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BARATARIA BASIN: GEOLOGIC PROCESSES AND FRAMEWORK

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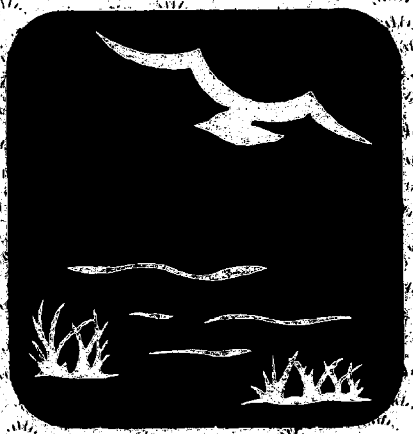

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BARATARIA BASIN: GEOLOGIC PROCESSES AND FRAMEWORK

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Abstract

This report describes the landforms and processes that are operative in Louisiana's coastal wetland. It also discusses processes that cause marsh deterioration and land loss. To obtain information on land loss the environmental units were inventoried and assessed to determine the status of existing resources for environmental units, parishes, and basin. Study of dredge and fill activities and their intensities for each environmental unit and parish were established. Coastal erosion and inlet changes were quantified. Sea-level changes, subsidence, storms, and salinity intrusion were studied as a combination of natural destructive processes, balanced by detrital sediment produced in the marshes and swamps and storm-deposited inorganic sediments deposited over the marshlands.

Coastal erosion effects, marsh deterioration by water movement, and vegetation response to salinity intrusion and tidal pulses that remove organic detritus and cause erosion of the marsh surface are also considered in this study.

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Introduction

The geologic characterization of the Barataria Basin that introduces this study describes the landforms and processes that are operative in Louisiana's coastal wetland. It considers eustatic changes and land subsidence, and it documents land loss in the Barataria Basin Management Unit.

The remaining sections expand on the land loss with studies of coastal erosion, marsh deterioration by water movement, and vegetation responses to water movement.

Coastal erosion effects are very dramatic where man's activities infringe on a zone that is undergoing constant attack by waves and longshore currents. Without replenishment of sand-size sediments from active river mouth bars, coastal processes can only rework existing beach deposits and sands are lost in the process. Groins, jetties, and other structures can alter patterns of sediment movement but select in favor of one site at the expense of another.

The process most directly associated with marsh deterioration is water movement. This can take the form of salinity intrusion that causes marsh plants to die back, or tidal pulses that remove organic detritus from the marsh and cause erosion of the marsh surface. Both of these processes destroy the ability of marsh plants to keep pace with subsidence. Lateral erosion caused by waves generated within the bays or lakes is another important process.

Vegetation response to each of these factors is the key factor to be considered. The ability of the marsh to trap and produce sediment at a rate that keeps pace with subsidence is essential to the survival of a viable marsh system. This ability is diminished when plants are stressed by salinity changes or when flushing exceeds production of detritus. The structure of the plant root system can also have a dramatic effect on resistance to erosion by waves and currents. The robust growth form of Spartina alterniflora and its extensive root system makes this salt marsh species much more resistant to erosion than most species characteristic of brackish marshes. A balance between sediment supply and subsidence is required for continued marsh maintenance. As long as the flow of Mississippi River water is confined to its channel by artificial levees, the natural processes will proceed toward conversion of Barataria Basin into a shallow water body at the expense of marshlands.

Existing settlements along the levees preclude returning to pre-artificial levee conditions. Therefore, imaginative and realistic water and sediment control schemes for nourishing depleted environments need be conceived and applied.

Geologic Characterization

Physical Setting of Coastal Louisiana

This report presents a digest of the salient physical aspects of Louisiana's coastal zone that are relevant to man's utilization of this vast, productive wetland. It is a companion text to the biological characterization (Bahr and Hebrard 1976) and hydrological/climatological characterization (Byrne et al. 1976) coastal zone management reports. These reports present a baseline inventory of significant biological, physical, and chemical parameters and describe related natural processes in this highly dynamic wetland. They comprise a scientific basis for management principles and guidelines to maximize wetland utilization, consistent with minimal impact on natural systems.

This section presents a general discussion of the geologic framework for the entire Louisiana coastal zone. A second section describes the geologic framework of the Barataria Basin[1] Management Unit, providing background for discussion of basin responses to natural and man-made stresses in a subsequent report.

Louisiana's coastal zone encompasses some 10,443,400 acres of geologically Recent[2] near sea-level wetland and inshore water bodies. Offshore the zone extends to the three-mile limit. Sediment- and nutrient-laden Mississippi River waters enter the north-central Gulf of Mexico, and tidal mixing and exchange of these waters between the extensive estuary systems and continental shelf zone create a richly endowed habitat for marine resources. Inshore the area is about equally divided between swamps, marshlands and estuarine water bodies. Only about 15 percent of the area

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1. Barataria Basin as used in the coastal zone management reports refers to the enclosed basin with its apex approximately at Donaldsonville. It widens coastwise, with Bayou Lafourche and Belle Pass forming the western boundary, and the Mississippi River and Red Pass forming the eastern boundary. The term is synonomous with hydrologic unit as used in the literature. The exact boundaries differ from those presented in Lindall et al. (1972) and Gagliano (1970), but the general area delineated is essentially the same.

2. The term Recent (capitalized) as used in this paper refers to offlapping sedimentary sequences associated with deltaic growth and coastal accretion. Some authors prefer the term Holocene, which had its origin

is subaerial land, which rises a few feet above sea level as natural levees, beaches, cheniers,[3] and elevated areas associated with intruded salt domes. Man has extensively altered both the wetland and high ground through his settlement and economic activities. Dredging operations associated with water-control systems, canals, and navigational channels interlace the area.

The near sea-level wetlands are framed inland by the Prairie Terrace (Fig. 1) which slopes and submerges beneath the Recent wetlands. Extending inland along the rivers crossing this region are broad swamp-floored flood plains that contribute significantly to the nutrient supply of coastal waters. Low flood plain elevations allow marine waters to invade far inland.

The Pleistocene terraces represent uplifted, weathered surfaces of deposits originally produced by processes still operating in the marine and fluvial environments of coastal Louisiana. Regional tilting of the terraces resulted in surfaces that are higher inland and lower seaward, sloping about 3.5 ft per mile (Russell 1940).

Extensive near sea-level essentially flat Recent deposits onlap Pleistocene material along an irregular boundary inland from the coast. These are primarily deltaic deposits; however, the stranded beach ridge complex in southwestern Louisiana forming the chenier plain is comprised of reworked deltaic material and sediments eroded from along the coast.

The landforms within the coastal zone, with the exception of salt domes, result from dynamic interactions between river deposition, waves and currents, eustatic sea level changes (worldwide changes of sea level associated with melting of the polar ice caps or isostatic adjustments of the continent) and subsidence.

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in Europe. Both are part of the late Quaternary record underlain by older Pleistocene deposits. There is considerable confusion in the literature concerning the application of the two terms; for additional information refer to Fisk (1955), Russell (1968), and Gould (1970).

[3] "Chenier" is used in southwestern Louisiana to mean old beaches now stranded in marsh (Russell and Howe 1935). "Cheniere" is used in the southern part of the Mississippi Delta to mean any high ground and ordinarily refers to natural levees of abandoned channels. In both cases the name refers to the oaks, which are dominant among the trees covering such eminences (Russell 1936, p. 45).

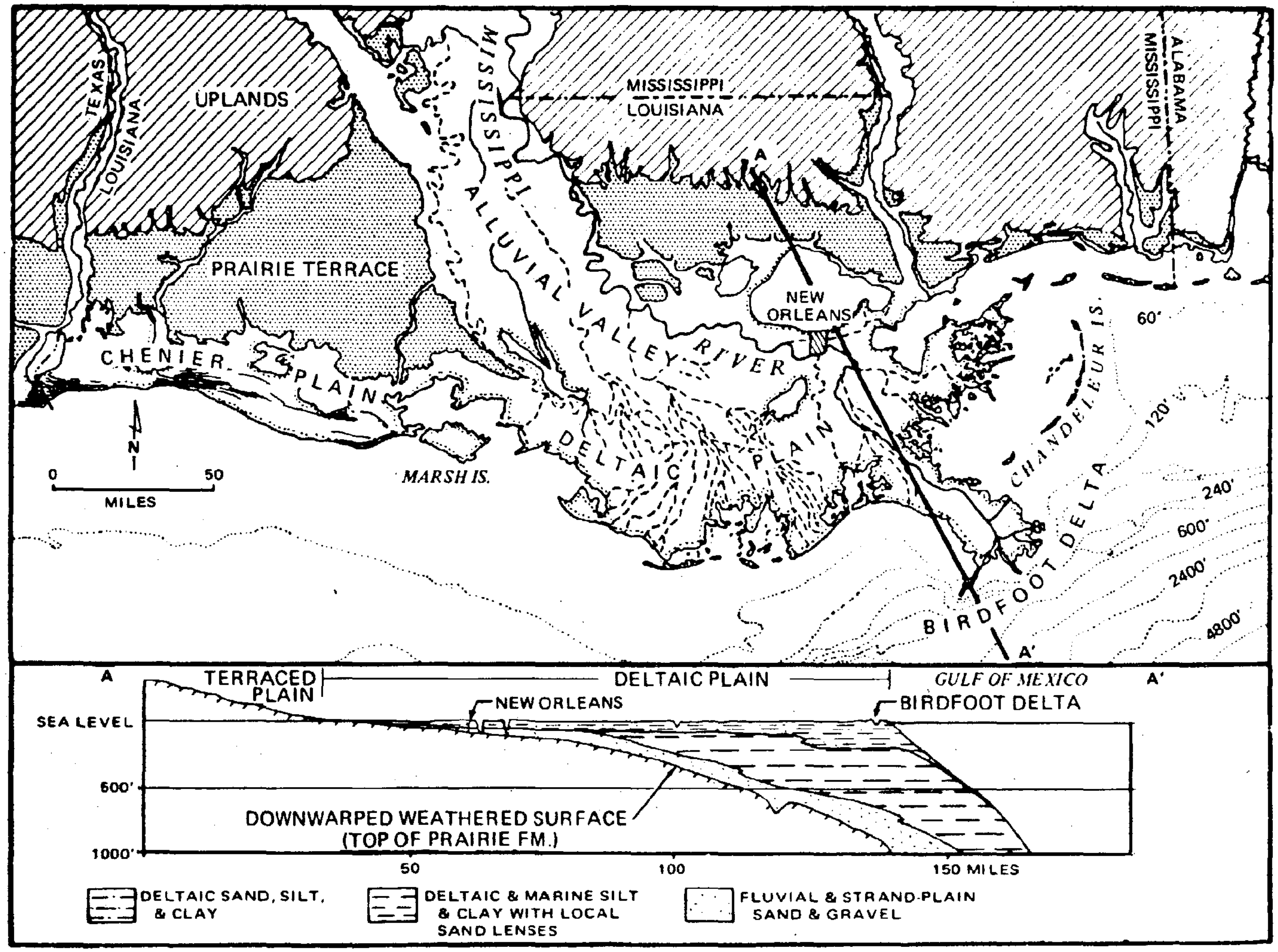

Fig. 1. Index map indicating major surfaces in the coastal zone. Bathymetry lines show deep water near the Modern Delta and shoal water off the remainder of the coast. Cross-section A-A' illustrates downwarping in the deltaic plain. (After Fisk and McFarlan 1955)

Although widespread in the subsurface throughout coastal Louisiana, salt domes (Fig. 2) only locally protrude through the marshlands and form topographic highs. The Five Islands in south-central coastal Louisiana extend along a northwest-southeast geologic activity line. Belle Isle forms the southern dome near the coast with Jefferson Island the northernmost dome where it outcrops through the Pleistocene surface. The islands are heavily wooded in contrast to the flat marshlands that surround them (except Jefferson Island). The islands are approximately two miles in diameter and the highest in elevation extend about 171 ft above the near sea-level marshlands.

In the subsurface, lying at varying depths, are several hundred domes that are known to exist. Many more topographic highs are suspected of being salt domes (Jones 1969). The domes are significantly important as sources of salt, sulfur, petroleum, and natural gas where they are present in the upwarped sediment around the periphery of the salt plug.

EUSTATIC CHANGES (WORLDWIDE CHANGES IN SEA LEVEL)

Sea level rise occurred as a result of the continental glacial melt that concluded the last ice age. Seas were lower than at present, and the eustatic rise averaged about 0.5 ft per century during a 4,000-year period ending about 3,000 years ago. Evidence indicates that minor fluctuations of sea level have occurred since that time resulting in a net rise of about 0.1 ft per century or 3 ft (McIntire 1969). Part of this rise appears to have occurred during the last 40 to 50 years (Marmer 1954). Indications are that marsh surfaces kept pace with the relative rise in sea level through accretion of some mineral sediment (sands, silts, and clays) in addition to plant (organic) detrital accumulation.

LAND SUBSIDENCE

Submergence comprises one of the most critical problems in the coastal zone. Combined with wave attack and loss of river-borne sediment supply, it constitutes the primary cause of severe land loss in the marshlands and landward retreat of the coastline. Its causes are highly complex. Excepting mud lump emergence near major passes at the mouth of the Mississippi River and possibly some salt-dome displacement, all natural vertical movements in the deltaic plain are associated with subsidence processes. Factors that contribute to lowering of the land surface relative to sea level include:

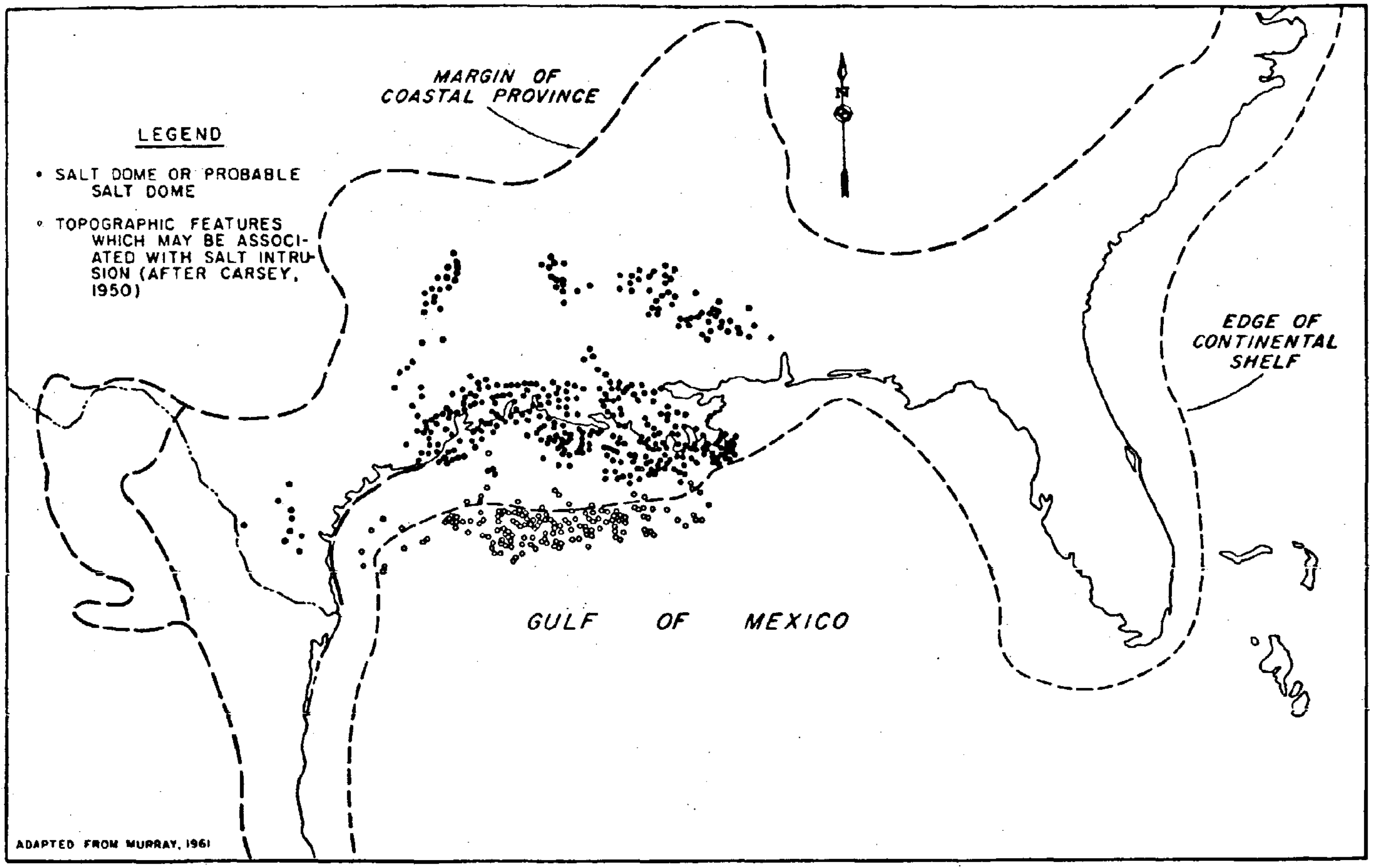

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Fig. 2. Distribution of salt domes and topographic features that may be associated with salt intrusion (Jones 1969).

1) Eustatic sea level changes (mainly rising during late Quaternary including Recent times).
2) Regional subsidence caused by crustal downwarping (isostatic adjustment) from sedimentary loading. Greatest downwarping along Louisiana's coast has occurred beneath the present birdfoot delta, where as much as 1,000 ft of late Quaternary sediments have accumulated (Fisk and McFarlan 1955; Gould 1970; Fig. 1). Inland the Recent deposits thin out along the surface contact line where the Pleistocene surface emerges above the Recent. Downwarping diminishes westward; sediments comprising the Recent Chenier Plain in southwestern Louisiana are only about 30 ft thick at the coast.
3) Tectonic processes that include growth faulting (Jones 1969, p. 20), folding, fracturing, and flowing are phenomena that develop within the thick sedimentary section. They occur contemporaneously with downwarping (isostatic lowering), compaction of sediments, and filling in the basin with sediments. The development of salt domes and mud lumps are thought to be related to these tectonic processes.
4) Compaction of sediment through dewatering processes:
    a) Differential consolidation owing to textural variability in the sedimentary column.
    b) Consolidation of underlying sediments from weight of features such as natural levees, beaches, artificial levees--particularly when the features have been deposited over weak compressible foundations.
    c) Local subsidence of compressible materials through consolidation or displacement by objects such as buildings, pile structures, fills, benchmarks, and tide gages.
    d) Lowering of the water table through extraction of groundwater, salt, or sulfur; also "reclamation" practices that employ diking, construction of water control structures, and drainage of lands for agriculture or flood protection. Cumulatively, these practices become major concerns at the parish, hydrologic/management unit, and state levels.
    e) Extraction of oil, gas, sulfur, and water from salt domes is known to have resulted in subsidence. Scientists have done little in coastal Louisiana in relating extractive processes to subsidence except those connected with industry. Often, this information is privileged. A better understanding of processes related to extraction and subsidence is necessary, particularly when considerations are underway for utilizing subsurface domes for storage.

f) Other phenomena and activities that contribute to subsidence through dewatering include the following:
   1) Extended drought periods are thought to result in lowering the near-surface water, and compaction occurs within the dewatered, relatively thin layer.
   2) Oxidation, hydration, and removal by wind are important factors in lowering of highly organic soil surfaces. This applies particularly to beaches along shorelines and coast.
   3) Some observers claim that marsh burning dries out the near-surface water resulting in subtle amounts of compaction. Certainly it destroys organic litter that would otherwise contribute to maintenance of the land surface.
   4) Marsh buggies traversing marshland surfaces compact underlying material leaving permanent scars.

The complexity of the subsidence problem negates estimates of precise rates and cumulative amounts that would apply regionally. At a given locality all the above subsidence processes may occur contemporaneously. In addition, sediment texture and composition vary greatly from place to place and each type responds differently to loading. Organic content of sediment is an important factor in compaction. Dewatered and dried organic sediments shrink dramatically in proportion to the percentage of organics present in the sediment. Volume reductions as great as 85 percent are not uncommon in some dried marsh and swamp soils.

Depositional environments associated with sediments laid down by rivers vary greatly over short distances (Fig. 3) both transversely and parallel to the stream. Silts and sands mixed with clays are the textural components of natural levees. Back slopes of natural levees grade into levee-flank depressions (low areas generally parallel to natural levees and marginal to marsh basins) or into marsh basins. Over relatively short distances downslope, natural levee sediments grade from coarse to fine-grained mineral soils to high percentages of organics. Grain size distributions and composition also change (more gradually) downstream. Within stream channels and along the coast, currents and waves winnow, transport, and deposit sediments whose forms and textural/compositional properties relate to particular sedimentary environments. Each compacts differentially.

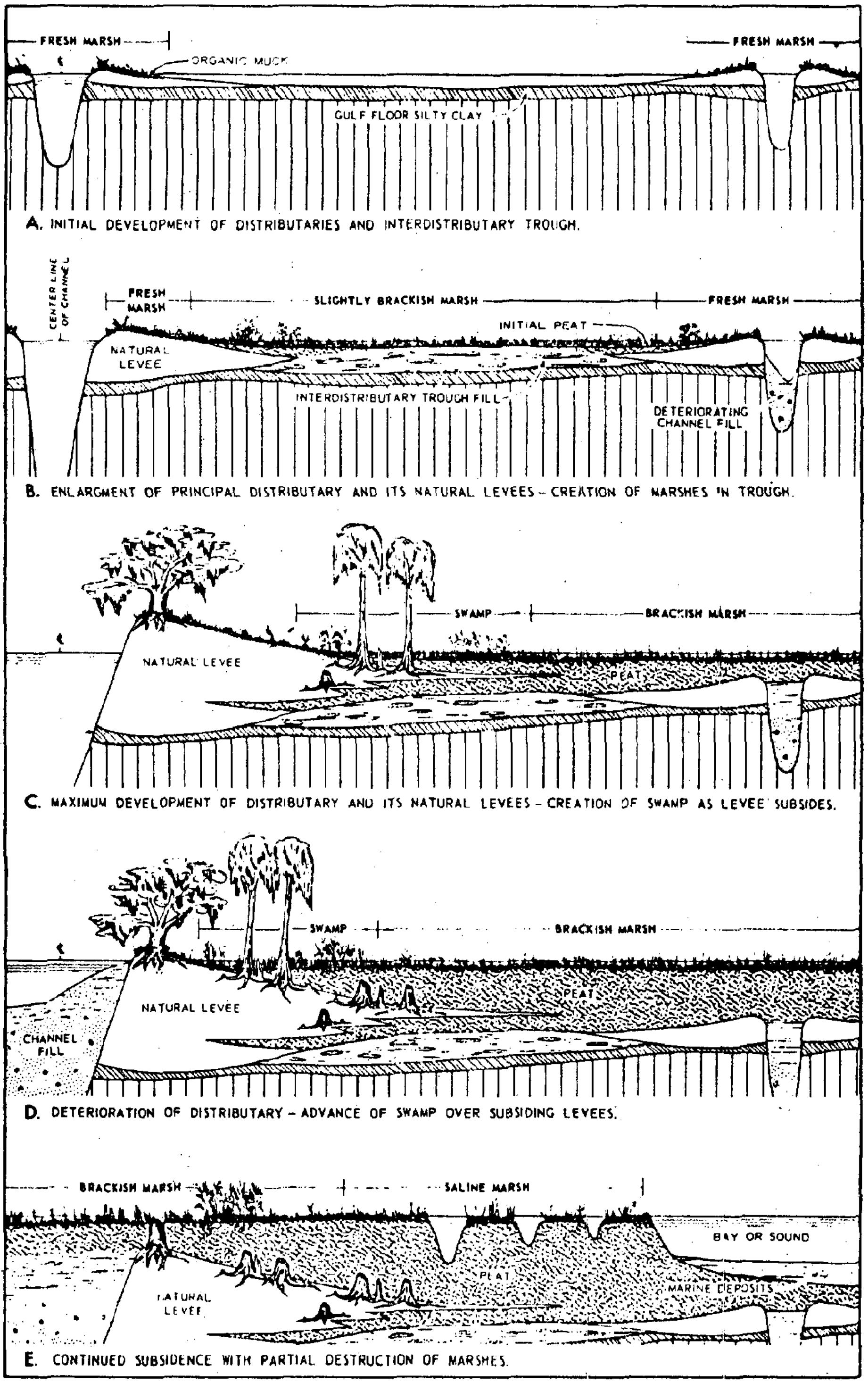

Fig. 3. Progressive stages in natural levee development, peat accumulation, and subsidence are illustrated in graphs A-E (Fisk 1955).

A study made by Kolb and Van Lopik (1958) summarizes the subsidence problem as follows:

> It is apparent from the preceding discussion that only three of the component factors, true sea level rise (A), basement sinking (B), and consolidation of the Pleistocene and pre-Pleistocene sediments (C_1), are sufficiently broad in aspect to permit general application to all of southeast Louisiana. Although the subsidence rates dictated by these factors vary considerably with geologic time, thus making average rates less indicative, it is felt that minimum values have been established. Therefore, the sum of the values for true sea level rise (0.32 ft per century), basement sinking (0.07 ft per century), and consolidation of Pleistocene and pre-Pleistocene sediments (0.39 ft per century) should provide an average regional subsidence rate (0.78 ft per century) for southeastern Louisiana at the present time. As a distinct component rate cannot be presently assigned to regional tectonic activity (E), the 0.78 figure includes the effect of this factor. In addition, it should be borne in mind that this value is a regional estimate and local deviations resulting from compaction of Recent sediments (C_2), consolidation caused by weight of minor land forms (D_1), consolidation caused by weight of manmade structures (D_2), and local faulting or uplift (E), as well as normal deviations from the average should be expected.
>
> For the present several broad statements concerning subsidence in this region can be made: (1) subsidence is greatest--on the order of five or more feet per century--in the present Mississippi River Delta; (2) subsidence on the order of one to two feet per century is a realistic figure at the present shore line throughout the remainder of the study area; (3) subsidence decreases with distance inland and approaches zero at the surface Recent-Pleistocene contact.
>
> Subsidence caused by engineering structures (D_2) can be accurately calculated. On the other hand the effect of long-range regional subsidence on these structures can only be based on data such as those presented here. Long-range planning for control of the river depending on precise elevations, municipal developments and their future protection from floods, the effect of long-range confinement of the Mississippi River between artificial levees and the gradual inundation of the deltaic plain as a result of subsidence, are but a few of the items that are affected by the omnipresent factor of subsidence. For some long-range

> considerations, subsidence of the order of magnitude prevalent in southeastern Louisiana may be negligible; for others it may be a key factor that might easily be overlooked. In any event, there can be little doubt that as the rapid industrial and commercial development of the deltaic area continues, engineers will become more and more cognizant of the factor of subsidence and its effect on engineering projects and programs.

