PRIMARY ECONOMIC IMPACT OF THE GULF INTRACOASTAL WATERWAY IN TEXAS

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FOREWORD

Preparation of this report, "Primary Economic Impact of the Gulf Intracoastal Waterway in Texas," was undertaken to identify and quantify marine-related activities of the Waterway contributing directly to the economy of Texas.

A significant effort was made by the authors to include information relative to the development and growth of the Waterway. In addition to analyses of current and future economic impact, particular emphasis was placed on history, land use, commodity flows, industrial users, and technological innovations relating to the Waterway. A supporting study to clarify indirect economic stimuli of the Waterway on the Texas economy is currently under investigation.

Grateful appreciation is extended to the many individuals, firms, and Federal and State agencies assisting in the study. Particular mention is due the representatives of the U. S. Army Corps of Engineers, Galveston District, for their cooperation.

Special thanks go to Robert R. Richards for his valuable assistance in researching data and analyzing future developments impacting on the Waterway.

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SUMMARY

Historically, the Gulf Intracoastal Waterway in Texas has continued to contribute to the growth of economic activity in the coastal zone.

Consistent with the national experience, industrial development in Texas reflects the continuing economic importance of water transportation. Shippers' dependency on low-cost water transportation is evident with nearly three-fourths of the state's goods moving by water while Texas ports rely heavily on the Waterway to transport foreign commerce.

Over 21 million acres adjoining the 1,081 miles of shoreline in Texas constitute the coastal zone. The land is used for municipal purposes, industrial activities, agricultural production, living accommodations, transportation uses, and tourism and recreation developments.

An economic impact analysis was prepared on the basis of available commodity flow statistics and the major industrial users of the Waterway.

With the exception of chemical products, commodity flow statistics for the past 15 years have indicated few major changes occurring in the types of commodities transported. A major difference between Texas and United States commerce is that the latter imported more than it exported while Texas trade traditionally has exported more than it has imported.

Land areas contiguous to the Texas portion of the Gulf Intracoastal Waterway have become increasingly attractive to firms that require high-volume, low-cost transportation. Primary industrial users include manufacturing, mining and water transportation firms. Manufacturing industries producing chemicals and related products and engaged in petroleum refining account for 48 percent of all waterborne commerce in Texas. Shipment values of non-metallic minerals and shell totalled $62.1 million in 1966, and the water transportation industry generated revenues of approximately $263.8 million in 1969.

Applying multipliers from the Texas Input-Output model to the respective commodity and industry data produced the final economic impact of the Gulf Intracoastal Waterway on Texas. Excluding tertiary economic effects of supporting service industries, the total economic benefits were $1.8 billion.

An analysis of new concepts in barge technology indicates how they may affect the size of the waterway, traffic flow, safety hazards, and the volume of commerce shipped on the waterway. Current and anticipated future demands on the waterways require that new technologies be implemented to maintain and improve the competitive posture of the barge industry.

A forecast of future primary economic impact attributable to new work and maintenance of the waterway, the water transportation industry, and port cargo value moved in barges indicates an estimated economic impact of $2.9 billion by 1985.

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INTRODUCTION

CHAPTER I

INTRODUCTION

History of Inland Water Transportation

Inland waterway transportation has played a major role in the development of the United States since the days of the first colonizations along the Eastern Seaboard. Three general periods in the history of waterborne commerce may be perceived.

The first period began in the early seventeenth century when the nation's rivers in their natural state were used as routes of exploration. Later, settlers used the rivers as a means of travel to the frontiers. With settlement came production and trade between the hinterland and the cities, and gradually, the rivers became the major arteries by which raw materials and finished goods were exchanged between the frontier and the cities. With increased commerce came attempts to improve the rivers and to link them together by man-made canals such as New York's Erie Canal, which was such a financial success that other states and private firms commenced construction of what was to become an extensive system of inland waterways. This period of canal building, overlapped by the steamboat era, marked a stage of waterway development in which water transportation was unexcelled as a means of carrying goods. By the beginning of the Civil War, steamboats carried goods valued at one half billion current dollars into New Orleans daily.

The second period in the history of inland water transportation began with the Civil War and a subsequent suspension of river traffic.

Through this suspension, the railroads were able to gain supremacy in commercial transportation. From this period until the early 20th century, railroads were the undisputed leaders in the transportation field.

That waterway transportation survived the era of the railroads was largely due to two factors: government regulation of the railroads and technological advances. Engineering advances such as improved engine designs and the adaptation of the propeller to shallow water vessels prepared the way for the modern period of water transportation. Government regulations prevented railroads from using discriminatory rate-cutting to force barge operators out of business. However, the major stimulus to the rebirth of inland water transportation was World War I and the heavy strain which the war placed on the existing transportation network. The initiation of new barge operations by the U. S. Railroad Administration in 1918 encouraged new interest in this transportation mode. Federal realization that waterway transportation offered a method to cheaply expand the existing transportation network resulted in the improvement of old waterways and the construction of new ones.[1] The result was our present day system of inland waterways, shown in Figure 1, which also illustrates proposed extensions as well as those now under construction.

The Gulf Intracoastal Waterway in Texas

The Gulf Intracoastal Waterway, a major portion of the U. S. water transportation network, extends from Florida to the Mexican

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[1]Howe, Charles W., et al. Inland Waterway Transportation, Washington, D. C.: Resources for the Future, Inc., 1969, pp. 9-11.

SOURCE: Fulkerson, Frank B., U.S. Bureau of Mines, Transportation of Mineral Commodities on the Inland Waterways of the South-Central States, Washington, D.C.

WATERWAYS OF THE UNITED STATES
FIGURE 1

border. It is the major water route by which the Gulf Coast States and other areas of the United States exchange goods. Because it helps provide low-cost transportation to many major industries, it has greatly enhanced the industrialization of the South in general and Texas in particular, where it is used primarily for the transportation of petroleum, petroleum products and chemicals.

Construction on the Intracoastal Waterway first began in 1905 when canals were dredged to five feet deep and 40 feet wide along some areas of the Gulf coast. In 1934, a channel extending from New Orleans to Corpus Christi, Texas, was completed, and in 1941, the waterway extended as far down as Brownsville, Texas, with controlling dimensions of nine feet deep and 100 feet wide. World War II emphasized once again the importance of inland waterway transportation as the Gulf Intracoastal Waterway allowed sheltered passage for troops and supplies, and in 1949, the waterway was dredged twelve feet deep by 125 feet wide. Figure 2 shows the Intracoastal Waterway System of Texas, adjacent counties, and the major ports served by the waterway.

The economic importance of the Intracoastal Waterway in Texas is difficult to over-stress. Nearly three-fourths of the state's goods are shipped by water,[2] and Texas ports are largely dependent upon the waterway as a means of transporting foreign commerce inland. The high incidence of industry in the coastal area of the state is due in part to the existence of inexpensive water transportation.

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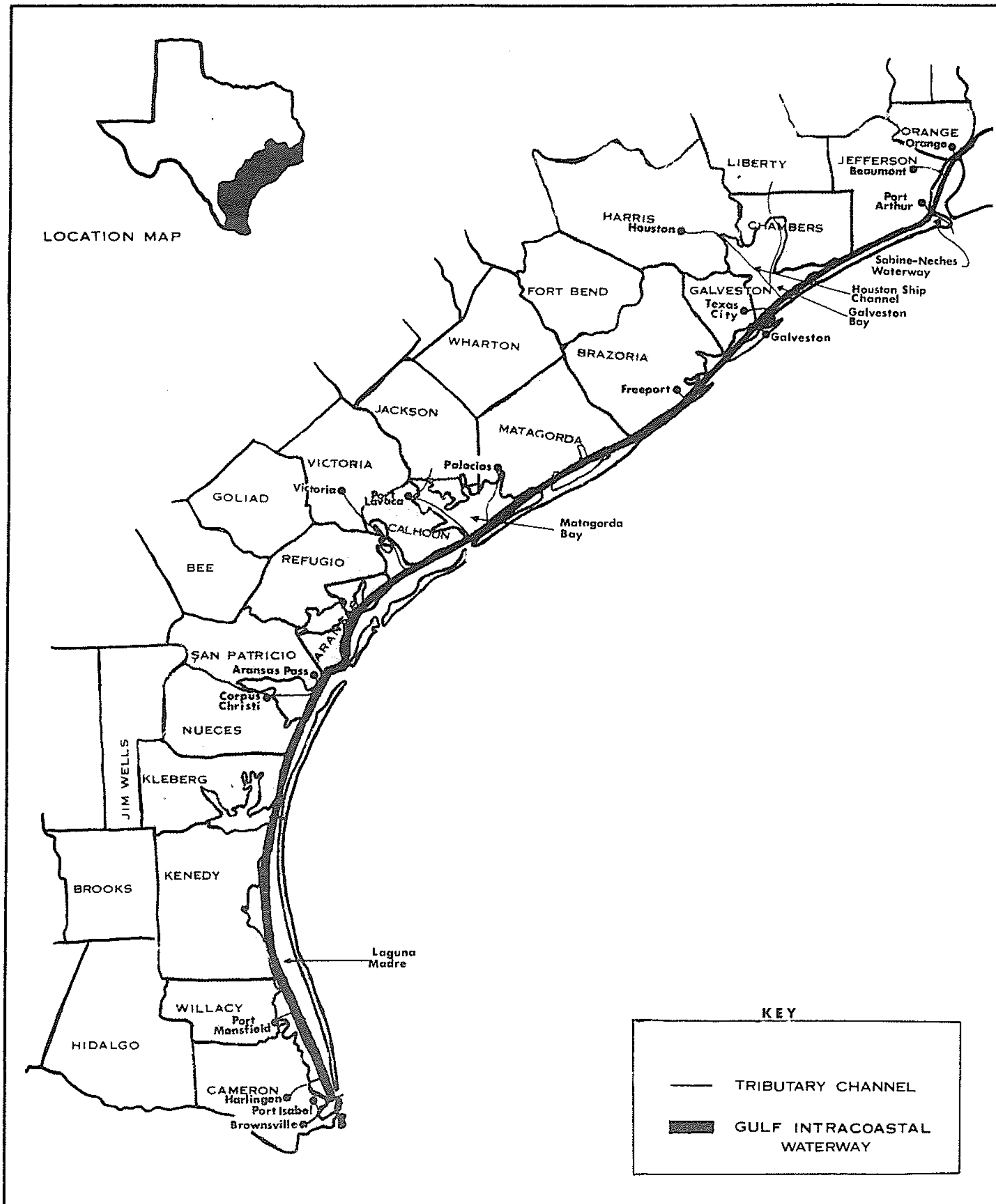
[2]Bureau of the Census, 1967 Census of Transportation, Area Series-Texas, Washington, D. C.: U. S. Department of Commerce, May, 1970, p. 3.



THE INTRACOASTAL WATERWAY OF TEXAS AND ADJACENT COUNTIES

FIGURE 2

The Role of the Corps of Engineers

Since 1824, the U. S. Army Corps of Engineers has been actively involved in the improvement and development of inland waterways. Through the Civil Works Program, the Corps builds and maintains waterways and engages in other water resources related programs. In addition, it plays a major role in assisting the Water Resources Council and the various federal-state river basin commissions in developing the Water Resource Development plans called for by the Water Resource Planning Act of 1965.[3] Corps responsibilities involving the Intracoastal Waterway fall mainly within two general categories: 1) planning and supervision, and 2) protection. If an investigation of a navigation project is authorized by Congress, the Corps makes the necessary cost-benefit and environmental studies, conducts public hearings to determine the degree of local cooperation and then makes the appropriate recommendations to the Board of Engineers for Rivers and Harbors and to the Public Works Committee of Congress. If Congress appropriates the necessary funds, the Corps then takes in bids from private contractors. Once construction is under way, the Corps serves in a supervisory capacity to ensure proper construction. In addition to the planning and supervision of waterway construction, the Corps also has various responsibilities under federal legislation designed to protect the quality and navigability of inland waterways. An example of such legislation is the Refuse Act of 1899. Under this Act, the Corps of Engineers is given the authority to grant permits

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[3] United States Department of the Army, Corps of Engineers, 1967 Annual Report, Washington, D. C.: United States Department of the Army, 1968.

before any construction that might prove to be an obstruction to navigation can be undertaken. In addition, the Act gives the Corps of Engineers the authority to prevent the deposition of refuse and other pollutants, unless permission is specifically granted. Under the National Environmental Policy Act, the Corps of Engineers must make an environmental impact study for any project which it recommends. Under certain conditions, the Corps of Engineers also has the authority to deny construction in navigable waterways if environmental damage may ensue.[4]

Expenditures on Waterways

The desirability of a navigation project is directly related to its cost of construction. For inland waterways, construction costs may vary greatly, depending on such conditions as the degree of local cooperation, availability of spoil disposal areas, and terrain conditions. The variability of construction costs between one waterway and another is shown in Figure 3. As illustrated by Figure 3, it may be seen that portions of the upper Mississippi cost as much as $7.2 million per mile, while parts of the Illinois Waterway cost $8.1 million per mile. By contrast, construction of the Gulf Intracoastal Waterway has averaged considerably less than $300 thousand of investment per mile. This low per-mile investment figure, coupled with the fact that the waterway has been heavily used has resulted in a benefit-cost ratio of approximately 26 to 1.[5] Table 1 shows expenditures on all

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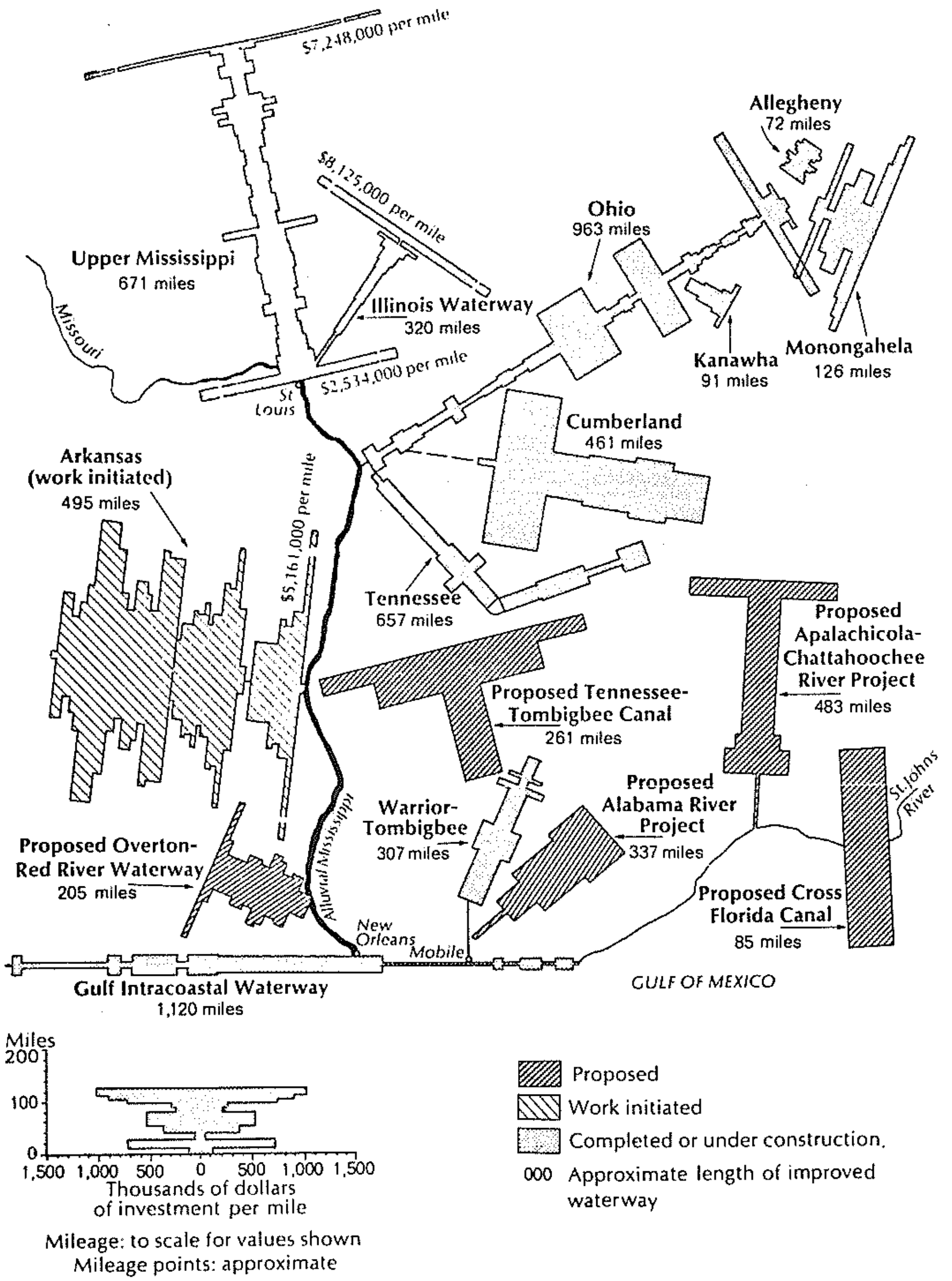
[4]Zabel vs. Tabb, U. S. Court of Appeals, Fifth Circuit, 1970, 430F. 2nd 199.

[5]Gulf Intracoastal Canal Association, Proceedings, 67th Annual Convention, Corpus Christi, Texas: Gulf Intracoastal Canal Association, September 24, 1972, p. 3.



SOURCE: U. S. Department of Commerce, <u>User Charges on Inland Waterways</u>, January, 1959, Washington, D.C.

COSTS OF CONSTRUCTION ON UNITED STATES WATERWAYS

FIGURE 3

TABLE 1

EXPENDITURES ON NAVIGABLE WATERWAYS IN TEXAS*
(Thousands of Dollars)

WATERWAY SECTOR	1956	1958	1960	1962	1964	1966	1968	1970	EXPENDITURES TO DATE
Gulf Intracoastal Waterway									
New Work	37	203	2,042	3,949	656	2,034	184	5	43,028
Maintenance	674	1,036	1,897	4,363	2,320	3,231	3,789	2,523	54,466
Rehabilitation	--	--	--	177	55	270	--	--	836
Total	711	1,239	3,939	8,489	3,031	5,535	3,973	2,528	98,330
Sabine Neches Waterway									
New Work	--	717	1,685	1,338	1,574	1,270	3,251	2,824	46,566
Maintenance	292	1,692	969	2,173	1,636	3,276	4,380	1,945	46,273
Contributed Funds	--	--	--	--	--	60	425	127	2,453
Total	292	2,409	2,654	3,511	3,210	4,606	8,056	4,896	95,292
Houston Ship Channel									
New Work	749	682	1,433	2,750	2,606	1,087	37	2	35,602
Maintenance	425	487	1,399	1,767	2,303	2,012	1,643	2,807	41,591
Total	1,174	1,169	2,832	4,517	4,909	3,099	1,680	2,809	77,193
Buffalo Bayou and Tributaries									
New Work	100	2,459	2,908	2,842	1,364	2,204	3,508	1,087	49,800
Maintenance	64	53	67	107	192	94	141	136	2,592
Total	164	2,512	2,975	2,949	1,556	2,298	3,649	1,223	52,392

TABLE 1 (Cont'd)

EXPENDITURES ON NAVIGABLE WATERWAYS IN TEXAS*
(Thousands of Dollars)

WATERWAY SECTOR	1956	1958	1960	1962	1964	1966	1968	1970	EXPENDITURES TO DATE
Galveston Harbor and Channel									
New Work	--	53	2,427	247	135	2,413	454	--	26,137
Maintenance	322	506	695	1,582	569	1,029	2,123	532	28,317
Rehabilitation	--	--	--	144	822	1,701	--	921	7,969
Total	322	559	3,122	1,973	1,586	5,143	2,577	1,453	62,423
Corpus Christi Ship Channel									
New Work	1,335	868	2,547	664	1,540	313	--	--	20,240
Maintenance	903	448	397	941	660	994	1,613	616	24,833
Rehabilitation	--	--	--	--	44	1,447	--	--	3,577
Total	2,238	1,316	2,944	1,605	2,244	2,754	1,613	616	48,650
Matagorda Ship Channel									
New Work	--	--	327	859	2,852	2,113	--	--	17,838
Maintenance	--	1	1	117	328	252	1,412	1,443	6,842
Contributed Funds	--	--	--	1,494	1,372	1,559	--	--	12,056
Total	--	1	328	2,470	4,552	3,924	1,412	1,443	36,736
Brazos Island Harbor									
New Work	--	1,309	1,602	--	207	24	3	--	10,471
Maintenance	75	561	357	694	307	683	795	572	10,911
Rehabilitation	--	--	--	--	92	336	--	--	1,464
Total	75	1,870	1,959	694	606	1,043	798	572	22,846

TABLE 1 (Cont'd)

EXPENDITURES ON NAVIGABLE WATERWAYS IN TEXAS*
(Thousands of Dollars)

WATERWAY SECTOR	1956	1958	1960	1962	1964	1966	1968	1970	EXPENDITURES TO DATE
All Others									
New Work	--	--	878	18	233	824	3,636	2,405	21,446
Maintenance	295	422	357	763	712	266	1,670	1,442	21,383
Rehabilitation	--	--	--	--	199	--	--	--	735
Total	295	422	1,235	781	1,144	1,090	5,306	3,847	43,564
GRAND TOTAL	5,271	11,497	21,988	26,989	22,838	29,492	29,064	19,387	537,426

* Sum of components may not equal given totals due to independent rounding

SOURCE: U. S. Army Corps of Engineers, Annual Report, Washington, D.C.

navigable waterways in Texas from 1956 to 1970. The total expenditures to date are shown in the far right-hand column of the table. Total expenditures on Texas waterways increased by nearly 600 percent between 1956 and 1968. However, in 1970, only $19.4 million was spent in Texas as compared with $29 million in 1968. This large decrease is primarily due to two facts: first, several projects under construction in 1968 were either completed or were near completion in 1970. Second, federal economic policy in recent years has greatly restricted new navigation projects. Actual expenditures on the Gulf Intracoastal Waterway have been quite modest in comparison with the expenditures on its tributaries in recent years.

LAND USE

CHAPTER II

LAND USE

Introduction

With 1,081 miles of shoreline, a coastal zone encompassing 36 counties of land area, and bays, estuaries and tidelands extending 10.4 miles from the shore, Texas has an immense area of over 21 million acres identified as the coastal zone of Texas.[1] Within this framework, fragments of land are being used for municipal purposes, industrial activities, agricultural production, living accommodations, transportation uses, and tourism and recreation developments. In addition to these land uses, a host of service enterprises utilize land areas throughout the coastal zone.

The surge of population and industrial growth in Texas urban areas creates a multitude of problems relating to the destruction of living resources by severe air and water pollution. Dredging, water table depletion, and dam construction produce dramatic changes in the coastal zone. Land use development should, therefore, be systematically planned and supervised in the form of a coastal management program to prevent the urban and industrial pressures and problems prevalent along the northeastern Atlantic coast.

Historical Trends

The history of the Intracoastal Waterway movement is intimately associated with the early history of the United States. It was

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[1]College of Engineering, Texas A&M University, Interdisciplinary Programs Relating to Coastal Zone Management and Marine Resources College Station, Texas: College of Engineering, Texas A&M University. January, 1972.

interest in public works of this type that led George Washington and his associates to arrange a series of meetings to consider these and other means of promoting commerce between the States.

Albert Gallatin, Treasury Secretary in 1808, said in his report to Congress concerning the acquired Louisiana Purchase that, "The map of the United States will show that they possess a tidewater inland navigation, secure from storms and enemy . . ." This conception of the national need for an intracoastal waterway 152 years ago is equally applicable today.[2]

The Gulf of Mexico is noted for storms and squalls so sudden and severe that water vessels found escape difficult.

A historic overview reveals the marine environment to have a strategic economic role in the world which is confirmed by the following facts:

1. All major industrial nations have extensive coastlines,
2. An estimated two-thirds of the gross world product is produced in coastal zones,
3. More than 80 percent of the world metropolitan areas are coastal areas,
4. Of the 25 largest United States cities, 18 are coastal cities,
5. More than 75 percent of the total population of the United States resides in coastal or Great Lake states,
6. More than 45 percent of the nation's urban population resides in coastal counties, and,
7. All of the major megalopoli now projected for the year 2000 are located in coastal zones.[3]

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[2]U. S. Department of the Army, Corps of Engineers, The Intracoastal Waterway: Gulf Section, Washington, D. C.: Government Printing Office, 1961.

[3]Marine Science Affairs--Selecting Priority Programs, Annual Report of the President to the Congress on Marine Resources and Engineering Development, Washington, D. C.: Government Printing Office, April, 1970, p. 31.

Discovery of oil and natural gas along the state's coastal region and the subsequent development of port and harbor facilities along the eastern half of the Texas coast provided the primary thrust for industrial growth and population expansion. Increased population, greater industrial diversification, and specialized industrial growth stemming from oil and gas contributed to the transformation of coastal regions from a rural to an urban industrial complex.

The Texas Gulf Coast currently has the world's largest petrochemical capacity and contains the most important sources of natural gas in the United States with its more than one trillion cubic feet.

The Texas marine environment has experienced a development pattern similar to the other regions of the world. Economic growth in Texas has a direct correlation with accessibility to the Gulf of Mexico and to the rich mineral resources found along the Gulf Coast.

The extent of this urbanization process can be readily observed from the fact that 50 percent of Texas residents live within a 100-mile radius of the coastline and thus reflects the general trend of population concentration in all the coastal areas. Predictions for the year 2000 indicate the population trend of coastal areas will continue.

Methodology

For purposes of obtaining an accurate perspective of land use along the Gulf Intracoastal Waterway, individual assessments of the counties bordering the coastal line will be made.

Total acreage of each county will be identified according to various uses in terms of residential, industrial, agricultural, public, recreational and other assorted activities. Additional information delineating population and industrial location per county will be integrated with land use in the form of maps and statistical summaries.

Drawing on the individual county maps and data as source material, a summary map and statistical information will be prepared to establish a comprehensive picture of land distribution along the Gulf Intracoastal Waterway in Texas.

General Description of the Waterway

Navigation facilities consist of the Gulf Intracoastal Waterway, oceanic ports, and connecting tributaries.

The Gulf Intracoastal Waterway serves as the major navigation artery for waterborne transportation along the Texas Coast extending from the Louisiana border to Brownsville, Texas. It provides a navigable channel with a minimum depth of 12 feet and a bottom width of 125 feet except in floodgates and locks where the horizontal width narrows to 75 feet.[4] Thirteen bridges and a set of floodgates at the Brazos River crossing exist along the Texas Coast. The tributary channels range from four to 12 feet in depth and 60 to 200 feet in width.[5]

There are 23 ports along the Texas Coastal area where dry and liquid commodities are shipped and received.[6] Eleven of these ports process more than 90 percent of the total tonnage shipped annually.[7]

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[4] Texas Coastal Basins, Interim Report, U. S. Department of Agriculture, Soil Conservation Service, Fort Worth, Texas, January, 1972.

[5] Ibid.

[6] Ibid.

[7] Ibid.

The Port of Houston is the largest, followed by Beaumont, Corpus Christi, and Port Arthur. Channels leading into these ports from the open Gulf range from 30 to 40 feet in depth.[8] With the exception of the Galveston port, over half of the cargoes handled by these ports consist of petroleum and chemical products in liquid form.

Detailed Description of the Waterway

This brief narrative describing the path of the Gulf Intracoastal Waterway in Texas will be discussed in sections.

A. Sabine River to Galveston Bay

This reach is 84.4 miles long from a point on the Sabine River three miles below Orange, Texas, to the Houston Ship Channel in Galveston Bay. The route follows the deep water channel of the Sabine-Neches Waterway to West Port Arthur where by land cut to East Bay and through an area of East Bay and another land cut, it reaches Port Bolivar and Galveston Bay.[9]

B. Galveston Bay to Freeport

This stretch is 44.8 miles long, following a dredged channel in the bay and across the northerly tip of Pelican Island to Galveston Causeway. It then proceeds westward across West Bay. Through a land cut that skirts the north shore of West Bay, across Chocolate Bay, to a land cut passing north of Oyster, Bastrop and Drum Bays, the waterway arrives at Freeport Harbor.[10]

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[8] Ibid.

[9] The Intracoastal Waterway: Gulf Section, op. cit.

[10] Ibid.

C. Freeport to Port O'Connor

The distance between these two locations extends over 79.3 miles through a land cut skirting the north shore of Cedar Lake and Matagorda Bay from Freeport Harbor to Oyster Lake about 12 miles west of the Colorado River.[11]

D. Port O'Connor to Corpus Christi Bay

This stretch of 65.2 miles goes between Aransas and Corpus Christi Bays. From Port O'Connor the canal extends through a land cut passing north of Espiritu Santo Bay to San Antonio Bay. Then across the San Antonio Bay to a land cut skirting the north shore of Mesquite Bay and across Aransas Bay. It extends in a southwesterly direction through a dredged cut in the Bay to Redfish Bay. There, via a dredged cut skirting the westerly shore of Redfish Bay past the City of Aransas Pass, the waterway reaches the deep water channel of the Port Aransas-Corpus Christi Waterway in Corpus Christi Bay.[12]

E. Corpus Christi Bay to Brownsville

This reach, 144.4 miles long, follows the deep water channel of the Port Aransas-Corpus Christi Waterway and the channel to Encinal Peninsula for a short distance and then extends across the natural depths in Corpus Christi Bay to a dredged channel in Laguna Madre. In a southerly direction, it then flows along the laguna to Port Isabel Turning Basin over to Brazos Island Harbor deep draft channels to Port Brownsville, the western terminus of the waterway.[13]

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[11] Ibid.

[12] Ibid.

[13] Ibid.

Geology of the Gulf Coast and the Gulf Intracoastal Waterway

The area is characterized by the low relief which is typical of the entire Gulf Coastal Plain. Elevations range from sea level to about 200 feet.

Climate is humid to semi-arid. Average annual rainfall ranges from 54 inches at Beaumont to 26 inches at Kingsville. The average length of the growing season varies from 319 days in Kenedy County to 241 days in Tyler County.[14] Average annual temperature ranges from about 70 degrees at Beaumont to 74 degrees at Corpus Christi. Except on rare occasions sea breezes prevent extremely high summer temperatures over most of the area.

Geologic formations discovered in the Gulf Coastal Plain range in age from Recent on the coast to Eocene (about 46 million years old) in the inland areas.[15] These formations consist of relatively unconsolidated clay, sand, and gravel that dip gently toward the coast. The most significant geologic structural features are salt domes which are an important source of mineral wealth.

Vegetation ranges from a dense pine and hardwood forest in the east to prairies of crops and grass in the central part of the study area while brush covered grassland appears in the southern portions.

Land Use Summary

In summary of land use within the entire Coastal Zone 38.7 percent of this resource is covered by rangeland defined as land on which the

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[14] Texas Coastal Basins, U. S. Department of Agriculture, Soil Conservation Service, Fort Worth, Texas, July 1972.

[15] Ibid.

natural plant community is composed principally of native grasses, forbs and shrubs.[16] About 13.6 percent of the study area is forest land. Pastureland which occupies approximately 11.6 percent of the study area, includes areas on which acclimated forage plants have been introduced for soil and water conservation, and increased forage production. Irrigated cropland with irrigation water delivery facilities is used for planned rice rotation and covers about 12.9 percent of the coastal zone area.[17] Land on which tilled crops are grown without systematic irrigation is classified under the dry cropland category occupying about 12.6 percent of the area.[18] Most of this dry cropland lies within the Gulf Coast Prairies Land Resource Area. Only 4.6 percent of the land is used for urban-industrial development--mainly metropolitan areas--while 3.5 percent is classified as marsh-rangeland.[19]

The physical properties of the soils naturally affect land usage, whether it be agricultural, engineering, recreational, or wildlife.

Properties important to agriculture include wetness, slope, texture, permeability, depth, and stoniness. Properties which affect the engineering use pertain to permeability, sheer strength, compaction characteristics, drainage, shrink-swell characteristics, texture, plasticity, and depth to the water table and to bedrock. For

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[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Ibid.

recreational use, the most suitable characteristics are freedom from stones and rock outcrops, gentle slopes, good drainage, and freedom from flooding. In the case of wildlife, soil influence on existing plants will be essential.

Most of the wildlife is produced on privately owned land used for the production of cultivated crops, livestock and timber. Up through the mid-1970's over 100,000 acres of the study area was converted from other uses to wildlife-recreation uses.

Over 15,000 farm ponds exist on private land many of which are stocked with fish. Also, over 300 irrigation reservoirs have been constructed with a dual purpose of storing pumped ground water and fishing.

Conservation plans developed by landowners with the technical assistance of the corresponding conservation districts include practices that promote both management and wildlife habitat improvements.

Availability of land for agricultural use will decrease as non-agricultural land needs and water requirements increase. Nevertheless, agriculture is and will continue to be the major user of land resources in the coastal zone.

Explanation of Land Use Maps and Statistical Data

In reference to the maps contained in the appendix, it will be noticed that the coastal zone was conveniently divided into five regions conforming to the general outline of the established Council of Governments. Beginning with the southernmost region bordering Mexico, the Lower Rio Grande Valley Region,[20] these maps will display

[20] Only Cameron and Willacy Counties are displayed on the map primarily because the two counties lie closest to and are consequently more directly affected by the Gulf Intracoastal Waterway.

land uses for each successive region up to the northernmost Texas coastal region, the Southeast Texas Region containing Jefferson and Orange Counties.

For standardization purposes, the individual maps will show the distribution and uses of land resources in terms of Agriculture, Urban and Rural Settlements, Open Space, Industry, Commerce, Water, Recreation, and Marshland.

From the obvious consideration that man is the single most important user of the land, separate population distribution maps were prepared in an effort to demonstrate graphically population densities or concentrations relative to the entire area. Noticeably, industry and commerce tend to locate near the existing urban concentration centers. In support of the maps, statistical summaries in tabular format subdivide the regional and coastal zone land areas into urban and federal land use sections and into small water areas. The agricultural portion is apportioned further to cropland, pasture, range, and forest uses. The "other land" category refers to wasteland, farmsteads, feed lots, roads, small ponds, and other similar uses.

The statistical portion of the population distribution by counties, regions and the coastal zone provide total population, population density, urban population, and housing information to assist in trend determinations.

County data was made available to show how the regional and coastal summary data was derived. However, greatest reliance will be placed on the regional and coastal zone summaries in retrospect to the primary purpose of this study which will emphasize the regional impact.

Referring to Table 2, data from the 1970 Conservation Needs Inventory reflect the size of the various regions and how the regions compare to the entire study area. The Gulf Coast Region, for example, with 13 counties, covers 37.7 percent of the study area followed by the Coastal Bend Region with 37 percent of the coastal zone land mass. In decreasing order by size the Golden Crescent, the Lower Rio Grande Valley and the Southeast Texas Region follow, respectively.

A survey and comparison of the 1960 and 1970 total averages of the different land uses reveals a 17.9 percent increase in the use of land for urban use in conjunction with a 28.4 percent rise in land use for small inland water areas. The facts also reveal that the coastal zone experienced a decline in the land usage of 13.5 percent for crop, 0.03 percent for range and 0.1 percent for forests, while land use for pasture rose by 48.1 percent during this same time period.

Several tentative conclusions can be drawn from these trends.

Both physical and economic phenomena play an important role in these changes. First, the productivity of soils has deteriorated to some degree due to the employment of inadvisable practices. Such practices, for instance, may have increased the salinity of soils when irrigation was attempted, and subsequently caused a decline in land available for the growing of crops. Secondly, there have been changes in markets and prices, governmental programs and alike which affected the profitability of crops and influenced farmers to redirect the use of their land resources.[21] The increasing demand for beef

[21] Warren L. Trock, "Testimony Developed for the Interim Committee on Coastal and Marine Resources" Department of Agriculture Economics and Rural Sociology, College of Agriculture, Texas A&M University, College Station, Texas.

TABLE 2

SUMMARY LAND-USE BY REGIONS
(ACRES)

AREA	TOTAL LAND AREA		URBAN & FEDERAL		SMALL WATER AREA	
	1958	1967	1958	1967	1958	1967
Lower Rio Grande Valley	1,922,100	1,939,008	143,300	144,708	1,400	1,469
Coastal Bend	7,795,100	7,796,433	241,800	260,129	6,200	7,521
Golden Crescent	2,578,000	2,592,192	38,600	83,463	2,100	2,434
Gulf Coast	7,953,500	7,962,984	677,900	812,666	6,300	9,109
South-East Texas	832,500	838,272	98,400	113,843	100	150
Coastal Zone	21,081,200	21,128,889	1,200,000	1,414,809	16,000	20,683
Percent of Total Coastal Area	----	----	5.7	6.7	0.0008	0.0001
Texas	168,218,323	168,001,086	6,501,869	7,283,027	457,901	456,949
Coastal Percent of Texas	12.5	12.6	18.5	19.4	3.5	4.5

TABLE 2 (Cont.)

SUMMARY LAND-USE BY REGIONS
(ACRES)

AREA	TOTAL LAND AREA		CROPLAND		PASTURE	
	1958	1967	1958	1967	1958	1967
Lower Rio Grande Valley	1,922,100	1,939,008	1,083,100	1,044,213	39,500	72,784
Coastal Bend	7,795,100	7,796,433	1,695,500	1,407,435	23,000	357,113
Golden Crescent	2,578,000	2,592,192	705,500	634,553	175,400	184,818
Gulf Coast	7,953,500	7,962,984	2,635,700	2,212,179	1,315,100	1,743,124
South-East Texas	832,500	838,272	248,500	209,323	103,300	95,770
Coastal Zone	21,081,200	21,128,889	6,368,300	5,507,703	1,656,300	2,453,609
Percent of Total Coastal Area	----	----	30.2	26.1	7.9	11.6
Texas	168,218,323	168,001,086	41,521,220	35,630,331	7,489,180	14,081,642
Coastal Percent of Texas	12.5	12.6	15.3	15.5	22.1	17 4

TABLE 2 (Cont.)

SUMMARY LAND-USE BY REGIONS
(ACRES)

AREA	TOTAL LAND AREA		RANGE		FOREST	
	1958	1967	1958	1967	1958	1967
Lower Rio Grande Valley	1,922,100	1,939,008	634,600	615,648	----	----
Coastal Bend	7,795,100	7,796,433	5,751,000	5,382,733	52,400	51,056
Golden Crescent	2,578,000	2,592,192	1,135,700	1,254,990	476,000	370,716
Gulf Coast	7,953,500	7,962,984	767,300	746,054	2,469,400	2,246,411
South-East Texas	832,500	838,272	172,300	180,898	174,000	199,400
Coastal Zone	21,081,200	21,128,889	8,460,900	8,180,323	3,171,800	2,867,583
Percent of Total Coastal Area	----	----	40.1	38.7	15.0	13.6
Texas	168,218,323	168,001,086	86,668,090	85,604,543	24,345,747	22,681,747
Coastal Percent of Texas	12.5	12.6	9.8	9.6	13.0	12.6

TABLE 2 (Cont.)

