

<u>Grand Bayou des Ilettes to Oyster Bayou (Subunit F)</u>

The mainland shoreline adjacent to Caillou Bay, relatively protected in the shadow of the Isles Dernieres, primarily consists of marsh, although the occurrence of incidental sand beaches increases westward toward Oyster Bayou. Proceeding west from Grand Bayou des Ilettes, the first small, perched pocket beaches are encountered a few miles southeast of Bayou Grand Caillou. From there west to Bayou de West, the shoreline is quite discontinuous because of the numerous bayous - functioning as tidal channels - which debouch into Caillou Bay. Discontinuous sand-shell barrier beaches are found on much of the shoreline, and in increasing amounts toward the west. Between Bayou de West and Oyster Bayou, the barrier beach is fairly continuous, although still "perched" upon protruding marsh deposits in the eastern sector.

Shoreline erosion rates, averaging 12.6 ft/yr (3.8 m/yr) between 1955 and 1978, increase from almost 0 in the eastern portion of the subunit to about 20 ft/yr (6 m/yr) near Oyster Bayou. The higher erosion rates in the west, also evidenced by the more seaward extent of the original property lines (surveyed during the 1830s and 1840s), are due to a more gulf-exposed location which, in turn, explains the more developed barrier beach and higher shoreline berm elevations.

<u>Point au Fer Island (Subunit G)</u>

The westernmost subunit within Hydrologic Unit 4--the shoreline between Oyster Bayou and Point au Fer--comprises a continuous sand-shell barrier beach fronted along its northwestern reaches by extensive mud deposits. Shoreline erosion rates, which averaged 16.7 ft/yr (5.1 m/yr) during 1955-1978, are quite variable along the subunit (ranging from 0 to 31.3 ft/yr [9.5 m/yr]). This is due to localized resistant headlands, accreting mudflats, and westward sediment transport factors. Oyster reefs occur at

Point au Fer, and recent observations indicate that fine-grained sediments from the developing Atchafalaya River delta were being deposited on them (Adams et al. 1978). What role is played by active deltaic sedimentation further southeast along Point au Fer island is not yet well documented.

Hydrologic Unit 6: Vermilion

The shoreline of the Vermilion hydrologic unit is comprised of two sections: the easternmost section of the Chenier Plain (centered on Cheniere au Tigre), and Marsh Island, the westernmost section of the Deltaic Plain (the early Teche delta complex). The two components are separated by Southwest Pass, a deep, entrenched tidal inlet linking Vermilion Bay with the Gulf. Shoreline erosion rates are low in this area (average: 11.6 ft/yr or 3.5 m/yr between 1955 and 1978), a fact attributed to 1) the antiquity of the associated delta cycle (Morgan and Larimore 1957); 2) shore protection provided by extensive nearshore oyster reefs (Orton 1959); 3) recent Atchafalaya River mud accretion along the shore (Adams et al. 1978); 4) a more resistant shoreline and source of beach nourishment at Cheniere au Tigre; 5) lower nearshore wave energies (Becker 1972); and 6) localized reversal of the overall dominant westward sediment transport (Figure 17). The two major shoreline segments are subdivided into five distinct subunits, based upon morphologic characteristics and sediment drift patterns.

Marsh Island, East Coast (Subunit A)

More directly oriented toward prevailing westerly currents and less well-protected by offshore oyster reefs, the east coast of Marsh Island (Lake Point to South Point) exhibits higher shoreline erosion rates (17.4 ft/yr or 5.3 m/yr) than the south shore of the island (Plate 13). The shoreline is primarily marsh, although short stretches of sand-shell beach are found at points and minor headlands. Nearshore currents are dominantly north-northeast along this coastline (CEI 1977), but because of available coarse beach material and low wave energies, longshore sediment transport is not apparent.

Marsh Island, South Coast (Subunit B)

The south shore of Marsh Island, from Southwest Pass to South Point, is fronted for the most part by extensive shell reefs and is quite irregular in outline (Plates 11-13). The reefs serve to break incoming waves, and shore erosion is minimal in this subunit. Between 1955 and 1978, erosion rates averaged 11.8 ft/yr (3.6 m/yr). The western and eastern reaches of the south shore (the latter confined to between Mound Point and South Point) are less well-sheltered by shell reefs. Erosion rates aproach 20 ft/yr (6 m/yr), and continuous sand-shell beaches characterize these shoreline reaches.

The central portion of the subunit is characterized by numerous, often tree-covered, headlands. These occur in areas where shell reefs occur within a few feet of the shore. Some short beaches are in evidence (Plate 12) and have probably resulted from erosion of in situ shell deposits. Continuous barrier beach development is restricted to areas where reefs are absent (Orton 1959).

Nearshore currents are westerly, but evidence of littoral transport is seen only in the westernmost reaches of the subunit, where the beach has slightly increased in width (Plate 11). A large amount of suspended fine sediments is being transported by the "Atchafalaya Mud Stream" south of Marsh Island (Wells and Kemp 1981), but shoreline mud accretion is presently most active along the Chenier Plain coast, further to the west.

Rainey Wildlife Sanctuary (Subunit C)

Between 2 mi (3.2 km) west of Cheniere au Tigre and Southwest Pass, the shoreline is primarily sand-shell beach, and sediment transport is bidirectional. Shoreline erosion rates average 11.0 ft/ yr (3.4 m/yr) in this subunit and increase from 4.4 ft/yr (1.3 m/yr) in the west to a high of 17.4 ft/yr (5.3 m/yr) near Southwest Pass. Closer to Cheniere au Tigre, eroded chenier deposits provide sediment nourishment for the shoreline to the east. Near Southwest Pass are

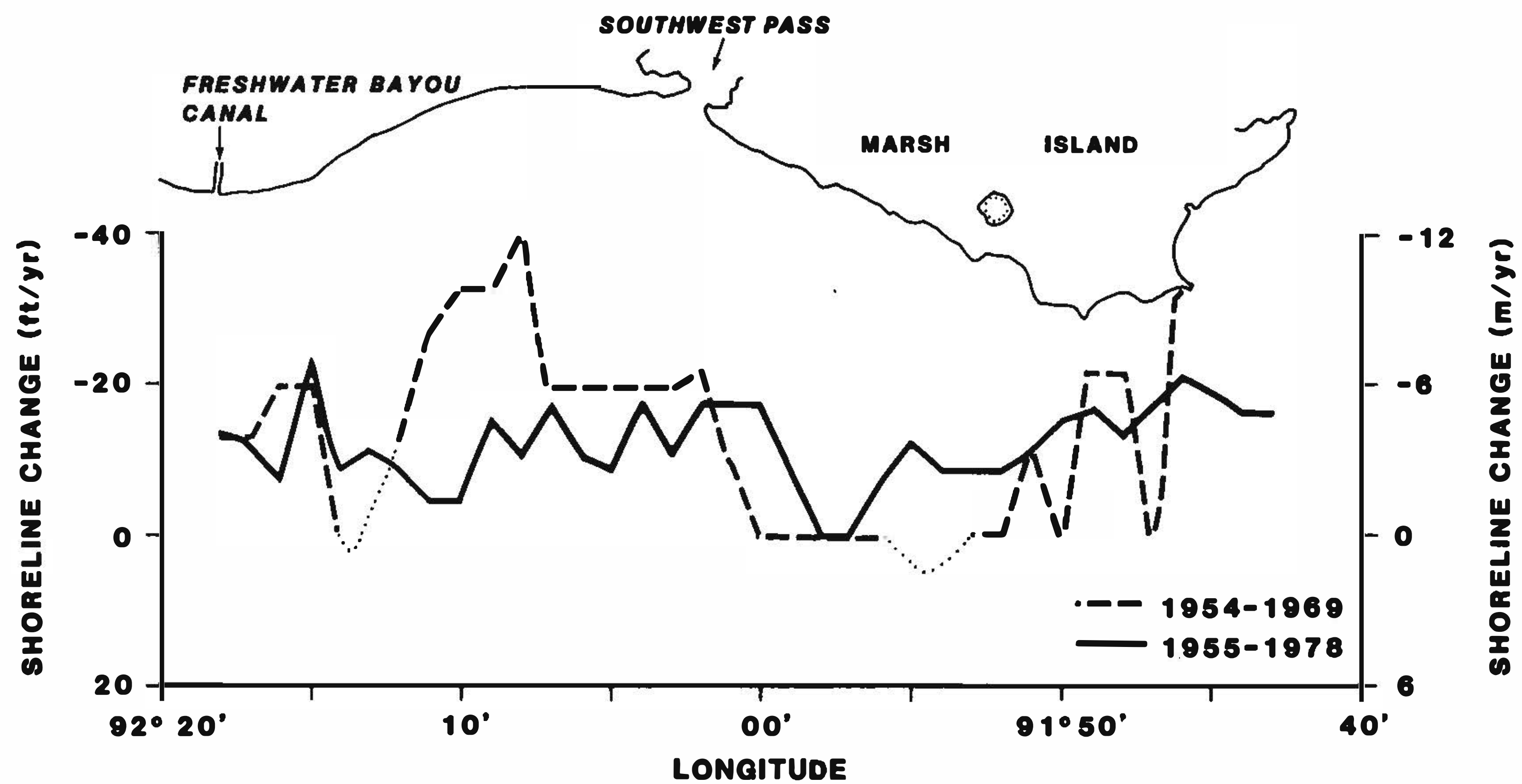


Figure 17. Shoreline Change, Hydrologic Unit 6.

some nearshore shell reefs, though not enough to significantly protect the shoreline from erosion. Tidal-exchange forces also contribute to erosion in this area.

Cheniere au Tigre (Subunit D)

The stretch of coastline from Tigre Point to west of Cheniere au Tigre is oriented NE-SW, and net longshore sediment transport is to the northeast (Plate 10). The eastern and western thirds of the subunit consist of sand-shell beach, eroded from the headland at Tigre Point and from Cheniere au Tigre. Between the two reaches of sand beach, the shoreline consists of marsh, although until the early 1970s extensive mudflats accreted here (Wells and Kemp 1981). (The zone of active mud accretion has since shifted westward, into Hydrologic Unit 7.) Average erosion rates approached 10 ft/yr (3 m/yr) between 1955 and 1978, although the Tigre Point headland (at the approximate point of sediment transport divergence) eroded at rates of 22.6 ft/yr (6.9 m/yr).

Bill Ridge (Subunit E)

The shoreline from Tigre Point to the Freshwater Bayou Channel is comprised of a narrow sand-shell beach which developed as a result of erosion of the Tigre Point headland and subsequent westerly longshore drift. Shoreline retreat rates averaged slightly over 10 ft/yr (3 m/yr) during 1955-1978, and were uniform over the whole subunit. At the mouth of Freshwater Bayou Canal, maintenance dredging of 1,000,000 yd^3 (764,000 m^3) every 18 months is required (USACE 1976). This reflects the high volumes of fine sediments introduced by way of the Atchafalaya Mud Stream. To minimize shoaling, plans call for construction of jetties out to the 1-fathom contour (USACE 1976).

Hydrologic Unit 7: Mermentau

The shoreline of the Mermentau hdyrologic unit is one of transition, from erosionary to accretionary in nature. The western two-thirds of the shore within this hydrologic unit experiences high erosion rates, about 40 ft/yr (12 m/yr), while in the eastern third newly accreting mudflats are slowing the rates of erosion. The zone of mudflat accretion has steadily been shifting westward since the 1950s (Wells and Kemp 1981), in response to an increased sediment load carried in the Atchafalaya Mud Stream and longshore transport processes. As the mudflats begin to accrete along the highly erosive Chenier Plain barrier coast, the rates of shoreline erosion diminish. This trend can be seen on Figure 18, which shows that erosion rates have diminished substantially east of Flat Lake. To the west, beyond the present influence of the mudflats, erosion rates remain high, partly because the accretion of mudflats reduces the ability of longshore transport processes to remove sand from that area for downdrift nourishment. The locus of mudflat accretion is expected to continue to migrate westward and presently critical shoreline erosion rates will be reduced. (The leading edge of the mudflat accretion zone is estimated to be migrating westward at average rates of approximately 0.8 mi/year [1.3 km/yr].) Average erosion rates are roughly 30 ft/yr (9 m/yr), although considerable variability exits within the hydrologic unit. Three distinct shoreline subunits are identified.

Freshwater Bayou Canal to Flat Lake (Subunit A)

From the mouth of the Freshwater Bayou Canal to approximately Flat Lake, the shoreline consists of irregularly alternating stretches of marsh, sand-shell beach, and mudflats (Plates 8 and 9). The greatest proportion of sand beach (and highest shoreline erosion rates) is found in the western portion of the subunit, where the accretion of mudflats has become important in recent years.

Shoreline erosion rates, which averaged 16.8 ft/yr (5.1 m/yr) between 1955 and 1978, increase from net accretion or low erosion near Freshwater Bayou to over 40 ft/yr (12 m/yr) of erosion near Flat Lake. Localized erosion near Freshwater Bayou reflects the removal of mudflats

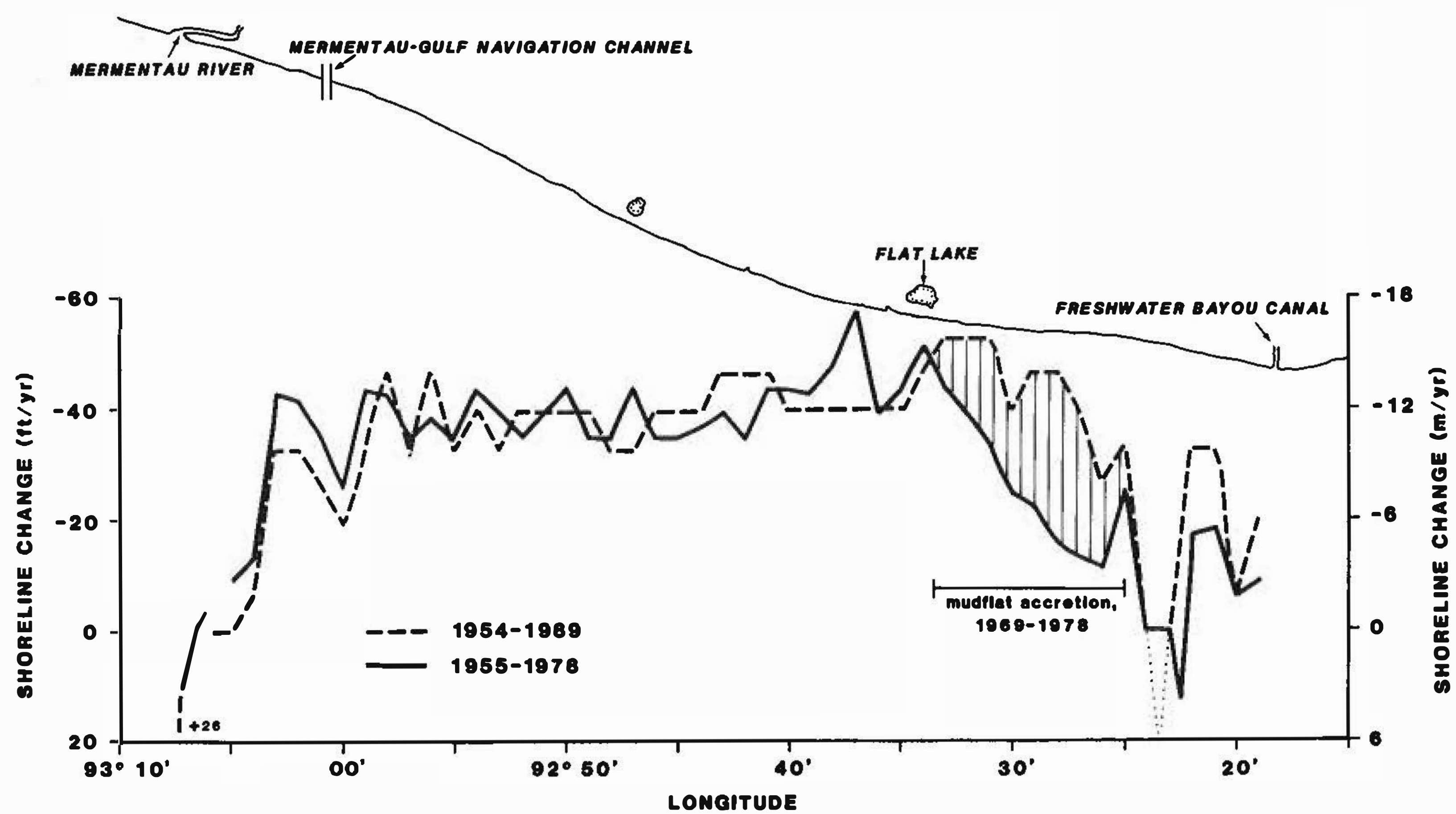


Figure 18. Shoreline Change, Hydrologic Unit 7.

deposited in the 1950s. Evidence of the influence of mudflat accretion upon erosion rates is seen by the reduction in shoreline erosion rates between longitudes 92° 25' and 92° 33' (see Figure 18). The average rates for the 1954-1969 period (Adams et al. 1978) have decreased significantly for the 1955-1978 period.

Flat Lake to Mermentau-Gulf Navigation Channel (Subunit B)

The 30-mi (48 km) stretch of coastline from Flat Lake to the Mermentau-Gulf Navigation Channel jetties consists of fairly continuous, narrow sand beach that is eroding at rates of approximately 40 ft/yr (12 m/yr) (Plates 5 through 8). Interruptions of the sand beach continuity are limited to mouths of bayous and canals and where the beach is washing over into large waterbodies, such as at Big Constance Lake (Plate 7). The present trend of a westward shifting locus of mudflat accretion is expected to offset the high shoreline erosion rates beginning at the eastern end of the subunit.

The sand-shell shoreline along this subunit is maintained by high erosion rates and the westward littoral transport of eroded sediments. Prior to construction of a navigation channel from Lower Mud Lake to the Gulf, longshore sediment transport processes accounted for considerable westward accretion of the Hackberry Beach spit and a continual westward deflection of the natural outlet of the Mermentau River. While the jetties presently exhibit patterns of reduced updrift erosion and accelerated downdrift erosion, the overall impacts of the navigation channel have not yet been evaluated adequately.

Hackberry Beach (Subunit C)

The Hackberry Beach subunit, extending from the Mermentau-Gulf Navigation Channel jetties to the natural mouth of the Mermentau River, exhibits high erosion rates immediately downdrift of the jetties and stable conditions where the Hackberry Beach chenier is directly situated against the coastline. The high erosion rates (up to 42.6 ft/yr or 13 m/yr) along a 3-mi (4.8 km) reach downdrift of the jetties are attributed to a combination of the easily erodible marsh deposits plus a reduction in sediment supply because of updrift sand trapping by the navigation channel jetties. The more resistant Hackberry Beach chenier has withstood erosional stresses, although a truncation of the updrift end of the chenier is evident (Plate 5). The Hackberry Beach spit has accreted westward since 1955, and the Mermentau River mouth has been deflected westward in response.

Hydrologic Unit 8: Calcasieu-Sabine

The westernmost of the eight major hydrologic units, the Calcasieu-Sabine shoreline, is composed of sandy beaches and also extensive mudflats, the latter occurring on the east sides of the Sabine and Calcasieu Pass jetties. Shoreline erosion rates averaged 8.9 ft/yr (2.7 m/yr) over the entire unit between 1955 and 1978, but considerable variability was encountered (Figure 19). The highest erosion rates occurred near the mouth of the Mermentau River and adjacent to the navigation channel jetties.

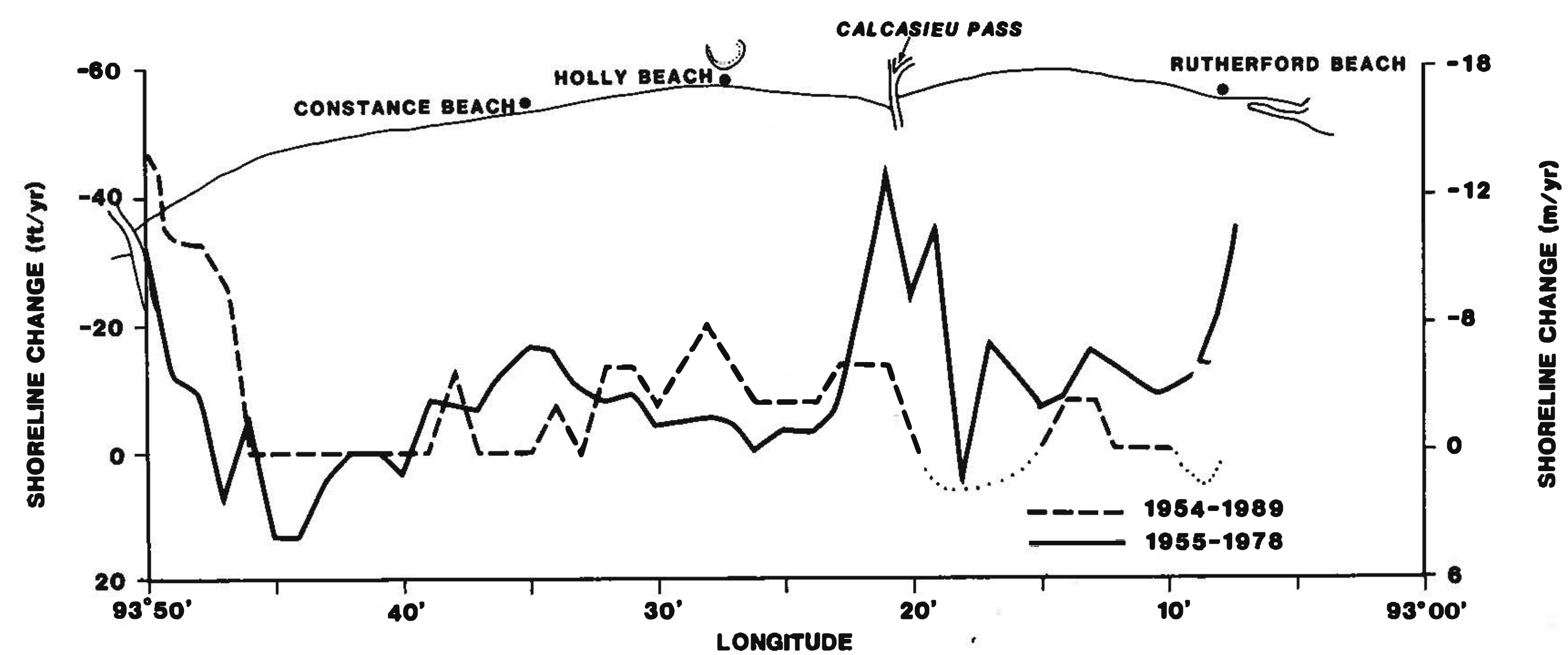


Figure 19. Shoreline Change, Hydrologic Unit 8.

Although shoreline erosion rates are not as high in this unit as along most of the barrier islands, or even most of the Chenier Plain coast in Hydrologic Unit 7, the consequences of continued erosion are much more serious in view of the extensive use in this zone. Outside of the Port Fourchon-Grand Isle shoreline in Hydrologic Unit 3, the only road-accessible sand beaches in Louisiana are found in this unit, and several recreational settlements have developed since the 1930s. In spite of Hurricane Audrey striking the area and totally destroying the beachfront communities in 1957, recreational reconstruction has proceeded at a rapid pace.

Sediment transport is dominantly westward along this hydrologic unit shoreline, although two reaches of little or no transport exist immediately east of the jetties where the shoreline orientation approaches northeast-southwest. Based on shore characteristics and transport pattern, four subunits are delineated.

Rutherford Beach to Calcasieu Pass (Subunit A)

From the mouth of the Mermentau River to Calcasieu Pass, the beach grades from one of coarse sediment to one of fine. Coarse sands eroded from the Hackberry Beach chenier migrate alongshore (westward), naturally bypass the mouth of the Mermentau, and reattach to the shore near Rutherford Beach. Proceeding westward, the proportion of coarse sediments decreases until, near Cameron Beach, the shoreline consists of a wide band of intertidal mudflats fronting marshland.

Shoreline erosion rates averaged 13.7 ft/yr (4.2 m/yr) over this subunit between 1955 and 1978, although localized sections experienced much higher retreat rates. The recreational community of Rutherford Beach, dating to the 1940s and presently containing about 35 recreational dwellings, was laid out on a precarious site at the mouth of the Mermentau River, directly across from the westward-accreting Hackberry Beach spit. As the spit builds across the river mouth, the channel becomes deflected against the opposite shoreline, thus causing increased erosion (Plate 4). Net shoreline erosion rates at Rutherford Beach, as a combined result of fluvial and marine processes, averaged over 34 ft/yr (10 m/yr) between 1955 and 1978 (see Figure 19). The other zone of observed high shoreline retreat rates is east of the Calcasieu Pass jetties, the site of extensive mudflats. Although shoreline erosion has been high, the measured rates of up to 34.8 ft/yr (10.6 m/yr) are slightly misleading because of the variance in water levels between the 1955 and 1978 sets of aerial photography. The wide band of intertidal flats was prominently exposed on the 1955 imagery and submerged on the 1978 imagery.

Because of the fine-grained nature of the beach sediments along most of this subunit--and consequent low recreational appeal--coastal land use is not very developed. Recreational development is restricted to Rutherford Beach, although prior to Hurricane Audrey in 1957 some recreational development existed at Broussard's Beach and Cameron Beach, south of Cameron. Although no direct settlement on the shoreline presently exists south of Cameron, several town subdivisions are located within 0.5 mi (0.8 km) of the coast.

Calcasieu Pass to Long Beach (Subunit B)

From the Calcasieu Pass jetties to slightly west of Long Beach the shoreline consists of sand beach, and littoral sediment transport is dominant in a westerly direction. A narrow beach ridge fronting the coast characterizes most of the subunit, although accretion ridges associated with Calcasieu Pass and Sabine Pass sedimentation occur at both ends of the subunit (Plates 2 and 3). The Gulf Coastal Highway (La. 82) follows the shoreline along most of the subunit, and much recreational development has occurred. While overall shoreline erosion rates are comparatively low, the proximity of the highway and recreational settlement to the shore makes coastal erosion a serious problem.

When highway construction in the 1930s first allowed easy beach access to the public, recreational beach settlements developed (Meyer-Arendt 1981). Holly Beach, Peveto Beach, Constance Beach, and Ocean View Beach all had their origins during this period. Recreational growth has been strong since the 1930s, in spite of occasional damaging hurricanes. Hurricane Audrey in 1957 totally destroyed all beachfront development and breached the coastal highway. The community of Peveto Beach, previously situated at the eastern end of the Sabine accretion ridges (that were severely truncated by the storm), was never rebuilt. Holly Beach and other smaller settlements between Peveto Beach and Long Beach were quickly rebuilt, however. A 1981 overflight and ground survey identified ten beach subdivisions in the area and inventoried existing structures. In order of importance, these included Holly Beach (583 structures), Constance Beach (117), Chaisson Subdivision (38), Ocean View Beach/Little Florida (14), and Long Beach (6). Commercial development is restricted to Holly Beach, which contains a number of small businesses and numerous motels and rooms for rent.

Shoreline erosion rates averaged over 10 ft/yr (3 m/yr) over the subunit (1955-1978), although higher average rates occurred adjacent to the Calcasieu Pass jetties and at the zone of accretion ridge truncation at Peveto Beach. Although mudflats occur on the west side of the jetties, a thin strip of sand beach comprises the shoreline. Retreat rates exceeded 40 ft/yr (12 m/yr) here, and it is surmised that the jetties (and maintenance dredging) have removed a source of sediment that was formerly redistributed along the flanks of Calcasieu Pass. In the vicinity of Peveto Beach/Constance Beach, erosion rates are almost double the subunit average, up to 16.5 ft/yr (5 m/yr). It is in this area that undermining of the coastal highway by wave action is a serious problem. Following a survey by the USACE (1971), the Louisiana Department of Public Works constructed gobi-block revetments along a 3-mi (5 km) stretch of highway along Peveto Beach (Dement 1977). The revetment mats have not successfully withstood storm impacts, and plans call for reinforcement of the revetments during the early 1980s.

Longshore sediment drift is dominantly westerly along this subunit. Sands eroded from beach ridges in the Holly Beach vicinity, and from truncation of the Sabine accretion ridges near Peveto Beach/Constance Beach, are being transported westward by littoral processes and deposited along the shoreline west of Long Beach.

West of Long Beach (Subunit C)

The shoreline in this subunit consists of sand which has been transported from further east. The shoreline has accreted here at an average rate of 3.7 ft/yr (1.1 m/yr) between 1955 and 1978. Accretion rates of over 13 ft/yr (4 m/yr) occur along localized reaches. Sediment transport is westerly, although rates of transport decrease as the shoreline takes on an increasing northeast-southwest orientation. The western end of the subunit contains the westernmost sand beach in Louisiana. (Partly owing to the increasing distance from the highway to the beach, no recreational development has occurred in this subunit.)

Sabine Mudflats (Subunit D)

The final subunit in the Calcasieu-Sabine hydrologic unit consists of marshy shoreline, fronted for the most part by mudflat deposits. While a pattern of accretion formerly characterized this subunit, recent trends indicate significant shoreline erosion (Plate 1). Average retreat rates of 9.6 ft/yr (2.9 m/yr) were calculated, although adjacent to the Sabine Pass jetties rates of 32.2 ft/yr (9.8 m/yr) were found. Sediment transport patterns are not apparent, and on the basis of the shoreline orientation, bidirectional drift is inferred.