Since the above study was made investigations on eustatic rise have been refined somewhat and the 0.32 ft per century figure indicated above appears high. Coleman and Smith (1964) show eustatic level reaching its present approximate level about 3,600 years ago. Radiocarbon dating of sediments from beneath Little Chenier (McIntire 1961) in western Louisiana indicates that eustatic rise has occurred during the last 3,000 years at a rate of approximately 0.1 ft per century.

For more detailed information on subsidence, refer to several excellent studies including Coleman and Gagliano (1964), Gagliano (1970), Coleman, Suhayda, Whelan, and Wright (1974), Coleman and Wright (1974), Gould (1970), Frazier (1967), Shelton (1968), Bruce (1973), Carver (1968), Russell (1936), Fisk (1955), Earle (1975), and New Orleans District, U.S. Army Corps of Engineers (1975).

Specific areas of concern in this portion of the study include the lower reaches of the river flood plains and back swamps, chenier plain, deltaic plain, and nearshore waters.

FLOOD PLAINS

River meander belts bounded by marginal back swamp basins characterize flood plains of the numerous rivers that extend to the coast in Louisiana. These features are generally low, level, and densely forested. They experience seasonal flooding. For additional information on flood plains and back swamps, see Saucier (1974) and Fisk (1944).

The meander belts of the Mississippi River (Fig. 1) that are located in the coastal zone include the belt outlining the present course; the Teche-Mississippi course, which formerly flowed along the western margin of the Atchafalaya Basin when the river occupied what is now Bayou Teche; and the Maringouin-Mississippi course, which flowed down the central and eastern portions of what is now the Atchafalaya Basin. These belts contain river cutoffs, ridges, and swales, representing former point bars and abandoned channels that may be partly or completely filled with clay deposits.

The dominant landscape features associated with these Mississippi River distributary systems are the broad, low, asymmetrical ridge complexes, which slope gently away from their present or former river channels, resulting from Mississippi River-constructed levees. Typically, such channels deteriorate into sluggish bayous when their flow is captured by other streams.

The back swamps and flood basins have remained peripheral to the meander belts throughout their development. They receive mainly clays and silts deposited during high river stages with over-bank flow and include environments ranging from infrequently flooded forests to continuously flooded swamps and lakes. The Atchafalaya Basin is a unique back swamp feature that received an accelerating flow from the time the Atchafalaya River began to capture Mississippi River waters (during the last 100 years) until 1959 when it was brought under control--at least temporarily--by the U.S. Army Corps of Engineers (completed in 1963). Relict Mississippi River courses predating the Mississippi-Teche system are in evidence in the mid- and upper sections of the Atchafalaya Basin. Of these, natural levees associated with Bayou Maringouin and other distributaries remain as high ground.

RECENT CHENIER PLAIN

The Recent chenier plain of southwestern Louisiana lies out of the direct influence of the delta proper. Its development is related to westward and eastward shifts of the Mississippi River; changes in the Sabine, Calcasieu, Mermentau, and Vermilion rivers; their associated sediment supply; and dominant westward-flowing littoral currents. Westward shifts of the Mississippi River supplied sediments that resulted in coastal accretion. Eastward shifts of the Mississippi River resulted in coastal retreat and beach ridge or chenier development. Seaward extension of the shoreline was primarily by beach accretion, with subsequent marshland development in swales between beaches. Local rivers (Sabine, Calcasieu, etc.) have also contributed to seaward land growth through accretion ridges forming at their mouths.

The plain dominates coastal Louisiana from Vermilion Bay westward to the Texas border. Recent deposits about 30 ft thick at the coast cover the underlying Pleistocene material and pinch out at the inland surface line of Pleistocene/Recent contact. Because of the relatively thin layers of Recent sediments, subsidence rates from compaction are low. The high ground (nonwetland) in this area includes remnant low Pleistocene islands that form outliers in the marsh, chenier ridges, and beaches. Shallow waters dominate the offshore zone; the 60-ft bathymetric line lies nearly 50 mi from the coast (Fig. 1). Extensive canal dredging and diking has occurred in this area; the Intracoastal Canal was cut in the more resistant Pleistocene deposits but is close to the line of Recent marsh contact. For detailed references on studies concerning the chenier plain consult Russell and Howe (1935); Byrne, LeRoy, and Riley (1959); Gould and McFarlan (1959); and Gould (1970).

RECENT DELTAIC PLAIN

A line drawn on the map between Franklin and Donaldsonville, La., separates the deltaic plain from the flood plain or alluvial valley. Figure 1 shows the Recent Deltaic Plain lying between two arms of the most southern part of the terraced plain. At the coast end of this line the deltaic plain fans out into a broad wetland surface with natural levees determining the course of drainage. Typically, the river networks are grouped together in distinct regions where delta growth was occurring at the time of levee formation.

Sedimentary deposits that formed the deltaic plain make up a progression of seaward deepening deposits (Fig. 1, A-A'), which interfinger with deposits from contemporaneously flowing adjacent distributaries (Fig. 3, D). The mass of these deposits which build the coast seaward over marine material are classified as offlap deposits.

When river sedimentation ceases through river diversion or artificial damming, marine processes become dominant, coastal sediments are then reworked and redeposited landward by wave and current action. The mass of this redeposited material is classified as onlap deposits.

Delta formation begins with the progradational (advance of shoreline) phase as a stream dumps its sediment load into a larger body of water. Most of the sand is dropped at the stream mouth and buried by more sand, while some is redistributed laterally by waves. The finer-grained sediments are carried further offshore where they settle out of suspension more slowly. This condition leads to the normal vertical sequence consisting of prodelta silty clays overlain by layered delta-front silty sands and clayey silts. The rate of delta advance is controlled by the kinds and quantity of material the river is transporting, and depth of water into which the stream is emptying.

While the nearshore subaqueous platform is deposited, the subaerial delta plain is aggrading (building up a surface) by primary deposition occurring along the flanks of the sediment laden stream, forming natural levees (Fig. 3, A-C). Concurrently with levee increase in height upstream from bank overflow, the downstream levees emerge as subaerial features as stream-deposited sediments build seaward.

As progradation continues through the distributary network the delta plain is enlarged (Welder 1959, p. 54-65). Once subaqueous land emerges above gulf level, vegetation inhabits the new land and initiates the formation of organic deposits.

Continued progradation leads to an overextension of the distributary network. Under these conditions stream flow seeks a shorter route to the gulf and initiates the diversion process and construction and locus of a new delta. In the former delta locality subsidence continues and delta deterioration sets in. Wave and current action reworks distributary-mouth bar sands along the former delta margins forming beaches and barrier islands.

River diversions are usually gradual occurrences, and flow at times is shared by major courses, which, on occasion simultaneously form deltaic complexes in different areas. Figure 3 illustrates the sequences of natural levee and marsh development that were repeated in each river course associated with the delta development. The diagrams illustrate the results of aggradational and subsidence processes in the coastal environment.

Recent History of Deltaic Plain

Five major delta complexes where the master stream has flowed in the past or is presently flowing dominate coastal Louisiana from the western margins of Vermilion Bay eastward to and including the Chandeleur Islands (Fig. 4). These delta complexes include the following from oldest to youngest:

Maringouin-Mississippi
Teche-Mississippi
St. Bernard-Mississippi
Lafourche-Mississippi
Plaquemines-Modern Mississippi

These deposits are in varying degrees of deterioration because of subsidence and eustatic sea level changes and are characterized by partially or completely buried levee ridges flanked by marsh and swamp deposits that grade to lakes or bays. They are bordered on their seaward margins by barrier islands, sand and shell beaches, fronting mainland marshlands. Along portions of the coast, little or no beach material has accumulated, and marshlands are exposed to direct wave attack. Frazier (1967) and Gould (1970) summarize knowledge concerning delta complex development and sequences of stream networks that form relatively discrete areas

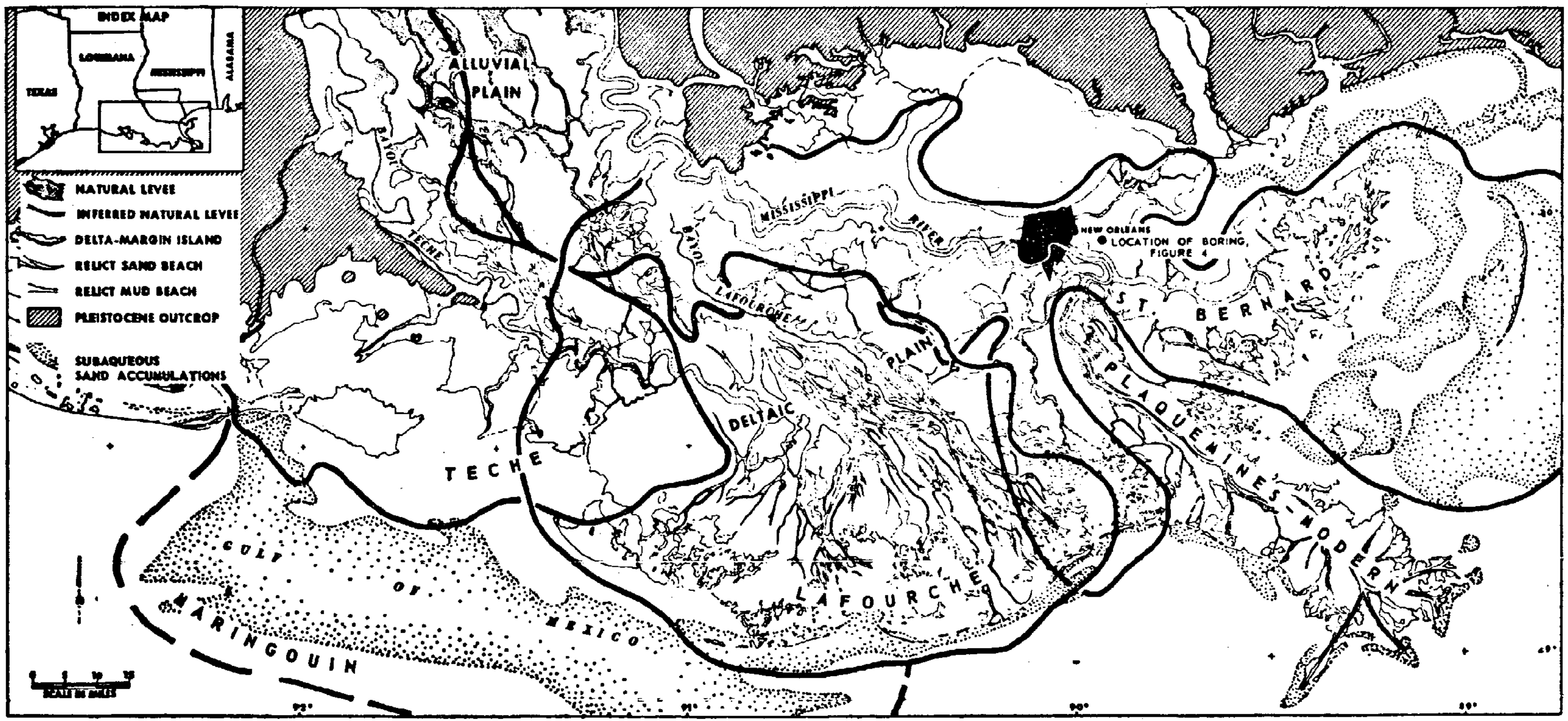

Fig. 4. Delta complexes of the Mississippi Delta Plain (Frazier 1967).

where delta lobes were formed. Figure 4 outlines the delta complex areas of deposition.

The Maringouin complex was functioning at a time when sea level was several feet lower than at present. Coastwise subsidence and sea level rise occurring contemporaneously with more recent sedimentation from adjacent distributaries has buried most of the coastwise elements of this delta complex. The only surface remains of this delta complex are upstream.

Bayou Teche served as the course of the Mississippi River during progradation of the Teche delta complex. Then the river shifted to approximately its present course along the eastern flank of the flood plain during the growth of the St. Bernard complex. Later, Bayou Lafourche received the major flow and the Lafourche delta complex resulted. Presently the river is feeding the Plaquemines-Modern delta complex.

Sixteen delta lobes have been identified among the five delta complexes (Fig. 5). These lobes developed in overlapping sequence as alternate distributary networks received predominant flow from the Mississippi trunk stream at different times. The sequence of delta lobes has been determined by the examination of over 30,000 borings, accompanied by hundreds of radiocarbon dating measurements on delta plain peat samples (Frazier 1967). Archeological evidence, based on the position and age of sites of human habitation, has also played a key role in solving this complex puzzle (McIntire 1958 and 1959; Saucier 1962). Delta lobes named for the major stream courses that formed them and their relative ages are shown in Figure 5. Frazier's (1967) sequence of delta lobe formation and chronology of active phases of stream courses constitute major contributions to study of deltas. He clarified previously conceived notions held by others but never enunciated that "successive delta lobes, each defined by a complete sequence of facies and the age of its delta-plain peat, were not necessarily developed by the same trunk stream, but were in several instances developed by different major courses which were penecontemporaneously (originating at the same time) prograding parts of separate delta complexes."

Nearshore Waters

Relatively shallow water occurs along the Louisiana coast except at the mouth of the Modern Birdfoot Delta (Fig. 1). The 60-ft contour line lies nearly adjacent to the mouths of the passes in the Birdfoot Delta, whereas westward this line extends to almost 50 mi offshore. Tides are diurnal (once daily) and low, averaging 1 to 1 1/2 feet in range. Wind effects on

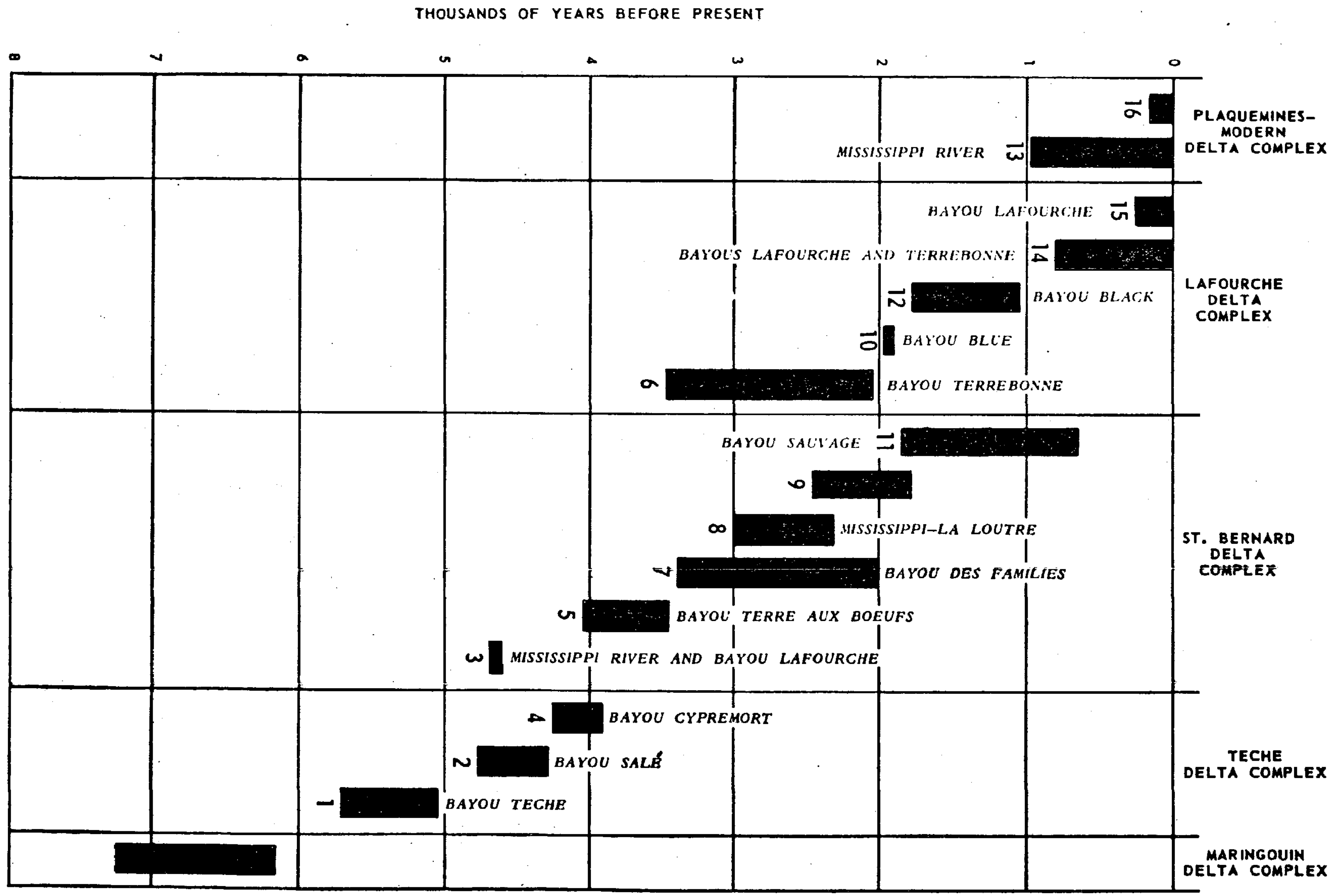

Fig. 5. Age of prominence of each of the 16 delta lobes of the Mississippi Delta Region (Frazier 1967).

water levels often exceed tidal influences. Gently shoaling nearshore bottoms dampen wave attack along most of the coast. Under normal conditions the Birdfoot Delta receives heavier wave attack than the remainder of the coast because of its proximity to deep water.

Littoral (alongshore) currents generally flow westward with the dominant easterly and southeasterly winds but seasonally and locally reverse their flow. Murray (1976) has assembled the present status of information on wind and wave generated nearshore currents. The barrier islands that front much of the Deltaic Plain result from accumulation and transport of sediments by littoral currents.

Salient Physical Features In the Deltaic Plain

Several major natural features that form distinctive environmental units characterize the Deltaic Plain. These include natural levees, estuaries, coastline beaches and barrier islands, and swampland/marshland wetlands.

Natural Levees

Throughout the Deltaic Plain, recently abandoned and relict stream courses and their associated natural levees remain as evidence of deltaic growths, subsidence, eustatic rise, and aggradation. The collective network of natural levees, bifurcating coastwise, form the only high ground for human habitation, roads, and farms. While levees provide high ground for north-south movement, the interlevee depressions are barriers against east-west movement.

All of the levees in the deltaic plain except in the Modern Delta below Venice and in the Atchafalaya Delta are deteriorating, as no natural overbank flooding has been allowed to take place for over a hundred years. The levees forming in the active Mississippi River Delta are lost almost as soon as they are formed owing to the high rate of subsidence and the deep water environment into which they are building. New levees forming in the Atchafalaya Delta should provide an area for inhabitation equivalent to the banks of Bayou Teche in a matter of 25 to 50 years (Gagliano 1975). Levees are broader and higher closer to the trunk stream and become lower and narrower at downstream distal ends. Even areas of natural levees presently above sea level may be marginal for development in a matter of decades.

Estuaries

Estuaries represent inshore water mixing areas that are transitional between marine and terrestrial environments. Estuaries include a great variety of water bodies, related mainly by possession of characteristics intermediate between fresh and marine water. They are noted for rapidly changing and highly variable physico-chemical conditions and high biological productivity. Their importance in the coastal system stems from the fact that approximately one third of coastal Louisiana presently lies in the tidal zone (Gagliano et al. 1970). The Louisiana estuaries (including the two great rivers'mouths) are typically shallow with bars forming at their mouths. This is typical of low-tide/low-energy coasts. Bar-mouth estuaries are usually well-mixed waters with a general absence of well-developed salt wedges or vertical salinity gradients.

Coastline

The coastline of Louisiana is fronted by barrier islands and mainland beaches along areas exposed to the Gulf, with tidal flats and marshes in protected areas behind barriers and estuarine shores. The single most important coastline component is the string of barrier islands, which occupies more than half of the total coastline and which is limited to the central and eastern deltaic area of the coast.

Louisiana barrier islands are multiple in origin and are associated with deltaic development and deterioration. Most of them originated as bay-mouth barriers on the flanks of and against abandoned natural levees and distributary mouth bars of the delta complexes (Kwon 1969). Details of their morphology are largely determined by sediment influx from active streams, erosion of retreating delta fronts, subsidence, and littoral currents (Kwon 1969). A summary chart listing the barrier islands and barrier beaches, their geographic coordinate location, sizes and natural environmental zones is included as Appendix A.

Swamplands and Marshlands

Freshwater swamplands, and fresh, brackish, and saltwater marshlands occupy the wetland basins. Vegetation communities and associated peat accumulations range in composition from coastwise salt marsh types to inland freshwater swamps. Plants are sensitive to water table levels caused by even slight changes in elevation. These changes are schematically indicated in Figure 3, which shows an idealized natural levee and marsh environment. Similarly, a transect from a natural levee to the swamp proper would cross a semiwooded fringe of trees and brush. Deltaic plain marshlands show more subtle differences in vegetation community assemblages than those in the firmer chenier plain. Frazier has identified swamp and marsh vegetation assemblages (Table 1), which characterize macroenvironments in the deltaic and chenier plain.

In the chenier plain peat development occurs between stranded beach ridges and in the flats between the inner ridges and the Pleistocene outcrop. Deltaic Plain peats form in deltaic flank depressions, interdistributary basins, and levee flank depressions (Fig. 6). Figure 6 (Block A and B) graphically shows the complexity and interrelationships of deltaic sequences. Blanket peats have developed over old deltaic surfaces in the Vermilion Bay and Marsh Island area (Coleman 1966). These wetlands generally lack naturally occurring relief features. The construction of canals and water-control structures has resulted in miles of spoil banks, conspicuously marked by vegetation characteristic of high ground. Normal marsh elevations average about 0.6 ft above mean sea level in the deltaic plain, and tides commonly inundate the marshes. The marsh zones based on plant communities are discussed in detail in Barataria Basin: Biological Characterization (Bahr and Hebrard 1976).

Barataria Basin Management Unit

The Barataria Basin Management Unit (Fig. 7) is closed to active river flow except for irrigation waters from Bayou Lafourche and the Mississippi River. Minimal amounts of fresh water enter the basin through the Harvey Canal Locks in New Orleans. Local rainfall provides the main source of fresh water for the basin. During periods of high water in the Mississippi River, and under certain wind and sea conditions, fresh water from the river influences the lower Barataria Basin.

The basin is a delta flank depression approximately 70 mi long with its apex at Donaldsonville. It widens to approximately 30 mi between Belle Pass (Bayou Lafourche) and Red Pass (Mississippi River). The basin forms a natural mixing area for saline and fresh waters and comprises a richly endowed habitat for a diversified flora and fauna.

The physiographic setting for the basin was formed by portions of three deltaic complexes that overlap into the basin. These are from oldest to youngest: St. Bernard (lobes 3, 7, 8 and 9, Figs. 4 and 5); Lafourche (lobes 10 and 15), and Plaquemines (lobe 13) and the Modern (Birdfoot) Delta complex (lobe 16) (Frazier 1967).

Table 1. Characteristic swamp and marsh vegetation (from Frazier and Osanik 1968)*

INLAND FRESHWATER SWAMP
(Trees and Shrubs)

Natural-levee flank

Dwarf palmetto
Sabal minor
Live oak
Quercus virginiana
Overcup oak
Quercus lyrata
Willow Oak
Quercus phellos
Bitter pecan
Carya aquatica
Red maple
Acer drummondi
Green ash
Fraxinus pennsylvanica
var. *lanceolata*
Black willow
Salix nigra
Wax myrtle
Myrica cerifera
Hackberry
Celtis laevigata
Red gum
Liquidambar styraciflua

Central portion

Bald cypress
Taxodium distichum
Tupelo gum
Nyssa aquatica
Sour gum
Nyssa uniflora
Red maple
Acer drummondi
Green ash
Fraxinus pennsylvanica
var. *lanceolata*
Black willow
Salix nigra
Swamp elder
Baccharis halminifolia

Table 1. Continued.

Semi-wooded fringe

Black willow
  Salix nigra
Bald cypress
  Taxodium distichum
Red maple
  Acer drummondi
Green ash
  Fraxinus pennsylvanica
    var. *lanceolata*
Possum haw
  Ilex decidua
Wax myrtle
  Myrica cerifera
Buttonbusy
  Cephalanthus occidentalis

HERBACEOUS VEGETATION

Central portion

Bull tongue
  Sagittaria lancifolia
Arrowhead
  Sagittaria latifolia
Spider lily
  Hymenocaulis occidentalis

Semi-wooded fringe

Bull tongue
  Sagittaria lancifolia
Arrowhead
  Sagittaria latifolia
Water millet
  Zizaniopsis miliacea

STREAM-MOUTH FRESHWATER MARSH

Initial natural levee

Roseau cane
  Phragmites communis
Water millet
  Zizaniopsis miliacea
Cattail
  Typha latifolia

Table 1. Continued.

Stream-mouth mud flat

Fresh three-cornered grass
  Scirpus americanus
Delta duck potato
  Sagittaria platyphylla

Initial interdistributary flood plain

Cattail
  Typha latifolia
Widgeon grass
  Ruppia maritima
Grayduck moss
  Potamogeton foliosus
Dogtooth grass
  Panicum repens
Oyster grass
  Spartina alterniflora

INLAND FRESHWATER MARSH

Chenier plain**

Paille fine or canouche
  Panicum hemitomum
Cattail
  Typha latifolia
Bull tongue
  Sagittaria lancifolia
Saw grass
  Cladium jamaicense
Spike rush
  Eleocharis quadrangulata
  Eleocharis pallustris
  Eleocharis cellulosa
Water millet
  Zizaniopsis miliacea
Roseau cane
  Phragmites communis
Bulrush
  Scirpus californicus

Deltaic plain

Paille fine or canouche
  Panicum hemitomum
Cattail
  Typha latifolia

Table 1. Continued.

Bulrush
Scirpus californicus
Saw grass
Cladium jamaicense
Delta duck potato
Sagittaria platyphylla

BRACKISH MARSH

*Chenier plain***

Saw grass
Cladium jamaicense
Cattail
Typha Angustifolia
Roseau cane
Phragmites communis
Hog cane
Spartina cynosuroides
Spike rush
Eleocharis palustris
Water millet
Zizaniopsis miliacea

Deltaic plain

Three-cornered grass
Scirpus olneyi
Paille fine or canouche
Panicum hemitomum
Wire grass
Spartina patens
Cattail
Typha latifolia
Typha angustifolia
Arrowhead
Sagittaria latifolia

SALINE MARSH

*Chenier plain***

Coco or leafy three-cornered grass
Scirpus robustus
Wire grass
Spartina patens
Salt marsh grass
Distichlis spicata
Clump grass
Spartina spartinae

Table 1. Continued.

