ENVIRONMENTAL ASPECTS OF GAS PIPELINE OPERATIONS IN THE LOUISIANA COASTAL MARSHES

Battelle
Columbus Laboratories

FINAL REPORT

on

ENVIRONMENTAL ASPECTS OF GAS PIPELINE OPERATIONS IN THE LOUISIANA COASTAL MARSHES

to

OFFSHORE PIPELINE COMMITTEE

December, 1972

by

John T. McGinnis, Robert A. Ewing, Charles A. Willingham,
Sharron E. Rogers, Dorothy H. Douglass, and David L. Morrison

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

The following companies are members of the Offshore Pipeline Committee who sponsored this program:

Columbia Gulf Transmission Company

Michigan Wisconsin Pipe Line Company

Natural Gas Pipeline Company of America

Southern Natural Gas Company

Tennessee Gas Transmission Company

Texas Eastern Transmission Corporation

Texas Gas Transmission Corporation

Transcontinental Gas Pipe Line Corporation

Trunkline Gas Company

United Gas Pipe Line Company

This report has been reproduced
on 100 percent recycled paper.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF FIGURES

ENVIRONMENTAL ASPECTS OF GAS PIPELINE OPERATIONS IN THE LOUISIANA COASTAL MARSHES

by

John T. McGinnis, Robert A. Ewing, Charles A. Willingham, Sharron E. Rogers, Dorothy H. Douglass, and David L. Morrison

CHAPTER 1. INTRODUCTION

Development of our domestic reserves of gas and oil is necessary to assure continued supply of energy for the United States. Toward that end, the U. S. Department of the Interior has announced a series of offshore lease sales. Of particular importance to the Offshore Pipeline Committee are the sales in the Gulf of Mexico, and a tentative schedule is proposed for sales over a period of 5 years.

At the same time that the nation is experiencing the pressures of an increased demand for energy with a decrease in present sources of supply, we are recognizing the ecological significance of our coastal marshes and estuary systems. Steps are being taken by the Federal government to adopt an active management plan and tighter control over the marshlands. The issue concerning wetlands development is primarily that due to the very high multipurpose productivity of these areas past and present and that these areas should be maintained for present and future yields whether the benefits are of either direct or indirect use to man.

Over the past few years, certain events have occurred to heighten attention to the coastal zone and wetlands of the United States. Oil pollution on the California and Gulf Coasts, particularly the Santa Barbara Channel, focused national attention to the coastal zone. Demand for agricultural, recreational areas, and second homes along the seashores has brought added pressures for the past several decades. Burgeoning coastal cities have literally spilled over into the adjacent wetlands as population pressures and technology has allowed.

These demands have come almost simultaneously with our increasing knowledge of the value of these wetlands and our increasing understanding of our long-term dependence upon them. Conflict of interests between a wide variety of individual users of land has led this nation's lawmakers to provide for the development of policies for multiple use and management of all of the nation's lands.

General legislation with a direct bearing on the wetlands includes the Rivers and Harbors Act of 1899 and the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500). These laws provide for a permit system necessary for any construction and waste discharge activities within the intertidal zone. In addition, 3.5 of the 7 million acres or half of the wetlands in Louisiana are intertidal over which the Corps of Engineers has jurisdiction. The National Environmental Policy Act of 1969 (P.L. 91-190) was a large and important step toward providing for the comprehensive consideration of our environment in planning present and future activities. The administrative requirements for evaluation of the environmental impacts of proposed actions by Federal agencies is embodied in this law. In accordance with this Act, the responsible Federal official is required to file a detailed statement on

(1) The environmental impact of the proposed offshore lease sales

(2) Any adverse environmental effects which cannot be avoided should the proposed lease sales be made

(3) Alternatives to the proposed lease sales

(4) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity

(5) Any irreversible and irretrievable commitments of resources which would be involved in the proposed offshore lease sales.

Such environmental impact statements were prepared off the Louisiana marsh area for (1) the 1972 Outer Continental Shelf Oil and Gas General Lease Sale, Offshore Eastern Louisiana and (2) 1972 Outer Continental Shelf Oil and Gas General Lease Sale, Offshore Louisiana.

These laws are directly regulatory and set philosophies but do not point out particularly important areas nor provide for state and national management guidelines. The Land Use Planning and Policy Assistance Act of 1972 would provide, if enacted, for these. Its provisions include (1) Department of the Interior administration, (2) a National Advisory Board, (3) Grants-in-Aid, and (4) coordination of planning and management of Federal land and adjacent non-Federal lands.

The importance of the coastal zone of the United States is further indicated by the National Coastal Zone Management Act of 1972 (P. L. 92-583). This legislation provides for the development of Federal and state programs for coastal zone management. In addition, it provides Federal interagency coordination and cooperation, grants for acquiring estuarine sanctuaries, and the establishment of a National Coastal Resources Board. This legislation will serve to coordinate, guide, and unify these efforts. The Gulf coastal wetlands became a particularly important center for implementation of local and governmental management interests both because of already extensive management to maximize utility of productive resources, and because 45 percent of the nation's wetlands occur here.

Because of the dependence of the migratory waterfowl on the Gulf Coast wetlands, some special international agreements are being made. These include the Convention Between the United States of America and the Mexican States for the Protection of Migratory Birds and Game Mammals.

The gas transmission industry through the Offshore Pipeline Committee has accepted its responsibility toward all of these goals - development of energy resources, coastal zone management, and environmental quality - and is seeking a way to achieve the optimum balance among these often conflicting goals. Development of the leases offshore Louisiana will require traversing of the marshlands by pipeline operations. The importance of this area to the nation's economy and environment is already clearly indicated by the multiple uses of Louisiana coastal marshes - oil and gas pipeline operations, industrial development, agriculture, navigation, commercial and sport fisheries, fur industries, recreation, wildlife preserves, etc. For orderly development to take place, it is necessary to provide a perspective for the environmental aspects of pipeline operations among the multitude of stresses, natural and man-induced, on the Louisiana marshland environment.

This report to the Offshore Pipeline Committee presents the results obtained on a study by Battelle with the objective of providing an overview of the broad environmental issues confronting the gas pipeline industry. The emphasis of this study is on the coastal marshes themselves, i.e., from the low water line at the Gulf of Mexico to high ground some 20 to 40 miles inland. Efforts by Battelle included:

- Developing and documenting the existing knowledge on the environmental effects of gas pipeline operations in the marshlands
- Identifying the gaps in existing data required to predict the consequences of additional pipeline operations and defining programs to fill these data gaps
- Formulating general conclusions, based upon the present state of knowledge, of the impacts of developments following the offshore lease sales.

Specific impacts of a particular pipeline development depend, of course, on the specifics of the site and the construction techniques used. This report because of its scope does not purport to address these specific impacts but rather will serve as a general background document for all subsequent environmental impact assessments. The study was initiated at such a time that the major focus of attention was on the Louisiana general sale, but the information being developed should be applicable to developments involving all marshland types.

APPROACH

In order to implement the objectives in a systematic and comprehensive manner, several procedural steps were developed and followed through the course of the study. This systematic approach permitted the development of information and concepts in a continuous and progressive way which would lead to the evolution of an assessment system for the gas pipeline industry.

The procedural steps employed were to:

(1) Define the issue of concern expressed by the public and the industry and to which future environmental assessment systems and evaluations must be directed.

(2) Develop a methodology for the orderly assemblage of information and data whereby all aspects of environmental impacts receive adequate consideration.

(3) Assemble descriptive information inclusive of the gas pipeline industry actions and components of the environment expected to respond to the actions of the industry.

(4) Define ranges of values identified from the literature and expert sources on changes expected to occur, and organize these potential

effects so that the significance of the magnitude and importance of the changes may be evaluated.

(5) Establish a perspective for environmental gas pipeline effects such that planners and decision makers can rationally judge the specific environmental effect for a projected pipeline case. Also to select measures which will result in a minimization of undesirable effects with maximization of benefits to the public and nature.

Because of the high productivity of the gulf coastal ecosystems and their concomitant complexity, an information study matrix was developed. Matrices have been similarly used[1,2] as a vehicle for organizing information and data and further they insure that each possible interaction category will be evaluated in an equally systematic manner. Additionally, the system provides the study team a uniform broadened scope and stimulates interaction between areas. The study matrix (Figure 1.1) contains, across the top, those activities of the gas pipeline activities which may have impact upon the human and natural environment. The vertical column contains groups of similar categories defined as components of environmental significance worthy of separate consideration. Each of these components represent terms of intermediate generality and to which information can be easily directed.

The key level in the assessment of environmental impacts is however, that of the more specific environmental elements of the wetlands and how they respond to the causative actions of the industry. These are listed in Appendix B. The entries contribute the detailed information and data requirements for an overall wetland evaluation framework and likewise is applicable for specific pipeline projects.

REFERENCES

(1) Leopold, L. B., Clarke, F. E., Hanshaw, B. B., and Balsley, J. R., "A Procedure for Evaluating Environmental Impact", U. S. Geological Survey Circular 645 (1971), 13 pp.

(2) "Design of an Environmental Evaluation System", Final Report to the Bureau of Reclamation, U. S. Department of the Interior, from Battelle, Columbus Laboratories (June 30, 1971), 61 pp.

Gas Pipeline Industry Activities			Construction										Operation										
Existing Conditions and Characteristics			Access canals	Access roads	Ditching and dredging	Spoil banks	Filling and berming	Station sites	Grounds-nonstructural	Power transmission and comm.	Camps	Noise	Pipeline operation-physical	Station sites-physical	Liquid releases	Atmospheric releases	Fuel and oil spillage	Noise	Grounds maintenance	Access canal maintenance	Access road maintenance	Fill and berm maintenance	Pipeline leakage and repair
Physical and Chemical	Terres-trial	Land form																					
		Earth																					
		Groundwater																					
		Atmosphere																					
	Aquatic	Streams and rivers																					
		Ponds and lakes																					
		Estuaries																					
		Marine waters																					
Biological	Terrestrial	Plant communities																					
		Game animals																					
		Nongame animals																					
		Birds																					
		Insects																					
		Rare and endangered species																					
	Aquatic	Pond and lake biota																					
		Stream biota																					
		Fisheries																					
		Nursery																					
		Food chains																					
		Rare and endangered species																					
	Cultural	Employment																					
		Community																					
		Life style																					
		Recreation																					
		Aesthetics																					
		Wilderness and scientific value																					
		Health and safety																					
	Land Use	Agriculture																					
		Natural areas																					
		Management areas																					
		Governmental																					
		Industrial and commercial																					
		Municipal																					
		Energy, mining, and quarrying																					
		Transportation and communication																					
		Other utilities																					
		Other special																					

FIGURE 1.1. INFORMATION STUDY MATRIX

CHAPTER 2. BACKGROUND – GAS PIPELINING AND THE LOUISIANA MARSHLANDS

STUDY AREA

Since the intent of this project is to examine the environmental aspects of pipeline operations on the Louisiana coastal marshes, the study area is defined as the low-water line at the Gulf of Mexico to the higher ground some 20 to 40 miles inland. The area is approximately bounded by the thirtieth parallel on the north and includes the parishes of

Cameron	St. John the Baptist
Calcasieu	St. Charles
Vermilion	Jefferson
Iberia	Orleans
St. Mary	St. Bernard
Terrebonne	St. Tammany
Lafourche	Plaquemines

Bayous, ponds, and standing water characterize this area (see Figure 2.1). In addition to gas pipelining, other industries and activities sharing the marshlands are

Mining – oil, gas, sulfur, salt
Agriculture, forestry, fisheries
Hunting and trapping
Construction
Manufacturing
Navigation
Recreation.

A detailed discussion of gas pipeline operations, the marshland ecosystems, and the socioeconomic patterns in the coastal Louisiana area is provided in the subsequent sections of this chapter to provide a descriptive basis for the evaluation of environmental effects.

DESCRIPTION OF GAS PIPELINE OPERATION

Gas from offshore wells is brought ashore at numerous locations along the coast of Louisiana, typically in pipelines from 12 to 30 inches in diameter. Since the entire coast is marshy, there is essentially no firm high ground on the Gulf Coast; these lines must generally transverse many miles of marshes and bays or bayous before reaching ground firm enough for conventional pipe laying. Two methods are used for all medium to large diameter pipe. These are commonly referred to as "push" or "shove" and "flotation" and a pipeline may employ both, depending upon the nature of the marsh terrain traversed. These lands vary widely in nature from soft to firm, and this significantly affects the method of pipe laying. Surveillance and maintenance considerations may also affect local application of alternative methods.

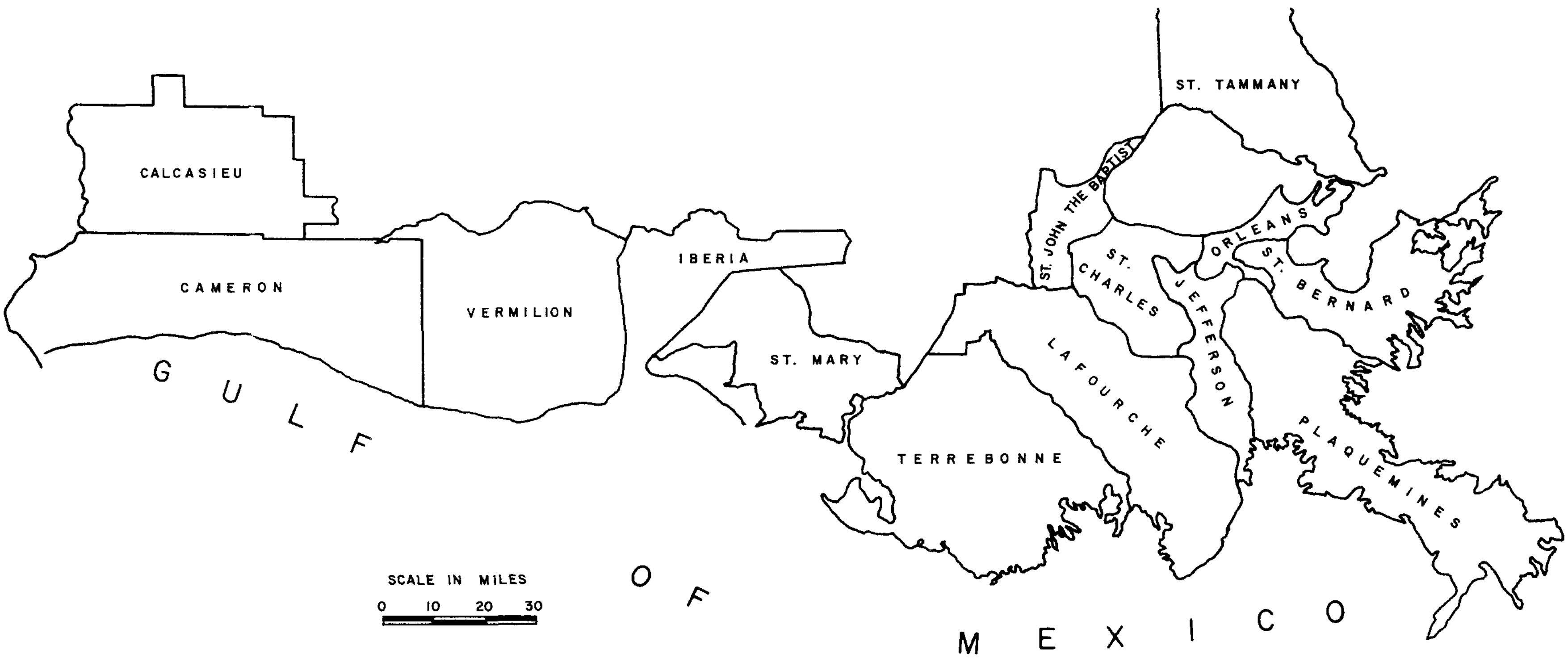


FIGURE 2.1. STUDY AREA

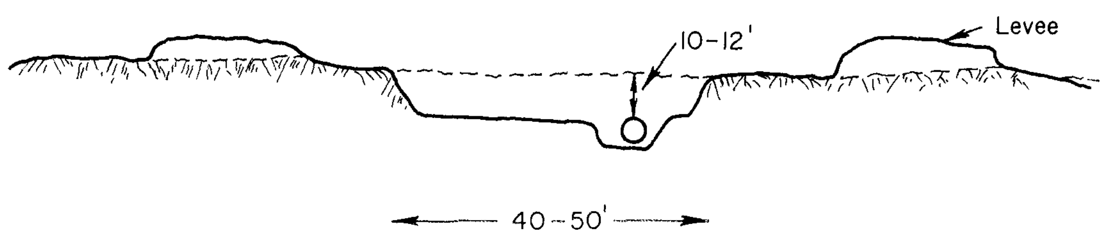
"Push" Method of Pipelining

The "push" or "shove" technique is possible only where the marsh is firm. In this technique, a narrow, relatively shallow ditch is excavated by a dragline or clam-shell digger from the bank. By using a marsh buggy base or by using runners or pads to spread the weight, the damage to the bank is minimized. The ditch may be 4 to 6 ft deep by 8 to 10 ft wide. The pipe sections are joined together at the point of origin of the ditch, the line given temporary buoyancy by strapped floats, and pushed or shoved down the ditch. A section as much as 15 miles long can be installed in this fashion. After being floated into place the floats are cut loose and the line allowed to sink to the bottom of the ditch. Typically, there will be approximately 4 feet of water above the pipe. The ditch may be left open but is more frequently backfilled. Even with firm marsh, there is generally sufficient subsidence and shrinkage that the spoils will not completely fill the ditch. However, there usually is no canal after completion.

The shove technique is less costly than using flotation barges, and is preferred where possible.

"Flotation" Method of Pipelining

The second method of pipe laying utilizes a flotation canal to provide access for the pipe-laying equipment. Such a canal may be 40 to 50 feet wide and 6 to 8 feet deep, and may have an additional trench in the bottom to provide 10 to 12 feet clearance above the top of the pipeline.



The pipeline is constructed on a series of lay barges and passed over the stern of the train. The pipe is large and heavy, and massive equipment is needed to manipulate it. For example, a standard 40-ft section of 36-inch-diameter pipe weighs approximately 8,000 lb. After the addition of a corrosion coating and 3 to 4 inches of concrete to give it negative buoyancy, a 40-ft section weighs about 34,000 pounds. Equipment to handle weights of this magnitude cannot be supported by the marsh.

This type of canal is excavated by a flotation dredge, which normally piles the spoils upon each side to form a low levee. Characteristically, where this type of canal-ing is carried on, the marshes are soft and unstable, sometimes to the point of being near-floating marshes.

Generally, the spoils are piled back some distance from the canal to leave a 30 to 40-foot berm between the canal and the levee. The levees are characteristically low and flat. Depending upon the width and depth of the canal (which determines the quantity of the spoils) and on their stability, a levee may be 3 to 5 feet high and possess a base width of 50 to 85 feet. The high water content (50-80 percent) and the organic nature of the excavated muck leads to major shrinkage and subsidence when piled on top of marshland with similar properties. Height reductions of 50 percent are possible. As noted by Nichols[(1)]* "the paramount factor in the permanence of a levee is the type of marsh upon which the levee is placed. The condition of the marsh at the time the levee is placed is of great importance. When water is over the marsh the surface material is supersaturated and becomes very weak and almost fluid. Poorly shaped levees which spread across the marsh result from this condition".

Because of these factors, there are never enough spoils from the excavation to backfill a flotation canal. Where canals traverse state-owned land or wildlife refuges, very stringent conditions may be attached to the right-of-way grant with the objective of minimizing impact on the territory, and these may include backfilling a flotation canal. In one recent example, nearly 2 miles of flotation canal crossing a wildlife refuge were backfilled. However, as usual there was insufficient spoil material, and additional backfill (nearly 160,000 cubic yards) had to be dredged from a nearby bayou and lake. Backfilling with foreign material on a large scale is probably economically unfeasible, and the environmental impacts of the extensive additional dredging required are unknown but probably not insignificant.

In the past, levees were characteristically continuous, with few or no breaks. More recently, the Louisiana Wildlife and Fisheries Commission has required openings to be cut in levees in order to minimize disturbances to existing drainage and use patterns. For example, in several recent canals in the Atchafalaya Basin, one 30-mile canal had 250 openings, and in another 9-mile canal, 72 spoil bank openings were made.[(2)]

In the course of laying such a line through marshland, numerous bodies of open water will also be traversed. The same equipment may be used, although only a trench will be dredged, or the assembled line can be jetted into place. Hydraulic dredges are also used for open water traverses. Hydraulic dredge spoils may be pumped to nearby land, dispersed over the nearby area, or piled up in a spoil island, depending on the particular situation.

Treatment of completed canals, whether "push" or "flotation" is a matter of negotiation between the pipeline owner and the owner of the land being traversed. Land owners may require bulkheads or plugs or dams wherever a canal intersects another waterway, in order to minimize erosion and to prevent navigation traffic, which is a prime cause of erosion. One reason for the concern about erosion is that, according to Louisiana law, water bottoms belong to the state, and the land area lost by erosion reverts to the state (as do any mineral rights underlying). Thus, there is a real economic incentive for the landowner to insist on minimizing the opportunities for erosion.

As an example of the preventive measures taken, for one 284-mile line constructed in the late 1950's which crossed 135 navigable streams, 240 bulkheads were constructed.

The types of dredging equipment used and the various methods of spoil deposition employed were described by Chapman[(3)], and are shown in the Table 2.1. The hopper

*References are given on pages 2.49-2.51.

TABLE 2.1. DREDGING EQUIPMENT AND SPOIL DISPOSITION(3)

Dredging Equipment and Method	Principal Use	Disposition of Spoil	Spoil Control	Comments
		Mechanical Dredge		
Bucket and dragline	Small channels	Place adjacent to channel	Small spoil area; minimum turbidity	Usually the preferred method; problem exists of blocking drainage and reducing water exchange or circulation
		or		
		Place on barge	Remove from site	High cost usually prohibitive
		Hydraulic Dredge		
Hopper	Large channels	Remove from site to designated spoil area of preferably low-value habitat	Excellent at site; moderate at discharge point where turbidity is frequently high	Used where spoil area is not available near site or where adjacent spoil deposition would increase maintenance dredging
Pipe discharge	Large and medium-size channels	Place in mounds adjacent to channel	Very poor unless spoil is retained by ring levee. Turbidity is high without ring levee and spoil area is large	Danger exists of segmenting bays and blocking drainage, tidal exchange, or circulation. Destruction of shallow bay and marshes by filling creates a major problem
Side broadcast discharge	Large channels	Scattered in layer over large area of bottom adjacent to channel	Depth of spoil on bottom can be controlled. Spoil area is large, turbidity is high, and silt is dispersed by currents	Can prevent bay segmentation but very large areas of water bottoms can be silted. Needs more study.

hydraulic dredge is not believed to be much used for gas pipelining; spoils are discharged adjacent to the dredged area.

Ancillary Facilities

A certain amount of condensate is generally associated with natural gas, low in "dry" wells and sometimes substantial in "wet" wells. Separation is not normally performed offshore, but at a conventient location soon after the gas comes ashore. These onshore terminals may include condensate strippers, dewatering devices, compressors, and storage tanks, and may require several acres of marshland for a site. Due to the general unavailability of high ground at the locations needed, such a site will almost always require some filling, shell being frequently used.

In the operation of an onshore terminal, some wastes are generated which must be disposed of. These may include such items as water stripped from the gas, used compressor oil, human wastes, etc. These wastes are disposed of in accordance with the current requirement of state and federal agencies.

Additional compressor stations are needed at intervals (50 to 100 miles) along the line to push the gas along; each one of these sites will require dedication of a few acres of land to this purpose.

General Construction Operations

As with any major engineering effort there are a number of actions and effects from the general pipeline construction operations irrespective of the type of canal constructed. Either type requires surveying and an alignment established and marked. Marsh buggies have normally been used for this operation; these may have a permanent effect on the marshes, especially some softer ones. Even though wide tracks are used, and the unit pressure on the soil is low, the weak marsh structure is compressed and depressed tracks are left. These may not be self-repairing in some cases because of their depth, and may act as erosion foci.

Similarly, when bank-supported draglines are used to dredge push canals, the berm may be damaged, even when pads are used, if the marsh is soft.

In the construction of a flotation canal and laying of a pipeline, there also can be erosion effects upon the canal from the ancillary boat traffic bringing men and materials to the site but this is a short term effect.

LOUISIANA MARSHLAND ECOSYSTEMS

Terrestrial Ecology

Introduction

The entire coastline of Louisiana from Texas to Mississippi is characterized by a wetland area. Separating the higher land from the Gulf of Mexico, the wetlands average 20 to 40 miles in width. Bayous, ponds, and standing water characterize this area.

Geologically, the Mississippi River is responsible for the existence of this land. The wanderings and meanderings of the river with its tremendous silt load have brought about the formation of this wide deltaic region. Silt deposition over many years led to land formation. Once a portion of this land is cut off from new silt by a change in the river course, natural compaction and concomitant subsidence follows, producing extensive areas of marsh with the development of meandering streams and bayous leading in a general north-south orientation to the seaward bays and finally the Gulf. The continuous flow of fresh water through these systems puts a positive pressure against the tidal pressures of open water thereby controlling the degree of saltwater intrusion.

The extensive management of the Mississippi River flow by man for flood control has led to a lessening of this freshwater pressure, and thus may contribute to saltwater intrusion in many areas. Man's management of the course of the Mississippi has also stopped much of the natural sedimentation necessary for land formation in much of the area. Natural subsidence and erosion are now dominant over siltation resulting in loss of marshland.

Land development in estuaries may proceed by organic accretion as well as by siltation. The mechanisms of this development in Louisiana will be considered. The various plant communities within the marshes are not equally productive with respect to organic buildup, just as they are not equally productive for support of differing shellfish or waterfowl species.

Along the seacoast or sea rim, the immediate action of the tides produces an area devoid of vegetation buildup or peat formation. Here, wave action piles up layers of sand and shale (marine sediments) on top of the river sediments. The sea rim is characterized by only pioneer species of plant life and an abundance of shore birds.

Behind the protective sea rims are vast areas of salt marsh (Figure 2.2). Salt marsh may also extend directly into adjacent open sea water areas protected from wave action. This occurs particularly in the numerous bays and terminal ends of the major stream channels of Louisiana. Frequent inundation by saltwater as a result of natural storm tides is necessary to maintain usual salinities. Protection against the abrasive action of waves is afforded by the sea rims and bays to the south and the natural levees along the transecting waterways. Organic accretion in these areas is moderate. The high production levels characteristic of smooth cordgrass (*Spartina alterniflora*) would provide for extensive accretion if it were not for the abrasive action of the tides. The vegetation produced in these areas is mechanically broken down, flushed by the tides, and enters the detrital food chains. Odum[4] reports that 50 percent of the *Spartina* organic matter is flushed from the estuary in Louisiana, and that

80 percent of that amount finally gets offshore to the Gulf. This in part accounts for the enormous value of this marsh type in shellfish and fish fry production.

Further inland where the pressures of the fresh water flow compensate for tidal pressures, a mixing zone occurs. These brackish marshes are the site of one of the most productive areas in the world. Vegetative land accretion in terms of peat accumulation can be very dramatic in the brackish marshes. The high nutrient levels provided by the fresh water flow, coupled with the preserving qualities of the salt water allow the accumulation of many yards of peat in the more productive areas. The most productive areas of coastal marsh are intermediate zones where salinity is not too high to restrict growth, and yet available nutrients are in high enough concentrations to allow good growth. These moderately saline marshes are in the greatest danger of being destroyed by salt water intrusion and industrial activities.

In the areas normally protected from salt water a different marsh type develops. While plant species differ, a good nutrient supply makes productivity nearly equal to that of the brackish marshes. Peat formation is, however, somewhat less in these areas due to the lack of protection against decay that the higher salt content of the brackish and saline marshes provide. Temporarily increased salinity from storm tide action, if not sustained, will usually be flushed from the system before serious changes occur. With prolonged salinity increases, existing salt-intolerant species will die out, followed by the growth of more salt-tolerent species until a new salinity equilibrium is established. The lag time in reestablishment of an equilibrium depends on the source of the initial salinity change and its duration. Aside from the initial impacts of such losses of vegetation, large expanses of mudflats may result if salinities do not become restabi-restabilized.

Coupled with the varying potential of the marshes in organic detrital production, substantially different substrate stabilities occur. The stability of a particular site will greatly influence the impact of construction on that area. A continuum of substrate makeup exists from the pure silt soils to the pure organic soils. The marshes of Louisiana contain all gradations. Both of the endpoints of this continuum represent highly unstable soils. The uniformity of both the silt and muck soils provides for little consolidation and thus little stability. However, areas where vegetation products and silt have mixed, soils may have greater stability. Peat areas and others, where root and tuber production are extensive, are characteristically very stable. It is these areas that represent the so-called "good" spoil of pipeline construction.

Coastal Louisiana has a wide range of environmental characteristics important to many forms of terrestrial and marine life. High productivity of fur and waterfowl, oysters, fish, and shrimp indicate the magnitude of importance to man. A map and compilation of areas of the major marsh zones is presented in part to demonstrate the extent of these areas (Figure 2.2 and Table 2.2). Table 2.3 and Figure 2.3 show the marsh types presented by hydrologic unit for the Louisiana coastal zone.