Chapter IV

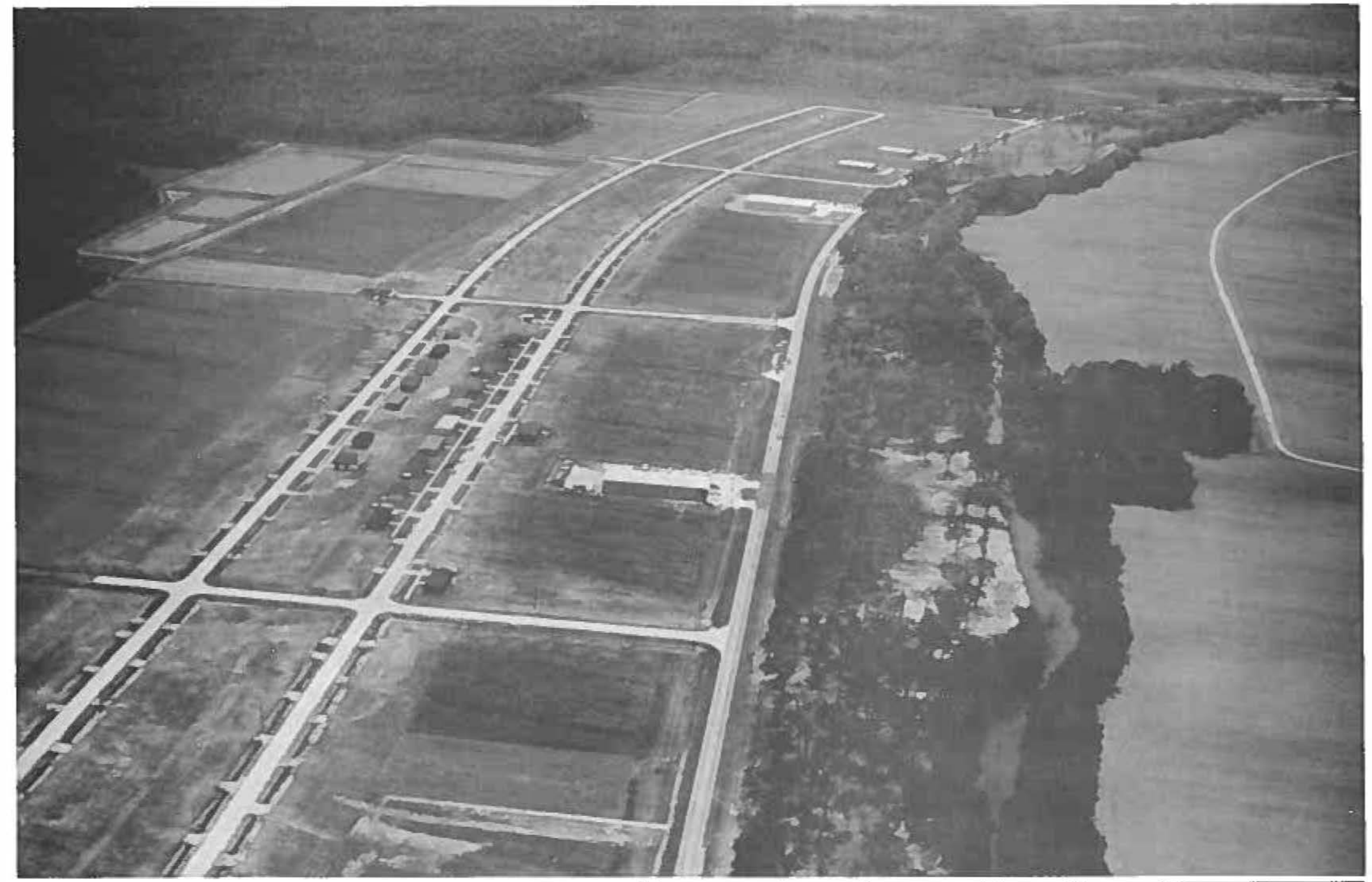
Impacts upon Land Use Patterns

When reviewing land uses in Louisiana's coastal area various trends can be observed. Some reflect changes in the natural system; others are the result of external economic forces. Examples include respectively the abandonment of agricultural operations in response to saltwater intrusion and the industrial expansion along the coast associated with offshore oil and gas extraction. Comparison of these trends illustrates a growing conflict that must be given full recognition. That is the conflict resulting from convergence of the seaward expansion of industrial and urban development and the landward expansion of the Gulf of Mexico.

Gulfward expansion of urban and industrial development occurs for numerous reasons. These include dependence on natural levee ridges, the distance to marine operations and related fuel costs, the location of existing development, and existing and newly created waterways. Agricultural development shows a similar trend as market prices allow larger risks associated with more floodprone areas. However, irrespective of the validity of these reasons, the natural processes of subsidence and erosion continue as part of the deltaic system, and resultant environmental changes are increasingly felt.

In response to these changes, in particular increased flood frequencies and levels, structural measures are often proposed and implemented. These include flood protection measures, ranging from hurricane protection levees to lower back-levees, as well as measures directed to stem saltwater intrusion, such as structural barriers. In recent years extensive back-levee construction has taken place to protect the communities at the lower ends of the smaller distributary ridges, especially in the parishes of Terrebone, Lafourche, Plaquemine, and St. Bernard.

The following paragraphs examine present development within each of the hydrologic units, associated development of protection measures, and ramifications of continued erosion and deterioration. Major land use patterns are displayed for the areas gulfward of, and immediately landward of, the first major inland development shown on Figure 20.



Urban expansion along natural levee ridge.

Hydrologic Unit 1: Chandeleur-Breton

For the most part, land use in this hydrologic unit is protected by back-levees of the Mississippi River and Bayou La Loutre. In Orleans Parish, the first inland line of development follows Paris Road from the Mississippi River back-levee to the Intracoastal Waterway, then along the northbank levee (the southern edge of the Almonaster-Michoud Industrial Development Corridor) to near Chef Menteur Pass. From that point, U.S. Hwy 90 is followed to the Pearl River. Land use patterns consist of a mixture of urban area, agriculture, and industrial development along the protected natural levees of the Mississippi River and Bayou La Loutre. Between Paris Road and Chef Menteur Pass an industrial corridor is situated north of the Gulf Intracoastal Waterway and west of Chef Menteur a strip development of stilt recreational camps flanks Hwy 90 (which follows the distributary ridge).

Land use gulfward of these leveed areas, other than isolated recreational camps and oil industry installations, is restricted to the lower Bayou La Loutre and Bayou Terre aux Boeufs distributary

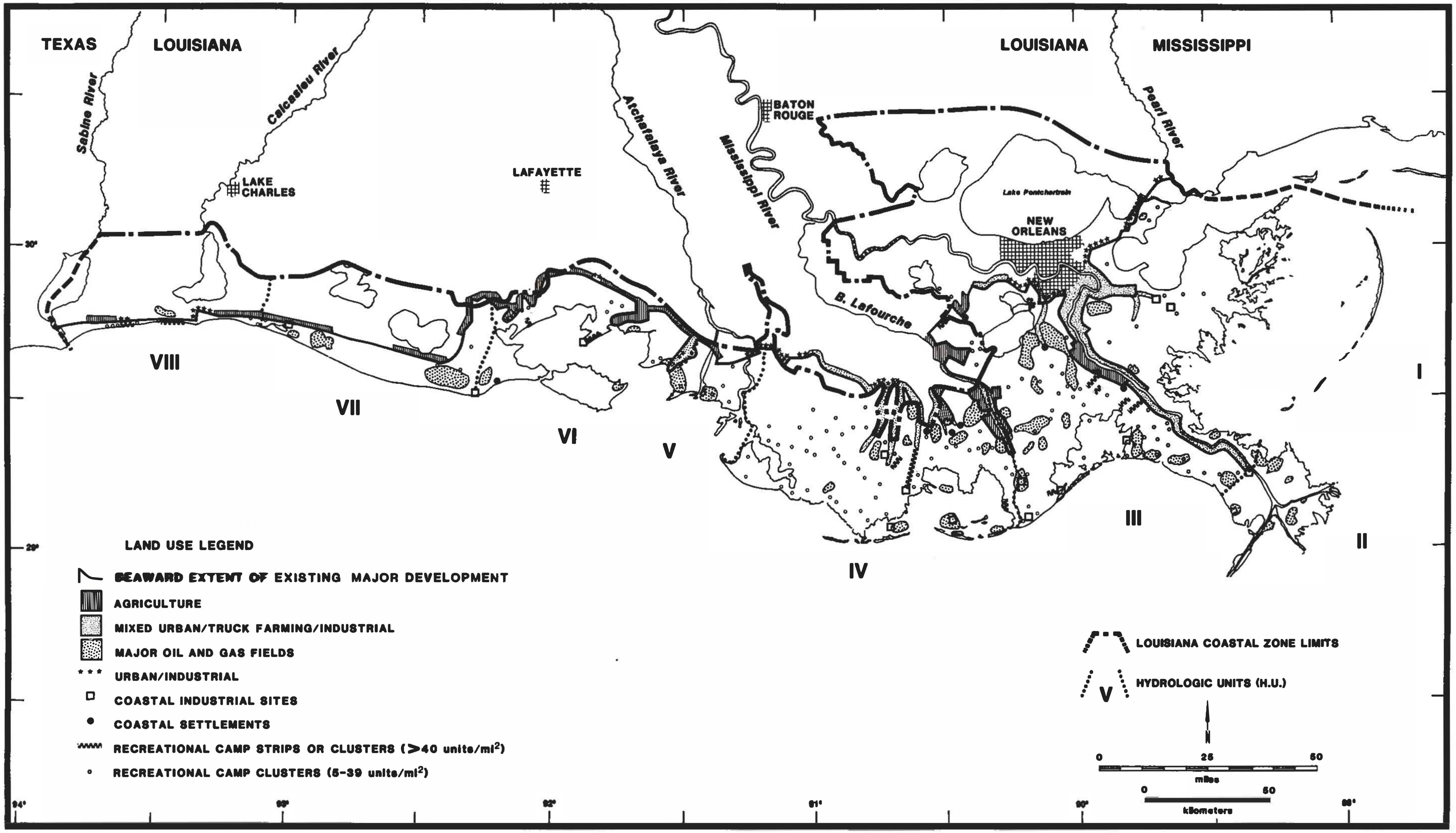


Figure 20. Land Use Patterns (after Davis and Gary 1979; Louisiana Department of Conservation 1973; Louisiana Office of State Planning 1972; and Wicker et al. 1980).

ridges. Land use is primarily urban and agricultural with scattered sites of industrial development. Settlements along these ridges - such as Ycloskey, Hopedale, Reggio, and Delacroix - are facing problems of subsidence and saltwater intrusion. Comparison of 1955 and 1978 conditions around Delacroix (Figure 21) indicates a large increase in waterbodies. In addition to new canalization, old canals and bayous have widened and many new lakes have appeared. Sections of the ridge have been back-leveed since 1955, as seen by the back-levee canal outlined on Figure 21.

Hydrologic Unit 3: Barataria

Existing major development in the Barataria hydrologic unit follows primarily the back-levees of the Mississippi River and Bayou Lafourche, which are flanked largely by agricultural land (dominantly sugarcane) and urbanized land and industry at the southern edge of greater New Orleans (see Figure 20). Much wetland has been reclaimed for agricultural and urban expansion along Bayou Lafourche, near Des Allemands, and south of New Orleans by means of back-levee construction. Gulfward of these levees, land use is limited to the Bayou des Familles/Bayou Barataria distributary ridge (containing the settlements of Barataria and Lafitte), numerous recreational camp clusters, small fishing settlements (e.g., Grand Bayou, Bayou Gauche), isolated industrial complexes (e.g., Leeville, Grande Ecaille), and the shorefront urban/industrial/recreational centers of Port Fourchon and Grand Isle.

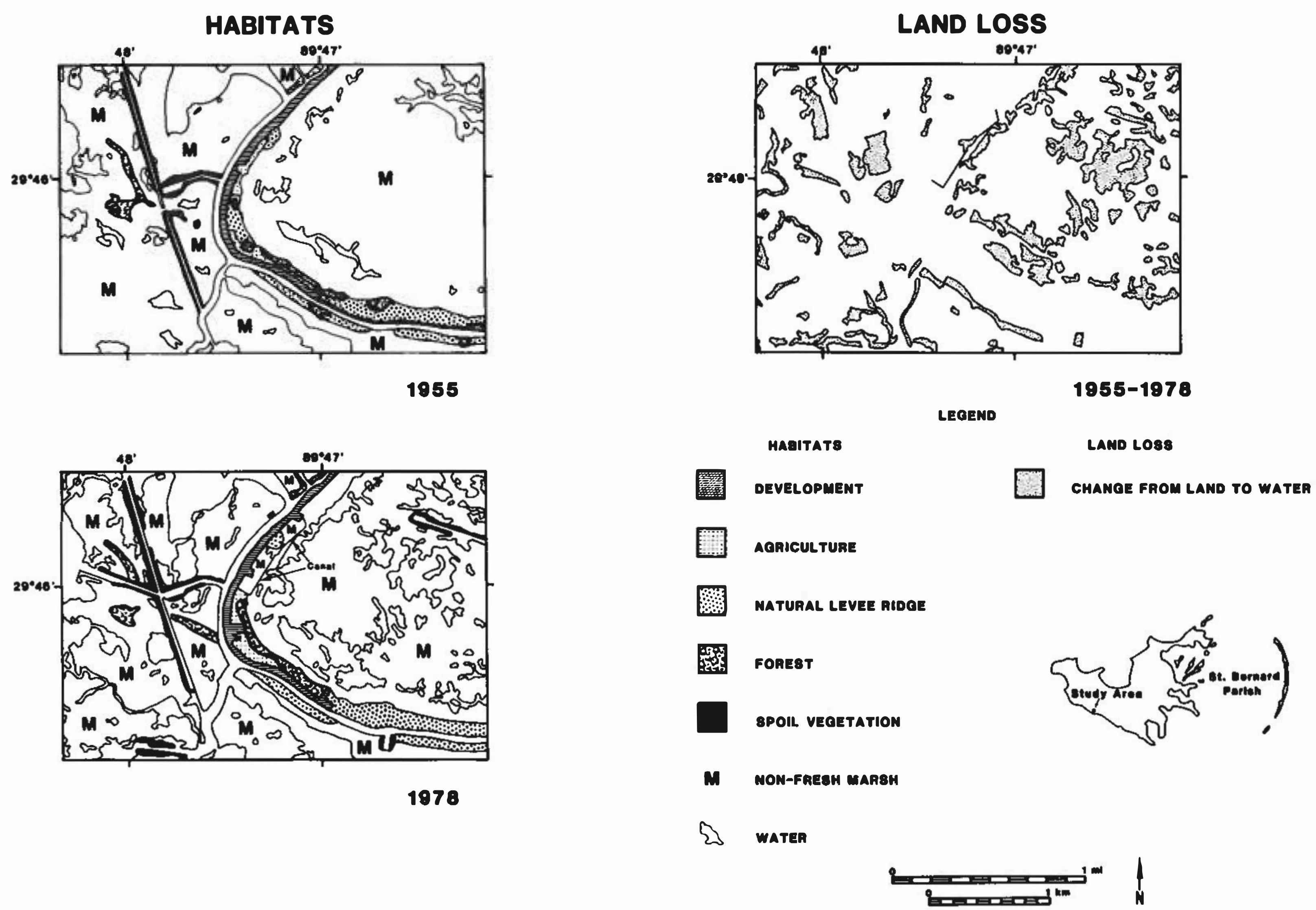


Figure 21. Habitat Change, Delacroix and Vicinity, 1955-1978.

Land loss rates within the wetlands exceed 4 acres per square mile of gross land area per year ($ac/mi^2/yr$), or 0.6 $ha/km^2/yr$, adjacent to Bayou Lafourche, and the recent construction of back-levees in that area was undertaken as a protective measure against flooding due to hurricanes. Similarly, the natural levee of the Mississippi River (west bank) is protected by back-levees as far south as Venice, the site of much oil industry development.

The greatest potential for property damage by shoreline erosion processes (both normal and storm-surge related) lies in the development sites of Grand Isle and Port Fourchon. Grand Isle, described in greater detail previously, is the targeted recipient of $14 million in shore protection measures (USACE 1980). An even greater potential threat exists at Port Fourchon, an industrial and recreational center near the mouth of Bayou Lafourche (where shoreline erosion rates exceed 70 ft/yr [21 m/yr]). A tank farm has occupied the site since the 1950s (Figure 22), but rapid industrial development did not take place until the early 1970s. Judging by the 1932, 1955, and 1978 overlays of the Port Fourchon vicinity, shoreline retreat has been rapid. The selection of this site for industrial development has not been wise, and it is anticipated that a considerable amount of shoreline protection will be required in the near future. (Although the extension of the Belle Pass jetties has slightly retarded erosion rates at Fourchon Beach, overwashed beach sands are already starting to fill in some of the treatment ponds at the site.)

Grand Terre Island, east of Grand Isle, is the site of a Louisiana Department of Wildlife and Fisheries field station and the historic Fort Livingston. The island is eroding mostly at its ends, and tidal-exchange processes account for most of this erosion. While shoreline retreat rates are not as severe as at Port Fourchon, some shoreline protection will be required in the near future.

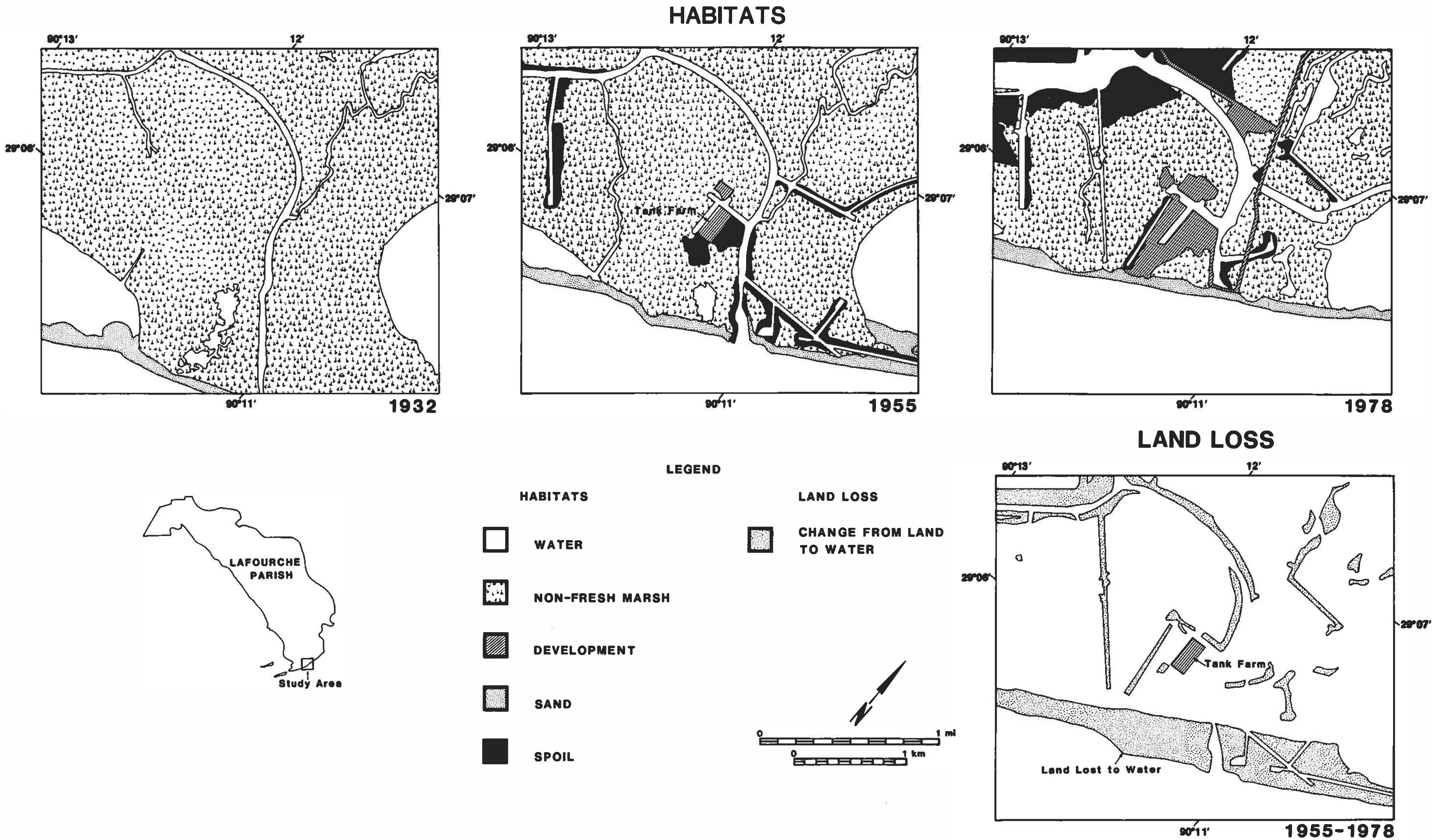


Figure 22. Habitat and Shoreline Change, Port Fourchon and Vicinity, 1932-1978.

Hydrologic Unit 4:
Terrebonne-Timbalier

With the exception of several north-south trending distributary ridges, the first inland high ground in the Terrebonne-Timbalier hydrologic unit is encountered at the east-west trending distributary ridges of Bayou Black and Bayou Blue. These ridges, in conjunction with the back-levees constructed along Bayous du Large, Grand Caillou, Petit Caillou, Terrebonne, Pointe au Chien, and a segment of Bayou Lafourche above Golden Meadow, comprise the limits of existing major development in this unit. Along many of these distributary ridges, back-levees were not constructed until the 1970s, in response to increases in subsidence, marsh-to-water conversion, and flood potential. To illustrate these points, the example of the village of Boudreaux along Bayou Grand Caillou is provided (Figure 23). Subsidence factors have led to a gradual narrowing of the ridge lands, and agriculture along the natural levees has decreased because of 1) urbanization, and 2) abandonment due to increasing wetness. Wetland forests have been killed off by increasing salinities and hydrologic impoundments, and marshes have become more saline. Considerable forest and marsh have converted to open water, especially to the east of Boudreaux. The potential for higher water level set-up by winds, and subsequent flooding, contributed to the recognition of a need for back-leveeing.

The southern distal ends of the Terrebonne distributaries, south of the back-leveed sections, contain many small communities, recreational camps, motels and marinas, and some industry (mainly fishing-related). These zones are quite vulnerable to increased saltwater intrusion and land loss, which are very severe here. As the surrounding marshes turn into open water, the danger of storm-surges increases the threat to these areas. Back-levee construction is not very feasible here because of the narrow widths of the natural levees. The value of the marshland as a protective buffer is recognized readily in these lower distributary ridges.

Land use along the Gulf shoreline is presently restricted to several recreational camp clusters and oil and mineral industry installations on and behind the barrier islands. Several of the oil companies have experimented with shore protection measures because the conversion of drilling sites from onshore to offshore (as the shoreline retreats) requires the expenditure of even greater amounts of money. Recreational camp clusters (of a dozen or so camps each) are found on Timbalier Island and Eastern Isles Dernieres, but presumably recreationists are aware of hurricanes and island erosion threats. (Recreational camps are numerous throughout the lower bayous and marshes of Terrebonne Parish.)

Hydrologic Unit 6:
Vermilion

Land use south of the Pleistocene terrace and the natural levee of Bayou Teche, the limit of present development (excepting the salt domes), is confined to recreational development (primarily at Cypremort Point and near Intracoastal City), commercial fishing centers (Cypremont Point, Intracoastal City), some oil industry installations, and USACE lock structures near the mouth of Freshwater Bayou Canal and near Intracoastal City. None of these areas are particularly threatened, except in cases of a severe hurricane. Land loss rates within the marshes are moderate to low, and shoreline erosion rates along the Gulf are also low. Cheniere au Tigre, a permanent settlement until the 1940s and now seasonally occupied by descendants of the original settlers, is situated directly on the coast. Several camps along the eastern reaches of the "island" are located at the

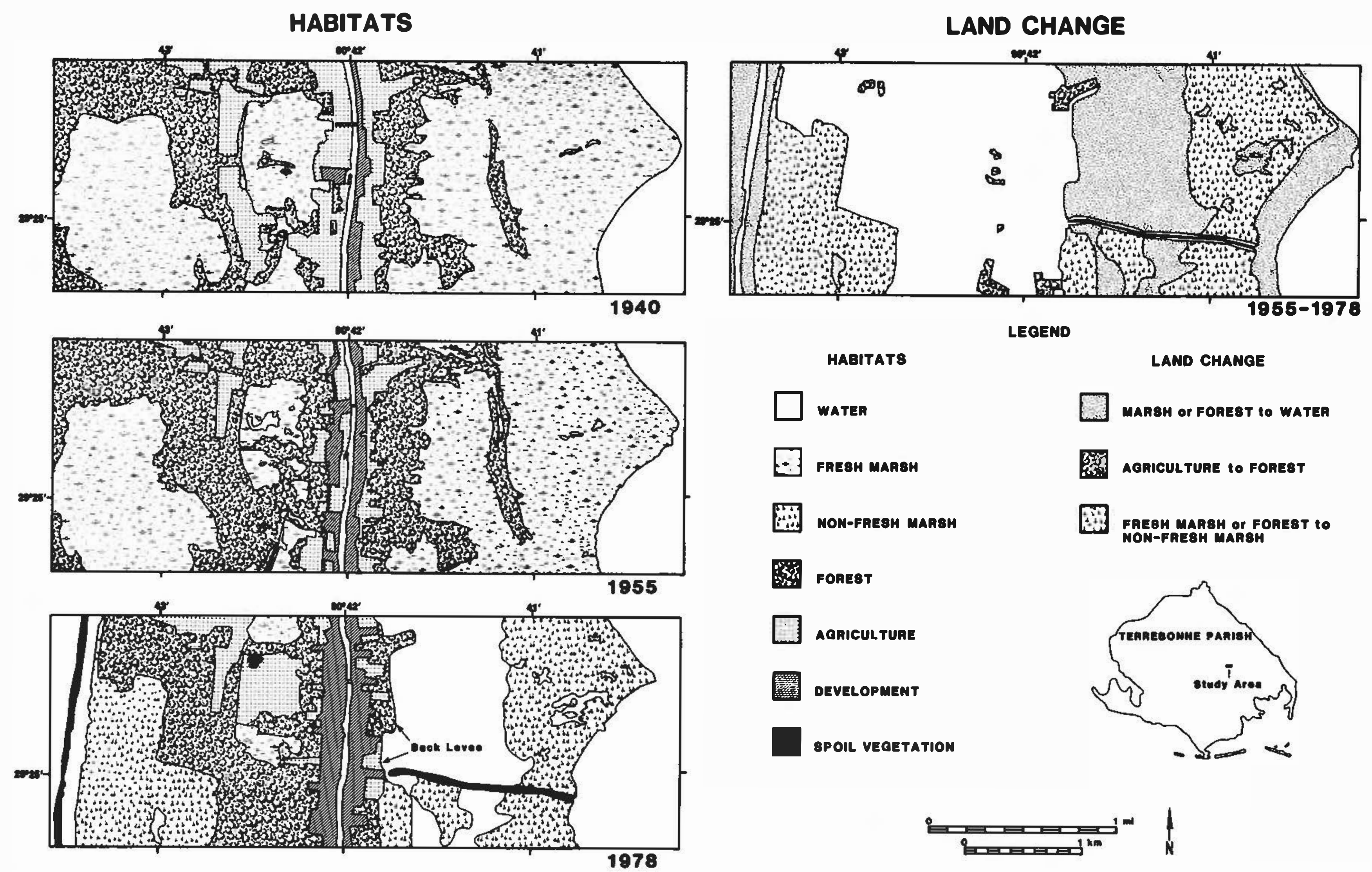


Figure 23. Habitat Change, Boudreaux and Vicinity, 1940-1978.

water's edge, but the high relative elevation of the chenier (10 ft MSL [3 m MSL]) and low retreat rates and periodic accretion of mudflats reduce the overall dangers. The developing industrial center near the Freshwater Bayou Canal locks is also in an area of relative shoreline stability, although hurricanes would lead to severe impacts. (The numerous unpopulated cheniers in the area support a large cattle-grazing industry.)

Hydrologic Unit 7: Mermentau

As in the Vermilion hydrologic unit, little danger to land use as a result of wetland deterioration and shoreline erosion is foreseen south of a line following the edge of the Pleistocene terrace and the first inland cheniers (along which La. Hwy 82 runs). Development has historically been restricted to the cheniers, although recently an industrial center developed along the Mermentau River just south of Hwy 82. The Rockefeller Wildlife Refuge, containing a number of housing units and other structures, is located south of Hwy 82. The greatest potential for damage lies in the erosion of the surrounding protection levees, which would lead to the inflow of saline water. Some of the levees are near the Gulf shoreline, which is retreating rapidly. Isolated oil drilling structures may be impacted by the high shoreline erosion rates, but little other land use would be affected.

Hydrologic Unit 8: Calcasieu-Sabine

Continued shoreline erosion could prove quite serious to the extensive recreational development along the beaches of the Calcasieu-Sabine hydrologic unit. La. Hwy 82, which dictates the position of the first inland line of development, follows cheniers and beach ridges which are situated close to the Gulf. The only developed areas south of the highway consist of beachfront recreational settlements and several urban subdivisions south of Cameron.