Deltaic plain

Wire grass
  Spartina patens
Oyster grass
  Spartina alterniflora
Black rush
  Juncus roemerianus
Salt marsh grass
  Distichlis spicata
Saltwort
  Batis maritima
Glasswort
  Salicornia perrenis
  Salicornia europea
Sand rush
  Fimbristylis castanea

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*After O'Neil 1949, Penfound and Hathaway 1938, Hall and Penfound 1911, Gould and Morgan 1962.

**The chenier-plain marshes are slightly firmer than the deltaic-plain marshes.

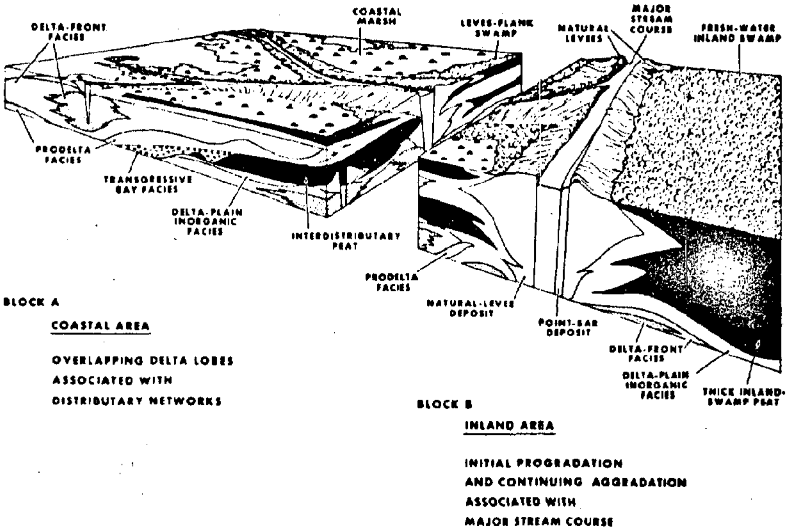


Fig. 6. Deltaic Plain sedimentary sequences of coastal and inland areas are depicted by major depositional environments in a typical delta complex (Frazier 1967).

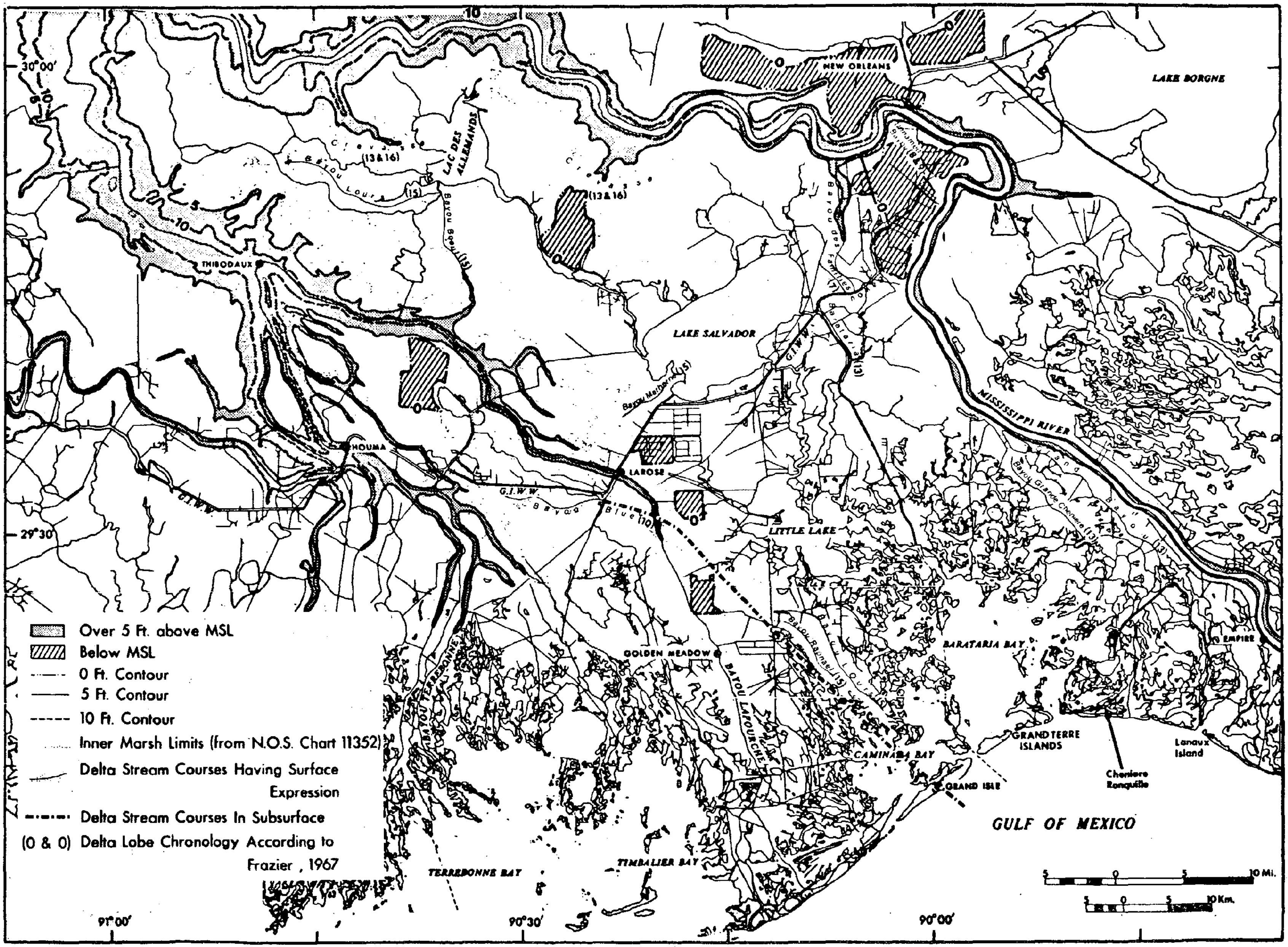


Fig. 7. The Barataria Basin Management Unit (map base after Gagliano 1970).

The St. Bernard Delta Complex is represented by portions of four lobes (3, 7, 8 and 9). The earliest (3) underlies the head of Barataria Basin and the present Mississippi River system eastward. The broad delta lobe (7, Bayou des Familles) extending southward from New Orleans formed approximately 3,500 to 2,500 years ago. Bayou des Familles, which received a large portion of the Mississippi River discharge during its heyday, was the main distributary of this delta (7). Lobes 8 and 9 overlapped Bayou Terre aux Boeufs in the St. Bernard Delta Complex but extended into the Barataria Basin via Unnamed Bayou northwest of English Turn.

After abandonment of the Bayou des Familles distributary network and subsidence of the associated delta lobe, the second Lafourche Delta Complex sequence (10), represented by the lobe that formed Bayou Blue, prograded over its drowned distal margin. Lobe 10 derives from the predominance of Bayou Blue as a major distributary of the Mississippi River during a relatively short period beginning around 2000 years B.P., according to radiocarbon estimates of its earliest peat deposits (Frazier 1967). This lobe extended into the Barataria Basin immediately east of present-day Bayou Lafourche, and, as it began subsiding, transgressive (encroaching) bay sediments accumulated on top of the peat and carbonaceous sediments. Grand Isle formed at the edge of the lobe during this transgression.

Rangia cuneata shells incorporated in the bay facies, which was deposited in the depression between the Bayou des Familles delta plain and the Unnamed Bayou course of the Mississippi River, were dated at 1,400 years before present. Shortly after deposition of these bay sediments, another deltaic progradation occurred when Bayou Barataria, a distributary of the Mississippi River, reoccupied the abandoned Bayou des Familles course (lobe 13). Deposition of clay and silt from floodwaters built up the old Bayou des Familles delta plain. The silt and clay flushed into Barataria Bay raised shallow portions of the bay floor until vegetation could again take hold. Peats on the Barataria delta plain (13) began forming approximately 700 years ago and are still accumulating. In addition to Bayou Barataria (13), river sediments were deposited in the basin through crevasses off the Mississippi River (lobes 13 and 16), and through numerous bayous in Plaquemines Parish such as Bayou Grand Cheniere (13) and Grand Bayou (13).

The Lafourche delta complex continued to develop, nearly filling the basin between Bayou Lafourche and the Mississippi River. As this lobe prograded it partially filled a large moderately brackish lake. An unfilled portion of this lake is now known as Lac des Allemands. Samples of sediment taken from the lake floor contain exclusively fresh to slightly brackish water ostracods. Bayous Boeuf, L'Ours, Matherne, Raphael, Portuguese, and the West Fork of L'Ours were active streams during the final lobe (15) of Lafourche Delta Complex. Bayou Lafourche was artificially dammed in 1904. Subsidence is again allowing transgression and Barataria Bay is enlarging as the organic deposits are eroded. Coastal retreat was occurring rapidly at Grand Isle until groins were constructed. Groins have temporarily retarded coastal erosion at Grand Isle but erosion along adjacent coasts appears to be accelerating. The Modern Delta Complex constitutes the current lobe (16), and, as in the past, the Mississippi River is forming a contemporaneous delta in the Atchafalaya Bay.

The above discussion on the deltaic complexes that have formed the Barataria Basin is presented to illustrate the dynamic behavior and intricacy of streams and related deposits that have overlapped, interlaced, and intercalated within the basin through time. With sea level rise, marine sediments along the Gulf front accumulated and formed sand bodies such as the barrier islands. The deltaic history has resulted in a highly variable and complex surface based on unstable, highly diverse substrates (Fig. 6). Barataria Basin is a delta flank depression between the latest Lafourche and Mississippi River delta complexes. Within the basin, levee-flank depressions have formed between natural levees of adjacent or bifurcating stream courses. Subsidence has continued at relative rates that generally increase seaward but vary a great deal locally. The heavier sands and silts that form the natural levees and beaches compact or dewater underlying clays and organic deposits more rapidly than sections of clays and organics which are not surface loaded. Clays also have a tendency to flow either laterally or upward along lines of least resistance when loaded by heavier material.

These processes, coupled with world-wide sea level rise, have produced a highly complex and variable substrate that varies in its response to erosion processes. Clays resist erosion when wet but are easily eroded after drying. Uncemented sands and silts erode rapidly. Some highly fibrous plant root systems bind the upper substrate, and thus resist erosion under permanently wetted conditions. Peats formed by fibrous and deeply rooted plants retard erosion. Other plants and plant communities lack deep root characteristics and the peat deposits formed by them are fine grained, homogeneous materials that erode easily when attacked by waves and currents.

In addition to substrate characteristics, subsidence, and eustatic changes, vegetative and surface physical processes affect stability of marsh surfaces. Plant die-back, marshland drowning by storm-driven salt waters, flooding by higher-than-normal tides, and drainage below normal low waters affect vegetation growth and propagation. Winter freezes frequently kill the Black Mangrove, which otherwise forms a protective zone around the coastwise marshland shores.

It remains then that marsh land deterioration, which is rapidly occurring in areas not receiving river-borne sediments, is a highly complex and variable process.

MAJOR DELTAIC FACIES

The complexity of Barataria Basin is evident from the general geologic history of its development. Responses to stresses within the water bodies and environmental units are directly related to the complex wetland surface and substrate. A two-dimensional longitudinal section (Frazier 1967) extending from Lake Pontchartrain through the middle of the basin to Grand Isle (Figs. 8 D-D' and 9) reveals the location and complexity of sedimentary deposits that underly the surface. Figure 9 displays two cross-sectional drawings of section D-D' of Figure 8, one of which depicts delta lobe relationships and the other facies relationships.

The Pleistocene boundary (Fig. 9) lies about 40 ft below the surface in the vicinity of New Orleans. From that depth it has been downwarped to approximately 500 ft beneath Grand Isle. In the section showing delta lobe relationships, former deltaic sequences of offlapping, overlapping, and onlapping sedimentary deposits are indicated (Fig. 9). The oldest lie at the bottom of the section and the youngest at the surface. In the facies relationship section, progradational (seaward building) and aggradational (upward building) facies illustrate depositional facies that construct the deltaic plain. These deposits range from relatively thick sections of peat to prodelta silty clays. The peat sections are evidence that in general plant growth and organic accumulation kept pace with relative rise of sea level during the past few thousand years. Gulfwise, transgressive (advance of the sea against the coastline) sedimentary

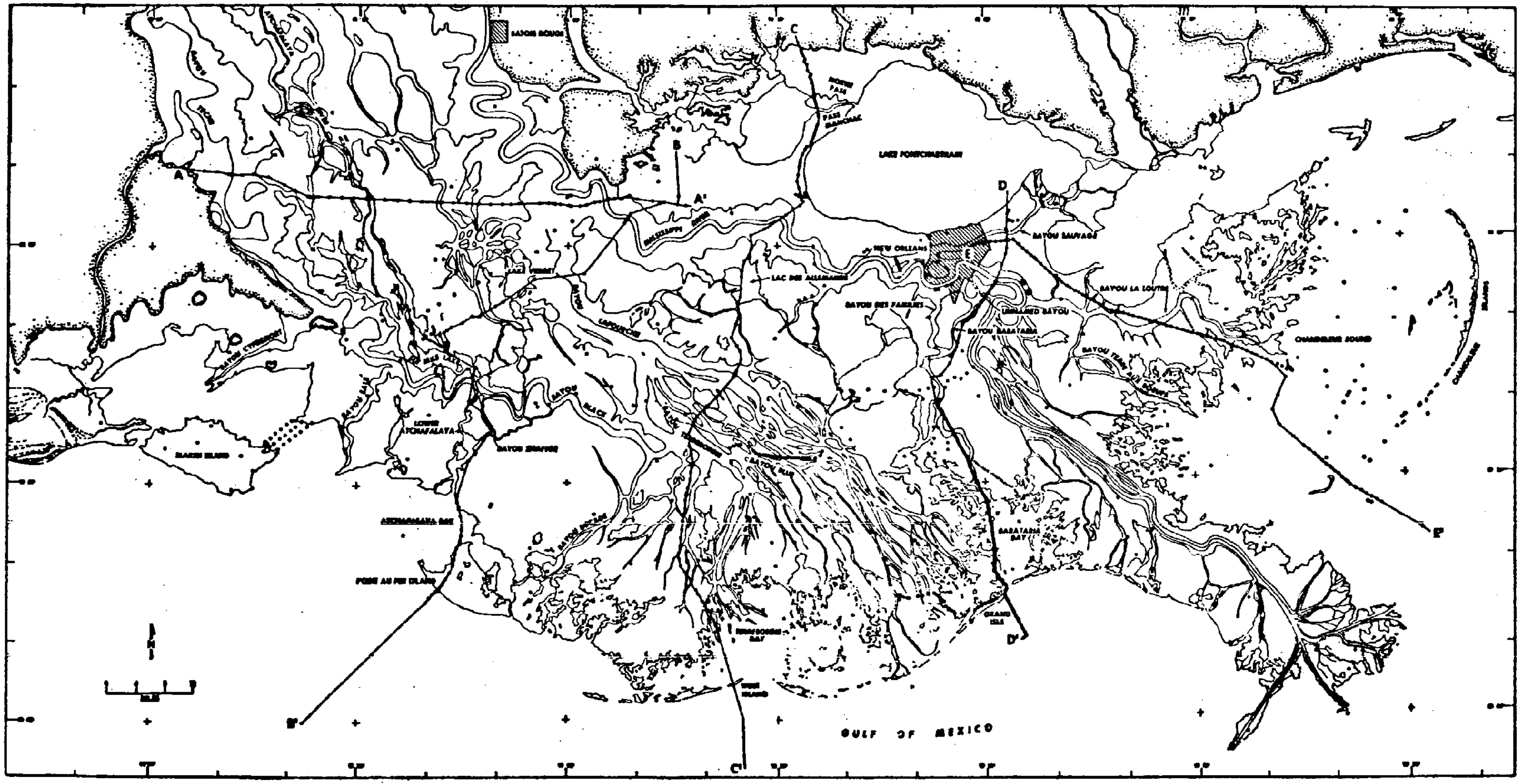


Fig. 8. Location of D-D' cross-section depicted in Fig. 9 and principal control borings (after Frazier 1967) in the Barataria Basin.

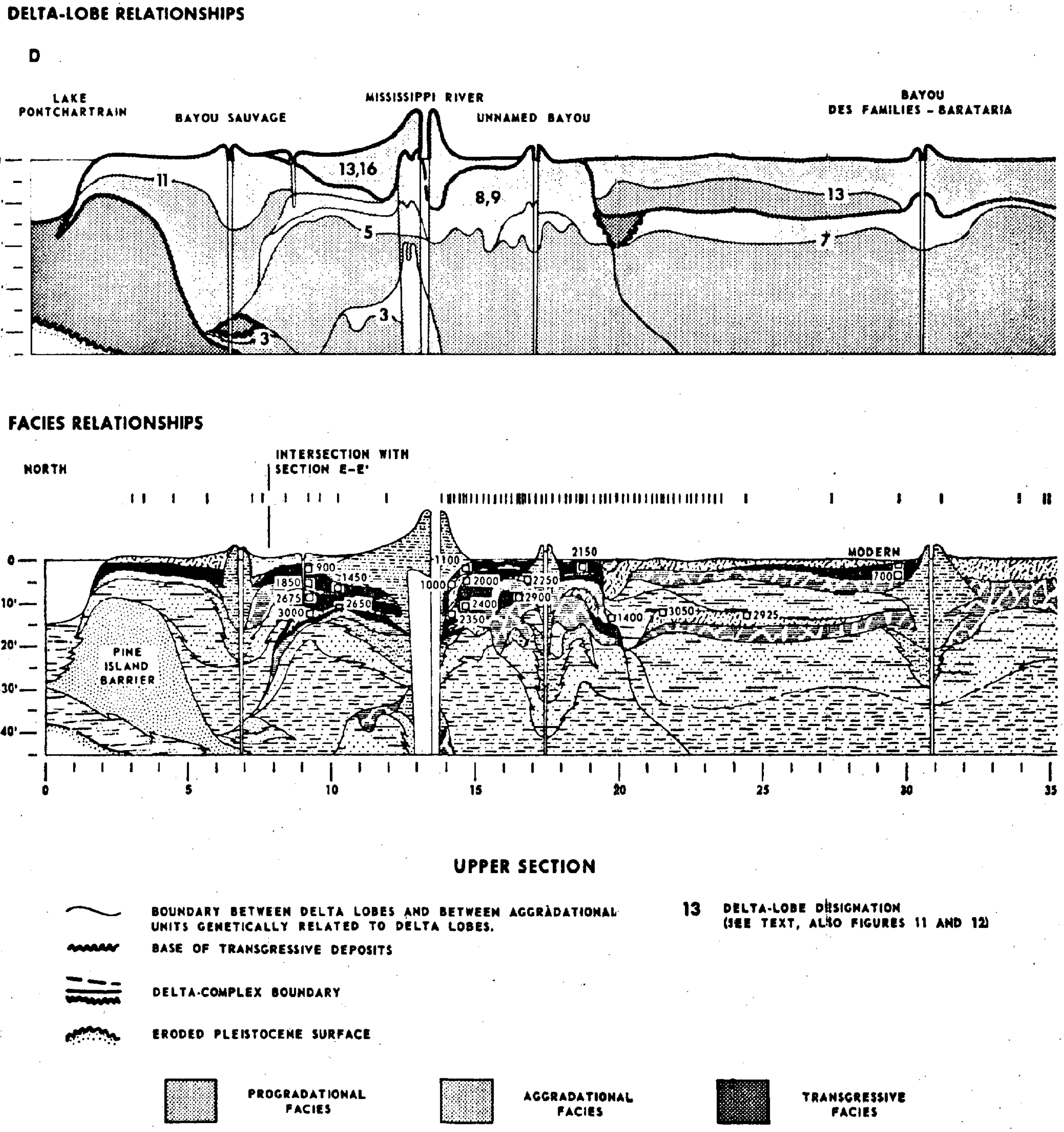
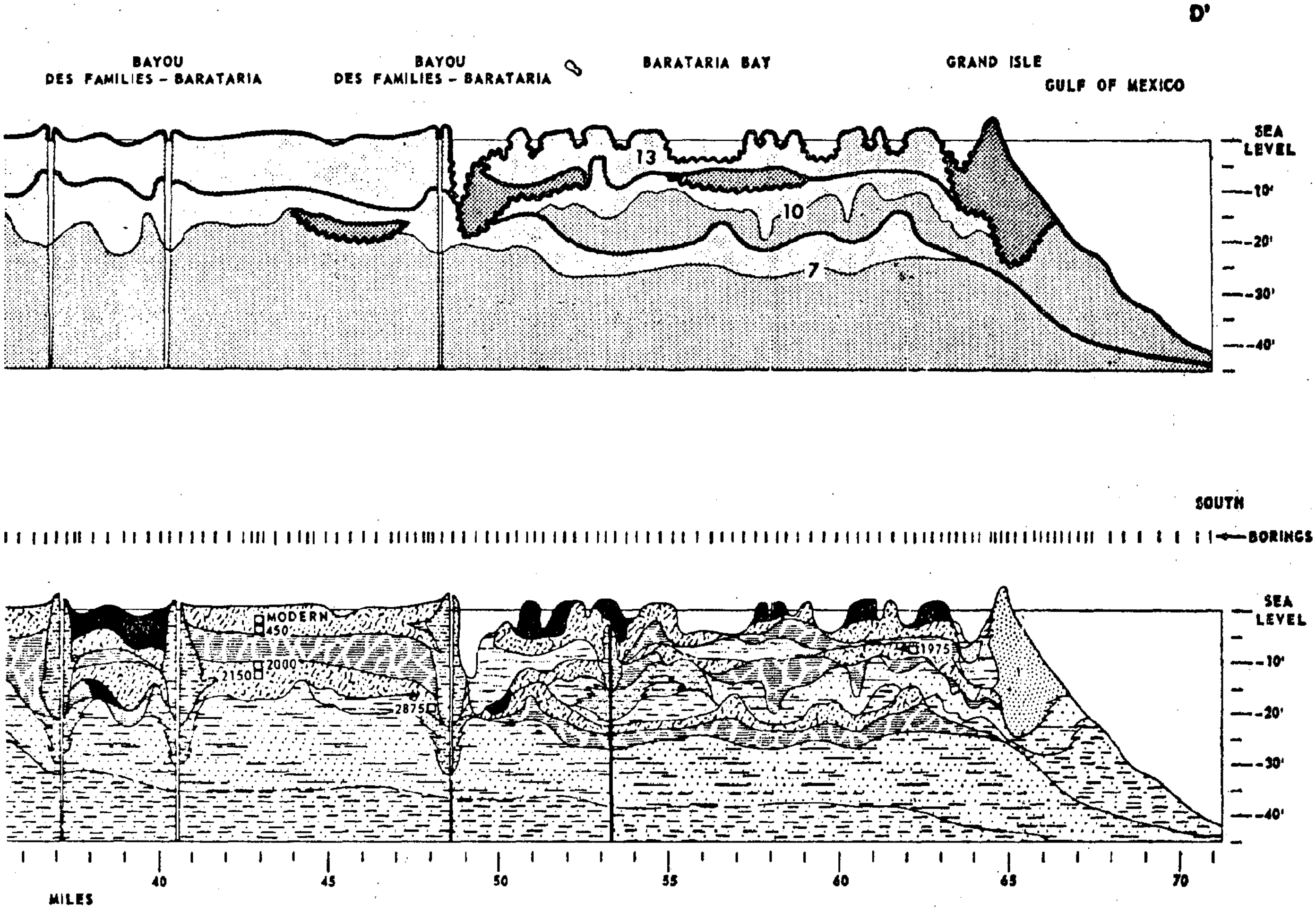


Fig. 9 (in two sections). Cross-section D-D' (from Frazier 1967) showing delta-lobe and sedimentary facies relationships through the Barataria Basin. Basin location of the section shown on Fig. 8.



LOWER SECTION

TRANSGRESSIVE FACIES
- ▨ BARRIER, TIDAL-DELTA, OR STRANDLINE SAND
- ▤ BAY SILT, CLAY, & SHELL

AGGRADATIONAL FACIES
- ■ PEAT
- ▨ CLAYEY PEAT, PEATY CLAY, ORGANIC MUCK
- ▨ INORGANIC CLAY
- ▤ NATURAL-LEVEE SILTY CLAY
- CHANNEL FILL
- POINT BAR

PROGRADATIONAL FACIES
- ▨ DISTRIBUTARY-MOUTH-BAR SILTY SAND
- ▤ DELTA-FRONT SILTY SAND & SILTY CLAY
- ▤ PRODELTA SILTY CLAY

| I I | LOCATION OF BORINGS
□ 2600 RADIOCARBON AGE YEARS BEFORE PRESENT
WEATHERED & ERODED PLEISTOCENE SURFACE

VERTICAL EXAGGERATION: x800

facies represent sediments that were reworked by waves and currents during the relative rise of sea level to its present position. Grand Isle and other barrier islands eastward are surface features of the transgressive deposits.

Between the western boundary of the basin and Grand Isle are a number of tributaries off Bayou Lafourche that formerly flowed into the basin (Gould 1970, Fig. 10). Bayou Fer Blanc and Bayou Moreau are shown on the cross and longitudinal sections (Fig. 10, A, B). Natural levee silts and sands and marsh deposits represent progradational and aggradational facies in the western section of the lower basin (Fig. 10, Section A-A'). In the vicinity of lower Bayou Moreau (Section B-B') a series of accretionary beach ridges dominate the surface. These ridges represent reworked deposits of delta front sands.

On the east side of the basin, distributary streams off the Mississippi River flowed into the basin as the Plaquemines Delta lengthened seaward (Fisk 1955, Fig. 11). Cheniere Ronquille (Fig. 7), represents, in part a relict beach ridge that underlies the distributaries off the Plaquemines Delta complex (Welder 1959).

Crevasse deposits form a nearly continuous apron of aggradational facies advancing into the basin around its upper periphery from the Mississippi River and Bayou Lafourche. Crevassing is an important aggradational process in delta construction; the associated fan deposits are significantly evident from both Bayou Lafourche and the Mississippi River.

Barataria Bay, Lake Salvador, Lac des Allemands, and connecting water bodies form the major water links for water exchange between the gulf and the inner basin. The water bodies form significant reservoirs for nutrient accumulation and chemical change, and serve as conduits for water and nutrient exchange. Characteristics of the hydrology and climatology for the basin are covered in a companion volume (Byrne et al. 1976). Wave characteristics (Suhayda 1976) along the Barataria Basin coast are included in the above report. Littoral currents that fashion the Louisiana coastline are described by Murray (1976).