Plant Communities

Sea Rims. The Louisiana coastline is characterized by a lack of well-developed beaches. The so-called sea rims develop as a result of wave and tidal action along the shoreline in areas where there is limited natural subsidence and an availability of sand and/or fragmented oyster shells. High salinities, numerous shore birds, and limited

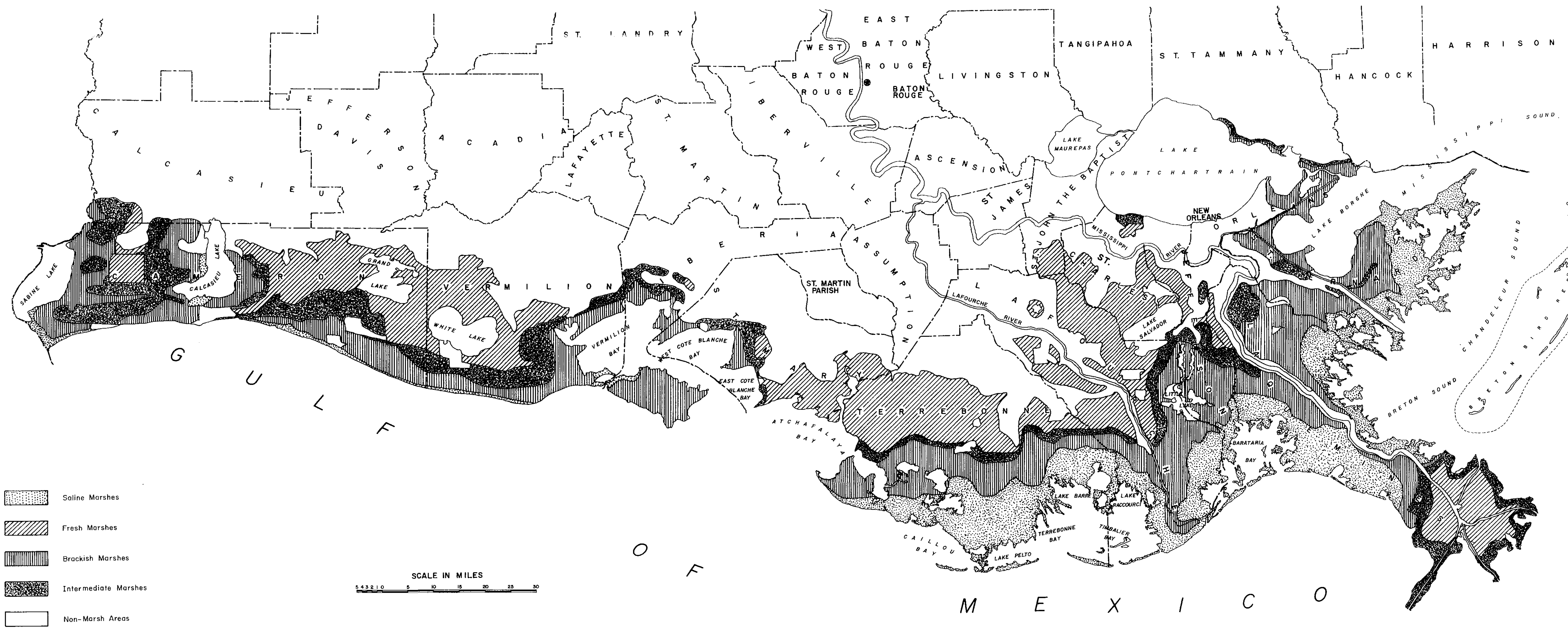


FIGURE 2.2. LOUISIANA MARSHLANDS VEGETATIVE TYPE MAP

TABLE 2.2. LOUISIANA COASTAL AREA MARSH VEGETATIVE TYPES[5]
(Acres)

Parish	Saline	Fresh	Brackish	Intermediate	Total
Cameron	35,200	206,250	241,422	209,441	692,313
Calcasieu	--	3,692	4,677	16,492	24,861
St. Mary	--	87,877	25,108	28,308	141,293
Vermilion	10,338	154,230	97,469	92,308	354,345
Iberia	1,969	2,708	95,262	22,154	122,093
Terrebonne	272,246	272,246	193,477	43,077	781,046
Lafourche	110,769	200,123	139,077	32,492	482,461
St. Charles	--	86,892	--	5,415	92,307
Jefferson	15,262	32,000	65,969	28,800	142,031
St. John the Baptist	--	25,600	--	--	25,600
Plaquemines	184,684	142,277	122,246	145,723	594,930
St. Bernard	168,169	--	134,480	15,754	318,403
Orleans	--	--	49,230	--	49,230
St. Tammany	--	7,631	17,723	11,815	37,169
Totals	798,637	1,221,526	1,186,140	651,779	3,858,082

TABLE 2.3. ACREAGE OF PONDS AND LAKES IN HYDROLOGIC UNITS AND VEGETATIVE TYPES ALONG THE LOUISIANA COAST, AUGUST, 1968[6]

Hydrologic Unit	Vegetative Types				
	Saline	Brackish	Intermediate	Fresh	Total
1	53,427	330,455	117,627	101,797	603,306
2	5,887	43,630	0	0	49,517
3	0	10,231	10,231	74,929	95,391
4	61,547	96,920	3,498	130,091	292,056
5	99,403	68,559	4,487	55,941	228,390
6	0	0	0	20,825	20,825
7	0	24,881	6,767	2,256	33,904
8	1,287	21,666	10,225	197,569	230,747
9	0	178,958	30,176	19,418	228,552
Total	221,551	775,300	183,011	602,826	1,782,688

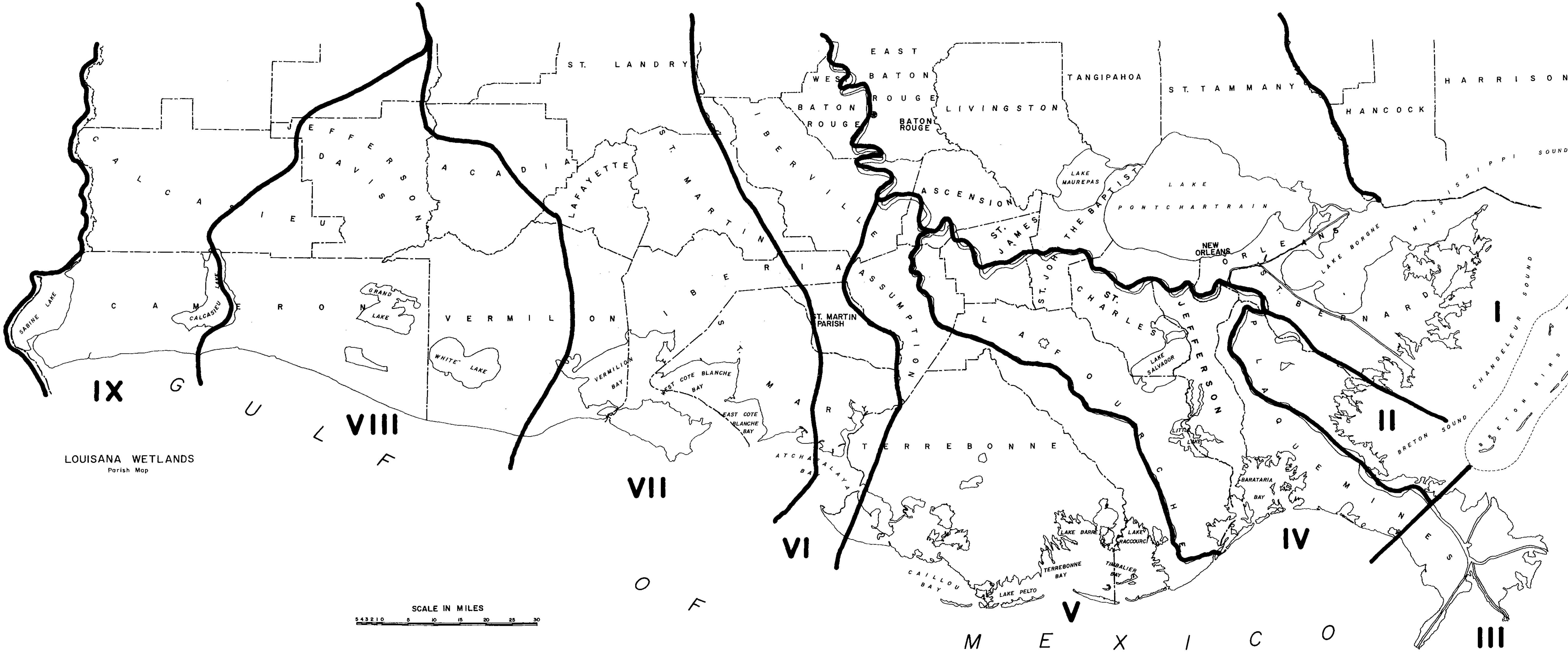


FIGURE 2.3. COASTAL LOUISIANA STUDY AREA AND HYDROLOGIC UNITS

pioneer vegetation characterize this habitat. Similar "beach" areas developing in a bay not contiguous with marsh or land are called "shell shoals".

Salt Marsh. The saline vegetative type makes up 22.1 percent of the coastal marshes, but contains only 17 of the 118 species of vascular plants found in the Louisiana marshlands.(6) The saline marshes are represented by nearly pure stands of the smooth cordgrass (Spartina alterniflora) (Table 2.4). Salt grass (Distichlis spicata) and black rush (Juncus roemerianus) are present though much less abundant. The profile of this community is very short, 2 to 4 feet. The deeper lagoons are usually free of standing vegetation, but are characteristically surrounded by pure stands of S. alterniflora. The upper few feet of marsh are well consolidated by the roots and rhizomes of the vegetation. Below this, the substrate is almost totally unconsolidated. These subsoils are almost pure silts or silt and clay and contain very little organic matter.

Brackish Marsh. In the Louisiana coastal zone all gradations of salinity exist within the marsh. The flora and fauna of the brackish or intermediate salinity indirectly reflect this salinity. While most of these organisms are adapted to a fairly wide range of salinities, extended periods of inundation with fresh or sea water would change and eliminate some of them. Organic content may be extremely high (Table 2.5). Deep layers of peat are not unusual.

The brackish marsh contains 40 species of vascular plants, with marsh hay cordgrass (Spartina patens) the dominant species (55 percent). The brackish vegetative type makes up 30.7 percent of the marsh area.(6) The brackish marshes are most often characterized by an association of S. patens, salt grass (D. spicata), and black rush (J. roemerianus). This vegetation is taller than the salt marshes, reaching heights of 4 to 6 feet. While this marsh type can and often does stand uniform for many miles, significant variations can occur with slight changes in elevation or salt content. One of the major variations is the cane zone (Phragmites communis-Spartina cynosuroides). Quill cane and roseau cane are major components of this taller plant association. Heights of 6 to 8 feet are not uncommon. The water table in these cane zones is usually below the surface. Another major variation in the brackish marsh is the three-cornered grass (Scirpus olneyi) marsh. While this species is often present in many brackish marshes, it frequently forms a dense uniform stand of large area. This is a sub-climax stage of the Spartina-Distichlis-Juncus association and will be naturally displaced if undisturbed. This three-cornered grass or Scirpus marsh is a favored habitat for the muskrats and waterfowl of coastal Louisiana, and as such is the site of extensive resource management.

Intermediate Marsh. The intermediate marsh vegetation type comprises only 16.3 percent of the marsh area and is composed of 54 species. Spartina patens, comprising 34 percent of the vegetation, remains dominant in these marsh areas. Roseau cane (Phragmites communis) and bulltongue (Sagittaria falcata) are also major species, contributing approximately 6.5 percent each.(6)

Fresh Marsh. A diversity of associations is found in the fresh marshes. Of the 118 species, 93 were found in the fresh marsh.(2) In the Delta region, the fresh marsh area is almost completely dominated by alligator grass (Alternanthera philoxeroides) and water hyacinth (Eichornia crassipes). These two exotics are so well adapted as to have displaced the natural vegetation in this area. Other widespread plant associations of the fresh marshes are edaphically controlled by water level and water quality for the

TABLE 2.4. PLANT SPECIES COMPOSITION OF THE VEGETATIVE TYPES IN THE LOUISIANA COASTAL MARSHES(6)

Scientific Name	Colloquial Name	Vegetative Type			
		Saline	Brackish	Intermediate	Fresh
Batis maritima	Saltwort	4.41	0	0	0
Distichlis spicata	Saltgrass	0	0	0.36	0.13
Juncus roemerianus	Black rush	0	3.93	0.72	0.60
Spartina alterniflora	Smooth cordgrass	0	4.77	0.86	0
Eleocharis parvula	Dwarf spikerush	0	2.46	0.49	0.54
Ruppia maritima	Widgeongrass	0	3.83	0.64	0
Scirpus olneyi	Olney bulrush	0	4.97	3.26	0.45
Scirpus robustus	Saltmarsh bulrush	0.66	1.78	0.68	0
Spartina patens	Marshhay cordgrass	5.99	0	0	3.74
Bacopa monnieri	Waterhyssop	0	0.92	4.75	1.44
Cyperus odoratus	Flatsedge	0	0.84	2.18	1.56
Echinochloa walteri	Walter's millet	0	0.36	2.72	0.77
Paspalum vaginatum	Seashore paspalum	0	1.38	4.46	0.35
Phragmites communis	Roseau cane	0	0.31	6.63	2.54
Alternanthera philoxeroides	Alligator weed	0	0	2.47	5.34
Eleocharis sp.	Spikerush	0	0.82	0	10.74
Hydrocotyle umbellata	Pennywort	0	0	0	1.93
Panicum hemitomon	Maidencane	0	0	0.76	25.62
Sagittaria falcata	Bulltongue	0	0	6.47	15.15
Other species		2.43	5.09	25.26	29.10
Total		100.00	100.00	100.00	100.00

TABLE 2.5. MEAN VALUES OF SOIL AND WATER CHEMICAL CHARACTERISTICS FOR MAJOR SPECIES OF MARSH VEGETATION

Vegetative Types	Species	Ph Range	Water Salinity (ppt)	DRY WEIGHT BASIS: Nitrogen (%)	Carbon (%)	Organic Matter (%)	C/N	WET WEIGHT BASIS: Phosphorus (ppt)	Potassium (ppt)	Calcium (ppt)	Magnesium (ppt)	Sodium (ppt)	Total Salt Soil (ppt)
SALINE MARSH	Batis maritima	4.0-7.9 (16)	23.60±9.97 (13)	0.23±0.14 (16)	4.33±3.30 (16)	7.47±5.69 (16)	17.92±7.23 (16)	0.11±0.06 (16)	0.33±0.15 (16)	0.54±0.84 (16)	1.22±0.73 (16)	6.45±9.22 (16)	10.55±6.38 (16)
	Distichlis spicata	4.1-8.0 (94)	13.32±6.70 (80)	0.77±0.61 (94)	13.03±10.61 (94)	22.46±18.29 (94)	16.92±4.42 (94)	0.06±0.05 (94)	0.29±0.12 (94)	0.32±0.39 (94)	1.05±0.41 (94)	4.12±3.92 (94)	8.81±4.03 (94)
	Juncus roemerianus	4.3-7.1 (70)	13.89±8.27 (63)	0.84±0.61 (70)	15.18±11.27 (70)	26.17±19.44 (70)	18.11±4.80 (70)	0.05±0.05 (70)	0.26±0.12 (70)	0.40±0.53 (70)	0.95±0.30 (70)	3.59±1.77 (70)	9.20±4.33 (70)
	Spartina alterniflora	4.5-8.5 (95)	15.19±7.78 (86)	0.68±0.56 (95)	12.32±10.87 (95)	21.24±18.74 (95)	18.35±6.66 (95)	0.07±0.06 (95)	0.30±0.11 (95)	0.31±0.37 (95)	1.03±0.36 (95)	3.98±1.73 (95)	10.10±4.38 (95)
BRACKISH MARSH	Eleocharis parvula	3.7-6.7 (29)	6.69±3.84 (29)	1.53±0.73 (29)	26.26±13.65 (29)	45.27±23.53 (29)	16.92±4.98 (29)	0.02±0.02 (29)	0.15±0.09 (29)	0.25±0.21 (29)	0.81±0.42 (29)	2.40±1.30 (29)	6.00±3.47 (29)
	Ruppia maritima	3.7-6.4 (26)	8.95±6.39 (26)	0.92±0.55 (26)	15.59±11.60 (26)	26.89±19.99 (26)	16.12±3.92 (26)	0.04±0.03 (26)	0.25±0.14 (26)	0.35±0.29 (26)	1.06±0.40 (26)	4.40±7.24 (26)	7.02±3.15 (26)
	Scirpus olneyi	3.7-6.9 (66)	7.23±5.10 (63)	1.25±0.67 (66)	20.72±12.00 (66)	35.31±21.07- (66)	16.26±3.58 (66)	0.03±0.02 (66)	0.19±0.11 (66)	0.28±0.28 (66)	0.88±0.35 (66)	2.71±1.34 (66)	6.40±3.35 (66)
	Scirpus robustus	4.0-6.9 (68)	8.90±5.30 (61)	0.80±0.57 (68)	13.02±10.13 (68)	22.41±17.45 (68)	16.08±3.62 (68)	0.05±0.03 (68)	0.27±0.13 (68)	0.36±0.48 (68)	0.96±0.35 (68)	3.54±4.60 (68)	6.78±3.59 (68)
	Spartina patens	3.7-7.9 (190)	8.55±6.33 (173)	1.04±0.67 (190)	17.31±12.05 (190)	29.70±20.87 (190)	16.15±3.72 (190)	0.04±0.04 (190)	0.21±0.12 (190)	0.32±0.34 (190)	0.97±0.38 (190)	3.00±3.03 (190)	6.81±4.06 (190)
INTERMEDIATE MARSH	Bacopa monnieri	4.0-7.5 (31)	3.93±2.27 (29)	1.76±0.89 (31)	28.41±14.90 (31)	48.99±25.66 (31)	16.14±3.05 (31)	0.02±0.03 (31)	0.12±0.09 (31)	0.55±0.68 (31)	0.90±0.67 (31)	1.87±0.86 (31)	4.60±2.65 (31)
	Cyperus odoratus	3.8-7.5 (66)	3.20±2.80 (61)	1.52±0.98 (66)	24.58±16.62 (66)	42.02±28.94 (66)	15.64±3.82 (66)	0.03±0.05 (66)	0.13±0.10 (66)	0.38±0.30 (66)	0.78±0.46 (66)	1.45±0.98 (66)	3.53±2.72 (66)
	Echinochloa walteri	3.8-7.4 (46)	2.89±2.43 (44)	1.60±0.94 (46)	25.65±16.41 (46)	44.31±28.15 (46)	14.97±3.96 (46)	0.02±0.03 (46)	0.10±0.09 (46)	0.39±0.27 (46)	0.79±0.58 (46)	1.21±0.69 (46)	2.80±1.92 (46)
	Paspalum vaginatum	5.1-6.7 (17)	3.27±3.47 (16)	0.73±0.34 (17)	10.18±7.76 (17)	17.80±13.09 (17)	12.88±4.49 (17)	0.04±0.03 (17)	0.25±0.12 (17)	0.65±0.43 (17)	1.28±0.38 (17)	1.80±1.21 (17)	3.40±2.88 (17)
	Phragmites communis	3.7-8.0 (35)	3.33±3.96 (29)	0.82±0.77 (35)	14.05±15.03 (35)	24.22±25.92 (35)	15.89±4.59 (35)	0.06±0.07 (35)	0.18±0.12 (35)	0.64±0.60 (35)	0.97±0.50 (35)	1.43±1.38 (35)	3.62±3.86 (35)
FRESH MARSH	Alternanthera philoxeroides	4.8-7.7 (33)	2.73±4.94 (30)	1.26±0.89 (33)	19.00±15.54 (33)	32.72±26.51 (33)	14.09±3.90 (33)	0.04±0.05 (33)	0.11±0.11 (33)	0.85±0.73 (33)	0.64±0.41 (33)	0.85±1.14 (33)	2.37±3.39 (33)
	Eleocharis sp.	4.0-8.0 (69)	3.88±4.29 (66)	1.99±0.87 (69)	33.62±15.11 (69)	58.30±25.47 (69)	17.00±3.33 (69)	0.01±0.02 (69)	0.08±0.08 (69)	0.47±0.31 (69)	0.50±0.35 (69)	1.31±1.24 (69)	3.38±3.24 (69)
	Hydrocotyle umbellata	4.3-6.9 (31)	1.22±1.16 (27)	2.38±0.83 (31)	39.87±14.50 (31)	69.51±23.24 (31)	16.68±2.09 (31)	0.01±0.03 (31)	0.03±0.04 (31)	0.46±0.23 (31)	0.29±0.26 (31)	0.49±0.52 (31)	1.30±1.21 (31)
	Panicum hemitomon	4.3-6.3 (50)	1.02±1.13 (43)	2.10±0.88 (50)	35.18±15.55 (50)	61.03±26.00 (50)	16.38±2.60 (50)	0.01±0.01 (50)	0.04±0.03 (50)	0.48±0.24 (50)	0.29±0.24 (50)	0.38±0.36 (50)	1.08±0.88 (50)
	Sagittaria falcata	4.3-6.3 (71)	4.70±1.59 (64)	1.79±0.93 (71)	28.78±16.19 (71)	49.55±27.92 (71)	15.68±3.01 (71)	0.01±0.02 (71)	0.06±0.06 (71)	0.46±0.29 (71)	0.55±0.48 (71)	0.73±0.52 (71)	1.79±1.49 (71)

most part. Some of these include large expanses of maiden cane (Panicum hemitomon). Spikerush (Eleocharis sp.) and bulltongue are also major components. Other species present are cattail (Typha sp.), bulrush (Scirpus californicus), saw grass (Cladium jamicense), wapato (Sagittaria platyphylla) with alligator grass and water hyacinth. These marshes may be attached or floating. Floating marshes are characteristic of some areas of fresh and brackish marshes. They may occur anywhere the clay pan has subsided allowing the root consolidated vegetation mat to float on a sea of water and organic muck.

Chenier. The dynamic nature of the Louisiana coastline is shown by the development of the chenier or stranded beaches within the marshlands. Earlier deltaic formations pounded by storm tides formed beach lines that have now become stranded inland. These terrestrial "islands" are usually parallel to the Gulf. A concentration of cheniers is located in Vermilion Parish between Rockefeller and Rainey Wildlife Refuges. The chenier differs from the sea rim because of its terrestrial sediment composition rather than the marine origin of sea rim sediment. Many of the cheniers have sunk below mean water level and now provide an area of sandy bottom and an important substrate for oysters; however, others remain above water level producing high ground, possible 2 to 3 feet above normal high tide. This condition provides for the occurrence of a different habitat. Similar species are seen to invade the natural levees of streams and rivers and the spoil piles along canals - areas in which the sand content of the soils may be elevated over the surrounding marshes. While absolute species composition is regulated by substrate composition (sand and silt content) and water level, certain plants are characteristic of the chenier and levee areas. The lower areas are occupied by various grass and sedge species depending on the salinity and water level.

A shrub belt (Baccharis-Iva association) of buckrush and marsh elder occurs as a band in areas of slight elevation with very low salinities. The crest of the chenier may have a forest cover with Quercus spp. (live and water oaks), red gum (Liquidamber styraciflua), and hackberry (Celtis laevigata) as dominants. Many of the song birds of marsh lands are limited to these shrubby areas. The large predatory birds that hunt in the marshes nest and roost in these areas as they provide a large proportion of the available tree canopy in most areas of the marsh.

Swamps. In certain areas adjacent to higher ground in the marshes and in protected inland areas, successional patterns have led to various tree associations. Two basic types are defined consisting of salt and freshwater swamps.

Mangrove swamps occur only in southeastern Louisiana, principally in southern Jefferson and Plaquemines Parish. They are composed entirely of the shrubby honey or black mangrove (Avicennia nitida) occupying high saline environments. The crest of a "ridge" in the salt marshes may provide a habitat for this species. As little as two inches above the adjacent salt marsh, this zone is usually above high water level. Very high soil salinities are characteristic. Reaching a height of approximately 25 feet, the honey mangrove is an evergreen shrub. Aerial roots or "knees" are characteristic physical features of the plants. With these structures, the mangrove has the potential to evade more deeply into the marsh, but is usually restrained from doing so by frequent marsh fires.[(7)] The mangrove is also intolerant of cold and is killed back by any frost or freeze, further reducing its potential for spreading.

The Cypress-gum swamps of the fresh and nearly fresh waters are characteristic of extensive areas inland and scattered areas within the open freshwater marsh where water conditions are static and where some protection from storms and fires is afforded. The Atchafalaya River Basin contains extensive swamp lands. Bald cypress (Taxodium distichum) and tupelo gum (Nyssa aquatica) are codominants. Other tree species include water ash (Fraxinus profunda) and swamp maple (Acer rubrum). Where the swamp is open numerous herbaceous species prevail. Along the swamp borders are a great number of black willows (Salix nigra) and buttonbush (Cephalanthus occidentalis). Other species associated in areas where inundation is only periodic include sweetgum (Liquidambar styraciflua), water oak (Quercus nigra), hackberry (Celtis laevigata), cottonwood (Populus deltoides), sycamore (Platanus occidentalis), and box elder (Acer negundo).

Stratification within a community often plays an important role in the number of kinds of animal organisms that community is able to support. The hardwood forest communities of the swamps and cheniers do provide multiple strata for support of types of organisms found nowhere else in the marsh, e.g., in the water, in emergent herbaceous vegetation, nor in shrubs. While the typical marsh plants and animals are found associated on the ground level within these communities, even here new species will occur when shading or water level changes bring about conditions that are different from the adjacent swamp. In effect there may be three or more different levels supporting corresponding plant and animal associations within one community type. The mangrove swamps (Avicennia) promote a similar effect. Here, however, fewer strata occur and the single species dominance of the mangrove reduces the available number of ecological niches. Still, there is one association of plants and animals associated with the root zone and another with the canopy of the mangrove swamps.

Prairie Marsh. Note should be taken that some variation exists in the marshes of Louisiana from east to west. The eastern marshes are currently subject to some and in the past have faced extensive recent deltaic activity. Water flow is less restricted and tidal action, both lunar and storm, is more frequent and pronounced in the flatter, more gently sloping eastern marshes. Floating marshes in the fresh and brackish of the eastern areas are more common because of the undercutting action of this water flow. Small lagoons and ponds are more common, but the water level in them is considerably more dynamic. Waterfowl make extensive uses of these small open water areas.

In the western marsh lands or prairie marsh, sites of much older deltaic activity, water conditions are much more static. With more stable water levels, salt water intrusion is not as frequent (except from man or storm action) and undercutting of the clay pan seldom occurs.

Rare and Endangered Species. No rare or endangered plant species from the Louisiana wetlands has been identified at this time.

Animal Components

Furbearers. The State of Louisiana ranks first in fur production in the United States. Because of this it is perhaps best to discuss this special segment of the mammal group in terms of economics. The 1970-71 hunting season produced nearly 5 million dollars from fur pelts with nutria, muskrat, mink, otter, and raccoon being the main sources, respectively. Other furbearers include opossum, skunk, lynx, fox, and beaver.

Over 12.3 million pounds of nutria, muskrat, raccoon, and opossum meat for use in animal-food industry resulted in another 0.75 million dollars of income.[1] These animals are actively trapped in the managed and unmanaged coastal marshes, mainly fresh, intermediate, and brackish. Results of the 1970 and 1971 harvest seasons are reported in Table 2.6.

The large numbers represented above are a result of intensive management of large portions of the Louisiana wetlands, particularly in the brackish marshes. Three-cornered grass marshes produce more than 80 percent of the muskrats and many of the nutria. To insure good three-cornered grass production extensive late fall burning of the marshes is practiced annually. Table 2.7 presents the distribution of muskrats across Louisiana by hydrologic unit and by marsh type. Notice the abundance of animals in the brackish marshes of hydrologic Unit 2 and in all marsh types of Units 4 and 5 as examples of distribution in the State of Louisiana.

Other Mammals. The white-tailed deer and black bear are the only large mammals in the Louisiana wetlands. The deer presently have a strong healthy population. They are abundant in all parts of the marsh except the saline where only a limited population exists. The success that Louisiana has had in attracting out-of-state deer hunters indicates both the quality and size of the herds.[5]

The black bear, which once ranged over all of Louisiana is now basically limited to two sections of the State. From 1964 to 1967, 161 black bear were live-trapped in Minnesota and released in the Mississippi and Atchafalaya River bottoms. These animals combined with the severely limited native population appear to be maintaining their numbers.[1] One large population is centered in the area of East Cote Blanche Bay (Chabreck, Louisiana State University, Baton Rouge, La., personal communication, June, 1972). The extensive home range required by the bear has been displaced by man so that the bear is now limited to largely "uninhabitable" areas. Mortality within this closely monitored species is caused mainly by man's guns, automobiles, trains, and poisons.[8] While the bear is not officially listed by the Department of the Interior as an endangered species, its continuing presence in Louisiana, and, indeed, the southeastern United States, will depend on a concentrated effort by man to protect the remaining habitat and in fact to enhance them. The effects of gas pipelining on the black bear have not been studied. However, no major problems are expected to occur normally. Difficulty would arise when water regimes for large areas were changed, followed by the loss of large areas of woodland.

Other important mammals include the fox, cottontail and marsh rabbits, and squirrels. All seem to have healthy populations and are surviving the effects of man on the wetlands because of their adaptability in habitat preference.[5]

Insects. The mosquito is the major insect of importance to man in the wetlands. Or perhaps, it is better to say the control of the mosquito is of importance to man. Large-scale chemical control is now limited mainly to the urban areas. Drainage of freshwater marshes is another important control method used in the suburban and urban areas. State authorities are now encouraging flooding as an effective and of less harm as a method of mosquito control. Flooding of an area by means of dams, levees, and weirs prevents the female from laying eggs and thus produces a significant population reduction. This procedure has also proven very beneficial to fish and waterfowl production as well (Personal communication, A. W. Palmisano, Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana, April, 1972).

TABLE 2.6. COMPARATIVE TAKES OF FUR ANIMALS IN LOUISIANA(2)

			Approximate Price to Trapper	Value
		1969-70 Season		
Muskrat (Eastern)	432,052	at	$ 1.00	$ 432,052.00
Muskrat (Western)	800,000	at	1.35	1,080,000.00
Mink	46,294	at	5.00	231,470.00
Nutria (Eastern)	704,175	at	1.60	1,126,680.00
Nutria (Western)	900,000	at	3.00	2,700,000.00
Raccoon	103,725	at	2.25	233,381.25
Opossum	7,648	at	.50	3,824.00
Otter	6,632	at	23.00	152,536.00
Skunk	108	at	.50	54.00
Fox	636	at	3.00	1,908.00
Bobcat	110	at	5.00	550.00
Beaver	646	at	5.00	3,230.00
Coyote	3	at	5.00	15.00
Total Pelts	3,002,043			$5,965,700.25
Nutria Meat (lbs.)	9,500,000	at	.08	$ 760,000.00
Muskrat Meat (lbs.)	550,000	at	.08	44,000.00
Raccoon Meat (lbs.)	380,000	at	.20	76,000.00
Opossum Meat (lbs.)	50,000	at	.20	10,000.00
Total Meat (lbs.)	10,480,000			$ 890,000.00
Total Pelts and Meat				6,855,700.25
		1970-71 Season		
Muskrat (Eastern)	377,960	at	1.35	$ 510,246.00
Muskrat (Western)	400,000	at	1.80	720,000.00
Mink	21,648	at	5.00	108,240.00
Nutria (Eastern)	500,000	at	1.60	800,000.00
Nutria (Western)	726,739	at	3.00	2,180,217.00
Raccoon (Coastal)	25,000	at	1.00	25,000.00

TABLE 2.6. (Continued)

			Approximate Price to Trapper	Value
Raccoon (Upland)	30,726	at	$ 1.50	$ 46,089.00
Opossum	3,563	at	.50	1,781.50
Otter	4,808	at	25.00	120,200.00
Skunk	6	at	.50	3.00
Fox	242	at	3.50	847.00
Bobcat	55	at	5.00	275.00
Beaver	14	at	5.00	70.00
	2,090,761			$4,512,968.50
Nutria Meat (lbs.)	8,000,000	at	.08	640,000.00
Muskrat Meat (lbs.)	400,000	at	.08	32,000.00
Raccoon Meat (lbs.)	330,000	at	.20	66,000.00
Opossum Meat (lbs.)	40,000	at	.20	8,000.00
Total Meat (lbs.)	12,370,000			746,000.00
Total Pelts and Meat				$5,258,968.50

TABLE 2.7. AERIAL INVENTORIES OF MUSKRATS IN COASTAL LOUISIANA(2)

(Muskrat Nests per 100 Acres)

Marsh Vegetative Type	Hydrologic Unit 1	2	3	4	5	6	7	8	9	Average
	Southwestern Louisiana					Midcoastal	Southeastern Louisiana			
November 1969										
Saline	0	0	--	11.2	16.3	--	0	0	0	11.5
Brackish	0.2	48.4	--	16.8	32.1	--	11.7	3.7	5.9	15.8
Intermediate	0.9	--	2.4	4.1	5.9	--	2.9	1.7	2.4	2.3
Fresh	--	--	0.3	1.9	1.2	0	0	0.4	0	0.8
Average										8.0
February 1970										
Saline	0	1.9	--	11.9	10.8	--	0	0	0	9.14
Brackish	0.5	103.0	--	20.2	81.2	--	15.3	3.9	6.6	30.5
Intermediate	0	--	2.4	14.2	35.1	--	9.0	1.7	0.2	4.4
Fresh	--	--	0	0.4	0.8	2.0	0	0	0	0.3
Average										13.3
December 1970										
Saline	0	0	--	13.1	18.5	--	0	0	0	13.3
Brackish	10.4	38.6	--	15.5	58.2	--	27.4	8.8	14.0	26.9
Intermediate	0	--	1.6	23.3	25.6	--	8.0	0.6	8.8	7.0
Fresh	--	--	0	2.3	3.4	1.3	0	1.3	1.0	1.8
Average										13.5
February 1971										
Saline	0	5.6	--	19.2	25.1	--	0	24.1	0	20.7
Brackish	3.3	81.8	--	22.2	75.2	--	30.7	7.6	18.7	34.3
Intermediate	0	--	5.6	23.3	26.3	--	18.7	1.9	0.2	3.4
Fresh	--	--	0	5.2	2.5	3.3	0.5	1.1	0.7	2.1
Average										17.7
December 1971										
Saline	0	3.76	--	17.69	11.88	--	0	0.55	2.92	11.67
Brackish	1.37	24.07	--	6.93	19.20	--	4.06	0.80	4.80	8.22
Intermediate	0	--	6.38	28.34	5.85	--	5.81	0.89	0.24	0.53
Fresh	--	--	1.34	5.30	4.05	4.18	9.26	0.24	0.33	2.61
Average										6.17

Major carnivorous insects in the marsh include the praying mantis and dragon fly. Herbivores include, among many others, grasshopper species that graze on the grasses of the marsh. The importance of the grazing herbivores in the marshlands is less important as compared to their usual value within temperate ecosystems because of the particular energy dynamics of the marshes. The marsh system results in most of the grass biomass being broken down mainly by physical processes to small fragments where it is acted upon by bacteria and detritus feeders. The larger carnivores feed from this aquatic chain rather than from the terrestrial chain as would be the case further inland or on higher dry ground.