SUMMARY LAND-USE BY REGIONS
(ACRES)

AREA	TOTAL LAND AREA		OTHER LAND		REGIONAL AREA AS A PERCENT OF COASTAL ZONE	
	1958	1967	1958	1967	1958	1967
Lower Rio Grande Valley	1,922,100	1,939,008	20,200	60,186	9.1	9.2
Coastal Bend	7,795,100	7,796,433	25,200	330,446	37.0	36.9
Golden Crescent	2,578,000	2,592,984	44,700	61,218	12.2	12.3
Gulf Coast	7,953,500	7,962,984	81,800	193,441	37.7	37.7
South-East Texas	832,500	838,272	35,900	38,888	3.9	4.0
Coastal Zone	21,081,200	21,128,889	207,800	684,179	99.0	100.1
Percent of Total Coastal Area	-----	-----	0.01	0.03	--	--
Texas	168,218,323	168,001,086	1,234,316	2,262,847	--	--
Coastal Percent of Texas	12.5	12.6	16.8	30.2	--	--

SOURCE: Texas Conservation Needs Committee, "Conservation Needs Inventory," Temple, Texas, 1970 and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

and new varieties of grasses quite suited to the coastal zone, led to a substantial rise in land used for pasture.

Land use for range has not changed perceptibly. Most of the range is located in Rio Grande Plain, while large acreages of pasture may be found in the Coastal Prairies and, again, in the Rio Grande Plain.

Pine forests and pine-hardwood forests are located in the eastern portion of the study zone.

From the data in Table 2, the sharp increase of 83.3 percent in the acreage of "other land" becomes evident. This may reflect the increasing use of rural lands by part-time and non-farmers to include certain suburban uses of land that can not be easily classified. Part of this large percentage figure may result from the classification system currently employed in land use inventories which indicate a need for improvement.

As the changing trends in land uses of the coastal zone and the entire State of Texas are compared in Table 3, it will be noted that fluctuations in the various land uses are more pronounced for the coastal zone. This implies greater economic activity with its inherent need for change to meet new demands. As the study progresses the existence of a more decided degree of commerce in the coastal area relative to the remainder of the state will emerge.

Population Distribution

Land use and economic activity are meaningless terms until the human factor is introduced, which evolves into the following discussion of the population distribution, both urban and rural, population density, and the housing supply by counties, regions, and the coastal zone.

TABLE 3

LAND-USE TRENDS IN THE COASTAL ZONE
(ACRES)

AREA	URBAN AND FEDERAL			SMALL WATER AREA			CROPLAND		
	1958	1967	PERCENT CHANGE	1958	1967	PERCENT CHANGE	1958	1967	PERCENT CHANGE
Coastal Zone	1,200,000	1,414,809	+ 17.9	16,100	20,683	+ 28.4	6,368,300	5,507,703	- 13.5
Texas	6,501,869	7,283,027	+ 12.0	457,901	456,949	- .002	41,521,220	35,630,331	- 14.2

TABLE 3 (Cont.)

LAND-USE TRENDS IN THE COASTAL ZONE
(ACRES)

AREA	PASTURE			RANGE		
	1958	1967	PERCENT CHANGE	1958	1967	PERCENT CHANGE
Coastal Zone	1,656,300	2,453,609	+ 48.1	8,460,900	8,180,323	- 0.03
Texas	7,489,180	14,081,642	+ 88.0	86,668,090	85,604,543	- 0.01

TABLE 3 (Cont.)

LAND-USE TRENDS IN THE COASTAL ZONE
(ACRES)

AREA	FOREST			OTHER LAND		
	1958	1967	PERCENT CHANGE	1958	1967	PERCENT CHANGE
Coastal Zone	3,171,800	2,867,583	- 0.1	207,800	684,179	+ 228.3
Texas	24,345,747	22,681,747	- 0.07	1,234,316	2,262,847	+ 83.3

SOURCE: Texas Conservation Needs Committee, "Conservation Needs Inventory," Temple, Texas, 1970, and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

Again, statistical data by counties are presented in Table 4 to provide the source for the resulting summaries.

The relative size of each region in relation to the entire coastal area has already been expressed in terms of acres in Table 2. Actual population numbers by counties are displayed in Table 5 while those for the regions and to the whole study area plus Texas may be found in Table 6.

The Gulf Coast region not only possesses the largest land mass, but also contains 65.8 percent of the total coastal population. Followed in a declining order by population size are the Coastal Bend region with 12.4 percent, the Lower Rio Grande Valley with 9.6 percent, the Southeast Texas region with 9.1 percent, and the Golden Crescent region with 3.1 percent of the study area population.

In the discussion of population characteristics both the urban and rural concentrations require consideration. According to the maps and from what has been learned about the economic behavior in this area of study, the location of these urban population centers becomes evident. As shown in Table 7, the predominant portion of about 84.2 percent of the 1970 inhabitants in the coastal zone live in urban locales, the precise locations where the greater part of economic activity transpires. With this fact in mind, the continued rise in urban population can be readily qualified.

Although the coastal zone makes up only 12.6 percent of the total Texas land area, Table 8 shows that the coastal zone contains 31.3 percent of the total Texas population which further substantiates the previous conclusions of increased commercial activity in this area as compared to the entire state.

TABLE 4

LAND-USE BY COUNTIES
(ACRES)

COUNTY	TOTAL LAND AREA	URBAN & FEDERAL	SMALL WATER AREA	CROPLAND	PASTURE	RANGE	FOREST	OTHER LAND
LOWER RIO GRANDE								
Cameron	573,440	68,689	678	353,501	27,691	107,737	----	15,144
Hidalgo	987,328	66,441	591	514,153	34,674	345,560	----	25,909
Willacy	378,240	9,578	200	176,559	10,419	162,351	----	19,133
Total	1,939,008	144,708	1,469	1,044,213	72,784	615,648	----	60,186
COASTAL BEND								
Aransas	173,184	52,445	57	5,478	587	73,737	9,584	31,296
Bee	538,880	24,096	600	114,525	31,941	359,926	5,064	2,728
Brooks	578,560	5,177	250	50,175	14,277	505,417	----	3,728
Duval	1,160,414	8,865	75	69,356	25,130	1,047,796	----	9,192
Jim Wells	540,500	15,552	550	114,157	104,475	303,750	----	2,192
Karnes	484,992	12,046	2,150	184,322	33,216	242,121	420	10,717
Kenedy	892,032	3,228	50	3,310	9,517	737,318	----	138,609
Kleberg	544,576	13,209	75	50,927	15,532	430,582	----	34,251
Live Oak	670,391	7,118	2,098	144,249	40,187	455,166	8,460	13,113
McMullen	741,504	3,766	1,175	6,288	18,711	710,338	----	1,226
Nueces	540,992	81,577	99	340,969	27,019	49,850	----	41,478
Refugio	495,488	6,814	132	89,723	4,718	362,779	19,577	11,745
San Patricio	434,920	26,236	210	233,956	31,803	103,953	7,951	30,811
Total	7,796,433	260,129	7,521	1,407,435	357,113	5,382,733	51,056	330,446

TABLE 4 (Cont.)

LAND-USE BY COUNTIES
(ACRES)

COUNTY	TOTAL LAND AREA	URBAN & FEDERAL	SMALL WATER AREA	CROPLAND	PASTURE	RANGE	FOREST	OTHER LAND
GOLDEN CRESCENT								
Calhoun	337,216	27,690	45	94,567	17,222	167,004	----	30,688
DeWitt	582,336	12,820	375	158,781	100,887	203,477	102,164	3,832
Goliad	557,440	4,809	1,000	65,000	13,282	264,985	195,083	13,281
Jackson	544,192	12,364	870	195,226	30,657	235,669	67,489	1,917
Victoria	571,008	25,780	144	120,979	22,770	383,855	5,980	11,500
Total	2,592,192	83,463	2,434	634,553	184,818	1,254,990	370,716	61,218
GULF COAST								
Austin	424,064	12,424	1,414	99,831	172,693	52,882	62,000	22,820
Brazoria	910,784	81,000	575	267,806	228,371	148,719	176,281	8,032
Chambers	394,304	19,457	----	174,740	52,426	91,749	35,400	20,532
Colorado	607,104	15,095	1,255	204,957	97,693	86,473	192,069	9,562
Fort Bend	555,368	14,630	870	250,105	156,153	46,762	77,243	9,605
Galveston	255,360	35,201	----	61,549	40,244	90,466	5,073	22,827
Harris	1,102,400	435,050	600	162,168	278,135	9,783	182,800	33,864
Liberty	756,480	24,666	136	144,465	125,539	----	453,600	8,074
Matagorda	740,736	16,761	23	285,399	140,355	187,278	96,841	14,079
Montgomery	697,408	61,208	951	5,724	96,806	----	518,900	13,819
Walker	505,472	64,613	1,279	11,523	103,428	11,309	308,200	5,120
Waller	423,928	15,363	1,591	113,288	104,572	20,633	61,200	8,281
Wharton	688,576	17,198	415	430,624	146,709	----	76,804	16,826
Total	7,962,984	812,666	9,109	2,212,179	1,743,124	746,054	2,246,411	193,441

TABLE 4 (Cont.)

LAND-USE BY COUNTIES
(ACRES)

COUNTY	TOTAL LAND AREA	URBAN & FEDERAL	SMALL WATER AREA	CROPLAND	PASTURE	RANGE	FOREST	OTHER LAND
SOUTH-EAST TEXAS								
Jefferson	608,704	82,034	50	189,677	87,770	164,391	54,400	30,382
Orange	229,568	31,809	100	19,646	8,000	16,507	145,000	8,506
Total	838,272	113,843	150	209,323	95,770	180,898	199,400	38,888
SUMMARY								
Coastal Zone	21,128,889	1,414,809	20,683	5,507,703	2,453,609	8,180,323	2,867,583	684,179
Texas	168,001,086	7,283,027	456,949	35,630,331	14,081,642	85,604,543	22,681,747	2,262,847
Coastal Percent of Texas	12.6	19.4	4.5	15.5	17.4	9.6	12.6	30.2

SOURCE: Texas Conservation Needs Committee, "Conservation Needs Inventory," Temple, Texas, 1970.

TABLE 5

POPULATION DISTRIBUTION BY COUNTIES

COUNTY	TOTAL (1970) POPULATION	POPULATION DENSITY (1960)	POPULATION DENSITY (1970)	URBAN POPULATION	RURAL POPULATION	URBAN PERCENT OF TOTAL	RESIDENTIAL HOUSEHOLDS
LOWER RIO GRANDE VALLEY							
Cameron	140,368	171.12	158,97	108,805	31,563	77.5	40,645
Willacy	15,570	33.75	26.17	7,583	7,583	51.3	4,715
Hidalgo	181,535	117.40	117.80	47,014	47,014	74.1	50,694
Total Region	337,473	116.62	111.78	251,313	86,160	74.4	96,054
COASTAL BEND							
Aransas	8,902	25.38	32.25	4,605	4.297	52.0	4,431
Bee	22,737	28.21	27.00	13,506	9,231	59.0	7,297
Brooks	8,005	9.52	8.86	6,355	1,650	79.0	2,492
Duval	11,722	7.39	6.46	6,563	5,159	56.0	3,936
Jim Wells	33,032	40.84	39.04	24,134	8,898	73.0	10,133
Karnes	13,462	19.78	17.76	7,082	6,380	53.0	4,509
Kenedy	678	0.63	0.49	-----	678	--	212
Kleberg	33,166	35.31	38.97	28,711	4,455	87.0	9,624
Live Oak	6,697	7.47	6.37	-----	6,697	--	3,079
McMullen	1,095	0.96	0.95	-----	1,095	--	408
Nueces	237,544	264.41	283.47	223,266	14,278	94.0	74,695
Refugio	9,494	14.18	12.27	4,340	5,154	46.0	3,343
San Patricio	47,228	66.21	69.45	30,340	16,948	64.0	15,163
Total Region	433,822	34.45	35.60	348,902	84,920	80.0	139,322

TABLE 5 (Cont.)

POPULATION DISTRIBUTION BY COUNTIES

COUNTY	TOTAL (1970) POPULATION	POPULATION DENSITY (1960)	POPULATION DENSITY (1970)	URBAN POPULATION	RURAL POPULATION	URBAN PERCENT OF TOTAL	RESIDENTIAL HOUSEHOLDS
			GOLDEN CRESCENT				
Calhoun	17,831	30.96	33.27	10,491	7,340	58.8	6,304
DeWitt	18,660	22.37	20.51	9,412	9,248	50.4	7,110
Goliad	4,869	6.23	5.60	----	4,869	----	1,829
Jackson	12,975	16.44	15.19	5,332	7,643	41.1	4,537
Victoria	53,766	52.04	60.21	41,349	12,417	76.9	16,865
Total Region	108,101	25.40	26.60	66,584	41,517	61.6	36,645
			GULF COAST				
Austin	13,831	20.81	20.89	2,685	11,146	19.4	5,500
Brazoria	108,312	53.59	76.19	66,392	41,920	61.1	34,694
Chambers	12,187	16.82	19.75	----	12,187	----	4,687
Colorado	17,638	19.43	18.57	6,929	10,709	39.3	6,707
Fort Bend	52,314	47.01	60.69	29,074	23,240	55.6	15,035
Galveston	169,812	327.19	395.83	151,744	18,068	89.4	61,890
Harris	1,741,912	726.57	1018.07	1,664,296	77,616	95.5	587,671
Liberty	33,014	26.94	28.14	15,022	17,992	45.5	12,642
Matagorda	27,913	22.58	24.49	15,375	12,538	55.1	10,964
Montgomery	49,479	24.62	45.39	11,969	37,510	24.2	18,412
Walker	27,680	27.32	35.22	17,610	10,070	63.6	7,965
Waller	14,285	23.81	28.18	3,916	10,369	27.4	4,390
Wharton	36,729	35.36	34.04	16,444	20,285	44.8	12,220
Total Region	2,305,106	136.69	185.48	2,001,456	303,650	86.8	782.777

TABLE 5 (Cont.)

POPULATION DISTRIBUTION BY COUNTIES

COUNTY	TOTAL (1970) POPULATION	POPULATION DENSITY (1960)	POPULATION DENSITY (1970)	URBAN POPULATION	RURAL POPULATION	URBAN PERCENT OF TOTAL	RESIDENTIAL HOUSEHOLDS
SOUTH-EAST TEXAS							
Jefferson	246,402	259.96	260.74	234,022	12,380	95.0	82,207
Orange	71,203	169.54	200.08	47,179	24,024	66.3	22,219
Total Region	317,605	235.22	244.12	281,201	36,404	88.5	104,426

SOURCE: Respective Council of Governments and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 6

POPULATION CHANGES IN

THE TEXAS REGIONS, 1960-1970

AREA	POPULATION 1960	POPULATION 1970	PERCENT CHANGE	PERCENT OF COASTAL POPULATION 1960	PERCENT OF COASTAL POPULATION 1970
Lower Rio Grande Valley	352,086	337,473	- 4.2	12.2	9.6
Coastal Bend	419,778	433,822	+ 3.3	14.8	12.4
Golden Crescent	103,219	108,101	+ 4.7	3.6	3.1
Gulf Coast	1,698,748	2,305,106	+ 35.7	59.0	65.8
South-East Texas	306,016	317,605	+ 3.8	10.6	9.1
Coastal Zone	2,879,847	3,502,107	+ 21.6		
Texas	0,579,677	11,196,730	+ 14.4		

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 7

POPULATION CHANGES IN
THE TEXAS COASTAL ZONE, 1960-1970

CLASSIFICATION	1960	1970	PERCENT CHANGE
Urban	2,339,488	2,949,456	26.1
Percent Urban	81.2	84.2	
Rural	540,359	553,651	2.5
Percent Rural	18.8	15.8	

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 8

SUMMARY OF POPULATION DISTRIBUTION BY REGIONS

AREA	POPULATION		LAND IN SQUARE MILES	POPULATION DENSITY		HOUSING UNITS	
	1960	1970		1960	1970	1960	1970
Lower Rio Grande Valley	352,086	337,473	3,019	116.62	111.78	95,570	96,054
Coastal Bend	419,778	433,822	12,185	34.45	35.60	129,869	139,322
Golden Crescent	103,219	108,101	4,064	25.40	26.60	35,014	36,645
Gulf Coast	1,698,748	2,305,106	12,428	136.69	185.48	561,908	782,777
South-East Texas	306,016	317,605	1,301	235.22	244.12	97,737	104,426
Coastal Zone	2,879,847	3,502,107	32,997	87.28	106.13	920,098	1,159,224
Texas	9,579,677	11,196,730	262,840	36.45	42.60	3,153,127	3,829,502
Coastal Percent of Texas	30.1	31.3	12.6	----	----	29.2	30.3

TABLE 8 (Cont.)

SUMMARY OF POPULATION DISTRIBUTION BY REGIONS

AREA	POPULATION		URBAN POPULATION		RURAL POPULATION		URBAN PERCENT OF TOTAL	
	1960	1970	1960	1970	1960	1970	1960	1970
Lower Rio Grande Valley	352,086	337,473	254,593	251,313	97,493	86,160	72.3	74.4
Coastal Bend	419,778	433,822	316,061	348,902	103,717	84,920	75.3	80.0
Golden Crescent	103,219	108,101	59,256	66,584	43,963	41,517	57.4	61.6
Gulf Coast	1,698,748	2,305,106	1,433,967	2,001,456	264,781	303,650	84.4	86.8
South-East Texas	306,016	317,605	275,611	281,201	30,405	36,404	90.1	88.5
Coastal Zone	2,879,847	3,502,107	2,339,488	2,949,456	540,359	552,651	81.2	84.2
Texas	9,579,677	11,196,730	7,187,470	8,920,946	2,392,207	2,275,784	75.0	79.7
Coastal Percent of Texas	30.1	31.3	32.5	33.1	22.6	24.3	----	----

SOURCE: Respective Councils of Government, and United States Census of Housing 1960 & 1970, Bureau of the Census, Washington, D. C.

While the simultaneous population increases of 14.4 percent for Texas and 21.6 percent of the study area evolved, a similar incline in the demand for housing occurred. In comparing the growth in housing in Texas from 3,153,127 units in 1960 to 3,829,502 units in 1970 and for the coastal area from 920,098 in 1960 to 1,159,224 in 1970, one may point to the decided difference in the growth rate of 20.6 percent for the study area over 17.7 percent for Texas.

The Role of the Intracoastal Waterway in Texas

One of the major reasons among many that causes economic activity to be so profound in the coastal zone is accessibility to water where inexpensive transportation costs for the movement of commerce prevail.

Not only are large quantities of export and import goods processed through the 11 principal Texas ports, but also huge numbers of intrastate tonnages of goods are handled by these same ports. Much of the intra- and interstate commerce along the Texas, Louisiana, and Florida coast travels via the Gulf Intracoastal Waterway. But more specifically, upon arrival at these ports, the predominant proportion of goods must be delivered inland. The map entitled "River and Coastal Basis with Major Reservoirs" shows a network of rivers and reservoirs, all of which eventually connect with the Gulf Coast and the Intracoastal Waterway, that may be used for the transport of goods into the Texas inland. What emerges, is the implied importance of the Gulf Intracoastal Waterway which due to the protection it affords intra- and interstate waterborne vessels, enables the movement of tremendously large quantities of resources in a relatively inexpensive manner.

Conclusion

Realizing that land is a fixed resource that cannot be expanded, effective and conscientious management of the many uses of this valuable resource becomes essential.

Population growth which brings about the inherent upward changes in demand for goods and services imposes a need for continuous evaluation of land uses. Such evaluation must answer the question of how to employ this limited resource in order to achieve the maximum productive use with a minimum of loss in terms of soil deterioration and soil erosion, especially in the counties that directly border the Gulf Coast.

This trend of changing land use was illustrated with the data presented in this chapter to include their application and implication thereof. It was also pointed out that the Gulf Intracoastal Waterway indirectly influenced the population pattern. It also contributed and will continue to achieve increasing productivity through its tremendous yet inexpensive transportation potential.

COMMODITY FLOW STATISTICS

CHAPTER III

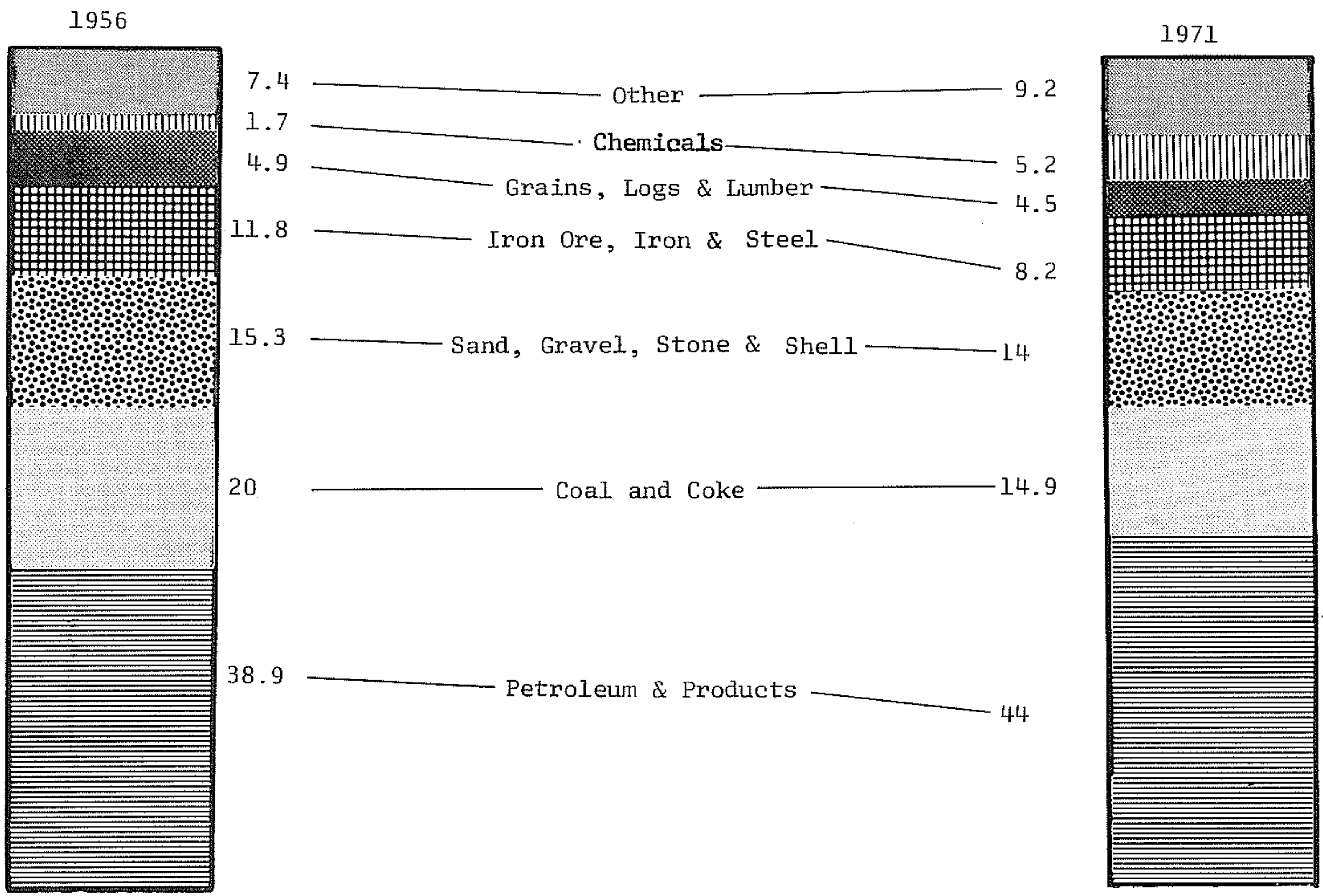
COMMODITY FLOW STATISTICS

This section is devoted primarily to a comparison of the types of goods moving on the Texas and the United States waterways and an overall analysis of waterborne commerce flows on the Texas Gulf Intracoastal Waterway and its tributaries.

United States and Texas Comparisons

Figure 4 illustrates the types of products carried on the inland waterways of the United States. Generally it may be seen that there have been few major changes in the types of products carried in the last 15 years with the exception of the transport of chemicals, which has approximately tripled, increasing from 1.7 percent in 1956 to 5.2 percent of total waterborne commerce in 1971. The transport of coal and coke has decreased from 22 to approximately 15 percent while during the same period the transport of petroleum and petroleum products has increased from approximately 39 percent in 1956 to 44 percent in 1971, reflecting changes in fossil fuel demands.

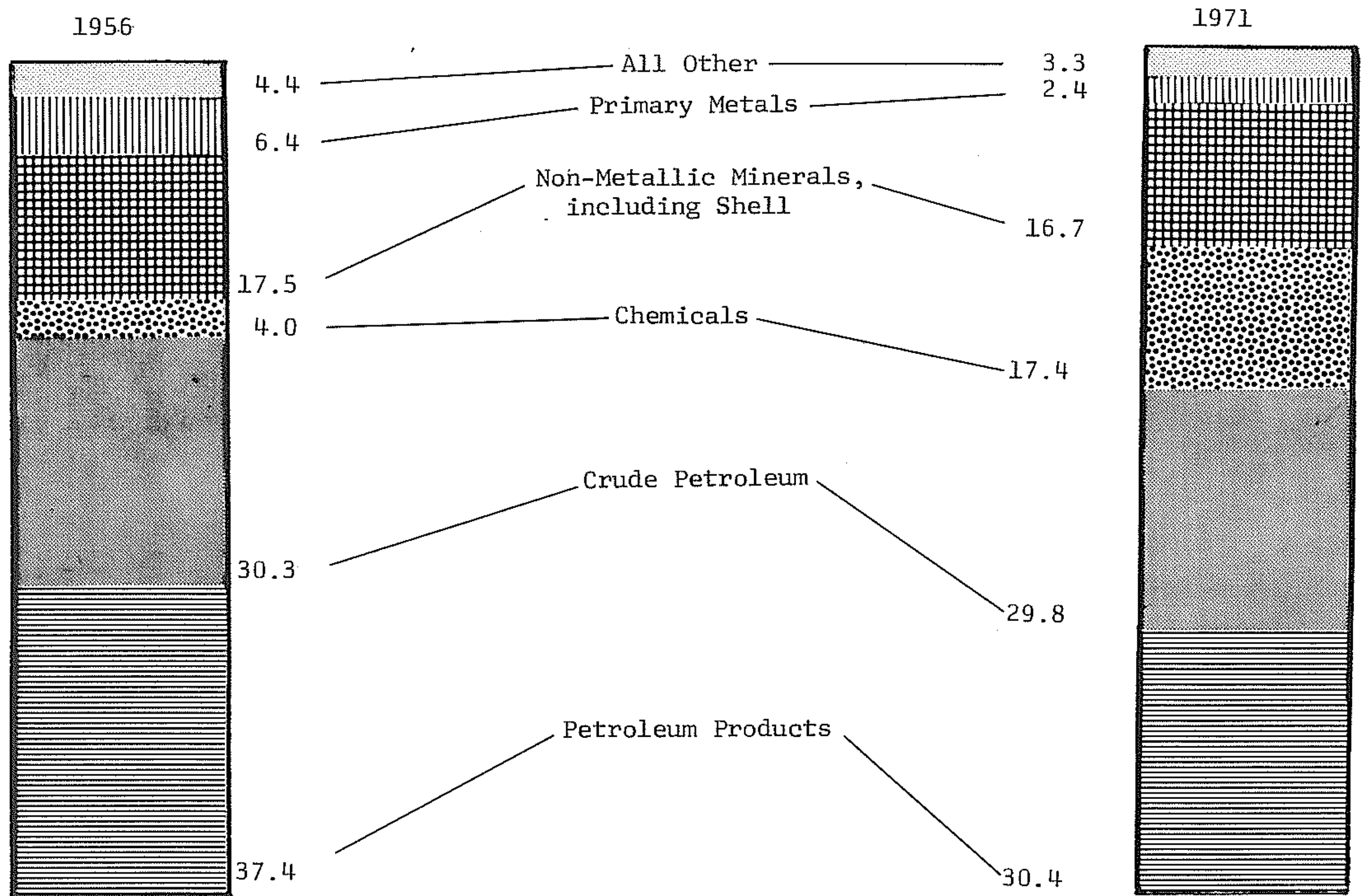
The types of products carried on the Intracoastal Waterway in Texas are shown in Figure 5. Changes between the two time periods are considerably different than those shown in Figure 4; the most significant one being the increase in the transport of chemicals. In 1956, chemicals composed only four percent of total commerce carried; by 1971, they accounted for 17.4 percent of total commerce. During the same time period, although the absolute quantity of petroleum



SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, 1956 and 1971, Part 5, Washington, D. C.

PRODUCTS CARRIED ON INLAND WATERWAYS OF THE UNITED STATES
(Percent)

FIGURE 4



SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, 1956 and 1971, Part 2, Vicksburg, Mississippi.

PRODUCTS CARRIED ON THE INTRACOASTAL WATERWAY IN TEXAS
(Percent)

FIGURE 5

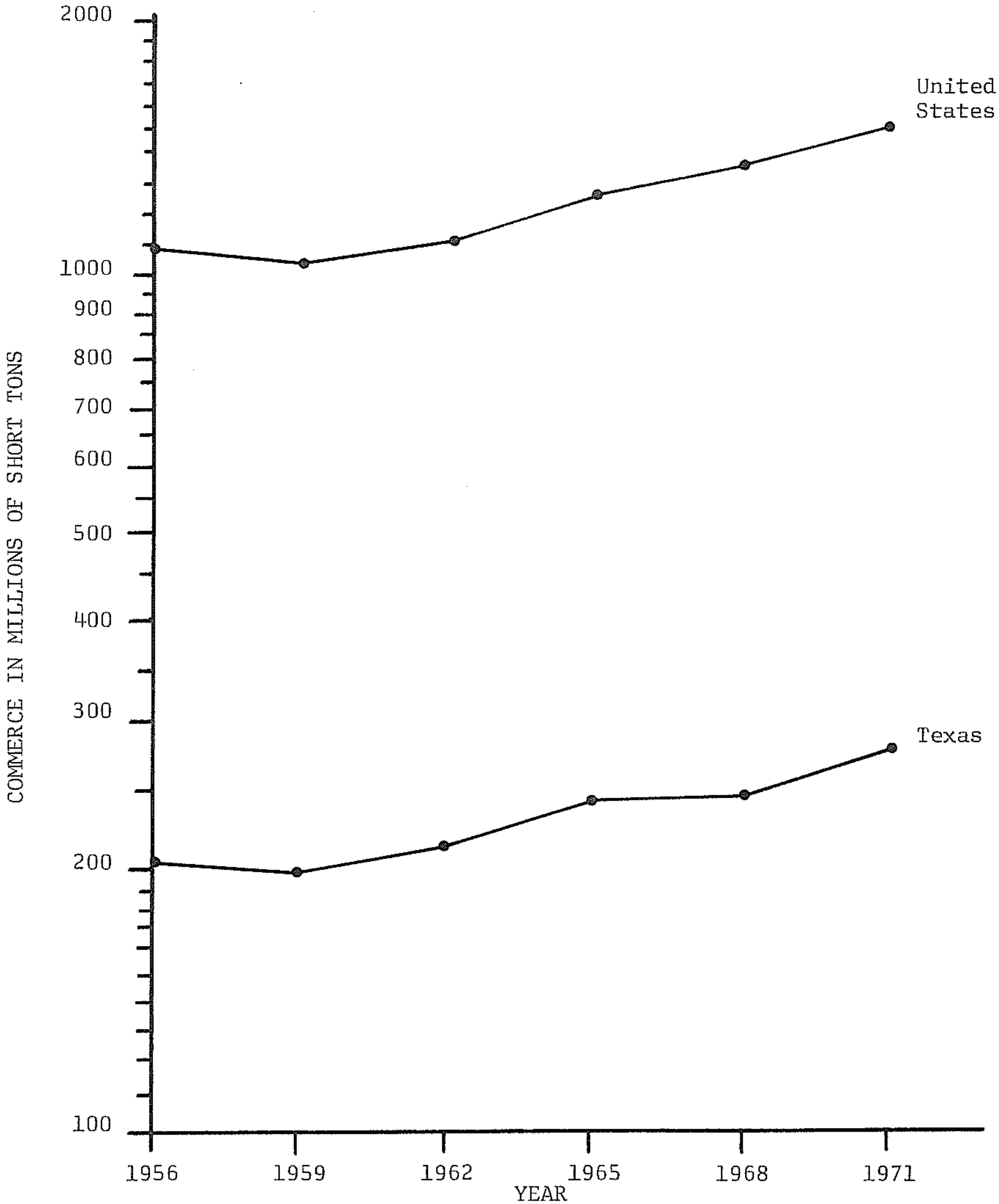
products carried increased, as a proportion of all goods carried on the Intracoastal Waterway, the importance of petroleum products decreased from 37.4 percent in 1956 to 30.4 percent in 1971. Approximately 94 percent of all products carried on the Intracoastal Waterway in Texas consists of either petroleum and petroleum products, chemicals, or non-metallic minerals, including shell. This would tend to indicate that those industries which find the waterway most attractive are those which deal primarily in low-cost bulk goods.

Figure 5 also offers an opportunity to compare the types of goods carried on the Waterway in Texas to the types of products carried on all inland waterways in the United States. A general correlation exists in that most products which increased or decreased as a percentage of the total commerce on all inland waterways of the United States also increased or decreased as a percentage of the total products carried on the Intracoastal Waterway in Texas. This does not necessarily indicate a one-to-one correlation between the two areas. For instance, between 1956 and 1971, chemicals increased approximately 300 percent in relation to all other goods carried on the inland waterways in the United States. During the same time period, the amount of chemicals carried on the Intracoastal Waterway in Texas increased over 400 percent, as a percentage of total commerce. Other discrepancies between the two areas exist. For example, in Texas, petroleum products became less important as a percentage of all products carried; at the same time, petroleum products become more important as a percentage of total commerce on all inland waterways of the United States. All of this would imply that although there is some degree of correlation between the types of commerce carried on the inland waterways of the United States and those carried in Texas, the industrial base in Texas is such that the demand for water transportation is considerably different than that in the United States as a whole.

Comparative Growth Rates of Waterborne Commerce

As shown in Figure 6, the growth rates of waterborne commerce in the United States and Texas have been relatively the same with the exception of the period between 1965 and 1968, when Texas showed relatively little growth. On a percentage basis, the growth of Texas waterborne commerce has been only slightly greater than that of the United States. Greater variations between the two areas occur in the area of foreign commerce, as shown in Figure 7. Although both areas show an increasing trend in total foreign commerce, a major difference exists in the fact that the United States as a whole has imported more tonnage than it has exported, while Texas has traditionally exported considerably more than it has imported. The growth rate of United States exports has been increasing at a slightly decreasing rate since 1959. Texas export rates have been considerably more erratic, although a slight increase over time is shown. The growth rate of United States imports has been relatively constant since 1962. In contrast, the growth rate of Texas imports increased at a slightly decreasing rate between 1962 and 1968, and increased sharply between 1968 and 1971.

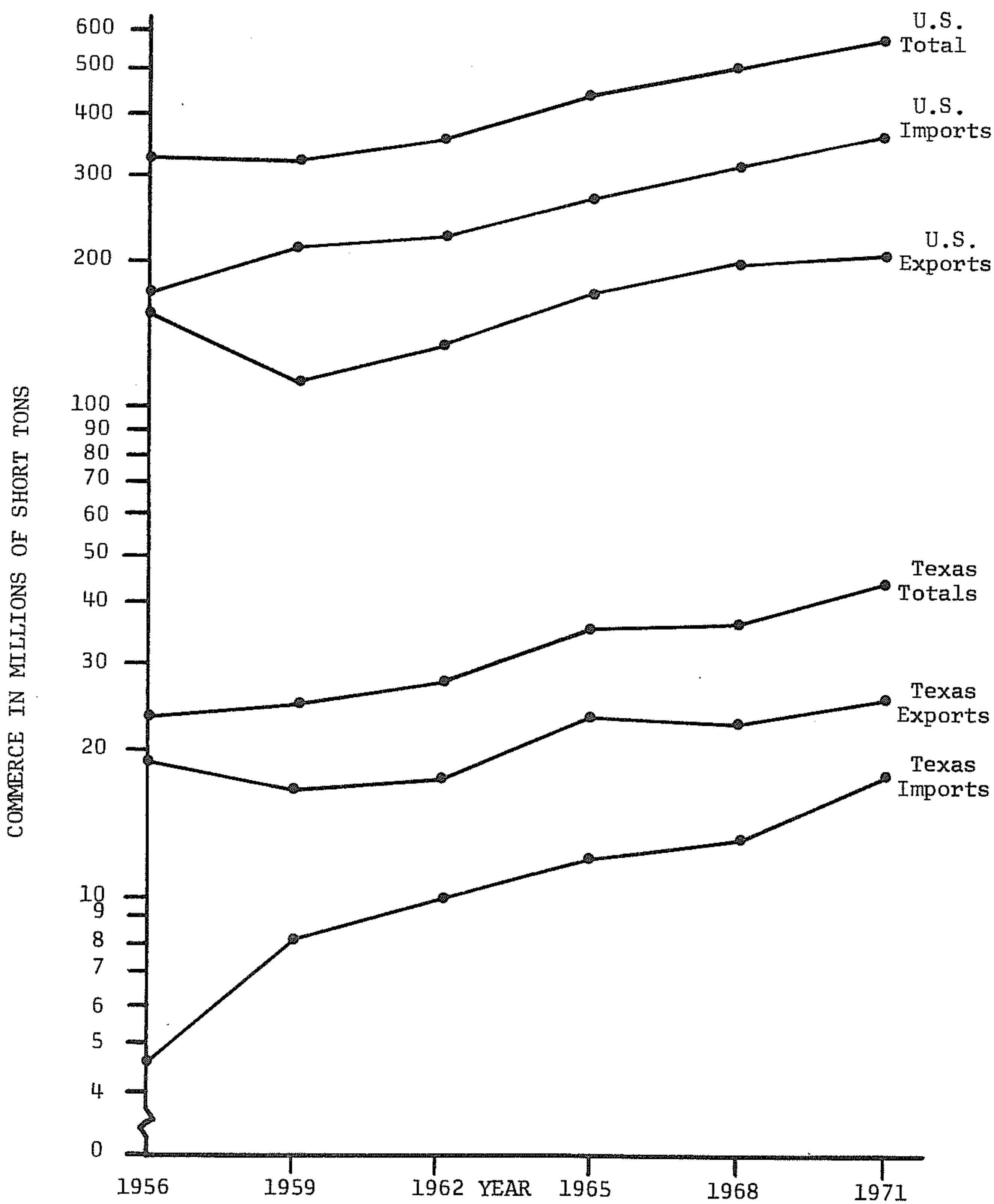
Some concept of the Texas foreign commerce mix is given by Table 9, which indicates the relative importance of the major Texas areas



SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States.

TRENDS IN UNITED STATES AND TEXAS COMMERCE

FIGURE 6



SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States.