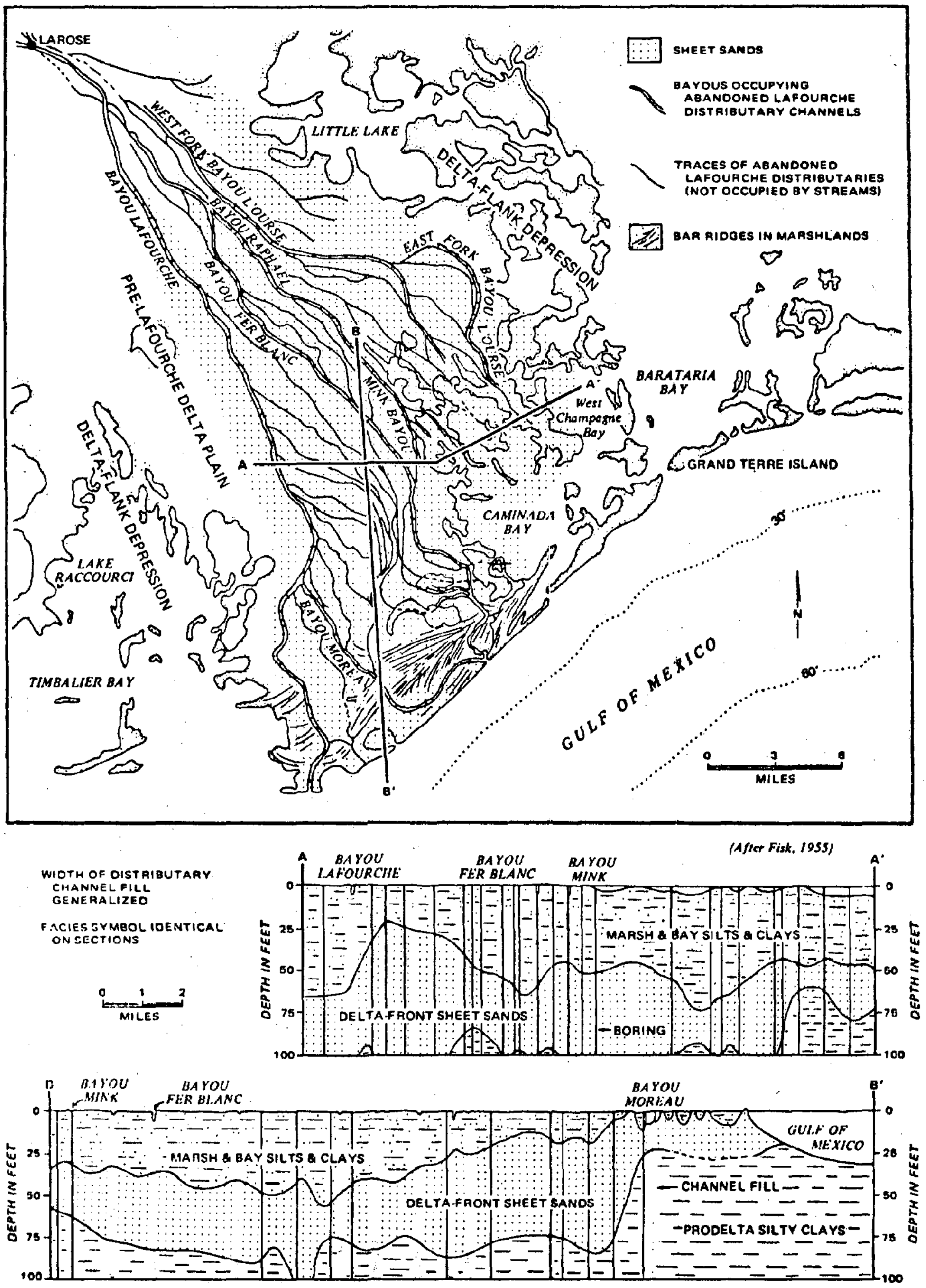


Fig. 10. Bayou Lafourche stream systems and east-west trending beach ridges that dominate the southwestern corner of the basin. Cross-sections A-A' and B-B' show major sedimentary sequences underlying this basin section (after Gould 1970; Fisk 1955).

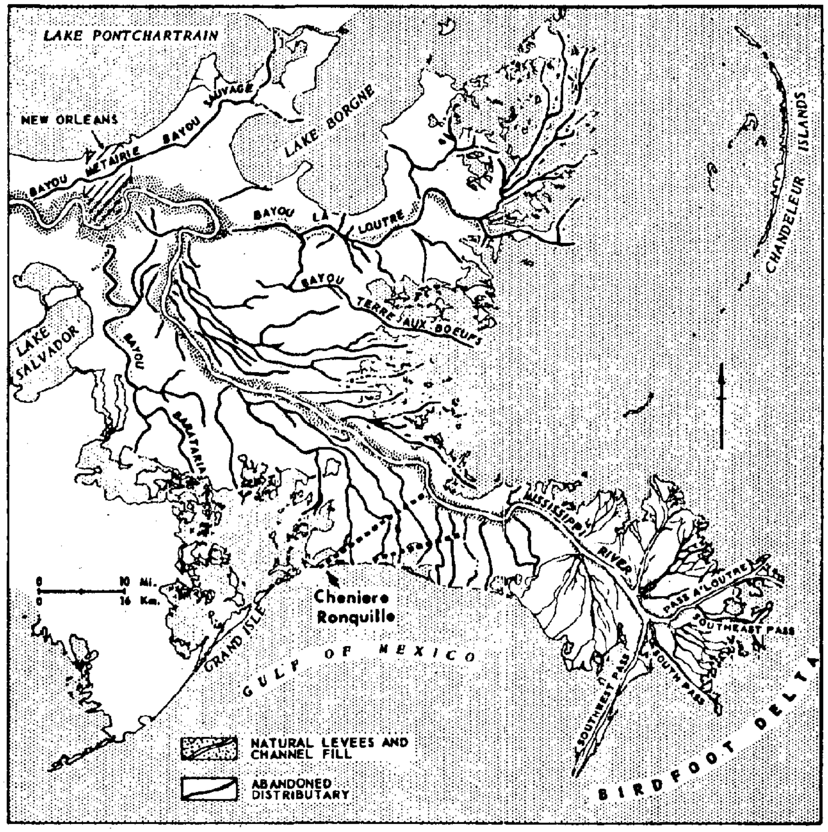


Fig. 11. Reconstructed positions of distributaries abandoned during lengthening of the Mississippi River, southeast of New Orleans, La. (after Fisk 1955). The dashed lines indicate the approximate position of old beach ridges that have been essentially buried by later Plaquemines Delta distributaries (Welder 1959).

Documentation of Land Loss

Land loss in the Barataria Basin is attributed principally to natural processes associated with a deteriorating delta mass and further complicated by man's activities during settlement of the area. Artificial flood control levees were constructed along the Mississippi River and Bayou Lafourche, and in 1904 Bayou Lafourche was artificially dammed. These practices cut off virtually all of the river-borne sediments into the basin that were critically needed for basin maintenance. Subsequently, stresses on the environment have followed a chain of events associated with more intense utilization of the wetland proper and encroachment from industry, agriculture, and urban spread. Land loss has directly resulted from (1) removal of marsh through dredging and filling operations, (2) secondary effects of boat wake erosion and habitat deterioration by salinity intrusion into brackish and fresh waters, and (3) interruption of overmarsh flow. While it is impossible to assign values to all of these components, some quantification is possible to show historical trends of land loss and obtain some insights into possible causes. It is necessary to understand impacts from the various uses in order to effectively formulate management practices that allow for multiple use of wetland resources with minimal impact.

This documentation of land loss includes: an environmental inventory; dredge and fill characterization; coastal retreat and inlet changes, with a Grand Terre Islands case history study; and marsh deterioration. Except coastal retreat and inlets the above categories are treated by environmental unit and parish. Coupled with results of how the basin functions hydrologically and climatologically (Byrne et al. 1976) and biologically (Bahr and Hebrard 1976), this information provides background information on which to formulate and base management options. Salinity intrusion (Van Sickle et al. 1976) from the Gulf and eutrophic water conditions encroaching from the basin and periphery (Craig and Day 1976) provide an example of cumulative effects and stresses affecting the basin.

Environmental Inventory.—Before land loss rates can be evaluated an inventory of land and water environments as they presently exist is desirable. However, the only maps that cover the entire coastal zone are the US Geological Survey (USGS) quadrangles, which extend from 1952 to 1967. While 10 year-old information is not an ideal base to measure environmental units and land/water changes, the quadrangle sheets are presently the best available. A description of the methodology is provided in Appendix B.

Based on these maps the environmental unit inventory for land and water surfaces (Fig. 12) for the basin is presented in Table 2. The environmental unit breakdown for each parish is included in Appendix B, Table B.1. The intermediate marsh category as presented by Chabreck (1970) is included with brackish marsh figures. Our land loss data and biological inventories indicate that intermediate marsh is not a distinct enough entity for formulation of separate management considerations.

Table 2. Environmental Inventory--Barataria Basin Management Unit

	Square Miles	Acres
Total Area	2,427.1	1,553,344.0
Total Water Area	621.2	397,568.0
Total Saline Marsh Area	247.0	158,080.0
Total Brackish Marsh Area*	359.1	229,824.0
(Total Intermediate Marsh Area)	(92.4)	(59,136.0)
Total Fresh Marsh Area	349.2	223,488.0
Total Fresh Water Swamp Area	378.2	242,048.0
Total Topographic High Areas	472.4	302,336.0

*Includes intermediate marsh

<u>Dredge and Fill Activities</u>.--Calculations were made of the total land loss in the Barataria Basin resulting from dredge and fill operations. These include canals, embankments, and drainage projects within Barataria Basin. Computations were made by environmental unit for the entire basin and by the parish portion in the basin.

Dredge and fill features were classified according to their function (Appendix C) and digitized. US Army Corps of Engineers uncontrolled photomosaics (1970) mainly were used for the basin. Where coverage was not complete the latest edition of the USGS quadrangle sheets were used. The resolution for canals and impoundments includes all features that are depicted on standard 7 1/2 minute quadrangle sheets. This means that there exists a large number of small canals that are not included and places the resultant figures on the conservative side. Large urban areas were also not included

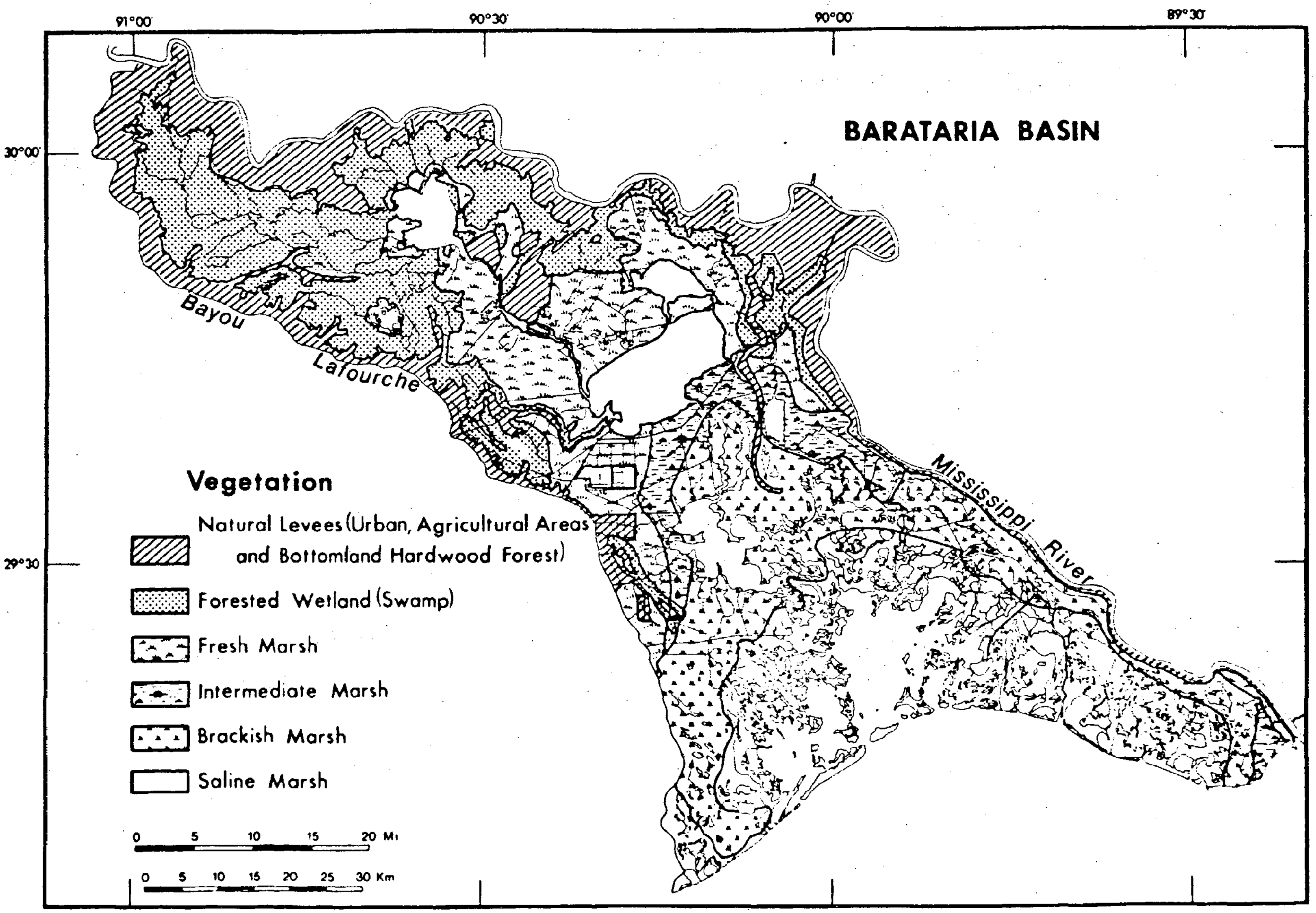


Fig. 12. Vegetation environmental units are depicted. The discussion in the text includes ate marshes with the brackish category (after Palmisano 1970; and Chabreck 1972).

in the results because the entire area of settlement is impacted, and it is impossible to assign these fast lands to any of the existing environmental units. It remains then that the focus was on canals and impoundments within the basin wetlands up to 1970.

Results for the entire basin by canal and impoundment activity type are listed in Table 3. The total land loss in the basin for dredge and impoundment activities up to 1970 amounted to some 44,800 acres.

Table 3. Inventory of Dredge and Fill Activity by Environmental Unit for the Barataria Basin.

	Environmental Unit (in square miles)				
	Saline	Brackish	Fresh	Swamp	Total
Rig Access Canals	5.29	11.68	5.20	1.08	23.24
Pipeline Canals	2.52	1.71	.63	0.20	5.07
Oil Field Navigation Canals	0.02	0.19	0.19	0.0	0.40
Navigation Canals	0.86	1.98	0.50	1.18	4.52
Transportation Embankments	0.0	0.43	0.51	0.48	1.42
Agr. Drainage Canals	0.0	0.91	0.82	0.98	2.71
Agr. Impoundments	0.0	3.55	21.39	6.07	31.01
Industrial Impoundments	0.05	0.0	0.0	0.07	0.13
Urban Drainage Canals	0.0	0.39	0.11	0.07	0.56
Agr. Commodity Transportation Canals	0.0	0.03	0.0	0.02	0.04
Oil Field Embankments	0.0	0.0	0.0	0.22	0.22
Mineral Extraction Navigation Canals	0.61	0.0	0.0	0.0	0.62
Other	0.03	0.0	0.0	0.0	0.03
Total for Environmental Unit	9.38	20.87	29.35	10.37	69.97

(1 sq. mile = 640 acres)

The breakdown by canal type and environmental unit was calculated for each parish and included in Appendix C. Summary figures by parish and environmental unit are included on Figures 13-16. Utilization of four

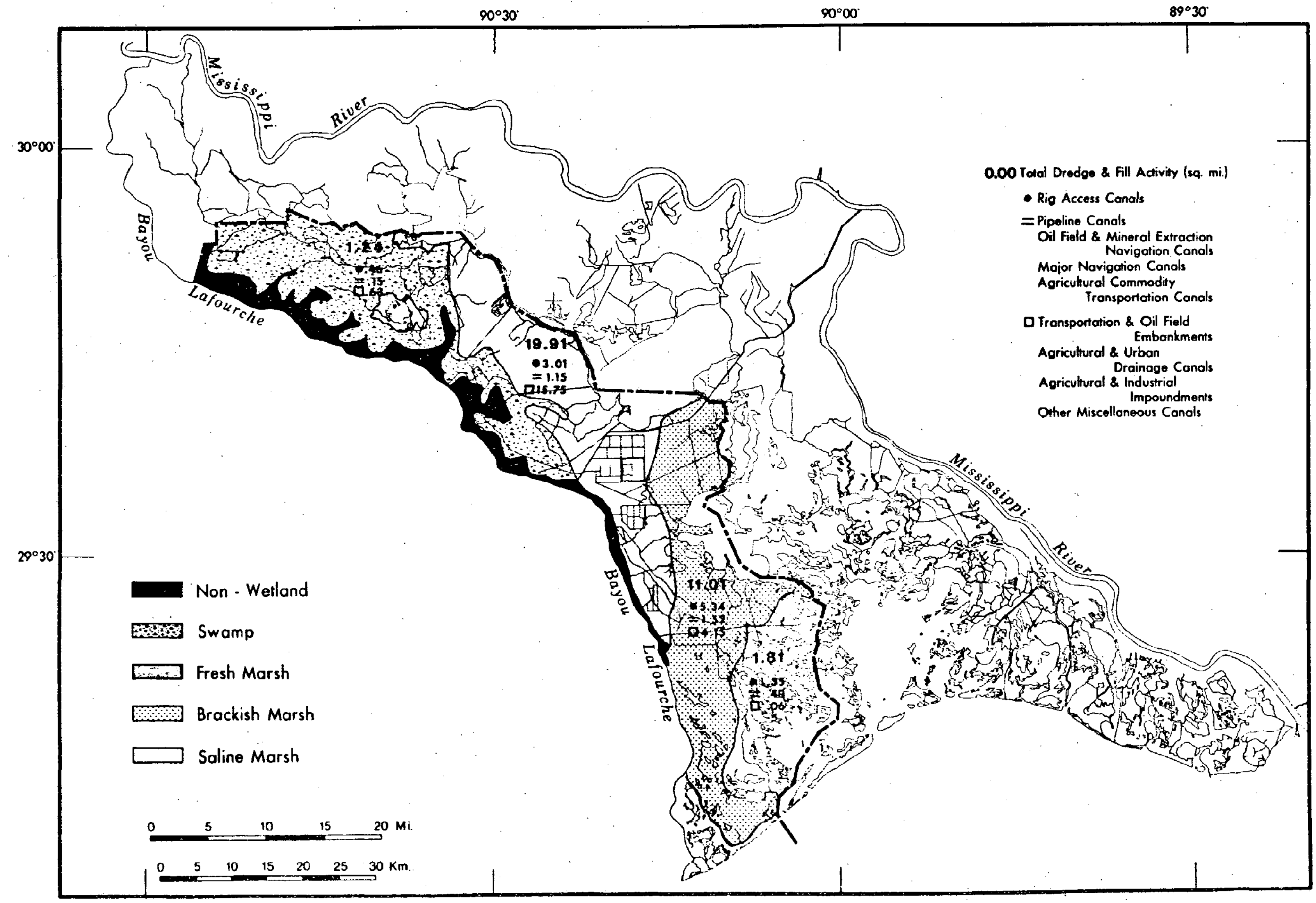


Fig. 13. Dredge and fill computations by environmental unit for portions of Lafourche Parish within the Barataria Basin.

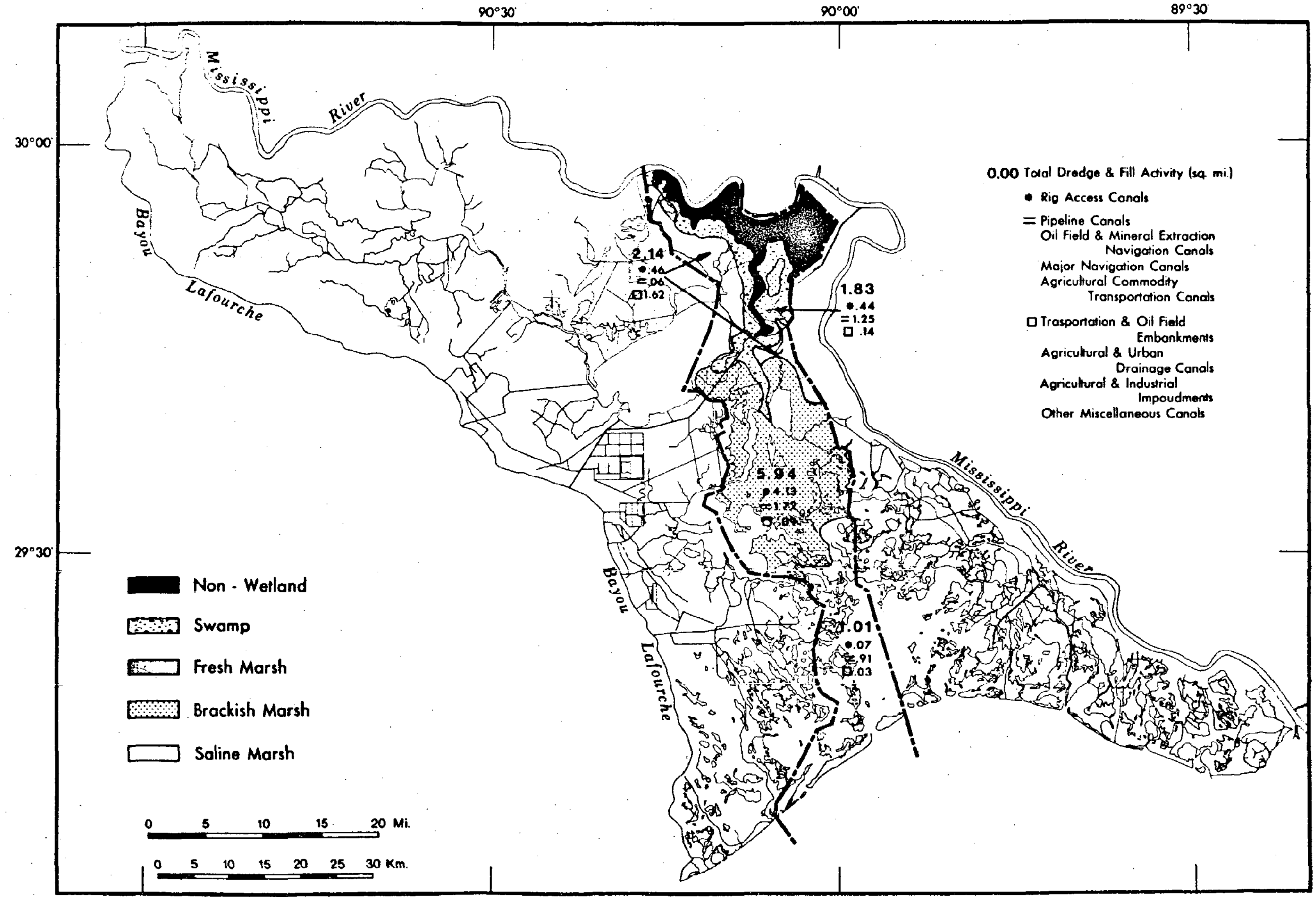


Fig. 14. Dredge and fill computations by environmental unit for Jefferson Parish.

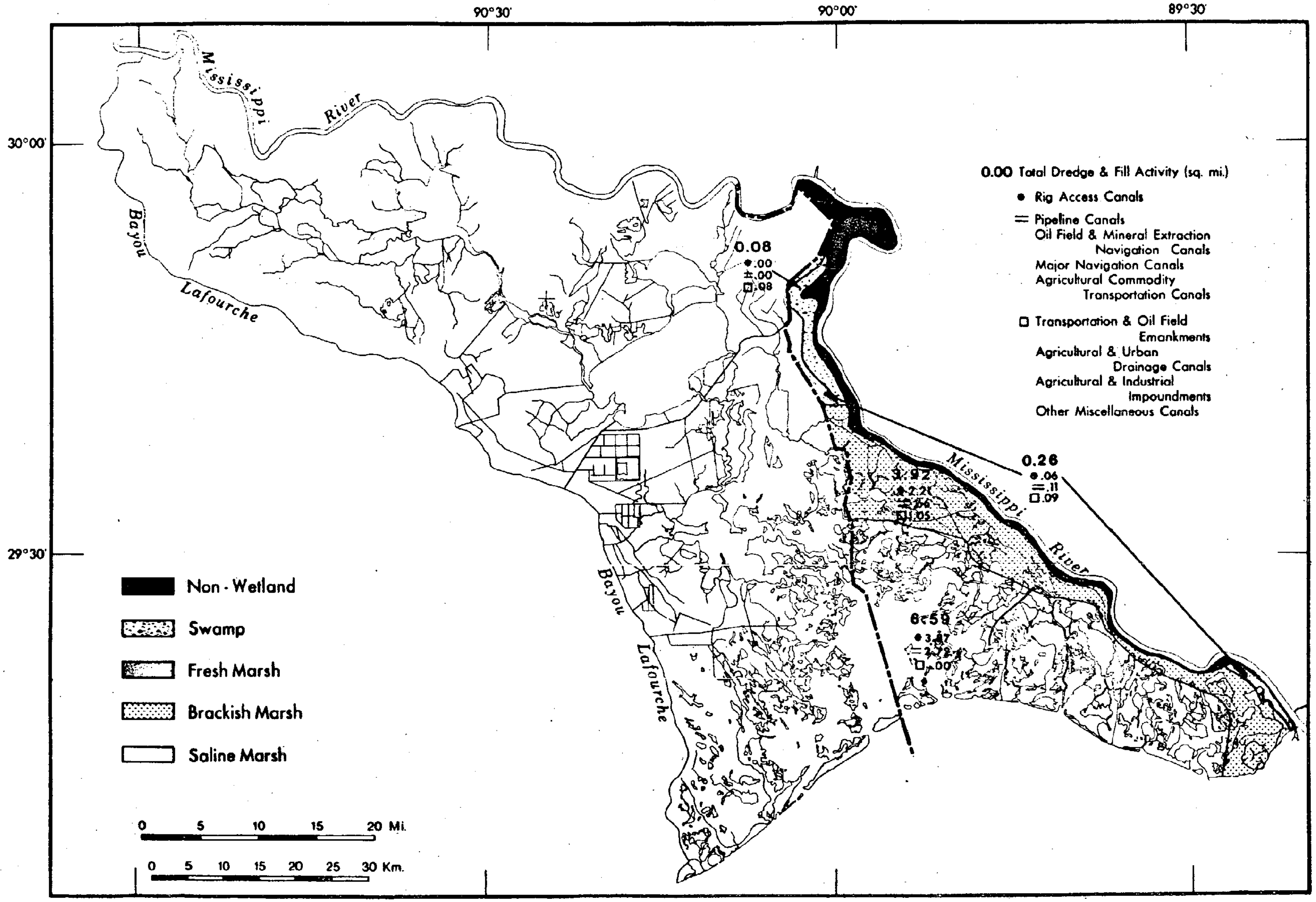


Fig. 15. Dredge and fill computations by environmental unit for Plaquemines Parish.