Reptiles. Snakes present in the wetlands include several species of water snakes, blue runners, ribbon snakes, black snakes, and bull snakes, as well as water moccassins, rattlesnakes, copperheads, and coral snakes. Information is needed on the potential effects of gas pipelining on the abundance and mobility of poisonous snakes.

Several species of fresh and salt water turtles are found in the wetlands. Sufficient quantities are found to make commercial harvest profitable. During the last ten years, the freshwater turtle harvest has been from about 19,500 pounds to about 163,500 pounds per year. Market value during this period fluctuated from 16 to 28 cents per pound. Baby green turtles were also harvested. Yearly production ranged from 1800 to 22,000 pounds. Market prices for this species fluctuated from $4.00 to $12.50 per pound.[9]

The alligator deserves special reference, since it is officially listed as an endangered species.[10] Through intensive study of alligator breeding habits and land-carrying capacity, Louisiana state officials have successfully returned approximately one million acres of marshland to near capacity or better and limited hunting has been allowed. Much work still remains to be done with the alligator in Louisiana as well as in the other Gulf states.

State research currently under way on the alligator includes breeding physiology. This project will determine the onset of sexual maturity, confirm the limits of the natural breeding season, and determine the number of sexually mature females that do not nest in a given year as well as investigating the reasons why. Another study concerns the determination of carrying capacity of the alligator in the various marsh types. This is coupled with a study of salinity tolerance of young alligators. Early results from this work indicate the reproductive period to extend from mid-May through the end of June, a period of approximately 40 days. The effects of disturbance during this period are not known. The carrying capacity studies are not yet completed.[1]

The Louisiana Wildlife and Fisheries Commission has established a helicopter flown, permanent transect system for census of natural alligator populations. Early analysis indicates that "a sizeable population of alligators are present in the fresh, intermediate, and brackish types of Louisiana's coastal marshes. No nests were transected in the saline marsh type. The highest concentration of alligators were located in the southwestern part of the state's coastal marsh".[1]

"Water levels appear to be extremely important in terms of nesting success... Field observations... indicate that nesting success is highly influenced by the amount of surface water accrued during the spring or until actual egg deposition occurs in late June. High nesting densities appear to coincide with years of moderate to high water levels during spring and early summer."[1]

Telemetric studies of alligators in the Rockefeller Refuge indicate "that they have extremely large territories, occasionally traveling from four to five miles in one night's time... The majority of the males tended to prefer open water areas, such as canals, bayous, and large marsh ponds and these were the animals that showed the greatest amount of movement."(1)

Amphibians. Frogs are extremely abundant throughout the marshlands. The Wildlife and Fish Commission has recently abandoned an investigation of bullfrog farming for scientific markets.(5)

No information is available on other amphibians-salamanders, etc.

Unique and Endangered Species. The alligator remains classified nationally as an endangered species by the U. S. Bureau of Sport Fisheries and Wildlife.

The Louisiana vole is on the official list, but no information as to its range or status are available. Apparently, this species was once reported as a new endemic and has never been seen or reported again from anywhere.

The Black bear is approaching extinction within Louisiana but retains viable populations elsewhere in the United States.

Avifauna and Its Habitat

The importance of birds in the Louisiana wetlands can be stated simply with these facts:

- Mississippi and Atlantic flyways cross in southern Louisiana.
- This point is the southern terminus for many species.
- 9/10 of the bird species of eastern North American spend some time in coastal Louisiana.(11)

The above statements mainly refer to the migratory birds; the marshes also provide a habitat for many species of nonmigratory song birds, the wild turkey, and several of the large predatory hawks and owls.

About 355 species of birds occur in Louisiana(12) of which some 301 are associated, either as breeders, regular migrants, or transients, with the immediate coastal wetland regions affected by gas or oil explorations. Of the total, seven species or subspecies are currently considered rare or endangered(10) while two species are considered peripheral and their retention in our nation's fauna is a matter of concern.

Rather than dealing with species per se, broad categories will be considered except where special attention needs to be drawn to certain problem areas of species. Under the various habitat groups the following avian statuses, where salient or applicable, are considered: permanent residents, summer residents, winter residents, and migrants.

Coastal Marshes (Includes Mainly Salt, Brackish, or Intermediate Marshes)

Permanent Residents. Grebes form a minor part of the avifauna and are fish feeders. They are, for the most part, dependent on small fish although invertebrates are also eaten. The few hawks and owls that frequent the marshes on a permanent basis are mostly adaptable species and are primary, secondary, or tertiary consumers. One species that may be encountered there that should receive special consideration is the Swallow-Tailed Kite. Kites in general seem to be seriously declining in parts of the southern United States and a couple have a tenuous hold on their environment or, in the case of the Swallow-Tailed, have an undetermined status. Some Kites seemingly respond markedly to only minor habitat disruptions.

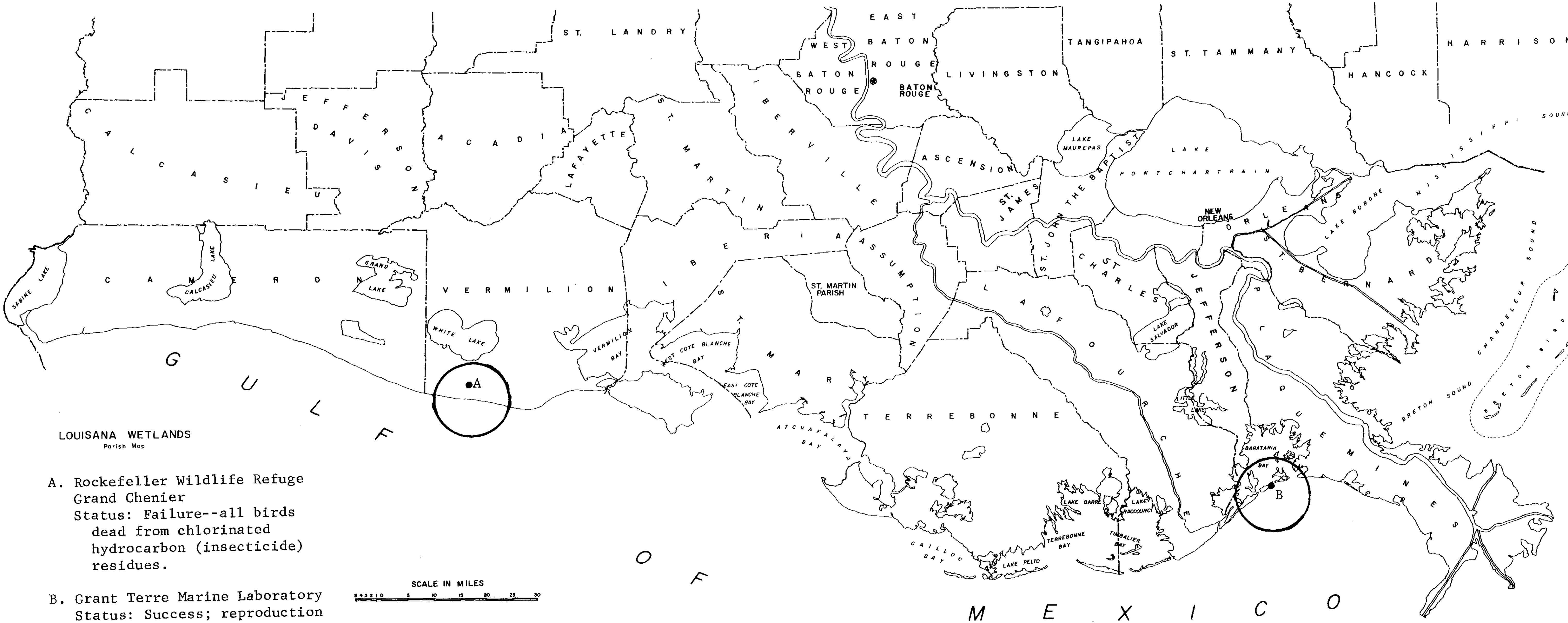
Pigeons, Kingfishers, Woodpeckers, or perching birds that may occur in this habitat are generally numerically healthy and widespread.

Four groups of major importance, in part because of economic reasons, are the Herons, Pelican-like birds, ducks and geese, and rails and their relatives. Ducks and geese are of major importance as wintering or migrant birds and will be considered under that heading. Rails and Coots are prime inhabitants of this environment and of economic importance as a sport and food bird. One would a priori suggest that Coots are versatile enough to be little affected by habitat changes but Rails demand special attention as they seemingly have a much more narrow range of tolerance and more specific habitat requirements. Both are rather general in food habitats though Rails are primarily invertebrates, a fact which dictates within limits the habitat that can be used. Habitat considerations are principally concerned with water depth or density of vegetation.

The Brown Pelican is the Louisiana state bird and has virtually disappeared from the state. The reason for this decline is apparently variable but probably not related to habitat destruction. However, as the state now has undertaken a project of reintroducing the species (Figure 2.4), the question of habitat of proper quality and quantity becomes germane. Successful reproduction seemingly depends on a certain amount of seclusion for nesting and a proper spectrum of water depth from which to secure food.

Herons, Egrets, and relatives are generally colonial breeders. The colonies are local in nature. That the habitat is not used with generally uniform frequency suggests the spotty distribution of limiting factors and perhaps semi-rigid requirements. However, many of the requirements may be a function of social convention and the physical destruction of habitat holding colonies may be simply temporary. With regard to specific pipeline routes, this group of birds requires attention as they form a conspicuous part of the environment both in feeding and nesting habitat requirements. They cannot use water over a certain depth as dictated by the length of bill or leg of the species involved. They may conflict with man's interests in the commercially important invertebrates should the habitat become limited to the extent that utilization of remaining habitat becomes intensive and severe.

Winter Residents. Ducks and geese are of major importance because of the drastic buildup of members in fall and winter. Mid-winter counts of waterfowl for all of Louisiana (included are also fresh water marshes, bayous, and adjacent agricultural lands) indicate between 5- and 6-1/2-million birds are present (Table 2.8). The major species are Gadwall, Green-Winged Teal, Pintail, Scaup, and Blue and Snow Geese. Of the total, between 1-1/2- and 3-million birds are Dabbling Ducks[13] which utilize most heavily the shallow coastal waters and marshes and adjacent agricultural lands.



A. Rockefeller Wildlife Refuge
Grand Chenier
Status: Failure--all birds dead from chlorinated hydrocarbon (insecticide) residues.

B. Grant Terre Marine Laboratory
Status: Success; reproduction is good.

FIGURE 2.4. BROWN PELICAN RELEASE AND BREEDING GROUNDS

TABLE 2.8. LOUISIANA MID-WINTER WATERFOWL INVENTORY[a](2,5)

Species[b]	Jan. 15-18, 1968	Jan. 6-11, 1969	Jan. 7-21, 1970	Jan. 5-18, 1971
Mallard	380,000	308,100	750,000	415,600
Black Duck	8,500	500	1,600	500
Gadwall	754,000	938,000	941,300	871,500
Baldpate	575,000	373,000	352,400	261,400
Green-Winged Teal	536,000	1,077,000	1,069,000	781,100
Blue-Winged Teal	131,000	46,000	26,200	46,200
Shoveler	155,000	257,000	179,000	154,900
Pintail	769,000	615,800	634,700	475,200
Mottled Duck	63,000	70,000	57,600	92,000
Red-Head	23,000	23,000	28,000	22,400
Canvas Back	15,000	19,400	23,400	21,000
Scaup	712,000	1,354,000	984,100	928,100
Ringnecked	63,000	184,000	65,600	46,400
Ruddy	10,600	6,500	7,200	7,200
Merganser	4,000	20,000	15,000	15,000
Total	4,199,000	5,294,400	5,156,400	4,139,200
Canada Geese	1,700	1,300	1,500	1,500
White Fronted	26,000	21,000	50,600	39,300
Blue and Snow Geese	341,000	267,600	316,150	422,400
Total	368,700	289,900	368,250	463,200
Coots	626,500	956,000	742,500	1,679,200
Grand Total	5,194,300	6,540,000	6,267,150	6,281,600

(a) State-wide estimates.
(b) Wood ducks separate census.

Blue Geese winter in few localized regions in the United States (California, Texas, and Louisiana in the main). Louisiana coastal marshes constitute one of the prime wintering areas where, together with the Snow Geese, about 300- to 400-thousand individuals winter. Loss of large amounts of natural habitat of any of the waterfowl will have considerable impact on adjacent rice and agricultural lands which they will utilize as resting and foraging areas.

Canada Geese have declined in recent years with the improvement of resting areas in more northern states. Therefore, the state has implemented a program of breeding and introducting this species into the state. Coastal marshes in the Rockefeller Refuge and Grand Chenier region are the prime locations of these efforts and thus proper habitat is essential to the success of this project.[5]

Migrants. This category is so vast that only a few specific species need comment. However, most of the species to be considered fit in the status of rare or endangered species. Suffice it to say that about 9/10 of the eastern North American migrants pass through the Gulf Coast[11] and a similar, perhaps slightly smaller, figure would apply to Louisiana. The marshes or related habitat provide resting and foraging areas for a great many of the species during their sojourn there.

Rare and Endangered Status or Peripheral Populations. Wood Ibis, White Ibis, Roseate Sponbills, and Sandhill Cranes occupy this habitat either in a permanent or transient nature. The first three species seemingly spill over into Louisiana from centers of breeding either in Florida or further west down along the Gulf Coast. An appraisal of this category is difficult since the habitat for them is possibly only marginal. If indeed the habitat is marginal in the natural state, it is not possible to assess what effect minor changes in the environment, natural or man-induced, will inflict on the species.

Sandhill Cranes of the populations wintering in southwestern Louisiana are currently considered an endangered species.[10] That habitat used in Louisiana is restricted and local in nature and special effort should be extended to preserve it.

Winter Residents and/or Migrants. Beaches form major resting areas for land migrants or winter residents such as some shorebirds. Areas for feeding, resting, and loafing prior to the start of a trans-Gulf migration is essential. This habitat satisfies the requirement for many land birds.

Bayous, Levees, and Inland Marshes (principally fresh water).

Permanent Residents. Those items mentioned under the earlier heading of marshes equally applies to groups such as Herons, Ducks, shorebirds, Pelicans and relatives, and perching birds and, therefore, need not be repeated here. Certain groups, however, require special attention.

Turkeys have commercial importance as game and sport birds and may use this habitat peripherally where proper cover occurs on elevated areas. The Turkey in Louisiana declined from an estimated 1-million birds to about 1500 in the mid-1940's. The state has made a concerted effort to transplant and reestablish this species.[5]

Canada Geese, as mentioned previously, are being raised on Rockefeller Refuge and proper marsh habitat of adequate area is essential to the success of this project.

Two species heretofore unmentioned are the Bald Eagle and Osprey. Both of these are secondary and tertiary consumers and because of their often long or complex food webs, they have been affected over broad areas of North America. Some populations of Bald Eagles have declined almost to the point of no return. Ospreys also show locally severe reductions. Since both of these species have specific habitat needs and both are of a local, spotty or sparse nature within this habitat a rather strict protective control should be maintained.

Migrants. This area provides major resting area for migrants of a variety of kinds depending on the nature of the cover type. This category is so broad and general that only the most drastic changes in habitat or cover type would have impact and then the impact would be of questionable nature. Specific problems may arise in this area as field investigations reveal them (see Figure 2.4).

Aquatic Ecology

Introduction

The coastal area of Louisiana below the Intercoastal Waterway contains some 3,378,924 acres of water.[14] This area, considered to be one of the most productive fisheries in the world, accounted for 1.1 billion pounds of commercial fish and shellfish in 1970.[1] Estuarine dependent species made up 98 percent of this catch[15] (and personal communication, James M. Coleman, LSU, April, 1972).

The value of estuaries and marshlands to the United States fisheries is realized when it is considered that almost two-thirds (in value) of the commercial catch and most of the sports fish are composed of species who spend at least a part of their life in estuaries.[16] Indeed, freshwater, saltwater, and estuarine fishes taken in amounts of a million pounds or more in the Gulf commercial fishery are found in an approximate ratio of 1:3:143, respectively.[17] In 1960, Sykes[18] cited a dollar value of estuarine dependent fish and shellfish catch of over $1 billion. He further estimated the estuarine contribution to these catches at 230 lb per acre. In this same year, Allen[19] estimated the value of Alabama's coastal estuaries and marshlands to be $1,000 per acre per generation (of 30 years).

The thousands of acres of marshes and brackish water areas in the highly productive coast of Louisiana serve as the area of mixing of freshwater runoff with the waters of the Gulf. Small tide extremes and intricate water courses combine to produce gradual salinity and water volume transitions with resultant large zones of relatively stable conditions. These zones may range from quite salty near the Gulf to nearly fresh on the inner edge. The wide range of environmental characteristics provides the necessary habitats for many aquatic forms of life leading ultimately to an estimated $150 million annual value of the Louisiana commercial fishery not including recreational fishing and tourism.[20]

The continued stability of this productive zone of Louisiana is now being questioned. Conflicting and summation of uses in the area have been cited as a threat to the productivity[21] with uses requiring dredging operations conflicting with aquatic production.

Allen[22] cites canalization and streamflow diversion as one of the most critical alterations made to estuarine areas by man. His conclusions are that no man-made change in an estuary system is beneficial to estuarine productivity and, in most cases, is harmful. He states that we have reached a point where benefit ratio is not equal to estuarine value.

The near subtropical climate regime of the Louisiana coastal area provides an average temperature of 20 C with very infrequent freezing temperatures and mild winters. The temperature changes over a period of a year have minimal effects over short periods, but pronounced changes in the fall and spring initiate the mass migration of many species.[23]

The most important factor involved in the distribution of estuarine species is salinity. Although organisms typically found in estuaries must have capacities to tolerate changing conditions, many are adapted to function more effectively in given ranges. Gunter[24] has reported that a difference of less than 0.5 parts per thousand salinity seem to be important over large and stable estuaries. He indicated, also, that the fauna in brackish water is predominantly marine both in species number and number of specimens, and that about 90 percent more marine fishes invade freshwater than come from freshwater into the sea.

An excellent illustration of the importance in salinity ranges is that of two enemies of the oyster grown optimally in brackish water areas. Both the oyster drill, Thias haemastoma, and a marine fungus, Dermacystidium marinum, invade waters of higher salinity during drouth and saltwater intrusions.[25]

Fishery Resources

The fishery resources of Louisiana are represented by commercial (including industrial) and sport fisheries, most of which are dependent upon the estuarine areas during all or part of their life. Biologically, approximately 75 percent of the fishes and invertebrates collected in the Louisiana coastal area are estuarine dependent.[15]

General groupings of species comprising the fisheries can be made based on distribution and life histories (with some variation). Three such groupings are convenient and include resident, semicatadromous, and seasonal migrant species.

Resident Species. Species dependent on the estuarine environment most of the time and completing their life cycles in this zone are termed resident species. These are represented by oysters, blue crabs, and spotted seatrout, although the latter two species do venture into the shallow waters of the Gulf.

Of the three members of this group, oysters are by far the most valuable of these commercial species which are supported by the estuaries. The oyster of commerce in Louisiana is the Virginia oyster, Crassostrea virginica. Production of this species in Louisiana estuaries is equal to 20 percent of the United States production.[26] This relatively stable and high level of production has been maintained in the isolated bayous mostly under a system of private farming assisted by a state seed-production program.[27]

Production comes from 116,318 acres of private oyster leases and a 1,200-acre area of public oyster reefs.[15] Both of these areas are concentrated primarily in the eastern portion of the state and diminish almost to none when reaching the Marsh Island area. Total commercial production average for the five years of 1962-66 was 8,856,540 lb at a value of $2,759,506 (see Table 2.9). The preponderance of farming over natural reef production is explained by the fact that these areas have been overfished, higher salinity waters have encroached the natural reef areas, and pollution has affected the suitability of organisms from these areas for anything other than seed.[23]

A continued high production in the now suitable areas of bayous and bays will depend in great part on the continued salinity range of 7 to 30 ppt. Alteration of the environment to change these ranges will have serious consequences. These will be discussed later.

Although a part of the commercial fisheries, both spotted seatrout and blue crabs are also valued by recreational fishermen. Perret[15] reported that large numbers of spotted seatrout are taken in Louisiana waters by sports fishermen. Tabb[28], who reported that in several southeastern states this fish is harvested in about equal quantities by sports and commercial fishermen (see Table 2.9), also indicated that the wide tolerance to change in the estuarine habitat has permitted this species to occupy a niche not used by other seatrout and intolerable to most marine predators and competitors.

TABLE 2.9. AVERAGE ANNUAL HARVEST (1962-66) OF MAJOR COMMERCIAL FISH AND SHELLFISH PRODUCED IN LOUISIANA SHOWING QUANTITY AND EXVESSEL VALUE[15]

Species	Quantity, lb	Dollar Value
Shrimp	61,729,040	19,508,247
Menhaden	632,093,300	9,249,932
Oysters	8,856,540	2,759,506
Blue crab	8,412,980	637,478
Spotted seatrout	404,900	82,663
Red drum	460,447	78,865
Flounder	202,914	34,354
Sand seatrout	78,320	6,283

The large populations of blue crabs in Louisiana waters are indicated by their being the third most abundant commercial invertebrate taken in the commercial fisheries.[15] Menzel and Hopkins[29] have stated that they believe this species to be more abundant in Louisiana than in any other state. Their value to the commercial fisheries is indicated by their production average for the years 1963-67 of 8.27 million pounds averaging in value at $730,000. This represented 1 percent of the production poundwise and 1.7 percent of the Louisiana commercial fisheries value for the 4-year period.[30]

One species of fish which does not effectively fall into the resident species or semicatadromous grouping is the bay anchovy (Anchoa mitchelli). It is, nevertheless, an important species to the estuary habitat if for no other reason than its exceedingly large numbers and biomass. Perret[15] cites researchers who report that this species probably has the greatest biomass of any fish in estuarine waters of the south Atlantic and Gulf of Mexico. Perret[15] states that this species made up almost 85 percent of the noncommercial vertebrate catch in his survey of the Louisiana coastal area. Although not fished commercially, the bay anchovy constitutes a very important food chain organism in this area and must, therefore, be considered when alterations of its environment are contemplated. Its value has been recognized by Darnell[30] as furnishing food for at least ten predatory species whose habitat distributions suggest its importance in both weedy shallows and surface and bottom waters of open lakes.

Semicatadromous Species. The second and perhaps largest group of organisms are those termed semicatadromous. Species within this group exhibit a generally similar life history which includes (1) spawning in ocean waters, (2) migration of the young to estuarine areas, (3) growth to subadults in this area, and (4) return to ocean waters to complete the cycle. A relatively large number of commercially important species of the Louisiana coastal fisheries are included in this group, and because some return for short periods to the estuaries as adults they are significant in the inland sports fishery in addition to their commercial value in the Gulf.

Important species falling into this group include white shrimp, brown shrimp, menhaden, red drum, flounder, black drum, Atlantic croaker, spot, and sand seatrout.

By far the most abundant species in the commercial fishery of this area is the menhaden. It is second in value to the two species of shrimp taken. Its average production and value over the years 1962-66 was in excess of 632 million pounds and 9 million dollars (see Table 2.9).

The United States is the world's foremost producer of shrimp with the shrimp fishery occupying a relatively prominent position in the economy. For example, in 1960-62, the average volume and value produced in the United States was over 200 million pounds and over $60 million.

The shrimp fishery of the Louisiana coastal zone consists of two species, the white shrimp, Penaeus setiferous, and the brown shrimp, P. aztecus. The combined average production and value for the 5-year period of 1962-66 was almost 62 million pounds and $20 million (see Table 2.9) making these species the most valuable in the area and in the semicatadromous grouping.

Spawning of both species generally occurs offshore but at different depths; brown shrimp utilizing waters 240-250 feet in depth and white shrimp spawning in shallower waters of 35-50 feet. During the months of February, March, and April, postlarval brown shrimp begin their migration from offshore waters into the estuaries. White shrimp postlarvae are found migrating into the estuaries in greatest numbers during the months of July and August. While in the estuarine nursery area, shrimp feed on a variety of materials including plants, animals, and inorganic and organic detritus in areas where the substrata is muddy or peaty. Brown shrimp tend to be distributed rather uniformly in waters 2 to 3 feet deep having attached vegetation. White shrimp have a tendency to "school" in waters less than 2 feet deep in areas with large amounts of detritus.[23]

Migration out of the estuary occurs about early spring to midsummer for brown shrimp and around November and December for white shrimp. During their stay in the estuary, growth is quite rapid. White shrimp average about 1-1/2 inches of growth per month, while brown shrimp grow at an average rate of 1-1/2 to 1-3/4 inches per month.[31] Distribution of these species in the estuaries are also governed by salinity ranges: brown shrimp, 9.80-60 percent; white shrimp, 0.45-45 percent.[17] Alteration of coastal areas influencing salinity regimes can be expected to cause shifts in populations of these important species.

In addition to being important in the commercial fishery, most of the semicatadromous species mentioned (with the exception of menhaden) are also valued by recreational fishermen[16] and are taken in large numbers annually. Indeed, it has been reported that the value of the sports fisherman to the United States economy system probably exceeds that of the commercial fishery and will in the future.[32] Also, some species of this group constitute the largest industrial fishery in the United States for production of oil, pet foods, and fish meal. Although menhaden are the principal component of this fishery, others included in the semicatadromous grouping are sand seatrout, Atlantic croaker, spot, and several other species. It is interesting to note that the menhaden fishery does not conflict with estuarine sports or other commercial fisheries since the gear used does not select for other species of fish nor does it destroy the estuarine habitat as alleged.[33]

Seasonal Migrant Species. The third grouping of fishes in the Louisiana area is the seasonal migrant species which appear in the estuarine zones briefly during warmer parts of the year chiefly to forage. Because of this characteristic, they are more valuable recreationally than commercially. Major fishes of this group are tarpon, jacks, king mackerel, Spanish mackerel, ladyfish, bluefish, and cobia.

SOCIOECONOMIC FACTORS[5,34,37]

The coastal marsh area was defined earlier as comprising all or parts of 14 coastal parishes (the local government unit in Louisiana). Characteristically, the true marsh areas have a low population density, and are essentially rural in nature. The vast expanses of marshland have limited both the extent and mileage of highways, so that transportation and communication in these areas is hampered, which has contributed to their isolation.

Population

The 1960 and 1970 populations of the 14 parishes included in this study are shown in Table 2.10. This table also shows the percent change in population between 1960 and 1970 as well as the average annual growth rate during that time period. Only one parish – Orleans, containing the bulk of population of New Orleans – lost population between 1960 and 1970. However, Jefferson and St. Bernard Parishes which make up part of the New Orleans SMSA (Standard Metropolitan Statistical Area) grew substantially during this period. Jefferson Parish increased by 61.7 percent, while St. Bernard showed a population increase of 59.0 percent. The parish adjacent to Jefferson Parish and Lake Ponchartrain – St. Charles – also appears to be a part of this rapid suburban growth since it increased by 39.3 percent between 1960 and 1970. Total population of the three parishes in the New Orleans SMSA in 1970 was 982,220, 27 percent of the population of the state.

TABLE 2.10. POPULATION OF PARISHES AND STATE PERCENT CHANGE BETWEEN 1960 AND 1970, AND AVERAGE ANNUAL GROWTH RATE BETWEEN 1960 AND 1970[35,36]

	Parish	1960	1970	Percent Change	Average Annual Growth Rate 1969-1970	Area, sq mi	Population Density, persons per sq mi
1.	Assumption	17,991	19,654	9.2	0.9	356	55.2
2.	Cameron	6,909	8,194	18.2	1.7	1,441	5.7
3.	Iberia	51,657	57,397	11.1	1.1	589	97.5
4.	Jefferson	208,769	337,568	61.7	4.9	331	1020.0
5.	Lafourche	55,381	68,941	24.5	2.2	1,141	60.5
6.	Orleans	627,525	593,467	-5.4	-0.6	205	2890.0
7.	Plaquemines	22,545	25,225	11.9	1.1	1,030	24.5
8.	St. Bernard	32,185	51,185	59.0	4.7	514	97.8
9.	St. Charles	21,219	29,550	39.3	3.4	288	102.5
10.	St. James	18,369	19,733	7.4	0.7	253	78.0
11.	St. John the Baptist	18,439	23,813	29.1	2.6	250	95.5
12.	St. Mary	48,833	60,752	24.4	2.2	624	97.5
13.	Terrebonne	60,771	76,049	25.1	2.3	1,368	55.5
14.	Vermilion	38,855	43,071	10.9	1.0	1,205	35.7
State of Louisiana		3,257,022	3,640,442	11.8	1.1	45,155	80.6

Also shown in Table 2.10 are the areas of each parish and the average population density. Excluding the three New Orleans SMSA parishes, the average population density for the other 11 coastal parishes is only 50 persons/square mile.

It is extremely unlikely that additional pipeline construction would influence population trends at the parish level. Such construction and operation could possibly affect individual communities if they were to serve as bases for construction and operation personnel. The community population figures for the study area are shown in Table 2.11.

Employment

The employment structure of the 14 parishes included in this section of the report varies considerably among these parishes. If these parishes were divided into three groups based upon where the population lived, the first set would be considered to be predominately rural (i.e., at least 50 percent of their total population living on farms or in places with less than 2,500 people). This type of population distribution goes hand-in-hand with a certain type of employment structure. The parishes in this first group are Assumption, Cameron, Lafourche, Plaquemines, St. Charles, St. James, and Vermilion.* Table 2.12 shows the percentages of the employed in a number of industry groups for 1970 for all 14 parishes. (A more detailed table is contained in Appendix A.) Examination of this table shows the variation in employment structures among the parishes. In Assumption Parish, agriculture, forestry and fisheries, construction, and manufacturing industries are all important employers. The predominant industry groups in Cameron Parish are agriculture, forestry, and fisheries as well as mining and construction. Lafourche Parish has slightly over 10 percent of its employed in mining industries. This figure is more than double the State's percentage in this industry group. The Parish of Plaquemines has two very dominant industry groups; they are mining (20.19 percent) and construction (12.84 percent). This parish is obviously deeply involved with the oil, gas, and sulfur industries. St. Charles is clearly dominated by the manufacturing industries with 32.33 percent of its employed in this group. Half of this 32 percent is employed in industries producing chemicals and allied products. In St. James Parish, over half of its employed population is in agriculture, forestry, and fisheries and manufacturing. The agriculture-related group, mining, and construction are all important in Vermilion Parish.