GROWTH OF UNITED STATES AND TEXAS FOREIGN COMMERCE

FIGURE 7

TABLE 9

FOREIGN COMMERCE AT MAJOR TEXAS PORTS AND AREAS--1971
(Thousands of Short Tons) (a)

		FARM PRODUCTS		NON FUEL MINERALS		CRUDE PETROLEUM		FOOD & KINDRED PRODUCTS	
		VOLUME	PERCENT	VOLUME	PERCENT	VOLUME	PERCENT	VOLUME	PERCENT
Sabine-Neches Waterway (b)	IMPORT	1	---	---	---	544	58.9	22	2.4
	EXPORT	1,798	35.4	504	9.9	---	---	236	4.6
Houston	IMPORT	243	4.0	578	9.6	1,022	17.0	519	8.6
	EXPORT	9,080	65.8	184	1.3	60	0.4	615	4.5
Texas City	IMPORT	--	--	7	1.7	352	86.5	--	--
	EXPORT	0.1	--	2	--	--	--	10	2.4
Galveston	IMPORT	155	23.0	152	22.6	54	8.0	140	20.8
	EXPORT	1,363	66.1	423	20.5	--	--	182	8.8
Freeport	IMPORT	1	1.4	--	--	43.0	62.3	--	--
	EXPORT	--	--	--	--	--	--	18	1.4
Matagorda Ship Channel	IMPORT	--	--	3,184	100	--	--	--	--
	EXPORT	--	--	--	--	--	--	--	--
Corpus Christi	IMPORT	1	--	3,624	69.9	1,320	25.5	40	--
	EXPORT	1,483	65.1	--	--	69	3.0	61	2.7
Brazos Island Harbor (c)	IMPORT	1	--	26	1.7	1,368	89.1	2	--
	EXPORT	453	93.4	18	3.7	--	--	1	--
TOTAL ALL AREAS	IMPORT	402	2.2	7,570	42.1	4,701	26.2	723	4.0
	EXPORT	14,178	55.3	1,138	4.4	128	--	1,123	4.4

TABLE 9 (Cont'd.)

	CHEMICALS		PETROLEUM PRODUCTS		PRIMARY METALS		ALL OTHERS		TOTAL	
	VOLUME	PERCENT	VOLUME	PERCENT	VOLUME	PERCENT	VOLUME	PERCENT	VOLUME	PERCENT
Sabine-Neches Waterway (b)	94 248	10.1 4.9	235 717	25.4 14.1	15 1,029	1.6 20.2	13 552	1.4 10.8	924 5,083	100 100
Houston	225 2,043	3.7 14.8	916 1,045	15.3 7.6	1,709 471	28.5 3.0	789 307	13.1 2.2	6,001 13,804	100 100
Texas City	46 397	11.3 97.1	-- --	-- --	-- --	-- --	1 --	-- --	407 409	100 100
Galveston	15 48	2.2 2.3	-- --	-- --	7 7	1.0 --	150 33	22.3 1.6	673 2,063	100 100
Freeport	20 1,274	29.0 97.5	-- --	-- --	-- 1	-- --	5 14	7.2 1.1	69 1,306	100 100
Matagorda Ship Channel	-- 171	-- 75.3	-- --	-- --	-- --	-- --	-- 56	-- 24.7	3,184 227	100 100
Corpus Christi	116 546	2.2 24.0	-- 77	-- 3.4	76 35	1.5 1.5	9 9	-- --	5,185 2,279	100 100
Brazos Island Harbor (c)	1 --	-- --	128 --	8.3 --	8 2	-- --	3 11	-- 22.1	1,535 485	100 100
TOTAL ALL AREAS	517 4,728	2.9 18.4	1,279 1,839	7.1 7.2	1,814 1,543	10.1 6.0	971 674	5.4 2.6	17,976 25,658	100 100

(a) Commodity percentages may not total 100% due to rounding
(b) Includes parts of Beaumont, Orange, Port Arthur and Sabine Pass Harbor
(c) Includes Brownsville and Port Isabel

SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce in the United States.

dealing with foreign commerce, and the relative importance of eight major product categories which are imported and exported. The bottom line on each page of the table gives an indication of the relative importance of each commodity in the import-export mix. The far right-hand column, on the last page of the table, indicates the significance of each importing-exporting area. In 1971, farm products and chemicals were the two major products exported from Texas with farm products accounting for 55.3 percent, and chemicals accounting for 18.4 percent of all exports. Major Texas imports were non-fuel minerals, crude petroleum, and primary metals, comprising 78.4 percent of all Texas imports. From the table, it can be seen that Houston is the major foreign commerce center in Texas, with over 45 percent of all foreign commerce. Of the areas shown, only three--the Matagorda ship channel, Corpus Christi, and Brazos Island Harbor--imported more goods than they exported.

Interstate and Intrastate Flows

Interstate and intrastate flows primarily give an insight into: 1) the quantities and types of goods shipped to or received from other states; 2) the importance of different Texas regions in interstate commerce; and 3) the quantities and types of goods which are transported primarily within state borders. This information provides some concept of the importance of waterborne commerce to the development of Texas industry. A major difficulty in presenting information on interstate and intrastate waterborne commerce in Texas is a lack of available data regarding the quantities and types of products moving in these flows. The major information source separates inter- and intrastate commerce into five general categories: logs and lumber, petroleum and related products, iron and steel, and chemicals and related products.[1] Although these commodities are the major products carried on all U. S. waterways, significant information related to Texas waterborne commerce is lacking. However, the available information does provide some concept of the nature of Texas waterborne commerce and the above categories represent greater than 80 percent of all traffic carried on the inland waterways of Texas. The figures and graphs shown in this section represent only the five categories previously mentioned.

Texas Interstate Commerce

Of the five commodity groups on which the Corps of Engineers keeps records, petroleum and petroleum products and chemicals are by far the most important in terms of tonnage, comprising approximately 95 percent of all Texas interstate commerce. The relative importance of each commodity group to Texas interstate trade is indicated by Table 10. Of total interstate shipments, petroleum and related products comprised approximately 10.6 million short tons of the 15.4 million tons shipped out of Texas in 1970. Chemicals and related products accounted for approximately 4.6 million tons. These two commodity groups represent approximately 98.5 percent of all interstate shipments shown in the table. To a great extent, the remaining tonnage shown in the table was composed of iron and steel, which accounted for 205,000 tons. Petroleum and related products and chemicals and related products were also major commodities received from interstate origins in 1970, together accounting for approximately 92 percent of

[1]United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, part 5, Washington, D. C.

TABLE 10

INTERSTATE MOVEMENT OF SELECTED COMMODITIES
BY TEXAS WATERWAY SEGMENT, 1970
(SHORT TONS)

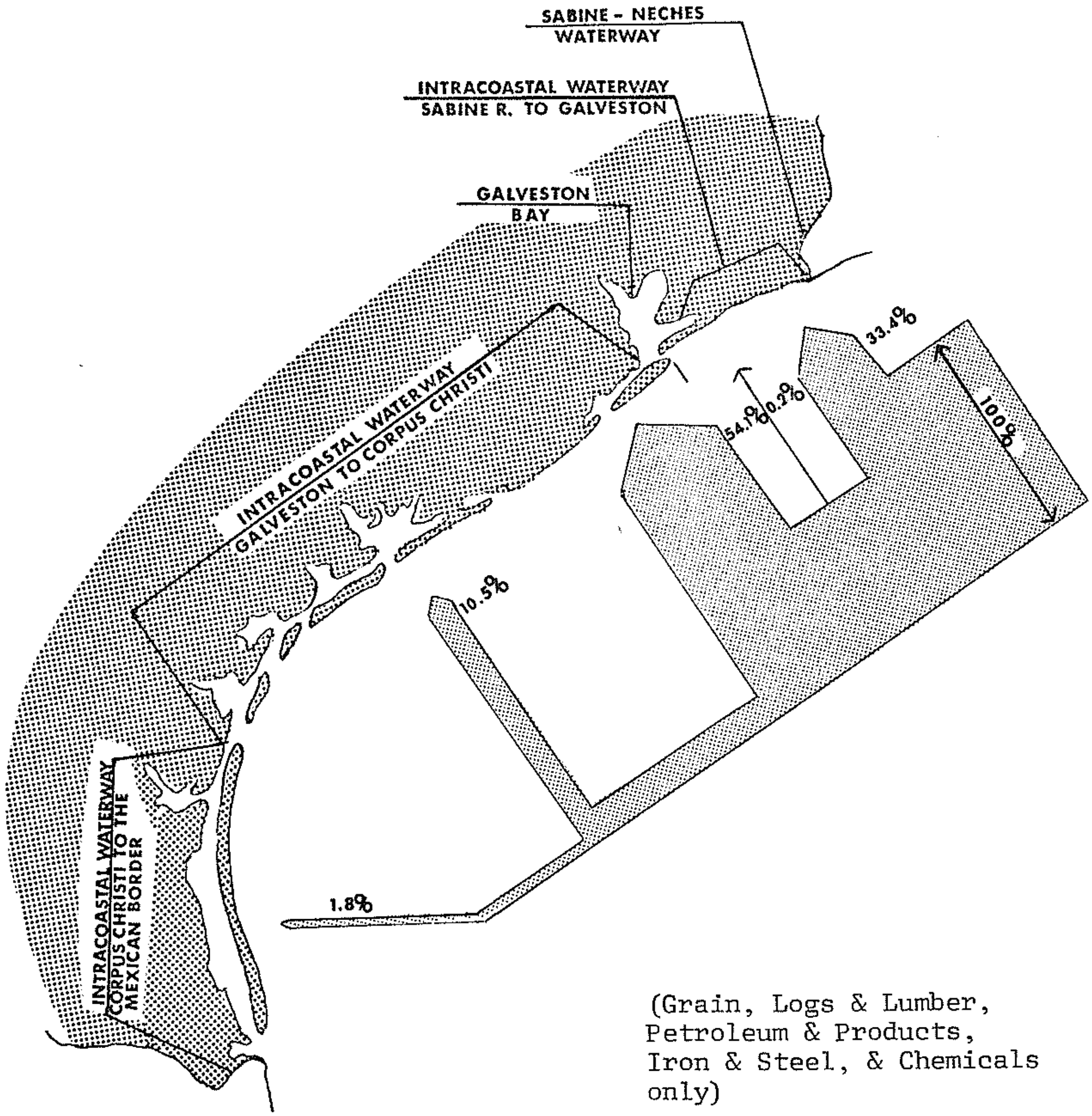
TEXAS WATERWAY SEGMENT	GRAIN AND SOYBEANS	COAL, LOGS AND LUMBER	PETROLEUM AND RELATED PRODUCTS	IRON AND STEEL	CHEMICALS AND RELATED PRODUCTS	TOTAL	PERCENT OF TOTAL TRAFFIC
Sabine Neches Waterway							
Shipments	----	----	4,941,110	46,132	614,284	5,601,526	36.3
Receipts	5,569	----	5,962,504	118,335	243,158	6,329,566	33.5
Sabine - Galveston							
Shipments	----	688	6,157	----	222,962	229,807	1.5
Receipts	----	----	1,393	943	25,039	27,375	0.1
Galveston Bay							
Shipments	11,253	5,091	4,410,815	148,343	3,101,766	7,677,268	49.7
Receipts	70,609	360,404	8,173,459	851,087	773,815	10,229,374	54.1
Galveston - Corpus Christi							
Shipments	----	----	369,951	----	507,345	877,296	5.7
Receipts	----	----	1,752,664	250	231,822	1,984,736	10.5
Corpus Christi - Mexican Border							
Shipments	1,316	----	872,540	10,798	161,457	1,046,111	6.8
Receipts	57,873	----	42,417	56,970	191,357	348,617	1.8
Total							
Shipments	12,569	5,779	10,600,573	205,273	4,607,814	15,432,008	100
Receipts	134,051	360,404	15,932,437	1,027,585	1,465,191	18,919,668	100

SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, 1970, Part 5, Washington, D. C.

all interstate receipts. Receipts of iron and steel were considerably more significant than shipments, and approximately 800,000 more tons of iron and steel were received than were shipped out in 1970. However, the total iron and steel receipts in 1970 accounted for only approximately five percent of all the tonnage shown on the table.

Table 10 also supplies pertinent data as to the relative activity of the different waterway segments in interstate trade. As would be expected, the two most heavily industrialized areas, the Sabine Neches Waterway and the Galveston Bay area, were also the areas most active in interstate trade. Together, these two areas accounted for 86 percent of all shipments and 87.6 percent of all receipts. It is perhaps significant that these two areas also indicate a relatively balanced flow of receipts and shipments in interstate commerce, while the other three areas show a considerable imbalance between the quantities of goods shipped and received. Figures 8 and 9 graphically illustrate the heavy volume of traffic which exists north of the Galveston-Corpus Christi segment of the Intracoastal Waterway. Figure 10 shows receipts and shipments of petroleum and petroleum products and chemicals for the different segments of the waterway.

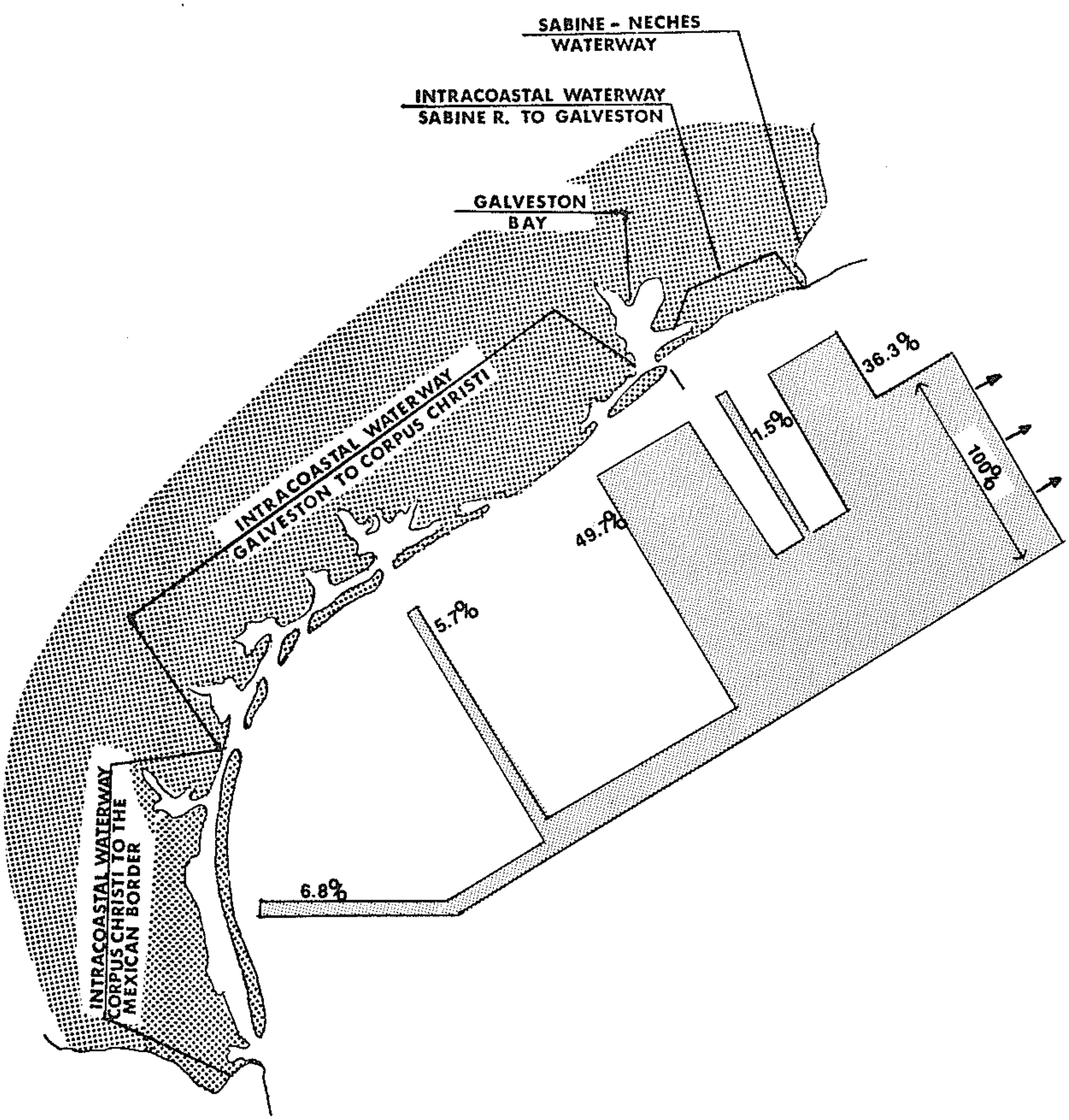
Texas is heavily dependent upon the Mississippi River System and its tributaries, both as routes of transportation for raw materials and finished goods from other areas, and as a means of transporting Texas goods to inland markets. The major areas which receive Texas goods and those areas which ship goods into Texas are shown in Figure 11. As is shown by the figure, approximately 80 percent of all tonnage leaving Texas on inland waterways uses the Mississippi River as a



SOURCE: Lamkin, Jack T., Jr., Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas.

DESTINATION OF GOODS SHIPPED INTO TEXAS ON INLAND WATERWAY SYSTEM
1970

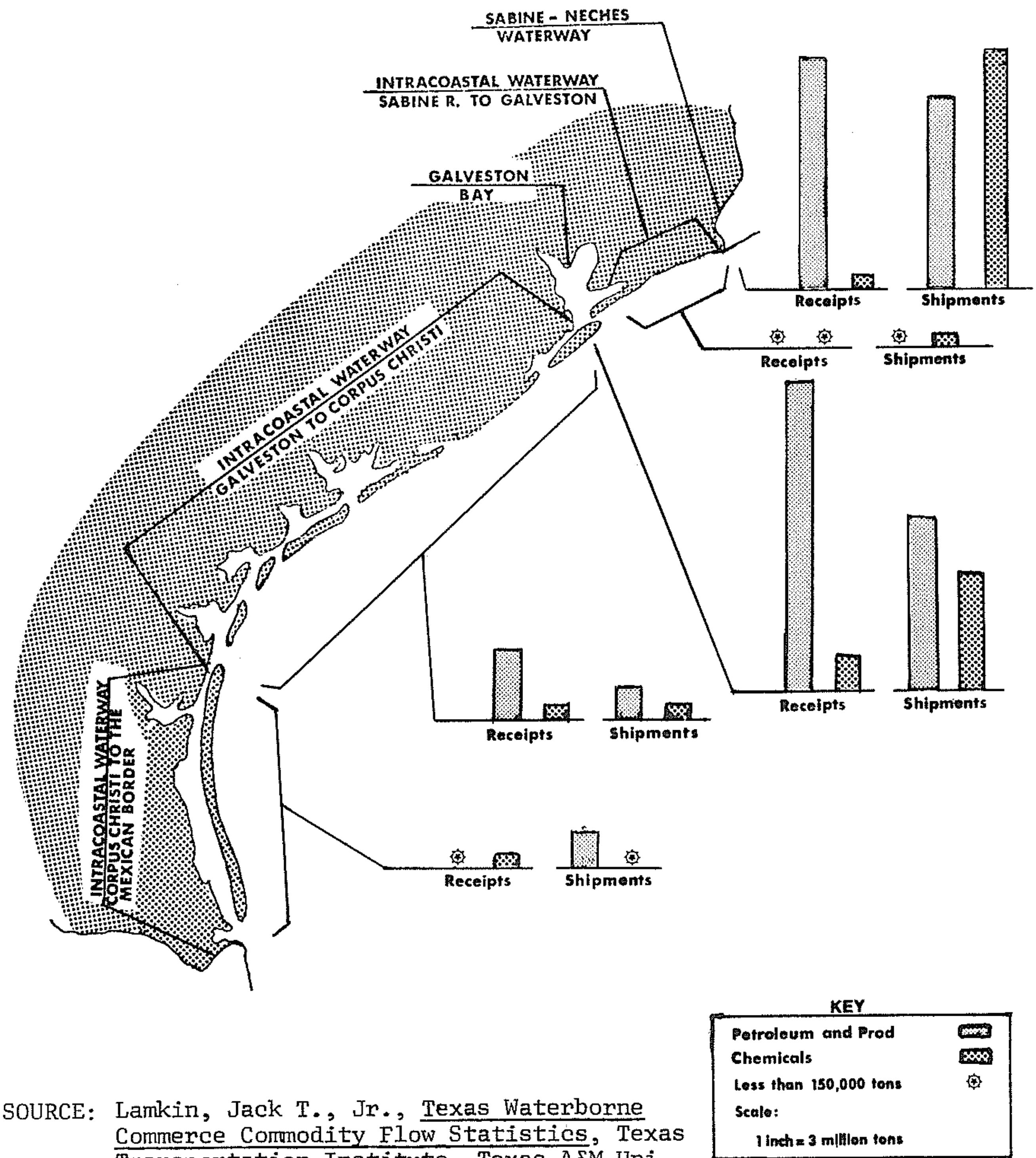
FIGURE 8



SOURCE: Lamkin, Jack T., Jr., Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas.

ORIGINS OF GOODS SHIPPED OUT OF TEXAS ON INLAND WATERWAY SYSTEM
1970

FIGURE 9

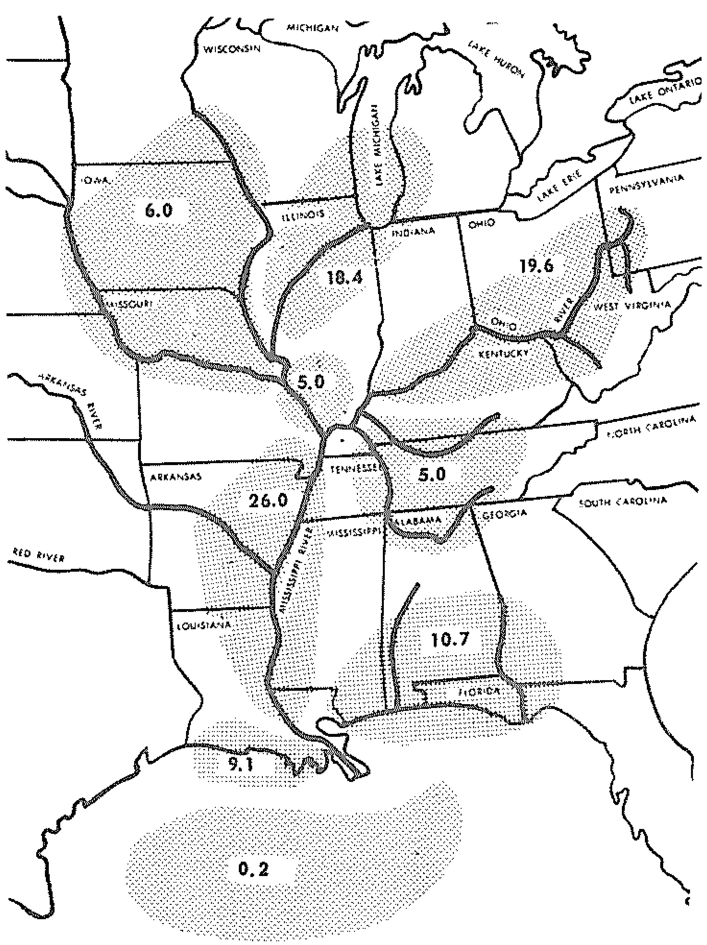


SOURCE: Lamkin, Jack T., Jr., Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas.

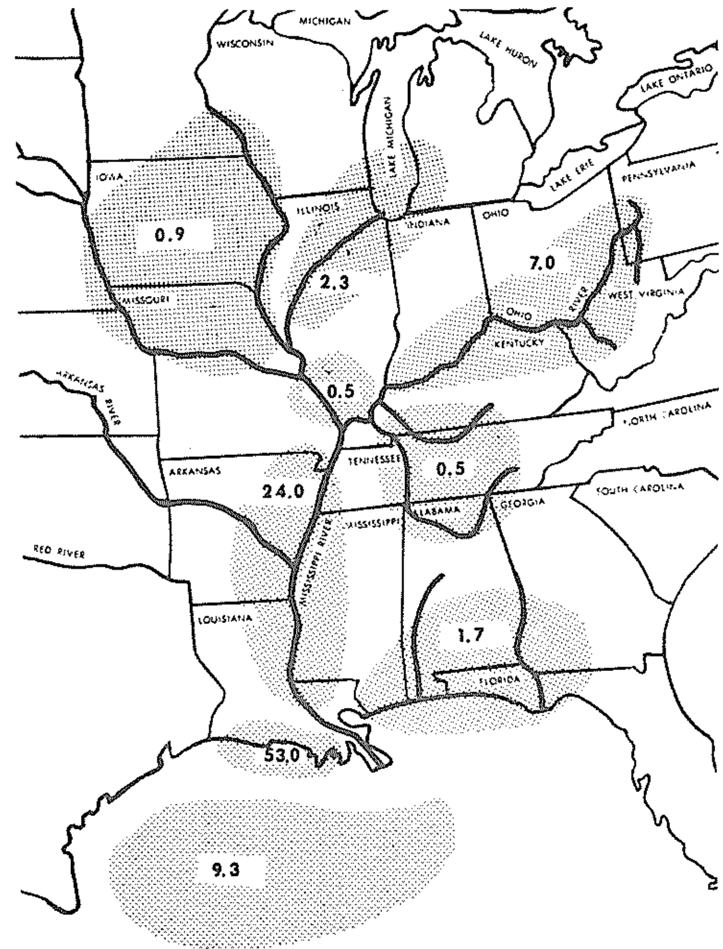
INTERSTATE RECEIPTS AND SHIPMENTS OF PETROLEUM AND PETROLEUM PRODUCTS AND CHEMICALS ON THE TEXAS WATERWAY SYSTEM
1970

FIGURE 10

MAJOR AREAS RECEIVING TEXAS GOODS



MAJOR AREAS SHIPPING GOODS INTO TEXAS



SOURCE: Lamkin, Jack T., Jr., Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas.

Includes Grain & Soybeans, Coal, Logs & Lumber, Petroleum & Products, Iron & Steel, & Chemicals Only.

RECEIVING AND SHIPPING AREAS OUTSIDE TEXAS ON INLAND WATERWAYS
1970
(Expressed as a Percent of Total)

FIGURE 11

means of transporting goods to market. The remainder of Texas waterborne commerce is shipped to Florida, Alabama, Georgia, Mississippi, Louisiana, and the Gulf of Mexico via the Gulf Intracoastal Waterway and ocean routes. Approximately 53 percent of all goods shipped into Texas comes from the coastal portion of Louisiana. Eighty-six percent of all Texas inland waterway receipts comes from Arkansas, Louisiana, Mississippi, or the Gulf of Mexico.

Texas Intrastate Commerce

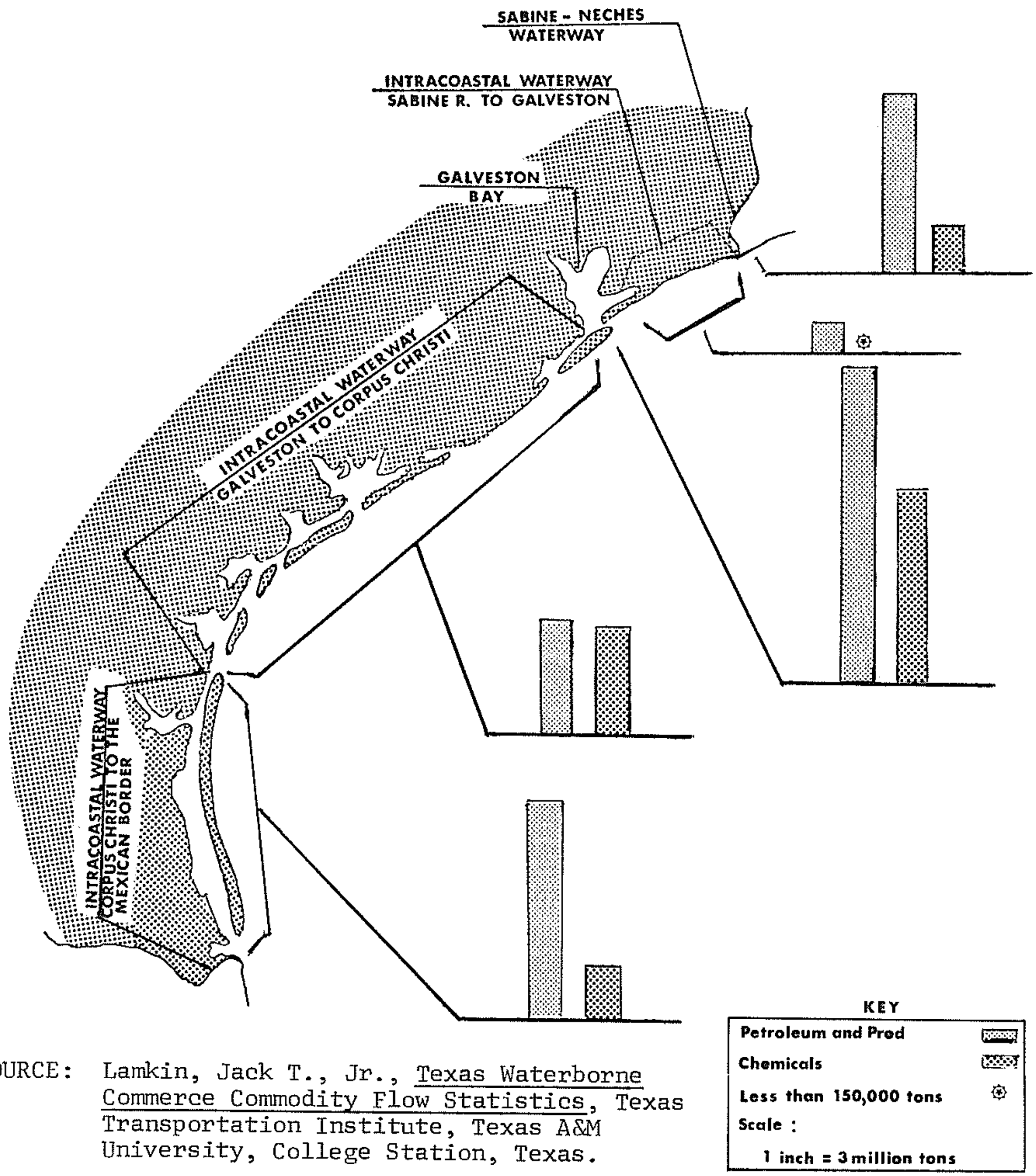
Texas intrastate waterborne activity in the five major commodity groups is shown in Table 11. As was the case with Texas interstate commerce, it can be seen that petroleum and related products and chemicals and related products were the dominant commodities on a tonnage basis. It can also be seen from the table that both the heavily industrialized portions of the Waterway and the segments of the Waterway south of Galveston Bay were important in intrastate commerce. The portion of the Waterway from the Sabine River to the Galveston Bay area was the least active in intrastate trade, with only 3.2 percent of all shipments, and .9 percent of all intrastate receipts. Again, the Galveston Bay area was the most active with 42.4 percent of shipments and 45.9 percent of receipts. The relative importance of different sections of the Waterway in the transportation of petroleum and petroleum products and chemicals is shown by Figure 12, which illustrates the quantities of the two commodities moving on different segments of the waterway. Table 12 is a shipping-receiving matrix for intrastate commerce in Texas, illustrating the tonnages received by one segment from other segments. Several interesting

TABLE 11

TEXAS INTRASTATE MOVEMENT OF SELECTED COMMODITIES BY WATERWAY SEGMENT, 1970
(SHORT TONS)

TEXAS WATERWAY SEGMENT	COMMODITY					TOTAL	PERCENT OF TOTAL
	GRAIN & SOYBEANS	COAL, LOGS & LUMBER	PETROLEUM & RELATED PRODUCTS	IRON & STEEL	CHEMICALS & RELATED PRODUCTS		
Sabine-Neches Waterway							
Shipments	----	----	1,568,788	4,132	583,994	2,156,914	14.1
Receipts	----	875	2,468,845	25,009	368,494	2,863,223	18.7
Sabine-Galveston							
Shipments	----	----	485,053	----	8,455	493,508	3.2
Receipts	----	----	1,444	----	131,194	132,638	0.9
Galveston Bay							
Shipments	27,865	1,435	3,864,383	32,138	2,565,293	6,491,114	42.4
Receipts	----	560	4,098,709	10,283	2,925,561	7,035,113	45.9
Galveston-Corpus Christi							
Shipments	----	----	1,430,245	----	1,136,368	2,566,613	16.8
Receipts	----	----	918,723	1,667	1,162,123	2,082,513	13.6
Corpus Christi-Mexican Border							
Shipments	----	----	2,969,692	914	633,927	3,604,533	23.5
Receipts	27,865	----	2,830,440	225	340,665	3,199,195	20.9
Total							
Shipments	27,865	1,435	10,318,161	37,184	4,928,037	15,312,682	100.0
Receipts	27,865	1,435	10,318,161	37,184	4,928,037	15,312,682	100.0

SOURCE: U. S. Corps of Engineers, Waterborne Commerce of the United States, 1970, Part 5, Washington, D.C.



SOURCE: Lamkin, Jack T., Jr., Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas.

INTRASTATE MOVEMENT OF PETROLEUM AND PETROLEUM PRODUCTS AND CHEMICALS ON TEXAS WATERWAY SYSTEM 1970

FIGURE 12

TABLE 12

TEXAS INTRASTATE WATERBORNE COMMERCE BETWEEN WATERWAYS, 1970*
(Short Tons)

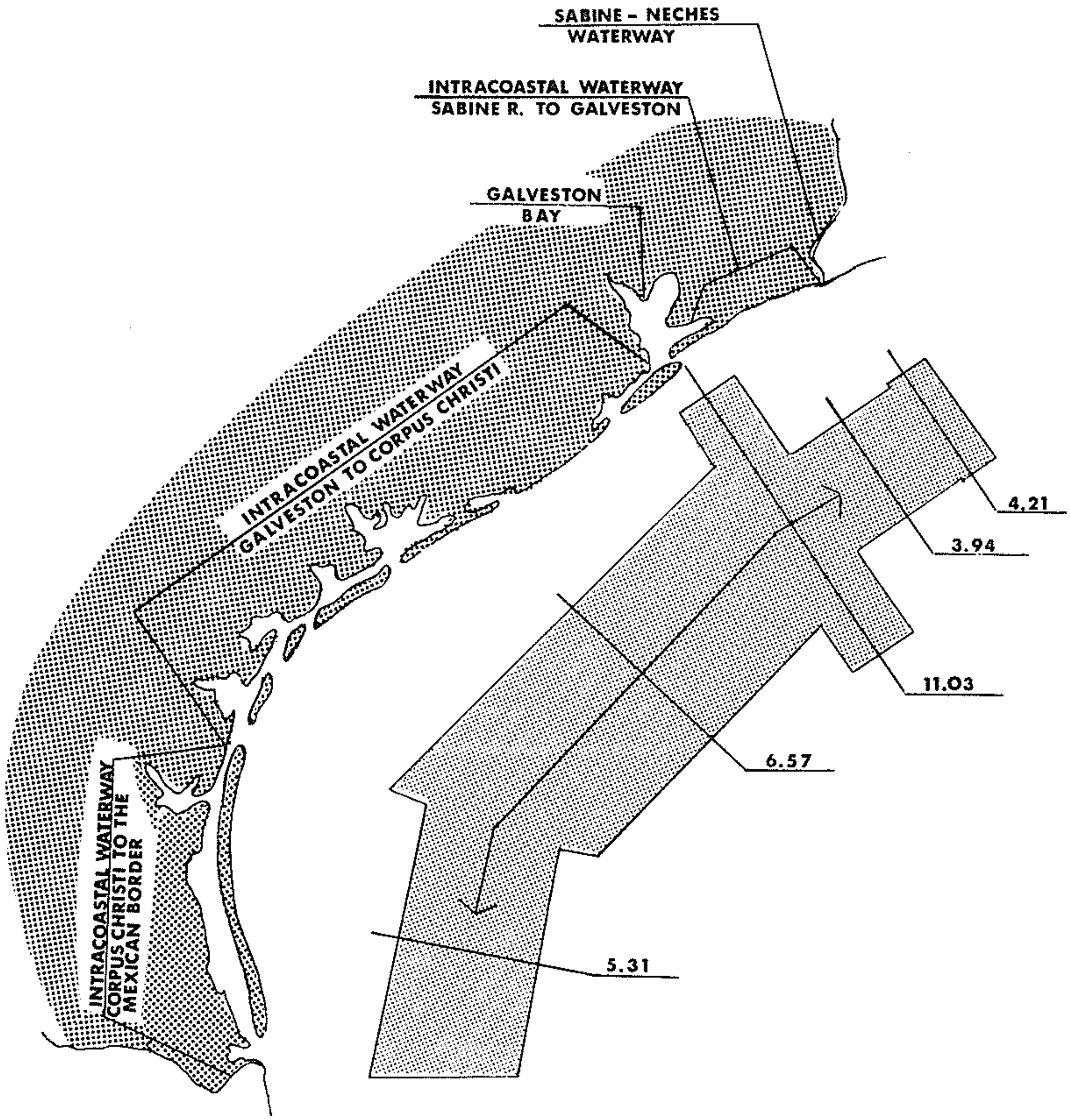
TEXAS SHIPPING SEGMENT	TEXAS RECEIVING SEGMENT						
	SABINE-NECHES	SABINE GALVESTON	GALVESTON BAY	GALVESTON-CORPUS CHRISTI	CORPUS CHRISTI-MEXICAN BORDER	TOTAL	PERCENT OF TOTAL
Sabine-Neches Waterway	806,291	66,519	917,517	174,879	191,708	2,156,914	14.1
Sabine-Galveston	21,788	----	471,720	----	----	493,508	3.2
Galveston Bay	1,054,534	64,614	3,845,994	938,060	587,912	6,491,114	42.4
Galveston-Corpus Christi	120,074	----	898,150	618,414	929,966	2,566,604	16.8
Corpus Christi-Mexican Border	860,536	1,505	901,732	351,160	1,489,609	3,604,542	23.5
Total	2,863,223	132,638	7,035,113	2,082,513	3,199,195	15,312,682	----
Percent of Total	18.7	0.9	45.9	13.6	20.9	----	100.0

* Only the following categories included: Grain & Soybeans, Coal, Logs & Lumber, Petroleum and Related Products, Iron & Steel, and Chemicals.

SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, 1970, Part 5, Washington, D. C.

characteristics of Texas intrastate commerce are shown in the table. For instance, it may be seen that most of the commerce carried by the shipping segment is either internal traffic (i.e., the traffic's destination is to a point within the shipping segment itself), or is received by a neighboring segment. Of the 6.5 million tons shipped by Galveston Bay in intrastate commerce, approximately 59 percent was internal traffic. By contrast, only nine percent of Galveston Bay's traffic was received by the segment of the waterway from Corpus Christi to the Mexican border. Thus, it can be seen that there is an inverse ratio between the distance between a shipping segment and a receiving segment and the percentage of the shipping segment's goods which are sent to the receiving segment. However, the quantity of goods one segment receives from another is dependent not only upon distance but also upon other factors, such as the relative industrialization of the two areas, and the relative demand of one area for another area's goods.

Figure 13 gives the volume of intrastate movement between the different segments and the Waterway. Such flows present a striking difference between the volume of trade in the Galveston Bay area and the other segments of the Waterway. One point which readily becomes apparent is that although the Sabine Neches Waterway is one of the most heavily industrialized areas in the state, it would appear that relatively little of its production capacity goes toward intrastate commerce. Another implication of this imbalance in intrastate trade is the fact that the Galveston Bay area could easily become so congested as to pose a bottleneck to waterborne commerce in Texas.



SOURCE: Lamkin, Jack T., Jr., Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas.

VOLUME OF INTRASTATE MOVEMENT ON TEXAS INLAND WATERWAY SYSTEM
1970

FIGURE 13

Because a major portion of the Texas coast lies below and to the west of the Galveston Bay area, this eventuality could pose serious restrictions in the industrial development of these areas.