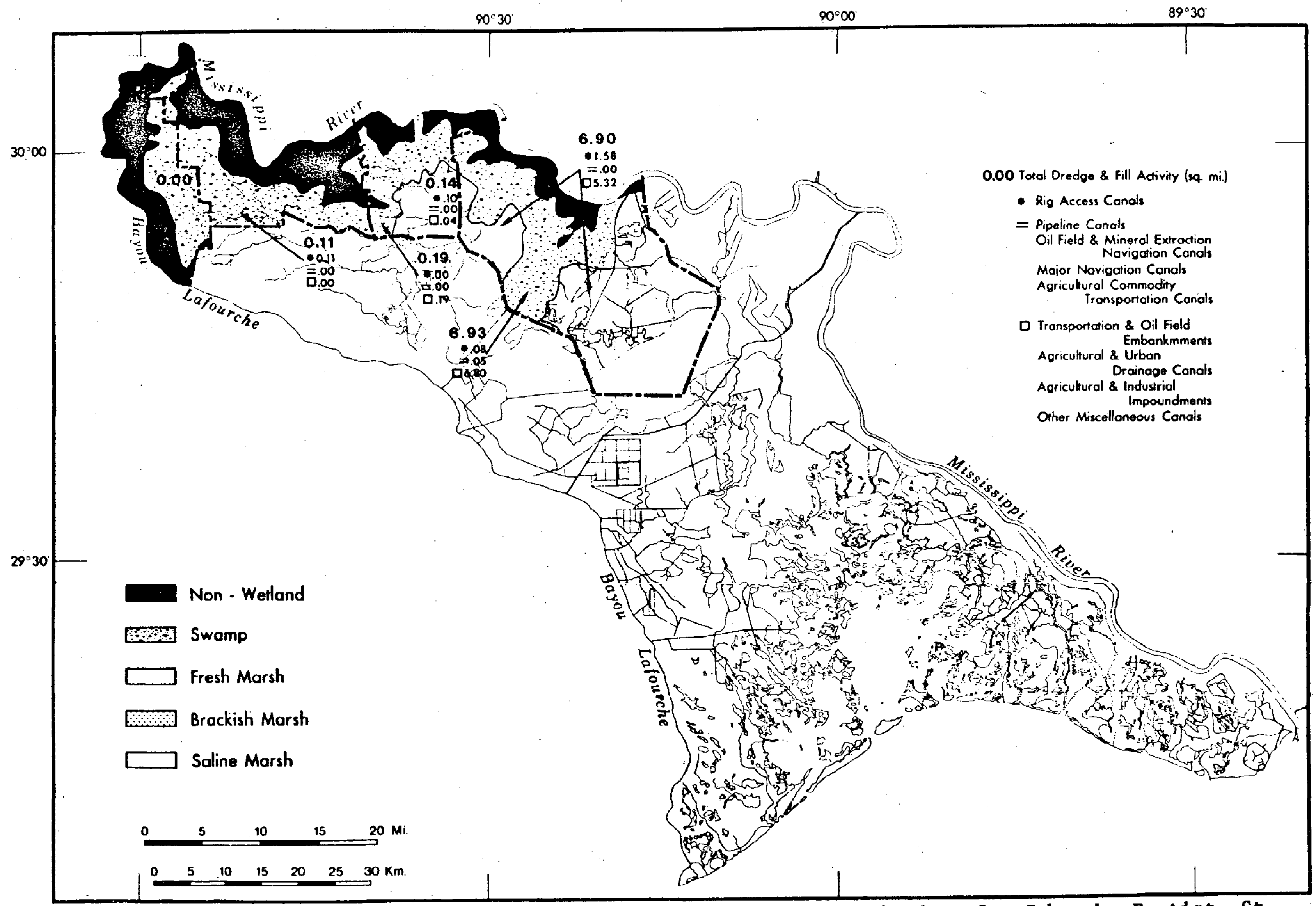


Fig. 16. Dredge and fill computations by environmental unit for St. Charles, St. John the Baptist, St. James, and Assumption parishes.

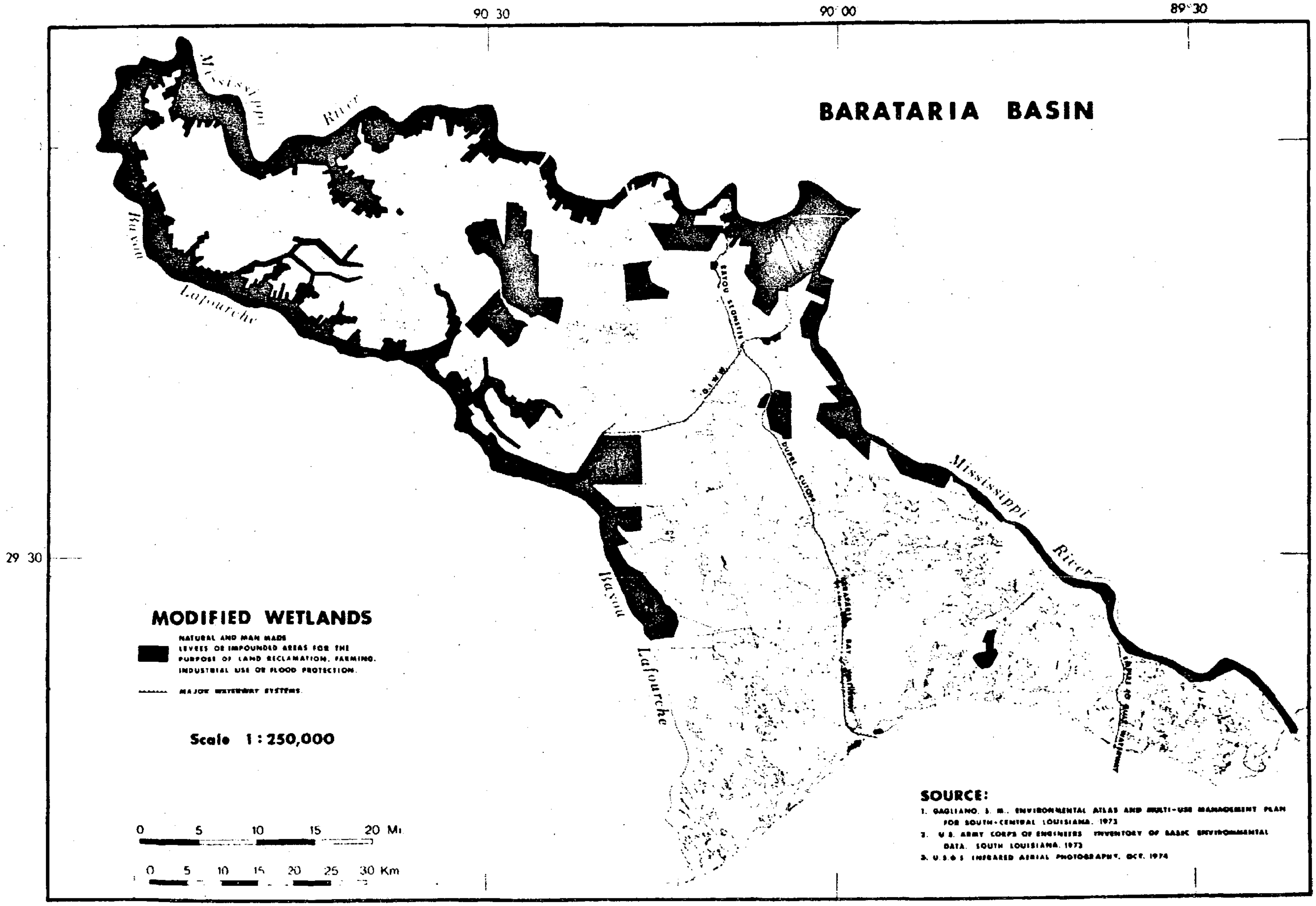
Figures rather than one for this display was for clarity in presenting information at the parish level. Total figures for dredge and impoundment activity in square miles with breakdown computations of major groupings of activity are included on the illustrations. In Lafourche and St. Charles parishes the fresh marsh is the most severely impacted by man's activity.

In general, the category including agricultural impoundments basin-wide is responsible for the majority of this impact. Figure 17 shows how land reclamation projects initiated in the period between 1860 and 1920 dominate this area. Values for this feature represent total area impounded as this marsh surface is taken out of the food web of the natural system. In calculating impacts that would occur if artificial levees were abandoned and breached to reestablish normal circulation to the basin, the spoil banks and canals were considered. In these cases formerly impounded marsh or resulting pond were returned back into the food web system. In the brackish (including intermediate marsh as mapped by Chabreck et al. 1968) and saline marshes intensive dredging for rig access canals contribute the greatest percentage of the total dredging impact. Pipeline and navigation canals also represent a considerable percentage of the total.

Pipeline and transportation canals show relatively low values in area compared to other categories. However, they produce maximum impact. If not properly planned they interrupt the natural drainage system and directly introduce salt or fresh waters into differing habitats.

Rig access canals serving oil fields have proliferated during the last several decades (Fig. 18), reducing the marsh surface area by impoundment activity. Figure 18 depicts the general area of major oil fields and shows connecting navigation and pipeline canals that transcend environmental units and, in some cases, the entire basin.

Coastal Retreat and Inlet Changes.--Coastal erosion along the front of the entire basin constitutes an additional land loss problem, resulting from a lack of river-borne sediments reaching this section of the coast. The erosion problem is tied to both natural and man-made processes. Suhayda (1976) and Murray (1976) have shown the natural processes associated with wave and nearshore current patterns respectively along the seaward margin of Barataria Basin. Severance of river-borne sediments into the basin was pointed out earlier in this paper. Improper placement of pipelines parallel to the strandline has resulted in accelerated coastal erosion in some localities. Groins placed along coasts



SOURCE:
1. GAGLIANO, S. M., ENVIRONMENTAL ATLAS AND MULTI-USE MANAGEMENT PLAN FOR SOUTH-CENTRAL LOUISIANA, 1973
2. U.S. ARMY CORPS OF ENGINEERS INVENTORY OF BASIC ENVIRONMENTAL DATA, SOUTH LOUISIANA, 1973
3. U.S.G.S. INFRARED AERIAL PHOTOGRAPHY, OCT. 1974

Fig. 17. Map showing modified natural levee and wetland areas that have been cleared, drained, and impounded for agriculture, commercial, or urbanization purposes (information partially from Burke and Associates).

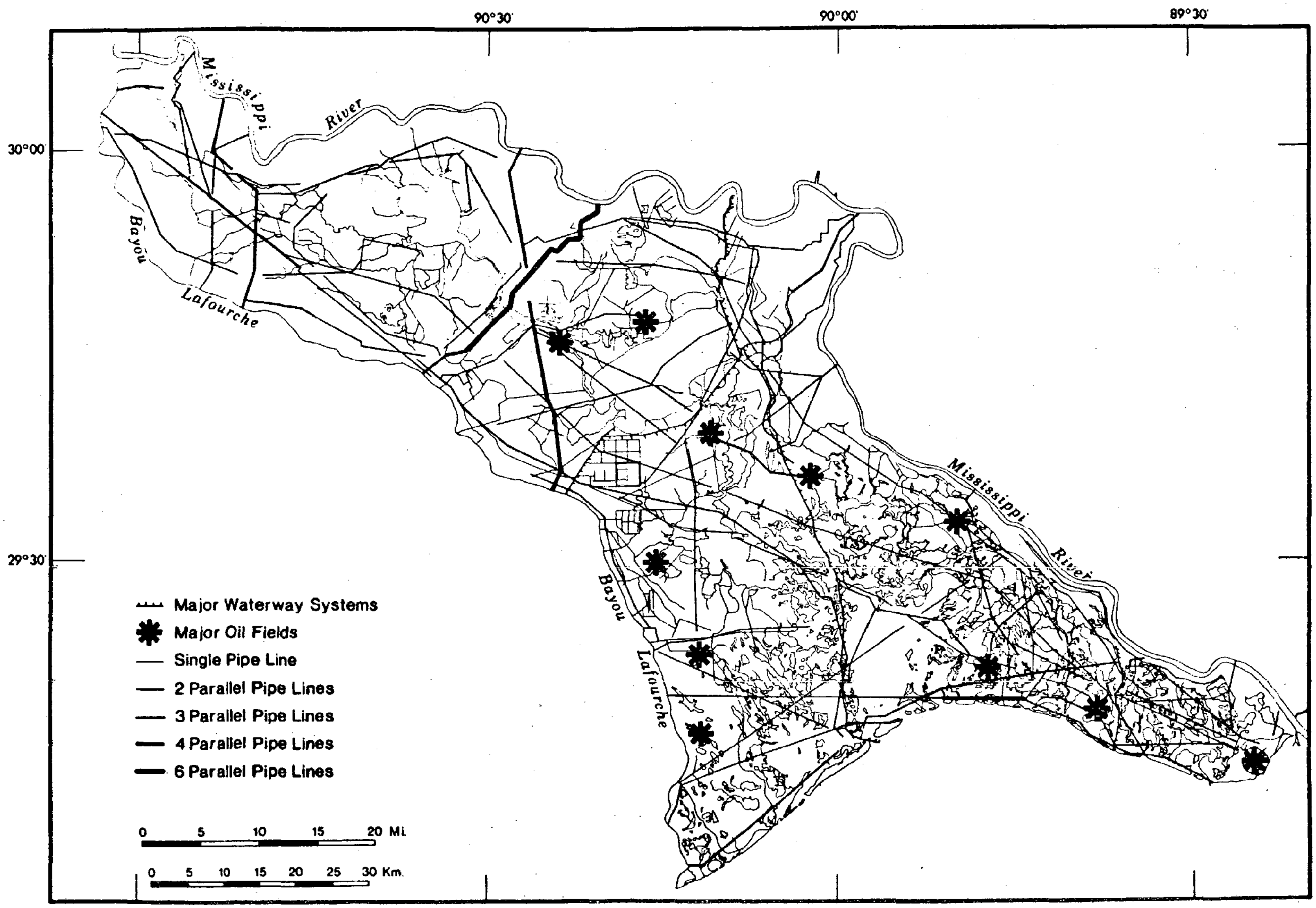


Fig. 18. Major waterways, pipelines, and oil fields within Barataria Basin.

where littoral drift constitutes an important process interrupts sediments destined for downdrift sections of the coast. This can result in local building or retarding coastal erosion along the groined areas, but, in the down-drift areas, erosion accelerates.

In Morgan's (1976) revised studies on coastal erosion for the entire Gulf front of the Barataria Basin, he found a loss of 4,515 acres of Gulf front coast occurred between 1932 and 1969 (Fig. 19). A detailed listing by parish for the periods 1932 to 1954 and 1954 to 1969 is included in Appendix D (Table D.1). On Figure 19 both coastal retreat and inlet changes are summarized by parish for the Barataria Basin Gulf front.

For inlets entering Barataria Basin, inlet changes were measured for the same time period as coastal retreat (1932 to 1954 and from 1954 to 1969). They are depicted graphically in Figure 19, and measurements for individual inlets by parish are included in Appendix D. Measurement of inlet changes between 1932 and 1969 resulted in a total widening of about one mile for the Barataria Basin Management Unit. Lack of water-depth data in the inlets constrains the possibility of relating the effect of widening to volume of water changes through the passes.

In general, inlet positions have moved laterally along the coast depending on the predominant direction of wave approach to the coast and resultant littoral currents. These processes are highly variable during the year as shown by Suhayda (1976) and Murray (1976). Individual storms can cause dramatic changes in inlets, closing some completely and forming new ones through beach breaches.

The highly variable nature of inlets is indicated by noting changes measured for individual inlets or by parish. Lafourche Parish experiences the highest rate of land loss from coastal retreat along the Barataria Basin Gulf front. Between 1932 and 1969, 2,307 acres of Gulf shoreline were lost. This averaged approximately 44 ft per year retreat along this section of the coast. When inlet changes were assessed for this section there was a net loss of about 50 percent in inlet widths for the above time period (Fig. 19). In 1932 and 1954 passes into Bay Marchand, Bay Champagne, and Pass Fourchon were open. These passes are now closed but are infrequently breached by high water. Belle Pass is maintained as the Bayou Lafourche ship channel and, although the opening across the beach has widened, the upstream width has changed little. It remains aporoximately the same width as in 1954 (Appendix D, Table D.2). Belle Pass is a natural distributary channel of Bayou Lafourche, and the composition of

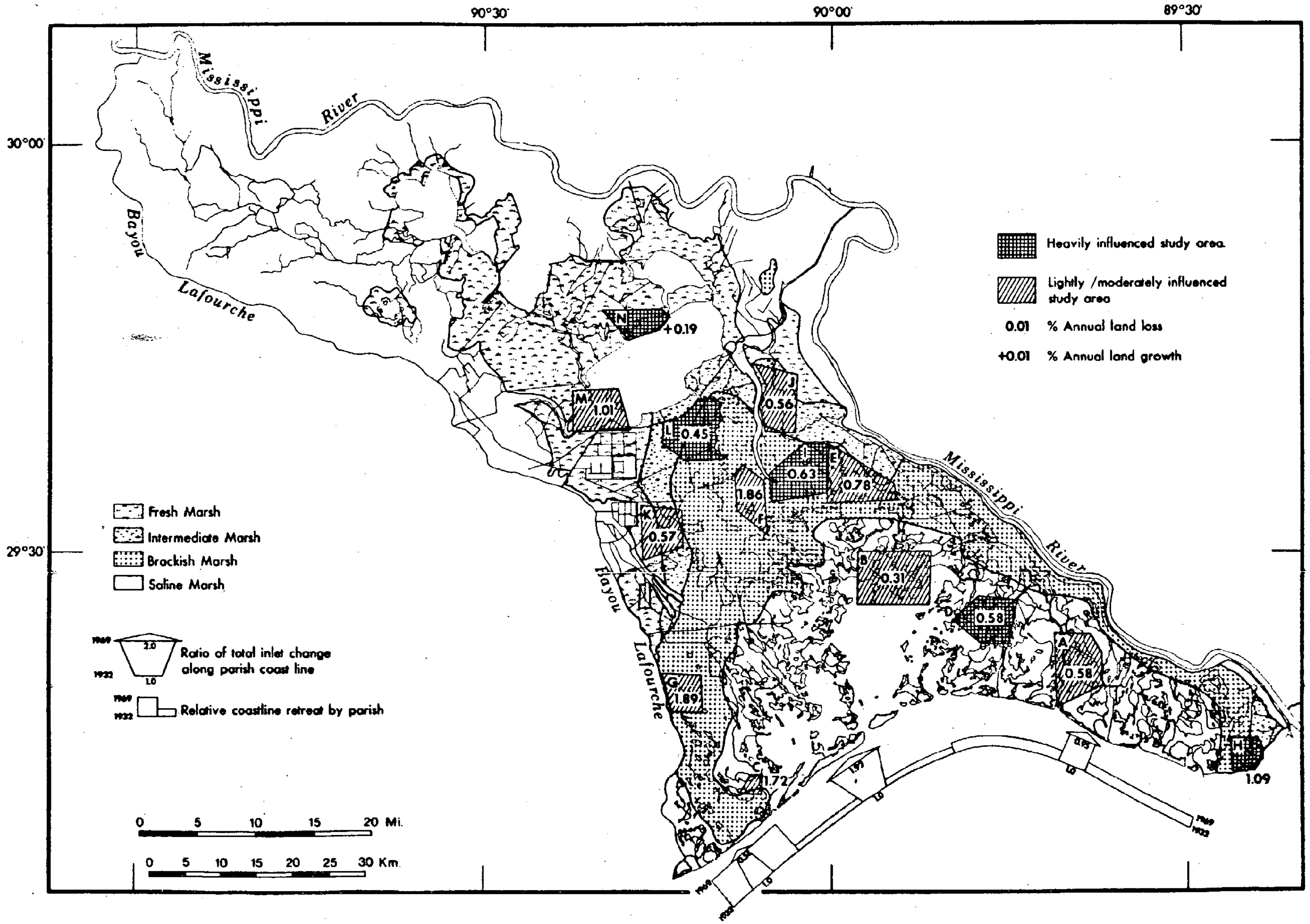


Fig. 19. Coastal retreat and marsh deterioration by environmental unit and parish (see Apps. D and E.)

natural levee material is more resistant to lateral erosion than interdistributary marshlands. The heavy boat traffic in this channel is causing bank erosion, but the map and photographic scale from which the measurements were made are too small to detect erosion changes of a few feet.

The Lafourche section of this coast is characterized by Bayou Lafourche and distributaries Belle Pass, Pass Fourchon, and Bayou Moreau forming natural levee complexes and an associated system of beach ridges (Fig. 10) generally paralleling the coast that was formed at a time when the coast was advancing seaward. The rapid rate of shoreline retreat and net reduction of inlet widths is most likely related to the general grain of the natural levee, east-west extending beach ridge topography, sediment characteristics of the beaches, and exposure to wave and current attack. This complex of levee and east-west trending beach ridges have precluded the formation of major passes into interconnecting bays (Fig. 10). The rapidly retreating shoreline and associated coarser-grained sediment supply from the former beaches has sealed off most of the tidal passes into the confined bays of Marchand and Champagne. This section of the coast lies in the direct path of wave attack from the south and southeast (Suhayda 1976). Proceeding east of Lafourche Parish the leeward affects from the protruding Mississippi River increase in importance in dampening the effects of southeasterly waves. Wave approach from the south and southwest causes easterly flowing currents from the Belle Pass area to Barataria Pass (Harper 1975, and Conatser 1971). East of Barataria Pass littoral currents correspond more closely to the westerly drift-direction. In addition to waves Gulf currents drift landward from the trapped vortex associated with the westward drift and protruding Mississippi River Delta (Murray 1976). The landward drifting currents strike the coast in the vicinity of Belle Pass-Bay Champagne area, where they divide and drift eastward and westward. Passage of fronts and storms further complicate current patterns through air pressure and wind direction changes. These phenomena cause discontinuities in current velocities and water body characteristics (sharp salinity and temperature gradients). The effect on this section of the Lafourche Parish coast is rapid erosion of the coast with a net transport of sediments westward and eastward out of the area. A high rate of coastal retreat results.

Inlets in Jefferson Parish nearly doubled in width between 1932 and 1969. In 1932 total inlet widths were 6,662 ft and by 1969 they had widened to 12,775 ft. Inlet behavior is high variable, along this section of the coast, some passes have closed and others opened exhibiting dramatic changes over a relatively short time period (Appendix D, Table D-2).

The relatively low coastal retreat rate of 2 ft per year (1954-69) for Grand Isle (Appendix D) is in contrast to 17 ft per year (1954-69) for the remaining coast of Jefferson Parish east of this island. The littoral current flowing eastward during parts of the year and construction of groins along the Grand Isle beach is likely the primary reason for the low retreat rate.

The coast east of Grand Isle has neither the source of sediments for nourishing beaches nor as well-established littoral currents as those fronting the Belle Pass-Grand Isle coast. The eastern section of the coast is subject to frequent flushing and flooding of water exchanged between the Gulf of Mexico and Barataria Basin. Sediment exchange also occurs, but not at a sufficient supply to offset a net, relatively high land loss along the coast.

Grand Terre Islands Case History.--A study was made by Maurice Lasserre and Barney Barrett, Louisiana Wildlife and Fisheries Commission, of landform changes on Grand Terre Island proper (westernmost island) (Fig. 20), and inlet changes in the island chain. The investigation covered the period 1893 to 1972[4]. The Grand Terre Islands presently comprise a chain of barrier islands that extend along the central Barataria Basin coast. In 1893 the islands were continuous from Barataria Pass to Quatre Bayou Pass (Fig. 20). Since then the island has divided into five islands and the largest remaining barrier island comprises Grand Terre proper, which lies across Barataria Pass east of Grand Isle. The study measures changes in the inlet widths of Barataria Pass, Pass Abel, and Quatre Bayou Pass between 1893 and 1972 (Fig. 21, A) and quantifies the westernmost island's aerial changes in acreage between the same dates (Fig. 21, B and C). Width measurements that show inlet changes for Barataria Pass, Pass Abel, and Quatre Bayou Pass between 1932 and 1972 are listed below in feet:

Date	Barataria Pass	Pass Abel	Quatre Bayou Pass
1932	2,148	423	2,180
1954	2,373	998	2,921
1960	3,500	1,200	3,000
1969	3,500	2,465	3,700
1971	3,480	3,200	unknown
1972	unknown	3,417	3,542

Inlet widening has undergone major changes since 1893 and has contributed significantly to land loss on the island (Fig. 21). Pass changes indicated by the above computations for the three passes are as follows:

Barataria Pass (1932-1971) Width increase 1,332 ft
Pass Abel (1932-1972) Width increase 2,994 ft
Quatre Bayou Pass (1932-1972) Width increase 1,362 ft

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[4] Calculations were made from quadrangle maps for the 1893 and 1960 dates. Aerial photographs were used for all other dates. Some of the maps did not show all of the passes and in 1893 the Grand Terre Islands were continuous from Barataria Pass to Quatre Bayou Pass. For this reason, comparisons of land area in 1893 with that of later dates were measured from Barataria Pass to Longitude 89°55'. Measurements after 1893 included all of Grand Terre. Because tidal stages at the time of photography are not available, the land-water boundaries are not adjusted to the same datum for each map.