The second group of parishes in this study are neither rural nor metropolitan. They are Iberia, St. John the Baptist, St. Mary, and Terrebonne. All of these parishes are between 35 and 48 percent rural. Iberia Parish has a large mining industry group with 15.41 percent of the employed population in it. Only three of the parishes in the study have a higher percentage than this. Iberia Parish also has a very large percentage of people employed in retail trade. In St. John the Baptist Parish, manufacturing is clearly the dominant industry with 36.28 percent of its employed in this group. This figure may be compared with the Louisiana figure of 15.89 percent. St. Mary and Terrebonne Parishes both have a large proportion of people in the mining industries. Both of these parishes have more than double the State's percentage in transportation-related employment.

*The Southern portion of St. Martin parish, below Iberia parish, would also qualify as a rural parish. St. Martin Parish has been omitted from the tabulation since most of the parish is not in the coastal wetlands.

TABLE 2.11. COMMUNITY POPULATION FOR 1960 AND 1970, PERCENT CHANGE AND AVERAGE GROWTH RATE(35,36)

Community	Population 1960	Population 1970	Percent Change	Average Annual Growth Rate, 1960-1970
Assumption Parish				
Napoleonville	1,148	1,008	-12.2	-1.29
Cameron Parish[a]				
Iberia Parish				
Jeanerette	5,568	6,182	11.0	1.05
Loreauville	655	728	11.1	1.06
New Iberia	29,062	30,147	3.7	0.37
Jefferson Parish				
Grand Isle	2,074	2,236	7.8	0.75
Gretna	21,967	24,976	13.7	1.29
Harahan	9,275	13,073	40.9	3.49
Harvey	--	6,178	--	--
Jefferson Heights	19,353	16,450	-15.0	-1.64
Kenner	17,037	29,900	75.5	5.79
LaFitte	--	1,223	--	--
Little Farms	--	15,715	--	--
Marrero	--	29,015	--	--
Metairie	--	135,804	--	--
Terry	--	13,822	--	--
Westwego	9,815	11,404	16.2	1.51
Lafourche Parish				
Golden Meadow	3,097	2,681	-13.4	-1.43
Larose	2,796	4,397	57.3	4.63
Lockport	2,221	1,995	-10.2	-1.07
Raceland	3,666	4,940	34.8	3.03
Thibodaux	13,403	14,922	11.3	1.08
Orleans Parish				
New Orleans	627,525	593,467	-5.4	-0.56
Plaquemines Parish				
Buras-Triumph	4,908	4,228	-13.9	-1.50
Port Sulphur	2,868	3,022	5.4	0.52
St. Bernard Parish[a]				
St. Charles Parish				
Allemands	1,167	2,318	98.6	7.10
Hahnville	1,297	2,483	91.4	6.71
Luling	2,122	3,272	54.2	4.43
Mimosa Park	--	1,624	--	--
New Sarpy	1,259	1,643	30.5	2.70
Norco	4,682	4,784	2.2	0.22
Saint Rose	1,099	2,106	91.6	6.72

TABLE 2.11 (Continued)

Community	Population 1960	Population 1970	Percent Change	Average Annual Growth Rate, 1960-1970
St. James Parish				
Gramercy	2,094	2,496	19.2	1.77
Lutcher	3,274	3,911	19.5	1.79
Vacherie	--	2,145	--	--
St. John the Baptist Parish				
Garyville	2,389	2,474	3.6	0.35
Laplace	3,541	5,953	68.1	5.33
Reserve	5,297	6,367	20.2	1.86
St. Mary Parish				
Amelia	--	2,292	--	--
Baldwin	1,548	2,117	36.8	3.18
Bayou Vista	--	5,002	--	--
Berwick	3,880	4,168	7.4	0.72
Franklin	8,673	9,325	7.5	0.73
Morgan City	13,540	16,788	24.0	2.17
Patterson	2,923	4,409	50.8	4.20
Terrebonne Parish				
Bayou Cane	3,173	9,137	188.0	11.16
Houma	22,561	30,864	36.8	3.18
Vermilion Parish				
Abbeville	10,414	10,996	5.6	0.55
Delcambre	1,857	1,975	6.4	0.62
Erath	2,019	2,024	0.2	0.02
Gueydan	2,156	1,984	-8.0	-0.83
Kaplan	5,267	5,540	5.2	0.51
Maurice	411	476	15.8	1.48

(a) No communities are shown in the Census for these two parishes. Apparently there is some sort of local option about whether or not to include unincorporated communities in the Census. There are, in fact, towns in both these parishes.

TABLE 2.12. SUMMARIZED EMPLOYMENT BY INDUSTRY GROUP FOR PARISHES[35]

Parish	Total Employed, >16 yrs	Agriculture, Forestry, Fisheries	Mining	Construction	Manufacturing	Transportation	Services
Assumption	4,929	19.01	4.44	11.54	21.93	3.77	58.32
Cameron	2,601	12.92	15.99	8.42	11.76	7.54	43.37
Iberia	17,346	6.28	15.41	6.20	12.93	4.28	54.90
Jefferson	122,345	0.92	3.93	8.67	15.79	9.22	61.47
Lafourche	20,964	6.50	10.45	8.53	15.23	8.23	51.06
Orleans	208,787	0.65	1.71	5.78	11.89	8.15	71.82
Plaquemines	7,905	4.69	20.19	12.84	10.46	9.72	42.10
St. Bernard	17,521	1.28	2.03	10.19	21.56	9.94	55.00
St. Charles	8,910	2.30	2.93	8.11	32.33	7.62	46.71
St. James	4,976	10.27	0.36	6.29	44.15	2.59	46.61
St. John	6,321	4.94	1.49	10.44	36.28	6.39	40.46
St. Mary	19,130	5.85	12.27	7.79	13.84	8.62	51.63
Terrebonne	22,958	4.51	18.53	6.38	11.75	8.88	49.95
Vermilion	12,519	12.93	11.52	9.65	8.00	5.27	52.63

The third group of parishes to be discussed are three parishes in the New Orleans SMSA. They are Jefferson, Orleans, and St. Bernard Parishes. Jefferson and Orleans Parishes have employment distribution typical of urban areas. That is, they have large numbers of people employed in the trades and services. St. Bernard Parish is slightly different in that its largest industry group is manufacturing.

While the data from the census (Table 2.12) show reliable general information, it is necessary to try and locate employment or industry groups which could be affected by either the construction and/or operation of a gas pipeline. The types of industries which one could expect to be affected (directly or indirectly) are those involved in hunting, fishing, trapping, the drilling of gas wells, related support services like supplies and transportation, construction of pipelines, and the transmission and distribution of the gas. Specific information on the location and size of these industries was gathered from a report from the Louisiana Wildlife and Fisheries Commission and the Louisiana Directory of Manufacturers.

The first of these sources gave information on the hunting, fishing, and trapping industries. Tables 2.13 and 2.14 show the number of commercial fishing and dealer's licenses, hunting club, hunting preserve, game breeder, fur buyer and fur dealer licenses sold in 1971 by parishes. This information is included to provide an idea of where these activities are taking place and some degree of their relative importance among the parishes. The licenses related to freshwater fishing are scattered throughout the 14 parishes in a manner directly related to population. The licenses for fur buyers shown in Table 2.14 are concentrated in the eastern group of parishes. Where the buyers are located is probably a good indication of where most of the trappers are. The parishes with the largest numbers of fur buyers are Jefferson, Lafourche, Plaquemines, St. Bernard, St. Mary, and Terrebonne.

The parishes where oil and gas well drilling is an important employer are Cameron, Iberia, Plaquemines, St. Mary, Terrebonne, and Vermilion. Pipeline construction is a fairly important activity in Plaquemines, St. Charles, and St. Mary Parishes. Companies in charge of gas transmission and distribution may be headquartered elsewhere, although some are in Iberia, Jefferson, Orleans, and Terrebonne Parishes.

The Louisiana Directory of Manufacturers was examined primarily to find unique-to-the-area types of manufacturing activities. Many of the unique or local-specialty manufacturing activities are not related to the gas industry, and some are related only indirectly. However, in order to get a more exact (but still general) picture of the coastal Louisiana economy, the principal manufacturing activities will be pointed out.

Sugarcane and rice are the main agricultural crops grown. These two crops are found all along the coast with rice generally being grown closer to the Gulf than sugarcane. From these two crops have come a variety of manufacturing industries such as rice milling, production of crop-related equipment, refining sugar, and making molasses. Another somewhat unique crop found in southern Louisiana is the pepper which enter the manufacturing process when it is transformed into sauces and seasonings. Another important manufacturing activity is the processing of seafood. This includes the canning freezing primarily of fish (menhaden), shrimp, and oysters. Also connected with the fishing industry is the building and servicing of boats and other fishing equipment as well as companies which produce ice. In the eastern coastal area, there are several large chemical and petroleum refining companies.

TABLE 2.13. 1971 COMMERCIAL FISHING AND DEALERS' LICENSES SOLD BY PARISH AND STATE(5)

Parishes	Salt Water Shrimp Trawl Vessel	Salt Water Fish Vessel	Menhaden Seine & Vessel	Salt Water Seine	Salt Water Trammel Net	Oyster Tonnage	Oyster Dredging	Oyster Shop Resale	Hoop Net	Fresh Water Seine	Fresh Water Trammel Net	Fresh Water Gill Net	Fish Farmer	Commercial Fisherman Bait, Seller	Retail Dealer	Wholesale Dealer Dealer & Agent	Total Licenses Sold
Assumption	36	-	-	-	-	-	-	-	62	1	6	11	38	108	28	10	300
Cameron	294	4	-	8	-	96	-	5	19	1	-	15	-	19	19	4	467
Iberia	560	3	-	13	2	2	-	1	30	2	3	46	-	27	82	5	776
Jefferson	1807	5	-	12	14	21	8	8	4	1	8	33	-	33	183	44	2181
Lafourche	1194	-	-	3	9	41	4	4	5	15	4	28	11	2	50	20	1390
Orleans	553	1	5	3	13	15	15	14	3	1	6	14	1	50	319	18	1049
Plaquemines	650	1	5	2	23	21	21	3	9	2	1	18	1	14	25	13	842
St. Bernard	688	7	-	6	9	4	4	5	-	1	-	3	-	9	43	11	807
St. Charles	251	-	-	1	1	1	1	2	5	-	2	5	3	13	37	8	330
St. James	65	-	-	-	-	-	-	-	-	1	2	2	-	-	18	1	89
St. John	129	2	-	-	-	-	-	-	1	-	-	3	-	4	11	-	150
St. Mary	893	17	7	5	-	2	-	1	96	5	20	44	3	79	58	24	1254
Terrebonne	2137	-	-	2	34	81	14	13	5	-	-	13	1	8	68	58	2434
Vermilion	753	1	-	83	-	29	-	2	7	15	1	158	8	26	69	6	1158
Louisiana	12,595	53	45	255	1035	635	81	70	1647	304	1035	3005	188	1033	3317	345	24,729

TABLE 2.14. 1970 MISCELLANEOUS LICENSES SOLD BY PARISH AND STATE(5)

Parishes	Hunting Club	Game Breeder	Fur Buyer	Fur Dealer	Total
Assumption	4	--	4	--	8
Cameron	1	3	3	--	7
Iberia	2	3	4	--	9
Jefferson	4	12	10	1	27
Lafourche	--	12	6	1	19
Orleans	4	5	5	5	19
Plaquemines	--	1	4	--	5
St. Bernard	--	5	6	--	11
St. Charles	2	5	2	1	11
St. James	--	--	--	--	--
St. John the Baptist	--	1	--	--	1
St. Mary	2	1	7	--	10
Terrebonne	2	4	16	3	25
Vermilion	7	3	6	1	17
Louisiana	187	183	106	20	500

Occupations

Occupational data for both employed and experienced unemployed in the 14 coastal parishes are presented in Appendix A. As of 1970, and the same general conditions should still prevail, there were experienced unemployed persons in all categories likely to be needed for gas pipeline construction.

Labor Force

Labor force statistics for the 14 parishes are tabulated in Appendix A. Overall, the unemployment picture appears comparable to the national U. S. picture.

Income Distribution

Seven of the 14 parishes have a mean family income above the Louisiana state average of $8,799. These parishes are Jefferson, Orleans, Plaquemines, St. Bernard, St. Charles, St. Mary, and Terrebonne. Of the remaining 7 parishes, 5 of them have 20 percent or more of all their families living at an income less than the poverty level. Poverty level was considered by the Bureau of the Census to be $3,388 in 1969. Only Orleans Parish falls into both of the above-mentioned groups. This indicates that Orleans Parish has high proportions of lower and higher income families and less than normal distribution of middle-income families. Two parishes do not fall in either group; they are Cameron and Lafourche Parishes. Their mean family incomes are higher than $8,000 per year but not quite up to the state average of $8,799. The poverty level percentages in Cameron and Lafourche are 16.7 percent and 15.4 percent, respectively.

Education

The median number of school years completed and the percent of high school graduates for the population 25 years old and over for the 14 parishes are shown in Table 2.15. The general economic-opportunity climate present in the parishes may be inferred by looking at these figures. For example, the parishes with relatively low percentages of high school graduates are the same parishes which had income levels lower than the state averages. It is doubtful that gas pipeline construction and operation would greatly affect the educational situation in a parish through which it ran. It is likely that any local people who would be hired to work on pipeline construction and operation could have a variety of educational qualifications.

Housing

Some housing information is available at the parish level (shown in Table 2.16) as well as for communities with a population of at least 1,000 and above. This information is of little use until it is known more precisely which towns might be affected

TABLE 2.15. MEDIAN SCHOOL YEARS COMPLETED AND PERCENT HIGH SCHOOL GRADUATES FOR POPULATION 25 YEARS OLD AND OVER BY SEX, 1970(35)

Parish	Median School Years Completed	Percent High School Graduates
Assumption		
Male	7.2	20.7
Female	7.9	24.3
Cameron		
Male	9.3	30.4
Female	9.6	34.4
Iberia		
Male	9.1	34.2
Female	9.5	33.4
Jefferson		
Male	12.1	53.8
Female	12.0	51.4
Lafourche		
Male	8.4	31.8
Female	8.6	30.9
Orleans		
Male	10.8	42.8
Female	10.8	41.8
Plaquemines		
Male	9.6	35.5
Female	10.0	35.9
St. Bernard		
Male	10.9	43.2
Female	11.0	41.8
St. Charles		
Male	11.2	45.1
Female	10.7	41.5
St. James		
Male	9.9	38.9
Female	9.4	34.0
St. John the Baptist		
Male	9.8	40.3
Female	10.0	36.6
St. Mary		
Male	9.8	37.8
Female	10.0	36.9
Terrebonne		
Male	9.2	35.5
Female	9.8	35.7
Vermilion		
Male	8.2	28.2
Female	8.4	27.0

TABLE 2.16. HOUSING STATISTICS BY PARISH, 1970[37]

Parish	Total Housing Units	Percent Year-Around Units Owner Occupied	Percent Year-Around Units Renter Occupied	Percent Vacant for Sale Only or for Rent
Assumption	5,345	63.3	29.6	2.8
Cameron	3,303	53.7	16.2	3.7
Iberia	16,595	62.6	31.5	2.8
Jefferson	101,314	65.3	29.0	3.6
Lafourche	19,205	66.4	27.3	2.5
Orleans	208,524	35.3	56.5	6.1
Plaquemines	6,836	58.2	37.4	1.2
St. Bernard	14,228	75.0	21.4	1.9
St. Charles	8,248	70.6	21.4	4.4
St. James	4,815	70.0	26.1	1.2
St. John the Baptist	6,470	66.3	22.9	7.9
St. Mary	17,279	57.7	35.4	3.1
Terrebonne	20,854	66.4	27.5	3.6
Vermilion	13,747	67.3	25.4	2.5

by labor force requirements for pipeline construction. At that point, a local realtor would be able to present a better picture of housing availability than would census vacancy rates.

Social Organization

In the 14 study parishes, there is only one group of people who are not found outside Louisiana. These people are the Cajuns, a French-speaking people whose ancestors had lived in the French colony of Acadia. This area is now the Canadian Province of Nova Scotia. During the latter part of the 1700's, many Acadians moved to the French-Catholic country around New Orleans after the British had taken over Acadia and forced the French farmers out. Most of these peoples settled west of the Mississippi River in coastal Louisiana. As can be seen from Table 2.17, this area is still heavily populated by people whose mother tongue is French.* Out of the 14 parishes being examined in this section, 10 of them have a higher percentage of French-mother-tongue people than the State of Louisiana's average percentage of 15.65. Five of these parishes have a Cajun population of over 42 percent. They are – starting with Vermilion Parish with a French-speaking population of 69 percent – Vermilion, Lafourche, Iberia, Cameron, and Assumption. Most Cajuns have remained a rural people. For example, only one parish out of the five just mentioned has a rural population of less than 50 percent. Generally speaking, the Cajun people today are involved in the same types of occupations as everyone else living in this area, although they are primarily engaged in hunting, fishing, and farming. In the western parishes of Cameron and Vermilion, cattle raising is of some importance.

In addition to the large Cajun population in many of these parishes, there are large percentages of black people. The percent black in each of the parishes is also shown in Table 2.17. Out of the 14 parishes being studied, four of them have a higher proportion of black people than the average (29.81 percent) for the State of Louisiana as a whole. The four parishes are, starting with the highest percentage, St. James (47.24), St. John the Baptist (46.34), Orleans (45.05), and Assumption (37.32). It is a very safe assumption that many of these black people work in the sugarcane fields. Of course, others are employed in a wide variety of industry and business.

Archaeology[38]

Man has been in coastal Louisiana for at least 2,000 years. This has been documented through the investigation of numerous sites in this area. These Indian sites are basically mounds and middens. The mounds are artificial structures in the form of steep, four-sided, truncated pyramids if they were constructed out of earth. Others were made from shell and are, therefore, less pronounced in form. The middens are "incidental accumulations of village refuse" or garbage dumps in modern-day terms. Over 500 sites of both variety have been found in coastal Louisiana and many of these sites are in the delta area. These early people apparently changed their locations as the Mississippi River shifted its course. Also, as the salinity of an occupied area changed, the number of clams and oysters available for food changed. As each of these sites is examined, more information is found to isolate the various types of cultures and living conditions of these early men.

*According to the census, the mother tongue is the language spoken in a person's home when he was a child.

TABLE 2.17. PERCENT OF FRENCH MOTHER TONGUE[a] AND BLACK BY PARISH AND STATE, 1970[35]

Parish	Percent French	Percent Black
Assumption	42.16	37.32
Cameron	42.45	6.52
Iberia	43.93	27.81
Jefferson	13.56	12.46
Lafourche	62.52	11.19
Orleans	7.21	45.05
Plaquemines	18.78	22.91
St. Bernard	10.65	5.29
St. Charles	22.67	26.31
St. James	28.81	47.24
St. John the Baptist	22.11	46.34
St. Mary	21.86	28.07
Terrebonne	39.39	15.02
Vermilion	69.29	13.48
Louisiana	15.65	29.81

(a) According to the census, the mother tongue is the language spoken in a person's home when he was a child.

REFERENCES

(1) Nichols, L. G., "Rockefeller Refuge Levee Study", Technical Bulletin of the Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana (1959), 17 pp.

(2) "Fourteenth Biennial Report 1970-71", Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana (1972), 205 pp.

(3) Chapman, C., "Channelization and Spoiling in Gulf Coast and South Atlantic Estuaries", Marsh and Estuary Management Symposium, Louisiana State University, Baton Rouge, Louisiana (July 19-20, 1967).

(4) Odum, W. E., "The Role of Organic Detritus in Marshes and Estuaries", paper presented at the Coastal Marsh and Estuary Symposium, Louisiana State University, Baton Rouge, Louisiana (17-18 July 1972).

(5) "Thirteenth Biennial Report 1968-1969", Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana (1970), 156 pp.

(6) Palmisano, A. W. and Chabreck, R. H., "The Relationship of Plant Communities and Soils of the Louisiana Coastal Marshes", Paper presented at the 13th Annual Meeting, Louisiana Assn. of Agronomists, Lake Charles, Louisiana (March, 1972), 42 pp.

(7) Penfound, W. J. and Hathaway, E. S., "Plant Communities of the Marshlands of Southeastern Louisiana", Ecological Monographs 8: 1-56 (1938).

(8) Taylor, D. F., "A Radio-Telemetry Study of the Black Bear (Euarctos americanus) with Notes on its History and Present Status in Louisiana", M. S. Thesis, The School of Forestry and Wildlife Management, Louisiana State University.

(9) "Draft Environmental Statement; Crude Oil and Natural Gas Production and Other Mining Operations in Navigable Water Along the Louisiana Coast", U. S. Army Engineer District, New Orleans Corps of Engineers (February, 1972), 82 pp.

(10) "Rare and Endangered Fish and Wildlife of the United States", U. S. Bureau of Sport Fisheries and Wildlife, Resource Publ. No. 34, Washington, D. C. (1968), 156 pp.

(11) Lowery, G. H. and R. J. Newman, "The Birds of the Gulf of Mexico", in "Gulf of Mexico, Its Origin, Waters and Marine Life", U. S. Fisheries and Wildlife Service, 55 (89): 519-540 (1954).

(12) Oberholser, H. C., "The Bird Life of Louisiana", Louisiana State Department of Conservation Bulletin 28 (1938), 834 pp.

(13) Bellrose, F. C., "Waterfowl Migration Corridors East of the Rocky Mountains in the United States", Illinois Natural History Survey, Biological Notes No. 61 (1968), 24 pp.

(14) Barrett, B. B., "Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana. Phase II, Hydrology, and Phase III, Sedimentology", Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana (1971), 191 pp.

(15) "Cooperative Gulf of Mexico Inventory and Study, Louisiana, Phase I, Area Description and Phase IV, Biology", Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana (1971), 175 pp.

(16) McHugh, J. L., "Management of Estuarine Fisheries", in A Symposium on Estuarine Fisheries, Ninth Annual Meeting, Supplement No. 3, pp. 133-153. American Fisheries Society, Atlantic, New Jersey.

(17) Gunter, G., "Some Relationships of Estuaries to the Fisheries of the Gulf of Mexico", <u>in Estuaries</u>. (George Lauff, Ed.) American Association for the Advancement of Science, Publication No. 83, Washington, D. C. (1967), pp. 621-638.

(18) Sykes, J. E., "Multiple Utilization of Gulf Coast Estuaries", 17th Annual Conference Southeastern Association of Game and Fish Commission, pp. 323-326 (1963).

(19) Allen, G. W., "Estuarine Destruction – A Moment to Progress", Twenty-Ninth North American Wildlife and Natural Resources Conference Transactions, pp. 324-331 (1960).

(20) St. Amant, L. S., "Biological Effects of Petroleum Exploration and Production in Coastal Louisiana", paper presented at the Santa Barbara Symposium, University of California at Santa Barbara (1970), 44 pp.

(21) Daiber, F. C., "Tidal Marsh – Conflicts and Interactions", Estuarine Bulletin 3(1): 4-16 (1968).

(22) Allen, G. W., "A Biologist's Viewpoint of Man-Made Changes in Estuaries", 19th Annual Session Gulf and Caribbean Fisheries Institute Proceedings, September (1967), 69-74 pp.

(23) Day, J. W., Jr., Smith, W. G., Wagner, P. R., and Stowe, W. C., "Community Structure and Energy Flow in a Salt Marsh and Shallow Bay Estuarine System in Louisiana", Office of Sea Grant Development, Louisiana State University, Baton Rouge, Louisiana (manuscript in preparation).

(24) Gunter, G., "Some Relations of Faunal Distributions to Salinity in Estuarine Waters", Ecology 37(3): (1956), 616-619 pp.

(25) <u>Handbook of Oyster Survey, Inter-Coastal Waterway, Cumberland Sound to St. Johns River</u>, U. S. Corps of Engineers, Jacksonville, Florida (1942).

(26) Louisiana Wildlife and Fisheries Commission Bulletin No. 6.

(27) Wallace, D. H., "Oysters in the Estuarine Environment" (1966), 68-73 pp.

(28) Tabb, D. C., "The Estuary as a Habitat for Spotted Seatrout, Cynoscion nebulosus", American Fisheries Society, Special Publication No. 3 (1966), 59-67 pp.

(29) Menzel, R. W., and Hopkins, S. H., "Crabs as predators of oysters in Louisiana", Proceedings of the National Shellfish Association, 46: 177-184, 1955.

(30) Darnell, R. M., "Trophic Spectrum of an Estuarine Community, Based on Studies of Lake Ponchartrain, Louisiana", Ecology 42(3): 553-568, 1961.

(31) Joyce, E. A., Jr., and Elred, B., "The Florida Shrimping Industry", Educational Series No. 15, Florida Board of Conservation Marine Laboratory (1966), 47 pp.

(32) Mock, C., "Importance of Gulf Estuaries and Problems Facing our Fisheries Resources", 11th International Game Fish Conference Proceedings, pp. 66-68 (1967).

(33) Gunter, G., "The Gulf of Mexico Menhaden Fishery in Relation to the Sports Fishery", Institute of Marine Science, Gulf and Caribbean Fisheries Institute, Proceedings of the 16th Annual Session (1964), pp. 99-108.

(34) Louisiana Directory of Manufacturers, Louisiana Department of Commerce and Industry, Baton Rouge, Louisiana, (1968).

(35) U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics PC(1)-C20, Louisiana.

(36) U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, Number of Inhabitants, PC(1)-A20, Louisiana.

(37) U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Housing Characteristics, HC(1)-A20, Louisiana.

(38) "Preliminary Report on the Indian Mounds and Middens of Plaquemines and St. Bernard Parishes", Department of Conservation, Louisiana Geological Survey, Geological Bulletin No. 8.

(39) Chabreck, R. H., T. Joanen and A. W. Palmisano, "Vegetative Type Map of the Louisiana Coastal Marshes", Louisiana Wildlife and Fisheries Commission (August, 1968).

CHAPTER 3. ENVIRONMENTAL, ECOLOGICAL, AND CULTURAL EFFECTS OF GAS PIPELINING

GENERAL

It is the intent of this chapter to present a summary of the observations made in the earlier chapters of this report and to develop, to the extent possible based upon the data and information evaluated to date, some general conclusions regarding the environmental, ecological, and cultural effects of gas pipelining in the Louisiana coastal marshes. An attempt has been made to develop conclusions that are generally applicable to gas pipelining in the coastal marshes, and not to the effects of a given pipeline. These conclusions will provide the background for the assessment of the impacts of a single pipeline once the route and construction techniques are specified. In addition, several factors bear emphasis so that the conclusions drawn are viewed in their proper context.

(1) The analysis of the effects of pipelining is performed by separating the problem into discrete units. While this is necessary to establish a basis for estimating changes in the environment and the direction and significance of these changes, it is important to remember that the coastal marshlands represent a continuous unit in time and space, i.e., we are dealing with an ecosystem. As Gates[(1)*] has noted, "the complexity of an ecosystem is enormous for, by definition, it is the total sum of the organisms, the environment, and the processes of interaction between and within all parts of the system." By concentrating our efforts on discrete factors, we may be ignoring important parts of the system or minimizing subtle but significant interactions.

(2) The high productivity of the Gulf Coastal ecosystems makes them an asset with regard to all of the areas economic stability and growth. National focus on the uses of coastal zones is being brought through the National Coastal Zone Management Act of 1972. Due to both the ecological significance and the public focus on the coastal zones, it is important that all factors be carefully weighed in further gas pipeline operations.

(3) The Louisiana coastal marshlands serve many users - gas and oil industry, agriculture, fisheries, hunting and trapping, recreation, navigation. It is difficult, if not impossible, to assign the relative contributions of each of these activities to changes in the marshland environment. Historical patterns or changes are difficult to interpret since they represent the superposition of all of man's activities on the natural variations in the marshlands. The specific environmental effects of gas pipelining operations can best be assessed in those areas where there is but a single use of the marshes. In those cases, where care has been taken in construction and operation of the gas pipeline, the environmental effects are minimal.

* References are given on pages 3.33-3.37.

(4) There is insufficient information available on the environmental effects of gas pipelining for the quantitative assessment of the impacts of additional pipelining on the Louisiana coastal marshes. No studies have been identified which provide environmental base line data on a single line before construction, during construction, and during operations. This type of data would clearly document any environmental changes in the marshes due to gas pipelining. Such changes must now be inferred from a variety of data sources.

PHYSICAL AND CHEMICAL EFFECTS

Changes in the physical and chemical environment from gas pipelining were identified as the more easily quantifiable of the environmental effects and, as such, they have received a large amount of attention in the past by study groups and concerned regulatory, management and conservation groups. It is also evident that changes in many of the biological and socioeconomic parameters were directly or indirectly dependent upon environmental changes in the nonliving environment. Thus, in each of the discussions on biological and socioeconomic categories, continual reference will be made to the changes which occur in the environmental parameters.

Canaling

The soft substrate characteristic of a large part of the coastal marshes results in great difficulty in the employment of standard terrestrial ditching equipment. In all lands which are neither artificially nor naturally drained and with a high water table, either lightweight or floating pipelining equipment must be employed. In either case, a channel is opened which is filled with standing water and will generally remain so unless the channel is refilled.

Land loss due to canaling is a matter of serious concern in Louisiana. In earlier times losses were balanced by the periodic flooding of the Mississippi as well as by the deposition of suspended silt drifting westward from the Mississippi outlets in the Gulf. With the river now well channelized and controlled, flooding is prevented and the river's silt is now discharged so near the excarpment of the continental shelf that quantities available for accretion west of the river are reduced. On the other hand, the natural phenomena tending towards losses, i.e., subsidence, storm and wave action, etc., continue. Thus, there is a significant annual loss from natural causes entirely apart from those resulting from man's activities.

Quantitatively, this loss is difficult to pin down. The most authoritative and complete study appears to have been that of Gagliano and van Beek[2] who statistically analyzed the most recent USGS 7-1/2-minute quadrangle maps (using a 1/2-mile x 1/2-mile grid = 255 intersection nodes per quadrangle) and compared them with earlier maps. Some uncertainties were introduced by the varying dates of mapping, since this has been a continuing effort, and by the incompleteness of earlier maps. However, on the basis of this statistical analysis it was estimated that there was a loss of 495 sq mi over a 30-year period, an average of 16.5 sq mi/year. This widely quoted value appears to be the generally accepted figure and appears to be supported by the available evidence.

Difficulties arise in attempting to apportion this average annual loss among the various sources of loss. These are numerous and include these man-caused losses:

Navigation canals
Logging canals
Flood protection
Drainage canals
Rig access canals
Gas pipelines
Oil pipelines
Highway construction
Agriculture
Industry.

These are in addition to those from natural causes. In the other direction, land reclaiming and purposeful drainage, primarily for agricultural purposes, is adding to the land area, though this seems to be found more in the northern reaches of the marshes.

Later an attempt was made (3) to estimate the split between natural and man-made water bodies, and to further subdivide man-made water bodies into ponds and canals. (Ponds include drowned land reclamation projects, reservoirs, wildlife ponds, etc.) Due to the map situation time cut-offs were not sharp; the early map series covered a span of years between 1931-1942, and the more recent series between 1948-1967. A nominal time span of 30 years between the two periods was assumed. Based on these data the water area was estimated to have increased 376.6 sq mi, from 6231.8 to 6608.4. Canals were estimated to have increased from 40.3 to 189.1 sq mi during the same period, an increase of 148.8 sq mi.* This represents 39.5 percent of the total increase in water area. Applying this to the 16.5 sq mi average annual loss would indicate about 6.5 sq mi per year loss from canal dredging of all types.

Overall, Gagliano, Light, and Becker's(3) analysis indicates that 45 percent of the loss is man-made and 55 percent arises from natural causes. Areas of maximum land loss were found to coincide with areas of maximum subsidence. Study of data of other investigators led to the determination of a mean subsidence rate of 0.36 foot per century for the coastal Louisiana area. However, rates as high as 1.5 feet per century were determined and rates of 0.7 foot per century are not uncommon. Since much of the outer marsh is only a foot or two above mean sea level, subsidence can be an important cause of loss.