WATERWAY USERS IN THE COASTAL REGION

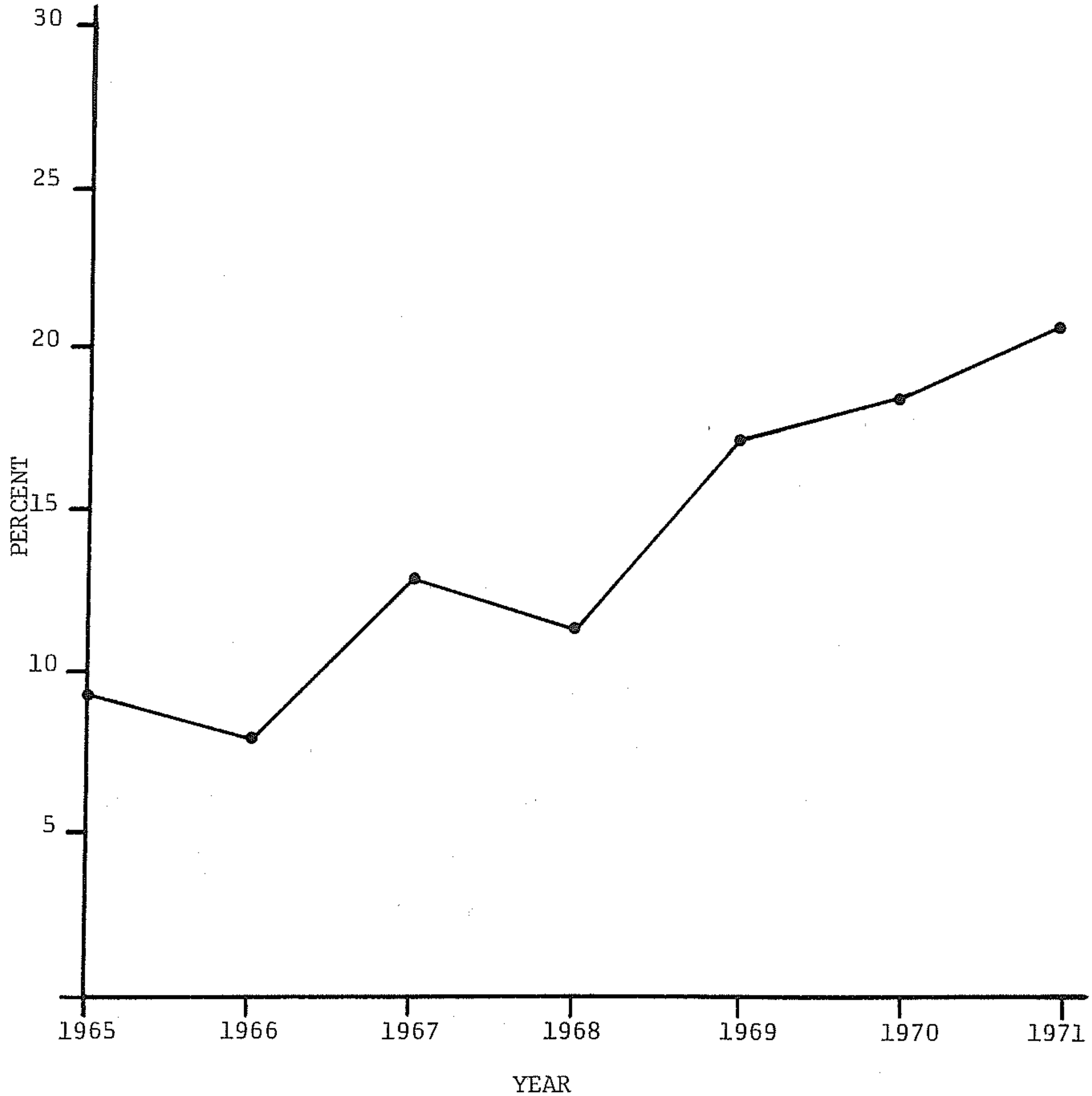
INDUSTRIAL
ECONOMICS
IERD
RESEARCH
DIVISION

CHAPTER IV

WATERWAY USERS IN THE COASTAL REGION

Waterway Plant Locations

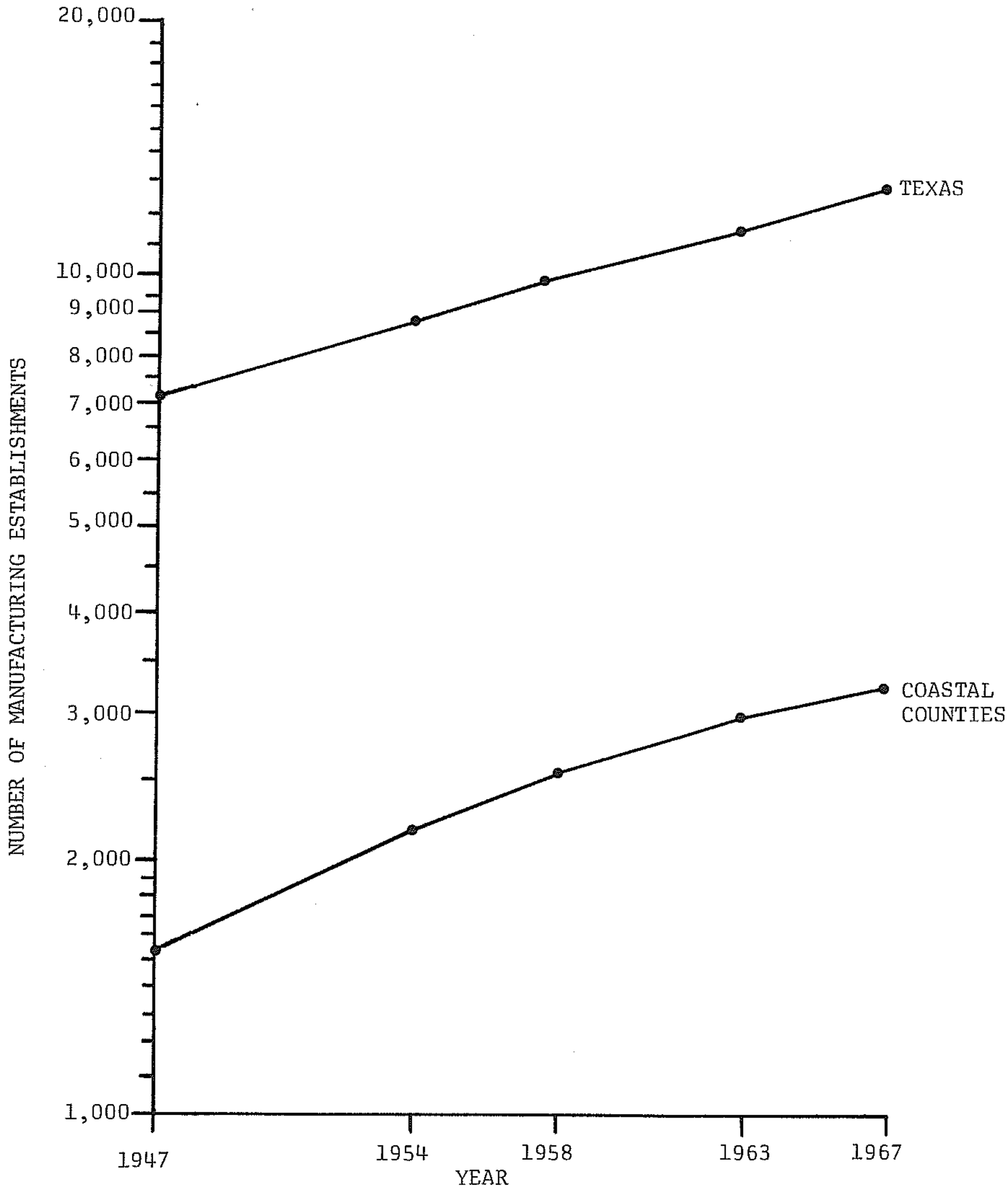
The coastal region is described as those counties either contiguous to the Intracoastal Waterway or having access to the Waterway in the form of a tributary channel. In recent years, the role of waterborne commerce in Texas has been growing, as shown by Figure 14, which implies that a Texas site is becoming increasingly attractive to firms wishing to establish a facility near a source of water transportation. In 1965, approximately nine percent of all waterside plant locations were in Texas. By 1971, more than 20 percent of all new plants established on a waterside site were located in Texas. The greater attractiveness of the coastal region to manufacturing establishments as compared to the state as a whole is shown in Figure 15. During the period 1947-1967, the number of manufacturing establishments in the entire state increased by 78 percent, while the number of manufacturing establishments in coastal counties increased 120 percent over the 1947 level. The number of manufacturing establishments in Texas have grown following a relatively constant trend, while the number of manufacturing establishments in the coastal region have increased at a slightly decreasing rate, implying the possibility of an increasing scarcity of prime location sites in the region.



SOURCE: American Waterway Operators, Waterside Site Plant Locations and Expansions, Washington, D.C.

TEXAS WATERSIDE PLANT LOCATIONS AS A PERCENTAGE OF UNITED STATES

FIGURE 14



SOURCE: Bureau of the Census, Census of Manufacturers, Washington, D.C.

NUMBER OF MANUFACTURING ESTABLISHMENTS IN TEXAS COASTAL COUNTIES
AS COMPARED WITH THE STATE

FIGURE 15

In this section, three major industry classifications are discussed as being major users of the Intracoastal Waterway in Texas. The industries are divided into manufacturing, mining, and water transportation industries.

Manufacturing Industries

The manufacturing industries which are primary Waterway users are those establishments producing chemicals and allied products and those engaged in petroleum refining. Together, these two product classifications account for approximately 48 percent of all waterborne commerce in Texas.

Chemicals and Allied Products

The greatest concentration of chemical plants in the United States is located on the Texas Gulf Coast. These plants produce more than 40 percent of all petrochemicals produced in the United States, 80 percent of all synthetic rubber, and approximately 10 percent of all sulfuric acid.[1] The chemical industry is heavily concentrated in the coastal region, in which approximately 37 percent of all Texas chemical and allied product establishments are located. On the average, the chemical firms located on the coast appear to be considerably larger than those firms located further inland, as is implied by the fact that a large percentage of all employees engaged in the manufacturing of chemicals or allied

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[1] Texas Almanac, 1972-1973, A. H. Belo Corporation, Dallas, Texas, 1971, p. 453.

products in Texas are employed by those firms located in the coastal zone. In addition, the average wage of a worker employed in the coastal region is higher than the wage of a worker located in other areas of the state. The greater concentration of chemical industries is found in Harris County.[2]

Petroleum Refining

Texas is the major petroleum refining state in the United States with over 27 percent of U. S. refining capacity. Again, the coastal region is a heavily concentrated area for petroleum refineries, with 43.1 percent of all Texas refineries. Refining establishments in the coastal region are considerably larger than those in other areas of the state. Approximately 82 percent of all employees engaged in petroleum refining work in the region. Correspondingly, the shipment value of products refined from petroleum in the coastal region comprises approximately 86 percent of the state's total. As was the case with chemical firms, the great majority of all petroleum refining establishments are located in Harris County.[3]

Mining Industries

Major waterway users among those industries engaged in mining activities include petroleum extraction, extraction of non-metallic minerals, and the dredging of reef shell.

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[2]Bureau of the Census, 1967 Census of Manufacturers, Area Studies--Texas, U. S. Department of Commerce, Washington, D. C., 1970.

[3]Ibid.

Petroleum Extraction

The petroleum industry in Texas is the most important mineral industry in the state, accounting for approximately 63 percent of the state's mineral value. Texas is the leading petroleum producer in the United States, producing approximately one-third of all petroleum in the United States. Although all 19 counties in the coastal region produce petroleum, the region's primary petroleum producing counties are Refugio and Jackson Counties.[4]

Non-Metallic Minerals

The non-metallic mineral industry represents the second major category of mineral industries. Materials produced by this industry include cement, clays, gypsum, lime, stone, salt, sand and gravel, and sulfur. Those products of major importance are cement, sulfur, stone, salt, and sand and gravel, in order of value. Approximately 38 percent of all sulfur used in the United States is produced in Texas. Cement is by far the most important commercially with more than 50 percent of all value-added for non-metallic minerals in the state.[5] Due to the diversity in the types of products categorized as non-metallic minerals, there is no one center of production in the coastal region.

Shell

Relatively little data is available concerning the reef shell industry in Texas, since it is not classified as a mineral industry

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[4]Bureau of Mines, 1969 Minerals Yearbook, Area Reports: Domestic, U. S. Department of the Interior, Washington, D. C., 1971, pp. 714-7.

[5]Kerr, Alex, Texas Reef Shell Industry, Austin, Texas: Bureau of Business Research, The University of Texas at Austin, 1967 pp. 6-20.

by the Bureau of the Census. Dredging of reef shell is restricted to the coastal region where it has become a major industry. Reef shell is used extensively as a source of lime for the cement and chemical industries, and as road bed material. Shell may be obtained by dredging from the living reefs of the Virginia Oyster, *Crassostrea virginica*, found mainly in low salinity bays and estuaries from Galveston Bay, the major producing area, south to Corpus Christi Bay. Fewer than 20 firms have the required permits from the Texas Parks and Wildlife Department.[6]

Transportation Industries

Water transportation industries in the coastal region may be categorized into two major areas:

1) Foreign and Domestic Transportation--this category includes only the actual carriage of goods and passengers. The types of water transportation included in this category are deep sea transportation, both foreign and domestic; transportation on rivers and canals and local water transportation.

2) Water Transportation Services--this category includes marine cargo handling and other water transportation services. Marine cargo handling deals with activities such as stevedoring, ship hold clearing, waterfront terminal operation, the unloading of vessels, and operation and maintenance of piers. Other water transportation services include ship cleaning, steamship leasing, and oil spill clean-up operations.

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[6]Hull, William J., "A Formula for Dismantling the Nation's Water Resources Program," Washington, D. C.: National Waterways Conference, Inc., pp. 16-17.

Many port functions are included in these two categories.

Water Transportation

All waterborne commerce originating in or destined for points along the coastal region in Texas utilize the Intracoastal Waterway or its tributaries to one extent or another. An example is the Houston Ship Channel, a deep-draft tributary channel in which both deep and shallow draft commerce move in the same traffic stream.[7] Table 13 shows relevant statistics for water transportation and the water transportation services industries. In 1969, the water transportation industry alone paid out $48.8 million in wages and salaries to 5,500 employees. Total revenues of the industry were approximately $222.1 million. As expected, the industry is primarily concentrated in the more heavily industrialized portion of the coastal region north of Brazoria County which accounted for almost 96 percent of the industry's revenues.

[7] Miloy, John, and E. A. Copp, Economic Impact Analysis of Texas Marine Resources and Industries, College Station, Texas: Industrial Economics Research Division, Texas A&M University, June, 1970.

TABLE 13

WATER TRANSPORTATION INDUSTRY
IN THE COASTAL REGION
1969

INDUSTRY SECTOR	NUMBER OF ESTABLISHMENTS	NUMBER OF EMPLOYEES	PAYROLL ($MILLION)	REVENUES ($MILLION)
Water Transportation	154	5,500	48.8	222.1
Water Transportation Services	165	2,900	18.0	41.7

SOURCE: Bureau of the Census, County Business Patterns, Washington, D. C.; and John Miloy and E. A. Copp, Economic Impact Analysis of Texas Marine Resources and Industries, Industrial Economics Research Division, Texas A&M University, College Station, Texas.

Water Transportation Services

In 1969 there were approximately 2,900 persons employed by water transportation services. The industry paid $18 million in wages and salaries while earning $41.7 million in direct revenues. These figures can be considered as being quite conservative. Although many port activities are included, data pertaining to some port activities is either unavailable or has been merged with other activities dealing primarily with land-based transportation.

Revenues Derived from Ports

The importance of a port to the regional economy is a function of the amount of tonnage which the port receives. Each ton of cargo received by a port generates a certain volume of expenditures in return for the various port services offered as in ship towing, cargo handling, and use of port facilities. The value of a ton of cargo to a port's economy may be derived from cost estimates developed by the American Association of Port Authorities. In order to use these cost estimates, it must be assumed that freight handling costs in Texas are the same as freight handling costs in the rest of the United States. Table 14 shows the value of cargo to port economies for major ports and shallow draft ports in Texas. Approximately 90 percent of the over $1.6 billion of cargo value can be attributed to the major ports of which 80 percent can be attributed to the region north of Brazoria County. The shallow draft ports, primarily located below Brazoria County, receive their primary cargo value from general cargo, as do the major ports. Only major ports handle the larger volume of grain and ore shipments.

TABLE 14

VALUE OF CARGO TO PORT ECONOMIES IN TEXAS, 1970*

(Thousands of Dollars)

PORTS	GENERAL CARGO	TANKER CARGO	GRAIN	ORE	TOTAL
Major Ports	886,658	476,389	80,763	14,045	1,457,855
Shallow Draft Ports	135,040	14,324	----	----	149,364
Total	1,021,698	490,713	80,763	14,045	1,607,219

* 1970 estimates of cargo value based on 1968 tonnage figures.

SOURCE: John Miloy and E. A. Copp, Economic Impact Analysis of Texas Marine Resources and Industries, Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TECHNOLOGICAL INNOVATIONS IN THE BARGE INDUSTRY

INDUSTRIAL ECONOMICS RESEARCH DIVISION

CHAPTER V

TECHNOLOGICAL INNOVATIONS IN THE BARGE INDUSTRY

Introduction

A summary of technological innovations as they apply to barge and towboat design and construction, to include the resulting changes in port and harbor facilities, will be limited to the more important ones only. The voluminous material available coupled with the daily application of new techniques and instrumentation limited their identification in view of the scope of this report. Detailed engineering application may be found in the references listed throughout.

Interdependence of all forms of transportation is much greater than is generally realized. Over half of all domestic cargo shipments and nearly all of foreign trade shipments require the services of more than one kind of transportation. For this reason, the advent of supertankers and superships must be considered. Due to limited harbor depths, super vessels must anchor several miles from the ports. Their effect is of an indirect nature. An analysis made by public agencies and the petroleum industry reveals the use of a single point mooring (SPM) system (also known as a monobuoy). From there, liquid cargo is discharged inland via pipelines. Such a method proves to be economical as well as ecologically more desirable than movement by barges. Therefore, the flow of direct traffic from superports to various smaller ports will be negligible. However, it is expected that increased petroleum product shipments from refineries to markets due to the larger crude oil shipments to the refineries by supertankers, will have a more direct bearing on barge technology.

To meet the ever increasing volume of traffic and the demand for deeper and wider channels to accommodate many of the new and larger barges, plans for expansion of the Gulf Intracoastal Waterway are under consideration. Such plans envision deepening of the channel from 12 feet to 16 feet and widening it from 150 feet to 200 feet.

When the project was authorized it was predicted that general commerce of at least 500,000 tons annually would move on the waterway between Texas and Louisiana. In 1971, the total traffic on the canal exceeded 100,000,000 tons. In the decade from 1960 to 1970, traffic in Texas increased 79.5 percent, an average of approximately eight percent a year. Cargo movement through the Texas coast jetty channels grew to 121 million tons in 1971.

To give a further indication of demand for barge transportation, demand for enlarged barges, and the need for waterway expansion, consider the fact that Texas seaports handled a total of 196,317,388 tons of freight in 1971. This was an increase of more than three million tons over 1970.[1]

The Port of Houston, alone, set a new cargo record of 69,439,058 tons in 1972 according to preliminary figures. The statistics indicated an increase of more than 1,000,000 tons over the previous record set in 1971.[2]

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[1] The Waterways Journal Weekly, September 16, 1972.

[2] The Waterways Journal Weekly, February 17. 1973.

Port authority officials attributed this increase to heavy foreign trade shipments in the last three months of 1972, which totaled almost 20 million tons.

Barge traffic for the port also made substantial gains. An increase of 2.5 million tons was recorded over the 1971 total of 25.2 million tons.

During the first three months' period of 1973, 21 million tons of cargo was handled as compared to 16 million tons for the same period last year, which is equivalent to about a 30 percent increase.

Intercoastal movements were stronger, moving six million tons in comparison to five million in 1972.[3]

The vast growth in vessel size has been stimulated by a variety of factors. Notable among them is sheer growth of demand from rapidly increasing population numbers and consumption.

Rocketing costs of labor and supplies and the development of instrumentation systems and handling techniques incited operators to take advantage of economies of scale inherent in large vessels, be they barges or ships.

Shipping Industry

The dramatic increase in the capacities of tankers and bulk carriers in recent years has had their effect on barge sizes.

In 1957, the largest tanker in the world fleet and the only one of that size, was between 80,000 and 100,000 deadweight tons (dwt.). By the end of 1971, there were 163 tankers of that size and 278

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[3] The Waterways Journal Weekly, May 26, 1973.

vessels of larger sizes, of which 18 were over 250,000 dwt. Presently a vessel with a capacity of 477,000 dwt is operating in Japan.[4]

Speculation of a million-ton ship has come about for the simple reason that marginal transportation costs per unit decrease with an increase in tanker size. However, economies of scale are expected to reverse between the currently built 477,000 dwt GLOBTIK TOKYO and a million-ton vessel. The GLOBTIK TOKYO was contracted for slightly under $49 million. The cost of a million-ton ship has been estimated as high as $130 million. The 100-foot drafts anticipated for these ships could be handled by few ports, none of which are located along the Texas portion of the Gulf Intracoastal Waterway. There would be even fewer oil dumps and refining sites capable of storing and processing a million tons of crude oil at one time.[5]

Economic justification for such a vessel will be difficult. American oil demands in 1985 will require 2,600 tankers of 47,000 dwt equivalent or 500 vessels of 250,000 dwt equivalent. The same load could be handled by 125 tankers of the million-ton classification, assuming that supporting facilities in the form of ports and repair shops exist.[6]

Growing ship sizes render many traditional ports obsolete with regard to capabilities. To remain abreast with the new workload, other ports need to adopt radically new handling, storage and distribution techniques. This fact is borne out by statistics in Table 15.

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[4] "Surveyor", February, 1973.

[5] Ibid.

[6] Ibid.

TABLE 15

PROJECTED VESSEL CHARACTERESTICS
1970-2000

VESSEL	1970	1980	1990	2000
CONTAINER SHIPS/ GENERAL CARGO SHIPS:				
Max. DWT in World Fleet*	25,000	33,500	43,500	50,000
Length (feet)	850	930	1,010	1,050
Beam (feet)	108	117	127	132
Depth (feet)	74	80	85	88
Draft (feet)	36	39	40	40
Average DWT in World Fleet	8,168	8,583	9,043	9,350
TANKERS:				
Max. DWT in World Fleet	300,000	760,000	1,000,000	1,000,000
Length (feet)	1,135	1,460	1,570	1,570
Beam (feet)	186	252	276	276
Depth (feet)	94	129	142	142
Draft (feet)	72	98	104	104
Average DWT in World Fleet	39,825	76,225	90,000	94,325
DRY BULK CARRIERS:				
Max. DWT in World Fleet	105,000	185,000	317,000	400,000
Length (feet)	870	1,040	1,230	1,325
Beam (feet)	125	152	183	198
Depth (feet)	71	84	99	106
Draft (feet)	48	57	66	71
Average DWT in World Fleet	14,750	18,750	23,575	27,350

* DWT - Deadweight Tons

SOURCE: Architecture Research Center, Texas A&M University, College Station, Texas.

Ship construction affects barge size in ways other than sheer volume of goods that barges must move inland from the ports. Construction of specialized ships designed to carry particular types of cargo bring about concurrent changes in barge designs.

Container ships fall into this category of specially designed ships. Full container ships are increasingly utilized in response to world-wide general cargo trade. These vessels are replacing traditional break-bulk ships because they minimize time for loading and unloading. Some of the factors that limit the size of container ships pertain to harbor orientation, shoreside space and existing distribution systems.[7]

LASH (Lighter Abroad Ship) and SEA BEE (Sea Barge Carrier) are variations of the containership. These vessels differ in that they carry barges instead of containers where the barges actually serve as floating containers which can be distributed to inland waterways. Theoretically, they need no pier and can work cargo in open but protected roadsteads outside of inner harbors which may be congested, shallow or otherwise inadequate.

In conjunction with LASH vessels, fiberglass barges have been built by Northrop Corporation at Port Hueneme, California. Fiberglass has been used for structural material for many years, but has never been put into production of such large vessels. They measure 60 feet long, 31 feet wide, and 14 feet from keel to hatch cover. Their prime advantage is that these barges are 40 percent lighter than

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[7] Port and Harbor Development System, Architecture Research Center, College of Architecture and Environmental Design, Texas A&M University, College Station, Texas.

comparable steel barges of the same size. This reduced weight allows for higher payload capacity in terms of weight. Absence of corrosion problems with this material further reduces maintenance costs while repairs become easier and less expensive by as much as 80 percent.[8] These vessels have a 450-ton capacity and weigh 100,000 pounds when empty.

Additional advantages for their construction lie in their ability to accommodate high-density loading because of the uniform support provided by the honeycomb-core sandwich structure. Available loading specifications allow for loading on the floor of the fiberglass lighter of about 15,000 pounds per square foot compared to 1,500 pounds per square foot for a steel lighter.[9]

The SEA BEE vessel is 720 feet long, 106 feet wide with a loaded draft of 33 feet. The LASH ship is 124 feet long, 100 feet wide and has a loaded draft of 28 feet. Their respective speeds are 20 and 23 knots.[10]

Introduction of container ships is attributed to the shipowner's desire to reduce ton-mile costs, provide faster service and thereby increase his share of the general cargo market.

They also have the advantage of fast turnaround in ports. The barges, however, account for a certain amount of lost cargo capacity for the mother vessel. In addition to the sizable investment

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[8] Container News, November 1972.

[9] Ibid.

[10] Merchant Vessel Size in U. S. Offshore Trades by the Year 2000, Washington, D. C.: The American Association of Port Authorities, June 1969.

involved in the ownership of both vessels and barges, barge carriers cannot participate in a fully intermodal system as is possible for the traditional containership.

Sufficient operating experience for these vessels is not yet available. Should they prove to be successful, their uses will be limited to routes with the proper type of cargo-facilitating pickup and delivery for inland river movement. Their ability to work cargo barges offshore will eliminate most port development problems resulting from vessel size.

Improvement in the intermodal concept of cargo distribution and cargo solicitation is required. Unproductive time of containerships must be reduced. Due to their quick turnaround time, problems of fast fueling and repairing must be solved. More efficient berth and terminal productivity will need to be continuously explored.

Both the LASH and SEA BEE concepts point toward a standardization of barge sizes for use on a mother vessel. Such a barge must, of course, be of a smaller size as compared to a conventional one.

Notably, many other innovations regarding ship construction are presently in use. This chapter will concern itself mainly with those innovations that directly affect barge construction.

Need for Barge Transportation

The United States is endowed with over 25,000 miles of inland and coastal waterways that are commercially navigable.[11] The importance of barge transportation lies in its economic justification for it

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[11] Donald P. Courtsal, The Marine Business in the Central United States, The Society of Naval Architects and Marine Engineers, November, 1971.

provides over three times the labor productivity of rail transportation.[12] Each barge-operating employee produced some 11,000,000 ton-miles per year as compared to 3,500,000 ton-miles per operating employee in railroad service.[13] In addition to reduced labor costs, equipment cost per ton of carrying capacity for barge transportation has a $110 advantage over rail transportation in 1962.[14] Maintenance and repair costs, diesel fuel consumption, and ratio of equipment weight to carrying capacity all show similar comparisons.

It has been said that water transportation consumes less energy per ton-mile of freight than any other transportation mode. As shown in Table 16 , Dr. William Mooz of RAND Corporation has suggested the following fuel consumption figures, and Braxton B. Carr, former president of American Waterways Operators, Inc., expresses fuel consumption in terms of gallons.

In March, 1970, American Waterways Operators, Inc., estimated, on the basis of average costs, the distances that a shipper's dollar would move a ton of cargo with respect to the various transportation modes. Table 17 indicates these distances for four carriers.

Historical Overview of Barge Development

Early keelboats built by the early settlers and the flat boats built during the revolutionary period at Fort Pitt which resembled

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[12]George L. Grunthaner, Commercial Transportation on the Inland Waterways, The Society of Naval Architects and Marine Engineers, June, 1962.

[13]*Ibid.*

[14]*Ibid.*

TABLE 16

FUEL PER TON MILE OF CARGO

MODES	GALLONS*	B.T.U.**
Barge	3.15	500
Rail	4.21	750
Pipeline	N.A.	1,850
Truck	8.33	2,400
Air	N.A.	6,300

* Per 1,000 ton-miles.
**B.T.U.--British Thermal Units
N.A.--Not available.

SOURCE: Dr. William Mooz, Rand Corporation, Washington, D. C.; and Braxton B. Carr, American Waterways Operators, Inc., Washington, D. C.

TABLE 17

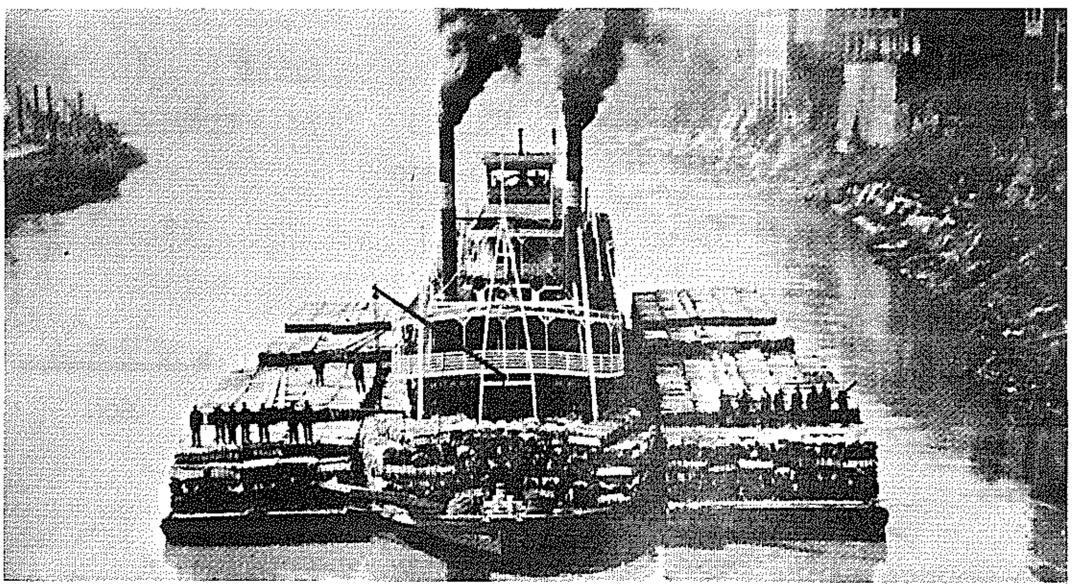
MOVEMENT OF A TON OF CARGO PER ONE DOLLAR BY MODES

MODES	DISTANCE (Miles)
Barge	333.3
Rail	66.6
Truck	15.4
Air	5.0

SOURCE: American Waterways Operators, Inc., Washington, D. C.

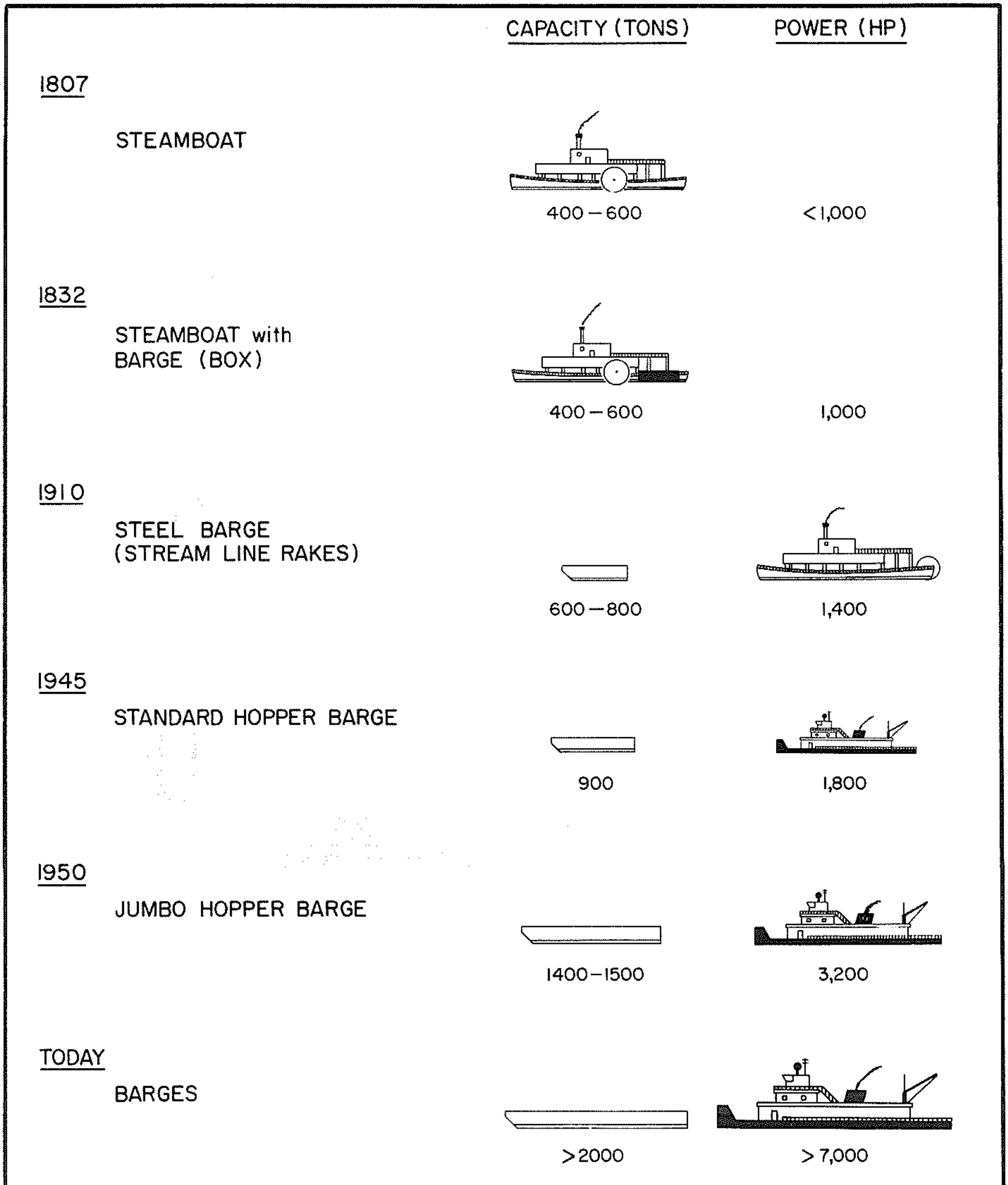
the shape of a rectangular box, gave way to the steamboat in 1807. Old and dilapidated steamboats were often stripped of their upper deck and converted into barges. The size of steamboats and barges was limited then as it is now, by the physical dimensions of the canals, depth, width, and other navigational aids such as locks. Figure 16 shows the growth of barges and the increase of horsepower in use by tugs from 1807 to the present time.

Barges had been lashed to steamboats as early as 1832. In the 1870's fleets of barges became a common sight. The growing use of crude oil found in locations convenient to water transportation spurred on this development.



BARGES LASHED TO STEAMSHIP

In the year 1900 waterborne commerce and commercial transportation was minimal. In many cases the economic advantage was definitely with the railroad. As iron and steel became more important, movement of coal rose. Industry's heavy reliance on coal called for larger and more regular deliveries. As a result, waterborne coal transportation



TREND IN BARGE AND TOW SIZES
1807 – TODAY
FIGURE 16

vessels such as the "SPRAGUE" were built. The giant towboat could move a 70,000 ton coal tow in 1907. To withstand the stress created by pushing the heavy tonnages, a steel hull was integrated into its design. Until World War I, few individual barges could carry as much as 800 tons and the average was around 400 tons.[15] In the period between 1910 and 1920 steel was introduced as a suitable hull material for both barges and boats. These barges of steel with streamlined rakes lessened resistance by 45 to 60 percent. Barge types continued to improve. Weatherproof, covered barges to protect cargoes came into operation and barge sizes were standardized to conform with the lock chamber dimensions.

As a result of the tremendous traffic growth of the inland waterway system immediately after World War II, the need for modernizing inland rivers emerged. During that time a standard hopper barge was 175 feet in length, 26 to 27 feet in width and around 10 feet in depth and could carry about 900 tons of cargo. Around 1950, the "jumbo" hopper barge, which has since become standard, began to appear. These barges are 195 feet long, 35 feet wide, 11 or 12 feet deep with a cargo capacity of 1,400 to 1,500 tons. By this time operators had become aware of the advantages of fleet integration for reducing wave resistance. In response, barges with two square ends were introduced.

Within the last eight years, 200-foot barges have come into service.

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[15] Waterways of the United States. The National Association of River and Harbor Contractors, 1963.

BARGE DESIGN TODAY

Barge construction has evolved into a relatively complex design problem. The only factor which tends to simplify the design of barges over ocean-going vessels is the absence of waves. On the other hand, a river barge must be designed to handle much higher local impact loads that come from a far greater variety of sources, which in turn resulted in the construction of several different types of barges.

Barges shown in Table 18 currently operate in Gulf Intracoastal Waterways. Their widespread use and the variety of cargoes carried indicates the versatility displayed by this form of transportation.

The tug-and-barge system offers several advantages. It permits the separation of cargo carrying barges from the tug housing the power plant and serving as navigation and crew accommodation center. Capital cost saving may be realized in the absence of crew requirements such as accommodation or life-saving equipment. Due to its smaller size, the tug can be operated by fewer people thus reducing operating costs. The system's optimality is further revealed when one barge is loading or is delayed for whatever reasons, the tug may be engaged in other revenue-earning activities.

The design of a simple hopper-type barge varies according to commodities to be transported, direction (up or down stream), length of haul, turnaround time, terminal conditions, river and lock conditions, interchangeability, and so on. Barges carrying dense cargoes such as sand, gravel and ores, have to be constructed with small cubic and high longitudinal strength. Therefore, sand and gravel barges are built for this specific purpose. A cement barge which provides its cargo protection from moisture became another type of

TABLE 18

SELECTED SUPER BARGES IN SERVICE

TYPE BARGE	DIMENSIONS	DWT*	NUMBER IN SYSTEM	PRODUCT
Dry Cargo	420' x 80' x 34'	15,000	3	Cement
Converted Liberty Colliers	441' x 56' x 37'	11,700	4	Bulk Coal
Open Deck Cargo	360' x 75' x 25'	10,000	2	Lime Rock
Log Carrier	364' x 80' x 23'	9,400	1	Logs
Dry Bulk	420' x 80' x 36'	17,000	1	Phosphate Rock
Covered	356' x 78' x 22'	7,200	3	Newsprint

*Deadweight Tons

SOURCE: Rationale of Tug and Barge Transportation, Society of Naval Architects and Marine Engineers, March, 1967.

specialized vessel. For versatility, the Pittsburgh Standard coal barge, for example, can be adapted for carriage of liquids and is even suited to carry a number of slurry by-products. Covered and uncovered hopper barges, a multi-purpose vessel, are employed in the movement of bulk commodities. Table 19 illustrates the dimensions and capacity of open hopper barges and covered dry cargo barges, respectively.