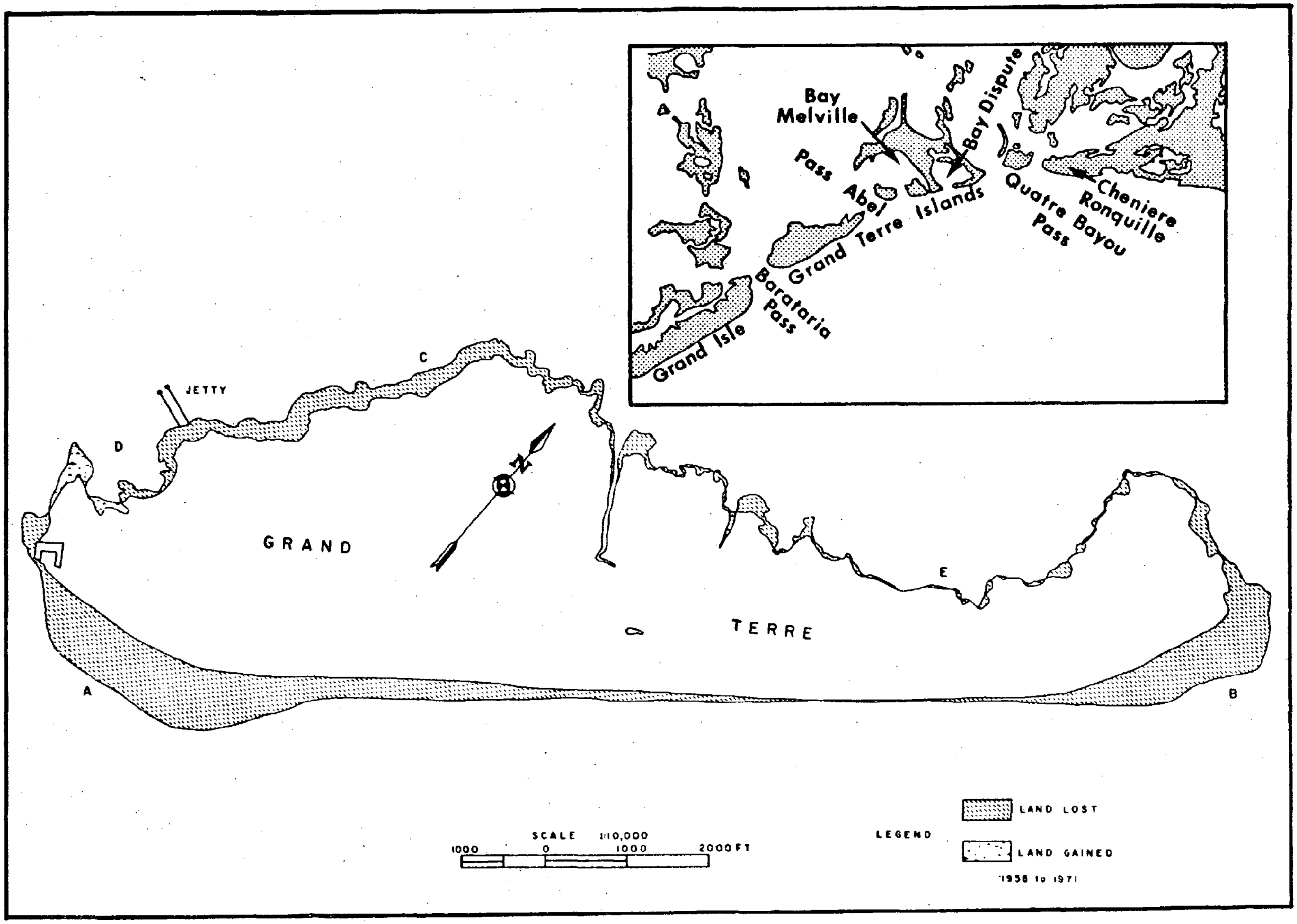

Fig. 20. Map depicting land loss and gain on Grand Terre proper. Inset: Index map of the Grand Terre Islands.

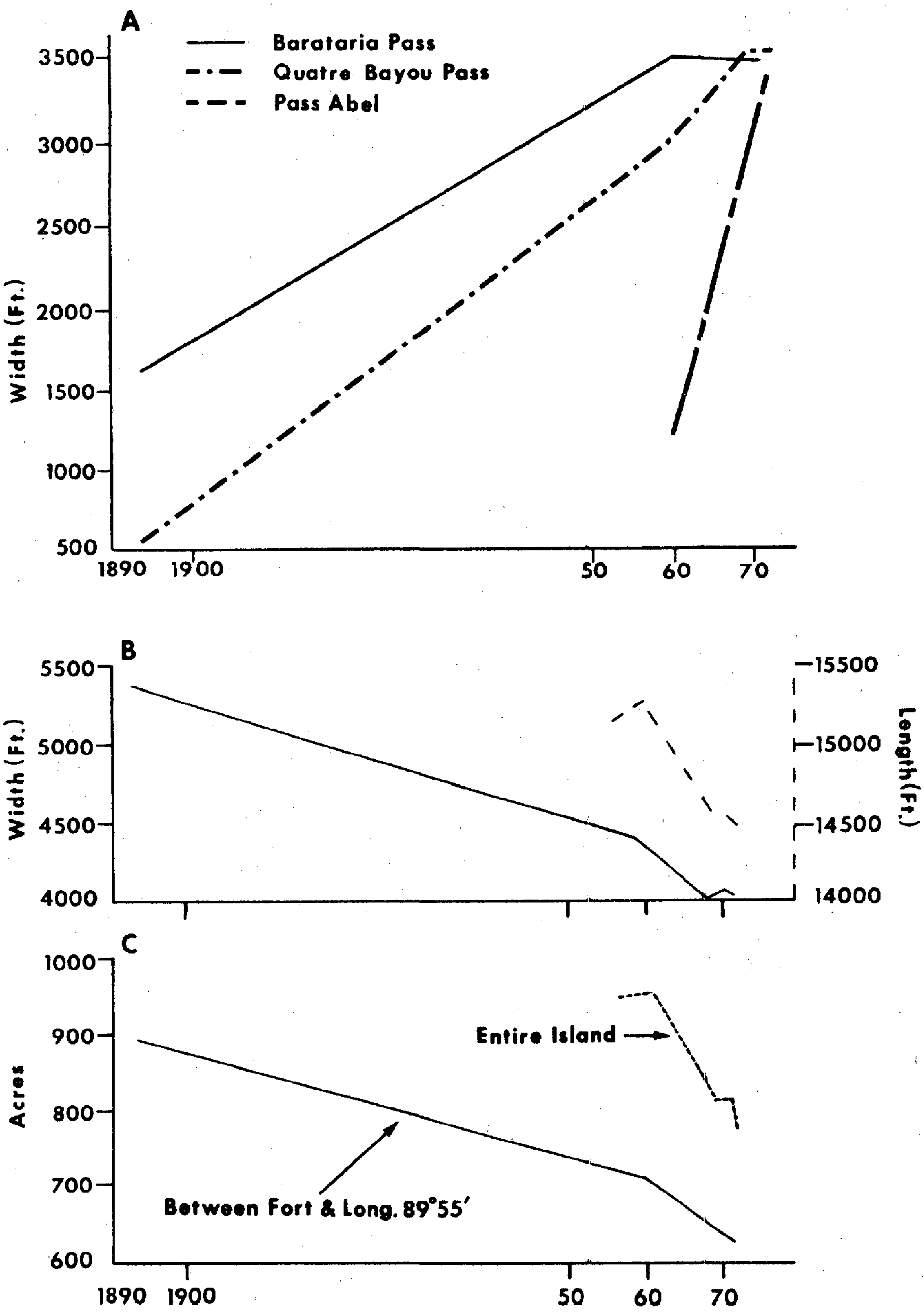

Fig. 21. Graph A illustrates inlet changes of the three major passes in the Grand Terre Island system. Note the rapid changes of Pass Abel. Graph B shows the width and length of the island in feet, and C the area in acres.

Barataria Pass has been relatively stable since construction of the rock jetty on the eastern end of Grand Isle in 1960. Fort Livingston, located across the pass on the western end of Grand Terre retards erosion.

Most of the erosion of Pass Abel has occurred on the eastern side of the Pass. Between March 1960 and May 1972 this Pass was widened by 2,217 ft, of which only 758 ft were gained by the erosion of the eastern end of Grand Terre. The other 1,459 ft were the result of erosion of the Grand Terre Island that forms the southern boundary of Bay Melville. In 1960 this eastern Grand Terre Island was continuous from Pass Abel to Bay Dispute (Fig. 20). By October 1969, this island was severely eroded and contained only 51.7 acres. By May of 1972, only 30.1 acres remained.

Pipelines dredged very near the high water line and parallel to the beach accelerated the erosion rate of this island east of Pass Abel. Waves eroded canal banks at a relatively rapid rate.

Land changes that occurred on Grand Terre proper (westernmost island) during the period 1956-71 are shown on Figure 20. Most of the erosion has occurred along the front beach, on the eastern end, and on the bay side of the island. Some accretion has taken place in the form of a recurved spit on the bay side of Barataria Pass (Fig. 20, D). Between 1956 and 1972 the island has decreased in size by 166 acres. The following measurements show land changes on Grand Terre proper during the years 1956-72:

Date	Acres	Island Length (ft)	Island Width (ft)
1956	952	15,167	4,458
1960	958	15,300	4,400
1969	812	14,583	4,000
1971	818	14,583	4,060
1972	786	14,542	4,042

It is readily discernible that shoreline retreat and inlet widening is a major land-loss problem along this section of the coast. This example is typical of the destruc--tional processes occurring along other sections of the coast. Groins constructed along the Grand Isle coast and the rock jetty at the island's eastern end restrict sediments from reaching Grand Terre during the season of easterly flowing currents. Although the westerly drift of coastal water predominates the direction of annual flow, this section of the coast receives minimum effect from this current because of its leeward position behind the seaward-protruding delta. Conversely, the vortex that develops generally offshore of Lafourche

Parish results in easterly moving currents during certain weather conditions and seasons of the year. Usually, this occurrence is associated with easterly winds during the fall and winter months, and is suspected to be less developed during the summer months. A major factor in addition to coastal sea conditions is the dynamic and highly variable water exchange flow between the Gulf of Mexico and Barataria Basin.

Jefferson Parish's central location in the basin is likely the main reason that it possesses most of the major tidal passes connecting the basin proper with the Gulf. These passes are significant when the Barataria Basin geometry is considered: east-west trending beach ridges in Lafourche Parish block direct water flow to the Gulf. Because of this, most of the water in the western basin section is funneled through passes in the central section. Southerly and northerly winds pile up water in the basin or depress basin water levels, and the passes form the connecting water exchange links. Byrne (1976) has shown that water levels at Bayou Rigaud tide station for the year 1971 experienced water levels above mean high tide levels 128 times for that year. It remains that the inlets and barrier islands are important water control features along the Barataria Basin coast.

The Plaquemines Parish coast has lost about 1,601 acres (an average 18 ft per year) to coastal retreat between 1932 and 1969 (Appendix D, Table D.1). The coast is breached by inlets nearly equaling the combined number for Lafourche and Jefferson parishes. The Plaquemines inlets displayed a high degree of variability in change between 1932 and 1969 (Appendix D, Table D.2); however, the net change shows total channel widths slightly less than those for 1932.

The topographic grain in the Plaquemines sector is controlled by distributaries off the Plaquemines Delta complex as it lengthened seaward to the Modern Delta position (Fig. 11). Except along the western sections of the Plaquemines coast where inlets connect with Barataria Basin proper, passes along the eastern sector connect with more restricted interdistributary basins. This section of the coast is also sheltered from waves approaching from the east and southeast.

Marsh deterioration.--This section concerns the problems of marsh deterioration and related processes within Barataria Basin. The goal for this activity was to build on the basis of land loss considerations that Gagliano (1970) introduced. He dealt with long-term changes based on point-counting procedures for determining land-water ratios that applied to specific periods through time beginning with the 1932 USGS quadrangle sheets. His studies covered large areas of marshlands, and, in general, conclusions he reached were valid. When grossly compared with short-term changes his rates are on the conservative side. This study is an attempt to obtain realistic information that would provide insight into short-term changes that are presently occurring. Secondly, it should provide information on land loss and gain responses at the environmental unit and parish level.

To obtain this information sample areas were selected and measured for the years 1960, 1971, and 1974. Areas were chosen from each environmental unit (salt, brackish including intermediate, and fresh marsh) within Lafourche, Jefferson, and Plaquemines parishes (Fig. 19). A total of 14 sample areas provided the desired coverage. The USGS quadrangle sheets (7 1/2 and 15 minute scale) were used for the initial 1960 base. For midpoint measurements, the USGS orthophoto quadrangle maps (1971) were used. When available, NASA infrared color photographs (Mission 194) were used for other examples. Infrared color photographs (NASA Mission 293) were utilized to obtain 1974 information. Details for the technique used are covered in Appendix E.

Man's activities have affected all areas within the basin so the sample areas were qualitatively classified as lightly/moderately or heavily influenced by man. The results show a wide range of marsh deterioration or gain rates. Variability both within and between marsh types is high. High variability also exists among the three time periods (Appendix E). Annual rates shown by percentages for each of the test sites are presented in Figure 19 and Table 4.

Since there was considerable variation in land loss rate for test sites within the same vegetation zone, the highest and lowest annual values are presented below (percentages converted to acres):

Salt Marsh--loss, 1,262.4 to 959.3 acres/yr.
Brackish Marsh--loss, 3,872.0 to 1,299.2 acres/yr.
Fresh Marsh--loss, 1,376.0 to 876.8 acres/yr.
Total combined marshes--loss, 6,510.4 to 3,135.3 acres/yr.

The long-term land loss computations (1890-1960) presented by Gagliano and van Beek (1970) were digitized by vegetation and management unit for comparison with the short-term rates presented above. They indicate changes:

Salt Marsh--loss, 818 acres/yr.
Brackish Marsh--loss, 901 acres/yr.
Fresh Marsh--loss, 188 acres/yr.
Total combined marsh--loss, 1,907 acres/yr.

Table 4. Rates of deterioration by marsh types within the Barataria Basin.

Sample Areas*	% Annual Land Loss/Gain	Acres/Annual Loss or Gain	Total Acres** Loss or Gain Sample Period
Saline Marsh			
A Eastern Barataria (lightly/moderately)	-0.58	-53.5	-749
B Central Barataria (lightly/moderately)	-0.31	-27.9	-391
C Western Barataria (lightly/moderately)	-1.72	-12.8	-218
D Central Barataria (heavily)	-0.58	-34.7	-486
Brackish Marsh			
E Eastern Barataria (lightly/moderately)	-0.78	-75.32	-979
F Central Barataria (lightly/moderately)	-1.86	-128.0	-1,664
G Western Barataria (lightly/moderately)	-1.89	-77.16	-1,389
H Eastern Barataria (heavily)	-1.09	-44.40	-710
I Central Barataria (heavily)	-0.63	-60.10	-781
Intermediate Marsh			
J Eastern Barataria (lightly/moderately)	-0.56	-80.2	-1,043
K Western Barataria (lightly/moderately)	-0.57	-41.6	-499
L Central Barataria (heavily)	-0.45	-48.2	-627
Fresh Marsh			
M Western Barataria (lightly/moderately)	-1.01	-85.9	-1,031
N Central Barataria (heavily)	+0.19	+10.0	+90

Note: These rates as reported apply only to those years for which data was analyzed. Refer to Appendix E for measurement period dates.

*A-N corresponds with sample areas on Figures 19 & E-1
**Figures represent loss or gain for sample plots A-N

These figures indicate an increasing erosion rate ranging from 150 percent to over 300 percent depending on whether we use the conservative or highest figures from the short-term study.

This increased erosion rate is to be expected in light of the geologic processes associated with deterioration of the delta mass that forms the framework for this basin.

Now that the Mississippi River plays only an indirect role in the conditions existing within the Barataria Basin, subsidence occurring at a more rapid rate than marsh build up is a dominant factor affecting the basin's marsh condition and is an underlying cause of some marsh deterioration. Gagliano and van Beek (1970) state that areas of maximum loss coincide with areas of maximum subsidence--a true statement in an idealized sense. However, it is an interplay of other factors that controls this rate at which deterioration will occur. The examination of sample sites within the basin has provided an indication of marsh deterioration/growth rates and an idea of factors controlling the variability of change in the marsh. The role of each of these factors can be expected to change per sample site, and only further research may provide a meaningful answer.

The Barataria Basin was formed by the deposition of sediments from three known phases of Mississippi River Delta formation--the Bayou des Familles lobe of the St. Bernard Delta Complex, the Bayou Lafourche Delta Complex, and the Plaquemines-Modern Delta Complex (Frazier 1967). Distributaries of all three complexes have at one time formed wedges of sediments in what is now the basin, and even now, minor sedimentation derived from the Modern Delta Complex appears to be occurring in the basin's extreme southeast corner.

The relict natural levees marking former active distributary courses, form fingers where localized subsidence and deterioration occur. They can serve as a sediment source for reworking and deposition of sediments and the levees form partitions in separating the basin into distinct provinces with respect to rates of marsh deterioration or growth.

Tidal currents and water exchange between the Gulf of Mexico and the basin constitute an additional factor for marsh deterioration. Byrne et al. (1976) has shown for 1971 that water levels exceed normal high water 128 times a year. This highly dynamic flooding and flushing must play an important role in land loss processes. Erosion of marsh by wind-generated waves within the bays and larger lakes has been noted and documented by Saucier (1963) and Morgan (1972). Any deposition of new sediment within the basin must come primarily from two sources: the reworking of internally derived sediments, or the addition of sediments from sediment-laden waters offshore and from the shallow bays.

The factors leading to variability in land-water ratios in lightly/moderately influenced examples are also highly significant in the sectors heavily influenced by man. The fact that man has altered the system makes each example more complex. Deterioration of the marsh is inherent in any dredging project, if only by the initial conversion of marsh to water. Other factors include:

1) Energy imparted to canal banks by boat wakes can lead to significant erosion (Doiron 1974). This factor is not of significance in many dredged canals, as many canal entrances are artificially blocked to prevent usage. Others are used only infrequently by oil and gas field personnel.

2) A dredged canal can serve as an artery of water flow or allow saline water to penetrate much more easily into marsh only previously penetrated via overland flow at high tides or after rainfall. The result of canals dredged in closed marshlands is the establishment of new sediment erosion and dispersion systems.

The dredging of a major navigation canal can have the same effects as those mentioned above, however, the effects may be of a greater magnitude. Canals serve as arteries for water exchange and allow greater circulation of fresh or higher salinity waters within the basin. The dredging of canals across marsh types could seriously alter the surrounding vegetation and in some cases may lead to vegetation diebacks and subsequent deterioration. There is little known about the positive effects of canals introducing water circulation into marsh areas removed from normal water circulation. Methods and techniques need to be developed to enhance "back" marsh areas.

3) Spoil banks, a by-product of every dredged canal, may influence the deterioration/growth rates of their surrounding marsh in quite opposite ways. First, the spoil banks act essentially as man-made levees. This mass is subject to localized subsidence and it too can result in the loss of marsh on its periphery, forming localized levee flank depressions.

On the other hand, spoil banks may behave as stabilizing agents in an otherwise unstable marsh. These banks can serve as barriers to flow, buffers against waves, and even sediment traps in an area of low land-water ratio.

4) Composition of the substrate is an additional factor when considering deterioration. Erosional

potential for the different sediment types is important. Clays, and peats formed from deep-rooted plants resist bank erosion more than silts, sands, and homogenous peat.

5) Heavy frosts kill off black mangroves, which thrive along lower bay and tidal channel shores. The frost during the winter of 1961-62 severely damaged these plants. Their root system is a natural barrier to retard erosion.

The fact that the rate of deterioration in the heavily influenced examples is generally lower than in the lightly/moderately influenced examples is undeniable (Table 4). Examples in each marsh type have consistently borne this out. However, projection of these rates to other examples within Barataria Basin or to the entire coastal zone should not be made until further research is done on this problem.

6) Stresses caused from storms accelerate erosional processes and have impact on biological phenomena. With an average annual lunar diurnal tide of about 1.2 ft, wind effects on water level changes often exceed tidal levels. North winds lower water levels in the bays and estuaries, whereas south winds raise water levels by driving Gulf waters far into the bays and estuaries. Storm-driven Gulf waters forced into the bays and estuaries introduce salt water into freshwater areas that can be fatal to vegetation. Hurricane-driven tides and waves severely erode the Gulf front, inlets, estuarine shores, and tidal channels. Large sections of marshes can be torn from their insecure footings and become floating pads of vegetation debris. These pads are of the magnitude that they have been detected by aerial photography floating in the nearshore waters of the Gulf following hurricanes. These floating pads also come to rest over other marsh surfaces following abatement of high water. Ponds and lakes can be formed within the marshes and bay shores expanded as a result of storm activity.

Storm tides overflow beaches and can result in formation of new inlets. Backwater flushing of waters flowing back into the Gulf following passage of storms is a major process influencing land loss. In general, storms disturb the sediment, vegetation, and water channel balance that develops during more normal conditions. Following a storm passage the stage is set for rapid changes to continue during the readjustment period. Although less dramatic than hurricanes, the same processes occur from storms which effect the coast many times each year.

It remains a highly variable, dynamic environment where normal conditions occur only in the thinking of individuals rather than in the actuality of nature. So long as there exists an imbalance between sediment supply, vegetation growth and hydrology, land loss or gain will result.

Summary

This study characterizes the natural setting for Louisiana's coastal zone by describing the landforms, water bodies, and the physical processes that have formed the highly productive environments. The investigation includes assessment of both natural and man-made stresses on the environments. The Barataria Basin management unit was selected as the pilot study area and receives the primary focus. Synthesis of information on the physical, biological and chemical, and man-made processes will be possible with the completion of companion reports covering those categories.

Information was presented on how the master stream has functioned in the past in constructing the deltaic plain, and how its present behavior is a continuum process of dynamic change. During the last 250 years man's practices in utilizing the rich, wetland resources have gradually affected the area either positively or adversely. As in the ancient past, the river is seeking a shorter route to the Gulf of Mexico--in recent years, through the Atchafalaya Basin. As the crow flies this distance is about one-half that to the mouth of South Pass. Diversions are gradual as this case history demonstrates. New land has aggraded above tide level as deltaic islands in the Atchafalaya Bay during the last few years. Some islands are already inhabited with marsh vegetation. Of more significance to this phase of the discussion are the natural and man-made processes that are challenging the existence of wetlands in the Barataria Basin.

Barataria Basin was naturally nourished with water and sediment through crevasses and overbank flow from the Mississippi River and Bayou Lafourche. With settlement on the natural levees in the early eighteenth century, protection from flooding required levee construction. By the time Louisiana became a state the basin was virtually walled in, except in its lower reaches. Riverborne sediments were funneled past the basin and deposited in deep water. In 1904 the last source was severed when Bayou Lafourche was artificially dammed. Severance of river-borne sediment and water initiated basin deterioration. Reclamation projects within the wetland resulted in additional construction of water control structures.

To determine the "state" of the basin the environmental units were inventoried by parish.

Determination was made of land loss or gain and causal processes, by assessing dredge and fill activities, coastal retreat and inlet change patterns, and marsh deterioration rates and distribution.

Dredge and fill activities associated with canal and waterway construction, urban expansion into wetlands, agriculture reclamation, and flood control have been intense in the basin. Measurements showed at least 44,800 acres of wetland have been reclaimed or converted to water bodies such as canals. Oil well access canals and agricultural impoundments account for the largest acreage. Rig access canals in the brackish marshes are nearly double the acreage in saline and fresh marshes. (As would be expected, urban spread and agricultural reclamation are predominant in the fresh marshlands with swamplands following in importance). The dredge and fill measurements showed that following the original dredging (converting marsh to water) land loss progressed at a lower rate than adjacent marsh areas in the natural system.

A number of canals, pipelines, and waterways extend through different environmental units or stretch across the basin. Water circulation and drainage effects, and salt and freshwater incursions are significant considerations in these circumstances. Canal and pipeline routes improperly oriented or emplaced can result in accelerated erosion. Pipelines improperly emplaced parallel to the beach in the eastern Grand Terre Islands resulted in accelerated coastal retreat.

Coastal retreat and inlet changes result in dramatic changes along the entire basin coast. Coastal retreat is occurring most rapidly along the coast fronting Bayou Lafourche distributaries. Averaged over a 37 year period, this section of the coast loses 44 ft per year. Southerly approaching waves directly attack this coastal section, and sediments are transported along adjacent coasts by littoral currents that drift westward and eastward from this general nodal area. Grand Isle lies in the downdrift area of the easterly flowing currents, and with the construction of groins have entrapped sediments. Coastal retreat along Grand Isle averages about 2 ft per year. Eastward from this area the coastline is undernourished and retreat averages about 17 ft per year.

Inlet changes are highly variable along sections of the coast. Over a 37-year-period combined changes show that inlets increased about one mile in widths. Because of basin geometry inlets increase in numbers east of the beach ridge systems that dominate the area from Grand Isle westward. Beaches fronting open water conditions in Barataria Bay and interdistributary depressions eastward are more prone for breaching and changing--particularly during storms. The inlets and barriers are significantly important features to processes that occur along the coast, water exchange between the Gulf and the basin, and within the basin.

Marsh deterioration constitutes a major concern in the basin. Causal factors are complex and are shared between natural processes that occur in a waning deltaic environment, and processes associated with man's activities. Measurements within the sample sites showed highly variable results both within the sites, between sites, and between marshland environmental units. This is to be expected in this complex area where composition of substrate material ranges from clays, through sands to peats.

Application of sample sites (A-N) results to basin-wide marshland environmental units a total of 3,130 acres per year were lost to erosion. Computations covered an approximate 14 year period, and the figures used come from the low side of the range. The figure includes land loss from both man-made and natural processes. Losses within the marshland environmental units show brackish marsh with the highest loss rates, followed by saline then fresh. This figure does not include the 4,515 acres lost from the Gulf front of the basin.

Concurrent with inlet widening and marsh deterioration, salt water is encroaching into the upper reaches of the basin. In addition to land loss the effects of salt water on brackish and fresh marshes is being felt. Distribution of oysters as determined from lease records show a gradual migration northward into the basin. In recent years oystering has moved into the Little Lake region.

Storms from both the Gulf and landward side pulse waters in and out of the basin. At Lafitte water levels for 1971 extended above mean high water levels about 23 percent of the year. Pulses above mean high water occurred about 79 times for that year. For Bayou Rigaud at Grand Isle this occurred 128 times.

The information assembled in this report and in the companion volumes provides a framework of information on which to begin development of planning and management concepts for the basin. Infortion is lacking in many areas, but through these studies identification of what is available, it's quality, and what's needed can be determined. In a general way, an inventory of the basin's natural resources is available and how the basin functions as a system is understood to a level that permits establishment of reasonable priorities. Trends in the physical processes of sea level changes and subsidence can be quantified, but not corrected. Through sediment and water control systems, it is possible to tap Mississippi River sources and manipulate specific environments. Aggradation of water bodies and marshlands can be accomplished by introducing river-borne sediments into subsiding areas.

The introduction of river-borne sediments down Bayou Lafourche to the coast would offset rapid erosion occurring at the present time. Current and wave patterns are sufficiently well known to permit generalizations regarding what would likely happen if this were accomplished. The quantity of sediments introduced would determine the amount of erosion that would be reduced. Littoral currents would drift the sediments both eastward and westward nourishing adjacent coasts. The river resource is available, conditions within the basin wetlands are known, and the technology is available for accomplishing meaningful management practices. How this technology will be employed is largely dependent on resolution of associated socioeconomic and political problems.

Appendix A

Barrier Islands

Barrier islands and beaches along the Louisiana coast are significant coastal features around the deltaic plain. Most of these features are undergoing rapid change because of the dynamic physical setting. Subsidence, absence of river-borne sediments, dynamic coastal currents, and waves combine to create an environment of high variability and change along the coast.