Water measurements have also been made by Barrett.(4) The water areas were divided into lakes, bays, and ponds; bayous and passes; and canals and channels. He was faced with the same problem of working with maps covering a varying time period;

---

* Unfortunately, an arithmetic error led to the calculation of the increase as being only 48.8 sq mi, which is only 13 percent of the 376.6 sq mi total. The error has been perpetuated in other publications, impact statements, etc., and the 13 percent has been applied to the 16.5 sq mi annual loss to derive a loss due to canal dredging of 2.15 sq mi/year.

those used were issued between 1948-1969. Because of this, his figures will be low since the intensive petroleum exploration and drilling activity in coastal Louisiana occurred following publication of some of the maps. His results are also not directly comparable with those of Gagliano, et al[3], since he considered the Intracoastal Waterway the northern boundary of the coastal marshes, whereas Gagliano included up to about 31°30' N, a line passing through Baton Rouge.

According to Barrett, the total area of canals and channels determined by his analysis was only 42,104 acres (65.8 sq mi). If these were all assumed to have occurred during the same approximately 30-year period, the average annual loss would be about 2.2 sq mi, coincidentally about the same as the erroneously derived one mentioned above, and about 13 percent of the total annual loss from all causes. This 2.2 sq mi/yr may be a little low; Barrett estimates that the 42,104 acres should be increased by about 20-30 percent to bring the figure up to date [personal communication, B. Barrett, Louisiana Wildlife and Fisheries Commission, (May, 1972)].

Barrett also reported that the total length of dredged canals and channels in coastal Louisiana was 4572.6 miles. A very important fraction of this total is due to navigation canals, particularly those designed and/or maintained by the U. S. Army Corps of Engineers. There were over 1,000 miles of these canals in 1967, of which the longest was the 302-mile Gulf Intracoastal Waterway traversing the state.[5]

Characteristically, navigation channels are perpendicular to the coastline and traverse an estuary from its connection with the sea to its headwaters, or offer access to the sea from inland marshes. Their conduit-like nature is deducible.

A third value for land loss due specifically to canal dredging for pipelines has been independently derived by a different approach [personal communication, William Manning, (July 1972), Superintendent of Marine and Fee Land Maintenance, Louisiana Land and Exploration Company (LLE)]. According to Manning, extrapolation of his company's experience to the 16.5 sq mi/year total indicates that only 5 percent of the yearly loss (i.e., ~1 sq mi/year) can be attributed to pipeline canals. His novel approach was to total from company records the areas of right-of-way granted for pipeline ditches and canals by his company over the past 35 years. Proportionately, their losses relative to the areas owned (and LLE is one of the large owners of land in coastal Louisiana, over 650,000 acres) support an estimate that about 6 percent of the total annual loss is attributable to pipelines. He did not similarly analyze other canalization – for navigation rig access, etc – so no value for these causes was derived. However, if it is assumed that these causes of loss are as great or greater than pipelines (and this has been suggested), a total estimate of 12-13 percent per year (2 sq mi) due to all canals would result, again in reasonable agreement with Barrett's figures.

Exploration for and production of petroleum in the coastal marshes of Louisiana has had an important bearing upon land loss due to canaling and possibly an even more important relationship with the changes brought about in water distribution patterns. Since access to the rig must be maintained during drilling and to the well site subsequently, if it is a producer, dams and bulkheads are not installed. Nor has it been customary to close off canals to unsuccessful dry-holes after their abandonment. Thus, there are thousands of rig access canals through the marshes of Louisiana, possibly equalling pipeline canals in area and exceeding them in hydrological effects.

Petroleum drilling activities in the coastal parishes appear to have passed their zenith in 1962-1963 as indicated by Table 3.1, current well completions have dropped to the range of 700/year. Nevertheless, the canals associated with onshore petroleum activities have had and are having major effects upon the environment which, however, cannot be extricated from the effects of pipeline canals.

Summarizing, the best estimate from the data available suggests that an average of from one to two square miles of marshland was replaced by water area as a result of gas pipelining. An equal or greater amount is lost by other canaling not associated with gas pipelining - oil rig access canals, navigation canals, drainage canals, etc.

The direct loss of land from canaling is directly proportional to the width and length of the canal. Per mile, land will be lost as shown in Figure 3.1. For the small shove-type pipeline canal, even when not backfilled, direct land loss is only about 1 acre/mi. For the large 65-ft exploration canals, such as those in Rockefeller Refuge described earlier(6), loss is nearly 8 acres/mi. If a 50-ft flotation barge-dredged pipeline canal is assumed, land loss is about 6 acres/mi (0.01 sq mi/mi of canal). Since coastal Louisiana comprises about 3,700,000 acres of land and 3,400,000 acres of water(4), a pipeline will typically be canaling through marshes only about 50 percent of the time. Thus, ~0.5 sq mi of marshland may be removed per 100 mi of pipeline.

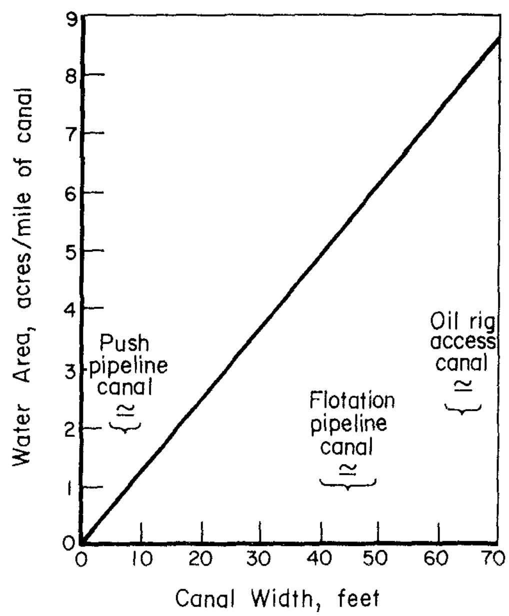


FIGURE 3.1. LOSS OF LAND AREA FROM CANALS

While not strictly land loss, there is an accompanying loss of availability of marsh resulting from the levee construction with the canal dredging spoils. While the land is still there it is no longer true marsh and has different characteristics and properties. Reestablishment of vegetation may be a problem in spite of the fact that the Louisiana marshlands are a high-productivity area, probably because of the reducing nature of

TABLE 3.1. LOUISIANA COASTAL PARISH COMPLETIONS

Year	Parish									Total
	Cameron	Iberia	St. Mary	Vermilion	Jefferson	Lafourche	Plaquemines	St. Bernard	Terrebonne	
1950	33	51	35	22	47	87	151	1	78	505
1951	30	47	31	22	32	110	217	2	85	576
1952	59	55	35	22	29	129	202	5	95	628
1953	91	62	75	38	44	162	284	11	162	929
1954	114	89[a]	68	36	61	206	332	20	188	1114
1955	88	63	92	65	50	218	164	3	161	904
1956	130	72	91	58	47	181	172	-	153	904
1957	111	67	97	95	54	201	213	2	215	1055
1958	79	58	113	100	46	200	204	9	244	1053
1959	94	61	136	113	38	168	223	5	242	1080
1960	73	35	98	80	46	200	270	15	217	1034
1961	94	37	113	93	70	163	276	7	234	1087
1962	118	46	105	121[a]	113	249[a]	290	21	285[a]	1348
1963	158[a]	39	157[a]	82	115[a]	232	315	59[a]	260	1417
1964	97	43	87	88	61	132	249	35	189	981
1965	103	35	124	80	67	211	352[a]	17	199	1188
1966	99	35	126	64	41	141	234	8	143	891
1967	65	23	79	55	41	100	183	14	207	767
1968	140	28	71	60	41	117	161	9	210	837
1969	130	34	86	72	29	101	128	13	148	741
1970	119	43	92	50	37	106	123	21	148	739
1971	86	56	82	20	46	104	105	15	150	664

Note: This information is from the International Oil Scouts publication and includes dry land as well as marsh and water bottom drilling; it does not include Zone 1.

(a) Peak drilling year.

Source: Hill, H., Private Communication (1972).

these spoils. As noted earlier, the amount of land lost to spoils banks and levees is a function of the amount of spoils and their character. As an approximation, the data of Nichols suggest that the actual width of land whose productivity is altered (including the berms inside the levees) may be 5-6 times that of the canal.

Thus, for the 50-ft flotation canal example, the diversion of marsh to levee will approximate 12-18 acres/mi, and the total marsh area with altered character would be in the range of 30-36 acres/mi, in addition to the direct loss of land of 6 acres/mi.

An additional diversion of land (loss of land from its original use) is that resulting from station siting. Soon after coming ashore a gas pipeline will generally pass through a compressor station where the gas may be dewatered, any condensate present stripped, and the gas compressed to push it along. Each of these stations will require dedication of a number of acres of marsh or beach to pipeline use.

Relative to contemplated gas pipeline operations resulting from the two proposed Louisiana offshore lease sales[8], the amount of marshland canal dredging likely to be necessary is estimated to be low. According to the Final Environmental Impact Statement for the 1972 OCS Eastern Louisiana Lease Sale [8a], it is estimated that none or possibly one new trunkline will be required to develop these tracts. This is due to a combination of excess line capacity already available and depletion of existing fields before the wells are developed. In the Final Environmental Statement for the Proposed 1972 OCS Oil and Gas General Lease Sale Offshore Louisiana[8b] it is estimated that possibly two new oil trunklines and one major gas pipeline would be required to develop the deeper water tracts of this proposed offering. Therefore, an estimate of marshland gas trunklines needed over the next several years might be one or two. A nominal figure for distances through the marshes and estuaries might be 200 miles total for two. If so, projected loss of marshland due to canaling in support of these lease sales would then be about 1 sq mi.

Comparison of Advantages and Disadvantages of Push and Flotation Canals (Adapted from Ref. 9)

Push Canal - Advantages

(1) Minimum disturbance to terrain and ecology.

(2) Minimum land loss unfilled which can be further minimized by backfilling which is often practicable.

(3) Lower cost where practicable.

Push Canal - Disadvantages

(1) Slower rate of construction – more delicate control required to push pipe down ditch usually confines work to daylight hours.

(2) If pipeline has to be lowered for other projects or repairs are necessary, cost savings can disappear.

(3) Limited access to pipeline for repairs or modification because of marsh condition.

(4) Water level may drop too low in winter for push construction due to north winds.

Flotation Canal - Advantages

(1) Adequate clearance above pipeline to accommodate future canals for other pipelines, oil rig access, etc.

(2) Levees provide resting places and foraging territory for deer and other terrestrial mammals.

(3) Access to pipeline in the event of repairs or future connections are required.

(4) In some cases, areas can be opened for wildlife management – possible recreation areas for hunters and fishermen.

Flotation Canal - Disadvantages

(1) More or less permanent alteration of landscape; greater loss of land.

(2) Drainage patterns may be changed depending on use of bulkheading and on spoil bank treatment.

(3) Erosion of land may result if navigation traffic is not prevented.

(4) Backfilling is impractical since spill that is removed is so fluid it cannot be stockpiled.

Canal Erosion

The soft and unconsolidated nature of the soils constituting Louisiana marshlands leads to erosion when stressed. As an example, it is reported that the barrier islands south of Timbalier and Terrebonne Bays are deteriorating from natural causes [personal communication, W. Manning].

The experience of one pipeline company at the point in Atchafalaya Bay where one trunkline came ashore is illustrative of the steady encroachment occurring from natural causes. At this location the flotation canal was backfilled for several hundred feet inland and the seaward face covered for several hundred feet with a protective shell mat (~3,000 cu yd of shells) to approximate the original shoreline. To mark the shoreline at the time of completion of the canal (1952), creosoted pilings were driven in at the toe of the shell mat and for several hundred feet on each side. These have been observed at intervals since. An inspection the following year, after a severe storm, indicated a considerable loss of shells and it was concluded at that time that very little advantage had been gained by their use. However, the shell facing may have offered some protection to the backfill while it was consolidating.

In a recent 1972 aerial inspection, the piles were estimated now to be 60-75 ft offshore. However, the receding of the shoreline appeared to be uniform; the canal was receding slightly slower, if at all. Based on this one documented experience, when properly done, damming of pipeline canals where lines come ashore from the Gulf eliminates them as foci of erosion.

Erosion of canals is a problem in coastal Louisiana. The primary cause appears to be boat traffic, though sometimes tidal currents can provide significant scouring action.

The erosion of the banks of several canals in the Rockefeller Wildlife Refuge has been observed for the past 20 years by Nichols.[6, 10] These data showed in some instances canals widened from the original 65 feet to 140 feet in less than 6 years, to the extent that the berms and portions of the levees were absorbed by the canal. Rates of from 1-2 feet per month were recorded. This rate of widening was not directly a result of their initial utilization for oil exploration, but rather because they turned into navigation canals offering access to the Gulf. Canals widen at a rate directly related to canal usage. Several factors influence this rate, of which the most important is marsh characteristics. The softer and more organic the marsh, the more susceptible it is to erosion.

Not all of the canal erosion can be attributed to boat traffic. Sometimes cutting a rather small canal will set up a circulation pattern which is self-generating. A small pirogue canal (3 feet wide x 6-10 inches deep) widened over the course of years to one 200 feet wide x 8 feet deep with no evidence that there had ever been any dredging [personal communication, Mr. D. Davis, Louisiana State University, Baton Rouge, Louisiana, (April, 1972)].

Gas pipeline canals are not generally used as navigation canals; in fact, the prevention of this boat traffic is one of the principal reasons for bulkheading or plugging the canal after completion of a pipeline. (The other is to minimize alteration of existing hydrology and drainage patterns.) Thus, gas pipelining does not appear to be a major contributor to the loss of land due to canal erosion where canals have been blocked.

However, if bulkheads and dams are not maintained they can wash out around the end permitting water flow, and inspection and maintenance is required to ensure that these continue to fulfill their designed function. Additionally, where a new canal offers an attractive short-cut across the marshes or to some trapping or fishing area, sabotage is a possibility. Earthen dams have been dug out, wooden bulkheads set afire and burned out, and concrete ones dynamited to open canals to unauthorized boat traffic.

Effects of Spoils

Disposal of the spoil from dredging can have both physical and chemical effects. Physically, the spoil banks or levees change the drainage and use patterns of the marsh. Spoil banks sink by compaction of the marsh upon which they are piled, which can alter the existing drainage. Where the spoil banks are continuous, as in a levee, even more interference with drainage patterns is possible.

Even though the elevation of a levee may be only 3 to 6 feet, this is sufficient to increase the drainage of moisture from the soil so that a drier soil results which can result in conditions more favorable for flora other than those of the surrounding marsh.

Turbidity

Louisiana's estuaries are relatively turbid. As part of the Cooperative Gulf Study[11] turbidity measurements were made at 82 stations throughout the coastal marshes and estuaries during the 1968-1969 period. Of the 710 turbidity measurements made during the sampling year, 23 percent had Secchi disc extention readings* of less than 1 foot and 70 percent were less than 2 feet. This report noted that

> "Causes of turbidity fluctuations varied during the sampling year. Generally there was a relationship between salinity and turbidity, i.e., low salinities and shallow Secchi disc extinction depths. This relationship was an indirect one as it was not the salinity of the water which regulated turbidity, except as it affected flocculation, but rather the suspended sediment load in freshwater entering the area which primarily determined the turbidity of the water.
>
> High turbidities at many stations were associated with high total phosphorus concentrations. Yet another factor was wind-generated waves. Because of the shallow depths of most water bodies, wave action was able to increase turbidities by picking up the fine-grained bottom sediments and placing them in suspension."

Thus, turbidities generally fluctuated directly with river discharge, i.e., with suspended solids received and with wind speed.

There are additionally several man-made causes of turbidity. Two, quite apparent from aerial observation, are oyster shell dredging, where the turbidity is fairly localized, and shrimp trawling, where turbid tracks extending for miles are visible. While normally conducted in open waters, it would seem plausible that wind and tide could transport these turbid patches well into the estuaries. Another source noted was that from small boat prop wash and this appeared in all open water and many of the canals. No data have been found, however, on the interrelationship, if any, between Gulf and estuarine turbidities.

Dredging in connection with pipe laying is a turbidity-causing operation. In severity, this would probably increase from shove or push canal dredging through flotation canal dredging (both of these in the marshes where the spoils are piled on the bank) to channel dredging through estuaries and bays. Clamshell dredges are most generally used in the marshes; in bays the hydraulic or suction dredge is more often

* A method of measuring turbid waters by submerging a 9-inch diameter disc with alternate black and white quadrants to the depth where the black color is no longer distinguishable from the white.

encountered. The spoils are pumped out the end of a pipe (commonly 10-12-inch diameter) either on to the marsh, on to a "spoil island", along the channel in a ridge, or spread out over a band two or three hundred feet wide. Advantage of the latter scheme is that existing land drainage current patterns are least disturbed.

According to Mackin,(12) who studied dredging operations in Lake Grande Ecaille, turbidities a few hundred feet from the discharge of a dredge did not exceed those attained at times under natural conditions. The greatest distance to which spoil was transported and silt deposited was about 1300 feet. Interestingly, samples taken in the vicinity of shrimp trawlers in Barataria and Cat Bays showed turbidities equal to or greater than those 300 feet from the spoil outlet of the dredge.

Chemical Changes

Changes in pH. It has been pointed out by Palmisano and Chabreck(13) that soils high in organic content have low pH values following disturbance. Highly significant negative correlation coefficients were found between pH and organic matter, total carbon and nitrogen. It has also been found that pH values were lowest in brackish mucks with high levels of sulfates.(14) This undoubtedly ties in with the buildup of reduced forms of sulfur in such mucks; upon subsequent reoxidation, acidity is liberated and the pH lowered.

Hydrogen Sulfide Toxicity. Smith(15) has observed the importance of hydrogen sulfide in marshland ecology. "Sea water moving through the marshes provides a continual supply of sulfate ion, the third most abundant ion in sea water. The reducing conditions in marshlands tend to fix this sulfur in three forms; hydrogen sulfide, free sulfur, and iron sulfides. The prevalence of this process is perhaps best shown in the problems encountered in most reclaimed marshlands around the world in which highly acid conditions develop with water table lowering as the reduced forms of sulfur become oxidized. One of these reduced forms, hydrogen sulfide, is highly toxic and levels of concentration could conceivably be high enough at times to kill *Spartina*."

The combination of low pH and sulfide toxicity may explain the slow revegetation of levees formed from the subterranean muck excavated in dredging a canal since oxidation and neutralization appear to proceed slowly. The artificial hastening of this neutralization may offer possibilities of reducing the time for revegetation.

Dissolved Oxygen. Dredge spoils are high in BOD and COD and the presence of sulfides is frequent. As an example of the response of a closed system, the dredging of a pond for some mariculture experiments at Nicholls State College is illustrative. The water in a 30-foot-diameter x 10-foot-deep pond dug in a peat marsh had a reading of zero dissolved oxygen in May when completed and it was not until September (4 months) that the oxygen content stabilized at normal levels [personal communication, Dr. Alva Harris, Nicholls State College, Thibodaux, La., (April 1972)]. These results cannot be extrapolated directly to pipeline canals due to the differing circumstances. The marsh was peaty, there was no exchange with any other water body, and the surface:volume ratio was low. No data on dissolved oxygen content associated with pipeline canaling have been accumulated, but they would not expect to be as low as in this special case since the canals do have exchange paths with other bodies of water and the surface: volume ratios are generally higher. Any low oxygen content would be expected to be only a transient condition.

Salinity. Salinity, important to the estuarine nursery area of the Gulf Coast, can be affected by numerous activities of man, including dredging for oil well exploration, pipeline laying, navigation, reclaiming land, and flood control.

Salinity's importance results from the varying tolerances of different members of the ecosystem. Salinity tolerances of some significant species are:[16]

(1) Oysters cannot grow well below 5 ppt salinity and oyster predation becomes of major significance at salinities of about 12 ppt.

(2) Shrimp prefer salinities of 8 ppt and above.

(3) Optimum requirements for fur animals and waterfowl are probably below.

"One of the most obvious and fundamental characteristics of any estuary is the gradation and orderly fluctuation of salinity in the zone of saltwater-freshwater mixing.* Since most of the estuaries along the Louisiana coast extend inland for many miles, the transition from ocean salinities (approximately 34 to 36 parts per thousand) to freshwater (less than 5 ppt) is usually gradual and isohalines are widely spaced (Figure 3.2). In the open bays at the seaward ends of estuaries, salinities change rapidly in response to winds and tides, whereas in the brackish zone salinity fluctuations tend to be muted by the complexity of tidal channels and passes connecting these areas with the open bays and Gulf. The shallow nature of the estuaries promotes rapid vertical mixing so that there is generally little change in salinity from water surface to lake or bay bottom at a given time. In general, inspection of data from many stations indicates that mid-depth salinity is representative of the vertical profile. However, it is recognized that in deeper channels a strong vertical component (gradient) may be present. Deeper channels serve as avenues of salinity intrusion into the estuaries."[17]

The principal factor influencing salinities along coastal Louisiana has been found to be freshwater discharge from the major streams, primarily the Mississippi and Atchafalaya Rivers. Thus, there are major seasonal variations. The isohaline lines for April, 1968-March, 1969 (Figure 3.2) shows differences from the 10-year mean.[11]

Salinity data have been accumulated and tabulated in Gagliano, et al[16], and in the Cooperative Inventory and Study.[11] As noted there, "Coastal Louisiana salinities are basically seasonal, varying primarily with seasonal changes in tides, rainfall, river discharge, and evaporation rates. Generally, rainfall influences the upper estuaries more so than it does the lower coastal area. Tidal action in the lower areas usually dissipates salinity dilutions by rainfall. Therefore, the salinity gradient is normally from a low in the upper part of the estuaries to a high in the lower part of the estuaries.

* Salinity is formally defined as the total amount of dissolved seawater in parts per thousand (o/oo) by weight when all the carbonate has been converted to oxide, the bromide and iodide to chloride, and all organic matter is completely oxidized.

FIGURE 3.2. MAP OF COASTAL LOUISIANA SHOWING 10 o/oo, 15 o/oo, AND 20 o/oo ISOHALINES LINES FOR THE PERIOD APRIL, 1968, THROUGH MARCH, 1969

During high discharge periods, the Mississippi and Atchafalaya Rivers dilute salinities in the lower estuaries along more than one-half of the Louisiana coastline."

The relationship between gas pipelines and salinity changes is difficult to quantify. Where a flotation canal, 40 or more feet wide, traverses marshlands and embayments without regard for changes in natural drainage patterns or for the disruption of currents in bays and water flows in marshlands, changes in salinity can be expected to result. However, this effect upon the salinity regimes would seem to be more associated with canals which are not bulkheaded or dammed, i.e., access rig canals and channels, especially, navigation canals.

For example, salinity ranges are now reported to be up 300 percent in Lake Pontchartrain which covers 640 sq mi as a result of one navigation channel.[18] Chapman[19], discussing changing salinity, noted that

> "In recent times an increasing number of canals and deep water channels with their spoil levees have been cut across the marsh both laterally and vertically. This has resulted in changed direction of water flow, the damming of flow by levees, and has greatly increased the velocity of saltwater flow into the marsh and freshwater flow through the marshes to the sea. The net result has been drastic increases in salinity in some areas and a rapid deterioration of productive marsh and bay conditions."

Numerous other examples of increased saltwater intrusion via deep channels have been studied or reported. Deep channels permit high-salinity waters from the sea to penetrate the upper reaches of an estuary and disperse throughout its area. Such a situation frequently develops in the Galveston, Texas, estuary during low river flow.

No salinity data for a localized marsh area which can be related to a canaling operation have been found. In view of the difficulty in separating canal effects from seasonal variations, such data may be extremely difficult to acquire except experimentally.

BIOLOGICAL EFFECTS

Terrestrial Ecology

The terrestrial environment for the purposes of this report includes all lands and lands supporting terrestrial and emergent vegetation. Although the boundaries between lands and the estuarine system are not always clear and the importance of the terrestrial energy system to the estuarine is immense, the separation permits categorization of ecological conditions and changes associated with gas pipelining. On a subject basis consideration is given to plants, animals, birds, insects, and rare and endangered species.

Plant Communities

Plant communities of the coastal marshes and swamps are highly productive and support a high diversity of consumer types both terrestrial and aquatic. The primary direct effects of pipeline activities on the communities is somewhat similar for all types studied. These effects include loss of vegetation in the line of the ditching or dredging activity and subsequent loss of vegetation through erosion of canal berms(10, 21, 22), compaction of vegetation and soils along areas traversed by surveying and construction equipment, and burial under spoil banks(6, 23).

The extent of vegetational loss is directly related to the width of the ditch or canal, i.e., 0.01 sq mi/mi for a 50-foot wide canal, and, of course, the larger the canal the greater the loss. The larger open canals in areas of very unstable soils subject to commercial and recreational navigation experience significant erosion from prop wash and wave action. Recent concern has been given to wave and storm erosion at the mouth of bulkheaded canals in a region of the Mississippi deltaic plain [personal communication, D. Davis (1972)].

Loss of vegetation by spoil and levee coverage is likewise directly related to the aerial extent of spoil spreading and is probably not greatly dependent upon method of placement. An exception may include pump dredging, however, little documentation is available on the effects of the technique.

In cases where very low marsh lands containing fresh or brackish waters protected from tides and flooding by natural or man-made levees or other features as vegetation, etc., canaling may contribute to regular or periodic flooding by more saline waters than previously experienced. Such environmental changes result in vegetational changes ranging from small shifts in species to complete loss of living vegetation through "die-back"(15).

Conversely, canals which capture freshwater drainage may result in transport of these waters into and on lands usually subject to high salinity concentration. This problem has apparently been confined to changes in the aquatic environment and to only a minor extent on the terrestrial environment. The fact that most of the lines transport gas to higher more stable ground for redistribution and trunkline collection make the situation of redirection of water flow on vegetation a matter for evaluation for each pipeline placement.

Changes in plant species diversity (species composition) will occur in all areas where there is either a major or minor change in the environment. Major changes as land excavation, drainage, or flooding result in a complete change in the kinds of organism occupying an impacted area. Such changes are usually undesirable unless the purpose of the environmental alteration is for management for maintenance of a particular likewise productive ecological system. Minor effects result in slight shifts in productivity and concomitant shifts in species occupying an area. Thus, slight changes may be either desirable or undesirable depending on the type of effect and vegetational shift. For example, changes which reduce productivity, species diversity, or availability of detrital material to aquatic environment are detrimental. Beneficial changes include increase in availability of detrital material, increase in habitat and species diversity, and increase in productivity. It has been noted that the stabilized spoil banks supporting shrub and tree vegetation provide food and shelter for both deer and rabbits but do not necessarily support the original vegetation and associated animals. This effect is particularly noticeable on protected lands.

The marsh and swamp lands are quite rich in dominant and successional plant species. This richness contributes to the dramatic resiliency of the systems to disturbance from natural forces and man-made activity. Because of the dynamic nature of the systems, no effects of gas pipelining were identified for rare and endangered plant species.

Additionally, the lowering of water tables via ditch and canal drainage of lands slightly higher than sea level may allow better aeration in the soils as well as spoil banks resulting in reduced forms of sulfur being oxidized. The resultant sulfides and acids, in some marshes, overwhelm the buffer potential of the salts and may cause extensive vegetation damage. The extent of the damage to vegetation is related to the extent of the washoff from spoil banks and the distance from the pipeline ditch that the water level has been lowered. As yet we are not able to adequately predict the location and possible extent of such occurrences from the information thus far reviewed. However, where sulfide toxicity to vegetation does occur, it is readily noticeable. Inputs of these toxic materials as well as contaminated dead vegetation become important with respect to effects on the aquatic environment.

The significance of the category of plant communities is perhaps the most complex but the more easily explained as compared to other ecological components of the marsh ecosystems. The marshes vary in productivity but may produce up to 15 tons per acre per year[24] or 5 to 10 times the average productivity for crops in the agricultural United States. Approximately 10 percent of this productivity is consumed by bird, mammal and insect grazers leaving 90 percent or over 13 tons per acre as an energy input as dead plant materials to be accumulated as organic matter on and in the soil, consumed by bacterial and fungal decomposers or as a detritus food source for estuarine organisms. The proportional quantity available for the latter is highly variable but of no small amount. It is these materials that contribute to the protection of food and food chain sources used by 95 percent of the estuarine fish and shell fish. The marshes are also the habitat for the myriad of organisms which either feed, nest, or rest in the marshlands.

In context of the impact of pipeline disturbance to marshlands, a unit area of vegetation loss is equivalent to 5 to 10 times the equivalent amount of productivity that would be disturbed within the agricultural lands of the central United States. Additionally, these lands are considered as inhibited successional stages as compared to advanced stages by Penfound and Hathaway[25] and Allan[26]. The nature of the vegetation patterns* are largely controlled by water depth and salinity. Slight changes in either of these results in a change of the vegetational type either to more advanced stages, i.e., shrub, or to mud flats if an early stage is subjected to extremely undesirable stresses[22]. As little as a 2-inch change in elevation will result in a shift in vegetation.[27]

In order to quantify and put in better perspective the effects of pipeline activities on plant communities, more detailed data are needed regarding magnitude and importance of effects of pipeline ditches and canals, scientific observation needs to be undertaken in the marsh types occurring in the central Gulf Coastal area, particularly within the Mississippi deltaic and Chenier Plains. Specific data are needed relative to (1) the direct losses of vegetation in terms of species and productivity from pipeline placement, (2) the indirect effects from water level changes, (3) vegetational effects from salinity changes, and (4) the nature and progress of revegetation of spoil banks. This

*Six salt marsh successional stages are described by Allan; (1) salt cane marsh, (2) salt grass flats, (3) salt meadow marsh, (4) cane marsh, (5) shrub zone, and (6) deciduous forest[1].

category is also one of the best suited for analysis of pipelining activities impacts and interactions with other land use requirements (see Appendix B).

A large portion of the Gulf Coastal area is under varying kinds of management ranging from casual manipulation of the environment to concerted control of drainage, navigation, insects, vegetation, and animal life. Thus, much of these lands have in some way been directly altered to serve a purpose. Effects in these areas require identification of specific problems for each proposed pipelining case.

The technique of ditching without backfilling whereby land is converted to a definite water form is relatively final with respect to the loss of vegetation. However, in certain cases where the ditch is small and berms unstable the ditch may in time become revegetated.

The minimization of effects on the plant communities can only be accomplished by detailed studies along potentially proposed pipeline route alternatives. Therefore, careful consideration need be given to the characteristics of the physical and chemical environment, the vegetation type, along with the possible types of ditching that is feasible to employ. Consideration should also be given to the expense and time effort that may be required to reclaim (revegetate) spoil banks.

Animal Populations

Populations of native and introduced game and non-game animals respond in numerous complex ways to environmental alteration. They are dependent upon the characteristics of and change in the physical and chemical environment and as consumers, the vegetation which supports them.

Considering these factors and the adaptability of the animals themselves to environmental change, the effects of primary importance are direct loss of habitat lands whether temporary or long term, dissection of terrestrial populations, and behavioral disturbance during construction.

Of particular interest is the loss of habitat land for animals of economic interest as the furbearers. This loss consists of both that disturbed by the ditching operation and the uncolonized spoil banks. On the other hand, considerable benefit has been realized historically through the use of open canals as access to lands by trappers and hunters. The magnitude of the effects and benefits has not been specifically evaluated such that we may assign values of importance.

A similar effect of reduction in habitat area has been identified for other terrestrial animals including game and non-game animals.