For further illustration of current barge capabilities and versatilities, the following examples of some of the newest vessels put into operations are cited.

> Heavy and oversized equipment such as nuclear reactors, steam generators, fractionating towers, etc., can now be transported safely and efficiently on new heavy-duty

TABLE 19

BARGE MEASUREMENTS

LENGTH (Feet)	BREADTH (Feet)	DRAFT (Feet)	CAPACITY (Tons)
	OPEN HOPPER BARGES		
175	26	9	1,000
195	35	9	1,500
290	50	9	3,000
	COVERED DRY CARGO BARGES		
175	26	9	1,000
195	35	9	1,500

SOURCE: Big Boat Afloat, The American Waterways Operators, Inc., 1966.

deck barges recently added to the fleet of Union Barge Line Corporation in Pittsburgh. These barges measure 200 feet in length, 50 feet in width and 13 feet deep. They are constructed with thick deck plate and closely spaced, extra-heavy, deep internal bracing with bulkheads and trusses that give each vessel a maximum load capacity in excess of 2,000 tons. It can hold a concentrated load capacity of up to 20 tons per square foot.

Internally, the barge is divided into a number of separate compartments for additional load-bearing strength.

Full support strength under the entire surface of the virtually flat decks facilitates loading and unloading of cargoes, while the internal compartment design permits flexibility in ballasting. The barges can be loaded or unloaded in a grounded condition, from the bow, stern or either side.[16]

Since tank barges are made to haul many types of commodities, a demand for double-skin barges arose. This type of barge facilitates easy handling of dissimilar cargo within its contamination-free compartments. The barge may be lined or unlined, with or without heating coils or insulation and may contain various pumping and piping systems. Table 20 gives the dimensions and capacity of several liquid cargo (tank) barges currently in use.

With the new water pollution regulations the switch from single skin to double-skin equipment will be accelerated.

The American Bridge Division of U. S. Steel Corporation currently has under construction at its Ambridge, Pennsylvania yards twenty 240 by 50-foot deck barges for Radcliff Materials, Inc., Mobile.

The big barges will be used for transporting oyster shell recovered from dead reef deposits in the Gulf. Each barge will carry about 2,600 tons of shell. A shallow, 54-inch high steel cargo box built on the deck of each vessel retains the shells while allowing water to drain off through a series of small openings along the deck.

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[16] The Waterways Journal Weekly, December 4, 1971.

TABLE 20

LIQUID CARGO (TANK) BARGES

LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS	CAPACITY GALLONS*
175	26	9	1,000	302,000
195	35	9	1,500	454,000
290	50	9	3,000	907,000

*Based on an average of 7.2 barrels per ton and 42 gallons per barrel.

SOURCE: Big Boat Afloat, The American Waterways Operators, Inc., 1966.

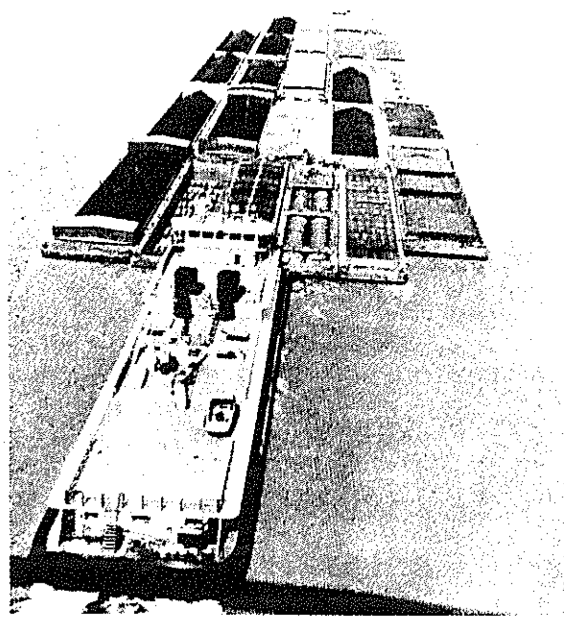
Crushed oyster shells are used for producing cement for road construction, aggregate for making cement blocks, chemical grade lime and as a poultry feed supplement.[17]

In general, 40,000 dwt barges with an average service speed of 10 knots is considered a reasonable size that would generally be suitable for the Gulf and east coast ports.

Barge Integration

Thirty years ago most river barges were designed as single individual units with a rake, or slope, on each end, which is still most efficient for navigating as a single unit. Model testing showed, however, that the assembly of many of these single units in the form of one tow resulted in great efficiency losses. These losses were caused by the cumulative drag of many water-breaking rakes in the middle of the tow.

To alleviate this resistance and loss of efficiency, barges are now designed to be assembled into integrated tows that will resemble the underwater shape and water resistance of a single vessel. This integrated tow will be led by a barge with an easy rake of the bow to minimize water resistance.



INTEGRATED TOW

[17]The Waterways Journal Weekly, January 13, 1973.

Its stern is square. The trailing barge has a short rake on the stern, and a square bow. Between the lead barge and the trailing barge, double square-ended barges are inserted to eliminate under-water surface break. This type of arrangement has an added advantage of increasing the tow's overall capacity caused by the increased buoyancy of the square ends.

The integrated high-speed tow carries large volumes of a single commodity over a long distance.[18] Figure 17 gives comparative data on barge integration.

The comparative data in Table 21 clearly demonstrates the inherent advantages that are introduced with barge integration both in the form of increased cargo capacity and faster towing speeds.

Locks

Barge sizes for fully integrated unit tows are determined almost entirely by the locks which the fleets must pass. Barge widths for unit tows vary between 50 and 54 feet. They must be designed so that these tows may pass through the locks of any waterway.

The Texas portion of the canal lies at sea-level and thus requires no locks to change water elevation. Portions of the waterway in Louisiana that lie some distance inland have a need for locks. Table 22 gives the name and dimensions of locks in Louisiana causing frequent delays for a duration from 24 to 30 hours before barges may gain passage. The channel dimensions of the Louisiana waterway section are 16 feet deep by 200 feet wide.

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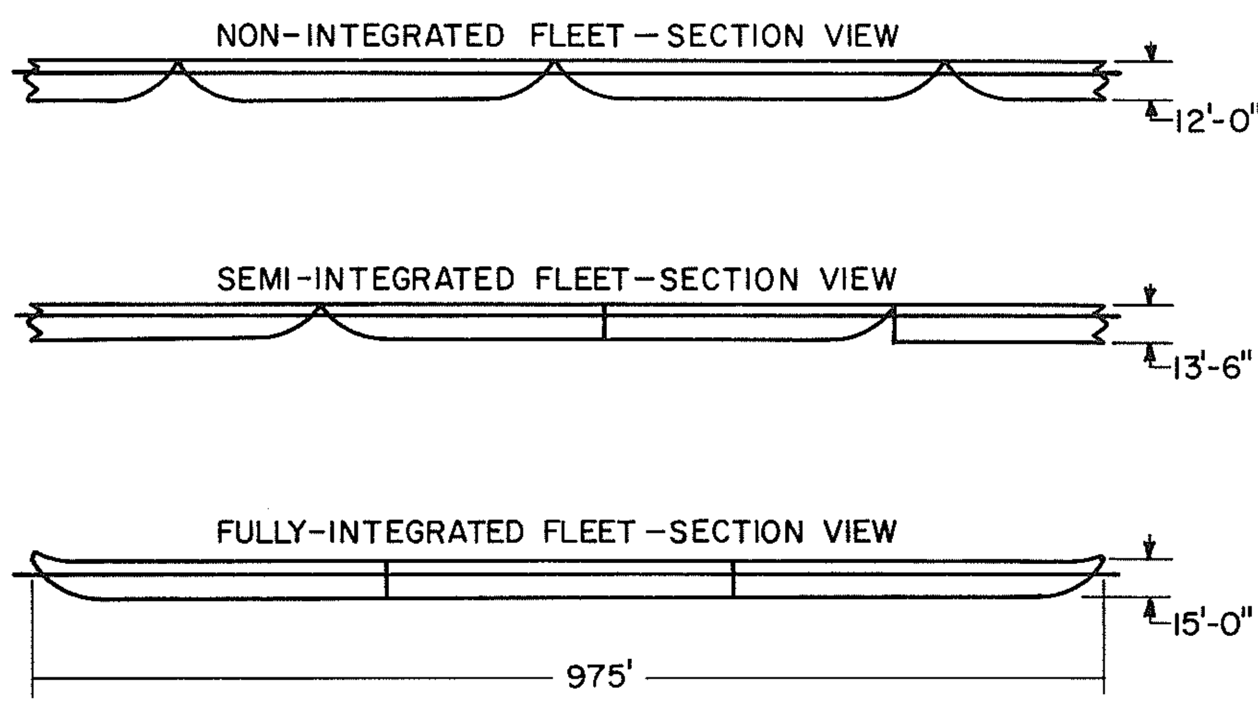
[18] Inland Waterway Transportation, Resources for the Future, the Johns Hopkins Press, Baltimore, 1969.



COMPARATIVE DATA ON BARGE INTEGRATION

FIGURE 17

TABLE 21

TYPICAL SPEED AND CARGO CAPACITY RELATIONS FOR FLEET TYPE BARGES

FLEET TYPE	PERCENTAGE CARGO CAPACITY	PERCENTAGE TOWING SPEED
Non-Integrated	100.0	100.0
Semi-Integrated	103.2	105.0
Fully-Integrated	104.8	110.0

SOURCE: The Marine Business in the Central United States, The Society of Naval Architects and Marine Engineers, New York, 1971.

TABLE 22

DIMENSIONS OF LOUISIANA LOCKS ON GULF INTRACOASTAL WATERWAY

LOCK	DIMENSIONS
Calcasieu	75' x 1,180'
Vermilion	56' x 1,182'
Old River	75' x 1,200'
Port Allen	84' x 1,200'
Bayou Boeuf	75' x 1,160'

SOURCE: The Intracoastal Waterway: Gulf Section, U. S. Army Corps of Engineers, Washington, D. C., Government Printing Office, 1961.

Virtually all of the 36 million tons of cargo that traveled the Texas portion of the canal in 1970 had to pass through the Calcasieu and Vermilion locks, the latter being the smaller. Based on the ultimate capacity of the Vermilion lock depicted in Table 23, Texas traffic consumes at least half of the total ultimate capacity of this lock.[19]

The Louisiana portion of the Gulf Intracoastal Waterway has locks as narrow as 56 feet, whereas other locks along Illinois, Ohio, or Upper Mississippi Rivers have a width of 110 feet.[20]

The length of barges for integrated tows vary anywhere from 150 to 300 feet. The maximum length of a tow including the towboat that can operate on the Gulf Intracoastal Waterway, for example, is 1,180 feet. Tows of this size and larger, however, present a certain number of navigational problems in the narrower channels or those channels with numerous, small angle bends.[21]

This problem, however, has been partially solved with the advent of the "Steermaster" bow steering system built by The Waterways Company in New Orleans, Louisiana. It is designed to improve inland waterway safety, and make operations more efficient and more profitable. The new system steers the vessel which may be a long tow, at low and high running speeds with precision maneuverability and steering control at all speeds, in all passing situations, and in crosswinds.

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[19] Texas Waterborne Commerce Commodity Flow Statistics, College Station, Texas: Texas Transportation Institute, Texas A&M University.

[20] Donald P. Courtsal, op. cit.

[21] Ibid.

TABLE 23

CALCULATION OF ULTIMATE CAPACITY
OF VERMILION LOCK

Assumptions:

Maximum Flotilla Size

5 barges, 1000 tons each, (26' x 175')

1 tow-boat (25' x 80')

Total Size: 26' x 955'

Average Lockage Time - 30 minutes

20% of Barges are empty
(due to imbalance of traffic)

Flotillas are waiting to enter lock after each operation

Calculations

Hourly capacity is

5 x 1000 x 2 = 10,000 tons/hr.

But 20% of barges are empty, so

Effective Hourly capacity = 8,000 tons/hour

If operation is continuous,

8000 x 24 x 365 = 70,080,000 tons/year

SOURCE: Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas.

The Steermaster employed a "Jackson" nozzle to overcome the head of water built up at the bow of the vessel and is accomplished by forcing water through its tunnels at volumes up to 450,000 gallons per minute. This creates the necessary forces to turn the head of a tow in any direction immediately at high running speeds. Its advantages are numerous. The device reduces underway time for carriers by cancelling the effect of winds on a tow thus eliminating windbound conditions.

It further cuts the time needed to navigate curves and bends and provides complete control over current when approaching bridges.[22]

New Concepts in Ocean-Going Barges

Robert D. Moss, a former tugboat captain from Metairie, Louisiana, submitted an idea of building barges as big as supertankers. The barges are to be linked together in a five-mile long seagoing unit to move petroleum products or crude oil between continents. According to his calculations, it will be cheaper to have a control vessel assisted by five power assist barges (PAB) move a shipment of oil rather than have the same shipment moved by five separate supertankers. Moss currently holds U. S. patents on a unique propulsion and control system for the proposed superbarges. Its dimensions will be 1,300 feet long, 200 feet wide and 85 feet deep, and it will travel at 14 to 16 knots.[23]

For maneuverability a propeller will be placed inside each tunnel located under the prow and stern of the vessel. Water drawn in at the bow will flow through the channel to be discharged through the ports on each side.

Linkage of five such superbarges will be accomplished by cables and electronic means to insure safe passage. Operation of the barge train is proposed to be handled by fewer crew members than is necessary for an equivalent supertanker.[24]

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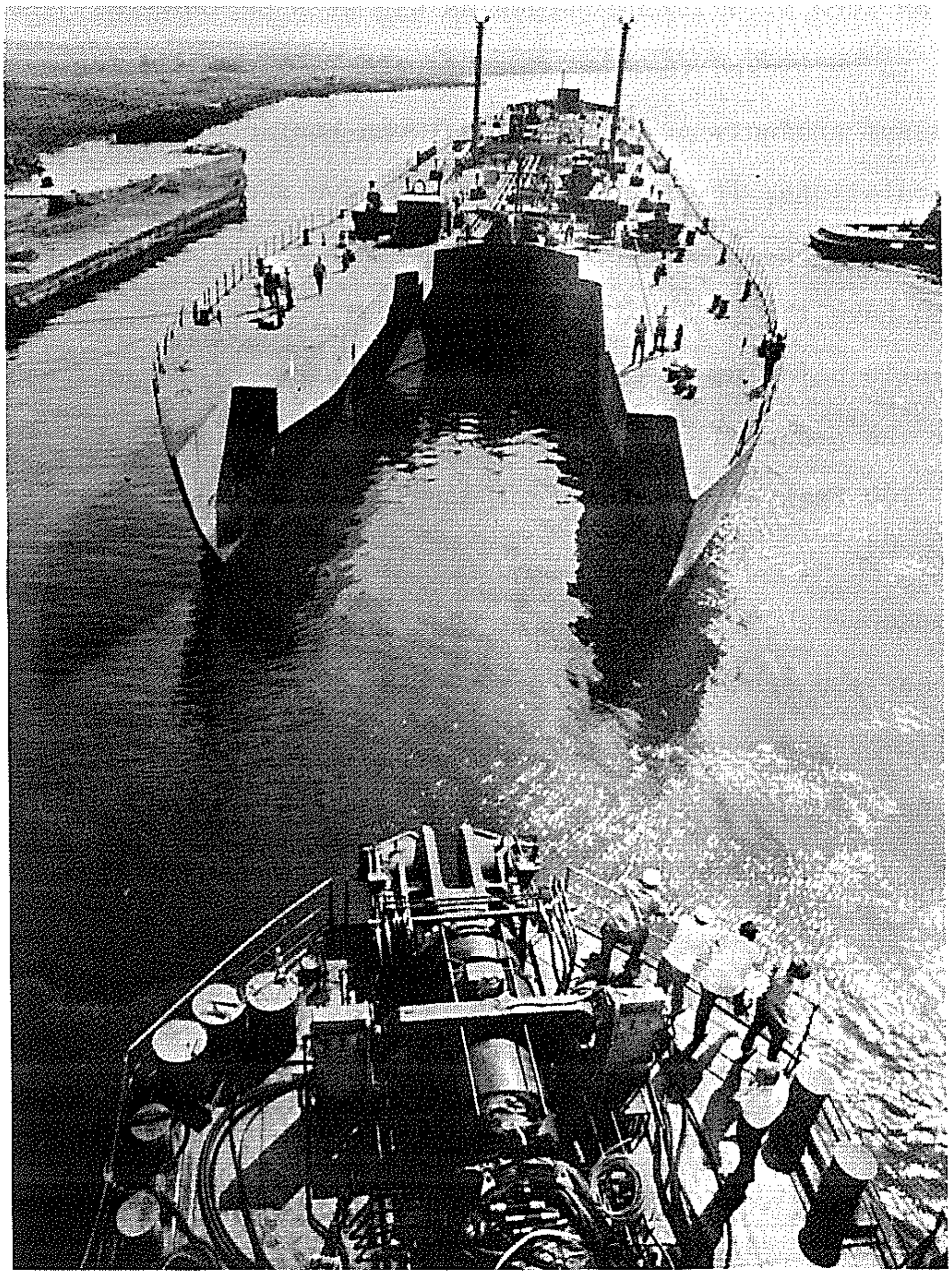
[22] The Waterways Journal Weekly, August 25, 1973.

[23] The Houston Post, March 11, 1973.

[24] Ibid.

Another new revolutionary concept in the barge industry evolved in the form of the "integrated tug-barge combination," which presents an alternative to the conventional ship. There are at least four different designs, only one of which is design-patented by Breit Engineering Incorporated in New Orleans, Louisiana.



INTEGRATED TUG-BARGE COMBINATION

The rigid tug-barge concept, supposedly, offers the ocean-going integrity of a small conventional ship coupled with the economic advantages of tug-barge construction, maintenance, and operation. It may prove to be ideally suited for trans-shipment of cargoes from deep-draft offshore terminals to coastal ports with relatively shallow depths.[25]

The critical point and emphasis of the new combination are placed on the rigid linkage system patented by Breit Engineering. The U. S. Coast Guard accepted the device in 1969. Its design calls for hydraulic rows at the tug prow and a series of laminated steel-and-rubber wedges secured at a point slightly abaft of midships of the tug on both port and starboard. Their purpose is to allow the tug bow to fit snugly into the notched stern of the barge while simultaneously permitting easy but fast disconnection.[26]

Based on the 60 round-trips between the U. S. Northeast Coast to the Gulf Coast and the Caribbean by MARTHA and CAROLE ITB's which entered service in July, 1971 and April, 1972, Ingram officials were satisfied. They reported no significant damage to the rigid linkage resulting from operations at service speeds of 14.5 knots. They passed through storms with seas over 35 feet and winds over 90 miles per hour. There was no sign of relative motion between tug and barge.[27]

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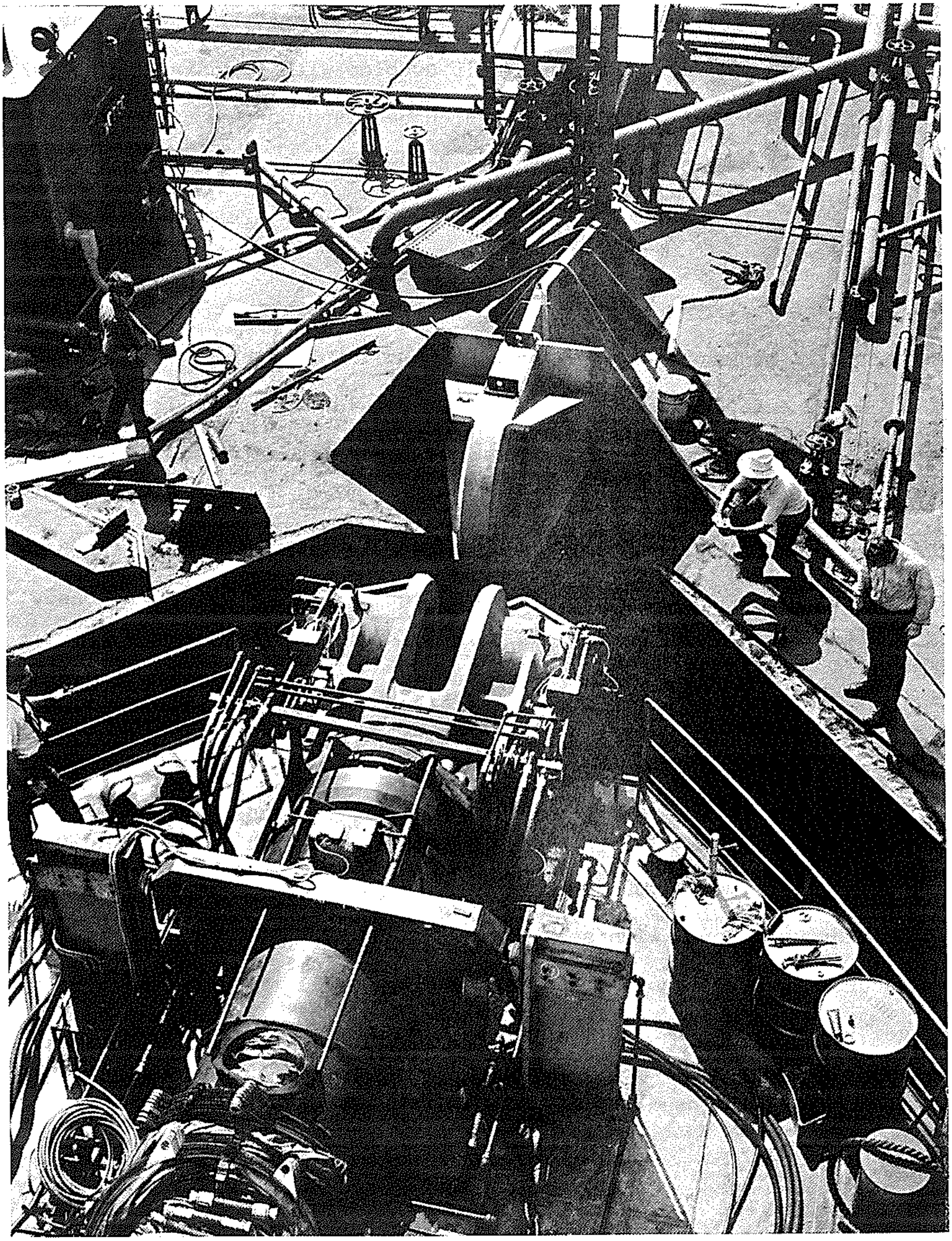
[25] Surveyor, February, 1973.

[26] Ibid.

[27] Ibid.



RIGID LINKAGE SYSTEM

The Ingram tug-barge units link an 11,128-hp tug to a 36,581 dwt tank barge.

Operation of the entire unit was accomplished with a 14-man crew.

The combination as a whole stretches for 620.5 feet, is 87 feet wide, and 46.3 feet deep. When loaded, the entire combination has a draft of 37.3 feet. Each barge is fitted with a diesel drive bow thruster and a propeller mounted in a tunnel through the bow for increased maneuverability in restricted waters.[28]

The magnitude of such an unmanned ocean-going barge can be realized from the following example.

> One of the largest unmanned ocean-going barges ever built was launched January 15, 1972 to be operated by Interstate Oil Transport Company, Philadelphia. This vessel measures 546 feet in length, 85 feet width and 40 feet deep. It has a maximum capacity of 261,000 barrels at a 32-foot draft and it is rated at 31,000 dwt. A semi-automatic anchoring device, automatic running lights, recessed mooring bitts, permanently secured towing bridles and a 40-foot notch on the stern for the tug are employed in this vessel.[29]

Towboat Design

A barge simply represents a stationary warehouse on water until it is moved. Consequently, a discussion of the barge industry must necessarily include a statement concerning the propulsion unit, the towboat.

Historically, the two main sources of power consisted of steam and diesel propulsion generated either through the steam wheel or a screw propeller.

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[29] The Waterways Journal Weekly, January 22, 1972.

Not until channels were dredged to a nine foot depth in 1929 did screw propellers become practical. The majority of boats were designed for shallow-draft operations.[30] Reconstruction of the stern form and the installation of "Kort" nozzles introduced in the early 1940's further modernized the design of towboats.[31] The "Kort" nozzle markedly improved propulsive efficiency in the high-thrust, low-speed condition under which these boats operate. It consists essentially of a cylindrical body surrounding the propeller to guide the water to the propeller and control the flow of water.

The stern wheel towboat was superior to many average propeller type towboats until the advent of the Kort nozzle boat. During open river conditions, 1,000 horsepower steamboats were able to push 24 standard coal barges of 1,050 feet in length by 104 feet in width amounting to 21,000 tons of coal. A 1,400 horsepower twin-screw diesel towboat was limited to a 16-barge tow.[32] The steam stern wheel towboat faded out of existence in the late 1940's and early 1950's, and thus the modern diesel vessel became one of the technological innovations that have caused river transportation to expand.

The size of towboats is usually defined in terms of horsepower which is determined by the size of the tow it is expected to push, the speed desired, the water depth in which it is to operate,

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[30] V. B. Edwards and F. C. Cole, "Water Transportation on Inland Rivers," Historical Transactions, The Society of Naval Architects and Marine Engineers, 1893-1943.

[31] Ibid.

[32] The Committee of Ship Channels and Harbors, op. cit.

maneuverability required, and the engine size available. Horsepower needs vary according to the river characteristics. If it is a river whose water depth is regulated by locks and dams, then 3,000 to 4,000 horsepower may be ample to handle currents. Open river operations may require up to 6,000 to 7,000 horsepower boat. A river towboat of 3,000 to 5,000 horsepower is capable of handling a 20,000 ton fleet.

Due to the tremendous demand by operators to handle increasing tonnages efficiently and profitably, the new line towboats must have an unusual balance of speed, power, and maneuverability.

Today nearly all boats have twin screws and a few triple screw boats have been built. Their medium-speed diesel engines controlled from the pilothouse are also equipped with reverse-reduction gear and quick-acting clutches. With the propulsion and steering systems found in many towboats, a normal river fleet can be turned through 180 degrees within a distance of about 10 percent above the length of the fleet.[33]

Many boats are highly instrumented. Instrumentation may include at least one radar-set, and a VHF radio for long-range communications. Some are even equipped with a rate-of-swing meter while others have an autopilot. Fathometers are found with twin portable transducers located at the head of the fleet on the port and starboard sides. Two large carbon arc or zenon searchlights make up the boat's lighting equipment.[34] Some boats are fully air-conditioned and have comfortable

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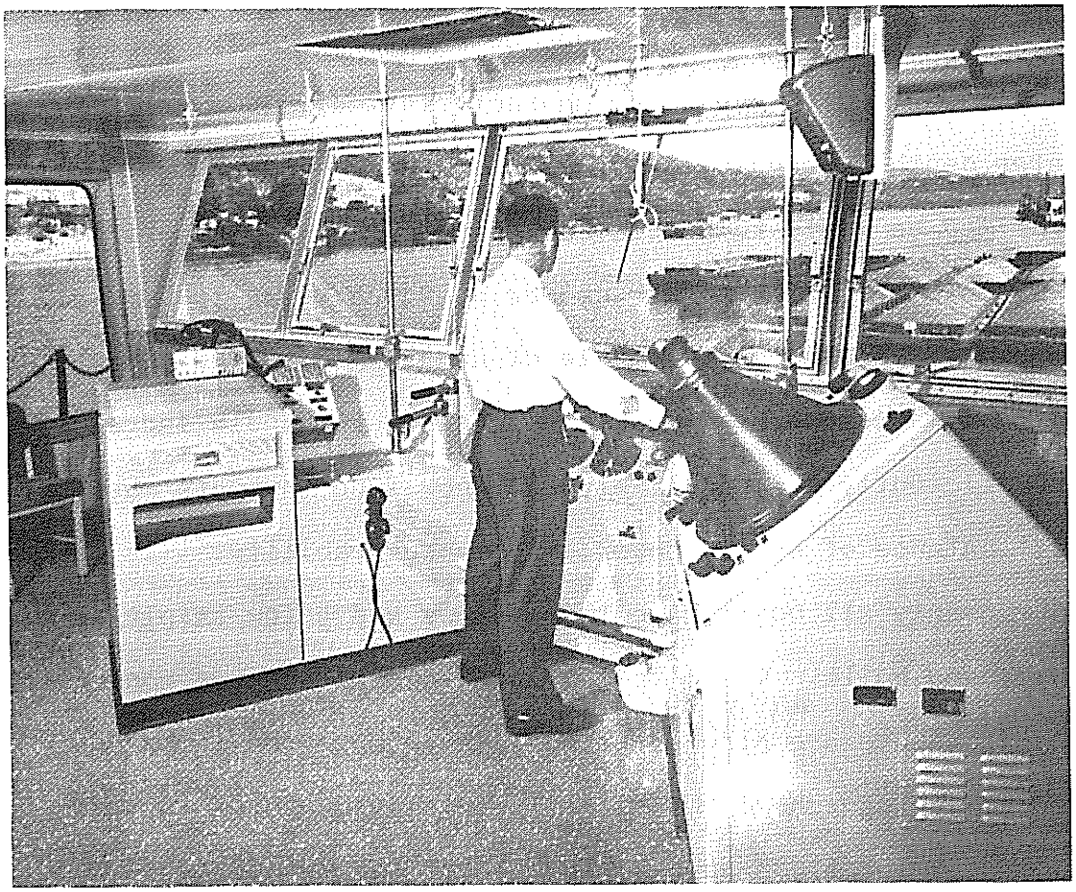
[33]Donald P. Courtsal, op. cit.

[34]Ibid.



TUG INSTRUMENTATION

quarters and one galley for their crews ranging from a minimum of four to a maximum of 16 men. The purpose of listing a few of the new tugboats that recently went into service is to illustrate the tremendous advances technology has contributed to towboat capabilities.

> The Exxon Kentucky, Exxon's newest and most powerful towboat was christened on March 1, 1973. Built by the St. Louis Ship Company, this vessel is 50 feet long, 52 feet wide, 11 feet deep and has an operating draft of 8½ feet. The towboat is capable of pushing a triple string tow of 12 barges having a capacity of about 350,000 barrels (34,000 tons) of petroleum products.
>
> The tow with the boat has a total length of 1,190 feet and a width of 156 feet.[35]

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[35] The Waterways Journal Weekly, March 10, 1973.

Tugs that can handle 40,000 ton, 30-barge tows are currently in operation between New Orleans and St. Louis. These are twin screw vessels.

The all-welded hull is heavily framed longitudinally and transversely with the aft deck raised to provide additional strength and reduce vibration. Bilge, headlog and bottom plating are 5/8-inch thick with tunnel areas increased to 3/4 inch. Side plating is 7/16-inch thick.

Propulsion power consists of two General Motors (Electro-Motive) model 20-645E5 marine diesel engines, each developing 3,500 hp at 900 rpm through Falk model 35-MR-48 horizontal offset reverse and reduction gears. A St. Louis ship-designed skin-cooling system is utilized for cooling the engines.

Two Avondale stainless steel five-bladed 114-inch-diameter propellers turn in stainless steel-lined kort nozzles. Two steering rudders and four flanking rudders are driven by four Webster Electric Pumps which activate a powerful four-cylinder hydraulic system.[36]

Port Facilities and Cargo Handling

Previous discussion has established that due to increased consumer demand, imports and inter- and intra-state commerce of all types of goods has risen. To reduce the marginal per ton mile transportation cost, cargo is moved on increasingly larger ships. When these huge ships discharge their tremendous capacity at one time, cargo processing problems arise.

Handling of cargo, loading and unloading of barges, and the processing of commodities from the barges to warehouses or other transportation media are usually performed in the port and harbors. The continuous growth of barge size and capacity not only necessitated larger and deeper ports, but facilities employed to lift, roll, push, and pull the increasingly larger volumes of goods had to be improved.

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[36] The Waterways Journal Weekly, September 16, 1972.

The main objective for efficient preparation, and expeditious movement of cargo is to accelerate rapid ship turnaround. To accomplish this objective, time saving processing methods must be utilized. Increasing the size of the cargo unit being handled reduces the frequency of repetitious procedures. Maximizing equipment efficiency can be achieved partially through standardizing the equipment and making it more flexible.[37] Safety considerations to reduce the loss of life and equipment through accidents are also vital to efficient port operations.

One of the newest concepts in cargo handling that have been advanced for reducing costs of moving and processing is the movement of solids in liquid form. This procedure will involve the conversion of iron ore, for example, into a 70 percent ore base slurry-water mixture at a mine site.[38] Once pumped on board a specially equipped barge or tanker, excess water is decanted, leaving a concentrate with over 90 percent solids. This procedure would eliminate loading and discharge cranes to include elaborate docking arrangements and shore-side steel mill facilities.

With respect to pollutants, the system eliminates contaminants such as dust found around loading facilities. Transfer losses of ore due to dust can run from one-half to one percent.[39]

To accelerate processing of heavy and large bundles, unitized and pre-palletized cargo, loose packages, and containers, specialized equipment was built for the respective types of packages.

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[37] Port and Harbor Development System, op. cit.

[38] Surveyor, February, 1973.

[39] Ibid.

Roll-on and roll-off loading techniques require that the particular vessels to be loaded have side or end doors through which vehicles may be driven.

Some superbarges have attained a certain degree of independence since they are able to discharge their cargo with cranes and hoists organic to the barge. This, of course, improves port operations in that wharfside cranes can be used to unload other more dependent barges and ships

Wharfside cranes have been made mobile by mounting them on tracks. This flexibility in addition to their tremendous capacity and lifting power make these cranes invaluable to effective port operations.

Other port equipment includes various forms of forklifts, straddle carriers, and portable conveyors.

A floating pneumatic elevator used for loading and discharging barges of grain is also used extensively.

The prime goal for all modes of transportation is to move cargo. To stratify or vertically separate these modes, a new concept in cargo handling called "Trans-Port" was introduced. Trans-Port will create separate lanes for each mode of transportation with a common terminal facility, and will facilitate interface at these modes. The Trans-Port tunnel will be placed 100 feet deep along the continental shelf to eliminate interference with deep draft vessels. This technique will provide a submerged tunnel/tube connecting the Trans-Port to land thus making available a dry connection for rail or conveyor systems. This will permit continuous submerged access with the advantage of being operationally independent of weather conditions. It would further establish a continuity in loading operations from the constant flow of commodities from existing terminal facilities. The usefulness of the system becomes apparent in the liquid cargo industry which, by itself, may justify the expense of building such a facility.

Some advantages pertain to unlimited expansion capabilities; a facility that can handle all types of cargo; and noise and air pollution from port and harbor activities would be eliminated. Also, ship turnaround and travel time will be enhanced which is profitable for it minimizes unproductive waiting intervals. Lastly, safety in navigation is enhanced through the elimination of treacherous channel navigation.[40]

All this points to the fact that port development is becoming increasingly mechanized and thus raises the productivity per worker, even though the number of workers hired may diminish. Technology has created a demand for skilled labor to perform specialized tasks in return for higher wages.

[40]Architectural Research Center, Texas A&M University, College Station, Texas.

Shipyards

This larger flow of waterborne commerce previously described had its effect on the shipyards that have to satisfy the constantly rising demand for bigger and better barges.

Marathon Shipbuilding Company which is a subsidiary of Marathon Manufacturing Company of Houston owns several shipyards. Located in Vicksburg is one of the most modern and well-equipped shipyards. Based on 1,000 feet of frontage on nine acres of the Vicksburg Harbor Canal, the covered manufacturing areas include 30,000 square feet in two metal buildings. Materials are handled by seven cranes; the largest crane being the revolving type. Rated at 20 tons, these cranes have the hook on a 40-foot radius. Traveling bridge cranes with 60 feet of clear span run on 300-foot rails. The shop is equipped with lathes, drill presses, milling machines and a key cutter. Marathon's other yard adds to this supply of mechanical equipment with its air compressors and blasting pots for cleaning and painting. A floating drydock measuring 130 feet in length and 65 feet between the wing walls has a capacity of 1,650 tons.

During 1972, the yard launched three towboats, three deck barges and two derrick crane barges. The yard employed 90 workers during this same time period.[41]

Twin City Shipyard, Inc., St. Paul, has an 85,000 square foot facility that is large enough (600 feet long and 400 feet wide) to accommodate four barges at a time in various stages of construction.

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[41] The Waterways Journal Weekly, May 26, 1973.

The yard received orders for 40 barges valued at nearly $5 million and letters of intent for 20 more.[42]

In 1972, Dravo launched a record 302 barges with sales of marine equipment in excess of $55 million. This was equivalent to $20 million over its 1971 record of $35.8 million.[43]

Competition and Costs

Economies of scale in the barge industry have proven to be similar to those existing in the ocean shipping industry. This applies to the building costs, maintenance and construction costs, and performance in terms of cost per ton mile.

Construction of larger vessels requires large sums of capital investments that usually cannot be raised by an individual. Also, the individual operator cannot effectively compete with the larger operators employing superbarges or large tows. Waterborne commerce is highly competitive not only among other water carriers, but also with other transportation modes, especially railroads. In order to meet the challenge, or simply stay in business, assets must be combined and operations must be analyzed and improved.

To demonstrate the competitive nature of barges relative to other means of transportation, Figure 18 depicts the trends of four transportation modes from 1929 to 1970.

A 1963 comparative transport cost comparison reflected statistics shown on Figure 19. The absolute numbers have increased since, but their relative standing remains.