The recreational centers of Rutherford Beach, Holly Beach, Constance Beach, and several smaller subdivisions south of Johnsons Bayou contain over 800 structures (Meyer-Arendt 1981). Practically all of these settlements are threatened by shoreline erosion (see earlier section for more detailed discussion). An area of particular concern to the state is the stretch between Holly Beach and Constance Beach. Hwy 82 near Peveto Beach is frequently overtopped, and existing revetments have not adequately withstood the force of the sea. Historically, the highest shoreline retreat has been between Peveto Beach and Holly Beach, but in recent decades the zone of highest erosion has shifted westward and is now between Constance Beach and Peveto Beach (Figure 24; Plate 2). No severe hurricane has struck this coast since Carla in 1961. Construction of camps has greatly increased since that time (Meyer-Arendt 1981), and a severe hurricane would cause extensive property damage in the area.

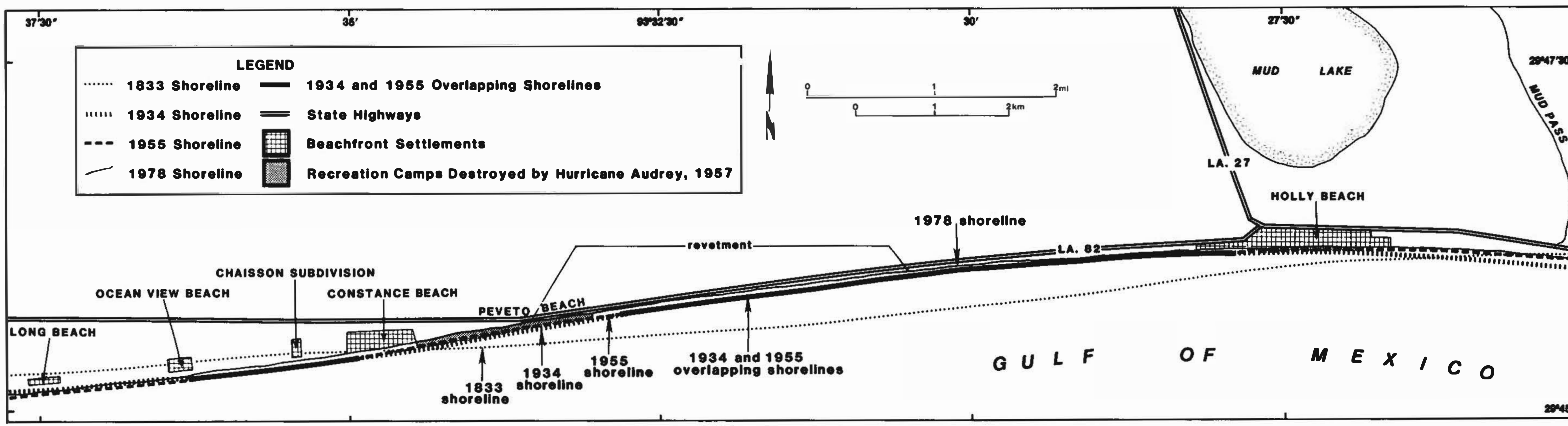


Figure 24. Shoreline Change, Holly Beach and Vicinity, 1833-1978.

Chapter V
Remedial Measures

Rigid Versus Flexible Solutions

A variety of measures are available for protection and stabilization of Louisiana's shoreline. Ranging from seawalls to beach nourishment, all could be implemented given sufficient time and money and could be expected to reduce erosion at least for some time. Benefits must, however, be weighed against cost, both for construction and maintenance.

Possibly the process of selecting remedial measures should begin with an economic analysis of direct costs and of lost benefits that would result from various rates of shoreline retreat and erosion of the barrier islands. This would then determine the amount of money one could reasonably commit to erosion protection measures given the cost and effectiveness of such measures.

Alternatively one may begin the selection process with consideration of available measures and of constraints posed by the natural environment relative to long-term effectiveness of those measures and to compatibility with coastal processes. This route has the likely advantages of reducing the number of measures that need be considered in future analyses and is followed here in part also because of the scope and objectives of the present study.

When considering available measures, a division into three general categories may be made. One category includes seawalls, revetments, bulkheads, dikes, and other similar structures whose primary function is to maintain a fixed boundary between land and sea by replacing the mobile shore sediments with rigid materials. These structures are usually the most costly because of construction methods, materials cost, the 1:1 ratio between structure length and protected length of shoreline, and the level of storm intensity they must be able to withstand.

The second category includes various types and combinations of groins and breakwaters. In this case, the beach remains the basic shore protection method, while direct function of the measure is to protect the beach deposits by modifying the littoral transport system in such a way that more sediment is retained along a particular shore segment. The effect may range from reduced erosion to deposition and may involve reorientation of the shoreline relative to wave approach, reduction of wave heights, or collecting of sediment to be used for redistribution.

Shore protection, East Timbalier Island.

Both the first and the second categories have one important element in common. That is that employment of each of these measures represents a perturbation of the littoral transport system so that the sediment supply to adjacent areas is adversely affected. Commonly, these measures have been employed to reduce erosion along a limited shoreline segment, resulting in at least a temporary acceleration of erosion in adjacent areas. Although undesirable, this type of situation may be warranted if existing development is of sufficient economic value, relocation of development is not feasible, and adjacent areas have an adequate sediment supply to withstand the adjustment.

The limited sediment supply along the Louisiana coast proves a major constraint to employment of the above measures on a selected basis. In particular, along most of the barrier islands, employment of these measures along limited shoreline segments could in many cases cause breaching of the beach system in adjacent shore segments. Application of the measures along the barrier islands, therefore, is likely to require a functional design that would extend along at least an entire island and possibly include downdrift islands within the same chain.

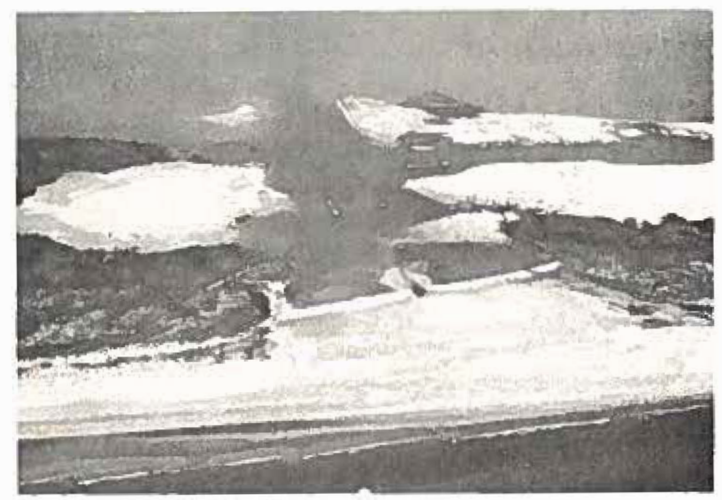
The utilization of permanent structural measures over extensive lengths of shoreline is extremely costly. Such cost is further augmented by frequent exposure to hurricane conditions. Since most of the shoreline retreat occurs as a result of hurricane landfall, the structures, to be effective, must be able to withstand hurricane-level forces requiring high structural integrity or large volumes of materials. Both contribute to cost increases.

A third constraint relative to permanent structures is subsidence. Retreat of the shoreline and landward migration of the barrier islands are largely a response to regional subsidence and associated adjustment of the shore profiles. Since subsidence will continue independent of shore protection measures, the tendency for inland migration of the shoreline will remain. Permanent protection structures therefore must arrest all sediment loss from the beach system or will be gradually separated from the shore. Yet, even if the first were feasible, subsidence would still result in a gradual submergence of the shore and an increased frequency of overtopping of the protection structures.

A similar separation of permanent structures from the beach may occur if design is inadequate. For example, overtopping of shore-connected, parallel breakwaters during storms may result in seaward transport of sediment from behind the breakwater. Subsequent return of sediments during low-energy conditions is prevented as a result of the breakwater, resulting in accelerated erosion, undermining of the breakwater, and breaching of the remaining, reduced beach system.

When considering constraints, costs, economic justification, and long-term benefits, it becomes evident that none of the above measures are likely to be cost effective or successful as an overall approach to Louisiana's coastal erosion problem. Any successful approach must deal with 1) the difference between the Chenier Plain and Deltaic Plain systems, 2) the irrevocable subsidence and associated system responses, 3) the limited availability of sediment and, correspondingly, major changes resulting from interruptions of littoral transport, and 4) the realization that Louisiana's barrier beach/island system should be viewed as a front line of defense. It must, however, also be recognized that present high rates of shoreline retreat and coastal erosion are not necessarily nature's normal course of events.

When taking the above factors into account, an overall approach suggests itself which focuses on retention of materials within a flexible rather than a rigid system. That is, where possible, protection measures should be directed at restoring and maintaining integrity of the beach/dune system as a means to reduce the rate of shoreline retreat and erosion rather than on maintaining the shoreline in a fixed position. To insure continued protection by the barrier beach system, management must be for an orderly retreat with minimal loss of sediment. This approach is the most cost effective while providing the necessary time to adequately plan and implement a long-term coastal protection system.



Beach restoration at washover associated with rig-cut.

As indicated, the suggested approach involves two major elements. The first task is one of restoring integrity of coastal segments in a manner compatible with natural system trends. This restoration must involve restoring a minimal sediment supply and beach barrier apron to reduce breaching and minimize loss of sediments from the active land/water interface. The second task is one of maintenance that must focus on retaining available sediments within each unit as landward migration takes place. To the largest extent possible, such retention should focus on promoting storage of sand through dune development along the existing shoreline and in particular on newly developing spits. Permanent structures should be utilized only where necessitated by essential development or where functional design assures no adverse affect on downdrift littoral systems.

Sand Nourishment

The erosion of Louisiana's barrier islands and beaches can best be retarded by the introduction of material for periodic nourishment. Modes of application include beach nourishment, dune reconstruction, and filling of waterbodies and creation of marsh habitat in the back-barrier zone. These measures can help minimize high shoreline erosion rates, offset loss of land area due to subsidence, retard washover development, and provide a foundation for landward-carried sediments to build upon in the back-barrier zone.

Beach nourishment can be conducted utilizing several basic methods: nearshore dumping, stockpiling, direct placement, and continuous supply (or bypassing). Nearshore dumping entails disposing the fill material in the nearshore zone of active sediment movement (less than 2 fathoms) and allowing the material to be distributed onto the beach by coastal processes. Stockpiling entails disposing the fill material directly upon the beach in one location and allowing longshore transport processes to move the material to downdrift areas. Direct placement is the nourishment (or creation) of beach over its continuous length. The continuous supply method refers to a system of bypassing, whereby sands are mechanically (or hydraulically) moved past interruptions in the sediment transport system such as jetties or navigation channels.

Dune construction consists of building up the elevations of the barrier island or active beach ridges, and is best suited for areas that have been subjected to breaching or extensive washover development or where the potential for such erosive processes exists. The actual dune need only be approximately 60 ft (18 m) wide and 4-6 ft (1-2 m) high at its crest. Where breaches need to be sealed to effectively restore a barrier island or beach, it may be necessary to fill the breaches with rock so that a dune can be constructed. Two important supplementary measures in dune construction are the installation of sand fences--to trap and build up wind-blown sands--and the planting of dune-stabilizing vegetation. These two measures serve to stabilize the introduced nourishment material by reducing the potential for erosion by winds and waves.

Back-barrier bay fill and marsh creation are island nourishment methods that can be applied effectively on the bay side of the dune crest. To prevent loss of valuable sediment due to overwash processes, it is important that a certain barrier island width--and fairly solid land area--is maintained. (In Louisiana, an absolute minimum acceptable width is 650 ft [200 m], although optimum widths range from 1500-2000 ft [450-600 m].) Bayous, ponds, and especially dredged canals located within 650 ft (200 m) of the Gulf shore should be filled with introduced sediment. If the width of a barrier island is less than this minimum critical width, a potential for breaching exists and additional back-barrier habitat needs to be created by pumping in nourishment material. To create back-barrier marsh habitat, finer nourishment material (that may be incompatible with beach sediments) can be utilized. A back bay retaining dike would prevent excessive slumping, and the seeding of marsh grasses (*Spartina alterniflora*) or mangroves (*Avicennia germinans*) will accelerate stablization (Meyer-Arendt and Wicker 1982). Considerable research and experimentation with marsh habitat creation has been conducted by the Dredged Material Research Program Section of the U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi (Saucier et al. 1978).

Sources of Nourishment Material

Potential sources of nourishment material, to apply to Louisiana's eroding barrier islands and beaches, are found in offshore and nearshore sand deposits, outer bars (ebb-tidal deltas) of tidal inlets, and the sediment-laden Mississippi and Atchafalaya Rivers. Additional sand deposits occur in land-stranded cheniers and beach ridges, inner bars (flood-tidal deltas) of tidal inlets, and in sediment sinks such as the numerous estuarine bays. However, these latter locations are considered less feasible because of environmental constraints (negative impacts upon wetlands), as well as economic/technologic limitations (for example, thin sand layers and a reduced cost-effectiveness), although more research needs to be conducted in these areas.

A large volume of coarse material is contained in offshore deposits (BLM 1979). In the central and eastern portions of the Louisiana coast, these sand bodies are former deltaic deposits, comprised of subsided delta-mouth bars, outer rims (former barriers) of delta lobes, and filled-in relict channels. Offshore of the Chenier Plain coastline are numerous exposed Pleistocene outcrops and coarse-sediment-filled channels. Considerable field research still needs to be conducted, specifically seismic analyses to accurately map the deposits and vibracore interpretations to determine thicknesses of the sandbodies. This research is particularly valuable in the nearshore zone, as the costs of pumping nourishment material onto eroding beaches would be reduced substantially.

The ebb-tidal deltas of tidal inlets contain large volumes of coarse material, and recent evidence indicates that these volumes are steadily increasing (see earlier section; also Howard 1982). The ebb-tidal deltas have been described as good potential sources of nourishment material, the removal of which would have only limited adverse environmental impacts (Walton and Dean 1976). In 1981, the outer bar of Redfish Pass was dredged to provide sand nourishment for a private resort beach on Captiva Island (Olsen 1982). A small jetty was constructed at the downdrift end of the beach to trap the sands that might be transported back into the inlet by the reversal of transport processes caused by waves refracting around the outer bar (Olsen 1982).

In those inlets where navigation channels are maintained, much maintenance dredging is required to prevent shoaling. The repeated dredging of the natural outer bar (and subsequent offshore dumping of the spoil) removes large quantities of valuable material that would be well-suited for nourishment purposes. The sediments of the Cat Island Pass section of the Houma Navigation Channel (from which an estimated 400,000 yd^3 or 306,000 m^3 of sediment are dredged annually) have been categorized as 70% sand, 5% shell, and 25% silt (USACE 1975). If the nourishment material to be applied to eroding beaches is finer than the native beach material, an overfill factor (which accounts for the finer sediments that will be winnowed out by wave action) is calculated (Dean 1974). At Grand Isle, the USACE examined borrow areas due south of the island and adjacent to Barataria Pass. It was found that the offshore area (that was finally selected) yielded material that would require an overfill factor of 1.4, while the area adjacent to the tidal inlet required overfill of only 1.02 (USACE 1980). Detailed sediment analyses need to be conducted at the other major navigation channel mouths (e.g., Calcasieu Pass, Freshwater Bayou Canal, Empire-Gulf Waterway, Mississippi River-Gulf Outlet, etc.) to determine the optimum potential of dredge spoil. Even the USACE is increasingly regarding dredge material as a natural resource rather than a waste product (Walsh 1977).

The Mississippi and Atchafalaya Rivers transport much coarse material to the Gulf, and this could be used to help reduce barrier island and beach erosion. While the mining and overland transport of river sand may presently be economically unfeasible, the diversion of a portion of Mississippi River flow south of Empire would help alleviate problems of saltwater intrusion, land loss, and barrier shoreline erosion in that area (Unit 3A) by filling in the deteriorating marshes behind the Gulf shoreline. Unlike the Mississippi River that is funnelling most of its sediments to the offshore slopes of the continental shelf, the Atchafalaya River sediments are actively contributing to a building phase (van Beek and Meyer-Arendt 1981). In addition to the delta development in Atchafalaya Bay, accreting mudflats in Hydrologic Units 6 and 7 are reducing shoreline erosion rates in that area. As the Atchafalaya delta continues to grow, increasingly coarse sediments will reach the Chenier Plain coast and further minimize erosion problems there.

Technology and Engineering

Once the optimum borrow sites for beach nourishment material are located, engineering specifications need to be worked out and technologic constraints evaluated. Regarding the engineering, detailed calculations regarding volumes of fill and beach design need to be made. Based upon sediment analyses, overfill and renourishment factors must be established. Cost projections must be based upon available technology, distances involved in the transport of fill material, and number of booster stations required if the material is to be hydraulically pumped.

Primary movers of fill are usually hydraulic or hopper dredges, the latter preferred because of their high mobility and ability to dredge under oceanic conditions (Richardson 1976). A combination self-contained vessel and dredge, the hopper can either directly transport fill material into the nearshore zone and deposit it by opening the split hull or by pumping it hydraulically. If the distance to the nourishment site is over 3 mi (5 km), a floating or moored booster pump may need to be installed (Souder et al. 1978). Hopper dredges have been employed successfully in beach nourishment projects in New Jersey, Florida, and Virginia (Hobson 1981), and should be evaluated for use in Louisiana.

Applications along Louisiana's Barrier Shoreline

In view of the overriding natural factors of subsidence and associated shoreline retreat, restoration measures should be restricted to those deemed compatible with the dynamic nature of the Louisiana coastline. The installation of coastal defense structures such as seawalls, revetments, and rip-rap dikes is not only extremely costly but functionally unsound. While short-term benefits may be realized, the long-term outlook includes subsidence and scouring of the structures, removal of valuable sand to the offshore, and a potential development of a new shoreline inland of the protective structures.

The greatest hope of maintaining a healthy barrier shoreline lies in the application of sediment nourishment. To reduce potential for island breaching (and consequent development of permanent tidal inlets) and minimize washover development, sediment fill is needed to 1) seal existing breaches and washovers, 2) construct dunes to mesh with existing adjacent dunes, 3) fill back-barrier sand traps such as canals, bayous, and ponds, 4) widen the back-barrier zone to a minimum island width of at least 650 ft (200 m), and 5) nourish the beach. Various ancillary measures should augment these techniques, the most important being the planting of vegetation as a stabilizing measure. Dune grasses should be planted to minimize erosion of the constructed dune by wind and waves, and the back-barrier zone should be planted with marsh grasses and/or black mangroves to minimize slumping and back bay erosion, as well as to trap sands eroded from the dune. The installation of sand fences along the dune will assist in the trapping of wind-blown sands and a building up of the dune. (Experimental sand-fencing and dune construction on Timbalier Island have so far proved quite successful.) Although a complete closure of existing tidal inlets in the barrier island chains is unfeasible and unrealistic (because of the advanced stages of development characteristic of many of the inlets), the restoration measures will reduce the rate of further deterioration, thus lengthening the projected life spans of the islands.

By nourishing the beaches with compatible, coarse-grained sediments, a presently deficient sediment supply can be revitalized and net erosion rates offset. Although shoreline retreat will not be stopped totally, erosion rates are expected to decrease, thus prolonging the life of the islands. On barrier beaches, such as west of Calcasieu Pass, shoreline retreat rates are anticipated to be stabilized (except for setbacks as a result of future hurricanes).

Additional structural measures that may be constructed to reduce the loss of nourishment material (to tidal inlets or less critical downdrift subunits) include sand-trapping jetties, groin fields, or offshore breakwaters. However, detailed field study--examining wave conditions, littoral transport, and tidal hydraulics--is imperative prior to recommendation of such measures. Also, impacts of such measures upon downdrift reaches plus costs of maintenance must be seriously considered.

Based upon the characteristics and observed trends within the various subunits, a matrix ranking the severity of erosion and outlining potential methods of restoration was developed using several key variables (Table 2). These included loss of shoreline areas, total land loss within the littoral zones, and extent of development proximate to the shoreline. Factors accounting for relative wave energies (per hydrologic unit) were included, although hurricane probabilities (based only on past occurrences) were omitted. The chances of hurricanes making landfall are considered to be uniform across the state. In addition to the ranking of the subunits based on those criteria, subjective judgments regarding potential restoration have been made. Specific recommendations are outlined on Figure 25, and are discussed by hydrologic subunit in the following pages.

Hydrologic Unit 1: Chandeleur-Breton

The Chandeleur-Breton Island chain has experienced extensive erosion in recent decades, much of it the direct result of hurricane activity. Subunit A contains an abundant sand supply (as seen by the well-developed dune system), although numerous washovers occur there. Subunits B and C are quite sand-deficient and the islands are breaching and rapidly eroding. Potential restoration measures in Subunit A entail primarily sealing off the washovers, constructing dunes across them, and applying fill material to narrow back-barrier areas. Subunits B and C, much lower in elevation and more subject to sheet washover, would require a more comprehensive plan involving dune construction, back-barrier fill, and beach nourishment. To properly restore breached islands such as Breton and Grand Gosier, a framework will need to be constructed in order to contain nourishment material. This in turn will provide a base upon which to reconstruct the islands.

Although restoration measures can be applied to the Chandeleur-Breton island chain, the question of the economic feasibility of such restoration must be considered. The islands lie 25 mi (40 km) offshore from the mainland, and it is unlikely that a restored Grand Gosier Island, for example, will afford much more protection than if left untouched. Several 5-mi (8 km) wide tidal inlets would have to be artificially reduced in size to significantly constrict water exchange. Even so, wind fetch between the islands and the mainland could still generate erosive waves. In view of the anticipated negative benefit-cost ratios, no action is presently recommended, although the possibility of pumping dredge spoil from the Mississippi River-Gulf Outlet upon adjacent islands instead of an offshore disposal area should be examined.

Hydrologic Unit 2: Barataria

Restorative measures are highly recommended along the Barataria shoreline because of direct potential impacts upon developed areas as well as upon the natural resource base.

In Subunits A and B, the beach is narrow and sand-deficient and the marshes in the littoral zone are exhibiting extremely high land loss rates. A feasible method of restoration here

												SEVERITY RANKING MATRIX 1 = most severe							REMEDIAL MEASURES			
								Types of Development[5]														
Hydrologic Unit	Hydrologic Subunit	Name	Sediment Transport Direction[1]	Shoreline Erosion (ft/yr)[2]	Shore Length (miles)[3]	Shorefront Development (miles)[4]	Total Development (acres)[5]	Urban-Industrial	Oil & Gas Drilling	Recreational	Existing Beach Protection	Land Loss[5]	Shore Loss[6]	Development[5]	Wave Energy[7]	Storm Surge Height[8]	Mean	Ranking	Sediment Diversion	Beach Nourishment[9]	Restore Island[10]	Proposed Pilot Project
	A	North & Central Chandeleurs	NW	-33.0	23.0	0	1-9	0	0	0	0	7	2	23			7.6	6	0	0	0	0
1	B	South Chandeleurs	SW	-31.8	11.0	0	0	0	0	0	0	3	6	27	2	4	8.4	8	0	0	0	0
	C	Breton Island	SW	>-70.0	2.7	0	1-9	0	0	0	0	1	17	21			9.0	11	0	x	x	0
	A	Sandy Point to Grand Bayou Pass	W	-21.8	12.5	0	10-49	0	x	0	0	2	8	12			5.8	3	x	x	x	0
	B	Grand Bayou Pass to Cheniere Ronquille	E-W	-29.1	9.1	0	0	0	x	0	0	11	9	27			10.8	19	x	x	x	0
3	C	Grand Terre Islands	E-W	-29.2	6.4	.11	10-49	0	0	x	0	9	18	15	1	6	7.8	7	0	x	x	X
	D	Grand Isle	E	+5.9	7.9	6.72	1,350	x	0	x	x	24	27	1			11.8	21	0	0	0	0
	E	Caminada-Moreau Beach	E	-41.1	10.5	.06	150	x	x	x	0	12	5	5			5.8	4	0	x	0	0
	F	Fourchon Beach	W	-42.3	3.0	.23	150	x	x	x	x	13	21	6			9.4	13	0	x	0	0
	A	East Timbalier Island	W	-54.8	8.8	4.4	50	x	x	0	x	6	3	9			5.2	1	0	x	x	0
	B	Timbalier Island	W	-24.5	8.7	.51	1-9	0	x	x	x	8	14	22			10.4	15	0	x	x	0
	C	Wine Island	W	--	0.1	0	0	0	0	0	0	4	--	--			--	--	0	0	0	0
4	D	Eastern Isles Dernieres	E-W	-41.9	10.7	0	10-49	x	x	x	0	10	4	13	5	3	7.0	5	0	x	x	X
	E	Western Isles Dernieres	W	-35.2	6.9	0	0	0	0	0	0	5	12	27			10.4	16	0	x	x	0
	F	Grand Bayou des Ilettes to Oyster Bayou	W	-12.6	17.8	0	1-9	0	x	0	0	14	13	18			10.8	18	0	0	0	0
	G	Point Au Fer Island	W	+16.7	17.3	0	1-9	0	x	0	0	16	7	20			10.2	15	0	0	0	0
	A	Marsh Island (east coast)	NE	-17.4	8.1	0	0	0	0	0	0	17	20	27			15.0	25	0	0	0	0
	B	Marsh Island (south coast)	W	-12.0	20.7	0	50	0	x	0	0	19	11	8			9.8	14	0	0	0	0
6	C	Rainey Wildlife Sanctuary	E-W	-10.2	9.3	0	1-9	0	x	0	0	23	22	16	8	5	14.4	23	0	0	0	0
	D	Cheniere Au Tigre	NE	-12.8	4.5	0	1-9	0	0	x	0	26	23	19			15.8	27	0	0	0	0
	E	Bill Ridge	W	-10.7	3.8	0	10-49	x	0	0	0	25	25	14			15.0	24	0	0	0	0
	A	Freshwater Bayou Canal to Flat Lake	W	-16.8	15.7	0	10-49	x	x	0	0	18	10	10			8.4	9	0	0	0	0
7	B	Flat Lake to Mermentau-Gulf Nav. Channel	W	-40.0	29.9	.04	100	0	x	0	0	15	1	7	3	1	5.4	2	0	0	0	0
	C	Hackberry Beach	W	-21.2	7.3	0	10-49	0	x	0	0	20	19	11			10.8	20	0	x	0	0
	A	Rutherford Beach to Calcasieu Pass	W	-13.7	13.9	.59	650	x	x	x	0	22	15	3			9.2	12	0	0	0	0
	B	Calcasieu Pass to Long Beach	W	-10.1	18.8	8.60	700	x	x	x	x	21	16	2			9.0	10	0	x	0	X
8	C	West of Long Beach	W	+3.7	8.1	0	300	x	x	0	0	28	26	4	4	2	12.6	22	0	0	0	0
	D	Sabine Mudflats	E-W	-9.8	4.4	0	1-9	0	x	0	0	27	24	17			15.0	26	0	0	0	0

1 dominant longshore sediment transport
2 average rate, 1955-1978
3 gulf shore only
4 includes shore protection structures
5 within littoral zone as displayed on Plates 1-31
6 shoreline erosion rate x shore length
7 at shoreline, based upon southeast winds and refraction of 12.5 ft wave height
8 based upon 100-year flood elevations x 1.55 (USACE 1970)
9 includes potential use of dredge spoil
10 seal breaches, build dunes, back-barrier fill, and revegetate

Table 2. Severity Ranking Matrix of Louisiana's Barrier Shoreline Subunits.