It is expected that ditching may, in some cases, act as a migrational and home range barrier for some terrestrial species. However, most of the organisms occupying the wet marshes are well adapted to crossing open barren water areas. The crossing of spoil banks would, however, subject many animals to increased predatory vulnerability. Very little may be generalized concerning these and other behavioral responses in nature except for selected species in better studies areas.

For animals which spend a large part of their existence in the aquatic environment, principally reptiles and amphibians, there is an increase in habitat which is directly proportional to the amount of water surface area gained. Species using new water areas are quite numerous and probably variable from area to area. Specific line consideration would include size of canal salinity, surrounding vegetation type, etc.

Pipelines crossing habitats containing protected species (i.e., Louisiana vole and alligator) require special attention relative to loss of habitat or dissection of populations. Increasing water surface area would increase habitat for the alligator but there may also be an increase in availability of habitat areas to poachers. The effect of poaching is outside the responsibility of the gas pipeline industry per se.

Another important area of concern is behavioral influence during pipeline construction and surveillance. In most cases, displacement and interruption of activities of animals would be temporary with little or no continued impact in backfilled canals. However, multipurpose canals would result in animals being periodically subjected to noise and sight of moving objects which may affect the local population success for some species. Additionally, it was noted in the field that aircraft may ellicit a significant amount of avoidance behavior in both mammals and birds when pilots bring their craft near the ground. A certain amount of this effect is unavoidable, however, in the construction and operation of pipeline services.

Similarly with plants, animals experience an increase in habitat diversity where stable spoils become revegetated with shrubs. Although the new vegetation may not be as the original it provides shelter and possibly food, particularly for deer.

The significance of this category is difficult to assess except for the importance for harvest of fur bearing and game animals which data are presented in the introductory descriptive sections. The change in environment resulting in changes in species and densities of animals is perhaps less important than changes in vegetation because they consume a lesser proportion of the fixed energy in the ecosystem than that consumed by the decomposers and perhaps the estuarine organisms. The parameters of species composition and density are, however, good and, in many cases, more sensitive indicators of ecosystem stability than many other of the categories.

Further documentation is needed concerning these population shifts, particularly with respect to vegetational changes associated with varying pipelining modes in varying marsh types.

Birds

As has been previously pointed out[28], the prime ecological consequence of gas pipeline construction and operation results from such physical alterations of the habitat from channelization and associated changes. In general, drainage patterns and water levels are changed, salinity is altered, actual marsh habitat is lost or altered, and beach or sea rims altered by lowered or raised water levels. These topics will be alluded to in terms of general or specific effects upon groups of birds or individual species.

Herons, egrets, and owls are colonial species. Thus, the colonies are local or spotty in nature. Bird behavior involves a great deal of tradition in the historical sense. Once traditional or established colonies are lost, say to erosion, it is uncertain how satisfactorily the species adjust to other regions. The colonies are where they are, in part, because of locally abundant food supplies. Changing drainage patterns, salinity content, etc., may alter the distribution of the food supply in such a way that even if the physical habitat for the colony remains they become unusable without food. There is no fear of herons and their allies invading agricultural lands where they might cause economic loss should their habitat be reduced. Rather, there will simply be a loss of numbers of individuals. One of the obvious impacts is the effect of a changing saline content on the birds invertebrate food base. Often the food web is complicated and dependent on such limiting factors as pH of the water or turbidity.

The physical conditions of water depth is often critical to fish, other vertebrates, or invertebrates used by birds. Fish may become unavailable as a food source if water becomes too deep. Further, much of bird behavior is dependent on energetic considerations. If changing habitat removes the food source too distant from the nesting sites and it becomes too costly calorically to exploit the food source, then nesting sites are often abandoned. Pelicans, cormorants, herons, etc., are species which show such responses.

Rails form a huntable economic resource. Density and nature of the vegetation appear to limit or determine the distribution of rails. The nature of the vegetation is in turn dictated, in part, by the pH or depth of the water. Thus, it is expected that rails will respond in a negative manner where marsh is converted to water.

Pelicans show the greatest productive fitness when in seclusion. The channeling opens the habitat to boat traffic and the physical proximity of boats or noise produced by them is known to keep pelicans away from their nests. The result is the exposure of eggs to environmental adversities (such as heat or predation) and, consequently, decreased nesting success. This population is extremely localized, however, in Louisiana.

A major impact with economic implications is the changing of feeding habits for waterfowl. With the elimination or alteration of the Spartina or Scirpus marshes, waterfowl can be expected to utilize more heavily agricultural lands and rice fields. Of special attention should be the preservation of the integrity of major local habitats where Blue Geese congregate to help keep them, along with Snow Geese, off of agricultural lands and in Louisiana.

Another complicated association exists with the endangered Peregrine Falcon and its food supply. This endangered species seemingly requires an abundance of the proper size range of food species during its migrations. These food species congregate along coastal marshes and sea rims. In many coastal areas in other regions of the migratory routes homes now occupied the essential environment and habitat diversity may be reduced. Since a considerable proportion of the species passes along the Gulf Coast, it is essential that the proper habitat for the prey species be maintained in sufficient quantity to help eliminate competition and starvation where these birds are forced to congregate locally.

For the birds in general, then, the responses to habitat perturbation will vary as covered above from essentially no measurable response, such as in many migrant and resident passerines and slight shifts to agricultural lands for feeding and nesting, to total abandonment or exclusion of the habitat resulting in mortality and loss of individuals.

As suggested by Sprunt[29], the value of the coastal marshes of Louisiana to many diverse groups of resident and migratory birds is hard to express in any quantitative manner, but it is evident that the carrying capacity of marshes is important to the continuance of the avifauna population.

Birds perhaps more than any other kind of organisms are able to rapidly disperse when disturbed. Except for studies of nesting success, very little is conclusively known as a general basis of ultimate effect of slight changes in landscape utilization and short-term dispersal of birds. More direct observations are required from pipeline operations. These studies could be incorporated into routine studies on the effects of existing pipelines on the environment and the effects of surveillance on numbers and kinds of birds dispersed by boat and aircraft passes.

Invertebrates

Mites, grasshoppers, snails, etc., are the primary consumers of the terrestrial vegetation and decaying vegetation products in coastal marshes. Although little information was reviewed concerning effects of habitat alteration on these organisms, Bourn and Cottam[30], studied changes in invertebrate populations from marshland drainage in Kent County, Delaware, types during the late 1930's. Observations were made in four marsh plant association types. They were (1) Spartina alterniflora, (2) Distichlis spicata, (3) Spartina patens, and (4) Scirpus robustus. Average reduction in invertebrates by plant associations were 48, 80, 80, and 91, respectively. Invertebrate groups included mollusks, crustaceans, spiders and mites, leafhoppers, beetles, and miscellaneous. Losses as high as 94 and 98 percent were reported for mollusks and crustaceans during one of the sampling periods for all marsh types. Reduction in numbers of species ranged from 15 to 25 in the study areas. The losses were attributed to drainage on loss of habitat and increased predation.

The significance of this category is twofold. First, these organisms are responsible for breaking down plant materials so that they are utilizable by decomposers and estuarine organisms. Secondly, the organisms themselves serve as important food chain components to estuarine organisms and to waterfowl.

Field data are needed on losses of these organisms along representative marsh pipelines for both spoil banks and surrounding marshes where groundwater or standing water has been altered.

Aquatic and Estuarine Biota

It has been reported that small amounts of damage to estuarine areas can lead to widespread damage to an estuarine resource.[31] Marshall[32] has cited dredging operations as being detrimental by: (1) destruction of swamp, marsh, and bay bottom habitats in the direct area of the operation, (2) destruction of nursery areas by siltation, (3) reduction of light available for photosynthesis, (4) creation of anaerobic bottom conditions, and (5) reduction in nutrient outflow from marshes and swamps. St. Amant[33] has pointed out a number of damaging effects which can result from dredging and related activities: (1) changes in the velocity and volume of water exchange on tidal cycles and a redistribution of saline or freshwater over estuaries, (2) increased or decreased mean salinities or more rapid and greater extremes of fluctuations in the salinity pattern frequently develop from interruption of the normal drainage pattern, and (3) indirect silting and bottom changes may occur at considerable distances from the site as a result of changes in current direction and/or velocity. Perret, et al[5] have pointed out the importance of spoil deposition on direct physical loss of habitat for wet marshes.

Although the above effects are quite inclusive of those which may be expected, others have been pointed out (personal communication, James M. Coleman, Louisiana State University, Baton Rouge, Louisiana, April 20, 1972). Since Louisiana is in a sea breeze condition, meteorological effects in the area have a classical pattern. Onshore breezes in the morning push higher water inland then reverse in the afternoon and push water away from shore. Normal activity allows establishment of somewhat stable, specific zones within the area supporting life characteristic of the normal high and low water. However, if more direct access of Gulf waters is allowed the embayments and marsh areas through, for example, pipeline canals, the high and low water marks in large areas are increased. Such alterations produce changes in life forms not only from water heights but also from changes in salinity.

The above effects relative to ditching and canalization as well as other subeffects will be discussed later as they relate to specific life forms and habitats.

The effects of changes in water quality as a result of dredging and canalization should be noted. The organic rich soils and muds of this area are characteristically high in organic matter [as high as 10 percent[34]], sulfides, and fine particulates. Hydrogen sulfide precipitates metals in solution[35], including those heavy metals of health importance. Any metal sulfides contained in spoil material can be released and/or remobilized by rainfall and tidal flooding. This process is aided by the metabolism of the aerobic colorless bacteria and the anaerobic photosynthetic purple and green sulfur bacteria[36]. Through the action of these microbial forms on H_2S, acid (H_2SO_4) is produced which can dissolve metal sulfides. The production of acid can also come about through first the oxidation of H_2S to sulfur, then subsequent oxidation of sulfur to the acid by the action of certain bacteria. Redistribution of heavy metals, such as lead, mercury, arsenic, and copper, have been reported to lead to eventual concentration in the tissues of oysters and other bivalve mollusks[37].

The fine particle size and high organic content of muds and silts of the area enhances the retention and persistence of a number of pesticides[38] and their degradation products. Depending on the specific persistence of a given pesticide and the time of dredging in relation to season, these toxicants can be flushed into the aquatic ecosystems. For example, Loosanoff[39] has reported kill of mollusks (including oysters) by DDT at a concentration of 1 ppm. Growth was retarded at 25 ppb. In this regard, it is interesting to note that one report[40] showed only a 44 percent reduction of DDT applied to soil at a rate of 25 lb/acre after eight years previous to analysis. Endrin, dieldrin, and two unidentified hydrocarbons were found in the blood of dead and dying fish[41]. Cronin[42] has stated that all chlorinated hydrocarbons are dangerous to aquatic life.

At even lower concentrations of mixed pesticides, Lowe, et al[43], found that growth was affected and pathology produced in oysters reared in waters containing 1 ppb each DDT, toxaphene, and parathion. Also reported was an infection caused by an unidentified fungus indicating a breakdown in the natural defense mechanism. In addition, high levels of toxicants were accumulated in the organisms requiring 90 days for depuration. However, since depuration is not a common practice in the area of concern, levels of both pesticides and heavy metals in oysters exposed to dredging operations could be of public health interest.

Other materials water quality changes in the locale of a dredging operations are gases. Both hydrogen sulfide and methane are natural products of marshes and bay bottoms and can be liberated during dredging[44]. Since the solubility of H_2S in water at 20 C is almost 90 percent greater than oxygen[35], effects of this gas might be expected to produce effects other than a reduction of oxygen for a few hours after dredging[44]. Likewise, even though methane was found to have no effect on oysters during months of exposure, it is uncertain what effects the gas may have on other more sensitive organisms since it is slightly soluble in water.

Sediment entrapped oil is another material which could be considered as lowering the water quality of an area being dredged. However, crude oil and its fractions incorporated in the sediments of marshes and bays are rapidly destroyed by indigenous bacteria[44].

That the coastal zone of Louisiana is one of the most productive fisheries areas in the world indicates a correspondingly high primary production discussed earlier. Studies of community nutrition in representative areas of coastal Louisiana[45, 46] have indicated organic detritus as the most important contributor to estuarine production. Species reported as chief contributors include the two grasses, Spartina alterniflora and S. patens. Seasonal death and decomposition of these producers result in a springtime release of nutrients[47] and detritus at a time when various stages of estuarine dependent species are returning[46]. Organic detritus thus made available to consumer species initiate the eventual fisheries production for the ensuing year. For example, species of fish and invertebrates in which organic detritus can constitute 50 percent or more of the food include large-scale menhaden, striped mullet, marsh clam, Atlantic croaker, white shrimp, sea catfish, river shrimp, gizzard shad, and hogchoker[45]. Through the support of a large number of organisms in the estuary at this lower trophic level, marsh vegetation serves as a most important step in overall fisheries production.

The interference of drainage caused by deposition of spoil banks (1) may retard normal flushing and, hence, normal distribution of valuable nutrients in the area and (2) may cause waterlogging of sometimes large areas of marsh. The latter has been regarded by Smith[15] as a probable cause for Spartina dieback due to increase in salinity in the poorly drained areas and, consequently, a loss of food energy to estuaries. He also indicated that Spartina could be affected by poor drainage producing (1) chlorosis from lack of available iron, (2) hydrogen sulfide toxicity, and (3) oxygen deficiency in the roots.

Where dredging activity produces drainage of marsh areas, loss of nutrients to the community may go beyond the primary level. For example, Bourn and Cottam[30], while studying the effects of ditching in tidewater marshes, found significant decreases in invertebrate populations in both Spartina alterniflora and S. patens associations after ditching. Estuarine organisms, notably mollusks and crustaceans, were most drastically reduced in number in the ditched zones of both associations. Losses of these two groups after ditching in the S. patens were as high as 95 percent with almost 100 percent in the S. alterniflora zone.

In more recent studies of community nutrition, Day, et al[46], have reported results of studies made in representative areas of the Louisiana coastal area indicating the extremely high production of invertebrates in the marsh and on the water bottoms adjacent to the shore. The high productivity of these important organisms leading to higher level production in the fisheries is influenced by two important factors: tidal flushing and maintenance of the proper amount of marshwater interface. Dredging operations could easily alter both of the factors recognized by Day, et al[46], as being most important to this production.

Earlier mention was made of some of the general effects dredging or similar activity may have on environments and biological populations in Louisiana's coastal zone. However, it is necessary now to examine some of these effects as they relate to specific life forms of both ecological and (ultimately) economic importance. Although most of the changes which can occur have effects on the total ecosystem by altering their environment either directly or indirectly, most of the following discussions will center around indirect effects on the more valuable species of the commercial fisheries.

Perhaps the one environmental parameter which has the greatest influence on the aquatic ecology of the coastal area of Louisiana is salinity. Alterations of drainage patterns which may cause this parameter to fluctuate or totally change will have an effect on the production of a number of organisms. Two of particular importance are the brown and white shrimp. Salinities at which one can find these organisms in the greatest abundance is more limited than the range in which they can live.[34] Also, as the postlarvae of these species migrate from offshore, the absence of optimal salinity (and temperature) within the estuaries can result in a slow growth and increased mortality.[46] For example, Gunter[48] reported a 200 percent increase in catch of white shrimp in waters of 0.80 ppt as opposed to 0.44 ppt.

Of the various types of man-induced modifications of the estuarine environment as a habitat for the young of economically important shrimp reviewed by Kutkuhn[49], many resulted in salinity alterations to some degree. However, salinity changes appeared to have an indirect effect on the environment for young shrimp more from a loss carrying capacity of the marsh areas through reduction of plant cover and food sources.

Direct effects of salinity on oysters are not as pronounced as indirect effects because of their wide tolerance range of from 7 to 30 ppt. However, changes which allow too much freshwater into an area can cause sudden and catastrophic results.[33] As has already been mentioned, salinity changes reaching oyster-growing areas of an estuary can create conditions favorable for two natural enemies of the oyster: the marine fungus, Dermacystidium marinum, and the oyster drill, Thais haemastoma[28,34]. St. Amant[33] has reported that the former has reached epidemic proportions in the 1940's. He surmised that the associated pipeline canals dredged in the estuarine areas allowed saltwater intrusion to establish favorable conditions for the fungus.

The blue crab population can be affected by changes in salinity both directly and indirectly. Larvae of this organism spend some time in the low saline marsh areas and, thus, changes in salinity can affect the distribution.[50] An indirect effect can be found in alteration of the available food for the adults of the species. Day, et al[46] have reported that the oligohaline marsh clam, Rangia cuneata, composed 46 percent of the diet of the blue crab. This clam, considered a community dominant in many

Louisiana estuaries[51], can also be affected by increases in salinity although it can tolerate exposures to 20 percent[5].

One important finfish of the commercial fishery, the menhaden, has been reported to be salinity sensitive during its early life. Young larvae develop normally only in very low salinities until past a certain stage of growth. If they are exposed to high salinities before this stage, they develop abnormally.[34]

A second factor which is a direct product of dredging activities is the production of turbidity and siltation together with a possible alteration of water quality.

The effects of dredging on finfish have been studied by a number of investigators. Ingle[52] observed no damage to fish in an Alabama study, even in close proximity of the dredge. He also reported that there was some evidence to show that organic detritus is stirred up producing a beneficial effect on both fish and shellfish. Biggs[53] also observed this effect and reported total phosphates and nitrogen increases to 50-100 times above ambient levels. Ingle, et al[54], found that when fish were confined to high concentrations of suspended solids from which they could not escape, they were killed. However, the natural reaction was for the fish to avoid the turbidities if possible. If fish were removed from turbid waters, they were able to dislodge and remove clogging mud from their gills. Those fish that died from high concentrations of suspended solids were found to have experienced mechanical interference with normal respiratory exchange through the gills.

Flemer, et al[55], reported finding no gross effects from disposal of fine materials on fish eggs and larvae or on adult fishes which were caught or held in cages near the area of operation. He also reported no effect on the phytoplankton and zooplankton but found a significant loss of bottom organisms in a wide area around the operation as a result of smothering. However, some species were able to survive and repopulate some areas soon after materials deposition.

Jones[56], after reviewing the literature, concluded that the main effects of suspended matter on fish are an interruption of the food chain as a result of reduced photosynthesis by food-chain and food-chain-consuming organisms.

Gunter[57] feels that too often it is assumed that all siltation is detrimental to the environment and we are unaware of the beneficial effects which can act to bring up buried nutrients for recycling. However, depending on the particular characteristic of the area being dredged, other materials may also be released. If such materials as pesticides are recently accumulated and deposited in an area, the results could be detrimental. Butler[58] has reported that spot (Leiostomas xanthurus) can flourish for at least eight months in a concentration of 0.05 ppb endrin. However, in 5 days at 0.1 ppb endrin, this same species exhibits 100 percent mortality. Therefore, it is imperative that the concentration of biocides present in the sediments to be dredged be known before operations begin.

Effects of turbidity on shrimp as a direct result of dredging are not known. More indirectly, the resuspension of nutrients could be beneficial whereas resuspension of toxic materials in the sediments would be negative. Although not a hydrologic effect, the alteration, physically, of the environment has been shown to affect shrimp production. Moffett[59] has reported a study in which production of brown and white shrimp was monitored in an altered and an unaltered area of an estuary. It was found that

2-1/2 times more brown shrimp and 14 times more white shrimp were taken in an unaltered area than in the altered.

The greatest concern over silting effects has been in regard to the oyster industry. This has been because of (1) the sessile nature of this valuable species and its inability to avoid unfavorable conditions and (2) because by far the highest production of oysters is on private leases. Alleged damage to these private oyster beds as a result of dredging activity in the area are commonplace and payment for damages are generally in excess of actual value. This is due to the claim by many growers that a larger number of seed oysters are planted than actually are.

Needless to say, a number of studies have been made in regard to silting effects on oysters, some as early as 1938. Lunz(60) conducted extensive experiments near dredgers on the coast of South Carolina. Results of these studies showed that oysters were able to survive dredging operations even when exposed to the mud and silt of the cutter. Only when oysters were covered or mostly covered with spoil discharge did they fail to survive. This was also reported later in a Corps of Engineers report(61).

Although turbidity and siltation may not cause death of oysters, Loosanoff(61) and Loosanoff and Tommers(62) have reported that they do have an effect. When oysters were placed in turbid environments, the pumping rate was reduced 38-57 percent of normal. This effect was noted in the presence of 0.1 gram per liter of suspended solids. Since Mackin and Hopkins(44) reported that even the finest silt moves only about a maximum of a quarter of a mile from a dredging site, these effects can be expected to be limited at least in area.

It is interesting to note that although Lunz(60) reported in his 1938 experiments that dredging had no effect on the spawning and setting of oysters, Mackenzie(64) reports that silting interferes with either setting or survival. Using information developed by Hopkins, et al(65), effect of siltation on almost all stages of oyster development would be minimized during the months of January and February.

Although not directly related to siltation, permanent local environmental alteration of areas suitable for oyster production takes its toll. As an example, Moore and Trent(66) observed setting, growth, and mortality of oysters in both natural and altered marsh areas. They found that in the natural marsh setting immature individuals were 14 times greater and growth of juveniles was also faster than in the altered marsh. In the altered marsh, average length of adults was 36 percent less, weight increase was 27 percent less, and mortality was 39 percent greater than in the natural marsh. The latter was not due to Dermocystidium marinum but the main cause of mortality was lowered dissolved oxygen and plankton blooms.

In his summary, Wallace(67) states that "alterations of estuaries through dredging for fill and channels, and filling of salt marshes have been detrimental to oysters and have made oyster farming more difficult".

It has been pointed out in this report that the productivity of coastal Louisiana is dependent upon the delicately balanced system which provides high nutrient input from marsh vegetation and its subsequent movement through the ecosystem containing organisms of specific salinity tolerances. The point has been made that all of the three most commercially important estuarine species harvested in this area are dependent on the marsh/estuary system.

A number of direct and indirect effects which are related to dredging activities in this area have been presented from the literature. However, in the final analysis, modifications of the environment which cause physical loss of habitat (either directly or indirectly) and change in salinity regimes stand out as the most important and dredging effects both of these. Since the shrimping industry is the most important in the fisheries of Louisiana, it is noteworthy that Kutkuhn[49] in summary states that "most of man's engineering activity in coastal lowlands generally affects the estuarine shrimp habitat in two major ways: (1) change in mean salt content and chemical composition, and (2) net loss of carrying capacity, particularly through loss of vegetated marshes as contrasted to open bay waters. It is highly problematical whether the estuary-dependent shrimps of commerce can adjust to such modification and still maintain their stocks at economic levels of productiveness".

St. Amant[33], in considering how long the important nursery areas of the Louisiana coast can withstand changes has stated that "At this point in time, it is difficult to predict the future except to point out that there must be a breaking point in the equilibrium of the ecosystem and none of us know how near we are to it. Fisheries statistics indicate little change in the productivity of the Louisiana coast over the past thirty years, but one does not have to be a professional ecologist to realize that this type of environmental abuse cannot continue forever."

If, indeed, modifications of the environment must be made, every precaution should be taken to minimize the impact. Each area in the Louisiana coastal zone has its own characteristics[65] and must be approached in regard to modifications on an individual basis. Appropriate timing of alternative operations in this environment and proper consultation during operations is one way to minimize effects. Based on information available now, any such activity would have its least effect on the biology and ecology of the area when carried out during the winter months. However, there is no way to escape the fact that where there are alterations, biological changes will occur.

As is readily apparent from the review of aquatic and estuarine responses to the gas pipelining activities, there is a distinct need for specificity in information. Much of the present information relates to total changes in the wetlands without regard to specific causative actions which promoted the reponses. Many of the problems can be readily solved by field programs designed to obtain data relevant to actions by the pipeline industry. Particular emphasis is suggested for the areas of

(1) Toxicity in sediments

(2) Magnitude of impacts resulting from various pipe-laying modes

(3) Effectiveness of backfilling and bulkheading in minimizing aquatic and estuarine effects.

An equally important consideration in establishing perspective for the pipeline industries is that of existing effects resulting from other marshland users and possible interactions that new pipelining efforts would have with the other users. Many of these problems can be addressed more specifically when specific routes are selected in the future. The nature of possible interactions are difficult to generalize at this time because of the geographic variation in the marshes themselves and the nature of distribution of other causative changes.

SOCIOECONOMIC AND CULTURAL EFFECTS

Economic Impacts

The socioeconomic impacts of gas pipeline construction through the Louisiana marshlands are related to the particular characteristics of pipeline construction. While also a very capital-intensive operation, like the other production operations of the oil and gas industry, pipeline construction is a transient one. Characteristically, there is an intensive effort by a large assembly of men and equipment for a brief period of time, but once construction is completed, long-term manpower demands are virtually zero. Also, since the construction does not occur in one place but may extend for as much as one hundred miles or more, construction communities are not established near the job site. As a matter of fact, due to the essentially aquatic nature of the marsh areas where the construction is performed and the lack of nearby housing accommodations, it is frequently necessary to house the workers in what are known as "quarter-boats" which follow the construction. Several hundred men, working round-the-clock shifts, may live on a quarter-boat for months for a major pipeline construction job.

Thus, the interactions between pipeline construction and the surrounding socioeconomic environment tend to be minimized.

The influx of construction workers and their families to nearby towns, a usual feature of major construction projects, is absent here. There are, of course, definite and positive economic impacts. Labor dollars for a major pipeline can run into tens of millions of dollars, a significant addition to the regional economy. Preparation of the pipe for marshland pipe laying also contributes to the regional economy. Since total costs to construct a major marshland trunkline can easily be $250,000 or $300,000 per mile, the economic results can be substantial.

Manpower requirements once construction is completed are minimal. There may be a compressor station every 50-100 miles of trunkline and a permanent work force of a few men is required for their operation. A minimal force is required for line inspection and maintenance. The direct employment benefits of an operating pipeline, thus, are rather small.

Employment groups which are likely to be adversely affected are those in the fishing and trapping industries. The trapping industry may be affected if a pipeline cuts through a trapper's hunting territory. This situation sometimes affects the movements of animals and may cause them to move to other areas. On the other hand, trappers can use the new canal as a transportation route which might allow them to enter areas which had previously been inaccessible by boat.

There are no data to indicate that the construction of gas pipelines (or other canaling, for that matter) has adversely affected the Louisiana fur industry to any significant extent.

T. O'Neil, Chief of the Fur Division of the Louisiana Wildlife and Fisheries Commission, commented recently[68] as follows:

"The Louisiana Fur Industry appears to be stabilizing after a quarter of a century of drastic fluctuation. Since 1940, it has averaged slightly over $5,000,000 annually. From 1950 to 1965, production was far below the average dropping to a low of $2,200,000 during the 1960-61 season. It underwent a period of recovery during the late 1960's, and has been above the long-term average for four out of the past five years.

Nutria have been the mainstay of this industry since 1961, prior to that time the muskrat being the undisputed leader. The establishment of the nutria in Louisiana was truly phenomenal. Since the introduction of 6 pairs of the animals in the late 1930's, they have spread to every parish in the state. Their population peaked in the mid 50's when an estimated 20,000,000 animals were present in the coastal area alone. Despite the fact that thousands were killed for sport or as pests and the skins discarded, a total of 17,654,329 pelts valued at over $39,000,000 has been shipped in the past 25 years. This is an excellent example of the reproductive potential of some of our fur animals and the need for a good uniform harvest program to prevent overpopulation."

Thus, while there have been drastic fluctuations during the last three decades of intensified oil and gas exploitation in coastal Louisiana (resulting in over 9,500 oil and gas wells) no long-term trend in fur yields is evident.

The fishing industry would be primarily affected during the dredging and canaling phases of the pipeline activities. The increased siltation, changes in salinity, and the cutting through oyster beds would all affect the environment which the finfish and shellfish rely upon. Secondarily, if there were serious decreases in marsh productivity, effects upon species dependent upon the marshes in their juvenile periods would be expected to make themselves apparent.

The available data are such that any definite conclusion on effects of gas pipeline canaling is difficult to extract. There have been and are year-to-year fluctuations, but a casual relationship is difficult to identify. Possibilities include the transient effects of a particularly active canaling year, hurricanes, year-to-year climatic variations, and other natural causes. In any event, the fisheries industry in the Gulf is a growing industry with annual harvests still trending upward.

Illustrative are the data on Louisiana production of shrimp, one of the most valuable marine harvests and one of the species most dependent upon the marshes during its growth cycle. As shown in Table 3.2, although there are sharp fluctuations, there is no discernible distinct long-term trend.

When considering an area as large as 14 parishes, a discussion of the social impacts of the construction and operation of gas pipelines enters the realm of general speculation. Some reasonable guesses can be made about impacts based upon past pipeline activities. However, it must be recognized that many of the following statements are general and may change relative to a specific pipeline.

As far as population growth trends are concerned, it is unlikely that additional pipeline construction would greatly affect, in either direction, the overall situation either at the regional or parish level. Individual communities could grow slightly if construction personnel stayed in them while working on a pipeline. However, this type of increase would be only temporary. Closely related to population growth is the

TABLE 3.2. SHRIMP HARVEST IN LOUISIANA (1930-1970)[68]

Shrimp are reported in round weight (heads-on).

Year	Production, Thousands of Pounds
1930	38,664
1931	35,148
1932	38,096
1934	55,572
1936	53,430
1937	68,781
1938	81,379
1939	100,612
1940	98,986
1945	116,904
1950	77,835
1951	85,718
1952	83,104
1953	86,941
1954	83,608
1955	71,994
1956	60,792
1957	34,103
1958	41,008
1959	57,353
1960	61,758
1961	31,027
1962	43,585
1963	80,809
1964	59,382
1965	62,593
1966	62,276
1967	75,325
1968	67,769
1969	82,889
1970	90,850

impact on housing. It is impossible to tell at this point how much, if any, additional housing would be required for construction and operational personnel. If a specific route were chosen for examination, then some reasonable assumptions could be made about housing impacts.

It is unlikely that pipeline activities would affect the educational levels at the parish level. If new personnel were moved into a community with their families, it is possible (though not probable) that the school system could temporarily become more crowded.

A single pipeline should not change, to any great extent, the social organization of any particular group of people living in coastal Louisiana. One could argue that the life style of Cajun people has become less provincial and more similar to the national culture. Apparently there are a number of Cajun people who do work in oil- and gas-related industries. Whether or not this phenomenon is good or bad is a very personal and subjective judgment. The black people in this area have not been affected to the extent that the Cajuns have. Some blacks work in pipeline construction crews, but very few have gotten involved in supply and transportation services.

Archaeology and Historical Sites

These topics can be discussed in detail only with respect to a specific pipeline route through the marshes. However, in general, the number of historic sites in the marshes is sparse and these are easily avoided so that the likelihood of impact upon a historic site would be most unusual.

There is a larger number of archaeological sites, believed to extend back nearly 2000 years. Although these are not too well documented, hundreds of sites are known. Most occupied sites were along natural levees where freshwater and dry land was available so that these tend to be located along present or past water courses. The impact from pipelines on the archaeology in the marshes and wetlands has generally been negative in the past. Apparently, some pipeline construction has gone through various Indian mounds without providing for any site examination. This is a matter which can be fairly easily changed by administrative procedures and by having some archaeological coordination of pipeline construction.

Esthetics

The impact on the esthetic qualities of the marshes is also generally considered to be negative. The primary reason for this feeling is the irreversible nature of the canals through the marshes. In a sense, it is like walking on the moon – the tracks never go away. The land-based observer, which will include most casual observers of the marsh, will not receive the full impact of the rearrangement of the marshes due to his limited horizon. The full impact is observed primarily by the aerial observer who can, in certain oil-field areas, see the marsh cut up for miles.

The relative isolation of the area, the lack of roads, and the general lack of external visitors has meant that to date any esthetic impacts have affected relatively small numbers of persons.