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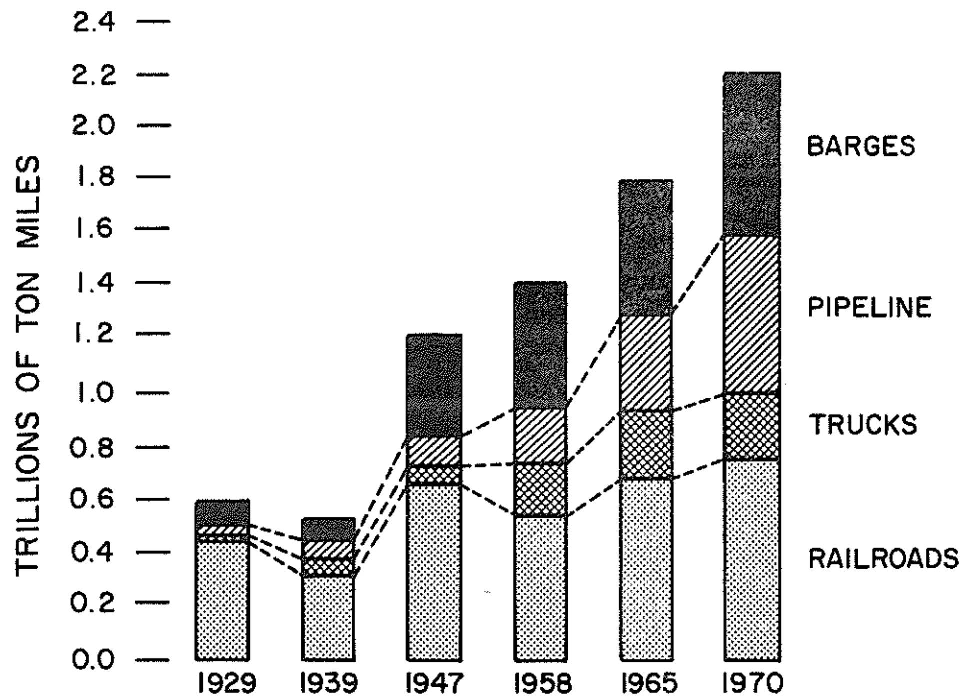
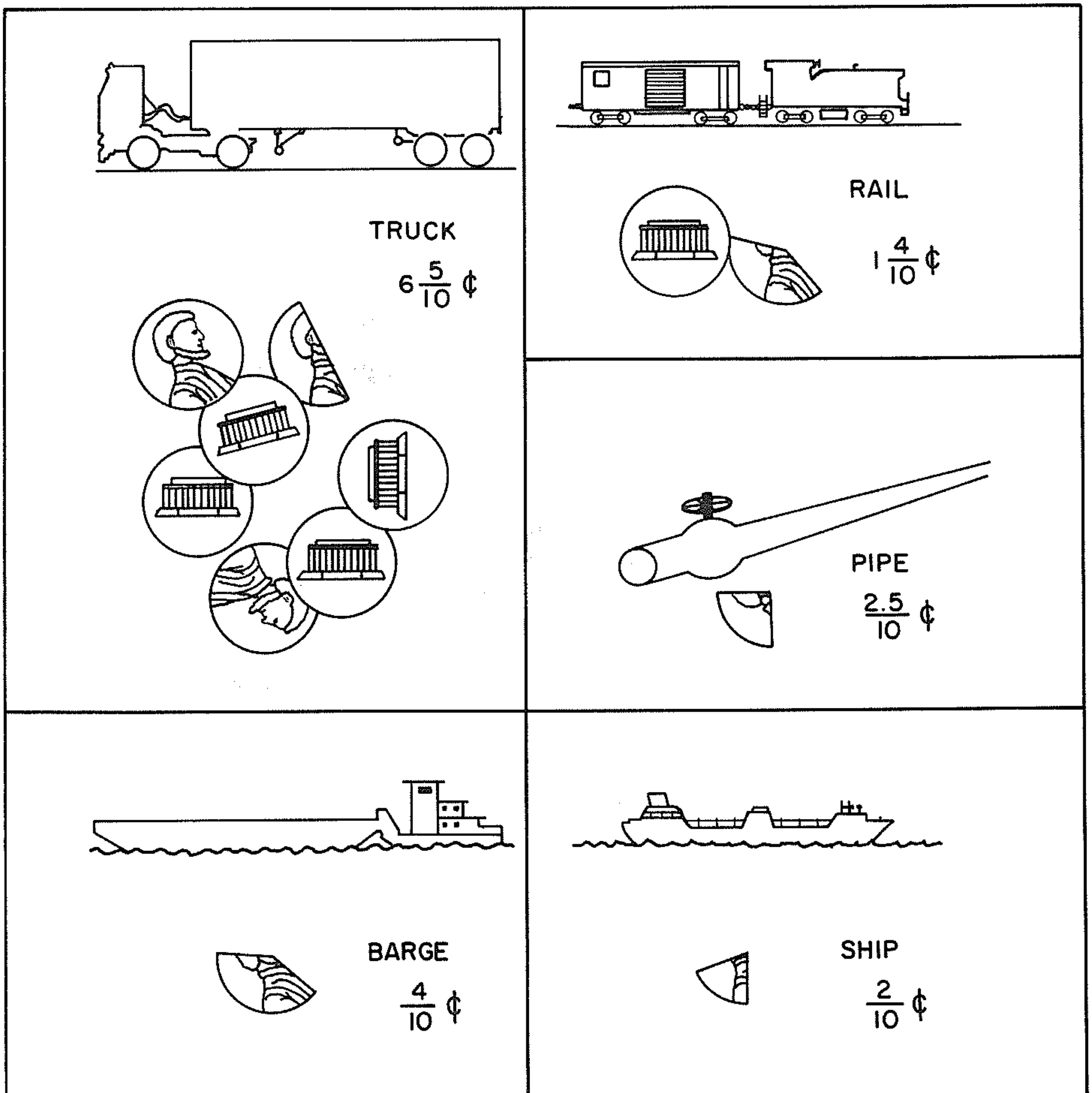
[42] The Waterways Journal Weekly, March 17, 1973.

[43] The Waterways Journal Weekly, March 3, 1973.



RAILROADS : A DECLINING SHARE OF FREIGHT TRAFFIC

FIGURE 18



COMPARATIVE TRANSPORT COSTS PER TON MILE IN 1963

FIGURE 19

Further comparisons reveal a shipper's dollar will move a ton of freight 333.3 miles by barge, 66.66 miles by rail, 15.4 miles by truck and 5.0 miles by plane.[44]

Conclusion

The foregoing briefly described some of the innovations that were developed to enhance the efficiency of barge operations. It should also be realized that these new ideas have generated a sizeable impact on the United States, let alone the Texas economy.

It was illustrated that, beginning with increased consumer demand, the flow of commodities had to increase. To facilitate such movement, inland river systems required expansion to accommodate the new and larger barges. In an effort to attain maximum efficiency, new techniques of building barges and towboats were invented and applied to include new methods of linking barges to form a sizable tow of amazingly large capacities. To satisfy the operators in their demand for the ever increasing and technologically advanced vessels, old shipyards had to be renovated and new ones built. New tools and specialized equipment were created and employed to maintain high levels of productivity.

Resulting from large barge sizes and their newly acquired capacity, cargo handling procedures were reviewed and adjustments made. Again in the form of new instrumentation and mechanical ingenuity, technological innovations evolved to accomplish the task.

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[44] Waterside Plant Locations & Expansions--A Study in Economic Growth, The American Waterways Operators, Inc., March, 1970.

In economic terms, all this was made possible by means of human labor, land and material. Income was generated, sales were conducted, and improvements made while profits were reinvested to bring about the present day barge and towboat industry. Increasing future demands and the implementation of new technologies to maintain or improve the competitive posture of the barge industry obviously are dynamic processes. The health and vitality of our waterways will depend to a large degree on the ability of the latter to react and meet the needs of consumers and industries.

ECONOMIC IMPACT ANALYSIS

CHAPTER VI

ECONOMIC IMPACT ANALYSIS

Introduction

To gain a more complete understanding of the economic impact that the Gulf Intracoastal Waterway has on Texas, the coastal region's economic interdependency with the remainder of the state will be explored.

While the coast is capable of producing a wide range of outputs as exemplified in the previous chapter, it must interface with social and economic contributions from resources outside the region in support of producing activities.

The products to be produced in the coastal zone will depend on the cost of other resources whether natural, human, or cultural. Product demand is directly related to prices and quantities of complementary inputs for production, prices and quantities of final products and other production possibilities open to other areas of Texas.

The Gulf Intracoastal Waterway, as an integral part of the coastal zone, is of extreme importance to Texas. This fact is borne out in Table 24, which reflects the distribution of Texas tonnage shipments by different modes of transportation. It can be observed that water transportation, which is responsible for the movement of 73.8 percent of all goods, serves as the primary mode. Assuming that operators opt to maximize profits and minimize costs, it follows that water transportation must provide more economical service than competing modes. Linkage to a complex inland waterway system affords Texas businesses the opportunity to cheaply transport their goods to many locations throughout the United States in sizable proportions.

TABLE 24

DISTRIBUTION OF TEXAS TONNAGE SHIPMENTS BY MODE

MODE	PERCENT OF TONS SHIPPED	
	ALL COMMODITIES	COMMODITIES OTHER THAN PETROLEUM AND COAL
Rail	11.7	39.9
Motor Carrier	8.4	23.9
Private Truck	6.0	19.9
Air	---	---
Water	73.8	15.9
Other	0.1	0.4
Total	100.0	100.0

SOURCES: United States Department of Commerce, Bureau of the Census, Census of Transportation, 1970; and Texas Transportation Institute, Texas A&M University, College Station, Texas.

This far reaching effect attributable to the inland waterway complex is brought out by the fact that 75 percent of the 14.4 million tons of goods shipped from Texas were designated for points north of Baton Rouge. Almost 60 percent of these commodities were destined for locations as far as Pittsburgh, Chicago, and Minneapolis.[1]

These interstate and intrastate transactions represent sales accompanied by an exchange of dollars and production technology, all

[1] Transportation in the Texas Coastal Zone, Texas Transportation Institute, Texas A&M University, College Station, Texas.

linked by a water transportation system which itself has economic significance. Labor, land and capital initiated the development or expansion of these waterways and will continue to be employed in the construction of tugs and barges and navigation aids such as dams and locks which in turn depend on inputs provided by industries located both inside and outside the respective region. These inputs must be planned, built, processed, integrated and the system managed, utilizing specific techniques and factors.

PURPOSE OF INPUT-OUTPUT ANALYSIS

Several interdependence approaches are available for use in economic impact studies. Regional income studies, commodity flow studies, economic base studies, multiplier studies, industrial location studies, and the interregional input-output approach are the most common. The latter approach identifies and partially evaluates the underlying processes that link together various sectors of the economy.

Primarily its detailed presentation of individual industry production and distribution characteristics, in addition to the nature of interrelationships among industries within different regions, enhances versatility of the analysis for application.[2]

A system of multipliers and interdependency coefficients for Texas was derived by the Office of the Governor, Division of Planning Coordination, to provide an inclusive technique for quantifying these economic relationships.

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[2]Walter Isard, Methods of Regional Analysis, the M. I. T. Press, Massachusetts Institute of Technology, Cambridge, Mass., 1972.

Researchers must be careful in their application simply because different multipliers exist and consequently must be defined before use.

The "final demand multiplier" shows the total dollar increase in output needed from all sectors to support a one-dollar increase in "final demand" for the sector. Its justification for use lies in the fact that it can clarify the likely effect or impact of changing output of a given sector or industry.[3]

"Output multipliers," derived on the basis of interdependency coefficients, reflect the change in economic activity resulting from a one-dollar change in output.[4]

The "personal income multiplier" indicates the increase in personal income resulting from an increase of one dollar in the final demand for the products of a given sector. Personal income includes wages, salaries, profit, interest and rent. Personal income gains are important in evaluating the potential benefits of an industry on the economy of a region.

LIMITATIONS

The technique is limited, however, because of its underlying assumptions which are necessary to retain any manageability for analytical purposes.

In the face of changing technology over time, which affects production processes, plant sizes, and management methods, multipliers

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[3,4]John S. Perrin, "Output Multipliers in Income-Output Analysis" Division of Management Science for Texas Industrial Commission, Office of the Governor, Austin, Texas.

and interdependency coefficients are assumed to be constant. A further limitation should be noted in the use of personal income multipliers which fail to distinguish the magnitude of economic effects between different sectors. Interdependency in an area where 100 new people earn $5,000 annually will certainly vary from one where 25 people make $20,000 each.

The use of these multipliers in an effort to conservatively estimate an economic impact will emphasize the direct effects of water transportation, transportation services, labor, and commodity values of cargo moved on the waterway upon the Texas economy. Additional recycling effects of reinvestment, resale, additional production and other revolving economic activities can be extended to a finite limit with only diminishing marginal value to the final results. They will, therefore, be omitted.

METHODOLOGY

Traditional economic impact studies insert total sales data, local value added, net exports and household income into their input-output model. With the exception of personal income in the form of wages, these traditional data cannot be applied here. Instead, revenues realized from the construction and sales of barges and supporting facilities located along or in close proximity of the waterway will be considered. Calculation will include expenditures on canal expansion and maintenance both in terms of capital and labor costs. Region 8 multipliers will be applied as the representative coefficient for the coastal zone because (1) it is the most active of located with regard to the coast, (3) most goods transported on the waterway either originate, terminate or pass through this particular region, and (4) the input-output model for this region is most comprehensive in that it accounts for more commodity classifications--152 to be exact.

The proportion of port activity due to inland barge traffic will be assessed as a percentage of total cargo tonnages handled by the ports.

Cost estimates per ton of cargo to the port economy calculated by the American Association of Port Authorities (AAPA) will be used to determine the effect of diverse port services.

Based on AAPA figures, total revenues generated by Texas ports was estimated at $2.5 billion in 1970,[5] of which $1.05 billion is attributed to barge traffic on the inland waterway transportation network.

Net imports increase production and processing activities to include inland transportation traffic by barges. Revenues from such imports coupled with the economic influence they generate will be included in a final impact statement.

PRIMARY ECONOMIC IMPACT ANALYSIS

Commodity flow along the Gulf Intracoastal Waterway illustrates the canal's importance to the economy of Texas. According to 1970 Waterborne Commerce Statistics published by the U. S. Army Corps of

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[5] Industrial Economics Research Division, Texas A&M University, College Station, Texas.

Engineers a total of 64,977,040 short tons moved on the waterway either in the form of interstate or intrastate commerce.

A flow of this magnitude encouraged the development of manufacturing and processing plants along this high capacity transportation route to process the large volumes of goods. In response, a few of the economically more significant industries will be exemplified. The Coastal Manufacturing Industry statistics in Table 25 present the number of employees, their payrolls and corresponding impact on the economy.

The table further illustrates the value of shipments and its implied total economic value in addition to similar data for capital expenditures.

Capital expenditures in chemical and petroleum refining will be assumed to represent reinvestments into "industrial processing equipment" (class 78) which lists a multiplier coefficient of 2.08. Chemical and Allied Products cover a broad class of commodities. For simplification and clarity, these goods were assigned under the classification of "chemicals" (46) while "petroleum refining" (52) is a separate class.

Another industry highly reliant on water transportation is the mineral industry. Table 26 depicts the number of establishments, number of employees' payrolls, value of shipments and capital expenditures for three types of mineral extraction industries. In this case, capital expenditures are assumed to take the form of reinvestments in "mining machinery and equipment." Petroleum extraction assumed to be equivalent to "crude petroleum" was assigned the class 17

TABLE 25

COASTAL COUNTY MANUFACTURING INDUSTRY STATISTICS

	INDUSTRY SECTOR	NUMBER OF ESTABLISHMENTS	NUMBER OF EMPLOYEES (Thousands)	PAYROLL ($ Millions)	MULTIPLIER	TOTAL PAYROLL VALUE ($ Millions)
(1)	Chemicals & Allied Products	251	33.2*	318.4*	1.93	614.5
(2)	Petroleum Refining	62	27.3	251.6	1.93	485.6
	TOTAL	313	60.5	570.0		1,100.1

TABLE 25 (cont.)

COASTAL COUNTY MANUFACTURING INDUSTRY STATISTICS

INDUSTRY SECTOR	VALUE OF SHIPMENTS ($ Millions)	MULTIPLIER	TOTAL SHIPMENT VALUE ($ Millions)	CAPITAL EXPENDITURES, NEW ($ Millions)	MULTIPLIER	TOTAL CAPITAL EXPENDITURE VALUE ($ Millions)	TOTAL ECONOMIC VALUE ($ Millions)
(1)	2,850*	1.69	4,816.5	260.0*	2.08	540.8	5,971.8
(2)	5,504.3	1.77	9,748.6	210.6	2.08	438.1	10,672.3
TOTAL	8,354.3		14,565.1	470.6		978.9	16,644.1

* Estimated from census data and questionnaire surveys.

SOURCE: U. S. Department of Commerce, Bureau of the Census, 1967 Census of Manufacturers, Washington, D. C., and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 26

COASTAL COUNTY MINERAL INDUSTRY STATISTICS

INDUSTRY SECTOR	NUMBER OF ESTABLISHMENTS	NUMBER OF EMPLOYEES (Thousands)	PAYROLLS ($ Millions)	MULTIPLIER	TOTAL VALUE ($ Million)
Petroleum Extraction	888	13.9	136.9	1.93	264.2
Non-Metallic Minerals	50	1.0	6.2**	1.93	12.0
Shell*	16	0.9	6.6	1.93	12.7
TOTAL	954	15.8	149.7		288.9

TABLE 26 (cont.)

COASTAL COUNTY MINERAL INDUSTRY STATISTICS

INDUSTRY SECTOR	SHIPMENTS ($ Millions)	MULTIPLIER	TOTAL VALUE SHIPMENT ($ Millions)	TOTAL ECONOMIC VALUE ($ Millions)
Petroleum Extraction	817.5	2.16	1,765.8	2,030.0
Non-Metallic Minerals	33.9	1.56	52.9	64.9
Shell *	18.3	1.56	28.6	41.3
TOTAL	869.7		1,847.3	2,136.2

* 1966 data

** Estimated from available census information and questionnaire surveys.

SOURCE: Bureau of the Census, 1967 Census of Mineral Industries, Washington, D. C. , Alex Kerr, The Texas Reef Shell Industry, Bureau of Business Research, University of Texas, Austin, Texas, and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

multiplier of 2.16 while non-metallic minerals and shell extraction were lumped in the class for "All Other Mining and Quarrying" (19).

In 1970, transportation demands were served by a number of water transportation and service establishments. Table 27 states the number of employees and their payrolls plus the revenues they earned in combination with their respective multipliers. The economic activity that these industries generate is accounted for in the multipliers used to derive the final impact values.

It becomes difficult, if not almost impossible, to separate these revenues into shipping, barge, or deep sea drilling operations according to surveys and interviews with shipyard operators and owners. Among those solicited were Todd Shipyards Corporation, Kelso Marine, Inc., Platzer Shipyard, Bethlehem Steel Corporation, Weaver Shipyards, etc. A more complete list appears in Table 28.

The degree of port and waterway utilization is expressed in Tables 29 and 30 which give the tonnage of cargo received by Texas ports and the tonnage handled over the Gulf Intracoastal Waterway since 1940. To complement this data, Figures 20 and 21 depict the established upward trend in commodity flow which point to the consequential economic reliance placed on the inland waterways by Texas industries. Table 31 indicates the tonnage of port activites at the various Texas ports that is attributable to barge traffic. Of the total 175,389,630 tons of waterborne commerce in 1972, 69,797,480 tons was due to internal movement while 69,075,834 tons came from coastwise movement.

Internal movement refers to the 44.7 percent of the tonnage that originates and terminates in Texas whereas coastwise movements

TABLE 27

ECONOMIC VALUE OF WATER TRANSPORTATION IN TEXAS
1970

	NUMBER OF ESTABLISH-MENTS	NUMBER OF EMPLOYEES (THOUSANDS)	PAYROLL ($ MILLION)	MULTIPLIER	DOLLAR VALUE ($ MILLION)	REVENUES ($ MILLION)	MULTIPLIER	TOTAL VALUE ($ MILLION)
Water Transportation	154	5.5	48.8	1.93	94.18	222.1	2.77	615.22
Water Transportation Services	165	2.9	18.0	1.93	34.74	41.7	3.18	132.61

SOURCE: Bureau of the Census, County Business Patterns, Washington, D. C., and John Miloy and E. A. Copp, Economic Impact Analysis of Texas Marine Resources and Industries, Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 28

TOWBOATS BASED IN TEXAS

NAME OF FIRM	AREA SERVED	OPERATING BASE	NUMBER OF TOWBOATS	AVERAGE HORSEPOWER	TYPE OF SERVICE*
A Line Towing Company	GIWW**	Port Arthur	1	700	E
Alamo Water Transportation Company	Inland Waterways, GIWW	Houston	1	900	E
Allan's Boats and Barges, Inc.	GIWW	Houston	1	330	E
Alvin Marine Service, Inc.	GIWW	Houston	2	1,290	E
American Inland Towing Company	Texas Gulf Coast	Highlands	2	377.5	E
Anderson Petroleum Transportation Company, Inc.	Lower Mississippi & GIWW	Houston	1	600	E
Arthur-Smith Corporation	Lower Mississippi & GIWW	Houston	1	500	E
Bacon Towing Company, Inc.	GIWW	Pasadena	7	449	E
Bauer Dredging Company, Inc.	Gulf and East Coasts	Port Lavaca	31	298	E
Berwick Brothers Towing Company	Inland Texas	Port Arthur	1	330	E
Clary Towing Company, Inc.	Inland Waterways, GIWW	Orange	2	680	E
Coastal Towing Corporation	Lower Mississippi below Memphis, GIWW	Houston	3	1,173	E
Dixie Carriers, Inc.	Mississippi River System, Gulf of Mexico, primarily GIWW	Houston	9	956	E
Dow Chemical Company	Mississippi River System, GIWW	Freeport	1	330	E
G & B Towing Company, Inc.	Gulf Coast	Bridge City	1	380	E
J. S. Gissel & Company		Houston	3	743	E
Gulf-Canal Lines, Inc.	Gulf Coast	Houston	6	1,550	C,E
Heldenfels Brothers	Western GIWW	Corpus Christi	3	323	E
Hillhouse Towing Company, Inc.	Inland waterways, GIWW	South Houston	1	1,000	E
Horton & Horton	GIWW	Houston	5	778	E
Houston Barge Line, Inc.	Mississippi, Illinois, & Ohio Rivers, GIWW	Houston	5	2,152	E

TABLE 28 (Continued)

TOWBOATS BASED IN TEXAS

NAME OF FIRM	AREA SERVED	OPERATING BASE	NUMBER OF TOWBOATS	HORSEPOWER	TYPE OF SERVICE*
Inter-Bay Towing Company, Inc.	Gulf Coast	Houston	1	500	E
Liquid Transfer, Inc.	Inland waterway, GIWW	Channelview	2	930	E
Lone Star Industries, Inc.	Gulf Coast	Houston	5	690	P
Mar-Ray Towing, Inc.	Western GIWW	Houston	2	800	E
Markham & Brown, Inc.	Inland waterway	Dallas	11	500	E
A. G. Middleton & Sons, Inc.	GIWW	Houston	1	330	E
Musgrove Towing Service	Western GIWW	Channelview	1	800	E
Parker Brothers & Company, Inc.	Gulf Coast	Houston	13	565	E
Port Arthur Towing Company	Mississippi River System, GIWW and Gulf	Port Arthur	7	1,430	E
Loyd W. Richardson Construction Corporation	Gulf Coast	Aransas Pass	13	276	E
Rubottom Marine Service, Inc.	GIWW	Ingleside	1	780	E
Sabine Towing & Transportation Company, Inc.	Lower Mississippi & GIWW	Port Arthur	1	1,020	E
Slade Higman Towing Division, Inc.	GIWW	Orange	7	804	E
South Texas Towing, Inc.	Western GIWW	Portland	3	380	E
Stapp Towing Company, Inc.	Lower Mississippi & GIWW	Dickinson	1	1,400	E
J. T. Stellman Transportation Company	Western GIWW	Aransas Pass	2	790	E
TRL, Inc.	GIWW	Houston	1	1,000	E
Texas Gulf Sulphur Company	Mississippi & Ohio Rivers & GIWW	Houston	1	460	P
Wade Towing, Inc.	GIWW	Brownsville	2	1 320	E
Western Towing Company	GIWW in Louisiana & Texas	Houston	6	550	E
Whittredge Towing Service, Inc.	Gulf Coast	Baytown	3	312	E
Yates Towing Service	GIWW	Port Arthur	1	700	E

*C-Common or Contract; E-Exempt; P-Private. **Gulf Intracoastal Waterway

SOURCE: Corps of Engineers, U. S. Army; and Transportation Lines on the Mississippi River System and the Gulf Intracoastal Waterway, 1972.

TABLE 29

TONNAGE HANDLED AT TEXAS PORTS
(Short Tons)

PORTS	1940	1950	1960	1968	1970
DEEP DRAFT PORTS					
Brownsville	201,935	1,141,800	970,361	4,838,193	4,986,243
Port Isabel	321,692	390,723	444,627	326,701	390,489
Port Aransas-Corpus Christi Waterway	14,180,404	21,131,509	24,840,443	28,400,998	30,544,712
Freeport	282,593	3,014,177	3,648,739	4,626,306	5,282,973
Galveston	4,098,371	6,953,452	6,072,922	2,821,873	3.463,152
Houston	27,385,598	40,825,048	57,132,659	57,806,214	64,654,263
Texas City	13,490,722	10,928,572	15,401,847	16,713,495	17.097,411
Sabine Pass Harbor	644,680	857,582	365,282	137,698	278,318
Port Arthur	18,520,456	19,323,487	28,207,396	22,627,804	22,671.406
Beaumont	19,387,986	21,425,323	27.113,480	30.791,856	30,480,706
Orange	65,412	632,299	1,022,784	1,535,167	1.623,431
Sub Total	98,579,939	126,623,972	165,220,540	170,626,305	181,473,104
SHALLOW DRAFT PORTS					
Port Lavaca	--	243,664	2,037,369	5,033,640	4,479,257
Anahuac	41,649	145,445	109,015	137,544	480,805
Trinity River, Channel to Liberty	16,336	30,858	965,416	366,385	344,359
Double Bayou	2,067	29,978	58,261	6,048	6,412
Cedar Bayou	427,796	658,417	227,893	155,985	487,220
Sweeny (San Bernard River, Texas)	--	1,605,308	840,223	1,440,344	530,994
Chocolate Bayou	--	--	--	2,300,617	2,527,999
Palacios	--	86,245	140,844	79,555	98,284
Rockport	--	--	5,701	355	698
Aransas Pass	--	46,563	97,001	16,709	6,528
Port Mansfield	--	--	114,799	20,695	18,004
Rio Hondo-Harlingen	--	650	215,100	357.528	425,242
Long Mott (Guadalupe River to Victoria)	--	--	252,504	1,799,172	1,777,940
Sub Total	497,848	2,847,128	5,064,126	11,704,557	11,194,742
TOTAL PORTS	99,077,787	129,471,100	170,284,666	182,330,862	192,667.846

SOURCE: Waterborne Commerce of the United States, Part 2, 1970, Corps of Engineers, Department of the Army, Washington, D. C.

TABLE 30

TONNAGE HANDLED OVER GULF INTRACOASTAL WATERWAY

GULF INTRACOASTAL WATERWAY	1940	1950	1960	1968	1970
Sabine River to Galveston	6,925,091	14,239,348	24,728,605	42,689,115	42,843,601
Galveston to Corpus Christi	362,205	6,198,624	8,558,825	18,729,357	20,212,427
Corpus Christi to Mexican Border	--	556,081	1,180,138	1,927,713	2,348,252
Sub Total	7,287,296	20,994,053	34,467,568	63,346,185	65,404,280
Less Duplications	- 214,526	-2,242,683	N.A.	N.A.	N.A.
TOTAL GULF INTRACOASTAL WATERWAY	7,072	18,751,370	34,467,568	63,346,185	65,404,280

N.A.--Not Available

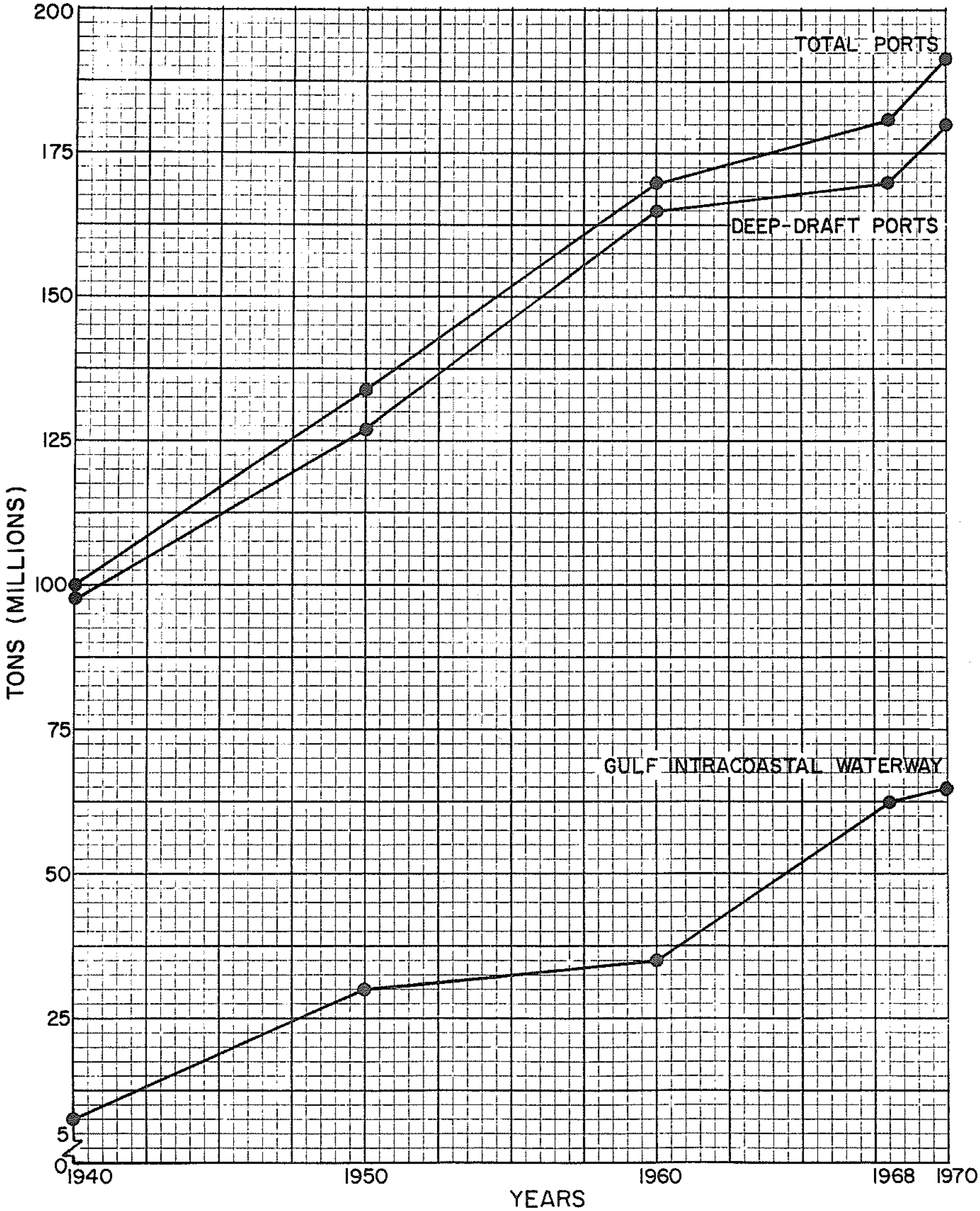
SOURCE: Waterborne Commerce of the United States, Part 2, 1970, Corps of Engineers, Department of the Army, Washington, D. C.

TABLE 31

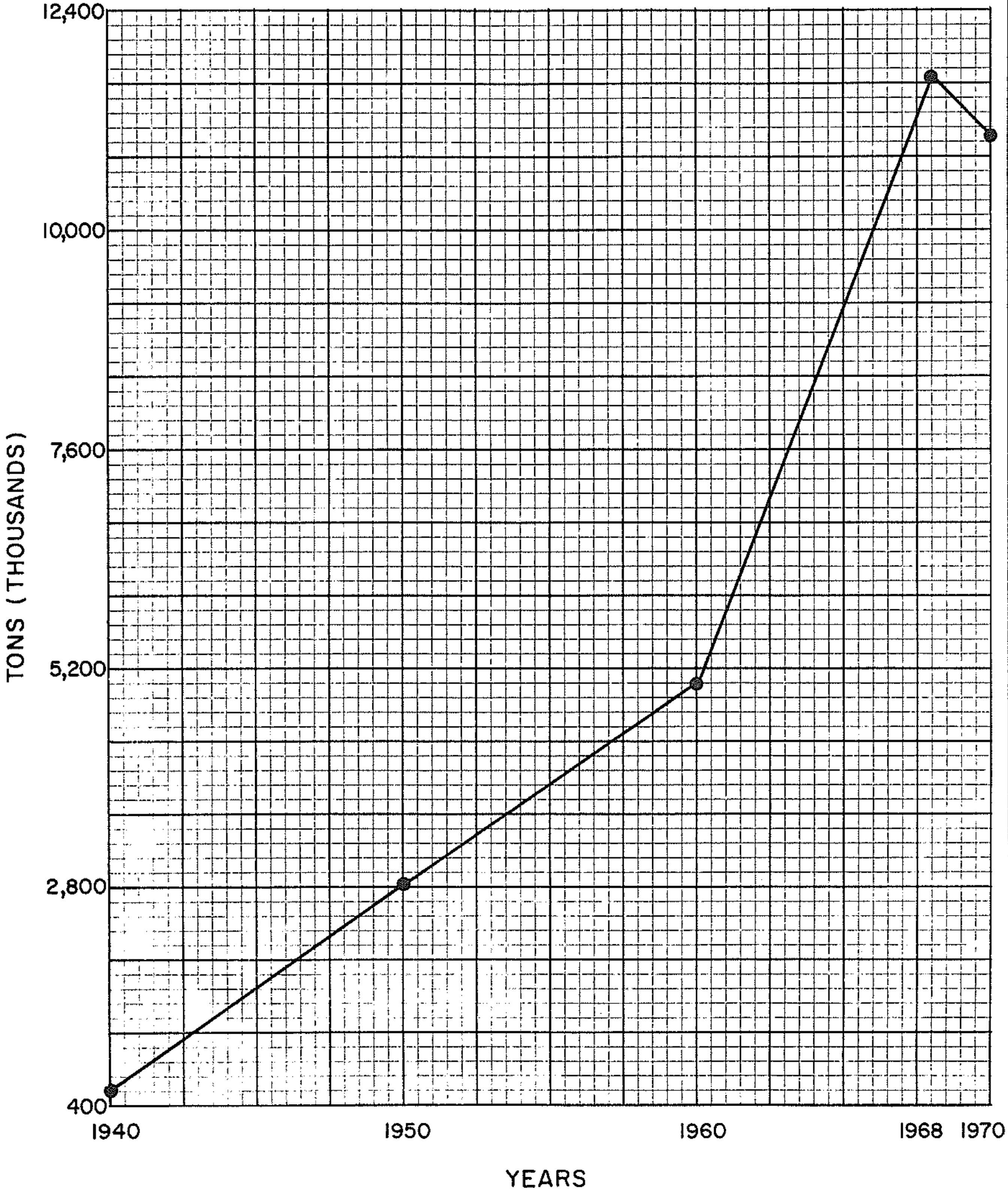
PORT ACTIVITY ATTRIBUTABLE TO BARGE TRANSPORTATION

PORTS	TOTAL PORT (Tons)	INTERNAL (Tons)	COASTWISE (Tons)
Orange	1,623,431	1,470,828	25,974
Beaumont	30,480,706	10,485,363	16,185,255
Port Arthur	22,671,406	6,733,408	13,806,886
Houston	64,654,263	30,322,849	17,198,034
Texas City	17,097,411	10,685,882	5,607,951
Galveston	3,463,152	432,894	595,662
Freeport	5,282,973	2,974,314	1,156,971
Corpus Christi	25,229,045	5,525,161	13,018,187
Brownsville	4,986,243	1,166,781	1,480,914
TOTAL	175,389,630	69,797,480	69,075,834

SOURCE: Texas Waterborne Commerce Commodity Flow Statistics, Texas Transportation Institute, Texas A&M University, College Station, Texas, 1972.



TONNAGE HANDLED AT TEXAS PORTS
1940-1970
FIGURE 20



TONNAGE HANDLED AT TEXAS SHALLOW-DRAFT PORTS
1940-1970
FIGURE 21

pertains to the 55.3 percent of total tonnage that was shipped from areas outside of Texas.

The barge industry generates a certain amount of barge construction and servicing. Assuming that inland water transportation is accomplished by means of barges only, which is equivalent to 40 percent of total tonnage shipped, this fraction, when applied to water transportation and services, employment, and revenues, will estimate the final economic value attributable to the Texas inland waterway system. Such a calculation points to $19.5 million of household income having a $37.7 million impact. Revenues due to barge operation amount to $88.8 million with a final effect of $246.1 million.

EVALUATION OF PORT CARGO

Each ton of cargo as it arrives at a port creates a number of jobs and generates additional business in the form of handling and storing of cargo, building and servicing of cargo handling equipment, and developing other miscellaneous port facilities to accommodate the flow of commodities.

In 1966 the Maritime Administration published "The Economic Impact of United States Ocean Ports," in which it was estimated that each ton of cargo loaded or unloaded at United States ports stimulates a direct dollar expenditure.

General cargo is by far the most important in terms of direct dollar expenditures. Since 1966, many of the nation's ports have calculated the direct revenue of a ton of cargo to their particular port community. The figures ranged anywhere from $18.00 to $32.00 per ton of general cargo. In the evaluation, the following components and the corresponding revenue figures were identified in Table 32.

TABLE 32

REVENUE COMPONENTS PER TON OF CARGO

COMPONENTS	REVENUE PER TON*
Port and Terminal Expenditures Pilotage, tug hire, line running dockage	$ .92
Government Charges Immigration service, entrance and clearance fees	.03
Labor Stevedoring, clerking, checking, cleaning, carpentering	7.44
Repairs	.03
Supplies Dunnage, doctor, laundry, chandler	1.56
Bunkers Coal, oil, water	.17
Miscellaneous Vessel Disbursements	.18
Port Terminal Income Car loading and unloading, handling, and storage, demurrage	2.42
Rail and Motor Freight Revenue Credited to Area	1.93
Vessel Crew Expenditures in Area	.30
Auxiliary Services Steamship agents, foreign forwarders, customhouse brokers, public warehouse companies, marine insurance companies, foreign departments of area banks	1.23
	$16.21

*1966 figures

SOURCE: "Method of Determining a Port's Economic Impact and Dollar Value of Earnings," American Association of Port Authorities, February, 1970.

Straight line projections, as shown in Table 33, gave the following conservative revenue per ton values for 1966, 1968 and 1970.

TABLE 33

VALUE OF ONE TON OF CARGO TO A PORT'S ECONOMY

CARGO TYPES	1966	1968	1970
General Cargo	17.71	18.46	19.21
Tanker Cargo (Crude and refined)	4.20	4.38	4.57
Coal	2.89	3.02	3.14
Grain	6.79	7.06	7.35
Ore	3.36	3.51	3.65
All Other	1.26	1.34	1.40

SOURCE: American Association of Port Authorities, February, 1970.

The economic impact of each cargo type to Texas ports can be estimated when the per ton cargo values are multiplied by the tonnage of each respective cargo. Resulting values are shown in Tables 34 and 35.

The term "All Shipments" mentioned on Tables 34 and 35 is defined as the value of all tons of cargo transported into each port by all assorted means of waterborne vessels. "Barge shipments" on the other hand, refers to only those shipment values of cargo moved to these ports by barges.

In comparison to 1968 cargo values, increased waterway utilization in 1970 on the basis of rising port activity in both tonnages handled and dollar value, signifies its tremendous economic influence on Texas and the coastal region.