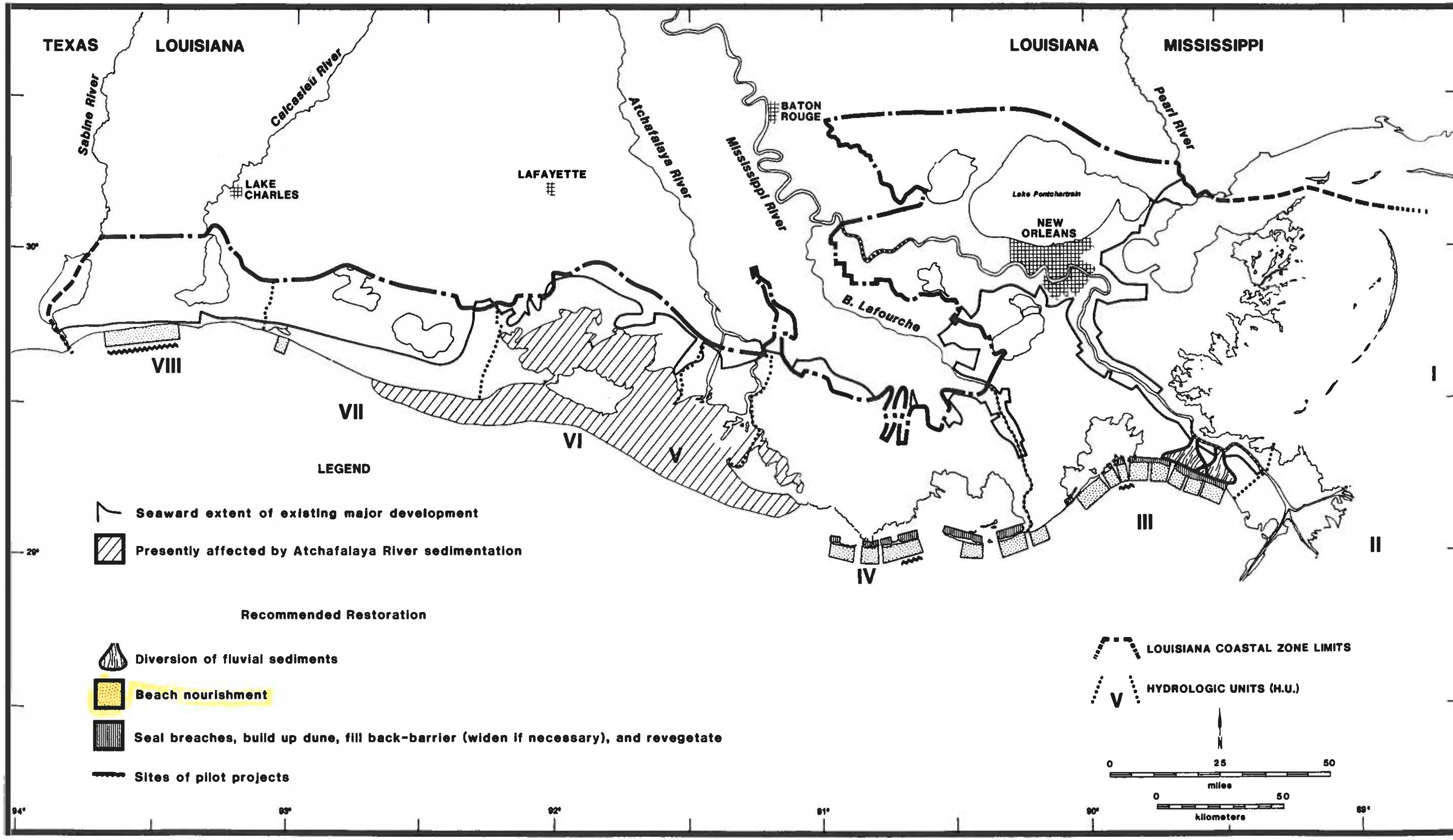


Figure 25. Recommended Restorative Measures Along the Louisiana Shoreline.

would be the diversion of Mississippi River flow and sediments into the marsh areas. This would, in several years, create sufficient land area to restore lost wetlands and cushion the impacts of future severe storms. Perhaps two diversion sites could be installed downriver of Empire, the exact locations and outlined management areas of which would be determined in detailed future studies. Although a portion of the diverted fluvial sediments may contribute to offset the beach sediment deficiency, it is recommended that sediment fill be applied to breaches and washovers, dunes be built up, and the beaches be nourished.

In Subunit C, the eastern Grand Terre Islands and the islands near Cheniere Ronquille Point have eroded at extremely high rates since 1955, and the adjacent tidal inlets have been widening correspondingly. It is highly recommended that this area be designated a demonstration (pilot) project and remedial measures be applied before the shoreline deteriorates much further (Figure 26). Major breaches should be sealed and dunes constructed. Where depths are already great, introduced sand fill would be subject to removal by tidal currents, and rockfill may be necessary to seal the breach before introduction of nourishment material. Numerous shore-parallel pipeline canals dissect the islands and serve as sand traps. These canals, and other waterbodies immediately behind the shoreline, should be filled and revegetated. In addition, the beaches need to be nourished. (The two small islands on the east side of Pass Abel may be past the point of economically feasible salvage, although this needs to be determined by field survey.)

Grand Terre itself is relatively healthy in comparison to the rest of the subunit, although shoreline erosion has been high near the flanking tidal inlets. The beach should be nourished along the island, and a feasible sediment source may lie in the spoil that is dredged from Barataria Pass.

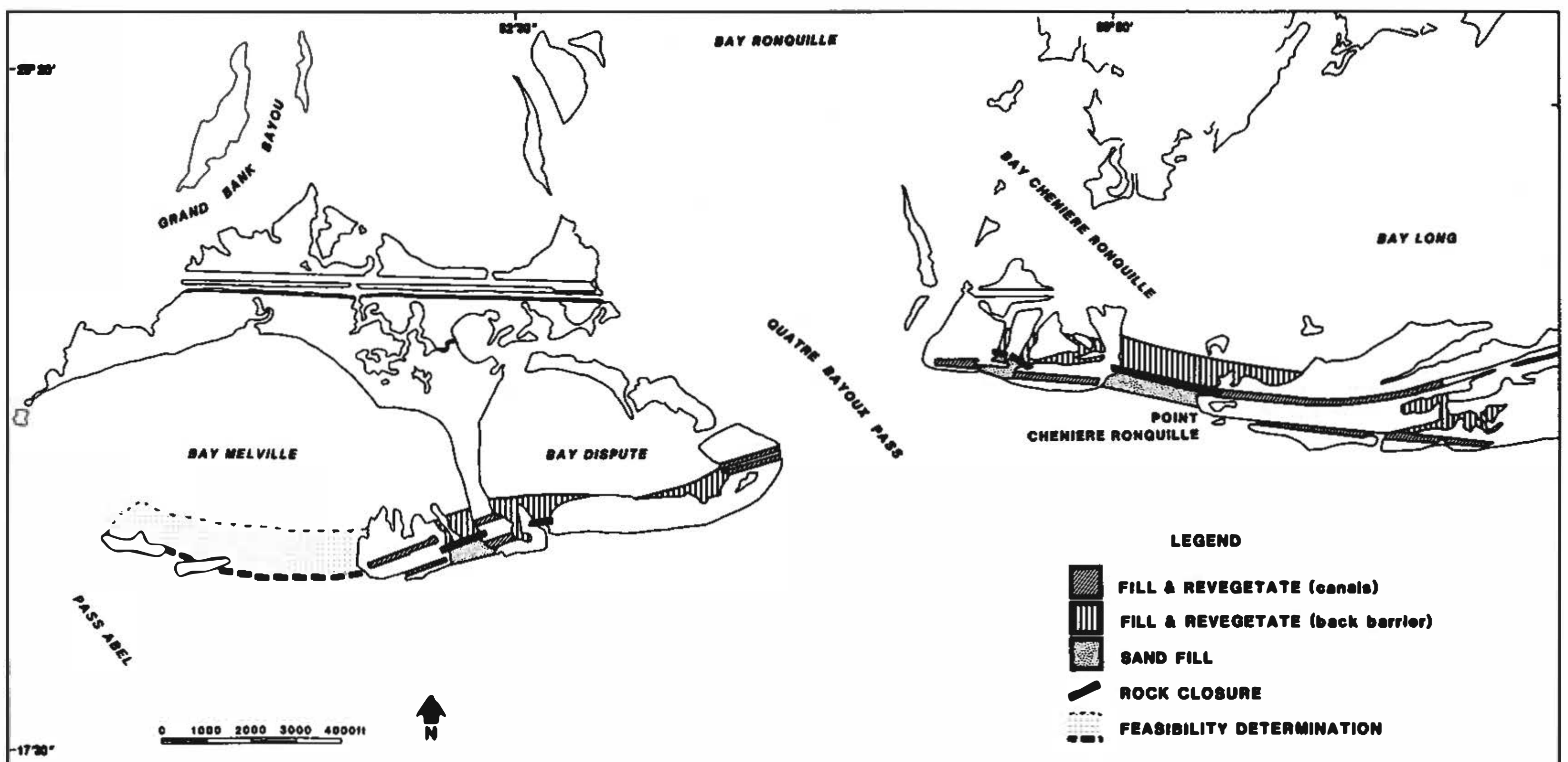


Figure 26. Recommended Demonstration Project, Grand Terre Islands and Vicinity.

Beach nourishment is also needed on Grand Isle (Subunit D). The USACE has already developed a comprehensive plan for the island (USACE 1980). A thorough study of Caminada Pass needs to be made, however, to determine its role in the removal of alongshore-migrating sediments eroded from the updrift Caminada-Moreau shoreline.

Erosion of the Caminada-Moreau beach (Subunit E) supplies sediments to downdrift Grand Isle, and it is recommended that this process be allowed to continue. Although erosion rates are high, no significant development has taken place in this subunit, and as the shore continues to erode into the beach ridges in the littoral zone, a continued supply of sand to Grand Isle can be expected. One feasible recommendation in this subunit is the sealing of one washover on Caminada spit, near the beach terminus of Elmer's Road. This would reduce the amount of sediment lost to the back-barrier bay behind the spit.

Subunit F, the shoreline fronting Port Fourchon, has historically eroded rapidly and provided sediment supply to the Timbalier Islands. Since the extension of the Belle Pass jetties in the 1960s, erosion rates have been reduced significantly. However, development has occurred quite close to the Gulf shoreline, and beach sands are presently being washed into the treatment ponds adjacent to an oil-storage tank farm. Based upon historic trends, it would have been best if no development occurred in this area, and the headland were allowed to continue to erode. However, in view of the recent development of the industrial/recreational Port Fourchon, it may (or may not) be economically beneficial to erect a more permanent shore protection structure (such as a dike along the south and east side of the zone of development). Careful consideration must be given to this prospect, as not only would construction costs be high, but maintenance costs would become prohibitive as the adjacent shoreline erodes and Port Fourchon develops into a peninsula. At present, it is recommended that sediment fill be applied at the beach terminus of the Fourchon Road in the amount necessary to maintain the beach in its present position at that location. It may be feasible to utilize spoil dredged from Belle Pass as beach nourishment material.

Hydrologic Unit 4: Terrebonne-Timbalier

As in the Barataria hydrologic unit, continued erosion of the barrier islands and beaches in the Terrebonne-Timbalier unit will have serious consequences not only upon shoreline areas but upon inland marshes as well. The extensive settlement along the lower distributary ridges of Terrebonne Parish makes the impact of high land loss rates and shoreline erosion particularly serious.

Subunit A, extending from Belle Pass to the western end of East Timbalier Island, has eroded greatly following installation of the Belle Pass jetty extension. Extensive canalization has occurred here, and one canal developed into a tidal inlet, separating East Timbalier Island from the mainland. It is recommended that this inlet be sealed and a back barrier built up with introduced sediment. Beach nourishment should be provided, possibly by utilization of Belle Pass dredge spoil. On East Timbalier Island, it would be feasible to introduce fill material between the two parallel existing dikes that follow most of the length of the island. Sand nourishment introduced west of Belle Pass should migrate alongshore (provided the existing inlet is sealed) and revitalize the beach fronting East Timbalier.

Timbalier Island (Subunit B) is eroding primarily along its eastern half, where many washovers between relict beach ridges are found. Dune development should be encouraged in these locations and beach nourishment provided. The central and western portions of the island contain several large canals in close proximity to the beach, and these should be filled to reduce further erosion. Some effort at sealing off washovers has already been made in this subunit, and additional dune restoration measures should be taken in remaining washover locations. The feasibility of constructing a sand-trapping jetty at the western end of the island should be examined. This measure would not only make available a source of nourishment material, but would reduce the amount of shoaling in the lower Houma Navigation Channel.

Wine Island (Subunit C) has been reduced to a mere shoal, and restoration of the island would prove quite costly. Nonetheless, water depths between Cat Island Pass and Wine Island Pass are shallow, and if some kind of framework could be constructed, fill (or dredge spoil) could be pumped in and a foundation for a new Wine Island established.

The Isles Dernieres (Subunits D and E) are in need of major restoration efforts. Eastern Isles Dernieres, precariously narrow along its eastern half, was breached in the mid-1970s and has not rehealed. It is recommended that a demonstration project be undertaken here to close the breach, widen the back-barrier zone to a minimum width of 650 ft (200 m), and build up the dune in potential washover areas (Figure 27). One abandoned oil company treatment pond located on the island should be filled with sediment, and the entire beach nourished. Considerable sand deposits in the ebb-tidal delta of Cat Island Pass and dredge spoil from the lower Houma Navigation Channel are potential sources of fill material. In the western half of the island, washovers should be closed off and waterbodies directly behind the beach filled with introduced material.

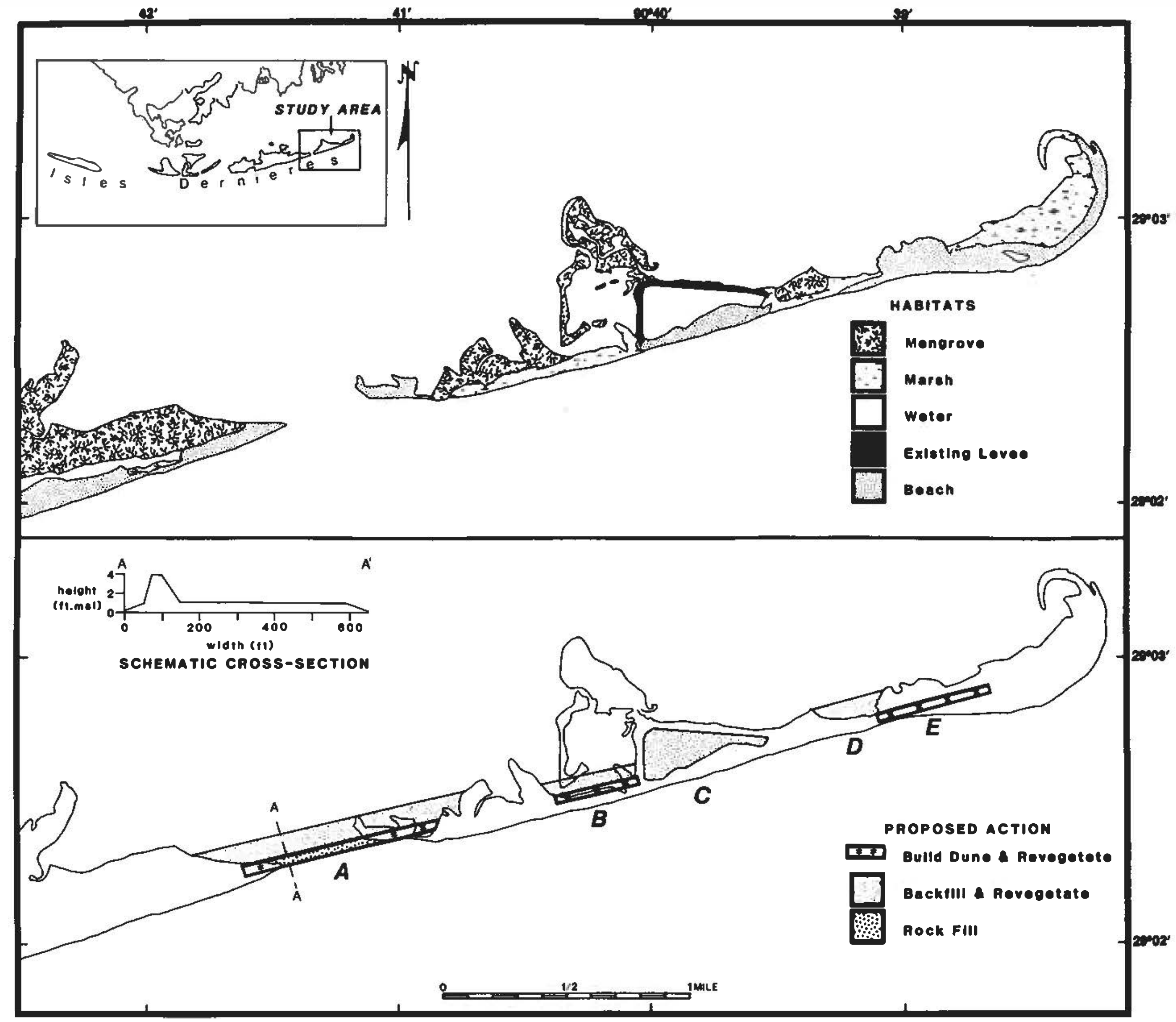


Figure 27. ***Recommended Demonstration Project, Eastern Isles Dernieres.***

The sealing of washovers and back-barrier fill also is feasible in Central Isles Dernieres, which is eroding rapidly. Western Isles Dernieres, now composed only of one small island, is presently so isolated that considerable costs are anticipated in the restoration of this island. These islands have historically afforded some measure of protection to the mainland coast north of Caillou Bay, and total removal of Western Isles Dernieres will increase erosion along that coast. Restoration measures of washover sealing and back-barrier fill are feasible short-term measures, and the feasibility of a sand-trapping jetty at the west end should be examined.

The mainland shore of Caillou Bay as far west as Oyster Bayou (Subunit F) is presently not critical, and no recommendations can be made presently. Subunit G, extending from Oyster Bayou to Point au Fer, currently is receiving some sediment input from the Atchafalaya River (via Fourleague Bay), and high, localized, shoreline retreat rates are expected to be at least partly offset by increased sedimentation.

Hydrologic Unit 6: Vermilion

The Vermilion hydrologic unit exhibits comparatively low shoreline erosion rates, and no restoration measures are presently recommended. A large proportion of the shoreline in this unit (most of Marsh Island) is protected by shell reefs, and it is important that this natural protection not be removed by shell-dredging operations. Active sedimentation from the Atchafalaya River also is expected to increase and help alleviate erosion by further reducing wave energies in this hydrologic unit.

Hydrologic Unit 7: Mermentau

The eastern half of the Mermentau hdyrologic unit shoreline (Subunit A) is receiving active Atchafalaya River sedimentation in the form of accreting mudflats, and shoreline erosion rates are comparatively low. The zone of mudflat accretion has shifted westward during the last 20 years, from the Cheniere au Tigre vicinity to near Flat Lake (Wells and Kemp 1981), and it is expected that this westward migration will continue as the Atchafalaya River and Wax Lake Outlet deltas develop further.

The shoreline from Flat Lake to Hackberry Beach (Subunit B) is subject to great erosion, although in view of the westward-migrating locus of mudflat accretion, no remedial action is recommended at this time. As the shoreline advances toward the leveed management areas of the Rockefeller Wildlife Refuge, the levees may require reinforcement or relocation inland. Downdrift of the Mermentau-Gulf Navigation Channel jetties (Subunit C), erosion has accelerated because of the jetty construction. It is recommended that material dredged from the channel be placed onto the beach or nearshore zone west of the channel to reduce this recent increase in retreat rates.

Hydrologic Unit 8: Calcasieu-Sabine

Shoreline erosion in the Calcasieu-Sabine hydrologic unit, while not as high as rates within the Deltaic Plain, may have more serious consequences in view of the extensive beachfront development, particularly west of Calcasieu Pass.

Subunit A, between the natural mouth of the Mermentau River and Calcasieu Pass, is fronted largely by mudflats and exhibits relatively low shoreline retreat rates. The only serious erosion has occurred at the resort community of Rutherford Beach. Erosion has occurred primarily in response to a deflection of the Mermentau River mouth by the westward-accreting Hackberry spit. Since construction of the Mermentau-Gulf Navigation Channel in the early 1970s, much of the outflow of the river has been diverted, and the natural mouth has shoaled accordingly. Erosion rates should decrease at Rutherford Beach because of the diversion, and no remedial measures are recommended at this time.

Between Calcasieu Pass and Long Beach (Subunit B) lies a zone of extensive recreational development. From Holly Beach to Peveto Beach, La. Hwy 82 hugs the shoreline. This important east-west artery and hurricane evacuation route is being undermined by wave attack and is frequently overtopped during storms. Existing revetments have not adequately withstood the forces of nature, and the Louisiana Office of Public Works is presently planning renewed revetment and T-groin construction. As a third demonstration project in beach restoration, it is recommended that a beach nourishment project be implemented, not only to supplement the construction of revetments and groins, but to minimize anticipated increased erosion to those beach communities (especially Constance Beach) downdrift of the reveted shoreline (Figure 28). Part of the required nourishment should be provided by redirecting the dredge spoil from Calcasieu Pass which is presently deposited in an offshore dumping area. By depositing the dredge spoil parallel to the shore in the shallow nearshore zone immediately west of the Calcasieu Pass jetties, the coarser material will be retained on the beach and enter the westward longshore transport system. Additional beach fill should be dredged from offshore where abundant sand deposits are known to occur (BLM 1979). A long-term beach restoration project might include the installation of a series of sand-trapping groins (to be constructed from west to east, beginning downdrift of Long Beach), although a more detailed feasibility study should be conducted prior to recommendation.

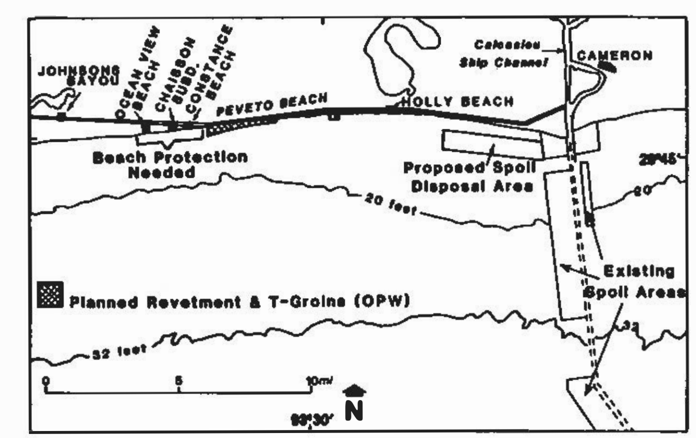


Figure 28. Recommended Demonstration Project, Holly Beach and Vicinity.

Subunits C and D, from West of Long Beach to the Sabine Pass jetties, do not exhibit serious erosion problems, and no remedial measures are recommended at present.

Chapter VI

Conclusions

Western end of Timbalier Island.

Shoreline erosion and wetland deterioration in coastal Louisiana are driven by three major, related processes: subsidence, redistribution of sediments by waves and currents, and saltwater intrusion. Now, as in the past, these processes are the dominant force in changing the coastal zone when and where severed from the Mississippi River's supply of fresh water and sediment. However, while this condition has always prevailed in part of the deltaic plain (since even under natural conditions the Mississippi River supported full development of only a single delta lobe), the observable and perceivable changes presently occurring greatly exceed those of the past in rate and extent.

The physical integrity of Louisiana's wetlands is dependent on Mississippi River water and sediment. In his economic endeavor man has chosen to apply more than two thirds of the Mississippi River resource to causes other than coastal zone maintenance. Remaining water and sediments distributed through the Atchafalaya River have therefore become even more valuable to the natural system. But without a commitment for their use toward wetland restoration and delta growth, that option is being similarly reduced as a result of present and future development and related needs for flood control and navigation. Further leveeing of the Lower Atchafalaya River should be avoided so that maximum land building and wetland nourishment can occur in this area.

As a consequence of these present limitations on the total Mississippi River resource application, nearly the entire coastal zone is now subject to changes that reflect primarily responses to subsidence and wave erosion. In addition, these changes are accelerated through various activities of man which affect the movement of water and sediment. These changes entail increasing salinities, loss of wetlands and commensurate areal gain of major water bodies, rising water levels, and rapid erosion of the Gulf shore.

The continuing decline in the physical integrity of the coastal zone gives ever greater importance to the barrier beaches and islands that form the seaward boundary of the coastal zone. This importance derives from their protective function with regard to both human life and property and the renewable resources represented by the remaining estuarine wetlands. It is for that reason that the present report makes recommendations for the implementation of a shoreline management and protection plan.

The basis of such a plan must be the recognition that subsidence cannot be halted and that the sediments composing the barrier islands and beaches are a finite resource. Under those conditions, to maintain a barrier system on a seaward sloping surface requires shoreward migration as illustrated by the present barrier islands. Recognition of and abidance by this natural process will be the most cost-effective approach to management of the barrier systems. At the same time, physical integrity of the retreating system must be maintained by minimizing loss of sediments from natural or man-made causes. It is within this framework that management measures are recommended in order to achieve a continuing protective function and a deceleration of shoreline erosion and retreat.

Development and implementation of a shoreline protection plan should be an integral part of a long-term coastal management effort. Such an effort must recognize that, while further loss of coastal wetlands is unavoidable and future changes will necessitate either retreat of development from the coastal zone or increasingly greater levels of protection, the maintenance and protection of the coastal zone can in part be achieved through natural processes. This would involve maximum feasible diversion of Mississippi River freshwater and sediment, and full utilization of Atchafalaya River flow and sediment without further levee construction. It is by integrating shoreline management and protection with these measures that the greatest long-term benefits can be achieved.

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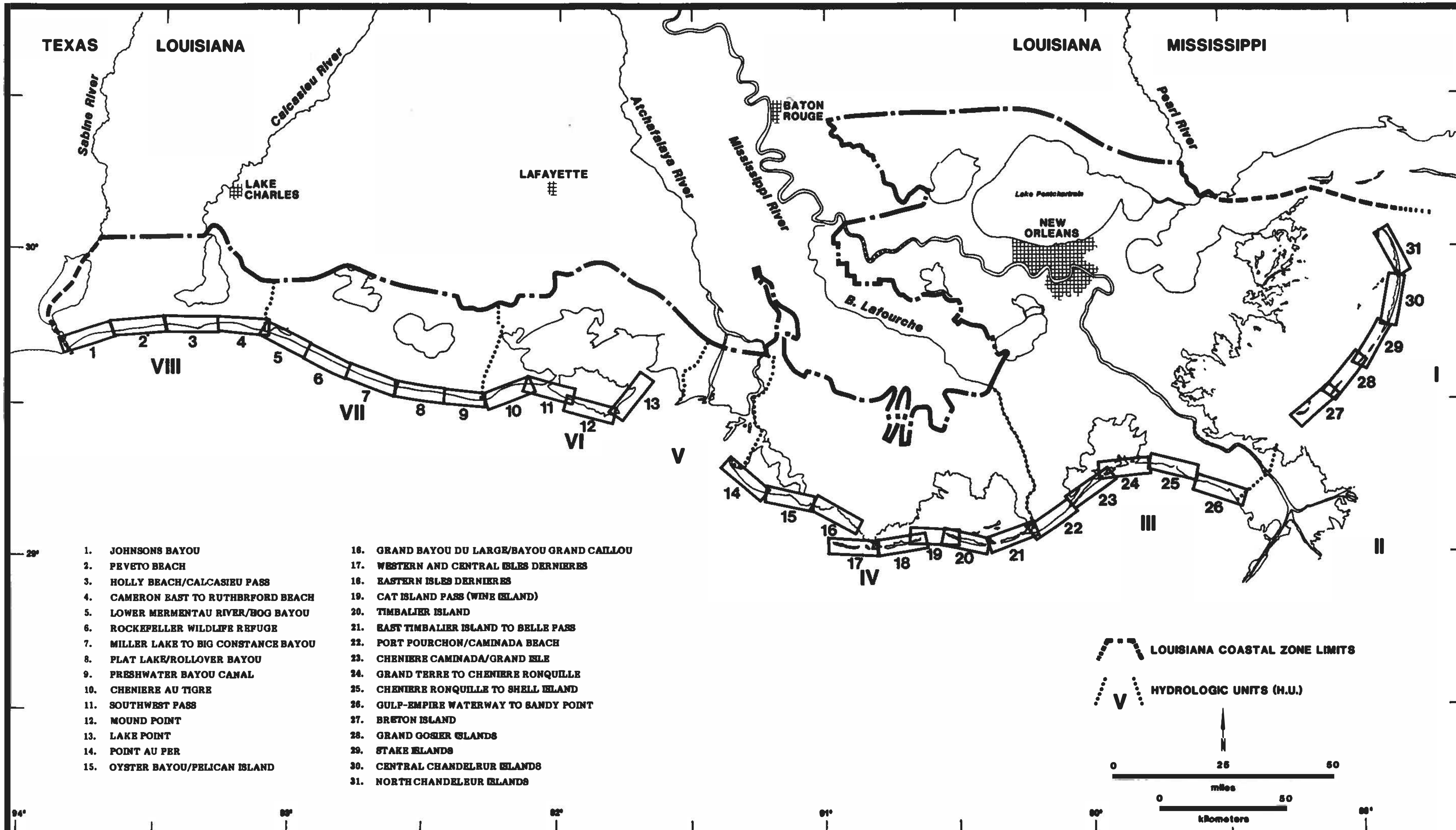
Appendix