Impact Upon Recreation

Recreation in coastal Louisiana is not generally negatively affected by gas pipeline operations. In a direct sense, the canals open up many areas for boaters and fishermen. If the population of southern Louisiana begins to grow much more rapidly than it has in the past, there may be some competition for as-yet-undeveloped areas along the coast. However, the New Orleans Standard Metropolitan Statistical Area (SMSA) has not exhibited a rapid growth in population in the last decade. Using this fact as a rough indicator, it is unlikely that there will be a great demand for more recreational areas in this area in the near future.

REFERENCES

(1) Gates, D. M., "Toward Understanding Ecosystemics", Advances in Ecology, 5: 1-35 (1968).

(2) Gagliano, S. M., and van Beek, J. L., "Hydrologic and Geologic Studies of Coastal Louisiana. Vol. I., Geologic and Geomorphic Aspects of Deltaic Processes, Mississippi Delta System", Louisiana State University, Coastal Studies Institute and Department of Marine Sciences, Baton Rouge, Louisiana (1970), 150 pp.

(3) Gagliano, S. M., Light, P., and Becker, R. E., "Hydrologic and Geologic Studies of Coastal Louisiana Vol. VIII. Controlled Diversion in the Mississippi Delta System; An Approach to Environmental Management", Louisiana State Universtiy Coastal Studies Institute and Department of Marine Sciences, Baton Rouge, Louisiana (May, 1971), 147 pp.

(4) Barrett, B., "Water Measurements of Coastal Louisiana", Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana (1970), 207 pp.

(5) Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana. Phase I, Area Description Louisiana WLFC (1971).

(6) Nichols, L. G., "Erosion of Canal Banks on the Rockefeller Wildlife Refuge", Louisiana Wildlife and Fisheries Commission (May 25, 1958).

(7) Final Environmental Statement for the Proposed 1972 OCS Oil and Gas General Lease Sale Offshore Eastern Louisiana (June 20, 1972).

(8) Final Environmental Statement for the Proposed 1972 OCS Oil and Gas General Lease Sale Offshore Louisiana (October 13, 1972).

(9) "Environmental Impact of Pipeline Construction South of Morgan City, Louisiana", Gulf South Research Institute (November 1, 1971).

(10) Nichols, L. G., "Erosion of Canal Banks on the Rockefeller Wildlife Refuge", Louisiana Wildlife Refuge (April 3, 1961), 10 pp.

(11) Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana Phase II Hydrology (1971).

(12) Mackin, J. G., "Canal Dredging and Silting in Louisiana Bays", Publications of the Institute of Marine Science, 7: 262-314 (1961).

(13) Palmisano, A. W. and Chabreck, R. A., "The Relationship of Plant Communities and Soils of the Louisiana Coastal Marshes", Paper presented at the 13th Annual Meeting, Louisiana Association of Agronomists, Lake Charles, Louisiana (March, 1972), 42 pp.

(14) Lytle, S. A., "The Soils of Terrebonne Parish", Louisiana Agricultural Exp. Station Bull, 651 (1971).

(15) Smith, W. G., "Spartina 'DIE-BACK' in Louisiana Marshlands", Coastal Studies Bulletin No. 5, Special Sea Grant Issue (February, 1970), pp. 89-96.

(16) Gagliano, S. M., Kwon, H. J., and van Beek, J. L., "Hydrologic and Geologic Studies of Coastal Louisiana. Part I, Vol. II, Salinity Regimes in Louisiana Estuaries", Louisiana State University, Coastal Studies Institute and Department of Marine Sciences (February, 1970), 66 pp.

(17) Gagliano, S. M., Muller, R., Light, P., and Al-Awady, M., "Hydrologic and Geologic Studies of Coastal Louisiana, Part I, Vol. III, Water Balance in Louisiana Estuaries", Louisiana State University, Coastal Studies Institute and Department of Marine Sciences (February, 1970), 102 pp.

(18) Yancey, R. K., Hearings before a Subcommittee of The Committee on Government Operations, 92nd Congress (June 9-10, 1971).

(19) Chapman, C., "Channelization and Spoiling in Gulf Coast and South Atlantic Estuaries", Marsh and Estuary Management Symposium, Louisiana State University, Baton Rouge, Louisiana (July 19-20, 1967).

(20) St. Amant, L. S., Friedrichs, A. V., and Hadju, E., "7th Biennial Report, 1956/1957", Louisiana Wildlife and Fisheries Commission (1958).

(21) Morgan, J. P., "Impact of Subsidence and Erosion on Louisiana Coastal Marshes and Estuaries", Paper presented at the Coastal Marsh and Estuary Symposium, Louisiana State University, Baton Rouge, Louisiana (July 17-18, 1972).

(22) St. Amant, L. S., "Impacts of Oil on the Gulf Coast", Transactions of the 36th North American Wildlife and Natural Resources Conference (1971), pp 208-219.

(23) Nichols, L. G., "Rockefeller Refuge Levee Study", Technical Bulletin of the Wild Life and Fisheries Commission, New Orleans, Louisiana (1959), 17 pp.

(24) Odum, E. P., "Fundamentals of Ecology", W. B. Saunders Co., Philadelphia (1957), 546 pp.

(25) Penfound, W. T., and Hathaway, E. S., "Plant Communities in the Marshlands of Southeastern Louisiana", Ecological Monographs, 8: 1-56 (1938).

(26) Allan, P. F., "Ecological Basis for Land Use Planning in Gulf Coast Marshlands", Journal of Soil & Water Conservation, 5: 57-62 (1950).

(27) O'Neil, T., "The Muskrat in the Louisiana Coastal Marshes", Louisiana Department of Wild Life and Fisheries, Louisiana (1949), 152 pp.

(28) St. Amant, L. S., "The Petroleum Industry as it Affects Marine and Estuarine Ecology", Journal of Petroleum Technology, 24(4): 385-392 (1972).

(29) Sprunt, A., IV, "Values of the South Atlantic and Gulf Coast Marshes and Estuaries to Birds Other Than Waterfowl" (J. D. Newsome, Ed.), Proc. Marsh and Estuary Management Symposium, Louisiana State University, Baton Route, Louisiana (1967), pp. 64-72.

(30) Bourn, W. S., and Cottam, C., "Some Biological Effects of Ditching Tidewater Marshes", U. S. Fish and Wildlife Service, Research Report No. 19 (1950), 30 pp.

(31) Clark, J., "Fish and Man, Conflict in Atlantic Estuaries", American Littoral Society, Special Publication No. 5, Highland, New Jersey (1967), 78 pp.

(32) Marshall, A. R., "Practices Affecting South Atlantic and Gulf Coast Marshes - Dredging and Filling", U. S. Bureau of Sports Fisheries, Vera Beach, Florida (1967).

(33) St. Amant, L. S., "Biological Effects of Petroleum Exploration and Production in Coastal Louisiana", Paper presented at Santa Barbara Symposium, University of California at Santa Barbara (1970).

(34) Gunter, G., "Some Relationships of Estuaries to the Fisheries of the Gulf of Mexico", In: Estuaries (George Lauff, Ed.), American Association for the Advancement of Science, Publication No. 83, Washington, D. C. (1967), pp 621-638.

(35) Brock, T. D., Principles of Microbial Ecology, Prentice-Hall, Inc., Enge Englewood Cliffs, New Jersey (1966), 306 pp.

(36) Stanier, R. Y., Doudoroff, M., and Adelberg, E. A., The Microbial World, 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey (1965), 753 pp.

(37) Galtsoff, P. S., "Environmental Requirements of Oysters in Relation to Pollution", In: Biological Problems in Water Pollution, 1959 Seminar, Robert A. Taft Sanitary Eng. Center Tech. Report W60-3, Cincinnati, Ohio (1960), pp 128-134.

(38) Lichtenstein, E. P., "Problems Associated with Insecticidal Residues in Soils", In: Research in Pesticides (C. O. Chichester, Ed.), Academic Press, New York, New York (1965), pp 199-203.

(39) Loosanoff, V. L., "Some Effects of Pesticides on Marine Arthropods and Mollusks", In: Biological Problems in Water Pollution, 1959 Seminar, Robert A. Taft Sanitary Eng. Center Tech. Report W60-3, Cincinnati, Ohio (1960), pp 89-93.

(40) Fleming, W. E., and Maines, W. W., "Persistence of DDT in Soils of the Area Infested by the Japanese Beetle", J. Econ. Entomol. 46:445 (1953).

(41) Biglane, K. E., and Lafleur, R. A., "Notes on Estuarine Pollution With Emphasis on the Louisiana Gulf Coast", In: Estuaries (George Lauff, Ed.), American Association for the Advancement of Science, Publication No. 83, Washington, D. C. (1967), pp 690-692.

(42) Cronin, L. E., "The Role of Man in Estuarine Processes", In: Estuaries (George Lauff, Ed.), American Association for the Advancement of Science, Publication No. 83, Washington, D. C. (1967), pp 667-689.

(43) Lowe, J. I., Wilson, P. D., Rick, A. J., and Wilson, A. J., Jr., "Chronic Exposure of Oysters to DDT, Toxaphene and Parathion", National Shellfish Association Proceedings, 61-71-79 (1971).

(44) Mackin, J. G., and Hopkins, S. H., "Studies on Oyster Mortality in Relation to Natural Environments and to Oil Fields in Louisiana", Institute Marine Sciences Publication, 7:1-131 (1962).

(45) Darnell, R. M., "Tropic Spectrum of an Estuarine Community, Based on Studies of Lake Pontchartrain, Louisiana", Ecology, 42(3): 553-568 (1961).

(46) Day, J. W., Jr., Smith, W. G., Wagner, P. R., and Stowe, W. C., "Community Structure and Energy Flow in a Salt Marsh and Shallow Bay Estuarine System in Louisiana", Office of Sea Grant Development, Louisiana State University, Baton Rouge, Louisiana (1972) (manuscript in preparation).

(47) Kalber, F. A., Jr., "A Hypothesis on the Role of Tide Marshes in Estuarine Productivity", Estuarine Bulletin, 4(1): 3 (1959).

(48) Gunter, G., "Some Relations of Faunal Distributions to Salinity in Estuarine Waters", Ecology, 37(3): 616-619 (1956).

(49) Kutkuhn, J. H., "The Role of Estuaries in the Development and Perpetuation of Commercial Shrimp Resources", In: A Symposium on Estuarine Fisheries, American Fisheries Society, Special Publication No. 3, Washington, D. C. (1966), pp 16-36.

(50) Rounsefell, G. A., "Preconstruction Study of the Fisheries of the Estuarine Areas Traversed by the Mississippi River-Gulf Outlet Project", U. S. Fish and Wildlife Service, Fisheries Bulletin, 63(2): 373-393 (1964).

(51) Gooch, D. M., "Studies on Brackish Water Clams of the Genus Rangia in Louisiana", National Shellfish Association Proceedings, 60:3-4 (1970).

(52) Ingle, R. M., "Studies on the Effect of Dredging Operations Upon Fish and Shellfish", Technical Series No. 5, State of Florida, Board of Conservation, Division of Oyster Culture (1952).

(53) Biggs, R. B., "Overboard Spoil Disposal. I. Interim Report on Environmental Effects", Proceedings of the National Symposium on Estuarine Pollution, Stanford University (1967).

(54) Ingle, R. M., Ceurvels, A. R., and Leinecker, J., "Chemical and Biological Studies of the Muds of Mobile Bay", The Marine Laboratory, University of Miami, Report to the Division of Seafoods, Alabama Department of Conservation (1955).

(55) Flemer, D. A., Dovel, W. L., Pfitzenmeyer, H. T., and Ritchie, D. E., Jr., "Spoil Disposal in Upper Chesapeake Bay. I. Preliminary Analysis of Biological Effects", Proceedings of the National Symposium on Estuarine Pollution, Stanford University (1967).

(56) Jones, J.R.E., Fish and River Pollution, Butterworths, Washington, D. C. (1964), 203 pp.

(57) Gunter, G., "How Does Siltation Affect Fish Production", National Fisherman, 39(3): 18-19 (1957).

(58) Butler, P. A., "The Problem of Pesticides in Estuaries" (1966), pp 110-115.

(59) Moffett, A. W. "The Shrimp Fishery in Texas", Texas Parks and Wildlife Department, No. 50.

(60) Lunz, G. R., Jr., "Oyster Culture With Reference to Dredging Operations in South Carolina (Part I)", U. S. Engineer Office, Charleston, South Carolina (1938).

(61) "Draft Environmental Statement; Crude Oil and Natural Gas Production and Other Mining Operations in Navigable Water Along the Louisiana Coast", U. S. Army Engineer District, New Orleans, Louisiana (February, 1972), 82 pp.

(62) Loosanoff, V. L., "Effects of Turbidity on Some Larval and Adult Bivalves", Proceedings of the Gulf and Caribbean Fisheries Institute, 14th Session (1961), pp 80-95.

(63) Loosanoff, V. L., and Tommers, F. D., "Effect of Suspended Silt and Other Substances on Rate of Feeding of Oysters", Science, 107:69-70 (1948).

(64) Mackenzie, C. L., "Cause of Oyster Spat Mortality, Conditions of Oyster Setting Beds, and Recommendations for Oyster Bed Management", Proc. National Shellfish Association, 60:59-67 (1969).

(65) Hopkins, S. H., Mackin, J. G., and Menzel, R. W., "The Annual Cycle of Reproduction, Growth and Fattening in Louisiana Oysters", Paper presented at the 1953 National Shellfish Association in New Orleans, Louisiana (1954), pp 39-50.

(66) Moore, D., and Trent, L., "Setting, Growth and Mortality of Crassostrea virginica in a Natural Marsh and a Marsh Altered by a Housing Development", Proc. National Shellfish Association, 61:51-58 (1971).

(67) Wallace, D. H., "Oysters in the Estuarine Environment" (1966), pp 68-73.

(68) "Fourteenth Biennial Report 1970-1971", Louisiana Wildlife and Fisheries Commission.

APPENDIX A

SOCIOECONOMIC DATA FOR COASTAL PARISHES

TABLE A-1. DISTRIBUTION OF LOUISIANA EMPLOYMENT BY INDUSTRY CATEGORY FOR PARISHES AND STAFF

Industry	Parishes														State of Louisiana
	Assumption	Cameron	Iberia	Jefferson	Lafourche	Orleans	Plaquemines	St. Bernard	St. Charles	St. James	St. John the Baptist	St. Mary	Terrebonne	Vermilion	
Total employed 16 years old and over	4,929	2,601	17,346	122,345	20,964	208,787	7,905	17,521	8,910	4,976	6,321	19,130	22,958	12,519	1,158,245
Agriculture, forestry, and fisheries	19.01	12.92	6.28	0.92	6.50	0.65	4.69	1.28	2.30	10.27	4.94	5.85	4.51	12.93	4.14
Mining	4.44	15.99	15.41	3.93	10.45	1.71	20.19	2.03	2.93	0.36	1.49	12.27	18.53	11.52	4.02
Construction	11.54	8.42	6.20	8.67	8.53	5.78	12.84	10.19	8.11	6.29	10.44	7.79	6.38	9.65	8.34
Manufacturing	21.93	11.76	12.93	15.79	15.23	11.89	10.46	21.56	32.33	44.15	36.28	13.84	11.75	8.00	15.89
Furniture and lumber and wood products	--	--	0.40	0.27	0.19	0.31	0.96	0.18	0.21	0.70	0.19	0.24	0.10	0.10	1.49
Metal industries	1.85	--	0.56	2.31	0.58	1.76	0.70	6.85	0.86	1.61	0.59	2.57	0.80	0.34	1.94
Machinery, except electrical	1.30	0.46	1.33	0.71	0.75	0.28	0.43	0.69	0.26	0.68	0.41	0.89	2.33	0.30	0.58
Electrical machinery	--	--	0.12	0.24	0.01	0.14	--	0.10	0.19	--	0.21	0.03	0.03	--	0.51
Transportation equipment	4.73	1.31	1.82	3.96	5.97	1.35	0.91	1.90	5.53	9.71	8.23	2.89	2.40	1.25	1.52
Other durable goods	0.53	0.35	1.29	1.63	0.44	1.62	0.66	1.77	1.57	0.96	1.36	1.05	0.80	0.30	1.27
Food and kindred products	10.14	5.54	3.62	2.13	3.97	2.09	1.32	3.84	0.62	11.60	10.96	1.93	3.25	3.77	1.93
Textiles and fabricated textile products	--	0.12	0.09	0.56	0.13	1.80	0.25	0.87	0.48	1.33	--	0.03	0.02	0.24	0.75
Printing, publishing, and allied industries	0.18	0.38	0.48	0.84	0.33	0.90	0.14	1.03	0.34	0.28	0.40	0.56	0.34	0.44	0.70
Chemicals and allied products	2.17	1.04	2.29	1.26	0.93	0.35	3.40	0.66	16.70	14.13	9.46	2.81	0.53	0.36	2.18
Other nondurable goods	1.03	2.58	0.92	1.88	1.92	1.29	1.70	3.68	5.57	3.16	4.48	0.82	1.15	0.90	3.04
Railroads and railway express service	0.45	0.23	0.42	1.30	0.10	0.71	0.37	0.76	0.66	0.38	0.95	0.23	0.12	0.15	0.71
Trucking service and warehousing	0.34	0.35	1.04	1.39	0.48	1.38	0.83	2.17	1.44	0.40	0.84	1.48	1.60	0.39	1.18
Other transportation	2.29	6.31	2.00	4.63	6.85	4.62	7.81	4.79	5.12	1.55	3.75	6.09	5.77	3.89	2.82
Communications	0.69	0.65	0.82	1.90	0.80	1.44	0.71	2.22	0.40	0.26	0.85	0.82	1.39	0.84	1.30
Utilities and sanitary services	1.38	3.23	1.90	2.42	1.53	2.44	3.23	2.58	1.89	1.73	1.72	2.68	1.93	2.16	2.26
Wholesale trade	1.74	3.65	4.95	7.58	3.57	6.27	2.80	6.19	3.91	1.77	4.73	4.50	3.70	3.64	4.82
Food, bakery, and dairy stores	2.52	0.85	3.19	3.04	3.61	2.77	2.92	3.55	2.64	2.29	2.64	3.09	3.06	2.64	2.83
Eating and drinking places	1.64	4.69	2.53	2.89	2.78	3.52	2.00	2.27	4.57	1.19	4.38	3.43	3.28	2.53	2.83
General merchandise retailing	1.34	2.23	2.85	3.41	2.10	2.96	0.96	2.97	2.42	0.80	1.76	1.75	3.13	1.55	2.59
Motor vehicle retailing and service stations	2.39	1.77	3.18	2.25	3.08	1.58	1.37	2.39	1.86	1.39	2.06	2.68	2.43	2.70	2.45
Other retail trade	3.96	1.73	5.74	5.18	5.58	6.21	3.12	5.69	3.47	2.55	2.01	4.84	5.52	6.20	5.69
Banking and credit agencies	0.43	1.77	1.18	2.05	1.07	1.76	1.16	2.03	1.21	0.46	1.14	1.18	1.25	1.30	1.60
Insurance, real estate, and other finance	0.93	1.11	1.63	4.05	1.37	4.02	1.13	3.61	1.72	1.93	1.96	2.06	1.75	1.29	2.82
Business and repair services	1.79	3.88	3.20	3.94	2.45	3.53	3.30	2.73	3.86	1.23	1.61	4.06	3.93	2.81	3.01
Private households	5.07	1.46	5.01	0.93	2.74	3.27	1.05	0.30	2.58	1.71	2.40	3.65	2.12	4.50	3.62
Other personal services	1.85	1.27	2.72	3.06	2.37	5.35	2.06	2.56	2.23	1.41	1.93	2.49	2.68	2.76	3.64
Entertainment and recreation services	0.39	0.58	0.84	0.99	0.71	1.18	0.81	0.47	0.30	0.08	0.14	0.77	0.71	0.36	0.71
Hospitals	1.95	1.92	2.23	3.28	1.87	4.97	1.09	1.61	1.29	2.17	0.51	1.80	1.53	3.28	3.47
Health services, except hospitals	0.69	0.38	1.60	1.67	1.38	1.97	1.00	1.22	0.64	0.94	0.43	1.16	0.95	1.72	1.78
Elementary, secondary schools, and colleges-gov.	6.29	3.81	4.72	3.50	7.79	4.73	3.55	2.86	5.71	8.44	5.73	4.13	4.30	6.77	6.38
Elementary, secondary schools, and colleges-private	0.41	1.23	1.41	2.41	1.65	3.62	2.20	1.28	1.23	0.58	1.25	1.41	2.06	0.75	1.99
Other education and kindred services	0.22	0.19	0.32	0.25	0.26	0.33	0.28	0.23	0.13	0.52	0.66	0.29	0.42	0.18	0.42
Welfare, religious, and nonprofit organizations	0.83	0.92	1.01	0.97	0.75	1.59	1.20	1.20	1.03	1.02	0.33	0.73	0.35	0.68	1.44
Legal, engineering, and misc. professional services	0.43	2.42	2.02	2.88	2.03	3.91	0.87	2.86	1.50	1.27	0.70	2.07	1.88	1.03	2.62
Public administration	3.06	4.27	2.66	4.74	2.39	5.83	5.98	6.40	2.49	2.85	2.37	2.90	2.97	5.79	4.62

Source: U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics, PC(1)-C20, Louisiana, Tables 55 and 123.

Occupational Distribution

Occupations

The occupational distribution of the experienced unemployed may provide an indication of the expansion potential in the economies of the 14 parishes. Table A-2 shows the last occupation of the experienced unemployed, 16 years old and over, for parishes in 1970. These are the types of people who would be available to be hired in the construction and operation stages of the pipeline activities. Presumably, the most likely people to be hired would be males in the following three categories:

(1) Craftsmen, foremen, and kindred

(2) Operatives, including transport

(3) Laborers, except farm.

Until it is known exactly through which parishes new pipelines will pass, there is no way of speculating about how many of these people may be hired.

The occupational distribution of the employed is shown in Table A-3. The more rural parishes (Assumption, Cameron, Lafourche, Plaquemines, St. Charles, St. James, and Vermilion) vary somewhat among themselves in occupational distribution. However, it is possible to generalize and say that the most important groups are the craftsmen and the operatives, except transport. If a parish has a small town or several of them, then occupations in professional, clerical, and laborers except farm categories become more important. In the SMSA parishes (Jefferson, Orleans, and St. Bernard), the white-collar types of jobs are dominant.

TABLE A-2. LAST OCCUPATION OF EXPERIENCED UNEMPLOYED, 16 YEARS OLD AND OVER, FOR PARISHES, 1970

Occupation	Parishes													
	Assumption	Cameron	Iberia	Jefferson	Lafourche	Orleans	Plaquemines	St. Bernard	St. Charles	St. James	St. John the Baptist	St. Mary	Terrebonne	Vermilion
Male – total experienced unemployed	248	78	532	2, 592	548	6, 602	165	501	261	204	202	451	481	502
Professional, technical, and managerial	4	4	42	301	10	654	5	70	9	--	5	71	19	39
Sales workers	--	--	--	149	8	250	--	13	--	--	5	4	19	5
Clerical and kindred workers	3	--	14	176	16	507	--	31	6	--	6	10	15	5
Craftsmen, foremen, and kindred	65	16	122	782	121	1, 511	39	161	79	64	32	60	63	77
Operatives, including transport	73	5	140	601	219	1, 557	70	122	77	28	46	130	190	215
Laborers, except farm	45	25	100	400	88	1, 050	46	66	71	76	83	102	141	77
Farm workers	51	5	54	5	47	49	--	--	6	25	16	31	10	30
Service workers, including private household	7	23	45	172	22	931	5	38	13	11	12	43	24	50
Female – total experienced unemployed	99	55	407	1, 697	307	5, 035	126	327	90	91	143	395	250	236
Professional, technical, and managerial	6	6	31	136	15	452	22	5	22	4	--	26	14	26
Sales workers	8	--	26	159	14	458	--	19	20	--	--	32	37	9
Clerical and kindred workers	16	13	61	620	34	1, 332	46	143	26	13	43	72	64	26
Operatives, including transport	9	17	106	211	64	608	11	89	--	7	9	51	28	43
Other blue-collar workers	5	6	17	67	18	173	5	9	--	6	4	31	15	40
Farm workers	27	--	7	--	--	19	6	--	--	--	6	57	--	--
Service workers	5	13	49	314	103	1, 212	27	40	22	32	50	69	73	20
Private household workers	8	--	99	109	19	483	9	8	--	15	25	31	15	54

Source: U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics, PC(1)-C20, Louisiana, Table 123.

TABLE A-3. *PERCENT IN MAJOR CATEGORIES OF OCCUPATION FOR PARISHES AND STATE, 1970*

	Parishes														
Occupations	Assumption	Cameron	Iberia	Jefferson	Lafourche	Orleans	Plaquemines	St. Bernard	St. Charles	St. James	St. John the Baptist	St. Mary	Terrebonne	Vermilion	State of Louisiana
Professional, technical, and kindred	7.8	7.0	10.2	15.7	10.5	15.6	9.2	9.6	12.8	10.6	9.8	11.9	9.8	9.5	13.9
Managers and administrators, except farm	5.5	12.6	9.6	11.1	11.2	7.9	10.7	8.1	9.3	5.3	6.9	11.3	12.5	9.8	9.0
Sales workers	3.2	2.4	6.4	9.1	5.2	7.5	3.5	7.7	4.1	2.5	3.7	5.0	6.8	4.7	6.8
Clerical and kindred workers	7.3	7.9	10.5	20.4	10.7	20.0	12.2	21.6	12.4	9.1	10.1	12.7	11.0	9.7	15.6
Craftsmen, foremen, and kindred	17.9	14.6	15.2	16.3	16.4	10.7	19.8	22.2	20.8	15.7	19.7	16.4	15.9	13.8	14.5
Operatives, except transport	17.5	18.3	16.0	8.7	17.6	8.7	18.4	11.9	15.1	22.2	18.8	14.1	16.9	14.5	10.9
Transport equipment operatives	4.9	5.4	5.3	3.9	4.2	4.9	4.4	3.9	3.7	3.7	3.8	4.5	5.7	4.6	4.7
Laborers, except farm	8.5	10.0	5.3	4.5	7.4	6.4	9.3	5.6	7.0	9.2	10.5	7.0	7.3	6.4	6.1
Farmers and farm managers	4.2	4.4	2.1	0.1	1.5	0.1	1.0	0.1	0.5	3.1	0.7	0.7	0.8	7.4	1.4
Farm laborers and farm foremen	10.4	2.4	3.2	0.2	2.2	0.2	1.3	0.1	0.8	6.6	3.8	3.1	1.2	3.9	1.8
Service workers, except private house	7.8	13.0	10.7	9.0	10.8	14.2	9.5	8.7	11.0	9.9	9.8	9.6	9.5	11.5	11.6
Private household workers	5.0	1.1	5.5	1.1	2.5	3.7	0.8	0.4	2.5	2.1	2.4	3.8	2.6	4.3	3.8

Source: U. S. Department of Commerce, Bureau of the Census, 1970 *Census of Population*, General Social and Economic Characteristics, PC(1)-C20, Louisiana, Tables 54 and 122.

Labor Force Data

Labor Force

Several types of labor-force statistics are presented in Tables A-4 and A-5. The first of these tables shows the absolute number of males and females in each parish's population 16 years and over, labor force 16 years and over, civilian labor force, employed civilian labor force, and unemployed civilian labor force. Unemployment rates are also included for each sex and the parish as a whole. Generally speaking, the employment situation in the 14 parishes appears sound. Six of the parishes have unemployment rates equal to or higher than the Louisiana rate of 5.4 percent. The six parishes are Assumption, Iberia, Orleans, St. James, St. John the Baptist, and Vermilion. These six parishes are the same six parishes discussed in the income distribution section in the context of having more than 20 percent of the families in each parish living on an income less than the national poverty level. Incidentally, Vermilion Parish is the only one of the six parishes that does not have a black population of at least 25 percent of the total population.

On the second table (Table A-5), labor-force participation rates are given by age and sex for the 14 parishes and Louisiana for 1970. Probably the most critical age and sex groups in terms of a good economic environment are the five male groups between the ages of 20 and 64. Orleans Parish has three age groups – the three groups between the ages of 20 to 34 – with lower participation rates than the state. Three other parishes – Assumption, St. James, and St. John the Baptist – all have a lower-than-state rate in the 20 and 21 years group. The remaining ten parishes all have higher participation rates than the state in the relevant five age groups.

Although the status of females in the labor force would probably not be affected greatly by gas pipeline construction and operation, it is interesting to note that there is only one parish – Orleans – where the parish rates are higher than the Louisiana participation rates. Twelve of the parishes have lower-than-state rates in all five age groups between the ages 20 to 64.

TABLE A-4. LABOR FORCE STATISTICS FOR PARISHES AND STATE, 1970

Labor Force Characteristic	Parishes														State of Louisiana
	Assumption	Cameron	Iberia	Jefferson	Lafourche	Orleans	Plaquemines	St. Bernard	St. Charles	St. James	St. John the Baptist	St. Mary	Terrebonne	Vermilion	
Total males, 16 years and over	5,704	2,614	16,682	103,923	20,934	185,017	8,001	15,954	8,579	5,477	6,867	17,829	22,353	13,393	1,139,748
Male labor force, 16+ years	4,051	2,073	12,650	85,953	16,352	131,718	6,466	13,000	6,614	3,996	4,888	14,077	17,459	9,555	825,511
Civilian labor force	4,051	2,062	12,638	85,201	16,347	130,213	6,206	12,920	6,587	3,996	4,888	14,050	17,348	9,552	788,384
Employed	3,799	1,984	12,029	82,441	15,760	123,068	6,041	12,399	6,311	3,787	4,675	13,580	16,840	9,030	749,825
Unemployed	252	78	609	2,760	587	7,145	165	521	276	209	213	470	508	522	38,559
Percent unemployed	6.2	3.8	4.8	3.2	3.6	5.5	2.7	4.0	4.2	5.2	4.4	3.3	2.9	5.5	4.9
Total females, 16 years and over	6,186	2,583	18,827	112,766	21,859	228,289	7,631	16,930	9,024	6,129	7,278	18,903	23,246	14,589	1,259,123
Female labor force, 16+ years	1,240	672	5,823	41,867	5,553	91,378	2,028	5,509	2,710	1,333	1,794	6,044	6,389	3,773	436,243
Civilian labor force	1,240	672	5,818	41,847	5,553	91,319	2,023	5,503	2,710	1,333	1,794	6,044	6,389	3,773	435,802
Employed	1,130	617	5,317	39,904	5,204	85,719	1,864	5,122	2,599	1,189	1,646	5,550	6,118	3,489	408,420
Unemployed	110	55	501	1,943	349	5,600	159	381	111	144	148	494	271	284	27,382
Percent unemployed	8.9	8.2	8.6	4.6	6.3	6.1	7.9	6.9	4.1	10.8	8.2	8.2	4.2	7.5	6.3
Total civilian labor force	5,291	2,734	18,456	127,048	21,900	221,532	8,229	18,423	9,297	5,329	6,682	20,094	23,737	13,325	1,224,186
Total unemployed	425	133	1,110	4,703	936	12,745	324	902	387	353	361	964	779	806	65,941
Total percent unemployed	6.8	4.9	6.0	3.7	4.3	5.8	3.9	4.9	4.2	6.6	5.4	4.8	3.3	6.0	5.4

Source: U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics, PC(1)-C20, Louisiana, Tables 53 and 121.