TABLE 34

VALUE OF CARGO TO DEEP-DRAFT TEXAS PORTS
1970

PORT	GENERAL CARGO ALL SHIPMENTS	GENERAL CARGO BARGE SHIPMENTS	TANKER CARGO ALL SHIPMENTS	TANKER CARGO BARGE SHIPMENTS	GRAIN ALL SHIPMENTS	GRAIN BARGE SHIPMENTS
Brownsville	$ 33,297,455	$ 13,318,982	$ 12,019,915	$ 4,807,966	$ 4,505,025	$ 1,802,010
Port Isabel	1,678,830	671,532	1,323,098	529,239	99,792	39,917
Corpus Christi	235,929,423	94,371,769	65,854,947	26,341,979	13,680,950	5,472,380
Freeport	97,733,901	39,093,560	892,591	357,037	---	---
Galveston	52,818,919	21,127,568	157,108	62,843	5,990,017	1,996,007
Houston	902,823,440	361,129,376	55,514,950	22,205,980	37,726,403	15,090,561
Texas City	205,718,989	82,287,595	29,175,991	11,670,396	---	---
Sabine Pass	2,021,882	808,752	790,914	316,365	---	---
Port Arthur	101,921,948	40,768,779	78,386,557	31,354,623	1,567,866	627,146
Beaumont	273,290,012	109,316,005	68,704,756	27,481,903	8,969,920	3,587,968
Orange	39,528,889	11,811,556	202,461	80,985	304,612	121,845
TOTAL	$1,936,763,688	$774,101,094	$313,023,288	$125,209,315	$71,847,585	$28,737,834

TABLE 34 (Continued)

VALUE OF CARGO TO DEEP-DRAFT TEXAS PORTS
1970

PORT	ORE		TOTAL	
	ALL SHIPMENTS	BARGE SHIPMENTS	ALL SHIPMENTS	BARGE SHIPMENTS
Brownsville	$ 35,757	$ 14,303	$ 49,858,152	$ 19.943,261
Port Isabel	---	---	3,101,720	1,240,688
Corpus Christi	7,268,943	2,907,577	322,734,263	129,093,705
Freeport	---	---	98,626,852	39.450,741
Galveston	1,120	448	58,967,164	23,586,866
Houston	1,372,952	549,181	997,437,745	398,975,098
Texas City	15,384	6,154	234,910,364	93,964,146
Sabine Pass	---	---	2,812,796	1,125,118
Port Arthur	---	---	181,876,371	72.750,548
Beaumont	---	---	350,964,688	140,385,875
Orange	1,906	763	30,037,868	12,015,147
TOTAL	$8,696,062	$3,478,426	$2,331,327,983	$932,531.193

SOURCE: United States Department of the Army, Corps of Engineers, and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TABLE 35

VALUE OF CARGO TO SHALLOW-DRAFT TEXAS PORTS
1970

PORT	GENERAL CARGO ALL SHIPMENTS	GENERAL CARGO BARGE SHIPMENTS	TANKER CARGO ALL SHIPMENTS	TANKER CARGO BARGE SHIPMENTS	TOTAL ALL SHIPMENTS	TOTAL BARGE SHIPMENTS
Port Lavaca	$ 82,595,812	$33,038,325	$ 829,914	$ 328,366	$ 83,425,726	$33,370,290
Anahuac	9,236,264	3,694,506	---	---	9,236,264	3,694,506
Trinity River to Liberty	6,826,446	2,730,579	---	---	6,826,446	2,730,579
Double Bayou	123,175	49,270	---	---	123,175	49,270
Cedar Bayou	5,653,925	2,261,570	881,544	352,618	6,535,469	2,614,188
Sweeny (San Bernard River)	5,034,610	2,013,844	1,228,924	491,570	6,263,534	2,505,414
Palacios	1,888,036	755,214	---	---	1,888,036	755,214
Rockport	13,409	5,363	---	---	13,409	5,363
Aransas Pass	112,116	44,847	3,161	1,264	115,277	46,111
Port Mansfield	333,198	133,279	3,012	1,205	336,210	134,484
Rio Hondo - Harlingen	3,781,060	1,512,434	1,043,853	417,541	4,824,913	1,929,965
Long Mott (Guadalupe River to Victoria)	34,000,730	13,600,292	36,516	14,607	34,037,246	13,614,898
Chocolate Bayou	---	---	11,552,955	4,621,182	11,552,955	4,621,182
TOTAL	$149,598,781	$59,739,523	$15,570,879	$6,228,353	$165,178,660	$66,071,464

SOURCE: United States Department of the Army, Corps of Engineers, and Industrial Economics Research Division, Texas A&M University, College Station, Texas.

Expenditures on navigable waterways becomes another source of revenue input to the coastal zone's economic picture. As shown in Table 36, expenditures were divided into new work, maintenance, and rehabilitation. In order to apply related multiplier coefficients, new work has been assigned to class 23, "facility construction." Maintenance and rehabilitation were categorized under "maintenance and repair" class 24. For description of the entire stretch of the Gulf Intracoastal Waterway in Texas, Region 8 multipliers were employed once more.

Although this report primarily concerns itself with the Gulf Intracoastal Waterway, expenditures on the expansion of tributaries which affect barge traffic on the canal, have similar effects on the economy.

A gross gain of $8.0 million was realized by the state's economy from 1970 expenditures of $2.5 million on the Gulf Intracoastal Waterway alone, while expenditures of $19.4 million on tributaries generated a total of $55.56 million.

Again, it must be emphasized that the various inland waterways which feed into the Gulf Intracoastal Waterway must be viewed as integral parts of the Texas water transportation complex. Any changes in the expansion of these will affect the canal. Conversely, consideration of the canal's dependence on the tributaries for the movement of goods further inland is also necessary.

TABLE 36

EXPENDITURES ON NAVIGABLE WATERWAYS IN TEXAS*
(Thousands of Dollars)

	EXPENDITURES 1970	MULTI-PLIER	DOLLAR VALUE
Gulf Intracoastal Waterway			
New Work	5	3.00	15.00
Maintenance	2,523	3.18	8,023.14
Rehabilitation	--	3.18	--
Total	2,528		8,038.14
Sabine Neches Waterway			
New Work	2,824	2.58	7,285.92
Maintenance	1,945	2.00	3,890.00
Contributed Funds	127	2.00	254.00
Total	4,896		11,429.92
Houston Ship Channel			
New Work	2	3.00	6.00
Maintenance	2,807	3.18	8,926.26
Total	2,809		8,932.26
Buffalo Bayou and Tributaries			
New Work	1,087	3.00	3,261.00
Maintenance	136	3.18	432.48
Total	1,233		3,693.48
Galveston Harbor and Channel			
New Work	--	--	--
Maintenance	532	3.18	1,691.76
Rehabilitation	921	3.18	2,928.78
Total	1,453		4,620.54
Corpus Christi Ship Channel			
New Work	--	--	--
Maintenance	1,443	3.18	4,588.74
Contributed Funds	--	--	--
Total	1,443		4,588.74
Brazos Island Harbor			
New Work	--	--	--
Maintenance	572	2.07	1,184.04
Rehabilitation	--	--	--
Total	572		1,184.04

TABLE 36 (Continued)

EXPENDITURES ON NAVIGABLE WATERWAYS IN TEXAS*
(Thousands of Dollars)

	EXPENDITURES 1970	MULTI-PLIER	DOLLAR VALUE
All Others			
New Work	2,405	3.00	7,215.00
Maintenance	1,445	3.18	--
Rehabilitation	--	3.18	4,585.56
Total	3,847		11,800.56
GRAND TOTAL	19,387		55,562.80

*Sum of components may not equal given totals due to independent rounding.

SOURCE: U. S. Army Corps of Engineers, Annual Report, Washington, D. C.

TOTAL PRIMARY IMPACT

The total economic impact of activities directly related to the Intracoastal Waterway in Texas is summarized in Table 37. Of the $1.77 billion which the Intracoastal Waterway directly contributed to the state's economy, the major components are revenues paid by the water transportation industry and the cargo value received by deep draft ports. These two inputs accounted for approximately 86.5 percent of the Waterway's total economic impact. Wages paid by the water transportation services industry afforded the least economic effect with less than one percent of the total economic impact.

SUMMARY

Total economic impact as shown in Table 37 is by no means all inclusive. There are numerous indirect side effects that are

TABLE 37

TOTAL REVENUE AND EXPENDITURES DIRECTLY ATTRIBUTABLE TO THE GULF INTRACOASTAL WATERWAY IN TEXAS 1970

SECTOR	REVENUES OR EXPENDITURES (In Dollars)	MULTIPLIER	ECONOMIC IMPACT (In Dollars)
PORT REVENUE			
Deep Draft Port Cargo Value	--	--	932,531,193
Shallow Draft Port Cargo Value	--	--	66,071,464
DIRECT EXPENDITURES			
Intracoastal Waterway and Tributaries			
New Work	6,323,000	3.00	18,969,000
Maintenance & Repair	12,016,000	3.18	38,210,880
WATER TRANSPORTATION & RELATED INDUSTRIES			
Water Transportation			
Payroll	19,500,000	1.93	37,635,000
Revenues	221,100,000	2.77	612,447,000
Water Transportation Services			
Payroll	7,200,000	1.93	13,896,000
Revenues	16,680,000	3.18	53,042,400
TOTAL	--	--	1,772,802,937

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

impossible to separate in an effort to determine even an approximate economic value attributable to different modes of water transportation. Nevertheless, the importance of the Gulf Intracoastal Waterway in conjunction with its tributaries in the coastal zone and the economy of Texas has been firmly established.

FUTURE ECONOMIC IMPACT

CHAPTER VII

FUTURE ECONOMIC IMPACT

Introduction

The future economic impact of the Intracoastal Waterway in Texas will be determined by future user demand for water transportation. The demand for water transportation is influenced by many interacting variables. The two most important variables pertain to the growth of an industry in the coastal region and the relative cost of competing modes of transportation.

A definite relationship exists between industrial growth in the coastal region and the Intracoastal Waterway, in that the Waterway provides a cheap transportation mode for industrial developers. Concurrently, the growth of major Waterway users, i.e., the petroleum and chemical industries, increases the importance of the Waterway as the region becomes more dependent upon these industries as a source of income and employment.

The relative cost of water transportation to industrial users is an important determinant in the demand for water transportation. Lower rates offered by water transportation relative to other modes attract many shippers. Similarly, as water carriers increase their rates while the rates of competing modes remain constant, customers will search for and utilize relatively less expensive alternate transportation modes, away from water transportation. This holds only if both modes are assumed to provide identical services. Major income from Waterway traffic in Texas is derived from producers of low cost, bulk goods such as petroleum, petroleum products and chemicals. Because of low product cost, its producers are sensitive to changes in transportation costs. Small changes in the cost of water transportation could cause a shift to other transportation modes, relocation closer to major markets, or reduced production.

Several factors may force an upward movement of transportation rates in the future. Perhaps the most important determinants of freight rates are (1) the cost of production factors to transportation industries, and (2) efficiency of the industry. Both factors influence the cost of transportation and thus affect the supply of transportation services.

Presently, water transportation has a competitive advantage over other modes in the form of publicly financed waterways. The custom of publicly financed waterways dates back to the early days of the republic when the federal government improved inland waterways free of charge to users in order to stimulate economic development. In recent years various proposals on levying user charges were initiated. The railroad industry favors such charges, while the waterways operators have strongly opposed them. Most economists favor the concept of user charges on the basis that government subsidization gives the water transportation industry a natural competitive advantage over other transportation modes. Waterway operators argue that the benefits of low cost water transportation are diffused throughout the economy in the form of lower prices for goods.

Confusion about the overall effect of user charges on the water transportation industry is prevalent. Depending upon the magnitude of the charges, the demand for water transportation would be reduced somewhat; operations of lesser-used waterways would be discontinued.

Efficiency of Operation

Another controlling factor in the cost of water transportation is the efficiency of operation within the industry. This applies not only to managerial effectiveness within the firm, but also to factors such as congestion of waterways and the best possible use of technology. The physical size of a waterway relative to the number of barges which travel on it are key determinants of industry efficiency. Waterway size influences the efficiency of the industry in three ways:

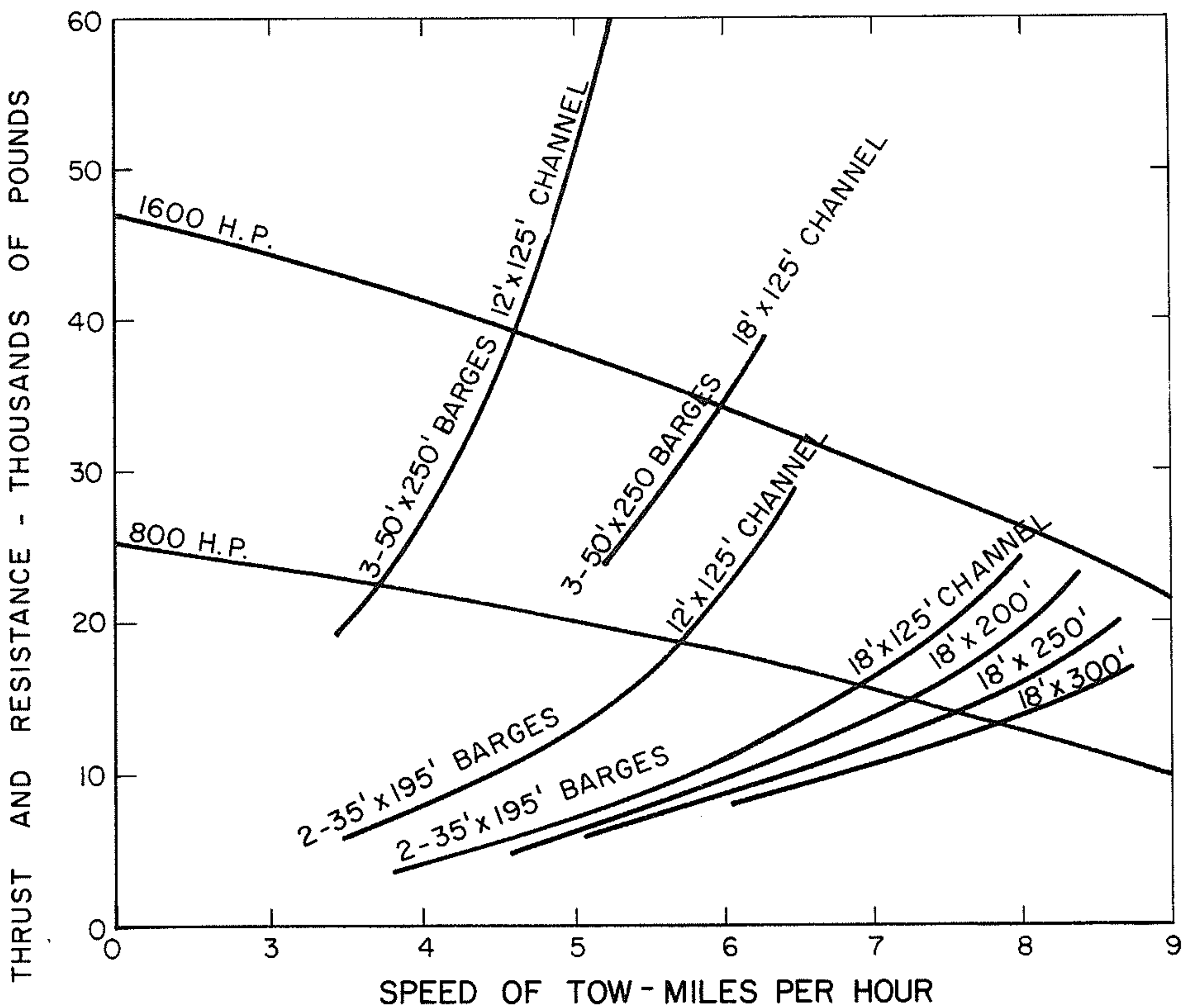
(1) There is an inverse relationship between the size of the waterway and the resistance to the tow. Thus, with a larger waterway, tows can travel at greater speeds. The relationship between tow speed and waterway size is shown in Figure 22.

(2) With a larger waterway, larger towboats and barges may be used, thereby permitting a more efficient use of available technology.

(3) As congestion in a given area increases, the probability of collision or other accidents increases. Increased accident rates reduce a firm's efficiency by incurring higher insurance premiums and more frequent vessel replacement or repair costs.

Forecast Methodology

The future direct economic impact of the Intracoastal Waterway in Texas will be based on anticipated economic activity of primary waterway users.



SOURCE: United States Department of the Army, Corps of Engineers, Economics of Improving the Gulf Intracoastal Waterway in Texas, Galveston, Texas, 1956.

RELATIONSHIP BETWEEN WATERWAY SIZE AND RESISTANCE TO TOWS

FIGURE 22

Major factors determining the future economic impact of the Waterway in Texas and its tributaries are as follows:

(1) Petroleum refining

(2) Chemical industries

(3) Petroleum production

(4) Non-metallic minerals industries

(5) Transportation related undustries

(6) Expenditures on navigable waterways

Future growth rates of the first four components can be determined by a forecasting future demand and supply situation for respective industries. Growth in transportation related industries may be derived from forecasts of foreign trade and future waterborne commerce on the Intracoastal Waterway in Texas. All forecasts are subject to the assumptions that:

(1) No major wars occur;

(2) No major changes in the national economy occur;

(3) No changes in federal policy, such as would be represented by user charges, occur;

(4) No unforeseeable technological developments come into use.

Forecasts

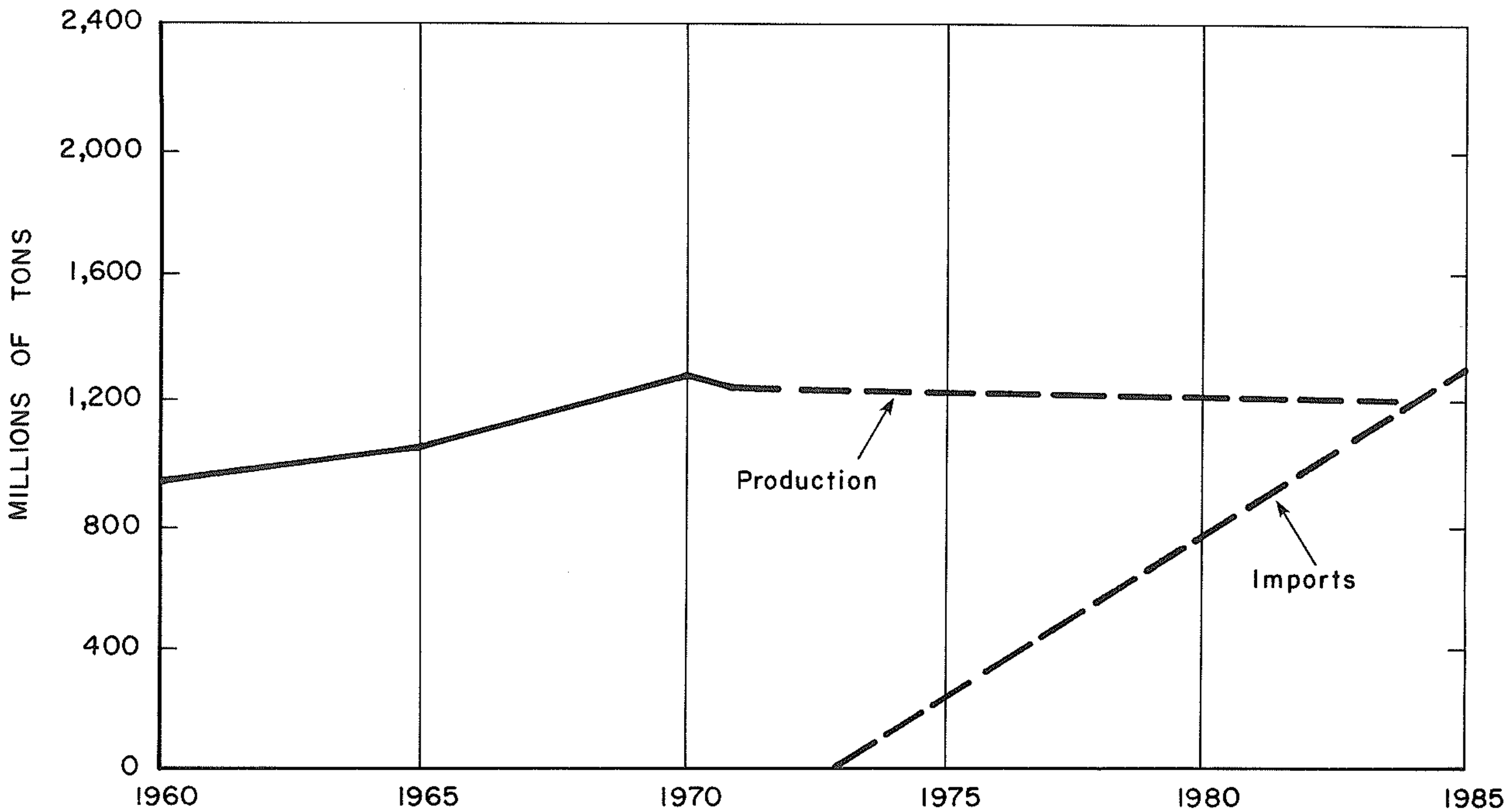
Growth of the Texas petroleum Industry

For several decades, the production of oil and gas has been a major factor in the growth of the Texas economy, accounting for approximately 90 percent of all of the state's mineral production. In addition to their direct economic contribution, these minerals have supported a variety of basic industries by supplying them with either raw materials or energy.

Several factors will determine the future of the state's petroleum industry. The majority of large oil fields in Texas are relatively old, while the rate of discovery of new fields has been declining steadily for several years. Increases in the price of petroleum encourage more exploration and development of petroleum fields in the absence of government interference, but an ultimate decline and eventual depletion of land-based petroleum reserves in the state is evident. The possibility of large unexplored reserves of petroleum on the continental shelf of the Gulf of Mexico exists. Although technology needed to extract the petroleum is available, it is presently too expensive to do so. Although crude oil production in Texas may increase significantly over the short run, overall state production is expected to remain fairly constant through 1985, as shown by Figure 23. The growth rate of the petroleum industry is assumed to be the same in both the coastal region and the State.

Petroleum Refining Growth

Based on past trends, expansion of the petroleum refining industry on the Texas Gulf Coast may be predicted from projected demand and supply functions for refined petroleum in the United States. Historically, the major demand for petroleum products has been from the East Coast, with approximately 40 percent of the national demand, while the Gulf Coast has accounted for only 16 to 19 percent of the total United States demand. In contrast, Gulf Coast refining capacity is approximately 40 percent of the



SOURCE : Bragg, Daniel and J.R. Bradley, <u>The Economic Impact of a Deepwater Terminal in Texas</u>, Industrial Economics Research Division, Texas A&M University, College Station, Texas.

TEXAS CRUDE PRODUCTION AND CRUDE IMPORTS

FIGURE 23

national capacity, while East Coast production accounts for only 12 percent. Because of several negative factors, such as adverse public opinion, restrictive legislation, and a general lack of suitable sites in the East Coast area, present ratios of refinery capacity to refined petroleum demand will probably continue in the future. The forecast given in Figure 24 assumes that the coastal region will continue to handle approximately 87 percent of the state's capacity. It is expected that production in the coastal region will approach 2,100 barrels per year by 1985, corresponding to an average annual increase of nine percent.[1] Although capital expenditures and shipment value should follow this general trend, increasingly large scale operations should cause total employment to increase at a much slower rate of approximately five percent per year.

Growth in the Chemical Industry

Growth of the chemical industry in Texas is largely dependent upon the growth of the petrochemical industry for its supplies of oil derivatives. Petrochemicals are defined as those chemicals derived from petroleum and/or natural gas, excluding fuel or energy products such as gasoline and such materials as asphalt, wax and coke.

A major shortage of petroleum and natural gas feedstocks and increasing demand for plastics, synthetic fibers and other finished goods derived from organic chemicals will affect the future growth

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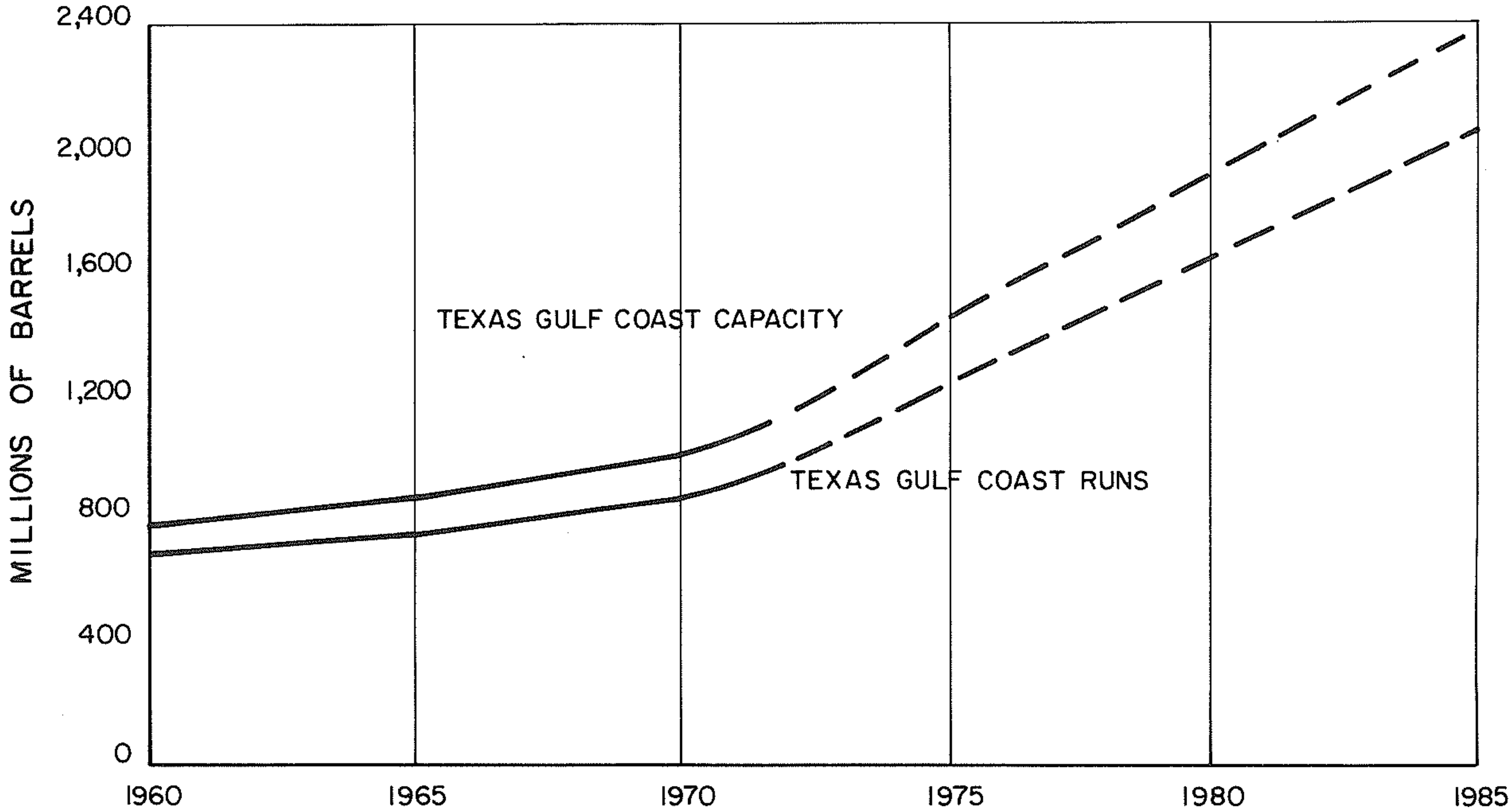
[1] Bragg, Daniel, and J. R. Bradley, The Economic Impact of a Deepwater Terminal in Texas, College Station, Texas: Industrial Economics Research Division, Texas A&M University, November, 1972, pp. 9-13.



SOURCE: Bragg, Daniel, and J. R. Bradley, The Economic Impact of a Deepwater Terminal in Texas, Industrial Economics Research Division, Texas A & M University, College Station, Texas

TEXAS GULF COAST REFINERY CAPACITIES AND RUNS

FIGURE 24

rate of the petrochemical industry. Industry representatives have indicated expectations of slightly higher growth rates in the near future, with 50 percent of those interviewed indicating an anticipated growth rate in excess of six percent per year in production until 1976.[2]

The United States Department of Commerce has forecasted a long term growth rate of approximately seven percent per year for organic chemicals, especially those used in the manufacturing of plastic materials. This forecast seems acceptable in terms of increasingly favorable export markets and the rising use of plastics as substitutes for wood and metal.[3] Employment in the chemicals industry should expand at a considerably lower rate of almost three percent per year, while capital expenditures may increase at an average annual rate of four percent.

Growth of the Non-Metallic Minerals Industry

A diversity of products limits any generalizations about the Texas non-metallic minerals industry. Major non-metallic mineral products such as sulfur, sand and gravel, and salt are used for construction and chemical raw materials. A brief analysis of the three major non-metallic minerals in Texas follows:

Sulfur: Sulfur, a basic chemical to industry, is used in a multitude of manufacturing processes. Manufacturing of fertilizers,

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[2]Ibid., pp. 61-62.

[3]Bureau of Domestic Affairs, U. S. Industrial Outlook, 1972, Washington, D. C.: United States Department of Commerce, 1972, pp. 155-161.

which accounts for approximately 50 percent of total annual consumption, represents the primary process. Salt domes, which are mined by the Frasch process in which heated water is used to produce molten sulfur which is then pumped out of the well, provides a major source of sulfur.

Although future demand for sulfur in the United States is expected to grow, little or no growth can be expected for the Frasch sulfur mined in the Texas Gulf Coast due to increased emphasis on the control of atmospheric pollution. These controls have reduced production of sulfur from "sour" natural gas and from industrial wastes. The low relative cost of raw materials allow sulfur to be sold at reduced rates, forcing producers of mined sulfur to lower their prices to more competitive levels. Increasingly severe sulfur emissions standards reduce incentives for expanding sulfur mining operations.

Salt: Salt is an important mineral commodity, not only for human consumption, but also as a source of the sodium and chlorine necessary in the chemical processing of pulp and paper, the manufacturing of detergents, and industrial chemicals. Salt produced in the U. S. and Texas is recovered by underground mining or by injecting water into salt deposits for subsequent recovery and evaporation of the artificial brine.[4]

The demand for chlorine, a primary salt component, serves as a basic chemical in the production of pulp and paper, solvents and

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[4]MacMillan, Robert T., "Sodium," Mineral Facts and Problems, 1970, Washington, D. C.: United States Department of the Interior, Bureau of Mines, 1971, p. 1201.

plastics and has grown at an approximate annual rate of eight percent for the last 20 years. On this basis, the demand for chlorine should increase about 6.5 percent per year in the United States.[5] National demand for sodium is expected to increase at approximately five percent per year, due to predicted growth of paper and allied products, and industrial and inorganic chemicals industries.[6] Employment in the industry is expected to increase at approximately two percent per year while annual expenditures on capital equipment are estimated to rise above 1967 levels at an annual rate of almost two percent.

Sand and Gravel: In terms of total volume produced, the sand and gravel industry is the largest non fuel mineral producer in the United States. Total available resources are considered to be nearly inexhaustible and are widely dispersed. Because of low per unit value, sand and gravel is usually transported over short distances by truck. Frequently, barges and railroads are utilized where market situations deem them feasible.

Major users of sand and gravel are the construction industries which accounts for 96 percent of the demand, and highway construction with approximately 50 percent of total demand. Total United States demand has been growing at an annual rate of approximately 5.5 percent

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[5] Wright, Arthur L., The Compatibility of Aluminum, Fertilizer, and Chlorine Production With a Texas Gulf Coast Nuplex, College Station, Texas: Industrial Economics Research Division, Texas A&M University, September, 1972, pp. 133-134.

[6] MacMillan, Robert T., op. cit., p. 1201.

for the last 20 years, partially because of the large-scale interstate highway program.[7]

In Texas, the quantity of sand and gravel produced annually has remained virtually constant since 1955 although its total dollar value has increased at about four percent per year. This rate of increase in the total value of sand and gravel is expected to continue through 1985. Total employment and capital expenditures are not expected to increase significantly. Increased environmental and land use conflicts may conceivably create a regional scarcity of sand and gravel, which would increase the total value of production at current production levels.

Summary: An average annual growth rate of approximately three percent per year is forecasted for the non-metallic minerals industry, based on the assumption that salt, sand and gravel, and sulfur are accurate indicators of demand conditions. The total shipment value of non-metallic minerals should follow this general trend. Total wages are not predicted to increase as rapidly in the presence of technological innovations and larger scale operations which tend to increase expenditures on capital equipment and reduce demand for labor. Correspondingly, only a one percent average annual wage rate increase is forecasted.

[7] Cooper, J. T., "Sand and Gravel," Mineral Facts and Problems, 1970, Washington, D. C.: Bureau of Mines, United States Department of the Interior, 1971, p. 1185.

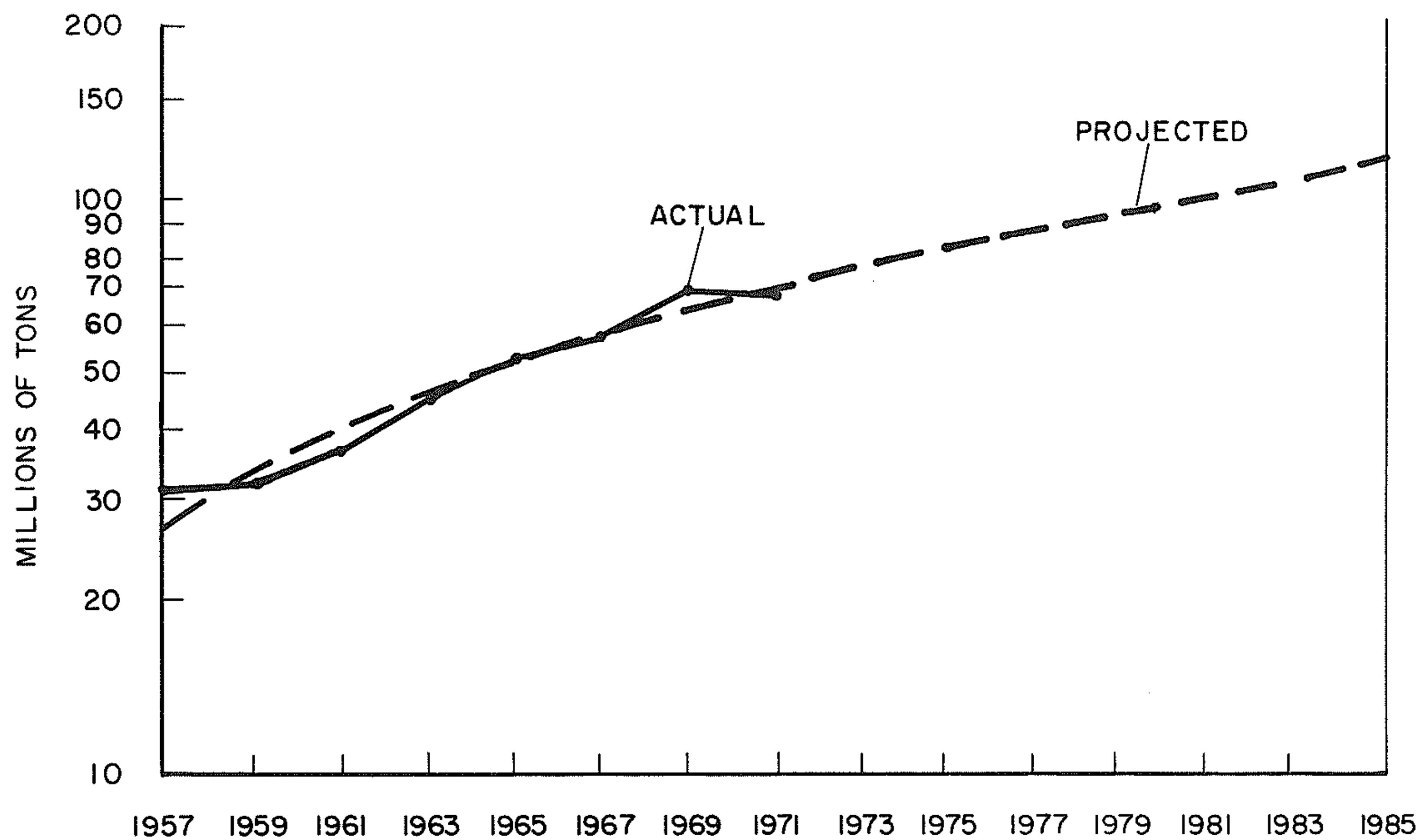
Transportation and Related Industries

Transportation and related industries include such diverse industries as shipping, marine cargo handling, barge building and repair, and port services. Because the growth of these industries is dependent upon the growth of waterborne commerce, it is assumed that the growth rates of these industries will equal that of waterborne commerce on the Intracoastal Waterway. The Waterway is also assumed to be expanded and improved as needed to prevent congestion.

As shown in Figure 25, waterborne commerce carried on the Intracoastal Waterway in Texas has grown at a slightly decreasing rate since 1957. The 6.9 percent average rate of growth per year for the years 1957-1963 has decreased to an average annual rate of approximately 5.1 percent for the years 1965 to 1971. A trend line projected to 1985 indicates a rise in waterborne commerce to be transported on the Intracoastal Waterway, up to 111 million tons, which is equivalent to a 4.2 percent annual rate increase.

Future Economic Impact

The forecast of the future economic impact of the industries which use the Intracoastal Waterway, and of the Waterway itself, is based on the assumption that inter-industry relationships will remain constant throughout the forecast period. Application of established growth rates to present economic values estimates the future primary economic impact. Direct economic impact attributable to new work, maintenance, transportation industries and port cargo value is shown in Table 38 as being approximately $2.9 billion by 1985, an increase of over 60 percent from the 1970 level.



SOURCE: United States Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 2, and Industrial Economics Research Division, Texas A & M University, College Station, Texas.

GROWTH OF GULF INTRACOASTAL WATERWAY IN TEXAS

1957 – 1985

FIGURE 25

TABLE 38

FUTURE DIRECT ECONOMIC IMPACT OF THE INTRACOASTAL WATERWAY OF TEXAS*
(Thousands of Dollars)

SECTOR	1970 VALUES	1985 VALUES
New Work	18,969	30,920
Maintenance and Repair	38,211	62,284
Water Transportation		
Payroll	37,635	61,345
Revenues	612,447	998.288
Water Transportation Services		
Payroll	13,896	22,650
Revenues	53,042	86,458
Port Cargo Value		
(Barge Cargo Only)	998,602	1,627,721
TOTAL	1,772,802	2,889,666

* 4.2 percent average annual growth rate.

SOURCE: Industrial Economics Research Division, Texas A&M University, College Station, Texas.

CONCLUSIONS AND FUTURE RESEARCH

CHAPTER VIII

CONCLUSIONS AND FUTURE RESEARCH

Perspective

The Gulf Intracoastal Waterway has served as a major catalyst for industrial growth along the Texas Coast. The low cost transportation enables producers of bulk goods to compete in markets which would otherwise be closed to them because of prohibitive transportation rates.

The types of commodities moving on the Waterway provide an insight into those industries dependent on water transportation for distributing their goods. In Texas, the petroleum, petroleum refining, non-metallic minerals, and chemical industries are by far the most important Waterway users, accounting for in excess of 94 percent of all waterborne commerce. Crude or refined petroleum make up over 60 percent of all waterborne commerce in Texas.

Most of the Waterway users in Texas are located north of the Galveston Bay Region, primarily because this area is the traditional refining and manufacturing center for Texas, and because Houston is the transportation hub for the coastal region. Continued industrial concentration in a relatively small portion of the coastal region may create several undesirable effects on both the immediate area in which they are located and upon the remainder of the coastal region. Traffic congestion in the northern portion of the Intracoastal waterway naturally impedes normal traffic flow below it and thus restrains industry growth in the southern coastal regions. Expanding the waterway north of Galveston Bay may reduce congestion and normalize commodity flow to desired levels.