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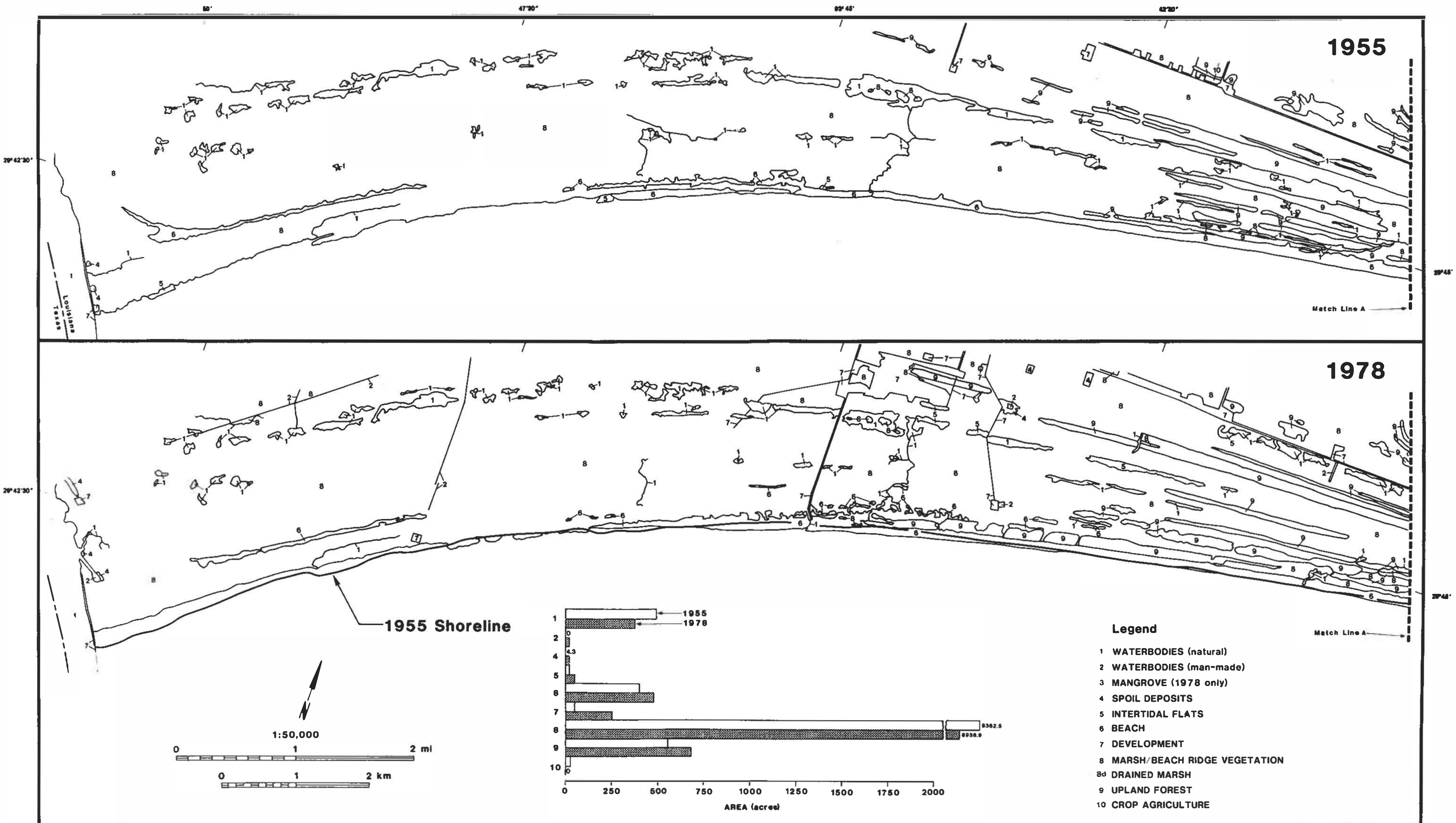


PLATE 1. JOHNSONS BAYOU

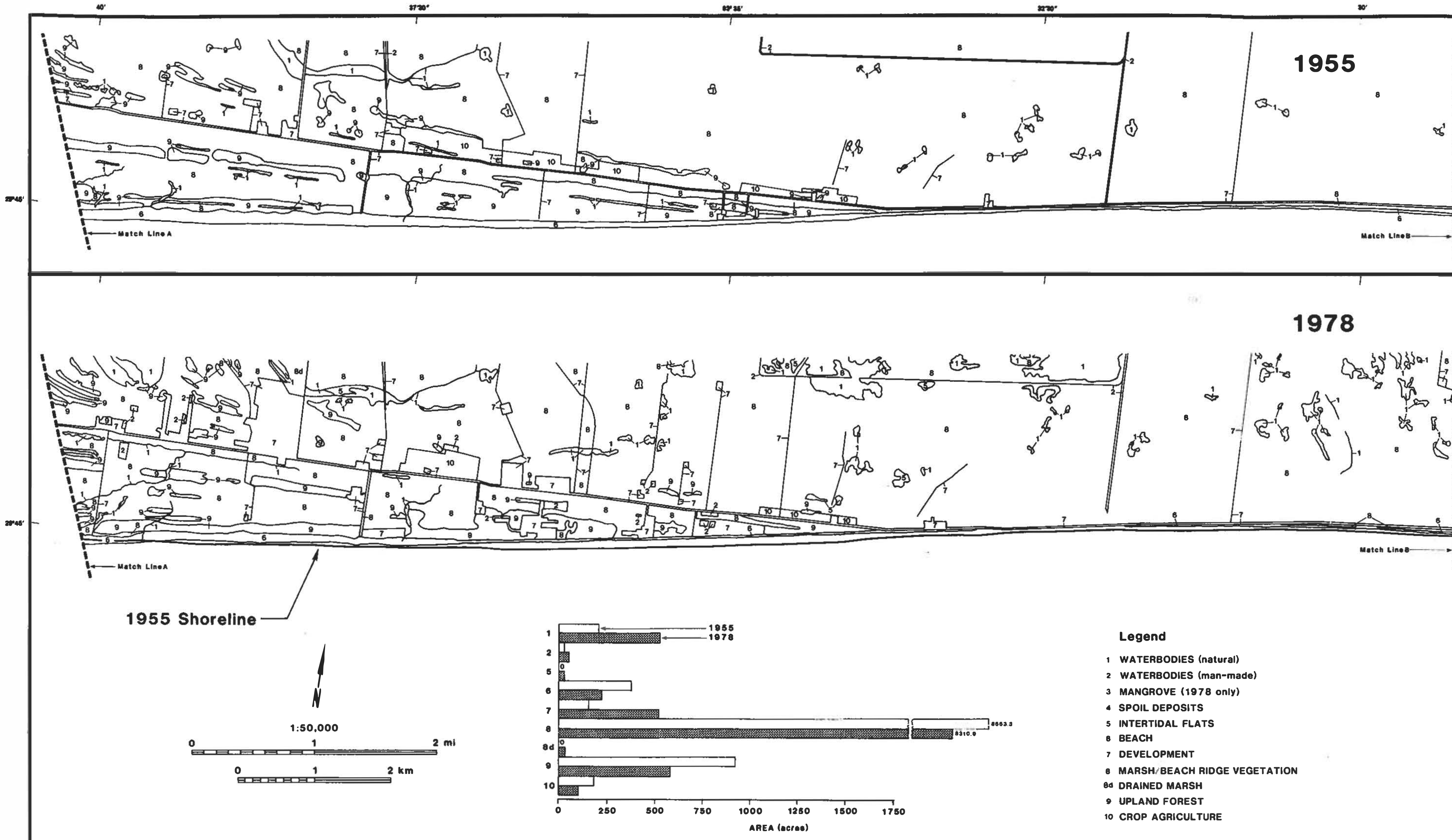


PLATE 2. PEVETO BEACH

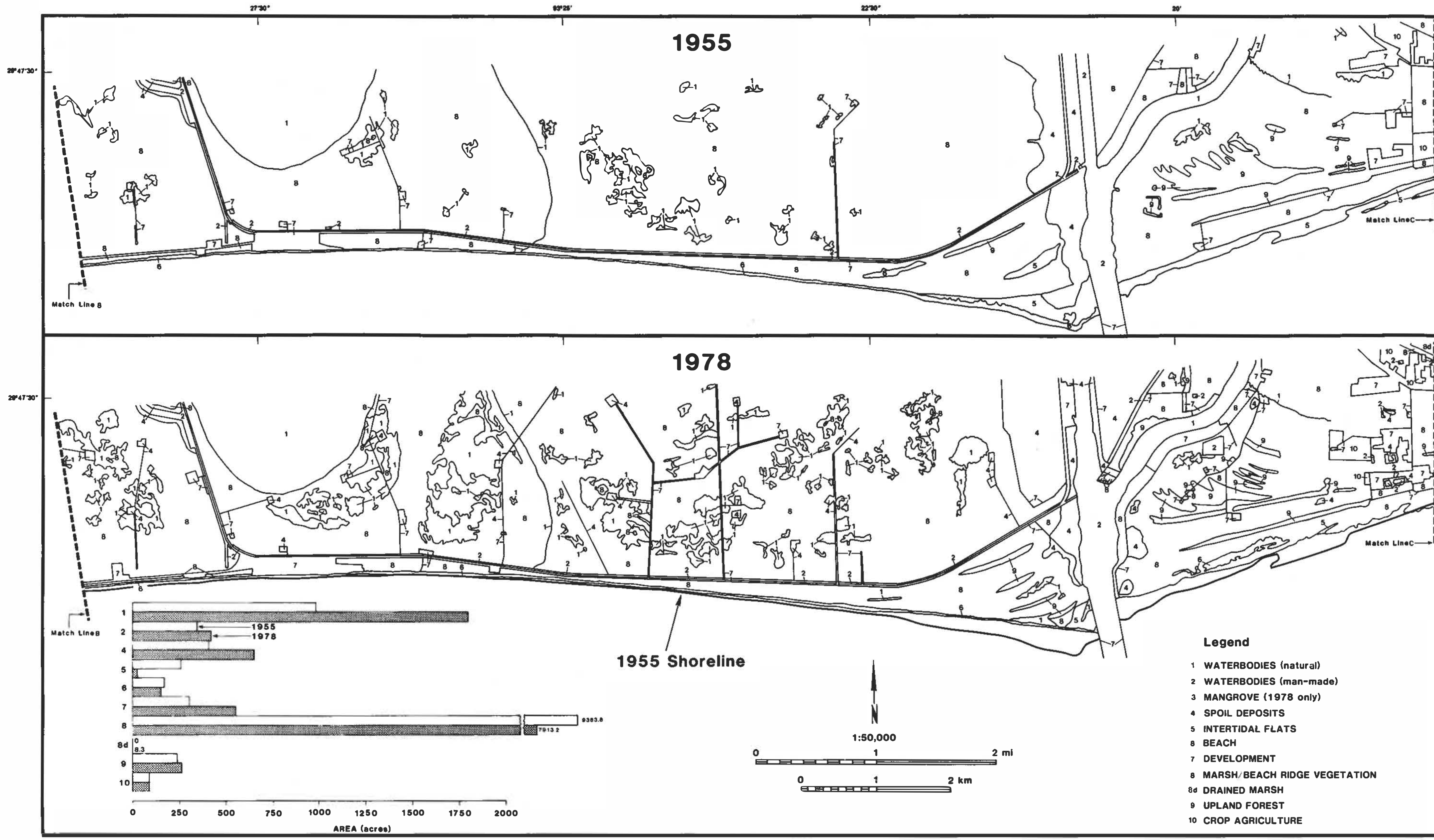


PLATE 3. HOLLY BEACH/CALCASIEU PASS

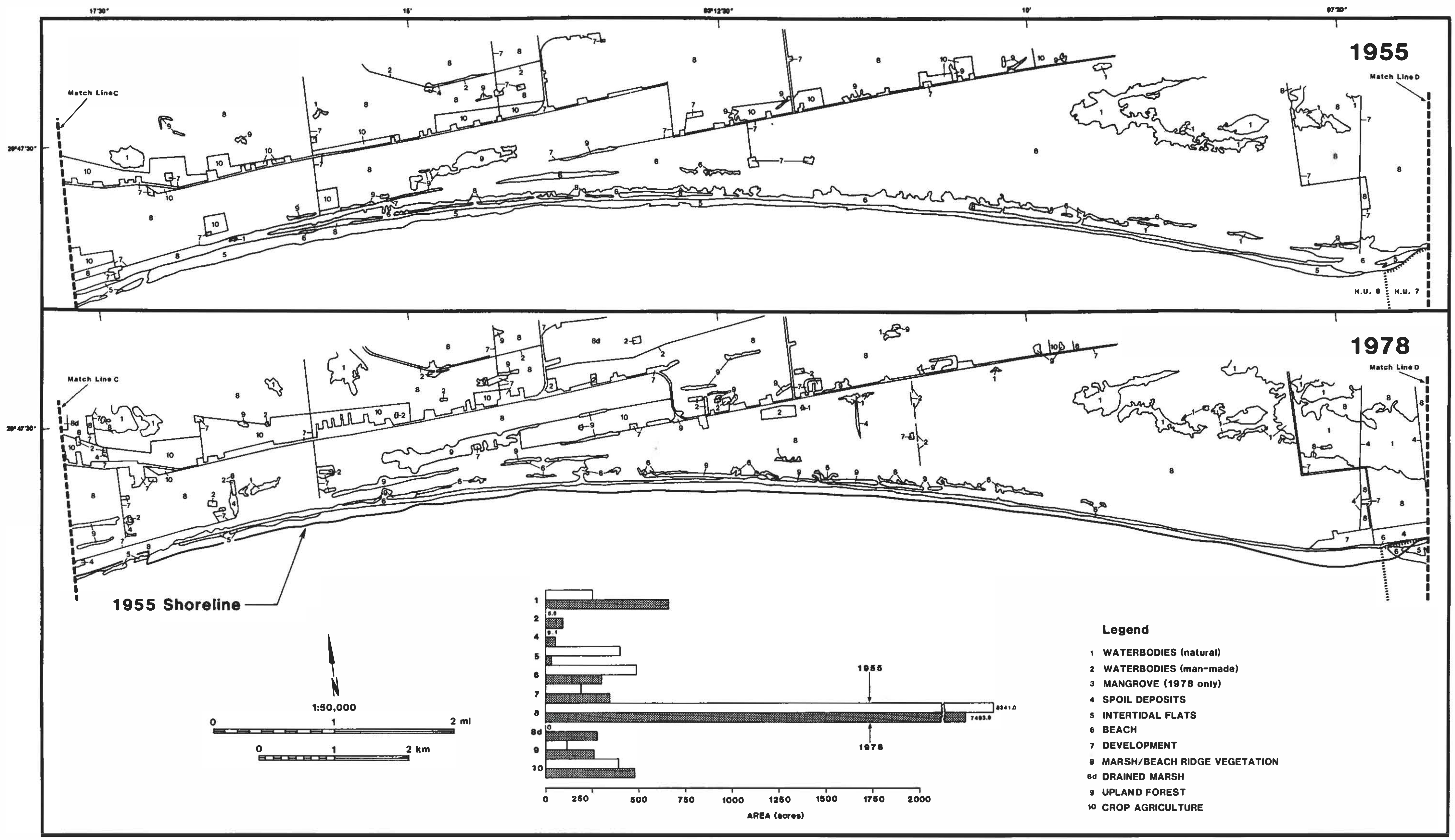


PLATE 4. CAMERON EAST TO RUTHERFORD BEACH

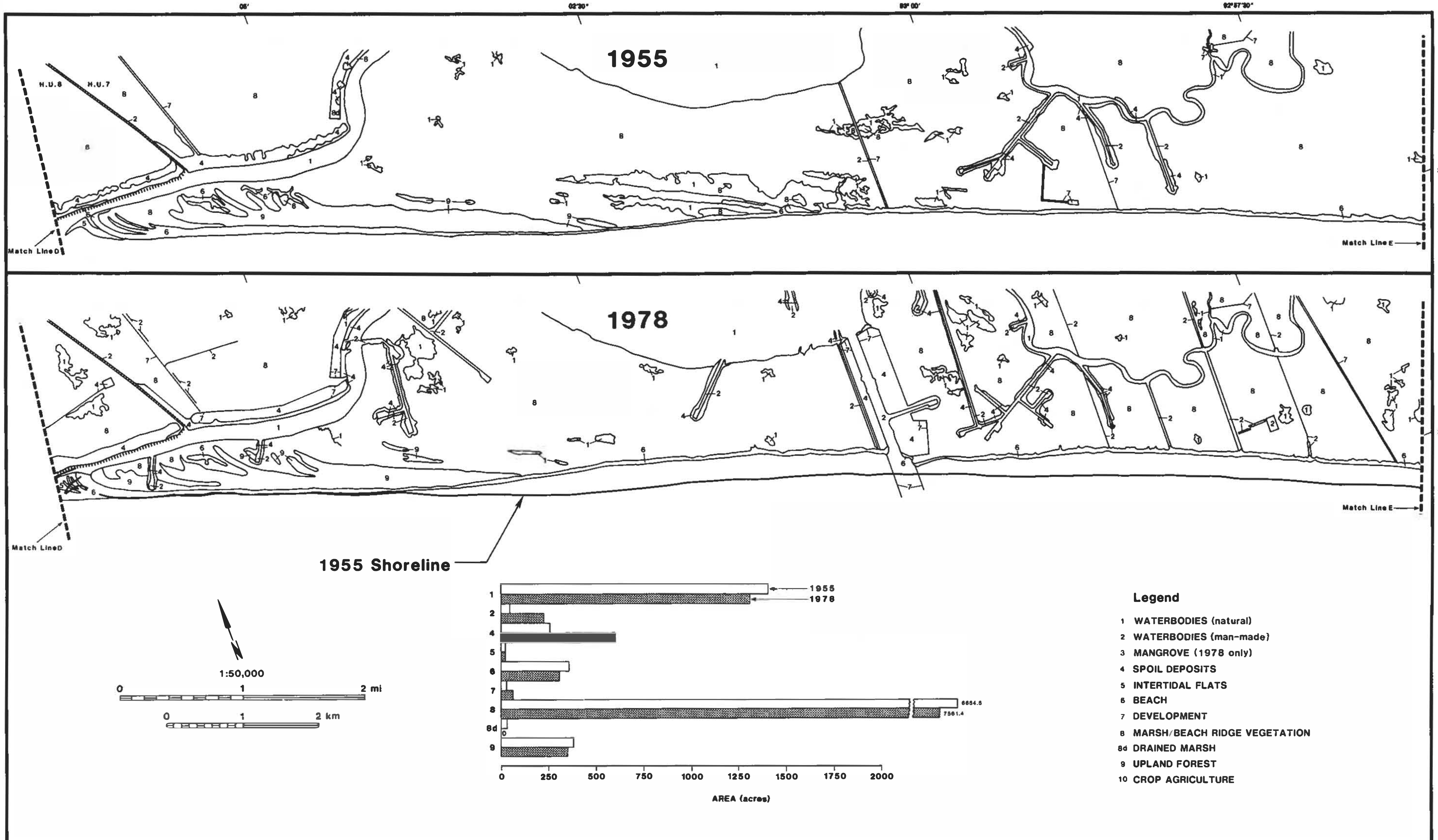
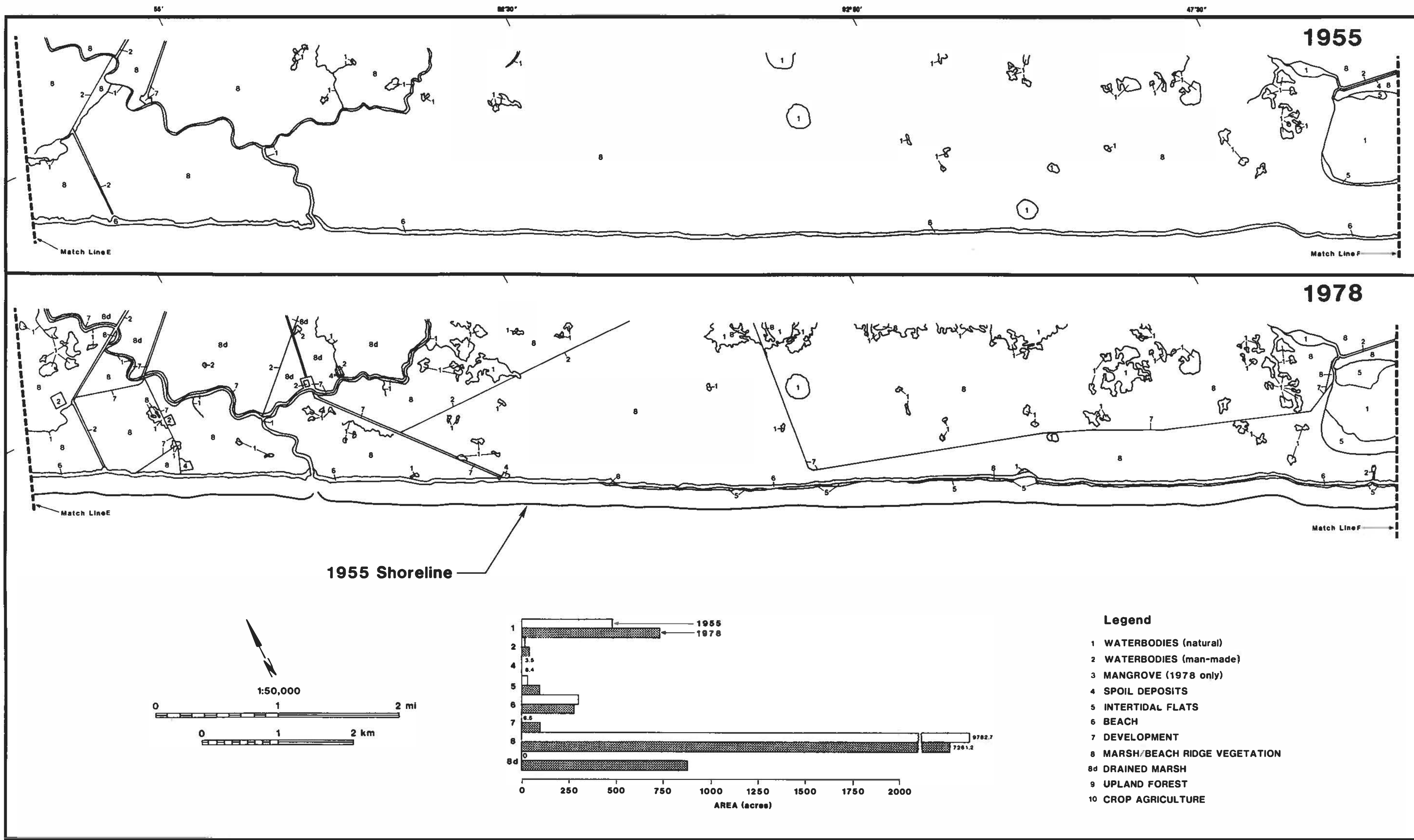


PLATE 5. LOWER MERMENTAU RIVER/HOG BAYOU



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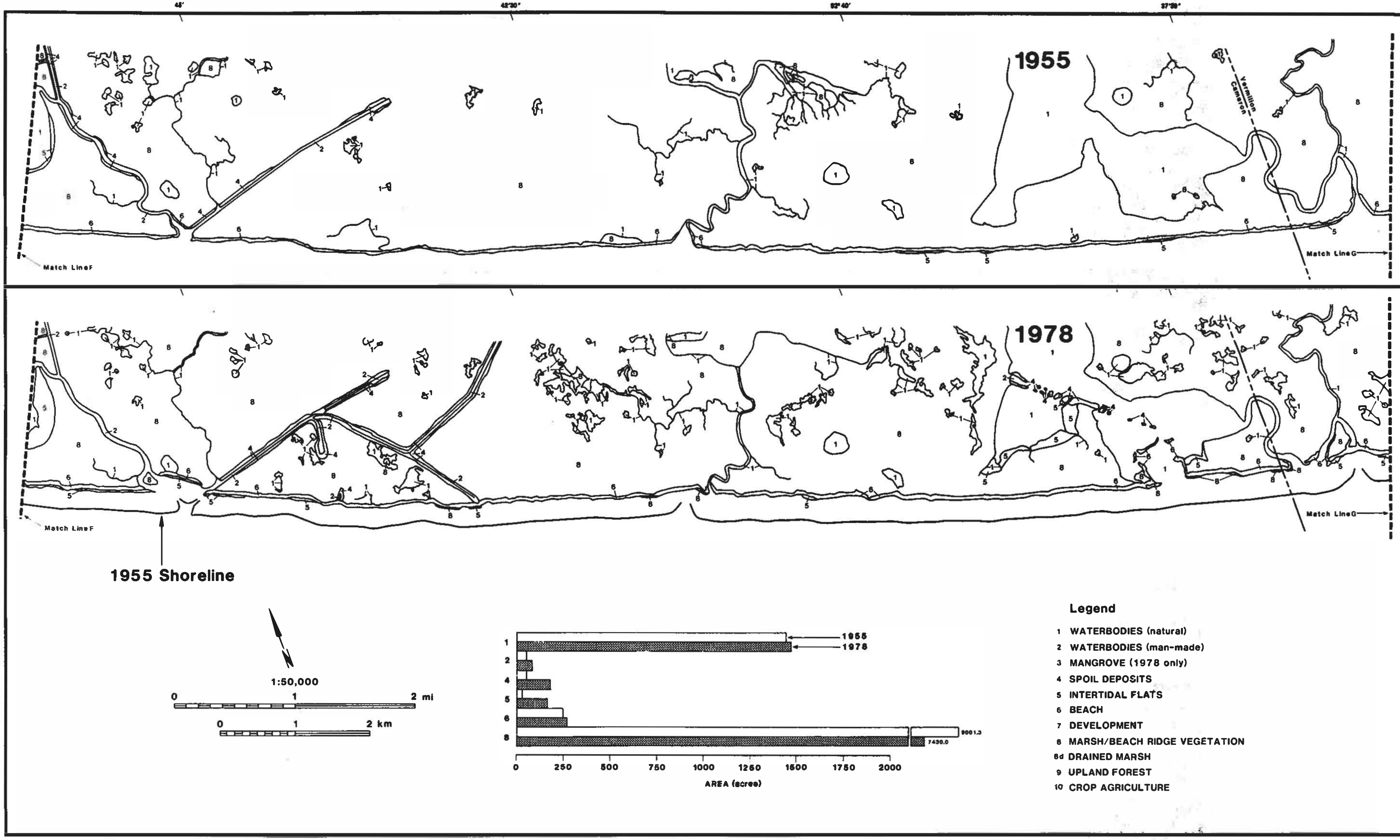