These features are listed on the following table (A.1). The table consists primarily of an inventory of barriers and lists some environmental considerations. Most of the barriers are only accessible by boat and, with the exception of Grand Isle, are presently not inhabited as residential property. Oil and gas production constitutes the primary use of the barriers.

Data sources for the information are from the following:

Linear and areal extent was measured from uncontrolled photomosaics compiled by the New Orleans District, U.S. Army Corps of Engineers (1969), except those reported for West and East Timbalier islands, which are based on maps prepared by the USGS showing 1954 conditions. Only those portions of marsh or mangrove considered as an integral part of the barrier have been considered.

Natural zone determination was interpreted from these same 1969 photomosaics, USGS quadrangle maps, and NASA High-altitude photography.

Appendix B

Environmental Inventory

The Barataria Basin Management Unit is defined as the center line of Bayou Lafourche, from Belle Pass to the Ascension Parish Line, then east along this boundary to the crest of the Mississippi River levee to Venice, turning southwesterly and running midchannel of Red Pass to the Gulf of Mexico. Closing lines between the Gulf of Mexico and inside waters have been drawn in accordance with Louisiana Revised Statutes pertaining to shrimping waters (La. Acts 1972 #203), as these appear to most closely approximate the current definition of the coastline within the Barataria Basin Management Unit.

An inventory conducted for environmental units within the Barataria Basin Management Unit was accomplished by digitizing 7 1/2 minute USGS quadrangle sheets, 1952-67 (latest issue). There is little doubt that changes

Table A.1. Louisiana Barrier Islands and Barrier Beaches

		COORDINATES		1969	1:20,000					EXISTING
		GEOGRAPHICAL	LONG/LAT	PHOTO REF.	LENGTH	WIDTH	ACREAGE	NATURAL ZONES	ACCESS	DEVELOPMENT
1.	**West Isles Derniere**	Racoon Point to Last Island Pass	90°58'- 90°53'30"	71	13" 21,666.66'	1.5" 2500'	595.4	25% Sand 20% Mangrove 55% Marsh	Boat	None
2.	Middle Isles Dernieres	Last Island Pass to Whiskey Pass	90°52'30"- 90°47'	83	14" 23,333.33'	4" 6,666.66'	1469.1	45% Sand 5% Mangrove 50% Marsh	Boat	Oil/gas canal
3.	East Isles Dernieres	Whiskey Pass to Wine Island Pass	90°46'- 90°38'	83 & 95	26.5" 44,166.66'	4" 6,666.66'	1967.8	20% Sand 80% Marsh	Boat	Oil/gas canals, wells, & impoundments
4.	West Timbalier Island	Cat Island Pass to Little Pass Timbalier	90°32'30"- 90°24'30"	107	27.5" 45,833.33'	3.5" 5,833.33'	2941.6	35% Sand 65% Marsh & Spoil	Boat	Oil/gas canals with some structures
5.	East Timbalier Island	Little Pass Timbalier to Belle Pass	90°22'30"- 90°14'30"	107 & 117	29" 48,333.33'	4" 6,666.66'	1274.0	30% Sand 70% Marsh & Spoil	Boat	Oil/gas canals, impoundments, and structures
6.	Barrier Beach just south of Cheniere Caminada	From mainland to Caminada Pass	90°05'- 90°03'30"	125	6.5" 10,833.33'	.75" 1250'	193.0	70% Sand 30% Marsh	Unpaved Road	None
7.	Grand Isle	Caminada Pass to Barataria Pass	90°02'- 89°57'	125 & 134	26" 43,333.33'	4" 6,666.66'	2136.6	65% Sand & Fill 35% Marsh	Paved Road	Residential, oil/gas related industrial, state park
8.	Grand Terre	Barataria Pass to Quatre Bayou Pass	89°57'30"- 89°52'30"	134	18.5" 30,833.33'	2.5" 4,166.66'	1052.4	25% Sand 75% Marsh	Boat	Oil/gas pipelines run behind La. Wildl. & Fish. Exp. Station
9.	Barrier Beach just south of Bay Joe Wise	Chaland Pass to Grand Bayou Pass	89°43'30"- 89°41'	143	10" 16,666.66'	1.25" 2,083.33'	356.9	25% Sand 35% Mangrove 40% Marsh	Boat	Pipeline canal runs immediately behind
10.	Shell Island (includes Bastian Island)	Grand Bayou Pass to Pecan Island	89°40'- 89°38'	152	10.5" 17,500'	1" 1,666.66'	371.8	40% Sand 35% Mangrove 25% Marsh	Boat	Pipeline canal runs immediately behind
11.	Breton Island	West Point to North Point	29°27'30"- 29°30'	172E	7.5" 12,500'	1.5" 2,500'	469.1	50% Sand 50% Mangrove	Boat	None

Table A.1. Continued.

	COORDINATES		1969	1:20,000					EXISTING
	GEOGRAPHICAL	LONG/LAT	PHOTO REF.	LENGTH	WIDTH	ACREAGE	NATURAL ZONES	ACCESS	DEVELOPMENT
12. Grand Gossier Island	ONLY ISLAND NAMES AVAILABLE	29°31'- 29°34'	172D	12" 20,000'	1.5" 2,500'	370.0	60% Sand 40% Marsh	Boat	None
13. Curlew Island		29°37'- 29°38'30"	172C	9.5" 15,833.33'	1" 1,666.66'	377.3	100% Sand	Boat	None
14. Stake Island		29°39'- 29°41'	172C	7.5" 12,500'	1" 1,666.66'	259.7	80% Sand 20% Mangrove 0% Marsh	Boat	None
15.* Palos Island (includes Boot Island)		29°43'- 29°44'30"	172C & 172	9" 15,000'	1" 1,666.66'	287.4	70% Sand 30% Mangrove 0% Marsh	Boat	None
16. Chandeleur Island		29°44'30"- 30°03'30"	172	69" 115,000'	3.5" 5,833.33'	5209.2	80% Sand 15% Mangrove 5% Marsh	Boat	Relatively none; 1 oil/gas canal
17.		29°47'- 29°49'	171	4.5" 7,500'	.75" 1,250'	143.9	50% Sand 50% Mangrove	Boat	None
18. North Islands		29°51'30"- 29°54'	171	8" 13,333.33'	1.5" 2,500'	604.4	5% Sand 90% Mangrove 5% Marsh	Boat	None
19. New Harbor Islands		29°50'30"- 29°51'30"	171	4" 6,666.66'	1" 1,666.66'	170.4	95% Mangrove 5% Marsh	Boat	None
20. South Pass Barrier Beach		28°58'30"- 28°59'30"	162	2,500.00'	833.33'	71.68	40% Sand 60% Marsh	Boat	None
21. Southwest Pass Barrier Beach		28°59'30"- 29°01'30"	159	extremely	variable	--	90% Sand 10% Marsh	Boat	Oil and gas activity, canals intersect
22. Pass du Bois Barrier Beach		29°06'- 29°06'30"	155	3,333.32'	416.67'	15.2	5% Sand 95% Marsh	Boat	None

Table B.1

Environmental Inventory by Parish, Barataria Basin

	Ascension		Assumption		Jefferson	
	Square Miles	Acres	Square Miles	Acres	Square Miles	Acres
Water area	0.5	320	1.3	832	162.2	103,808
Saline marsh	0.0	0	0.0	0	19.6	12,544
Brackish marsh*	0.0	0	0.0	0	115.8	74,112
(Intermediate marsh)	(0.0)	(0)	(0.0)	(0)	(37.3)	(23,872)
Fresh marsh	0.0	0	0.5	320	45.8	29,312
Fresh water swamp	0.0	0	30.5	19,520	40.7	26,048
Topographic Highs	13.3	8,512	57.2	36,608	55.8	35,712
	13.8	8,832	89.5	57,280	439.9	281,536

	Lafourche		Orleans		Plaquemines	
	Square Miles	Acres	Square Miles	Acres	Square Miles	Acres
Water area	151.2	96,768	0.5	320	208.8	133,632
Saline marsh	52.0	33,280	0.0	0	175.4	112,256
Brackish marsh*	156.8	100,352	0.0	0	86.5	55,360
(Intermediate marsh)	(42.1)	(26,944)	(0.0)	(0)	(13.0)	(8,320)
Fresh marsh	178.4	114,176	0.0	0	16.6	10,624
Fresh water swamp	168.6	107,904	0.0	0	1.4	896
Topographic Highs	124.7	78,808	16.0	10,240	51.3	32,832
	831.7	532,288	16.5	10,560	540.0	345,600

	St. Charles		St. James		St. John the Baptist	
	Square Miles	Acres	Square Miles	Acres	Square Miles	Acres
Water area	70.0	44,800	3.5	2,240	23.2	14,848
Saline marsh	0.0	0	0.0	0	0.0	0
Brackish marsh*	0.0	0	0.0	0	0.0	0
(Intermediate marsh)	(0.0)	(0)	(0.0)	(0)	(0.0)	(0)
Fresh marsh	95.7	61,248	1.7	1,088	10.5	6,720
Fresh water swamp	50.3	32,192	56.3	36,032	30.4	19,456
Topographic Highs	63.2	40,448	66.7	42,688	24.2	15,488
	279.2	178,688	128.2	82,048	88.3	56,512

*Includes intermediate marsh.

occurred during this period. The quadrangle sheets represent the only complete coverage for the state's coastal zone. The environmental units are:

Freshwater swamp
Freshwater marsh
Brackish water marsh
  (Intermediate marsh)
Saltwater marsh
Water bodies and water bottoms
Dry land (natural levees and beaches)

In addition to the total areas of the environmental units within Barataria Basin (Table 2), areas for each environmental unit were calculated for each parish within the basin (Table B.1).

During measurements on the digitizer, areas were automatically computed through the use of a Calmagraphic 11 Digitizing System.

Delineation of environmental units on quadrangle sheets were based on the Vegetative Type Map of the Louisiana Coastal Marshes (Chabreck et al. 1968, Palmisano 1970) and were derived by point-counting (grid sampling) of these quadrangle sheets (7 1/2 minute series used when available) using a method developed by Gagliano and van Beek (1970). The only variation from Gagliano and van Beek's method was that they measured only two major parameters--land and water, while this study employed seven environmental units. Tests comparing digitized areas and point-counted results yielded findings similar to Gagliano's.

The accuracy of the Barataria Basin computations are reliable, however, the areas of environmental units within the basin are:

1) only as accurate as grid sampling on a 1/2 mile interval will allow,
2) based on the accuracy of the USGS quadrangle maps themselves,
3) only accurate for the year of map publication,
4) only as accurate as Chabreck et al. and Palmisano were able to delineate the vegetation zones.

Appendix C

Dredge and Fill

Areas of dredge and fill were digitized from 1969 New Orleans District U.S. Army Corps of Engineers uncontrolled photomosaics. Coverage of the Barataria Basin is nearly total; where coverage is not complete, the latest editions and largest scale USGS quadrangle charts have been used. The resolution of this study includes all canals and impoundments that show areal extent on a standard 7 1/2 minute quadrangle chart. It must also be noted that urban areas have not been included in compilations because their entire sector has experienced intense alteration by man.

These mosaics being uncontrolled lends error to the area compilations; however, features are easily delineated, boundaries can be determined with reasonable accuracy, and such widespread coverage at one date and at one scale (1:20,000) yields consistent information.

Table 1 (listed in the main body of this report) lists the canal types considered for classification. Table C.1 contains an inventory of canals by type, parish, and environmental unit.

Classification of dredge and fill features according to their major function at present are listed below:

Rig Access--canals used solely for installment and maintenance of oil and gas field production apparatus.

Pipeline Canals (65 ft and 130 ft--dredged for pipeline installation. Widths were found to approximate either 65 ft or 130 ft and are reported in the nearest category.

Oil Field Navigation Canals--dredged to as access routes and oil rigs.

Navigation Canals--limited access routes for boat travel.

Transportation Embankments--filling or reinforcing swamp or marsh surface for land transportation.

Agricultural Drainage Canals--canals or ditches constructed to drain marsh or swamp and to allow planting or pasture.

Agricultural Impoundments--an area of former marsh or swamp converted for agricultural production.

Industrial Impoundment--artificially diked and sometimes filled marsh or swamp serving as an industrial site.

Urban Drainage Canals--dredged to drain marsh or swamp to allow urban growth. Only those portions beyond the limits of the urban sector have been compiled.

Agricultural Commodity Transportation Canal--dredged primarily to move goods by water (e.g. logging canals).

Oil Field Embankment--constructed to install and service oil and gas field production apparatus.

Mineral Extraction Navigation Canal--dredged to transport extracted non-petroleum minerals.

Other--canals, embankments, and impoundments not fitting into one of the above categories.

Table C.1. Canal type inventory by parish portion in the basin and environmental unit.

Ascension Parish--no swamp or marsh

Assumption Parish--no swamp or marsh

Jefferson Parish--Environmental Unit (sq. mi.)

	Saline	Brackish	Inter-mediate	Fresh	Swamp	Total
Rig Access Canals	0.06	3.29	0.83	0.45	0.43	5.08
Pipeline Canals - 65 ft width	0.08	0.19	0.09	0.60	0.05	0.48
Pipeline Canals - 130 ft width	0.03	0.0	0.0	0.0	0.0	0.35
Oil Field Navigation Canals	0.0	0.0	0.0	0.0	0.0	0.0
Navigation Canals	0.78	0.88	0.52	0.0	1.18	3.37
Transportation Embankments	0.0	0.0	0.0	0.02	0.0	0.02
Agricultural Drainage Canals	0.0	0.0	0.0	0.23	0.0	0.23
Agricultural Impoundments	0.0	0.0	0.0	1.25	0.0	1.25
Industrial Impoundments	0.0	0.0	0.0	0.0	0.07	0.07
Urban Drainage Canals	0.0	0.01	0.07	0.10	0.06	0.26
Agricultural Commodity Transportation Canals	0.0	0.0	0.02	0.0	0.01	0.04
Oil Field Embankment	0.0	0.0	0.0	0.0	0.0	0.0
Mineral Extraction Navigation Canal	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.02	0.0	0.0	0.0	0.0	0.02
	1.00	4.38	1.55	2.14	1.82	10.90

St. Charles Parish--Environmental Unit (sq. mi.)

	Saline	Brackish	Inter-mediate	Fresh	Swamp	Total
Rig Access Canals				1.57	0.07	1.65
Pipeline Canals - 65 ft width				0.0	0.0	0.0
Pipeline Canals - 130 ft width				0.0	0.0	0.0
Oil Field Navigation Canals				0.0	0.0	0.0
Navigation Canals				0.0	0.0	0.0
Transportation Embankments				0.03	0.35	0.39
Agricultural Drainage Canals				0.06	0.37	0.44
Agricultural Impoundments				5.21	6.06	11.27
Industrial Impoundments				0.0	0.0	0.0
Urban Drainage Canals				0.0	0.0	0.0
Agricultural Commodity Transportation Canals				0.0	0.0	0.0
Oil Field Embankments				0.0	0.04	0.49
Mineral Extraction Navigation Canals				0.0	0.0	0.0
Other				0.0	0.0	0.0
				6.89	6.92	13.81

Table C.1. Continued.

St. James Parish--Environmental Unit (sq. mi.)

	Saline	Brackish	Inter-mediate	Fresh	Swamp	Total
Rig Access Canals				0.0	0.10	0.10
				0.0	0.10	0.10

St. John Baptist--Environmental Unit (sq. mi.)

	Saline	Brackish	Inter-mediate	Fresh	Swamp	Total
Rig Access Canals				0.09	0.0	0.09
Agricultural Drainage Canals				0.03	0.19	0.23
				0.13	0.19	0.32

Lafourche Parish--Environmental Unit (sq. mi.)

	Saline	Brackish	Inter-mediate	Fresh	Swamp	Total
Rig Access Canals	1.34	2.08	1.25	3.00	0.45	10.15
Pipeline Canals - 65 ft width	0.34	0.64	0.23	0.30	0.15	1.68
Pipeline Canals - 130 ft width	0.02	0.04	0.0	0.16	0.0	0.23
Oil Field Navigation Canals	0.02	0.0	0.1	0.18	0.0	0.40
Navigation Canals	0.0	0.10	0.28	0.49	0.0	0.89
Transportation Embankments	0.0	0.03	0.40	0.44	0.12	0.99
Agricultural Drainage Canals	0.0	0.0	0.08	0.38	0.33	0.82
Agriculture Impoundments	0.0	0.0	3.55	14.92	0.0	18.47
Industrial Impoundments	0.05	0.0	0.0	0.0	0.0	0.05
Urban Drainage Canals	0.0	0.03	0.03	0.0	0.0	0.06
Agricultural Commodity Transportation Canals	0.0	0.0	0.0	0.0	0.0	0.0
Oilfield Embankment	0.0	0.0	0.0	0.0	0.17	0.17
Mineral Extraction Navigation Canal	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0
	1.80	4.97	6.03	19.91	1.24	33.96

Orleans Parish--no swamp or marsh

Table C.1. Continued.

Plaquemines Parish--Environment Unit (sq. mi.)

	Saline	Brackish	Inter-mediate	Fresh	Swamp	Total
Rig Access Canals	3.87	2.06	0.14	0.06	0.0	6.14
Pipeline Canals - 65 ft width	1.79	0.49	0.0	0.10	0.0	2.39
Pipeline Canals - 130 ft width	0.23	0.0	0.0	0.0	0.0	0.23
Oil Field Navigation Canals	0.0	0.0	0.0	0.00	0.0	0.0
Navigation Canals	0.07	0.17	0.0	0.0	0.0	0.24
Transportation Embankments	0.0	0.0	0.0	0.0	0.0	0.0
Agricultural Drainage Canals	0.0	0.63	0.17	0.08	0.07	0.98
Agricultural Impoundments	0.0	0.0	0.0	0.0	0.0	0.0
Industrial Impoundments	0.0	0.0	0.0	0.0	0.0	0.0
Urban Drainage Canals	0.0	0.23	0.0	0.0	0.0	0.23
Agricultural Commodity Transportation Canals	0.0	0.0	0.0	0.0	0.0	0.0
Oilfield Embankment	0.0	0.0	0.0	0.0	0.0	0.0
Mineral Extraction Navigation Canal	0.61	0.0	0.0	0.0	0.0	0.61
Other	0.0	0.0	0.0	0.0	0.0	0.0
	6.58	3.60	0.32	0.25	0.07	10.84

Appendix D

Coastal Retreat and Inlet Changes

This section contains the detailed information on coastline retreat of the Barataria Basin Gulf shoreline and inlet changes measured at three different time periods--1932, 1954, and 1969. The coastline retreat information was obtained from Dr. James P. Morgan and David Morgan (personal communication). Morgan and Larimore (1957) conducted a study for the state Attorney General on establishment of the Louisiana shoreline with the staff of the Coastal Studies Institute. This report, established quantitatively that the Louisiana shoreline was retreating except in a few isolated areas where sedimentation exceeded erosion. This study has been brought up to date for the Attorney General and the information collected for the Barataria Basin Gulf shoreline is included in this report.

Morgan has assembled maps at a scale of 1:20,000 for the entire Louisiana coastline covering three time periods to measure comparative shoreline changes: (1) a 1932 shoreline as based on U.S. Coast and Geodetic Survey Air Photo Compilation Charts, (2) a 1954 shoreline as based on aerial photographs taken by the Jack Ammann Corporation, and (3) a 1969 shoreline interpreted from uncontrolled aerial photographic mosaics compiled by the New Orleans District, U.S. Army Corps of Engineers. These maps were used in the measure of coastal retreat and inlet change. Inlet width for this paper represents measurement taken at the narrowest point in the channel that separates the two land areas.

Inlet width measurements at the different time intervals indicate the variable nature of the Barataria Bay coastline, and the results show an overall increase in inlet width. Bathymetry information on inlets does not exist in sufficient detail to calculate volume of water flow through the passes.

Information collected for the shoreline changes is included in Table D.1, and the data on inlet changes are shown on Table D.2.

Table D.1. Coastal Retreat.

	Period	Acres	
Barataria Hydrologic/Management Unit			
	1932 - 1954	2,652.56	acres lost
	1954 - 1969	1,862.39	acres lost
Total	1932 - 1969	4,514.95	acres lost
Jefferson Parish			
	1932 - 1954	269.96	acres lost
	1954 - 1969	336.24	acres lost
Total	1932 - 1969	606.20	acres lost
Lafourche Parish			
	1932 - 1954	1,485.75	acres lost
	1954 - 1969	821.67	acres lost
Total	1932 - 1969	2,307.42	acres lost
Plaquemines Parish			
	1932 - 1954	896.85	acres lost
	1954 - 1969	704.48	acres lost
Total	1932 - 1969	1,601.33	acres lost

Table D.2. Inlet Changes (in feet).

Barataria Hydrologic/Management Unit -
Total Inlet Widths (in feet)

1932	17,949.3
1954	17,274.4
1969	23,361.6

Lafourche Parish	1932	1954	1969
Belle Pass	158.6*	158.6*	158.6*
Pipeline Canal	0.0	72.7	0.0
Pass Fourchon	152.0	185.0	0.0
(unnamed)	0.0	79.3	0.0
(unnamed)	0.0	197.6	0.0
(Unnamed)	0.0	59.5	0.0
Pass at Parish Boundary	0.0*	33.0*	0.0*
	310.6	785.7	158.6
Jefferson Parish			
Pass at Parish Boundary	0.0*	33.1*	0.0*
(unnamed)	0.0	132.2	0.0
Caminada Pass	1,929.7	1,705.0	1,672.0
Barataria Pass	2,147.8	2,372.5	3,449.7
Pass Abel	423.0	997.9	2,465.0
(unnamed)	1,070.6	0.0	0.0
(unnamed)	0.0	105.7	1,116.9
(unnamed)	0.0	52.9	0.0
(unnamed)	0.0	535.3	2,220.5
Quatre Bayou Pass	1,090.4*	1,460.5*	1,850.4*
	6,661.5	7,395.1	12,774.5
Plaquemines Parish			
Quatre Bayou Pass	1,090.5*	1,460.5*	1,850.5*
(unnamed)	1,057.4	660.9	984.7
(unnamed)	343.7	0.0	247.7
(unnamed)	442.8	79.3	0.0
Chalaud Pass	1,255.7	191.7	119.0
(unnamed)	297.4	237.9	0.0
Grand Bayou Pass	2,313.0	1,949.6	2,154.4

Table D.2. Continued.

Plauqemines Parish - Cont'd

	1932	1954	1969
Bastian Pass	257.7	204.9	0.0
(unnamed)	746.8	165.2	0.0
(unnamed)	211.5	0.0	0.0
Empire to Gulf Waterway	0.0	185.0	185.0
(unnamed)	112.3	0.0	0.0
Scofield Bayou	271.0	284.2	297.4
Entrance to Sandy Point Bay	2,577.4	3,674.4	4,579.8
	10,977.2	9,093.6	10,428.5

*Parish boundary splits these passes. Total width of each pass marked by asterisk is double that given.

Source: Maps obtained from James P. Morgan.

Appendix E

Marsh Deterioration

Marsh deterioration constitutes a major problem in the Barataria Basin. Determination of land loss rates within environmental units should provide insights into marsh deterioration causes. This information is necessary for development of management methodologies and procedures concerning marsh maintenance and resource utilization. Gagliano (1970) developed a point-counting system for determining land-water ratios that has proven to be valuable in assessment of long-term changes in the marshlands. Information in this section concerns development of methods for measurement of short-term changes over a period of 10 to 15 years that occur in the marshland environmental units. This data could then be applied to either the environmental unit, parish, or basin level for considerations in resource planning and utilization. Aerial photographs, USGS quadrangle sheets (7 1/2' and 15' scale) and USGS orthophoto quadrangle maps (7 1/2' scale) were used. The time period for measuring comparative changes over an approximate 15-yr period involves three time periods. The time periods for Barataria Basin coverage were not always the same because of constraints on availability of uniform map and photo coverage. Generally, the beginning period fell within the 1956-60 range, with an in-between check at about 1971 and the third and last period 1973 or 1974.

Sample areas were selected within the environmental units and parishes from 9-in frames of aerial photography from available NASA missions. Selection of photos was based on the year flown, extent of coverage, and image quality. So that comparative changes could be measured, drawings were made from the photographs at the scale of the USGS quadrangle and orthophoto sheets. Computation of changes were made by utilizing the Colmagraphic 11 digitizing system in the Center for Wetland Resources.

Drawings showing only land-water interface were made from the 9-in aerial photos by reproducing the imagery on 35 mm slides with camera and flat field lens, projecting them on a drawing board, and carefully interpreting and tracing the land-water interface (Brown et al. 1975; Eng et al. 1974). Larger areas than the sample area were covered on the slide so that data near the edge of the projected image would not be utilized. This procedure minimized the effect of distortion. To achieve the best possible measurement accuracy, the projector lens was aligned perpendicular to the wall

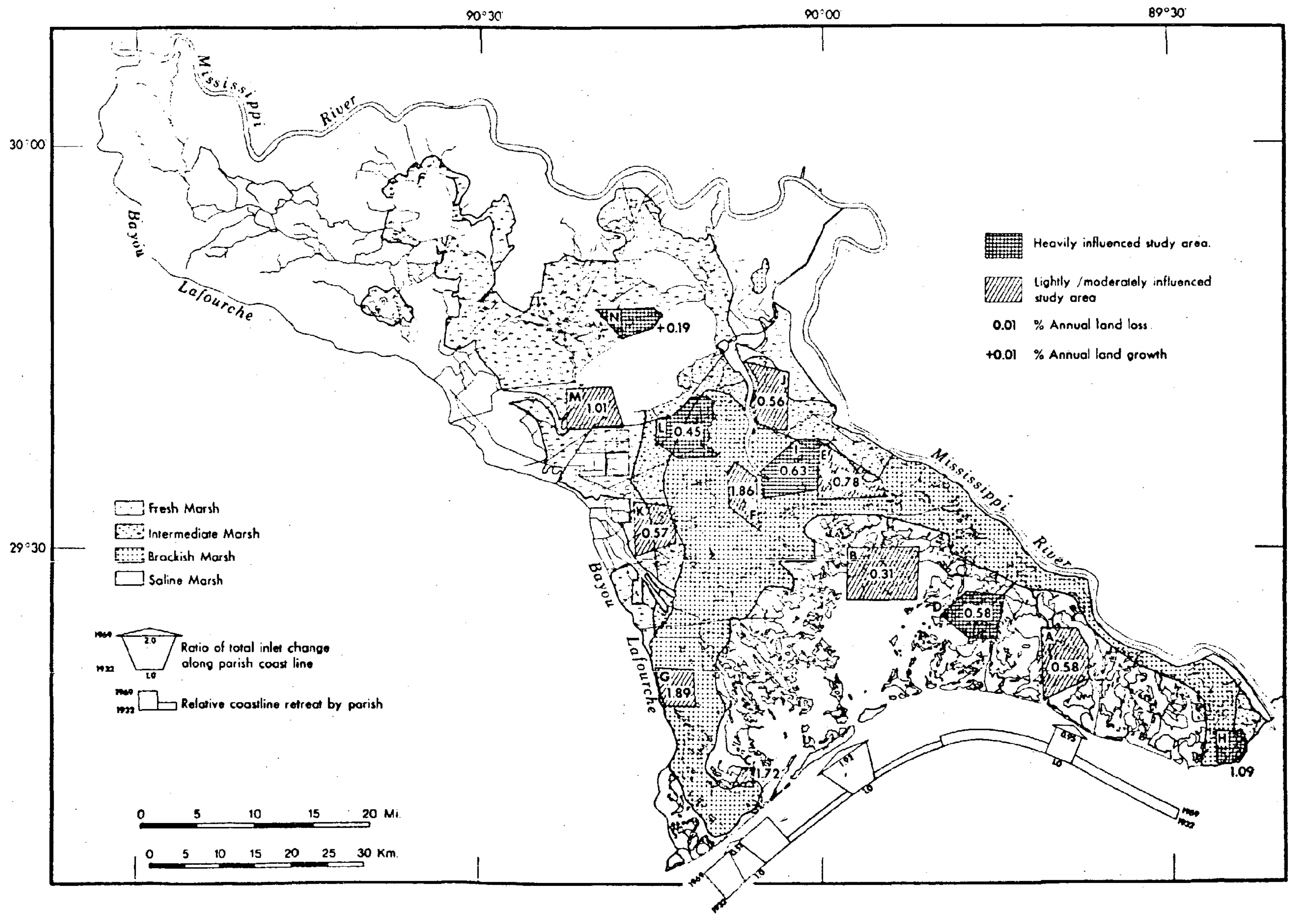

Fig. E.1. Coastal retreat and marsh deterioration by environmental unit and parish.