TABLE A-5. LABOR FORCE PARTICIPATION RATES BY AGE AND SEX FOR PARISHES AND STATE, 1970

Age	Parishes														
	Assumption	Cameron	Iberia	Jefferson	Lafourche	Orleans	Plaquemines	St. Bernard	St. Charles	St. James	St. John the Baptist	St. Mary	Terrebonne	Vermilion	State of Louisiana
	Male														
14 and 15 years	9.4	15.0	13.3	8.3	13.7	8.0	8.6	9.1	11.9	4.8	6.9	8.5	8.6	8.3	8.3
16 and 17 years	18.5	30.0	27.8	30.3	33.2	22.0	22.1	24.6	17.4	10.4	9.6	27.3	27.1	18.0	23.8
18 and 19 years	43.9	53.0	51.5	60.4	61.7	47.8	58.9	64.0	38.4	33.2	39.2	58.0	64.6	52.8	53.9
20 and 21 years	67.4	95.7	75.2	73.5	77.2	62.0	85.9	72.0	76.8	63.2	59.7	87.5	77.2	76.3	71.4
22 to 24 years	85.1	100.0	88.0	89.9	88.4	79.3	93.1	92.4	93.3	87.3	87.0	92.7	91.1	87.8	83.3
25 to 34 years	94.5	100.0	96.0	96.6	95.9	90.4	94.4	94.6	96.1	97.4	93.0	96.1	95.2	92.8	91.9
35 to 44 years	93.6	95.0	93.5	96.5	93.9	91.1	95.1	95.3	97.7	97.4	91.9	93.6	92.4	93.7	92.4
45 to 64 years	86.5	85.7	84.7	90.0	83.9	83.3	86.8	90.2	85.8	86.9	83.9	84.0	85.0	82.5	82.1
65 years and over	12.5	31.8	22.0	27.2	21.6	27.2	27.8	27.0	15.6	16.3	15.7	24.4	21.0	19.9	20.7
	Female														
14 and 15 years	4.9	2.2	5.3	2.9	4.7	2.8	5.0	1.3	6.2	3.7	2.2	8.2	5.4	2.2	3.6
16 and 17 years	4.9	8.5	13.3	14.3	14.9	11.9	6.5	10.3	10.3	3.1	6.4	19.0	10.3	7.7	10.3
18 and 19 years	26.7	42.2	34.4	41.1	31.3	35.1	29.7	45.4	30.8	13.6	26.5	30.4	37.1	30.5	32.5
20 and 21 years	21.4	30.9	39.5	51.7	35.0	49.1	28.9	47.0	42.6	31.0	30.7	40.4	39.5	38.2	43.1
22 to 24 years	25.8	23.6	38.3	51.5	31.5	56.5	27.0	42.4	26.5	30.5	27.2	36.2	31.4	34.9	45.4
25 to 34 years	22.2	28.4	36.0	36.8	26.5	50.5	24.4	30.5	34.1	24.3	26.4	32.2	27.8	32.8	40.3
35 to 44 years	27.5	22.8	37.9	42.4	30.2	51.0	38.4	36.7	35.7	35.2	40.6	42.3	30.2	38.6	45.4
45 to 64 years	24.8	34.4	34.4	40.8	26.7	45.9	29.7	37.4	36.2	26.5	24.9	36.0	29.6	26.5	39.7
65 years and over	3.8	8.0	8.1	8.1	5.1	11.5	7.0	4.9	7.8	3.7	6.5	9.3	10.7	4.0	8.2

Source: U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics, PC(1)-C20, Louisiana, Tables 53 and 121.

TABLE A-6. INCOME AND POVERTY STATUS IN 1969 FOR PARISHES AND STATE, 1970

Income	Parishes															
	Assumption		Cameron		Iberia		Jefferson		Lafourche		Orleans		Plaquemines		St. Bernard	
	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution
Total Number of Families	4,402	100.00	2,027	100.00	13,556	100.00	84,099	100.00	16,279	100.00	143,699	100.00	5,900	100.00	12,645	100.00
0 - $999	261	5.93	76	3.75	604	4.46	1,951	2.30	436	2.68	8,803	6.13	220	3.73	276	2.18
$ 1,000 - 1,999	287	6.52	100	4.93	930	6.86	1,978	2.33	765	4.70	9,052	6.30	312	5.29	292	2.31
$ 2,000 - 2,999	437	9.93	104	5.13	1,069	7.89	2,515	2.96	936	5.75	9,498	6.61	195	3.31	364	2.88
$ 3,000 - 3,999	460	10.45	143	7.05	1,021	7.53	2,825	3.33	979	6.01	9,979	6.94	297	5.03	472	3.73
$ 4,000 - 4,999	351	7.97	116	5.72	993	7.33	3,332	3.92	1,184	7.27	10,123	7.04	304	5.15	531	4.20
$ 5,000 - 5,999	354	8.04	216	10.66	1,023	7.55	4,002	4.71	1,203	7.39	9,823	6.84	468	7.93	573	4.53
$ 6,000 - 6,999	379	8.61	135	6.66	1,029	7.59	4,661	5.49	1,420	8.72	10,211	7.11	410	6.95	762	6.03
$ 7,000 - 7,999	298	6.77	170	8.39	998	7.36	5,931	6.99	1,423	8.74	9,791	6.81	494	8.37	1,032	8.16
$ 8,000 - 8,999	349	7.93	218	10.75	1,048	7.73	6,733	7.93	1,520	9.34	9,024	6.28	416	7.05	1,307	10.34
$ 9,000 - 9,999	314	7.13	153	7.55	1,073	7.92	6,585	7.76	1,304	8.01	8,041	5.60	500	8.47	1,119	8.85
$10,000 - 11,999	446	10.13	216	10.66	1,417	10.45	13,065	15.39	1,733	10.65	13,343	9.29	898	15.22	2,132	16.85
$12,000 - 14,999	216	4.91	226	11.15	1,245	9.18	13,403	15.79	1,763	10.83	13,202	9.19	703	11.92	1,909	15.10
$15,000 - 24,999	191	4.34	130	6.41	859	6.34	13,489	15.89	1,244	7.64	16,259	11.31	591	10.02	1,613	12.76
$25,000 - 49,999	40	.91	24	1.18	171	1.26	2,991	3.52	274	1.68	4,951	3.45	87	1.47	209	1.65
$50,000+ -	19	.43	--	--	76	.56	638	.75	95	.58	1,599	1.11	5	.08	54	.43
Median Family Income	$6,135		$7,726		$7,109		$10,235		$7,855		$7,445		$8,601		$9,638	
Mean Family Income	$6,920		$8,168		$7,985		$11,377		$8,728		$9,536		$9,023		$10,319	
Estimated Total Family Income	$30,461,840		$16,556.536		$108,244,660		$966,009,693		$142,083,112		$1,370,313,664		$53,235,700		$130,483, 755	
Percent of All Families With Income Less Than Poverty Level	30.2		16.7		22.7		8.5		15.4		21.6		14.8		8.5	

Income	Parishes													
	St. Charles		St. James		St. John the Baptist		St. Mary		Terrebonne		Vermilion		State of Louisiana	
	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution	No. of Families	Percent Distribution
Total Number of Families	6,738	100.00	4,013	100.00	5,135	100.00	14,002	100.00	17,298	100.00	10,815	100.00	872,772	100.00
0 - $999	197	2.92	100	2.49	287	5.59	404	2.89	562	3.25	630	5.83	41,960	4.81
$ 1,000 - 1,999	290	4.30	317	7.90	301	5.86	820	5.86	815	4.71	849	7.85	60,401	6.92
$ 2,000 - 2,999	365	5.42	260	6.48	358	6.97	949	6.78	746	4.31	1,064	9.84	62,494	7.16
$ 3,000 - 3,999	328	4.87	297	7.40	302	5.88	856	6.11	983	5.68	913	8.44	60,920	6.98
$ 4,000 - 4,999	409	6.07	203	5.06	291	5.67	801	5.72	833	4.82	1,032	9.54	58,364	6.69
$ 5,000 - 5,999	468	6.95	250	6.23	278	5.41	1,064	7.60	1,349	7.80	972	8.99	60,065	6.88
$ 6,000 - 6,999	297	4.41	219	5.46	253	4.93	975	6.96	1,411	8.16	806	7.45	60,099	6.89
$ 7,000 - 7,999	439	6.52	340	8.47	358	6.97	972	6.94	1,365	7.89	730	6.75	60,490	6.93
$ 8,000 - 8,999	574	8.52	417	10.39	508	9.89	1,094	7.81	1,729	10.00	731	6.76	60,825	6.97
$ 9,000 - 9,999	547	8.12	351	8.75	436	8.49	967	6.91	1,538	8.89	588	5.44	53,582	6.14
$10,000 - 11,999	1,019	15.12	496	12.36	638	12.42	1,949	13.92	2,057	11.89	927	8.57	92,856	10.64
$12,000 - 14,999	965	14.32	392	9.77	619	12.05	1,526	10.90	2,009	11.61	764	7.06	89,071	10.21
$15,000 - 24,999	690	10.24	313	7.80	456	8.88	1,324	9.46	1,474	8.52	598	5.53	86,253	9.88
$25,000 - 49,999	126	1.87	48	1.20	44	.86	248	1.77	342	1.98	159	1.47	20,020	2.29
$50,000+	24	.36	10	.25	6	.11	53	.38	85	.49	52	.48	5,372	.62
Median Family Income	$9,004		$8,049		$8,275		$8,146		$8,338		$5,946		$7,530	
Mean Family Income	$9,469		$8,260		$8,332		$8,811		$9,081		$7,319		$8,799	
Estimated Total Family Income	$63,802,122		$33,147,380		$42,784,820		$123,371,622		$157,083,138		$79,154,985		$7,679,520,828	
Percent of All Families With Income Less Than Poverty Level	16.3		21.5		21.8		19.0		15.3		25.0		21.5	

Source: U. S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics, PC(1)-C20, Louisiana, Tables 57, 58, and 124.

APPENDIX B

AREAS IDENTIFIED FROM THE LITERATURE, PERSONAL COMMUNICATION WITH EXPERTS, AND FROM THIS STUDY ON ENVIRONMENTAL CHANGES THAT MAY OCCUR ASSOCIATED WITH GAS PIPELINE INDUSTRY ACTIVITIES

TABLE B-1. AREAS IDENTIFIED FROM THE LITERATURE, PERSONAL COMMUNICATION WITH EXPERTS, AND FROM THIS STUDY ON ENVIRONMENTAL CHANGES THAT MAY OCCUR ASSOCIATED WITH GAS PIPELINE INDUSTRY ACTIVITIES

Environmental Characteristics and Conditions	Environmental Responses and Data Requirements
Physical and Chemical – Terrestrial	
Land form	a. Change in basic land-form pattern b. Change in relative positions of erosional and depositional features
Earth	a. Number and density of canals within a proposed area b. Change of land to water by dredging c. Creation of stable and unstable spoils d. Conversion of settled silts and organics to the dispersed aquatic system e. Compaction of marshland soils f. Stimulation of aerobic degradation of drained soils g. Change in sulfide reduction system
Groundwater	a. Water table changes with drainage or flooding b. Groundwater salinity changes
Atmosphere	a. Changes in oxides content b. Changes in the number of aircraft
Physical and Chemical – Aquatic	
Streams and rivers	a. Changes in tidal flow patterns b. Changes in seasonal flow characteristics c. Flooding and storm conditions worsened d. Salinity pattern changes e. Possible suspension of toxic organics and heavy metals f. Changes in turbidity levels, short term g. Changes in turbidity, long term h. Acidity i. BOD j. Fertility levels k. Drainage of impoundments l. Stagnation from spoil bank blockage m. Detrital content n. Stream capture and stream enlargement o. Changes in erosional and depositional patterns.

TABLE B-1. (Continued)

Environmental Characteristics and Conditions	Environmental Responses and Data Requirements
	Physical and Chemical – Aquatic (Contd)
Ponds and lakes	a. Draining and flooding of impoundments b. Salinity c. Turbidity d. Fertility e. Detrital content f. BOD
Estuaries	a. Turbidity b. Salinity c. BOD d. Acidity e. Currents f. Toxic substances g. Temperature patterns and profiles h. Enlargement in area
Marine waters	a. Turbidity changes b. Traffic and traffic patterns
	Biological – Terrestrial
Plant communities	a. Loss of vegetated land from canaling b. Loss of productivity from spoil banks c. Species shifts from drainage and flooding d. Increased diversity on habitat, stable spoil banks, and encouragement of successional species e. Dissection of habitats for vegetative reproducers
Game animals	a. Decrease in land habitat for existing animal levels b. Increase in land habitat on stable spoils, e.g., deer, rabbits c. Displacement behavior during construction d. Behavioral effects from canal usage and surveillance e. Increased accessibility to hunting and trapping areas f. Increases open water habitat, e.g., alligators
Nongame animals	a. Reduction in habitat area and carrying capacity b. Increase in habitat diversity on stable spoils

TABLE B-1. (Continued)

Environmental Characteristics and Conditions	Environmental Responses and Data Requirements
	Biological – Terrestrial (Contd)
Nongame animals (Contd)	c. Dissection of habitat and habitat isolation for animals with small home ranges d. Interruption of migration routes
Birds	a. Reduction in terrestrial and marsh habitat b. Behavioral displacement during construction c. Behavioral disturbance during surveillance d. Stable spoils increase resting areas for selected species e. Increase in succession and tree vegetation increases habitat diversity f. Local alteration of food chain species g. Change in habitat for open-water birds
Insects	a. Changes in habitat and food source b. Habitat dissection and possible population isolation for nonflying forms c. Increase in habitat diversity on stable spoils and fills
Rare and endangered species	a. Displacement of local population b. Isolation species with low genetic stock c. Increase in habitat for ridge and openwater species d. Increase in accessibility to collectors and hunters in open canals e. Behavioral disturbance during construction and surveillance activities
	Biological – Aquatic
Pond and lake biota	a. Change in productivity associated with change in fertility b. Change in productivity associated with change in turbidity and light penetration c. Change in consumer productivity with change in detritus availability d. Change in productivity with possible change in salinity through open canals e. Siltation of benthic community f. Temporary increase in successional species

TABLE B-1. (Continued)

Environmental Characteristics and Conditions	Environmental Responses and Data Requirements
	Biological – Aquatic (Contd)
Stream biota	a. Change in productivity with change in water quality parameters, e.g., salinity, turbidity, light penetration, suspension of toxic substances, and flow characteristics b. Siltation and smothering of sessile and benthic food sources c. Temporary disturbance to mobile organisms
Fisheries	a. Short- and long-term siltation of oyster and shrimp areas b. Local change in productivity resulting from changes in salinity, fertility, and current patterns c. Local change in availability of food chain species d. Behavioral disturbance to mobile forms during construction e. Change in densities and production resulting from station liquid releases and spills into canals f. Increase in importance in species favoring more turbid environments g. Change in predation and disease with changes in salinity h. Increase in density and diversity of species likely to occupy canals
Nursery	a. Change in availability and type food detritus and food plankton b. Change in quantity and type of spawning grounds c. Local changes in protective habitat for juveniles d. Change in patterns of orientation compounds e. Change in total habitat for juvenile estuarine forms f. Change in juvenile success with local water quality changes
Food chains	a. Change in productivity of food chain organisms b. Change in diversity and dominant species types with environmental disturbances c. Increase in habitat in flooded areas d. Decrease in habitat in drained areas e. Population changes affected by liquid releases

TABLE B-1. (Continued)

Environmental Characteristics and Conditions	Environmental Responses and Data Requirements
	Biological – Aquatic (Contd)
Rare and endangered species	a. Increase and loss of habitat from flooding and drainage
	b. Behavioral disturbance during construction and surveillance
	c. Suppression of population success from liquid releases
	d. Possible increase in habitat for some successional species with canaling operation
	Cultural
Employment	a. Short-term employment opportunities during construction
	b. Long-term employment opportunities at stations and surveillance
	c. Possible increase in unemployment at the termination of construction resulting from immigration
	d. Change in employment in fisheries industry
	e. Increase in employment in service industries
	f. Change in income level for property owners
	g. Change in income level from fisheries
	h. Change in income levels for commercial hunters and trappers
	i. General change in business conditions
Community	a. Population growth
	b. Change in number and quality of housing requirements
	c. Change in size and quality of educational system
	d. Change in social structure
	e. General change in municipal control and support requirements
Life style	a. Increased exposure to new people
	b. Change in life pace
	c. Change in personal concern for individuals and others

TABLE B-1. (Continued)

Environmental Characteristics and Conditions	Environmental Responses and Data Requirements
	Cultural (Contd)
Recreation	a. Increases access to desirable recreational areas by local and outside people through open canals b. Change in time spent on recreational activities versus time spent in life support c. Change in proportion of income spent in recreation
Esthetics	a. Change in diversity of landscape form b. Change in diversity of vegetational and animal forms and dominant types c. Increased sense of engineering presence of structure, signs, etc.
Wilderness and scientific value	a. Change in proportion of undisturbed lands b. Increased proportion of lands under management and hence control of natural processes (i.e., control of fire and vegetational types). c. Preservation of plant and animal successional areas and species d. Increased scientific and public cognizance and interest in wetlands and wetland values e. Stimulation to set aside preserves and refuges
Archaeological sites	a. Identification of sites from surveys and construction b. Possible disruption of small sites
Health and safety	a. Changes in occupational hazards during construction b. Changes in exposure to the elements of the environment and to water c. General change in health and safety with change in industrialization
	Land Use
Agriculture	a. Lines cross stations; structures occupy wetland grazing and farming environment

TABLE B-1. (Continued)

Environmental Characteristics and Conditions	Environmental Responses and Data Requirements
	Land Use (Contd)
Natural areas	a. Lines cross and dissect areas b. Station sitings occupy space c. Special backfill and burial conditions may be required
Management areas	a. Canaling, ditching, and stations occupy space b. Special placement and burial conditions may required
Governmental	a. New lines meet with increasing governmental control b. Canaling and ditching intersect with navigational and water control activities
Industry and commercial	a. Position of lines and stations affect placement of other structures and facilities b. Open canals may conduct effluents into other areas
Municipal	a. Open canals may conduct municipal effluents into other areas b. Placement of lines and stations affect local zonation for land use and habitation
Energy, mining, and quarrying	a. Lines may require replacement and special crossing effort and structures b. Areas may have to be avoided pending future land excavation and mining
Transportation and communication	a. Open canals may be required for multi-purpose usage b. Change in access and railroad requirements c. Change in small and large ship traffic d. Change in requirements for radio communication e. Change in requirements for telephone and telegraph services
Other utilities	a. Change in requirements for electric energy b. Change in requirements for fuel energy

APPENDIX C

SUMMARY OF CURRENT RESEARCH EFFORTS

APPENDIX C

SUMMARY OF CURRENT RESEARCH EFFORTS

As a part of the efforts to identify data and information pertinent to an assessment of the environmental effects of gas pipelining operations, several on-going or planned environmental research projects were identified. Readily available organizations and Federal and state agencies were contacted, but no exhaustive survey of all possible sources of research projects was made. These contacts were made during visits of the project team to Louisiana, through queries of the gas pipeline companies, and through a search of the Science Information Exchange at the Smithsonian Institution. Studies sponsored by private industry, either in-house or through universities or research organizations, may have been missed in the survey. The list of projects presented below, however, includes the most significant of on-going studies in the coastal marshlands.

While many environmental research projects are being conducted in the coastal regions around the Gulf of Mexico, it must be realized that most of the research results will not be available for a year or more. Time is required to complete the research, understand and evaluate the results, and to publish in the open literature. All of these on-going research projects, of course, contribute to the understanding of the complex coastal ecosystems, but many projects are directed at narrow scope studies in a specific area. General applicability of the results of these on-going research projects, listed below by title only, to the prediction of environmental impacts of pipelining can only be assessed with further study of the objectives of the projects and the nature of the results obtained. Also, many of the research projects listed pertain to the offshore areas which are only indirectly affected by changes in the marshlands themselves.

INDUSTRIALLY SUPPORTED RESEARCH IN GULF AREA

Outside of the current research project for the Offshore Pipeline Committee, no major environmental research projects in the coastal marshes under support by industry have been identified. Presumably some specific projects are under way, but these have not been brought to our attention. Several related items have been identified.

(1) "Environmental Impact of Pipeline Construction South of Morgan City, Louisiana" is the title of a report prepared last November by Gulf South Research Institute for Trunkline Gas Company. This is the only specific formal industrial research report identified.

(2) United Gas Company R&D material. United has investigated on an informal basis several items, on which they have supplied data. One of these was the record of the history of a shell-faced pipeline plug where a 20-inch line came ashore at Bayou Sale in Atchafalaya Bay. A number of years ago, United looked

at the various kinds of dams and bulkheads and the raw data file on this has been loaned to us. Unfortunately, there is no summary of the results and conclusions. Copies of a couple of examinations of specific oyster leases by Mackin relative to damage claims against United have been made available. There were, of course, circumscibed programs and the results are probably not generally applicable.

(3) Other Pipeline Companies. We have not been advised of either past or present studies conducted by any of the other pipeline companies, although presumably there are data in their files which would constitute informal R&D programs.

(4) Other Companies. While possibly not qualifying as R&D Louisiana Land and Exploration Co. (W. Manning) has studied canaling and land loss. None of this has been released. This company could well have other records and studies which would constitute raw material for wetlands research, although we have no knowledge if this is so.

GULF UNIVERSITIES RESEARCH CONSORTIUM PROGRAM

The Gulf Universities Research Consortium (GURC) is a university controlled nonprofit corporation in which twenty major universities from the five Gulf states and Mexico participate. Ten of these institutions are currently participating in a multi-million-dollar, 2-year program of base-line research in the Gulf. This program is being sponsored by 76 offshore petroleum companies and allied service industries. The following is a list of some individual proposals and current projects under GURC coordination:

Robert J. Menzies - Fla. State U.
Plankton - platforms and pipelines

Henry Kritzler - Fla. State U.
Benthic annelids - platforms

John R. Thompson, Univ. of South. Miss.
Using NMFS - Pascagoula Fisheries Center, Miss.
provide base line for macrofauna offshore

A. Geoffrey Fish - Univ. of S. Miss.
Feasibility of interstitial organisms as
pollution indicators

Robert Y. George - Fla. State U.
O_2 demand and energy models for oysters
"metabolic standards"

Sayed Z. El-Sayed - Texas A&M
Oil pollution effect on plankton
photosynthesis effects

Robert Menzies - Fla. State U.
Benthic amphipods - offshore operations effects

Harold J. Humm - Univ. of S. Fla.
Benthic algae and epiphytes on seagrasses as
indicators of environmental health

Gordon Gunter, Gulf Coast Research Lab
Off Grand Isle, La. - Upper Barataria Bay to
Offshore base line and impacts of oil industry

Menzies - Law, Fla. State U.
Succession and depth stratification of natural
communities on offshore platforms

Gulf South Research Institute - J. G. Montralro, H. P. Burchfield
New Iberia, La., metals and chemical analysis
of Gulf waters

Douglas C. McCain - Univ. of South Miss.
Radiocarbon (^{14}C) dating of Gulf crudes to be
used as indicators of petroleum pollution
in Gulf waters

Charles Brent - Univ. of South. Miss.
BOD and COD and total organic carbon versus inorganic
carbon hydrocarbon fingerprinting

Carl H. Oppenheimer - Univ. of Texas at Port Aransas
Distributions of hydrocarbon in water, sediment
and indicator organisms

George M. Griffin - Univ. of Fla.
Total suspended solids - turbidity
analysis - source

Mapping and charting physical parameters
Fla. State University
Gulf South Research Institute
Southwest Research Institute

Joseph R. Crump - Univ. of Houston
Refinery liquid waste model.

STATE-SUPPORTED RESEARCH PROJECTS

State research efforts vary greatly among the five Gulf states. Louisiana and Florida have the largest programs. Cooperative Wildlife and Fisheries Units (Federal with state) are active in each state. Texas and Alabama each have state laboratories located at the shore as a center for their activities. As an example of the scope of this work the Alabama laboratory at Dauphin Island is carrying out the following projects:

- Effects of dredging on water quality
  turbidity, heavy metals, nutrients, etc.
- Flushing rates of Mobile Bay,
  assimilative capacity, O_2 consumption
- Biological inventory of tidal weirs
- Limits of salt water intrusion
- Extent of marine species utilization of brackish and faintly brackish marshes
- Rangia distribution (clam)
- Culture techniques for Striped Bass with eventual reestablishment of lost runs
- Mariculture project on pompano and rainbow trout in brackish waters.

PROJECTS IDENTIFIED THROUGH SCIENCE INFORMATION EXCHANGE

The following research projects in the Gulf coast area were listed at the Smithsonian Institution as being active in the period July, 1970, through June, 1972. Many of these projects are broad in scope and will be active over a period of several years. The list is presented to indicate the number and nature of research efforts that are under way in the Gulf coast area which will continue to improve the data base for the evaluation of environmental impacts. The principal investigator or institution should be contacted for detailed and current information on these and related studies.

Title of Project	Supporting Agency	Principal Investigator/ Institution
Water Law of Southeastern Estuaries	Office of Water Resources, U.S. Dept. of Interior	C. Leavell, Univ. of Ga., Institute of Government
Evaluation of Estuarine Data	National Marine Fisheries Service, NOAA, U. S. Dept. of Commerce	C. R. Chapman, NOAA, Galveston
Sulfur Deposits in the Gulf Coastal Region	Geological Survey, U.S. Dept. of Interior	A. J. Bodenlos, USGS, Washington, D.C.
Bayou Lafourche Sedimentation Study	Geological Survey, U.S. Dept. of Interior	W. H. Boyle, USGS, Baton Rouge
Fish and Wildlife Study of the Louisiana Coastal Area	Dept. of Defense, Army	H. R. Haas, F. M. Chatoy, et al, U.S. Army Engineering District, New Orleans
Salinity Intrusion and Related Phenomena	Dept. of Defense, Army	H. B. Simmons, Waterways Experimental Station, Vicksburg
Impact of Corps of Engineers Construction Activities on the Ecological Environment	Dept. of Defense, Army	J. W. Keeley, Waterways Experiment Station, Vicksburg
Determination of Aquatic Ecosystem Response Trends Resulting from Man-Imposed Environmental Stresses	Dept. of Defense, Army	J. W. Keeley, Waterways Experiment Station, Vicksburg
Some Aspects on the Ecology of a Tidal Marsh Estuary at Marsh Island, Louisiana	Louisiana State Gov.	W. H. Herke, LSU, State Cooperative Fishery Unit, Baton Rouge
Marshgrass Productivity and Biodegradation	Louisiana State Gov.	S. P. Meyers, LSU, Agricultural Experiment Station, Baton Rouge
The Chemical Characteristics of the Soils of the Louisiana Coastal Marshes	Louisiana State Gov.	J. E. Sedberry, LSU, Agricultural Experiment Station, Baton Rouge
Cultural Machines for Improvement of Marshland for Wildlife and Cattle	Louisiana State Gov.	J. D. Newsom, LSU, Agricultural Experiment Station, Baton Rouge

Title of Project	Supporting Agency	Principal Investigator/ Institution
Chemical Water Quality and Sediment-Water Reactions in Louisiana and Mississippi Estuaries	Office of Water Resources, U.S. Dept of Interior	J. O. Snowden, LSU, Graduate School, New Orleans
Investigation of Commercially Important Penaeid Shrimp in Louisiana's Estuaries	National Marine Fisheries Service, U.S. Dept. of Commerce	W. J. Gaidry, State Div. of Oysters, Baton Rouge
Sedimentology of Louisiana's Estuaries	National Marine Fisheries Service, U.S. Dept. of Commerce	W. S. Perret, State Wildlife and Fish Commission, New Orleans
Biology of Louisiana's Estuaries	National Marine Fisheries Service, U.S. Dept. of Commerce	W. S. Perret, State Wildlife and Fish Commission, New Orleans
Phase II-Hydrology of Louisiana's Estuaries	National Marine Fisheries Service, U.S. Dept. of Commerce	W. S. Perret, State Wildlife and Fish Commission, New Orleans
Area Description of the Estuaries of Louisiana	National Marine Fisheries Service, U.S. Dept. of Commerce	W. S. Perret, State Wildlife and Fish Commission, New Orleans
Timbalier-Terrebonne Bays System	National Marine Fisheries Service, U.S. Dept. of Commerce	J. G. Bloom, State Wildlife and Fish Commission, New Orleans
Vermilion-Calcasieu-Saline System	National Marine Fisheries Service, U.S. Dept. of Commerce	J. G. Bloom, State Wildlife and Fish Commission, New Orleans
Atchafalaya River-Calliou Lake System	National Marine Fisheries Service, U.S. Dept. of Commerce	J. G. Bloom, State Wildlife and Fish Commission, New Orleans
Plankton Studies	Bureau of Sport Fisheries and Wildlife, U.S. Dept. of Interior	K. E. Lantz, State Wildlife and Fish Commission, New Orleans
Aquatic Vegetation Studies	Bureau of Sport Fisheries and Wildlife, U.S. Dept. of Interior	K. E. Lantz, State Wildlife and Fish Commission, New Orleans

Title of Project	Supporting Agency	Principal Investigator/ Institution
Comparative Value of Semi-Impounded Louisiana Tidal Marshes as Nursery Areas for for Fishes, Shrimps, and Crabs	Bureau of Sport Fisheries and Wildlife, U.S. Dept. of Interior	W. H. Herke, LSU, Graduate School, Baton Rouge
Geographic Atlas of Pesticide Occurrence in the Barataria Bay-Mississippi Delta	National Science Foundation	T. E. Shellenberger, Gulf South Research Institute, Baton Rouge
Mathematical Modeling of the Louisiana Coastal Ecosystem with Emphasis on the Interaction Between the Shelf and the Estuarine System	National Science Foundation	B. Wilkins, LSU, School of Engineering, Baton Rouge
The Water Balance of the Gulf of Mexico	National Science Foundation	G. A. Franceschini, Texas A&M, School of Geosciences, College Station
Mechanism of Acting Faulting on the Gulf Coast of Texas	National Science Foundation	R. O. Kehle, Univ. of Texas, School of Arts Austin
Development of a Comprehensive Plan for Implementing a Gulf Environmental Program	National Science Foundation	J. M. Sharp, Gulf Universities Research Corporation, Galveston
Archaeological Investigations at the Morton Shell Mound, Louisiana	National Science Foundation	R. W. Neuman, LSU, School of Arts, Baton Rouge
Develop a Coastal Zone Authority	National Science Foundation	E. Erdi, Univ. of Houston, School of Law, Houston
Utilization and Management of Coastal Marshes and Resources	National Science Foundation; also Sea Grant Office, U.S. Dept. of Commerce	J. Van Lopik, LSU, Graduate School, Baton Rouge
Nitrate Removal from Water at the Water-Mud Interface in Swamps, Marshes, and Flooded Soils	Office of Water Programs, Environmental Protection Agency	W. H. Patrick, LSU, School of Agriculture, Baton Rouge
An Inventory and Study of the Vermilion Bay-Atchafalaya Bay Estuarine Complex	National Marine Fisheries Service, U.S. Dept of Commerce	D. A. Neal, State Wildlife and Fish Commission, New Orleans

Title of Project	Supporting Agency	Principal Investigator/ Institution
Experiments to Reestablish Historical Oyster Seed Grounds and to Control the Southern Oyster Drill	National Marine Fisheries Service, U.S. Dept. of Commerce	J. F. Pollard, State Wildlife and Fish Commission, New Orleans
A Study of the Blue Crab Fishery in Louisiana	National Marine Fisheries Service, U.S. Dept of Commerce	B. G. Adkins, State Wildlife and Fish Commission, New Orleans
Evaluation of Effects of Various Coastal Construction Methods	National Marine Fisheries Service, U.S. Dept. of Commerce	B. L. Benefield, State Parks and Wildlife Dept. Austin
Law and the Marine Resources of the Gulf of Mexico	Sea Grant Office, U.S. Dept. of Commerce	J. B. Neibel, Univ. of Houston, School of Law, Houston