PLATE 7. MILLER LAKE TO BIG CONSTANCE BAYOU

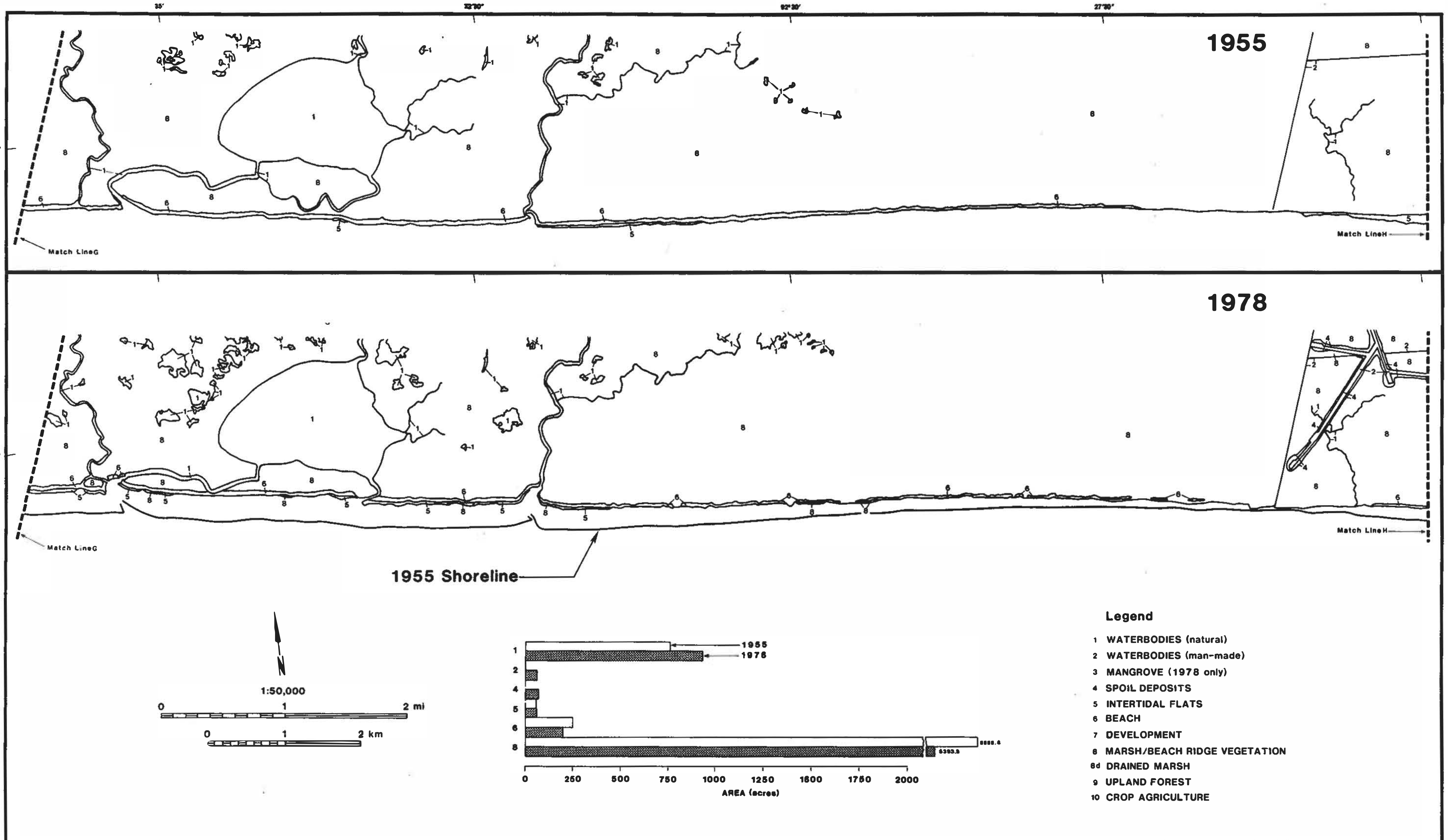


PLATE 8. FLAT LAKE/ROLLOVER BAYOU

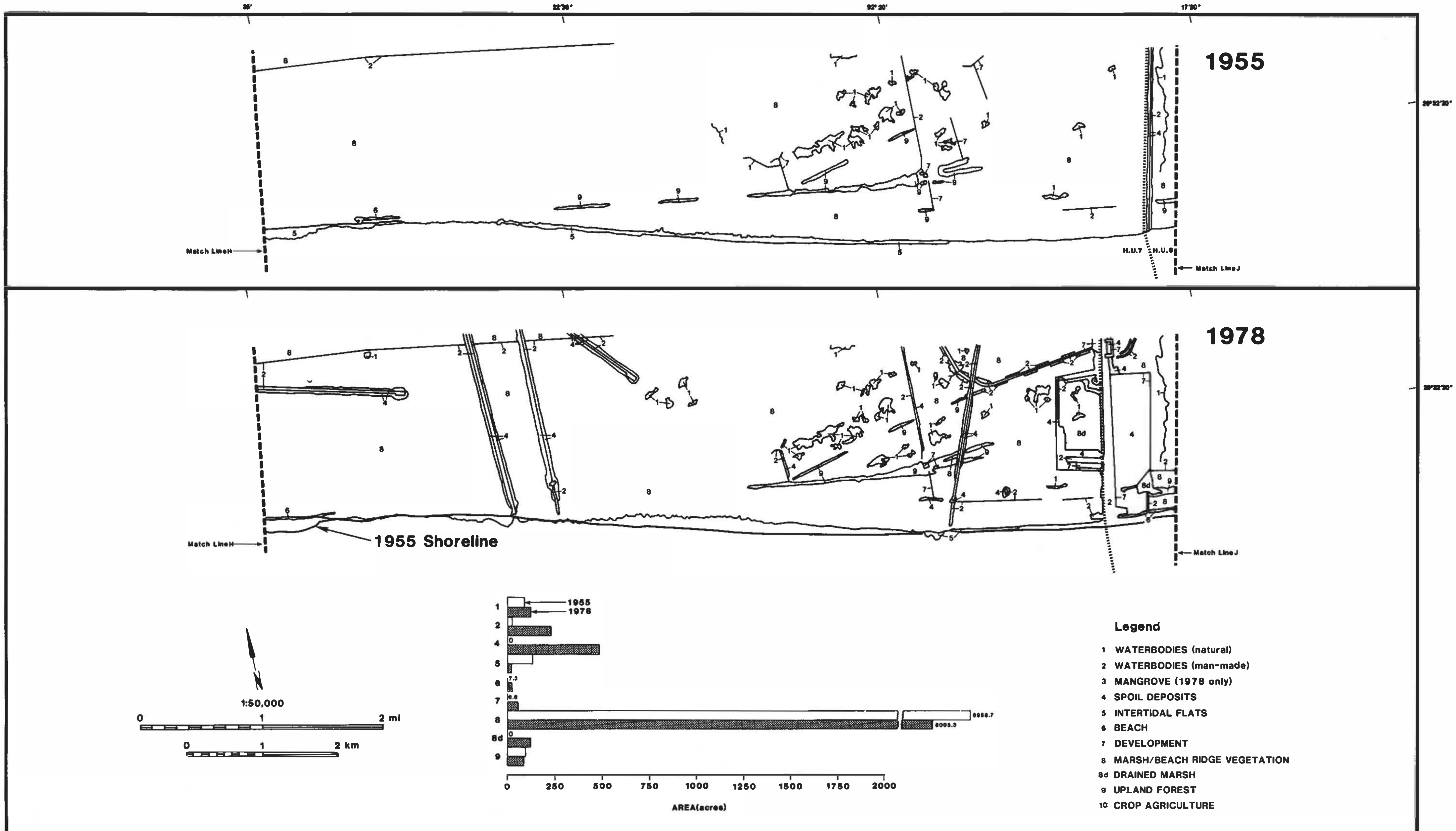
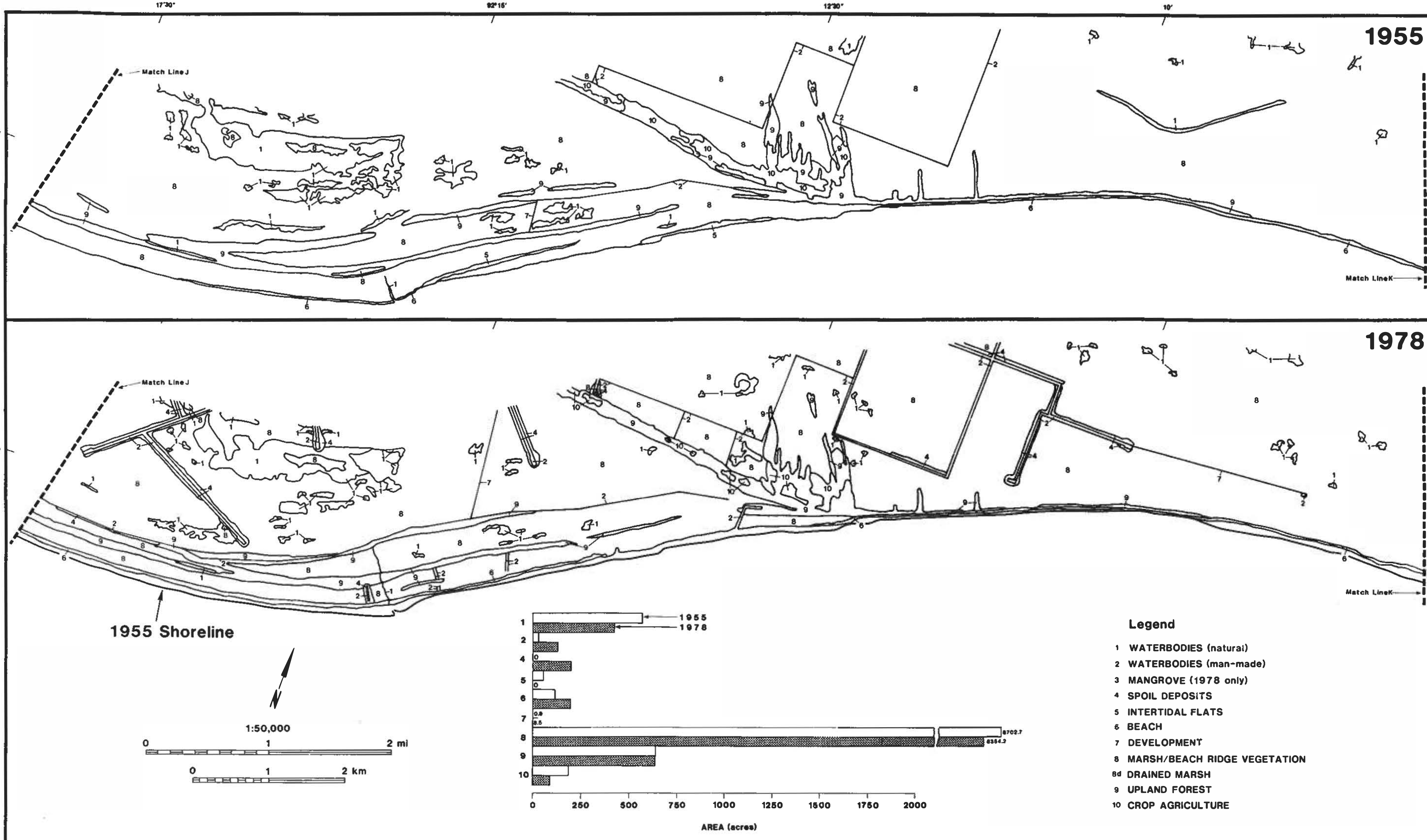


PLATE 9. FRESHWATER BAYOU CANAL



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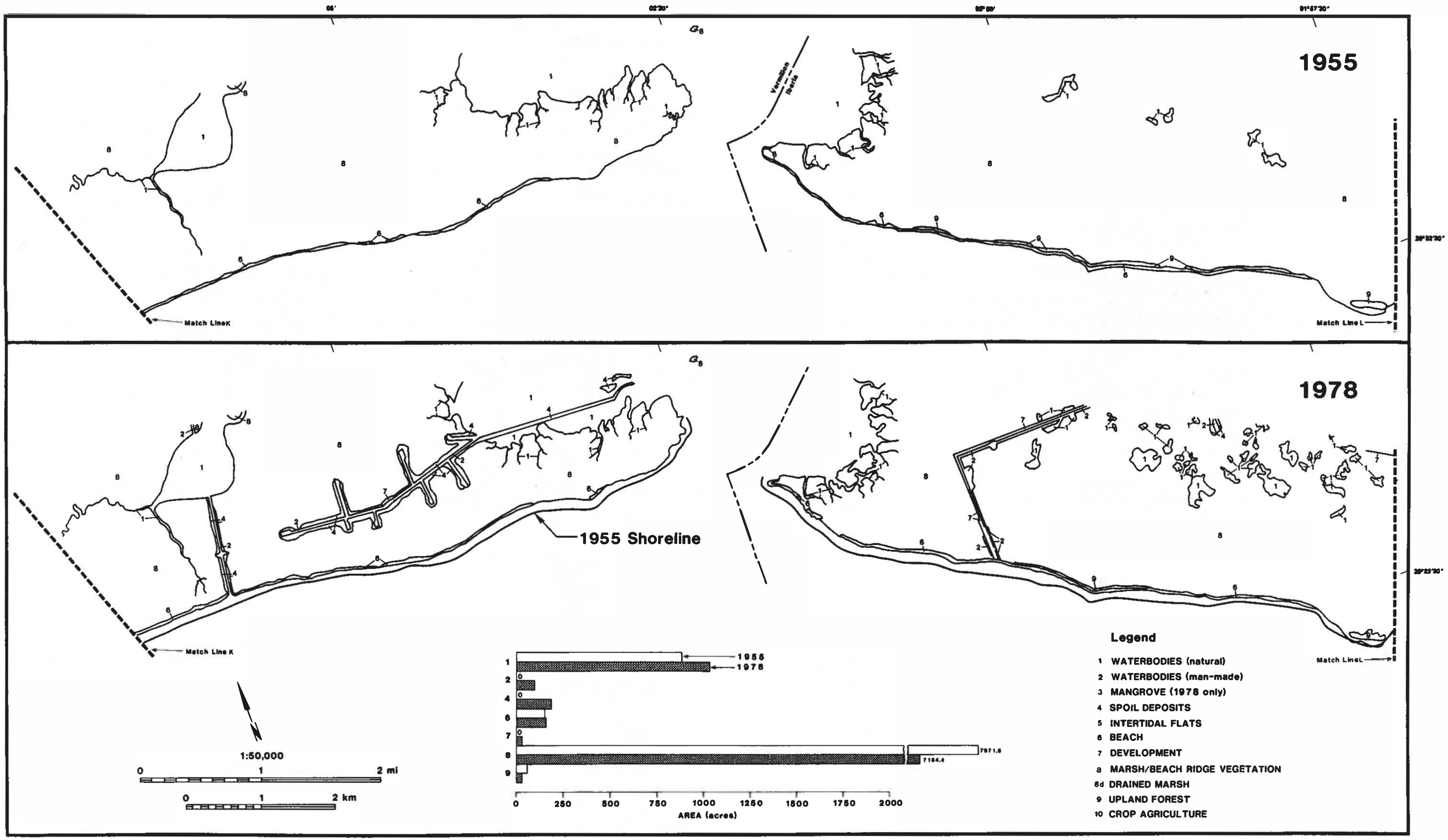

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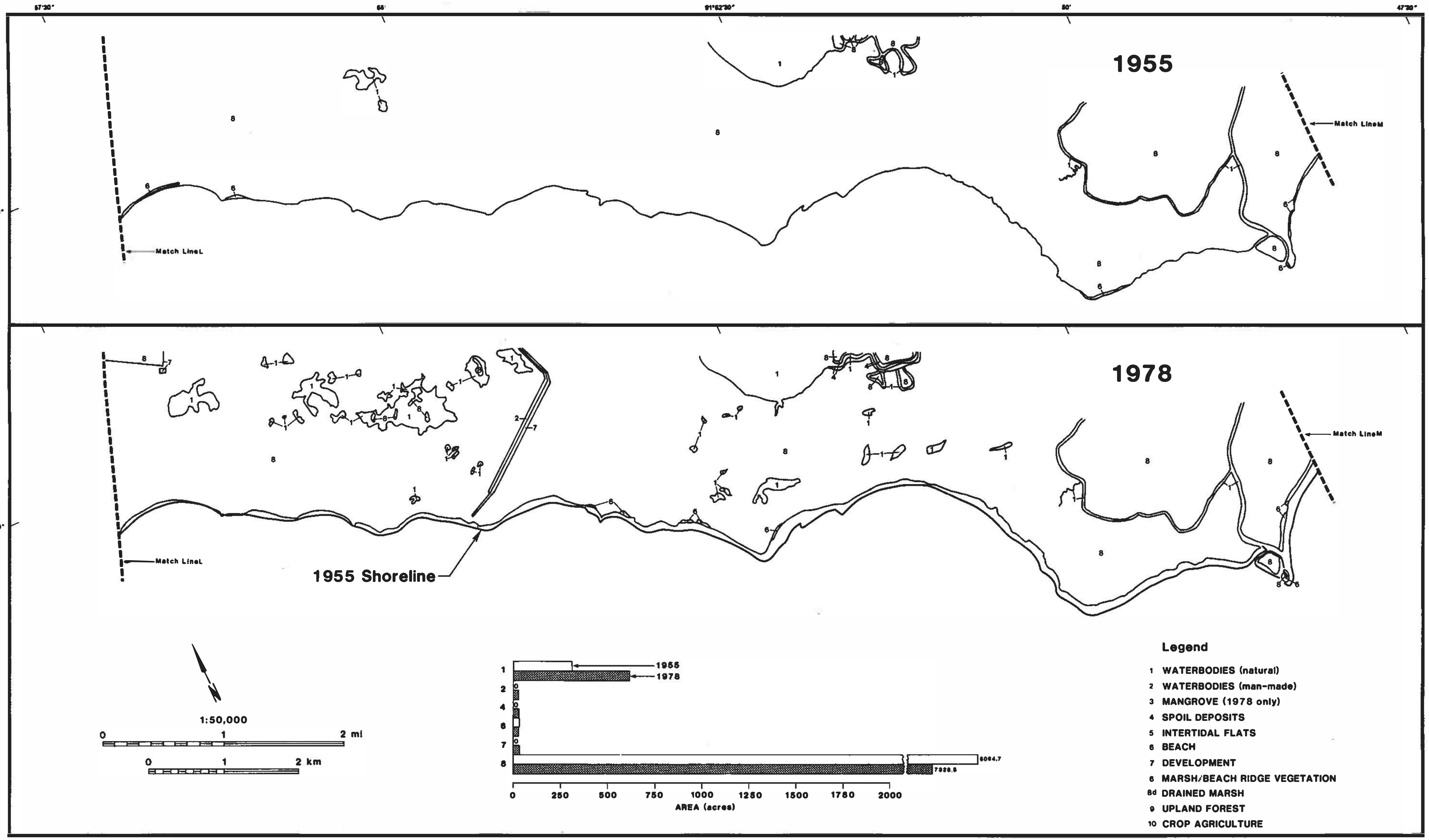

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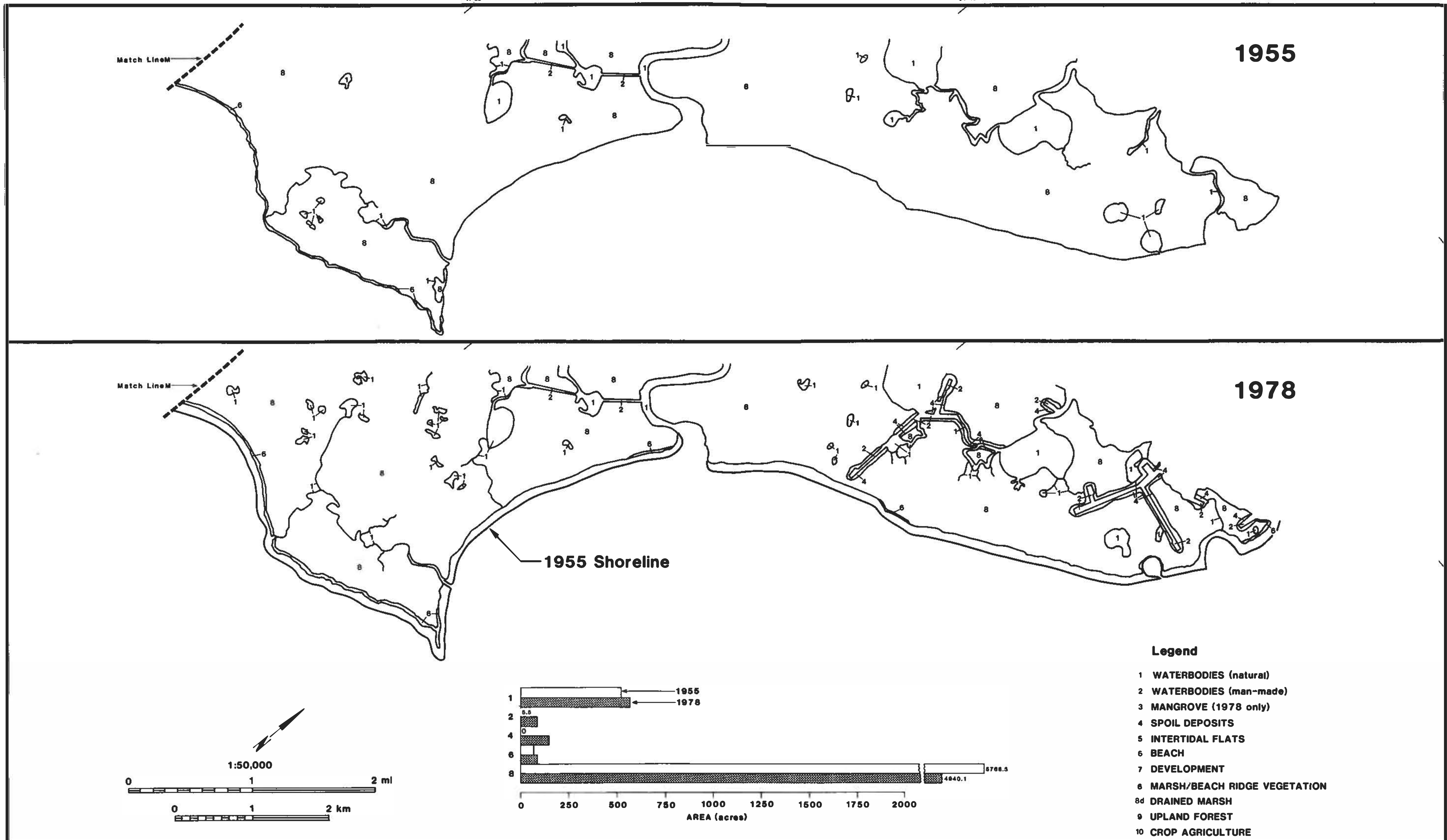

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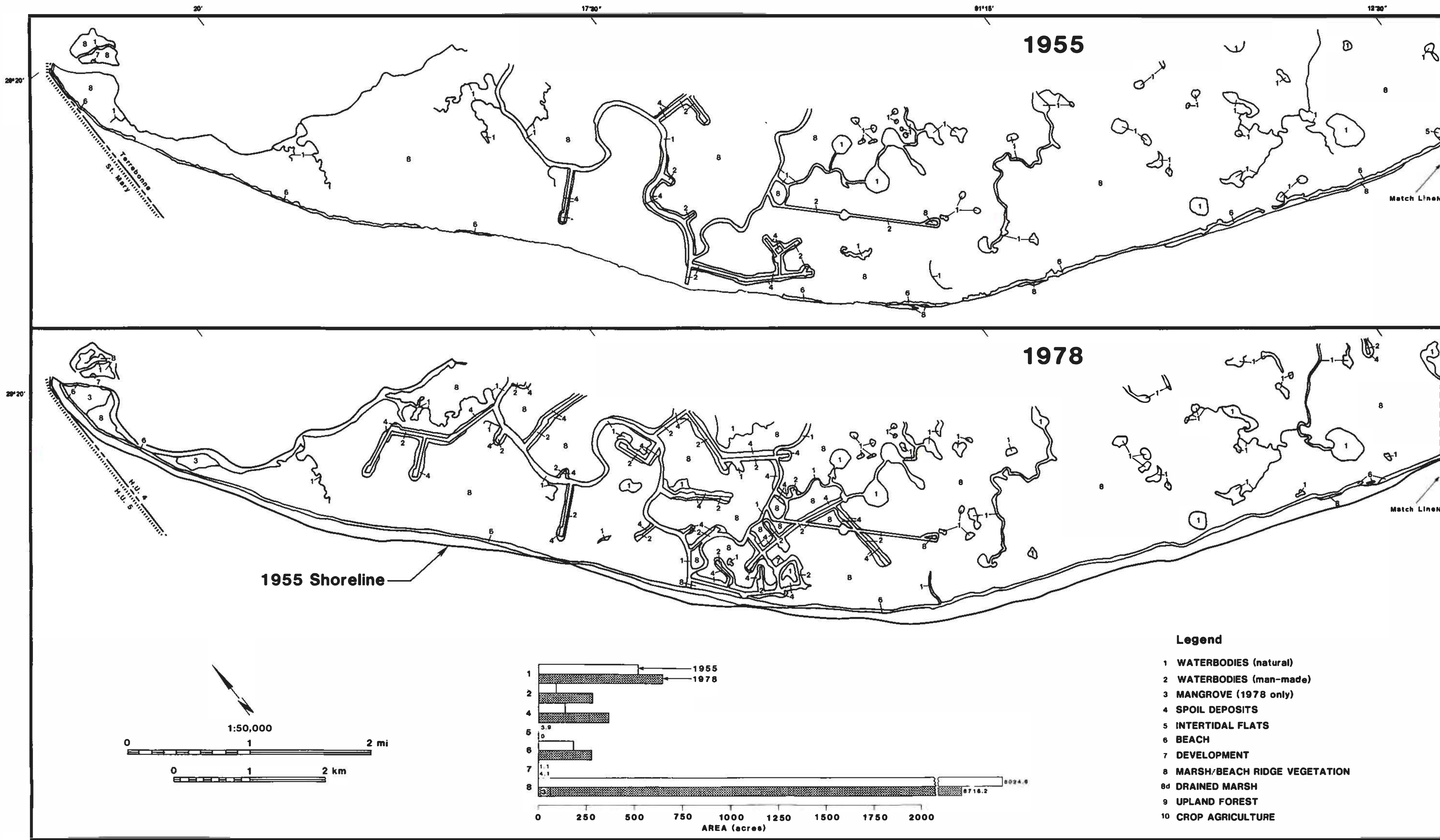