SAMPLE AREA - A (24.28 mi^2) (62.89 km^2)

Saline Marsh - Lightly/Moderately Impacted. This sample area is located in the southeastern section of the basin near the coast and Mississippi River (Fig. E.1). The area includes natural levees of Grand Bayou, marshlands, tidal channels, bay shorelines, canals, pipelines, and is adjacent to a large oil field.

Measurements of land-water changes consist of the following:

		mi^2	km^2
1960 (aerial photography) - Empire, La. USGS quadrangle map (1962 edition) 1:62,500			
Total water area	40.5%	9.84	(25.49)
Natural water area (39.4%)			
Man-made water area (1.1%)			
Total land area	59.5%	14.44	(37.40)
1971 (aerial photography) Port Sulphur, La. and Bastian Bay, La. USGS orthophoto maps (1973 edition) 1:24,000			
Total water area	43.3%	10.52	(27.26)
Natural water area (41.5%)			
Man-made water area (1.8%)			
Total land area	56.7%	13.75	(35.63)
1974 (aerial photography) NASA Mission 293 - Roll 7 - Color IR			
Total water area	45.3%	11.01	(28.52)
Natural water area (43.7%)			
Man-made water area (1.6%)			
Total land area	54.7%	13.27	(34.37)

Results:

1960-1974 - 4.8% land loss
1960-1974 - 1.17 mi^2 land loss
1960-1974 - 0.58% marsh loss per year
Average loss for 14 year period - 53.5 acres/year

SAMPLE AREA - B ($35.42\ mi^2$) ($91.76\ km^2$)

<u>Saline Marsh - Lightly/Moderately Impacted</u>. This sample area lies in the northern edge of Barataria Bay (Fig. E.1) and includes St. Mary's Point and a segment of the Barataria Bay Waterway. It differs from the other tracts in that it contains more water than land. Heavy boat traffic utilizes the Barataria Waterway. Erosion of the land areas would also be influenced by waves driven by south winds over the long fetch of the bay. Few man-made waterways are present in this area. Measurements of land-water changes consist of the following:

		mi^2	km^2
<u>1960</u> (aerial photography) Fort Livingston, La. USGS quadrangle map (1961 edition) 1:62,500			
Total water area	59.7%	21.15	(54.79)
Natural water area (59.5%)			
Man-made water area (0.2%)			
Total land area	40.3%	14.27	(36.97)
<u>1971</u> (aerial photography) Wilkinson Bay, La. USGS orthophoto map (1973 edition) 1:24,000			
Total water area	61.9%	21.93	(56.82)
Natural water area (61.7%)			
Man-made water area (0.2%)			
Total land area	38.1%	13.49	(34.94)
<u>1974</u> (aerial photography) NASA Mission 293 - Roll 7 - Color IR			
Total water area	61.4%	21.76	(56.38)
Natural water area (61.2%)			
Man-made water area (0.2%)			
Total land area	38.6%	13.66	(35.38)

Results:
1960-1974 - 1.7% land loss
1960-1974 - 0.61 mi^2 land loss
1960-1974 - 0.31% marsh loss per year
Average loss for 14 year period - 27.9 acres/year

SAMPLE AREA - C (2.24 mi^2) (5.80 km^2)

Saline Marsh - Lightly/Moderately Impacted. This example is located in the southwestern section of the basin (Fig. E.1). It includes parts of Lake Palourde, Lake Laurier, and Bayou Ferblanc. Impacts by man are mainly small. Measurements of land-water changes consist of the following:

		mi^2	km^2
1956 (aerial photography)			
Caminada Pass, La.			
USGS quadrangle map (1957 edition)			
1:24,000			
Total water area	48.7%	1.09	(2.82)
Natural water area (48.7%)			
Man-made water area (0%)			
Total land area	51.3%	1.15	(2.98)
1970 (aerial photography)			
NASA Mission 154 - Roll 37			
Black and white			
Total water area	61.5%	1.38	(3.57)
Natural water area (61.5%)			
Man-made water area (0%)			
Total land area	38.5%	0.86	(0.23)
1973 (aerial photography)			
NASA Mission 259 - Roll 23			
Color IR			
Total water area	63.7%	1.42	(3.69)
Natural water area (63.7%)			
Man-made water area (0%)			
Total land area	36.3%	0.81	(2.11)

Results:
1956-1973 - 15.0% land loss
1956-1973 - 0.34 mi^2 land loss
1956-1973 - 1.72% marsh loss per year
Average loss for 17 year period - 12.8 acres/year

The primary manifestation of deterioration for this area is the creation and enlargement of ponds in former marsh areas. Lake shoreline erosion is of secondary importance.

SAMPLE AREA - D (16.12 mi^2) (41.76 km^2)

Saline Marsh - Heavily Impacted. This sample area is located in the east central section of the basin (Fig. E.1) that includes the portion of the Lake Washington oil field exhibiting a high density of access canals, pipeline canals, and artificial impoundments (Fig. E.1). Measurements of land-water changes consist of the following:

		mi^2	km^2
1960 (aerial photography) Fort Livingston, La. and Empire, La. USGS quadrangle map (1961, 1962 editions respectively) 1:62,500			
Total water area	41.83%	6.74	(17.47)
Total land area	58.17%	9.38	(24.29)
1971 (aerial photography) Bay Batiste, La. and Port Sulphur, La. USGS orthophoto map (1973 edition) 1:24,000			
Total water area	49.07%	7.97	(20.49)
Total land area	50.93%	8.21	(21.27)
1974 (aerial photography) NASA Mission 293 - Roll 7 Color IR			
Total water area	46.51%	7.50	(19.42)
Total land area	53.49%	8.62	(22.34)

Results:
- 1960-1974 - 4.68% land loss
- 1960-1974 - 0.76 mi^2 land loss
- 1960-1974 - 0.58% marsh loss per year
- Average loss for 14 year period - 34.7 acres/year

SAMPLE AREA - E (20.72 mi^2) (53.66 km^2)

Brackish Marsh - Lightly/Moderately Impacted. This area lies in the east central section of the basin near the Mississippi River (Fig. E.1). It includes Lake Laurier, Round Lake, and part of Wilkinson Canal, a dredged navigation canal. It also has one small sector of rig access canals. Measurement of land-water changes consist of the following:

		mi^2	km^2
1961 (aerial photography) Pointe a la Hache, La. USGS quadrangle map (1964 edition) 1:62,500			
Total water area	27.8%	5.75	(14.89)
Natural water area (26.4%)			
Man-made water area (1.4%)			
Total land area	72.2%	14.97	(38.77)
1971 (aerial photography) Lake Laurier, La. USGS orthophoto map (1973 edition) 1:24,000			
Total water area	38.5%	7.97	(20.64)
Natural water area (36.9%)			
Man-made water area (1.6%)			
Total land area	61.5%	12.75	(33.02)
1974 (aerial photography) NASA Mission 293 - Roll 7 Color IR			
Total water area	35.1%	7.27	(18.84)
Natural water area (33.8%)			
Man-made water area (1.3%)			
Total land area	64.9%	13.44	(34.82)

Results:

1961-1974 - 7.3% land loss
1961-1974 - 1.53 mi^2 land loss
1961-1974 - 0.78% marsh loss per year
Average loss for 13 year period - 75.32 acres/year

SAMPLE AREA - F (13.25 mi^2) (34.34 km^2)

Brackish Marsh - Lightly/Moderately Impacted. This example lies in the central section of the basin southeast of Bayou Rigolettes and north of Turtle Bay, a northern extension of Little Lake (Fig. E.1). There are several large oil fields nearby, but only a few man-made waterways are present within this example. Impacts by land and water changes consist of the following:

		mi^2	km^2
1961 (aerial photography)			
Barataria, La.			
USGS quadrangle map (1964 edition)			
1:62,500			
Total water area	18.5%	2.45	(6.35)
Natural water area (15.9%)			
Man-made water area (2.6%)			
Total land area	81.5%	10.80	(27.99)
1971 (aerial photography)			
Three Bayou Bay, La. and Bay L'Ours, La.			
USGS orthophoto maps (1973 edition)			
1:24,000			
Total water area	31.1%	4.12	(10.67)
Natural water area (29.1%)			
Man-made water area (1.9%)			
Total land area	68.9%	9.14	(23.67)
1974 (aerial photography)			
NASA Mission 293 - Roll 7			
Color IR			
Total water area	38.1%	5.06	(13.10)
Natural water area (36.1%)			
Man-made water area (2.0%)			
Total land area	61.9%	8.20	(21.24)

Results:

1961-1974 - 19.6% land loss
1961-1974 - 2.6 mi^2 land loss
1961-1974 - 1.86% marsh loss per year
Average loss for 13 year period - 128.0 acres/year

SAMPLE AREA - G (7.75 mi^2) (20.08 km^2)

Brackish Marsh - Lightly/Moderately Impacted. This example lies on the extreme western side of the basin near the Bayou Lafourche natural levee (Fig. E.1). Measurements of land-water ratio are:

		mi^2	km^2
1956 (aerial photography)			
Mink Bayou, La.			
USGS quadrangle map (1957 edition)			
1:62,500			
Total water area	18.1%	1.40	(3.63)
Natural water area (17.6%)			
Man-made water area (0.5%)			
Total land area	81.9%	6.35	(16.45)
1972 (aerial photography)			
NASA Mission 194 - Roll 13			
Color IR			
Total water area	37.4%	2.90	(7.51)
Natural water area (34.3%)			
Man-made water area (3.1%)			
Total land area	62.6%	4.85	(12.57)
1974 (aerial photography)			
NASA Mission 293 - Roll 7			
Color IR			
Total water area	46.0%	3.57	(9.24)
Natural water area (42.7%)			
Man-made water area (3.3%)			
Total land area	54.0%	4.18	(10.84)

Results:
- 1956-1974 - 27.9% land loss
- 1956-1974 - 2.17 mi^2 land loss
- 1956-1974 - 1.89% marsh loss per year
- Average loss for 18 year period - 77.16 acres/year

This example shows the largest area of land loss for the basin. The loss is primarily due to lakeshore erosion. Ponding in former marsh is a secondary cause of loss.

SAMPLE AREA - H (7.68 mi^2) (19.89 km^2)

Brackish Marsh - Heavily Impacted. This sample area is located in the southeastern corner of the basin (Fig. E.1) and includes the Venice oil field. Access canals encircle the subsurface dome. Water exchange is dominated by tidal flow, with a possibility of minimal exchange via backwater flooding of Mississippi River waters discharging through Pass Tante Phine. Measurements of land-water changes consist of the following:

		mi^2	km^2
1958 (aerial photography) West Delta, La. and Forts, La. USGS quadrangle map (1958, 1960 editions respectively) 1:62,500			
Total water area	17.41%	1.34	(3.46)
Total land area	82.59%	6.34	(16.43)
1971 (aerial photography) Pass Tante Phine, La. and Triumph, La. USGS orthophoto maps (1973 editions) 1:24,000			
Total water area	26.83%	2.06	(5.34)
Total land area	73.17%	5.62	(14.55)
1974 (aerial photography) NASA Mission 293 - Roll 7 Color IR			
Total water area	31.87%	2.45	(6.34)
Total land area	69.13%	5.23	(13.55)

Results:
- 1958- 1974 - 13.46% land loss
- 1958-1974 - 1.11 mi^2 land loss
- 1958-1974 - 1.09% marsh loss per year
- Average loss for 16 year period - 44.4 acres/year

An extremely high rate of deterioration was seen within the area encircled by the major access canal, but fill is occurring on the southeast side where sediments are introduced from backwater flow out of Grand Pass. Although the rate of deterioration is high within the canal area, the overall rate for the sample area is lowered by the nearly stable marsh condition outside the ring canal area.

SAMPLE AREA - I (19.69 mi^2) (51.03 km^2)

Brackish Marsh - Heavily Impacted. This example is in the central section of the basin and includes the Lafitte Oil and Gas Field and a portion of the Barataria Waterway (Fig. E.1). Measurements of land-water ratio changes consist of the following:

1961 (aerial photography)
Barataria, La.
USGS quadrangle map (1964 edition)
1:62,500

		mi^2	km^2
Total water area	24.35%	4.79	(12.42)
Total land area	75.65%	14.90	(38.61)

1971 (aerial photography)
Three Bayou Bay, La.
USGS orthophoto map (1973 edition)
1:24,000

		mi^2	km^2
Total water area	32.80%	6.46	(16.74)
Total land area	67.20%	34.29	(34.29)

1974 (aerial photography)
NASA Mission 293 - Roll 7
Color IR

		mi^2	km^2
Total water area	30.53%	6.01	(15.58)
Total land area	69.47%	13.68	(35.45)

Results:
1961-1974 - 6.18% land loss
1961-1974 - 1.22 mi^2 land loss
1961-1974 - 0.63% marsh loss per year
Average loss for 13 year period - 60.1 acres/year

Areas of marsh on the natural levee are stable, but areas in the levee-flank depression are extremely deteriorating rapidly.

SAMPLE AREA - J (30.62 mi^2) (79.32 km^2)

Intermediate Marsh - Lightly/Moderately Impacted. This example lies near the Mississippi River in the northeastern section of the basin. It includes the Pen, a 1917 marsh reclamation project that is now flooded (Fig. E.1). Land-water measurements consist of the following:

		mi^2	km^2
1961 (aerial photography)			
Barataria, La.			
USGS quadrangle map (1964 edition)			
1:62,500			
Total water area	26.4%	8.07	(20.91)
Natural water area (23.9%)			
Man-made water area (2.5%)			
Total land area	73.6%	22.55	(58.41)
1971 (aerial photography)			
Lafitte, La.			
USGS orthophoto maps (1973 edition)			
1:24,000			
Total water area	30.1%	9.22	(23.88)
Natural water area (26.8%)			
Man-made water area (3.3%)			
Total land area	69.9%	21.40	(55.44)
1974 (aerial photography)			
NASA Mission 293 - Roll 7			
Color IR			
Total water area	31.7%	9.70	(25.12)
Natural water area (28.7%)			
Man-made water area (3.0%)			
Total land area	68.3%	20.92	(54.19)

Results:
- 1961-1974 - 5.3% land loss
- 1961-1974 - 1.63 mi^2 land loss
- 1961-1974 - 0.45% marsh loss per year
- Average loss for 13 year period - 80.2 acres/year

Marsh ponding and pond enlargement primarily account for reduction of vegetated marsh.

SAMPLE AREA - K (13.92 mi^2) (36.06 km^2)

Intermediate Marsh - Lightly/Moderately Impacted. This example lies to the east of Clovelly Farms and to the west of Little Lake in the very narrow band of intermediate marsh (Fig. E.1). How much this band of intermediate marsh has changed since Chabreck (1972) surveyed it in 1968 is unknown.

		mi^2	km^2
1962 (aerial photography) Cut Off, La. USGS quadrangle map (1963 edition) 1:24,000			
Total water area	17.5%	2.44	(6.31)
Natural water area (16.3%)			
Man-made water area (1.2%)			
Total land area	82.5%	11.48	(29.75)
1972 (aerial photography) NASA Mission 194 - Roll 13 Color IR			
Total water area	20.2%	2.81	(7.28)
Natural water area (18.3%)			
Man-made water area (1.9%)			
Total land area	79.8%	11.11	(28.78)
1974 (aerial photography) NASA Mission 293 - Roll 7 Color IR			
Total water area	23.1%	3.22	(8.33)
Natural water area (20.6%)			
Man-made water area (2.5%)			
Total land area	76.9%	10.70	(27.73)

Results:
1962-1974 - 5.6% land loss
1962-1974 - 0.78 mi^2 land loss
1962-1974 - 0.57% marsh loss per year
Average loss for 12 year period - 41.6 acres/year

SAMPLE AREA - L (19.78 mi^2) (51.24 km^2)

Intermediate and Brackish Marsh - Heavily Impacted. This sample area, fronting Bayou Perot to the east, the West Delta Farms Oil Field and Delta Farms Oil and Gas Field, is an example of a heavily impacted system (Fig. E.1). Bayou Perot flows from Lake Salvador and cuts across the Intracoastal Waterway lying just north of the example, then turns to the south and flows into Little Lake in its journey to Barataria Bay and the Gulf of Mexico. Bayou Perot, as it flows past this site, serves as the drainage route for water flowing from approximately 75% of Barataria Basin's freshwater marsh and swamp. This locale is subject to both wind-influenced tidal flow and freshwater surplus.

		mi^2	km^2
1961 (aerial photography) Barataria, La. USGS quadrangle map (1964 edition) 1:62,500			
Total water area	16.15%	3.19	(8.27)
Total land area	83.85%	16.59	(42.97)
1971 (aerial photography) Barataria, La. and Bay L'Ours, La. USGS orthophoto map (1973 edition) 1:24,000			
Total water area	18.03%	3.57	(9.24)
Total land area	81.97%	16.21	(42.00)
1974 (aerial photography) NASA Mission 293 - Roll 7 Color IR			
Total water area	21.09%	4.17	(10.81)
Total land area	78.91%	15.61	(40.43)

Results:
1961-1974 - 4.94% land loss
1961-1974 - 0.98 mi^2 land loss
1961-1974 - 0.45% marsh loss per year
Average loss for 13 year period - 48.2 acres/year

SAMPLE AREA - M (18.72 mi^2) (48.49 km^2)

Fresh Marsh - Lightly/Moderately Impacted. This example is on the southwest shore of Lake Salvador and includes part of this lake (Fig. E.1). It is directly north of Delta Farms (agricultural reclamation area). Relict natural levee features of a small distributary are present. Waves generated in the long fetch of this lake cause erosion along its bank. Dense concentration of water hyacinth in this area produced problems in determining the boundary between marsh vegetation and hyacinth from the photographs. In this case, the figures may show less loss than actually occurred.

		mi^2	km^2
1962 (aerial photography) Catahoula Bay, La. USGS quadrangle map (1963 edition) 1:24,000			
Total water area	29.1%	5.45	(14.11)
Natural water area (27.0%)			
Man-made water area (2.1%)			
Total land area	70.9%	13.27	(34.38)
1972 (aerial photography) NASA Mission 194 - Roll 13 Color IR			
Total water area	34.8%	6.51	(16.87)
Natural water area (32.1%)			
Man-made water area (2.7%)			
Total land area	65.2%	12.21	(31.62)
1974 (aerial photography) NASA Mission 293 - Roll 7 Color IR			
Total water area	37.7%	7.06	(18.28)
Natural water area (34.4%)			
Man-made water area (3.3%)			
Total land area	62.3%	11.66	(30.21)

Results:
1962-1974 - 8.60% land loss
1962-1974 - 1.61 mi^2 land loss
1962-1974 - 1.01% marsh loss per year
Average loss for 12 year period - 85.9 acres/year

The 1962 map shows very few ponds, however, by 1972 extensive ponding has occurred causing a 5.7% land loss. Increase in the size of the ponds and a slight increase in the area of man-made waterways caused a 2.9% increase in water area from 1972 to 1974, a significant land loss for such a short period of time.

SAMPLE AREA - N (9.54 mi^2) (24.73 km^2)

Fresh Marsh - Heavily Impacted. This sample area includes the Bayou Couba Oil and Gas Field that lies along the northwest shore of Lake Salvador, six miles northeast of the mouth of Bayou des Allemands (Fig. E.1). Access to the field is limited to one canal from Lake Salvador, the canal's opening partially protected by Couba Island.

		mi^2	km^2
1965 and 1964 (aerial photography) Lake Cataouatche West, La. and Lake Cataouatche East, La. USGS quadrangle map (1967, 1966 editions respectively) 1:24,000			
Total water area	17.00%	1.62	(4.20)
Total land area	83.00%	7.92	(20.53)
1972 (aerial photography) NASA Mission 194 - Roll 2 Color IR			
Total water area	16.87%	1.61	(4.17)
Total land area	83.13%	7.94	(20.56)
1974 (aerial photography) NASA Mission 293 - Roll 7 Color IR			
Total water area	15.61%	1.49	(3.86)
Total land area	84.39%	8.06	(20.87)

Results:
1965-1974 - 1.39% land gain
1965-1974 - 0.14 mi^2 land gain
1965-1974 - 0.19% marsh gained per year
Average gain for 9 year period - 10.0 acres/year

Bayou Couba Oil and Gas Field showed a consistent rate of marsh and canal fill over the three study dates, 1965, 1972, and 1974. Canals consistently showed fill throughout all portions of the site and marsh areas at a distance from the canals showed not only displacement of ponds from example to example, but often complete fill.

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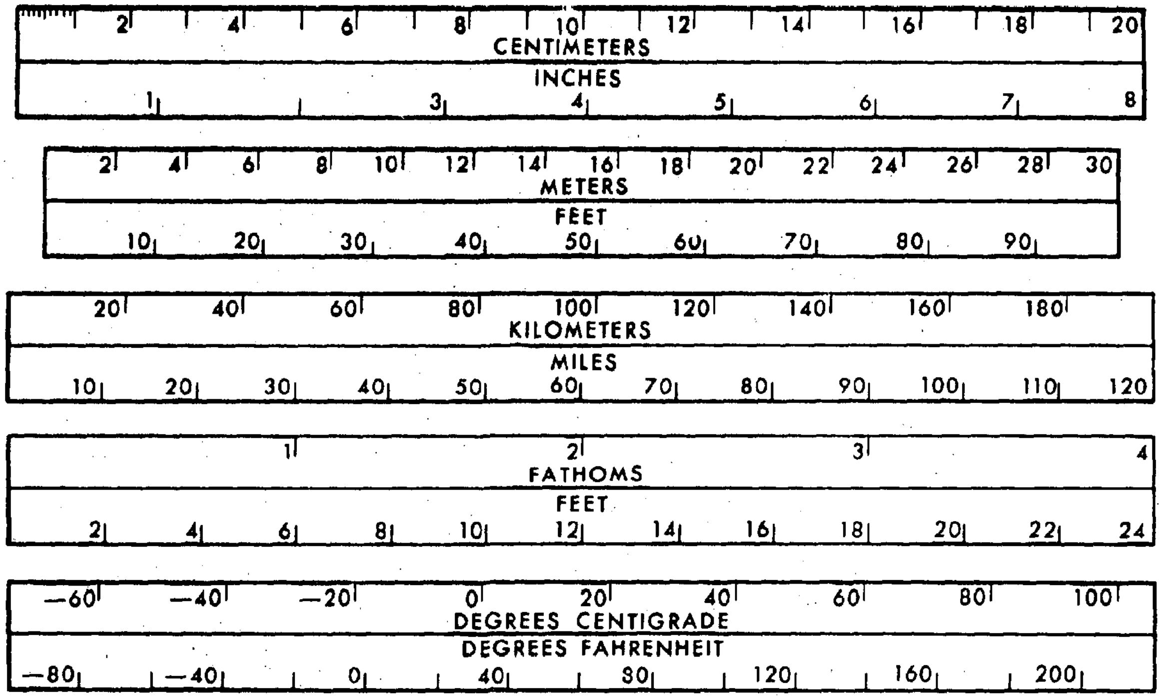

CONVERSION FACTORS

LENGTH

1 inch	=	2.54 centimeters	1 centimeter	=	0.40 inch
1 inch	=	25.40 millimeters	1 millimeter	=	0.04 inch
1 foot	=	0.30 meter	1 meter	=	3.28 feet
1 yard	=	0.91 meter	1 meter	=	1.09 yards
1 fathom	=	1.83 meters	1 meter	=	0.55 fathom
1 fathom	=	6.00 feet	1 meter	=	39.37 inches
1 foot	=	0.17 fathom	1 meter	=	100 centimeters
1 mile	=	1.61 kilometers	1 kilometer	=	0.62 mile
1 mile	=	1609.34 meters	1 kilometer	=	1000 meters
1 mile	=	5280 feet	1 kilometer	=	3280.84 feet

AREA

1 foot^2	=	0.09 meter^2	1 meter^2	=	10.76 feet^2
1 yard^2	=	0.84 meter^2	1 meter^2	=	1.20 yards^2
1 mile^2	=	2.59 kilometers^2	1 kilometer^2	=	0.39 mile^2
1 acre	=	0.40 hectare	1 hectare	=	2.47 acres

VOLUME AND CAPACITY

1 foot^3	=	0.03 meter^3	1 meter^3	=	35.31 feet^3
			1 meter^3	=	264.17 gallons (US)

VELOCITY

1 foot/second	=	0.68 mile/hour	1 meter/second	=	3.60 kilometers/hour
1 foot/second	=	1.10 kilometers/hour	1 meter/second	=	2.24 miles/hour
1 foot^3/second	=	0.03 meter^3/second	1 meter^3/second	=	35.31 feet^3/second
1 mile/hour	=	1.47 feet/second	1 kilometer/hour	=	0.91 foot/second
1 mile/hour	=	0.45 meter/second	1 kilometer/hour	=	0.28 meter/second

TEMPERATURE

°Fahrenheit	=	9/5 (°C + 32)	°Centigrade	=	5/9 (°F - 32)

[redacted]