PLATE 14. POINT AU FER

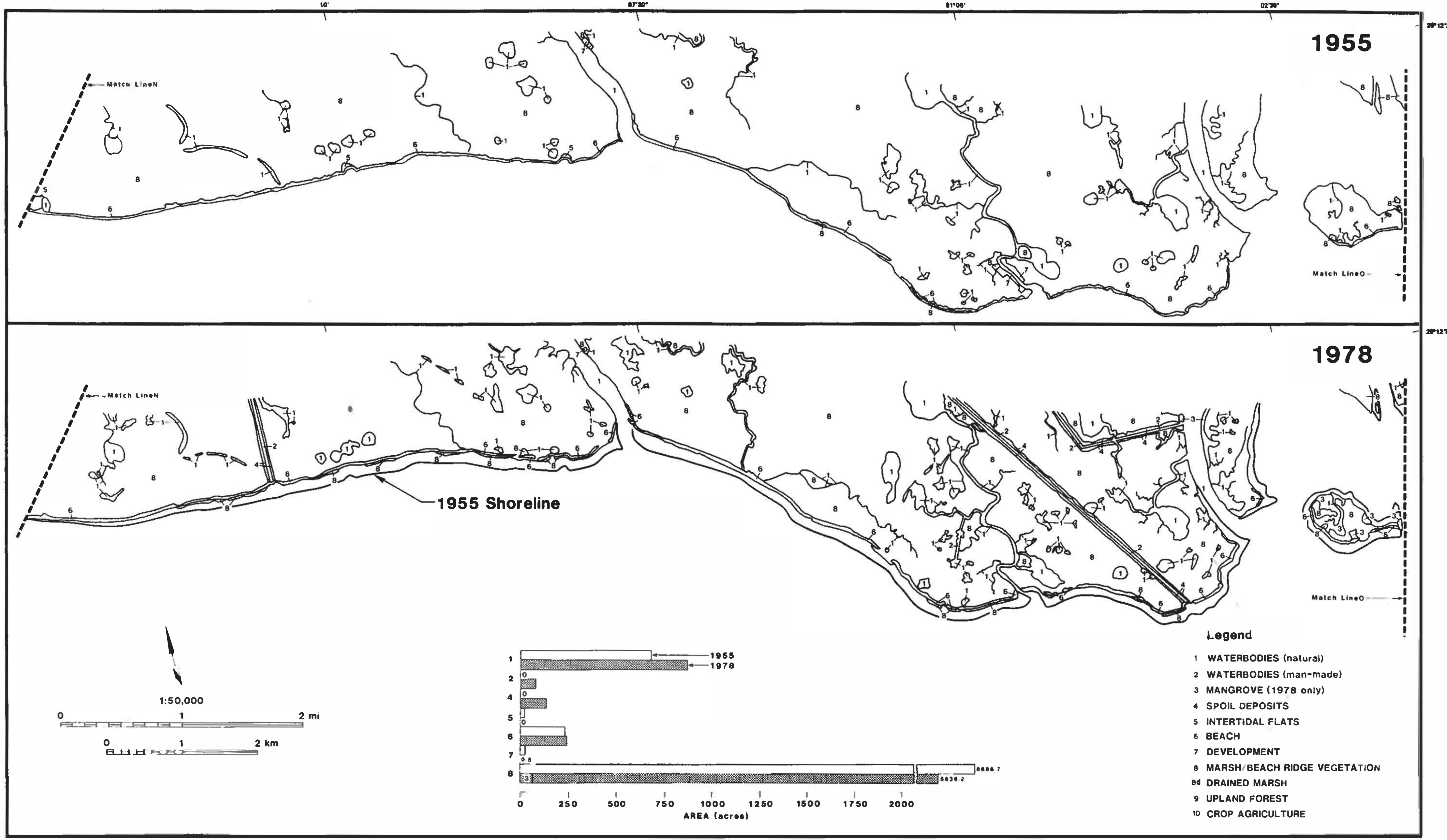


PLATE 15. OYSTER BAYOU/PELICAN ISLAND

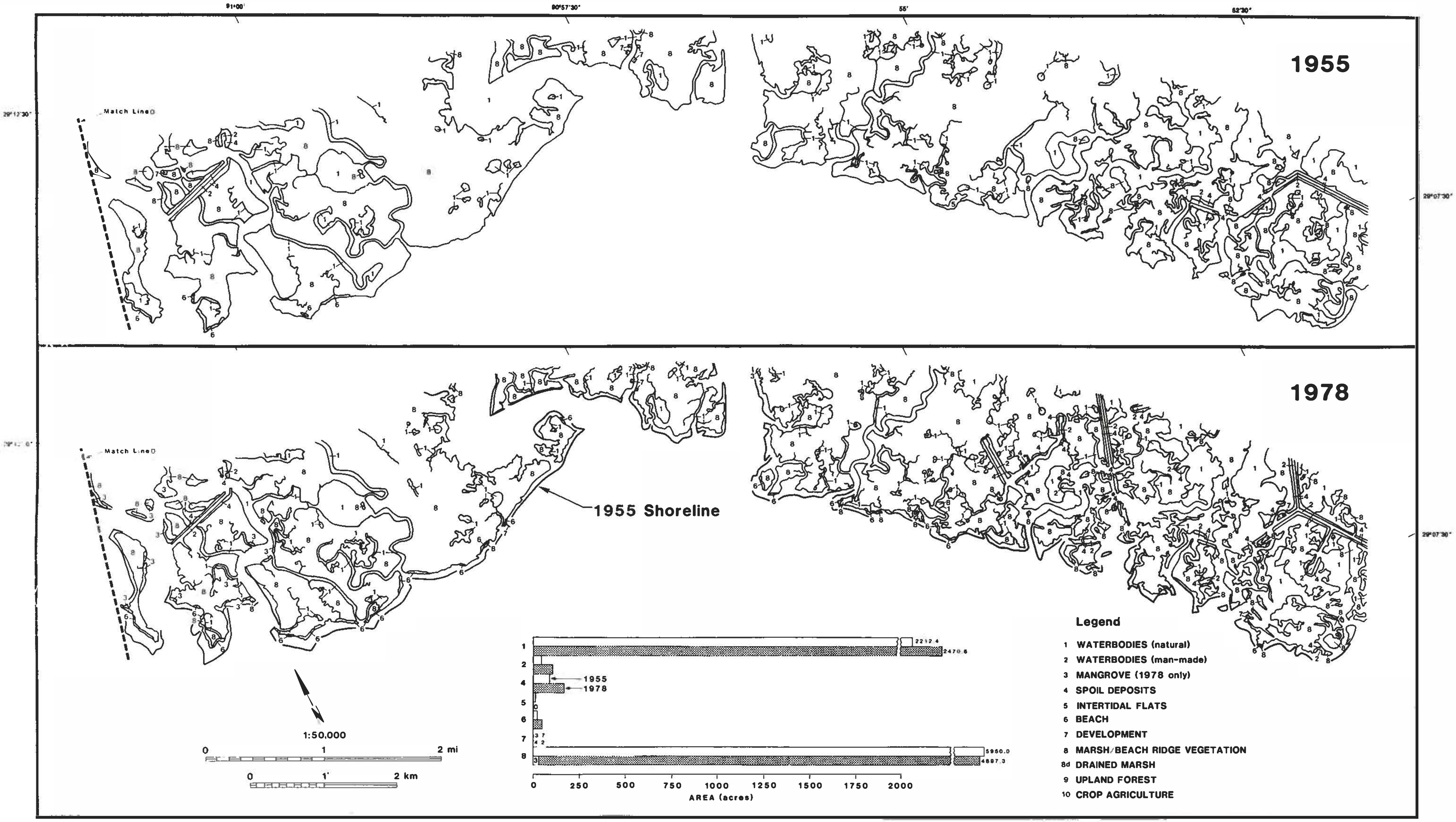
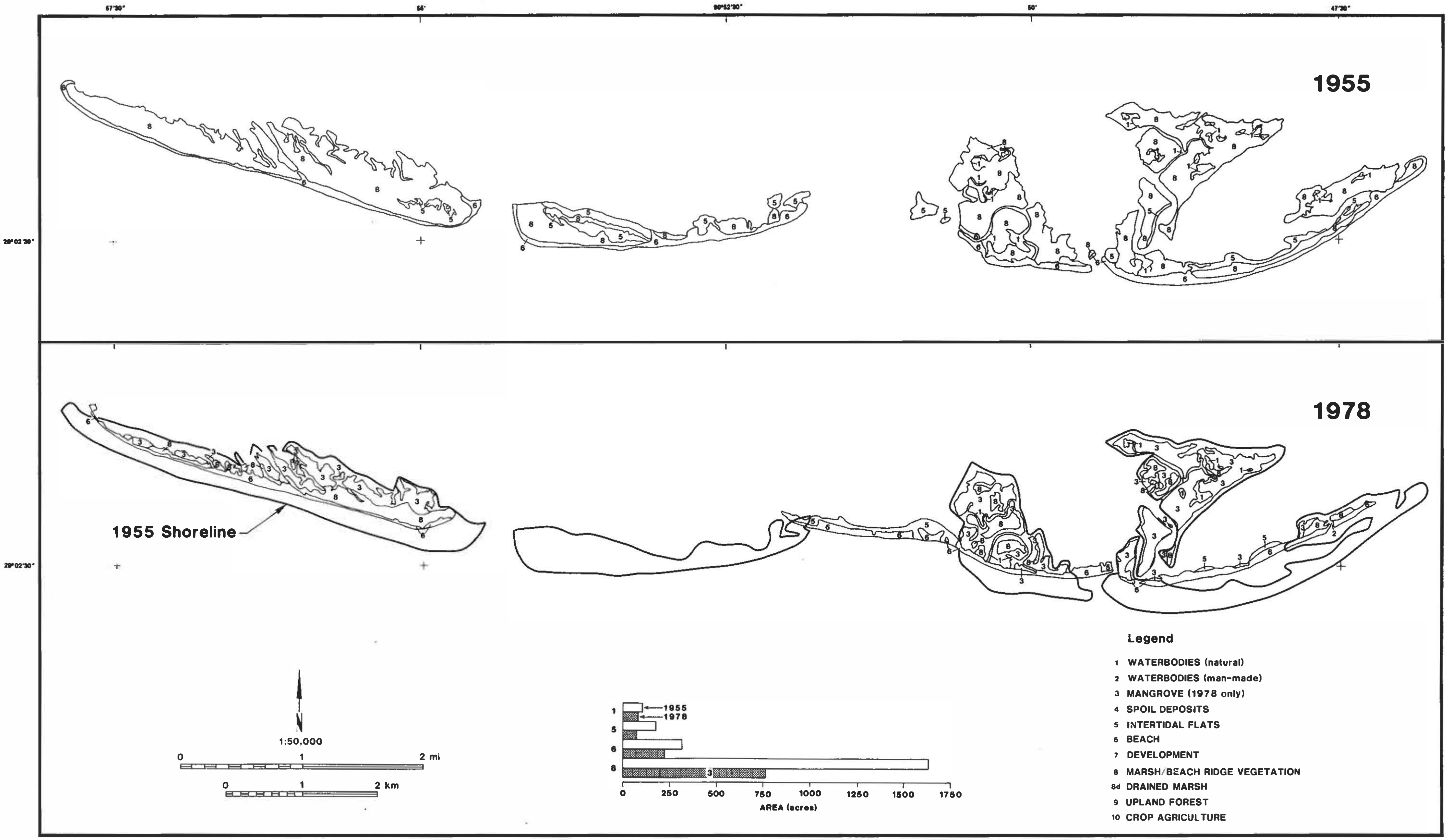


PLATE 16. GRAND BAYOU DU LARGE/BAYOU GRAND CAILLOU



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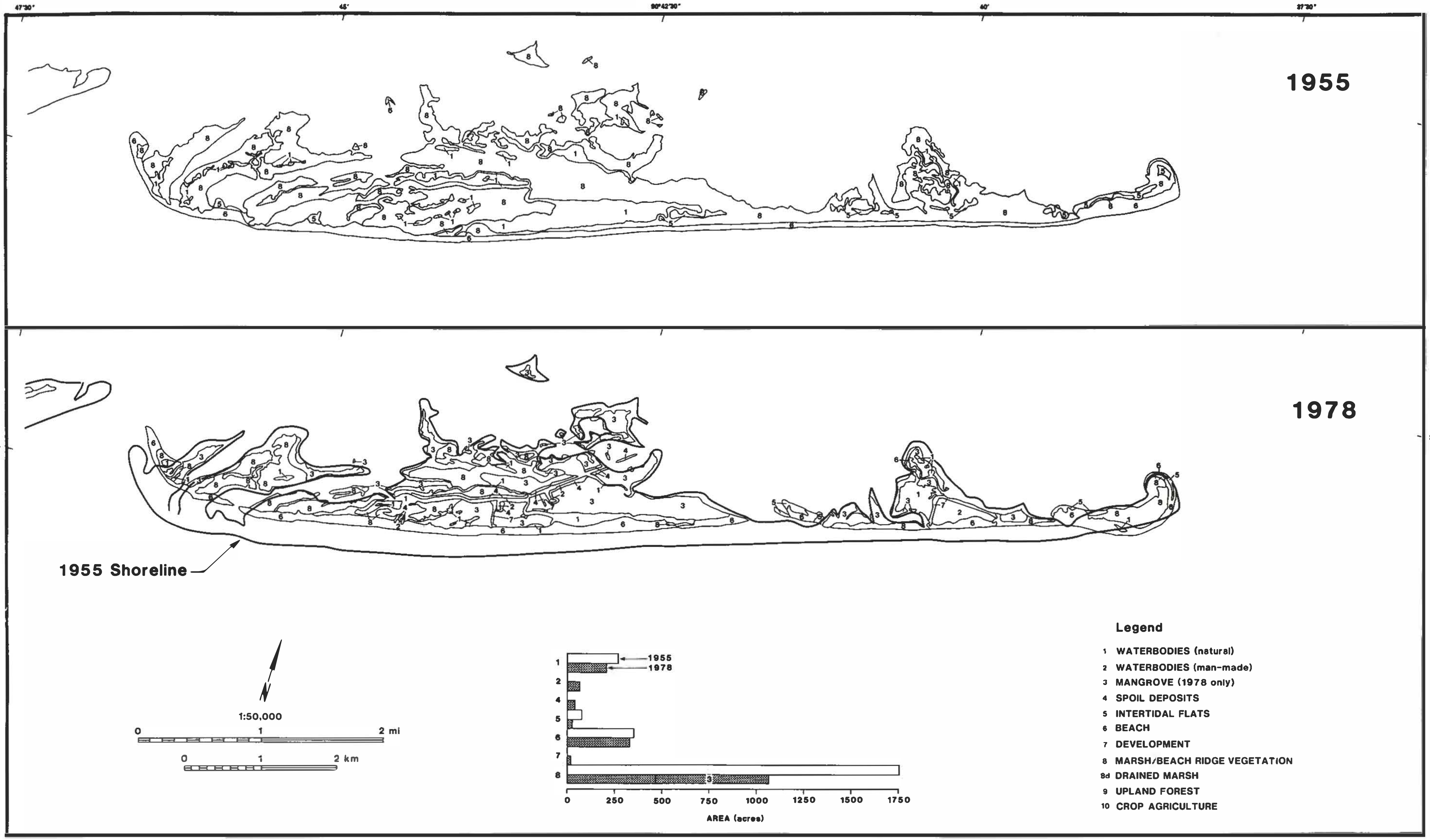
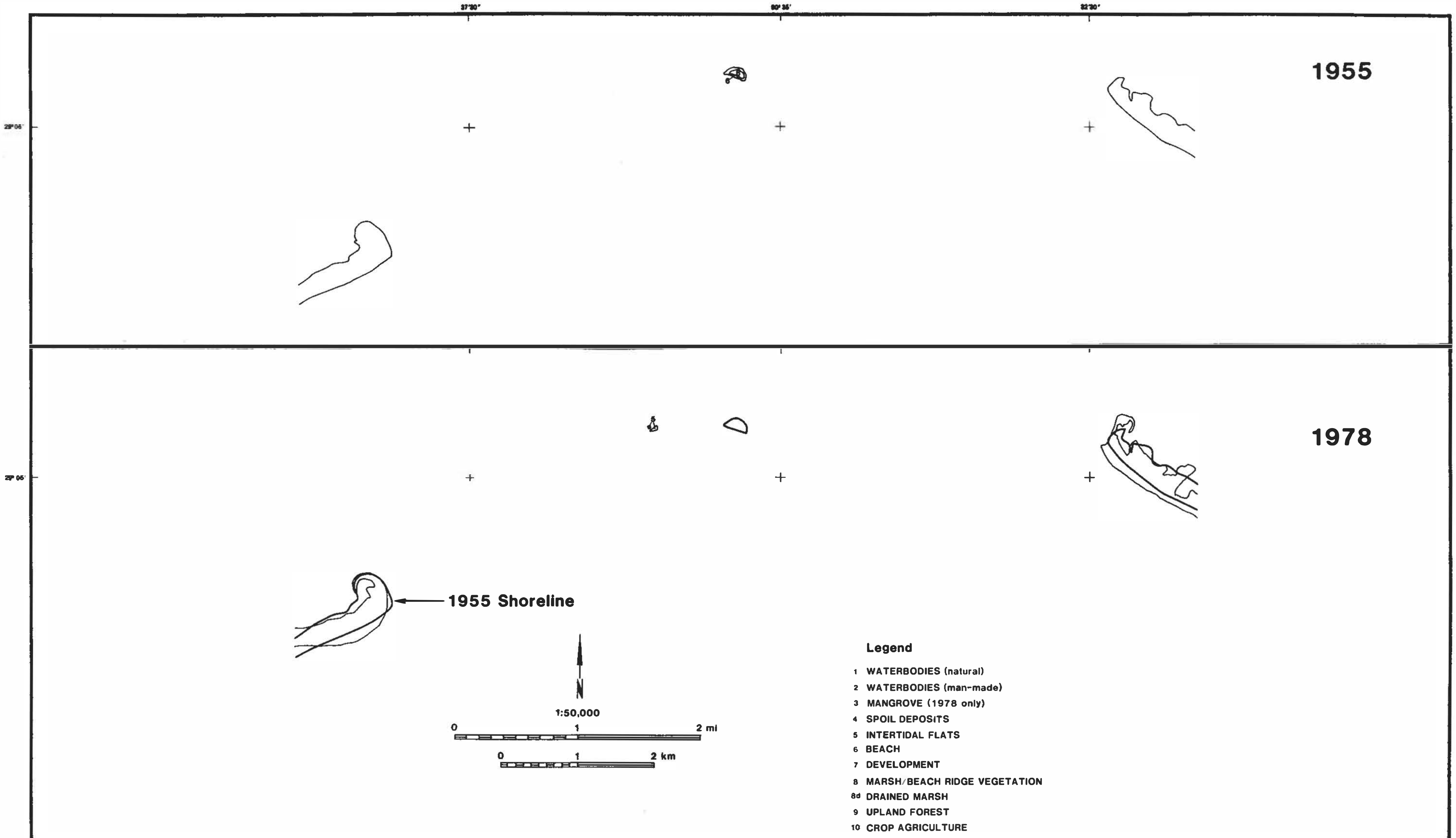


PLATE 18. EASTERN ISLES DERNIERES



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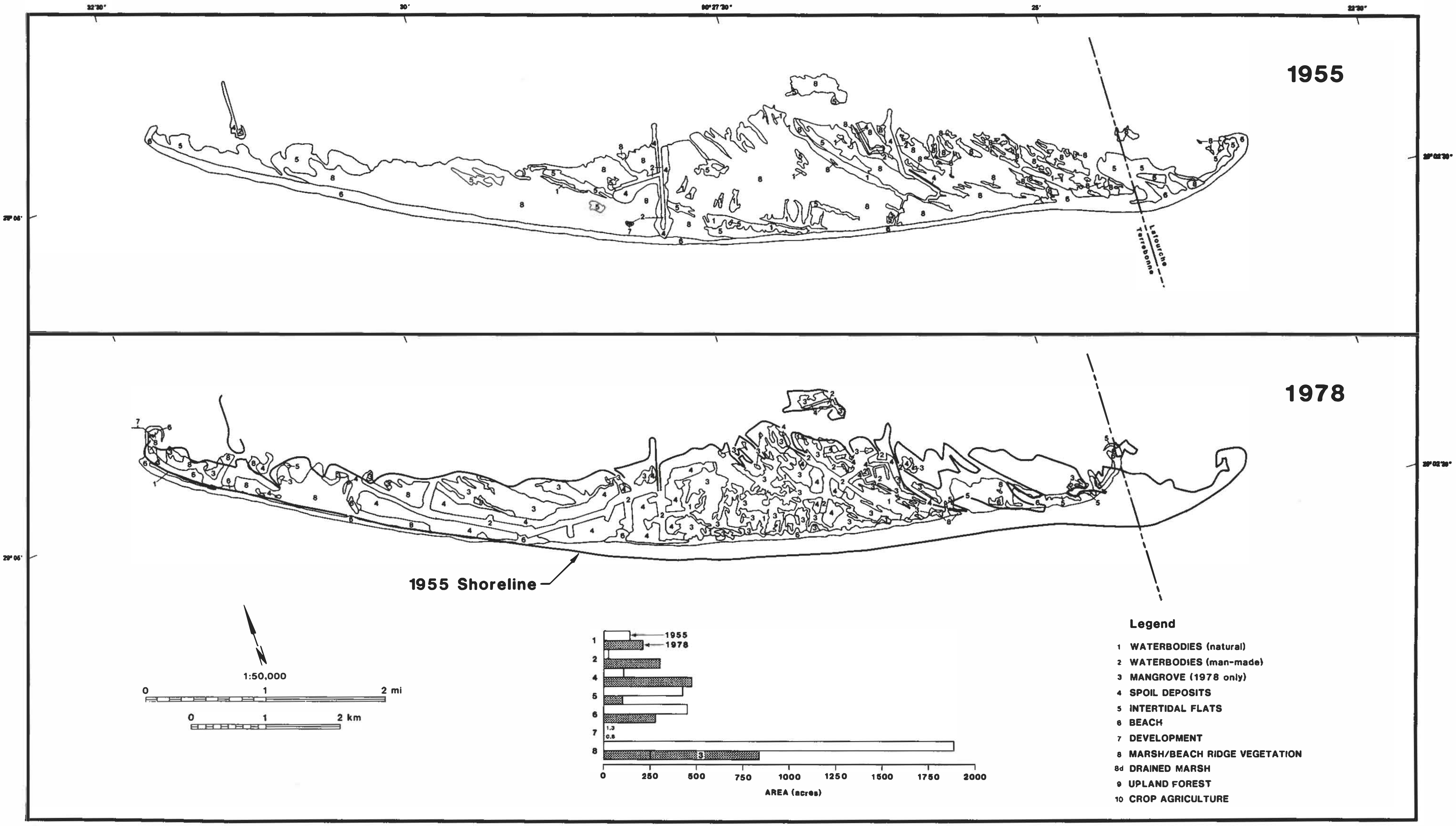


PLATE 20. TIMBALIER ISLAND

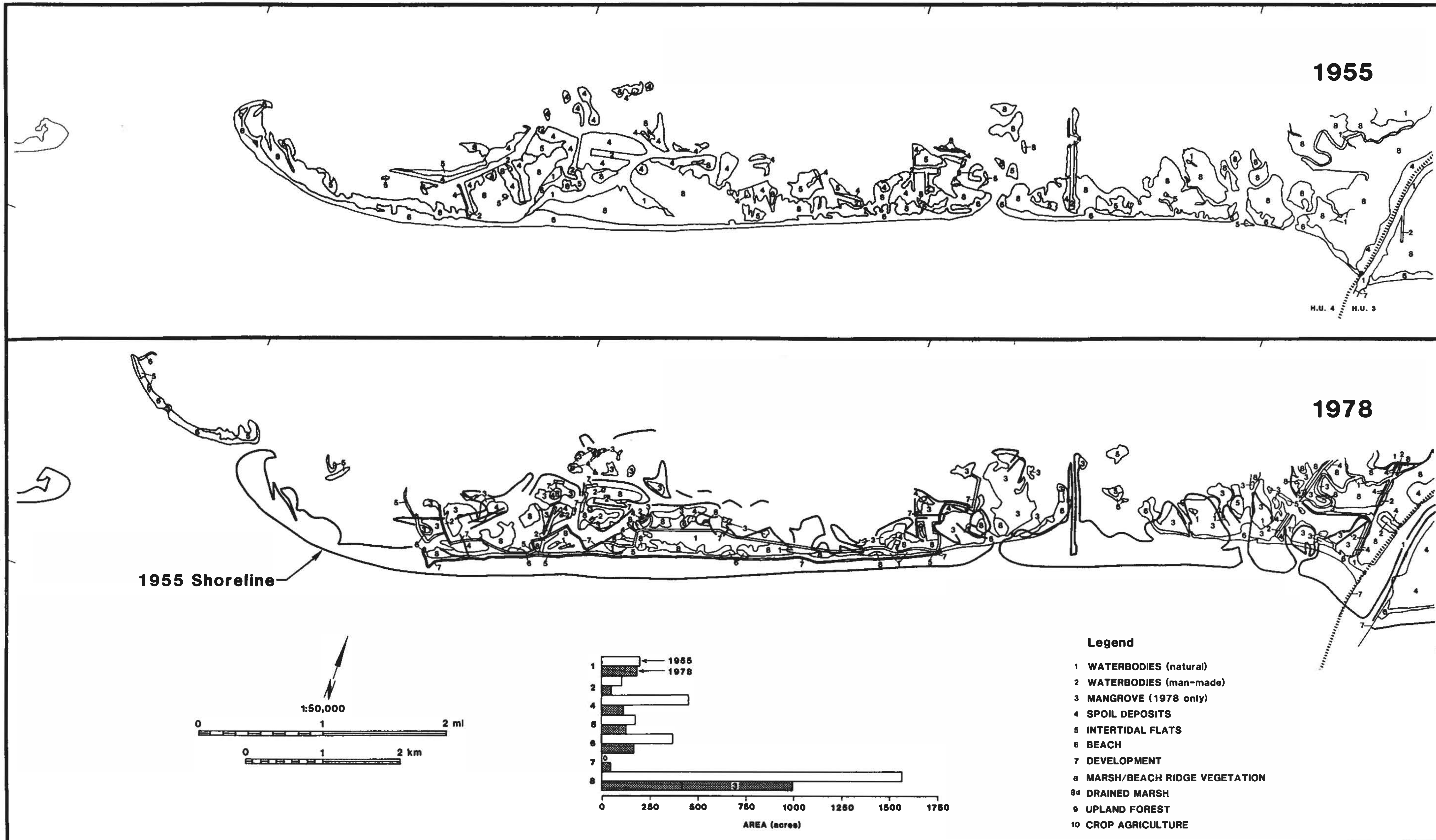
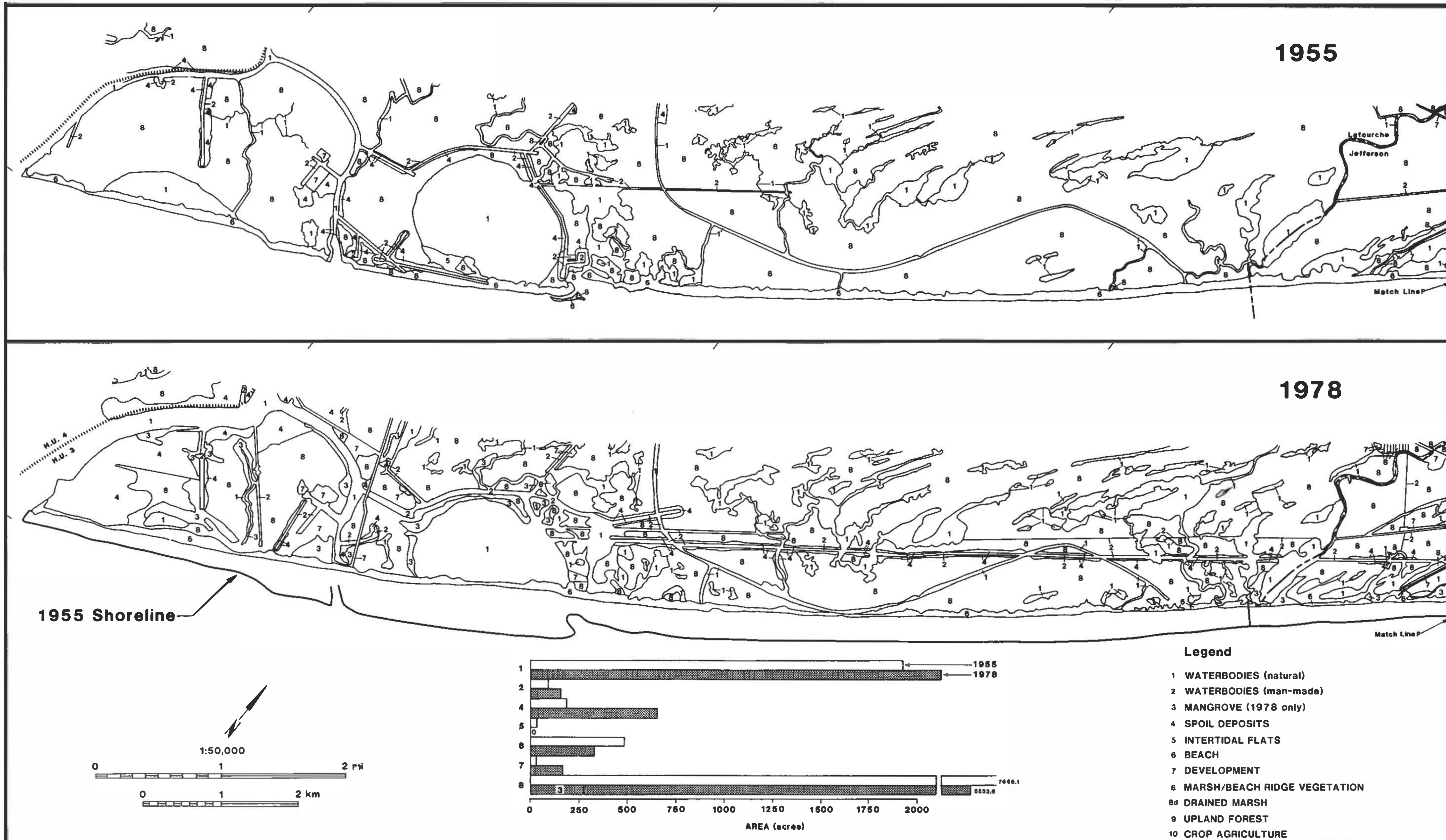


PLATE 21. EAST TIMBALIER ISLAND TO BELLE PASS



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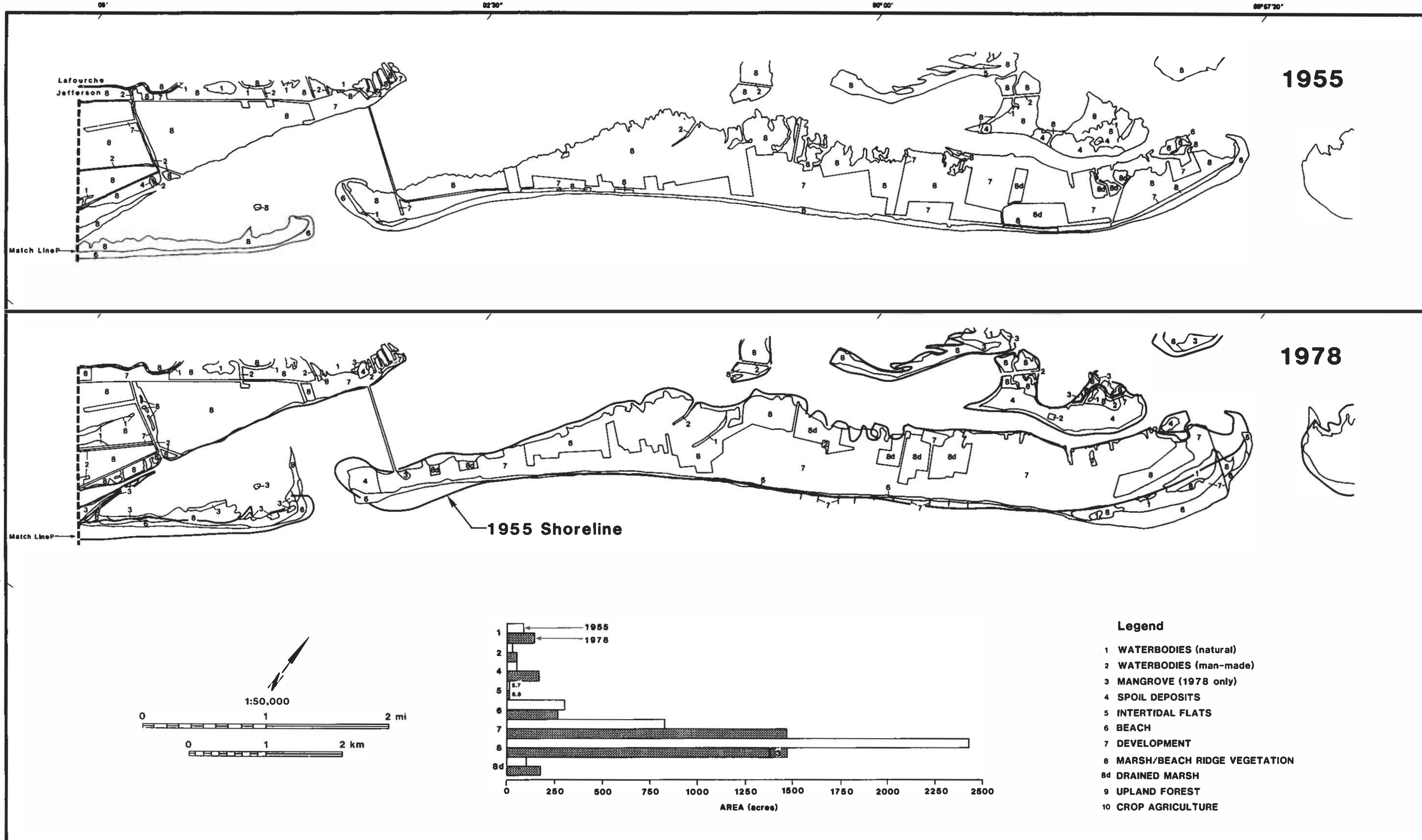
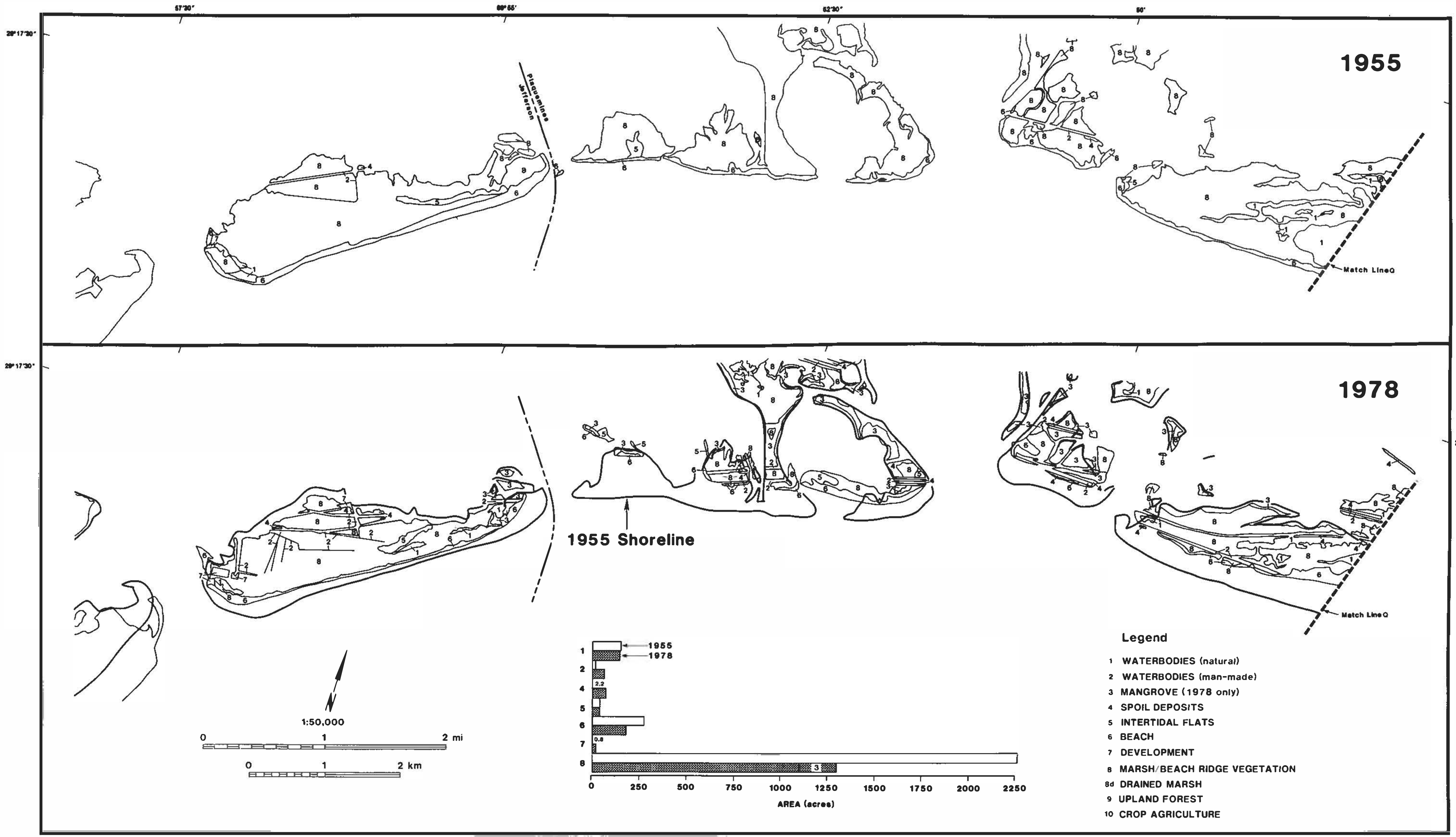


PLATE 23. CHENIERE CAMINADA/GRAND ISLE



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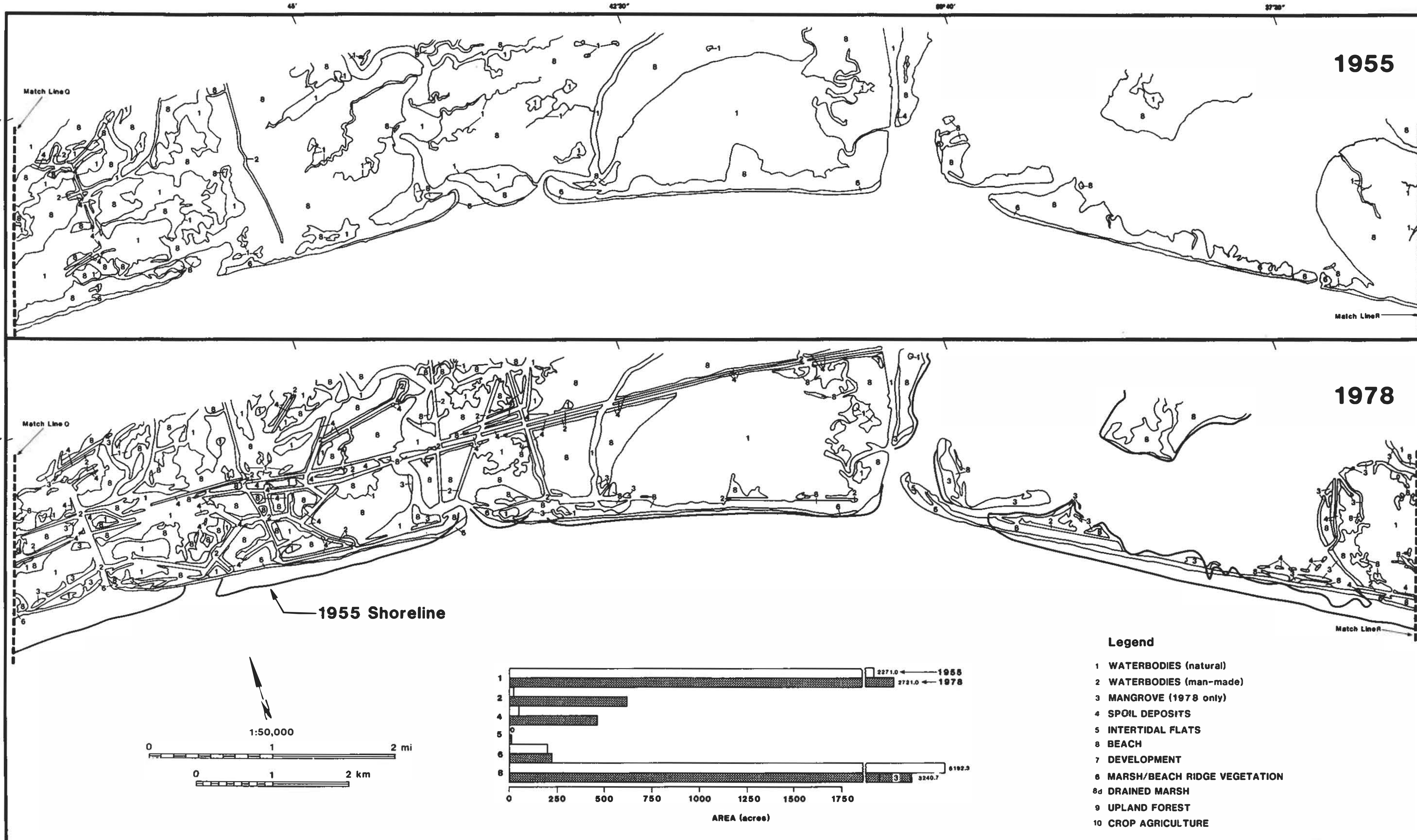

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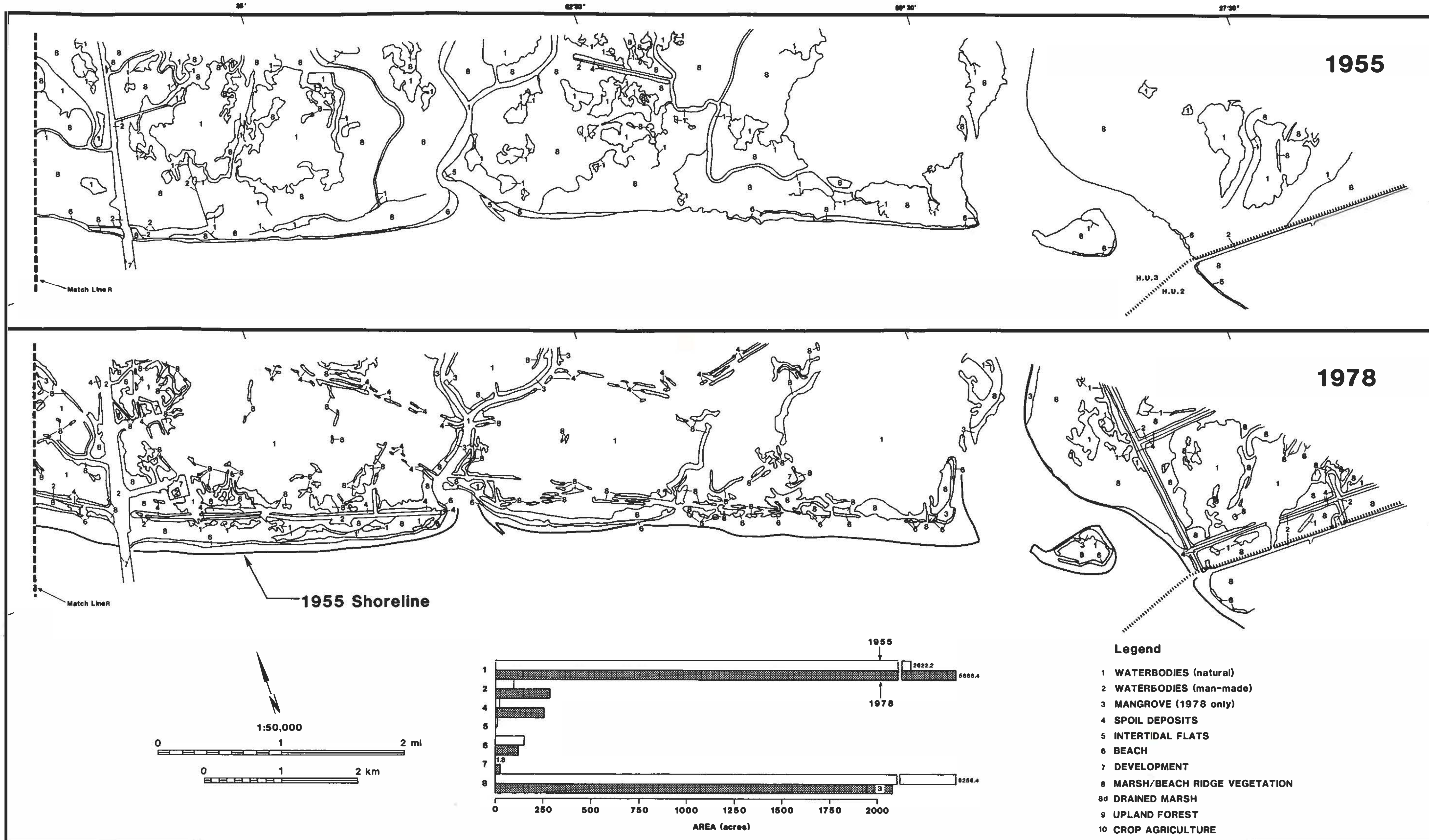

PLATE 26. GULF-EMPIRE WATERWAY TO SANDY POINT

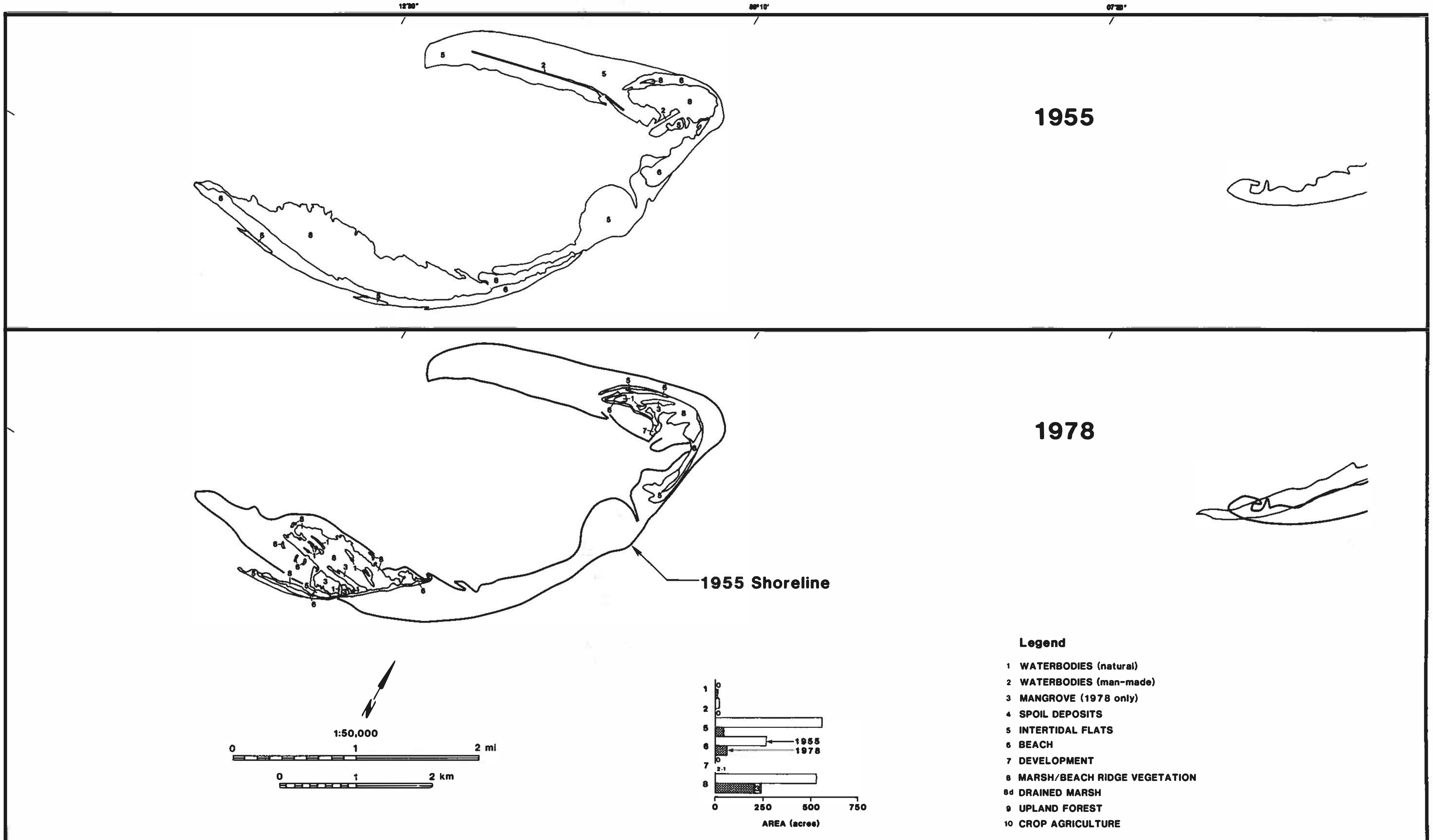

PLATE 27. BRETON ISLAND

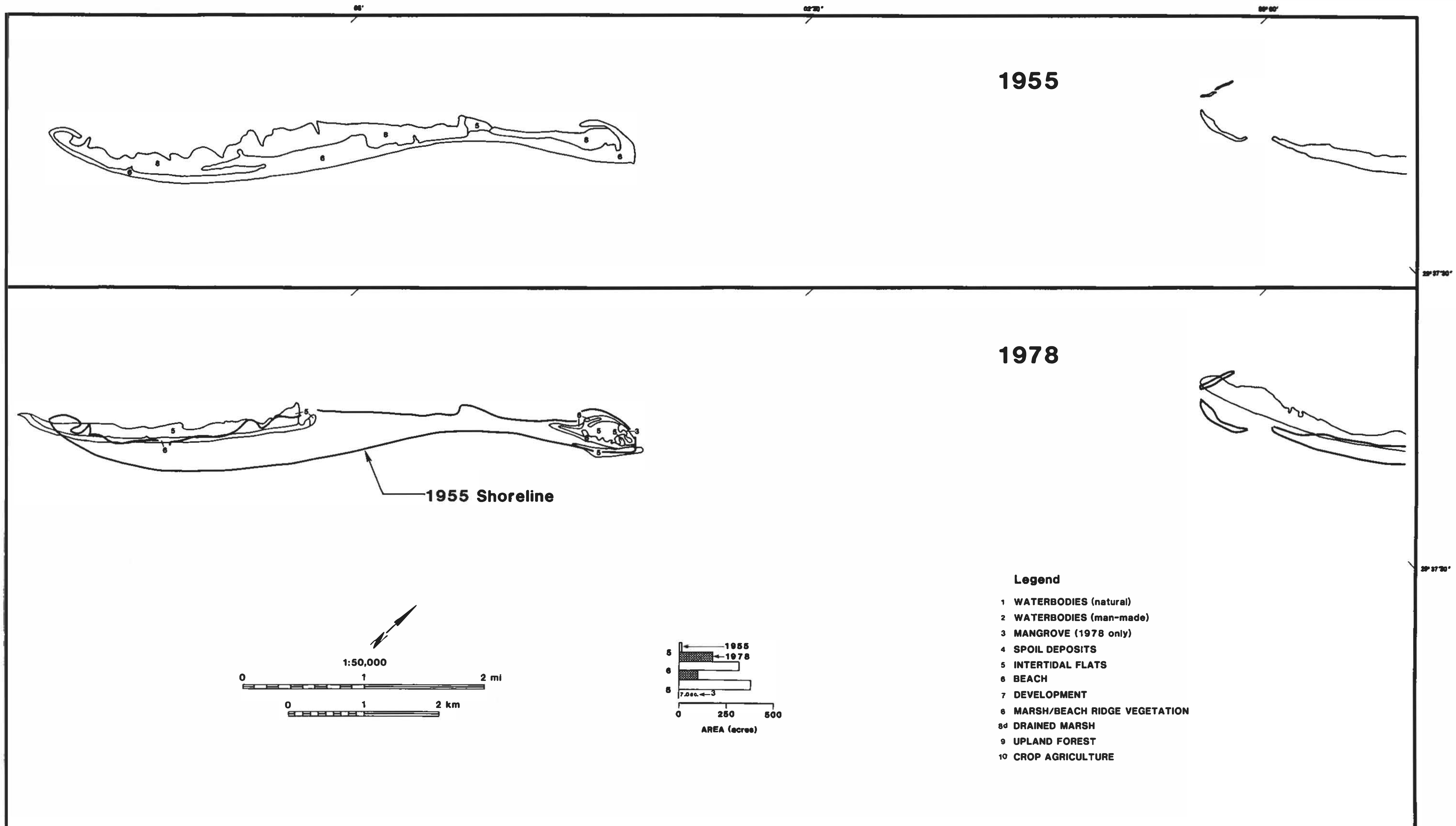

PLATE 28. GRAND GOSIER ISLANDS

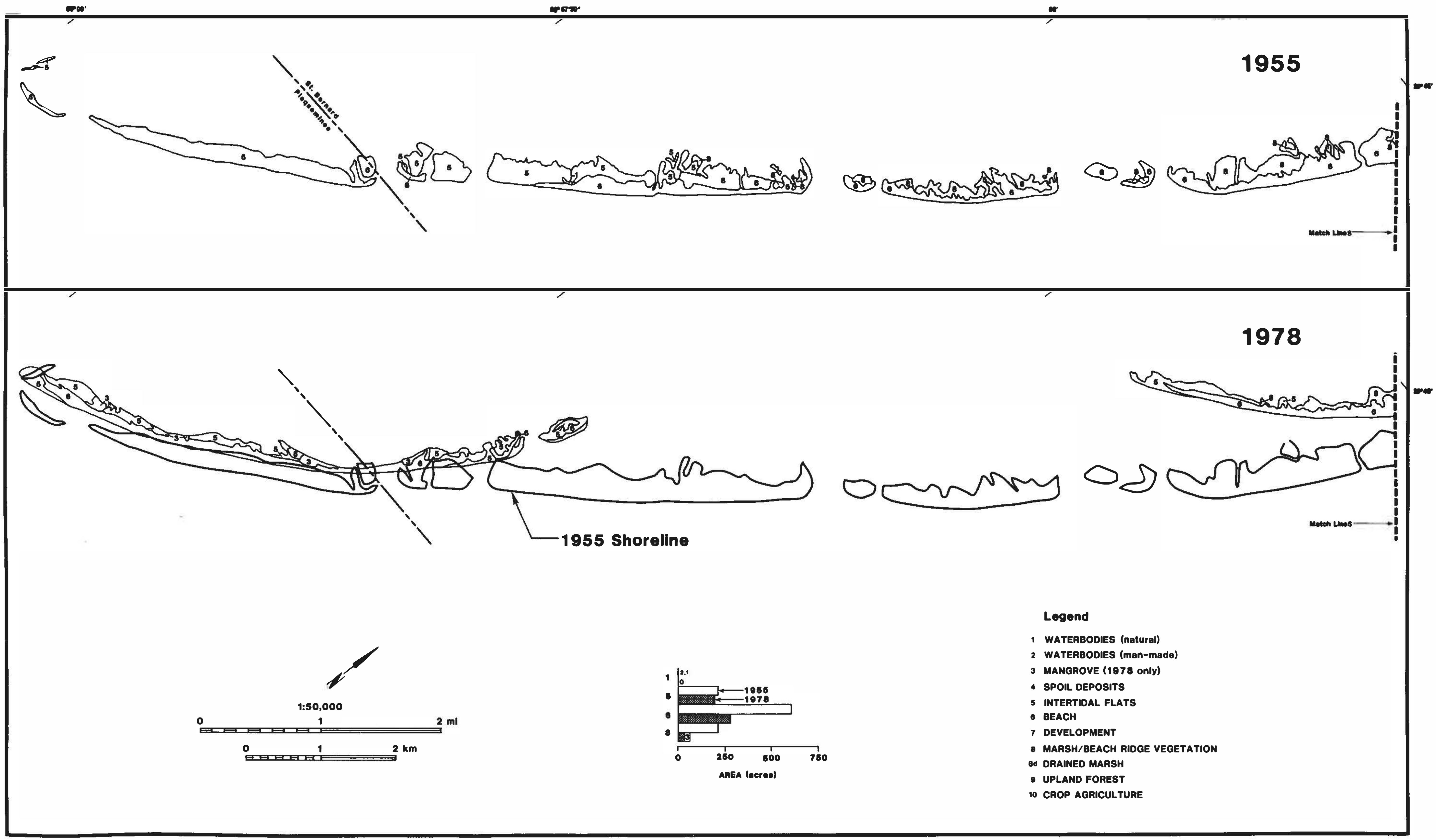

PLATE 29. STAKE ISLANDS

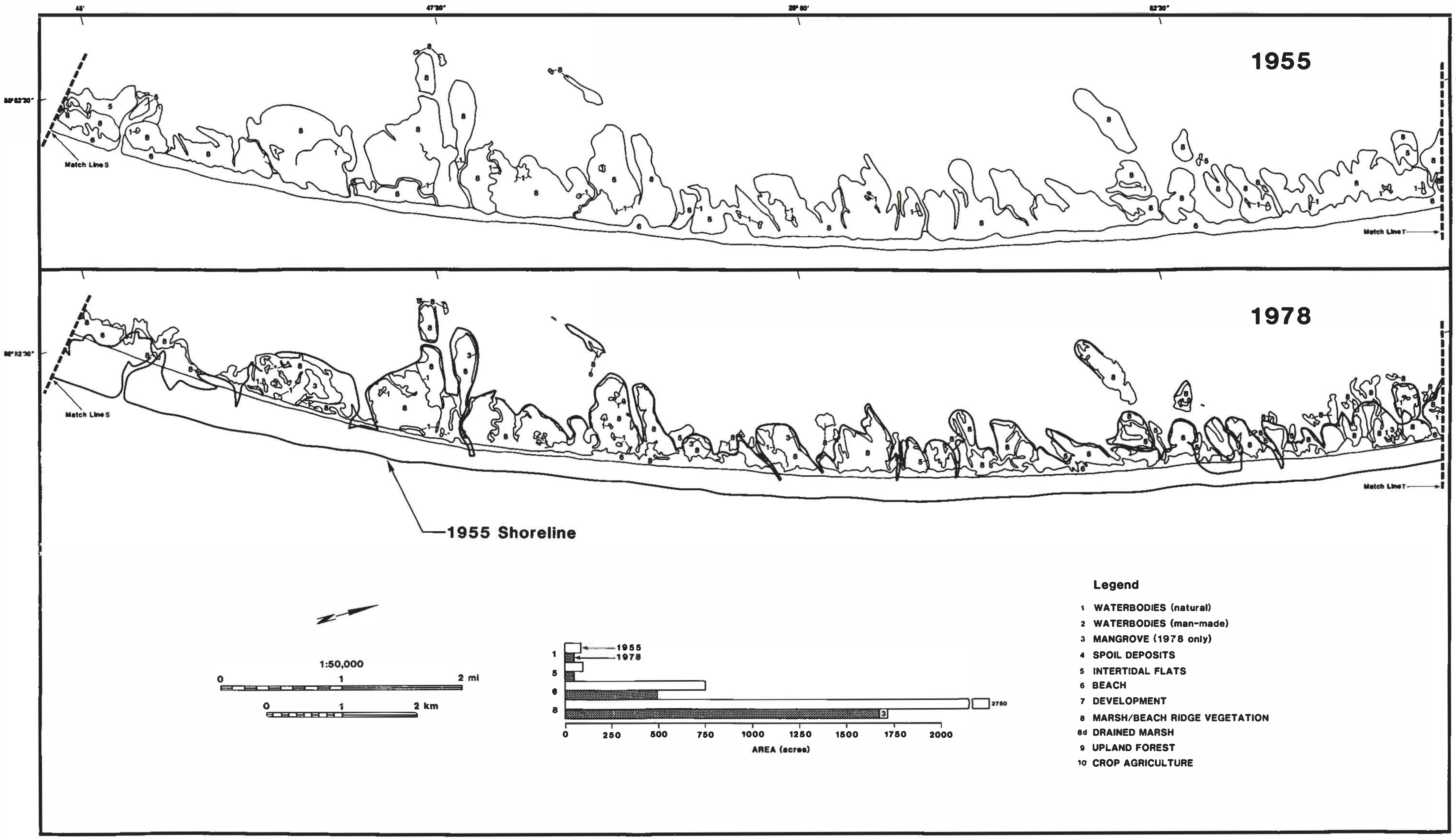

PLATE 30. CENTRAL CHANDELEUR ISLANDS

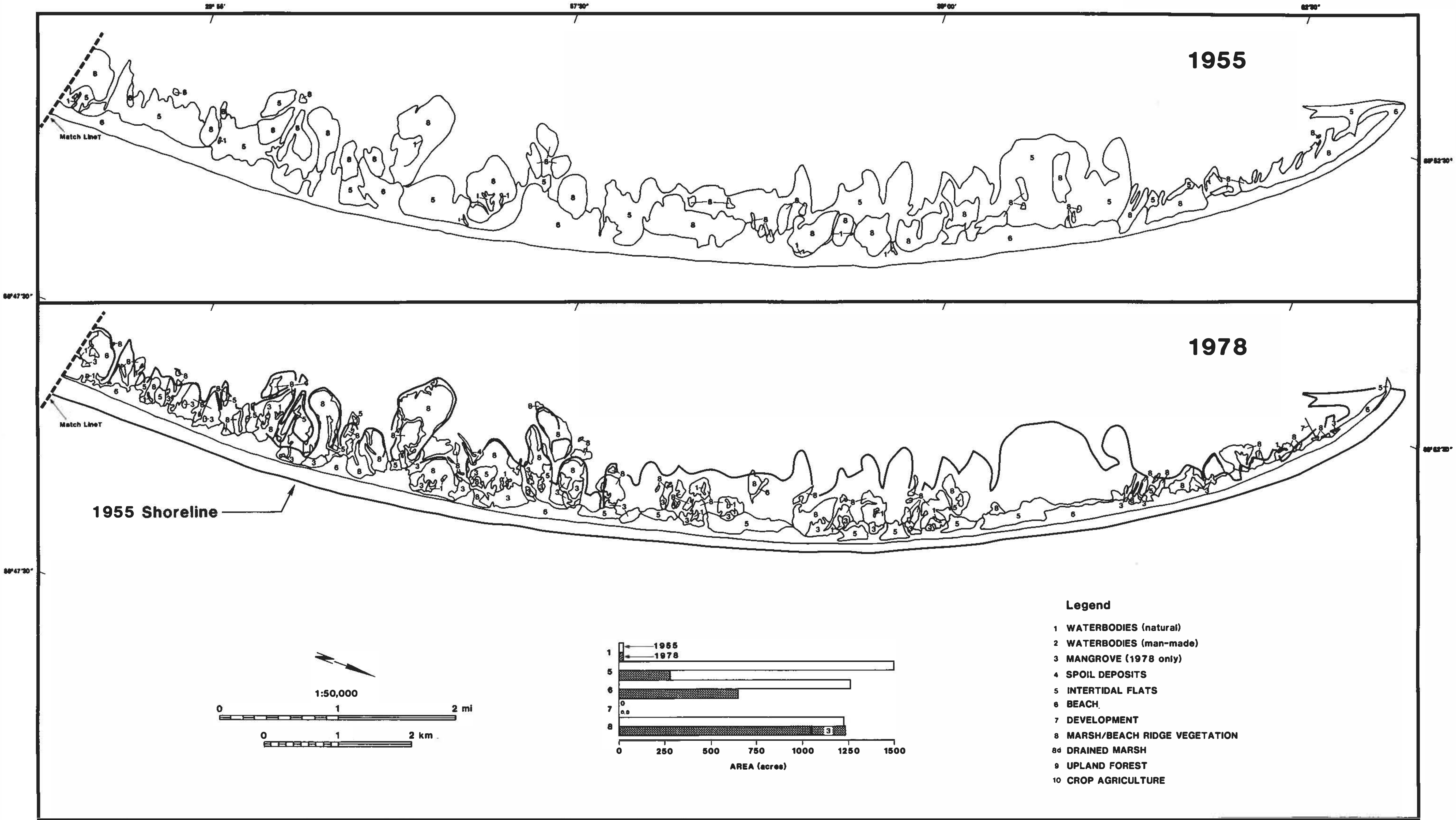

PLATE 31. NORTH CHANDELEUR ISLANDS