The Intracoastal Waterway is instrumental in providing Texas industry access to interstate markets, which serve both as sources of supply and as purchasers of goods and raw materials. Heavy industrialization north of Galveston accounts for approximately 87 percent of all interstate shipments and receipts. Although Texas goods are shipped to the Midwest via the Mississippi River System, over three-fourths of all Texas interstate receipts come from either Louisiana, Arkansas, or Mississippi.

New technology has stimulated the use of larger tows at higher speeds to increase the efficiency of barge operations. To achieve economies of scale, barge sizes increased from 900 tons capacity in World War II to a present capacity of over 3,000 tons. The advent of compartmentalized and double-skinned barges reduced probability of spillage and made barges more versatile. They allow a barge to carry different types of cargo in one haul. Improved barge design, propulsion and steering systems to include a more effective and reliable barge linkage system have raised operational efficiency.

The Intracoastal Waterway of Texas contributes to the economy. Directly, it creates jobs and dollars resulting from expenditures for maintenance and expansion, transportation and related services, and by transporting cargo into the various ports along the Texas coast. These expenditures directly attributable to the Waterway add up to an economic impact of nearly 1.8 billion dollars. A brief examination of several industry groups using the Waterway in Texas indicates an annual indirect economic impact in excess of ten billion dollars. Such a figure is conservative; a comprehensive survey of Waterway industries would provide a considerably higher total.

FUTURE RESEARCH

This report furnishes an overview of the effect of the Texas Gulf Intracoastal Waterway on Texas and provides a general concept of its importance to the Texas economy. Many questions relating to the Waterway remain unanswered, and their analysis would require entirely new studies. Some of the areas in which further study is needed are discussed below:

1. Texas must coordinate regional research with Louisiana in order to resolve mutual waterway problems. A case in point is the existence of locks in Louisiana which are serious bottlenecks, restricting commodity flows. Locks are expensive to build and maintain; in addition, they increase transportation costs by reducing tow speed. In addition, the sizes of locks restrict tow sizes, preventing the realization of the economies of scale offered by larger tows. An alternative for serious consideration is a 40-foot seaway channel as proposed by the Louisiana Intracoastal Seaway Association. An interstate compact to evaluate the costs and benefits of a seaway channel may be a logical approach to resolve this issue.

2. Alternative funding strategies for maintenance and improvement of the Waterway need to be developed in order to allocate the financial burden among all beneficiaries. At the present time, the Federal Government is, in effect, subsidizing waterway operators by financing expenditures on waterways. Research is needed which would accurately indicate who the true beneficiaries of water transportation are and these beneficiaries should pay some proportion of the expense of building and maintaining waterways. With a direct economic impact of 1.8 billion dollars, the importance of the Waterway to Texas is obvious. It is also obvious that Texas

should consider the investment of state funds to support and maintain the Waterway.

3. Federal and state actions or policies affecting waterway users must be summarized and their implications examined in depth. For example, it has been proposed that waterway operators be taxed in order to obtain funds needed for operation and maintenance of waterways. The effects of such an action on waterway operators and upon industries which depend on water transportation as a means of getting goods to market are not known at this time.

4. The disposition of discarded waste from dredging must be studied and acceptable means of disposal found. Spoil disposal is a major problem in dredging operations and can constitute a major factor in the cost of dredging. This problem is aggravated tremendously when the spoil comes from a polluted area such as the Houston Ship Channel. Historically, spoil was used to fill in marshy areas, which were then utilized on urban development projects. With the advent of environmental awareness, this method of disposal became unacceptable, as it destroyed valuable breeding grounds for fish and wildlife. In addition, vegetation will not grow on many types of spoil.

5. An analysis of the <u>indirect economic impact</u> of the Intracoastal Waterway in Texas and its neighboring states requires further investigation. The Waterway stimulates the growth of industry by virtue of the fact that it offers a source of inexpensive transportation. In order to make better decisions on matters regarding the Waterway, public administrators need information regarding the importance of water transportation to the economic development of their state. For instance, if the Intracoastal Waterway were shut down, the extent of damage which would occur to economic development is largely unknown.

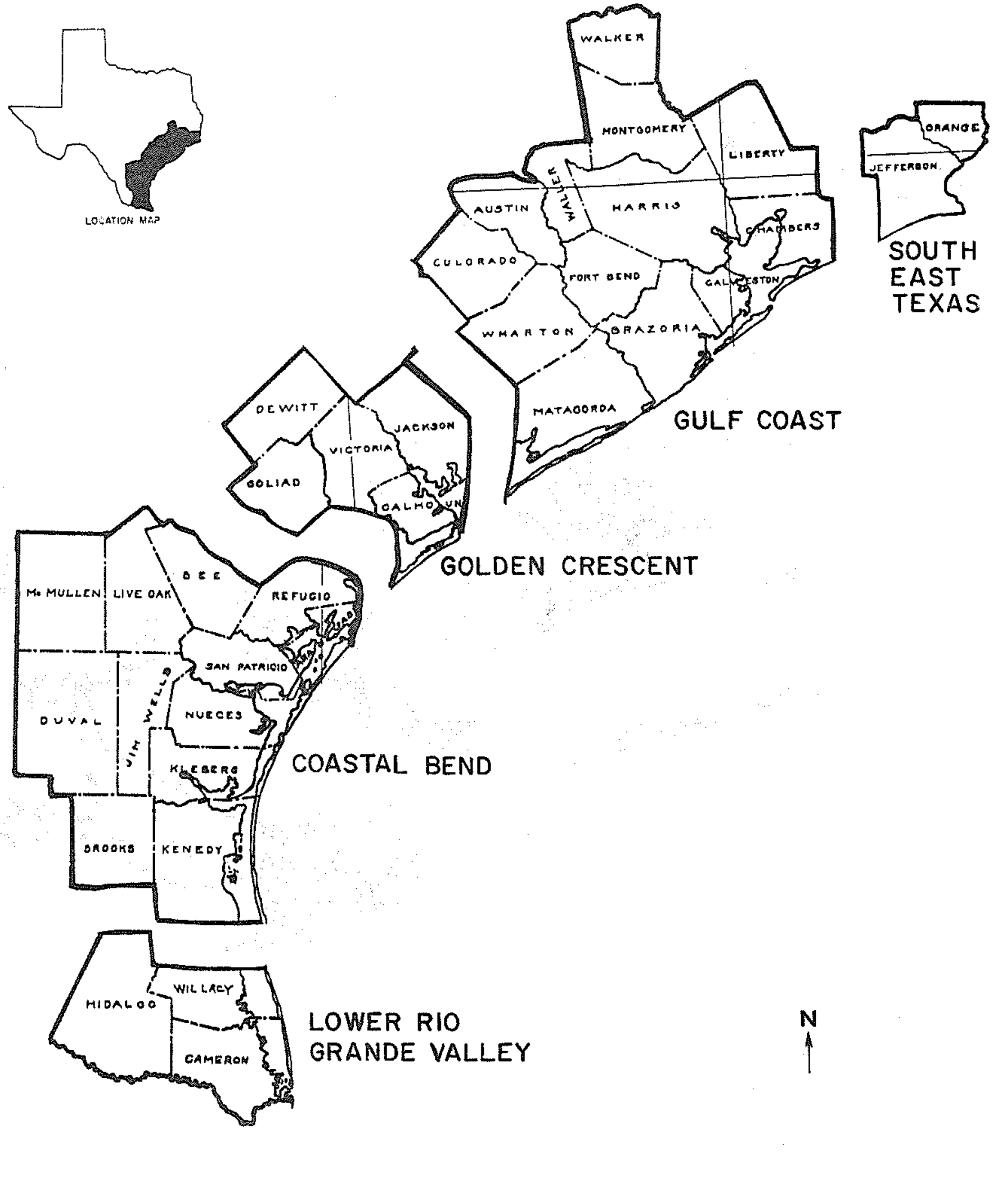
6. Future implications of new technology for barges and tugs in conjunction with the legal limitations must be reviewed. We need to know whether or not it is economically feasible to improve the Waterway in order to take advantage of the many technological developments which have occurred in the towing industry.

7. A systematic approach for the management of land resources in the coastal zone must be established

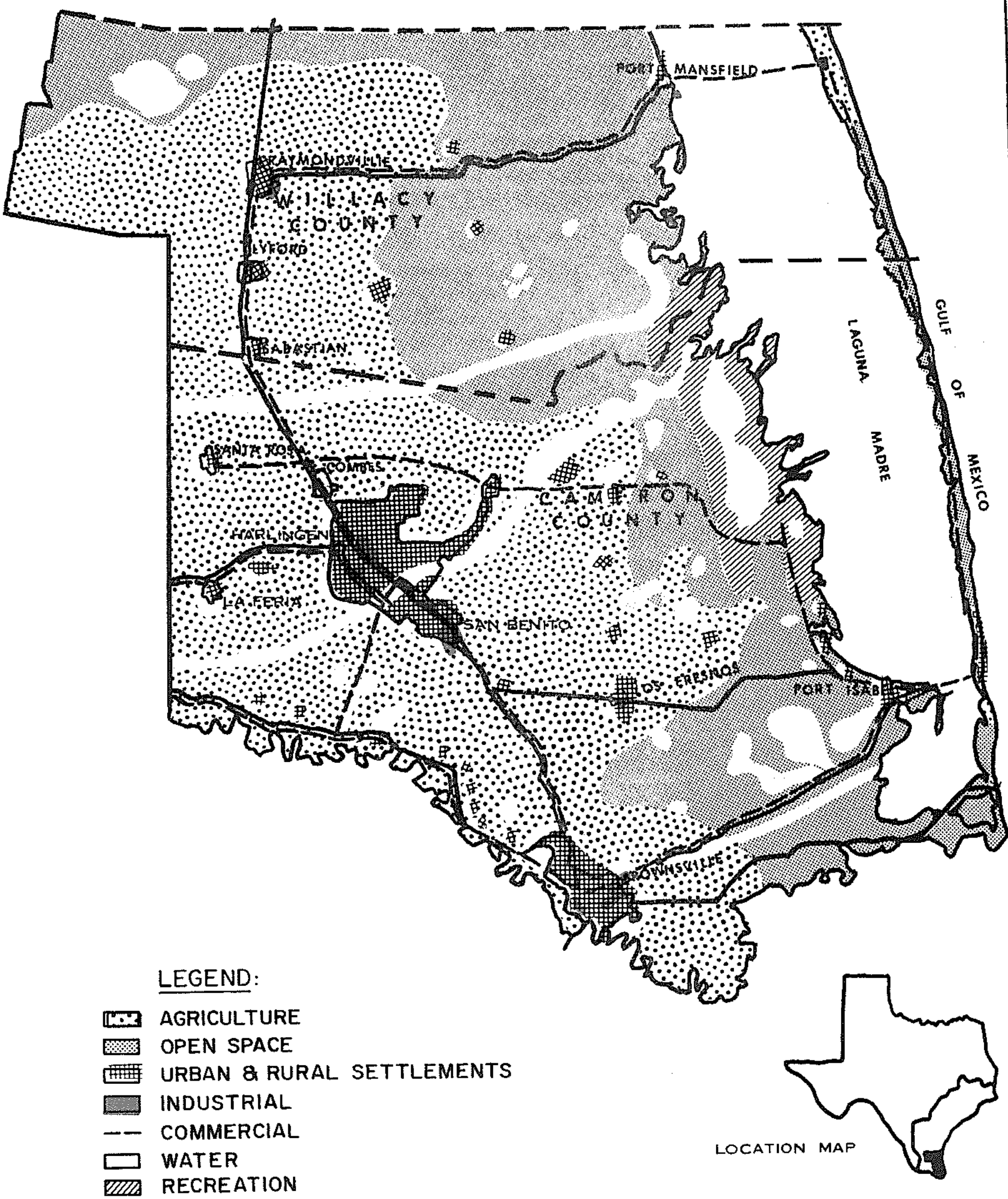
> in order to avoid the destruction of living resources by severe air and water pollution and prevent the urban and industrial problems found along portions of the Atlantic Coast. As has been the case with most states' coastal zones, the Texas Gulf Coast has been developed haphazardly, without an eye to the long-term effects of such development. As a result, portions of the state's coastal zone are heavily overdeveloped, while others are not developed at all. Land which might have been used to better purpose is not now available. The coastal zone must be viewed as a scarce natural resource and its use allocated among the different conflicting needs. In order to do this, a comprehensive, systematic approach is needed.

In terms of commerce carried, the Gulf Intracoastal Waterway of Texas has experienced steady growth in recent years. The 90 percent increase in commodity flow between 1961 and 1971 clearly indicates the waterway's tremendous economic potential. Once dollars become attached to this accelerated growth rate, the public and its policy makers must seriously weigh any and all decisions that may affect the state's great asset.

APPENDIX

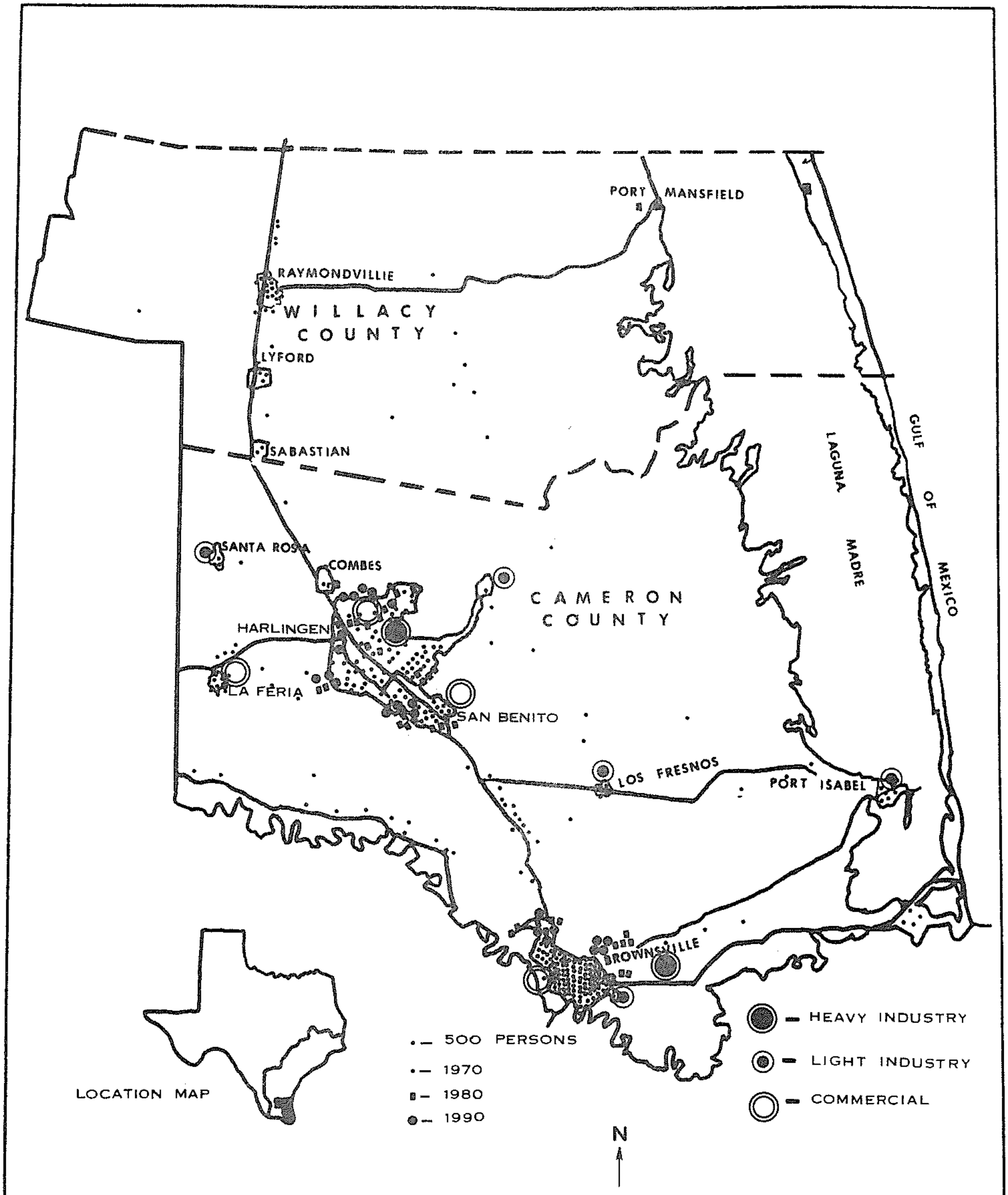


COASTAL ZONE
FIGURE 26

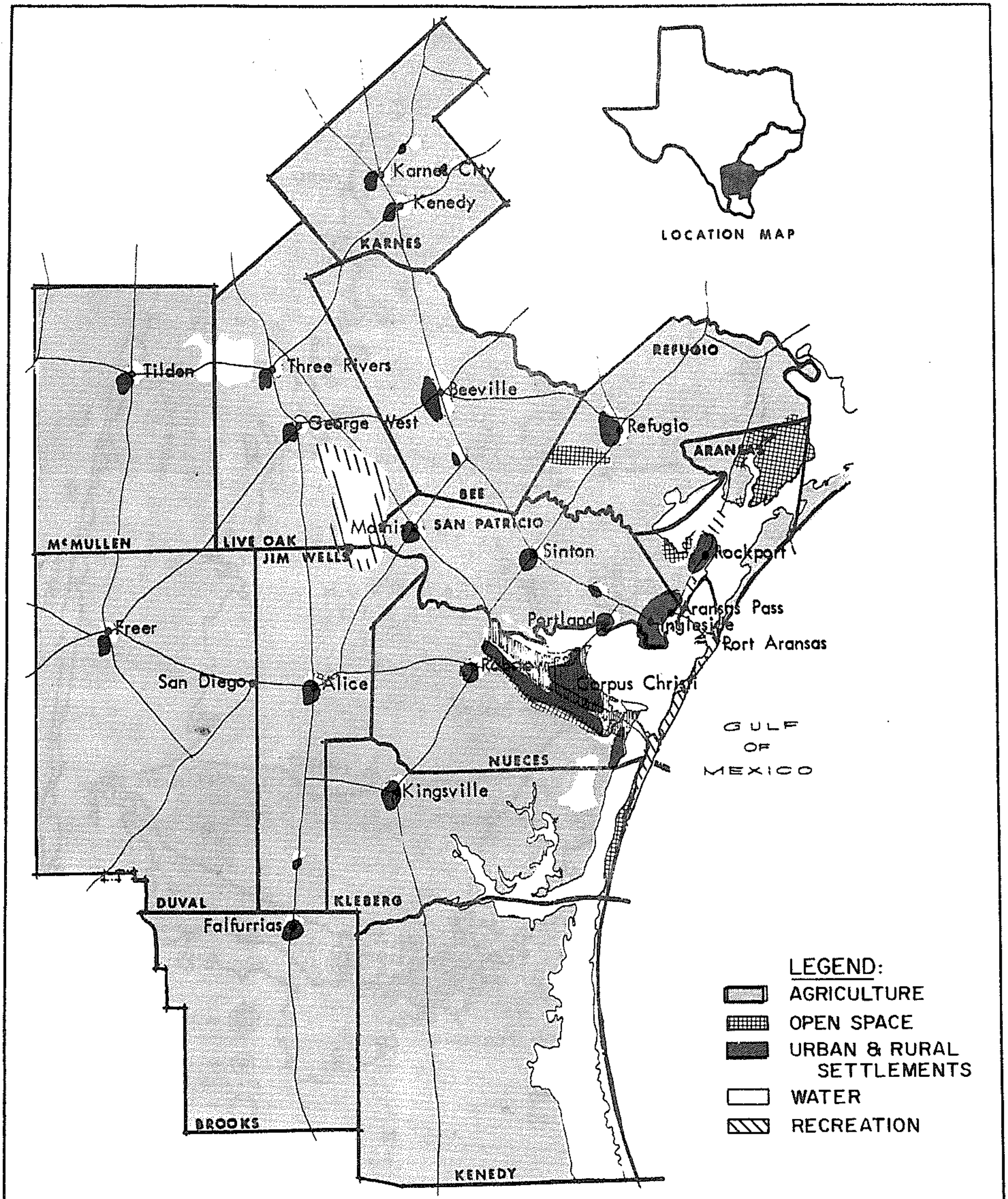


LAND USE IN CAMERON AND WILLACY COUNTY

FIGURE 27

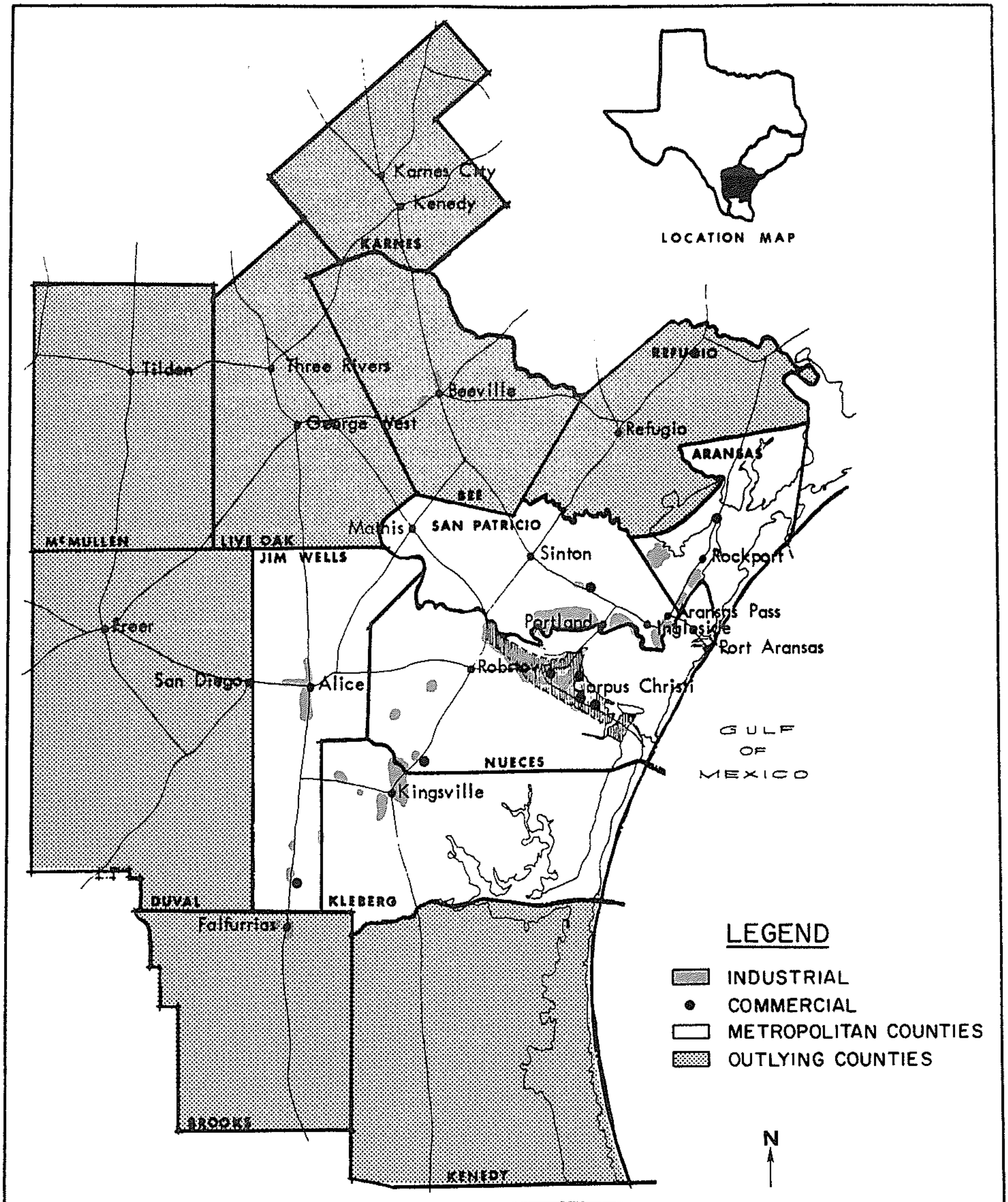


POPULATION DISTRIBUTION IN CAMERON AND WILLACY COUNTY
FIGURE 28



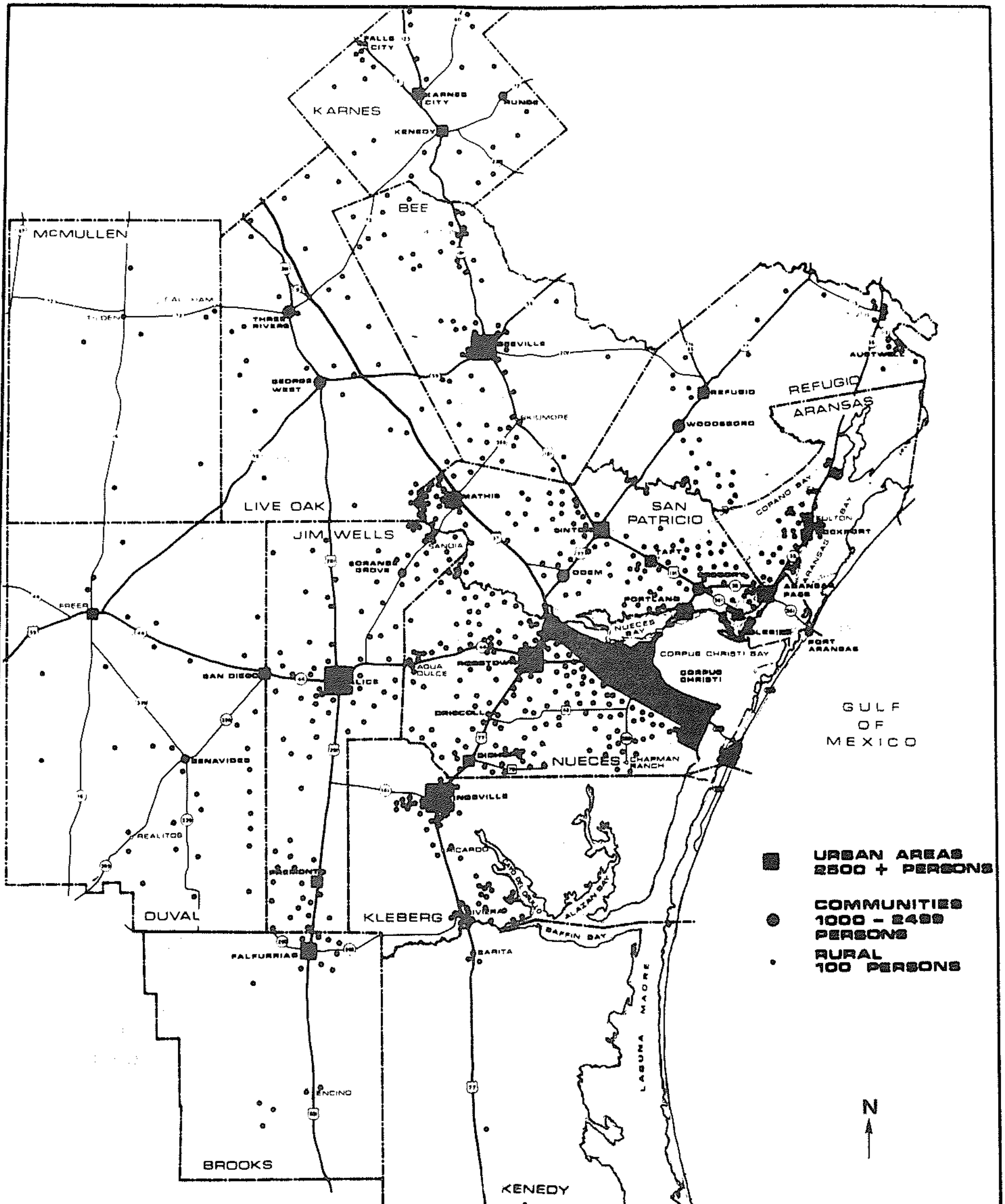
LAND USE IN THE COASTAL BEND REGION

FIGURE 29

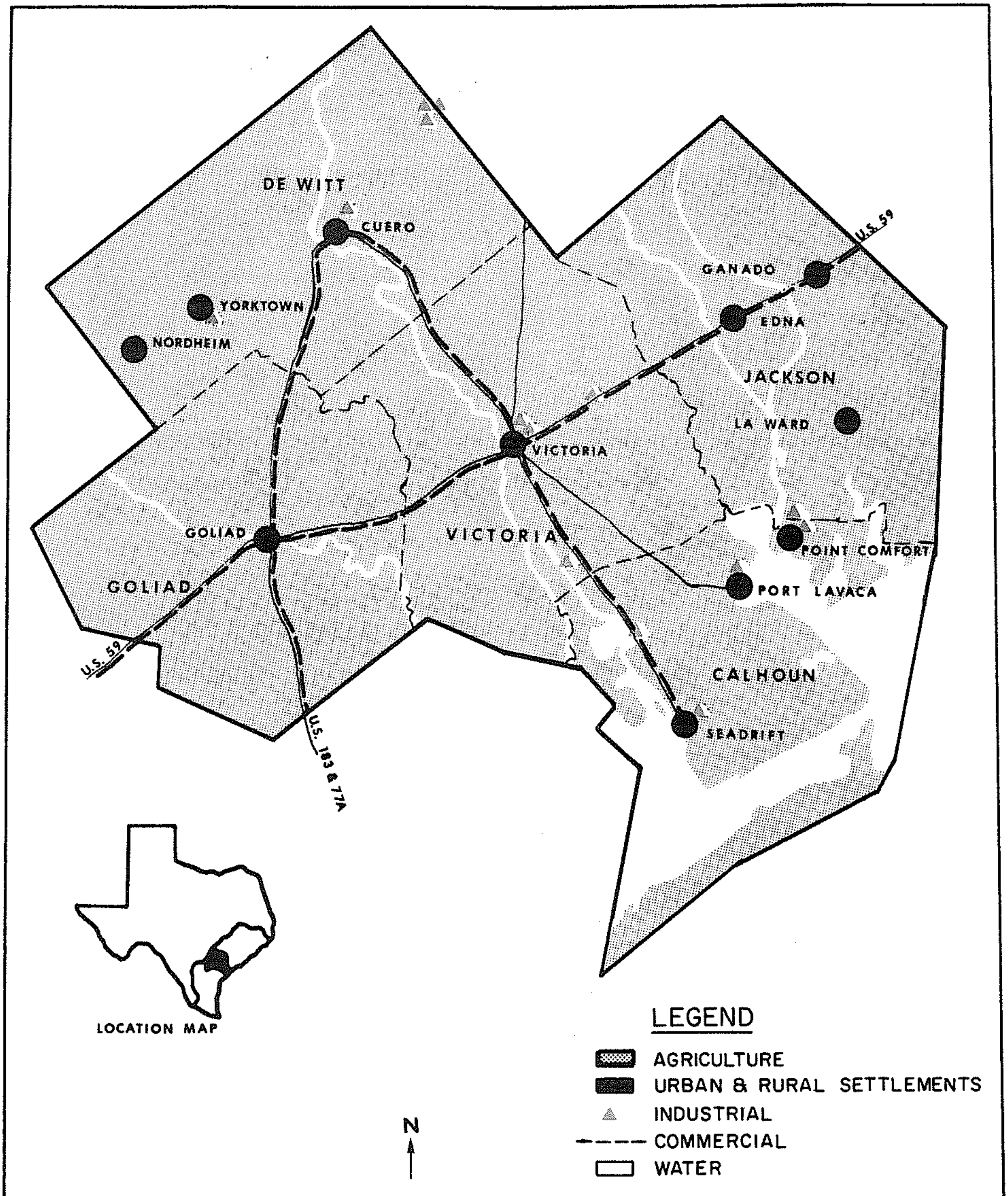


LAND USE IN THE COASTAL BEND REGION

FIGURE 29 (Cont'd)

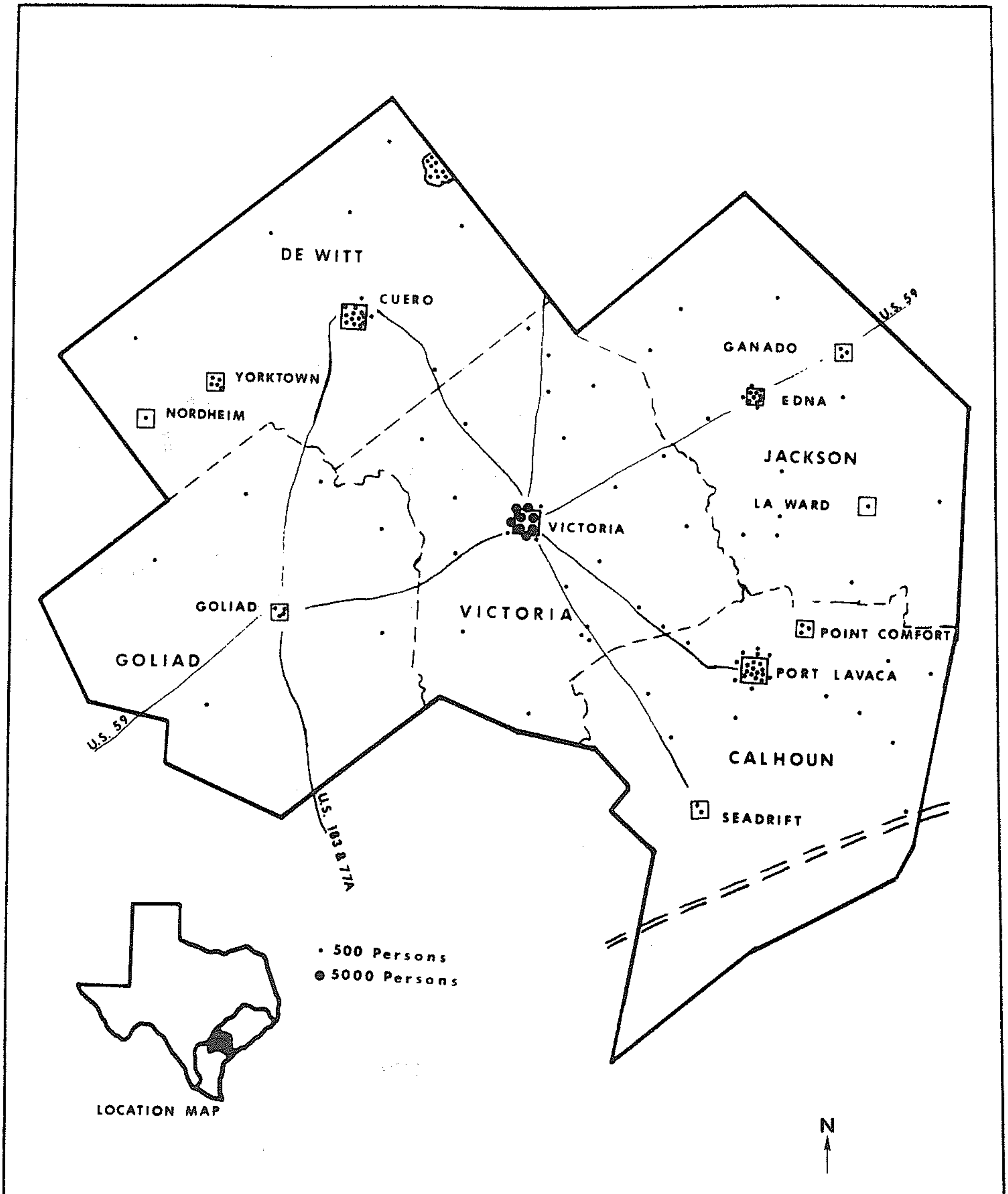


1970 POPULATION DISTRIBUTION IN THE COASTAL BEND REGION
FIGURE 30



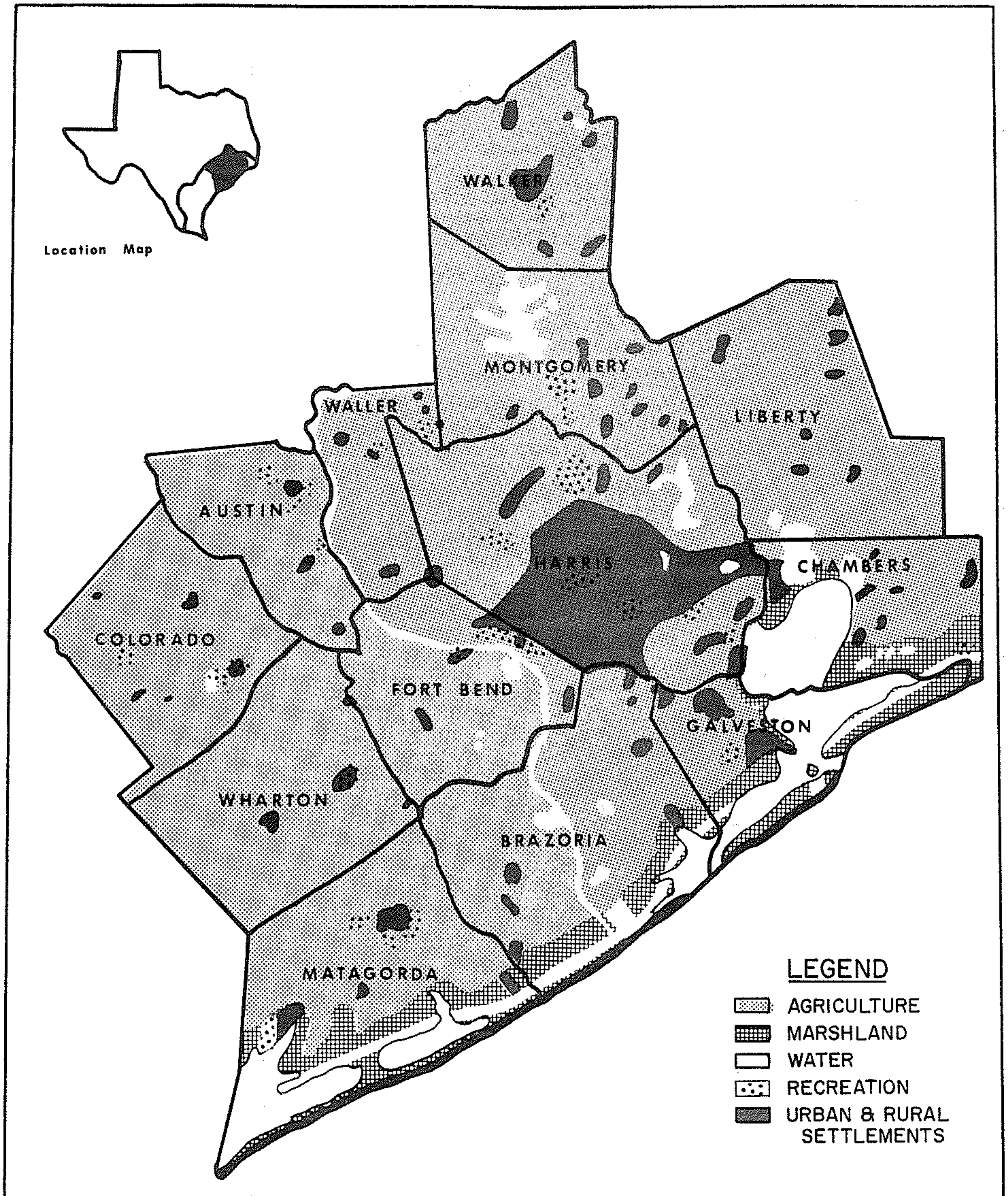
LAND USE IN THE GOLDEN CRESCENT REGION

FIGURE 31



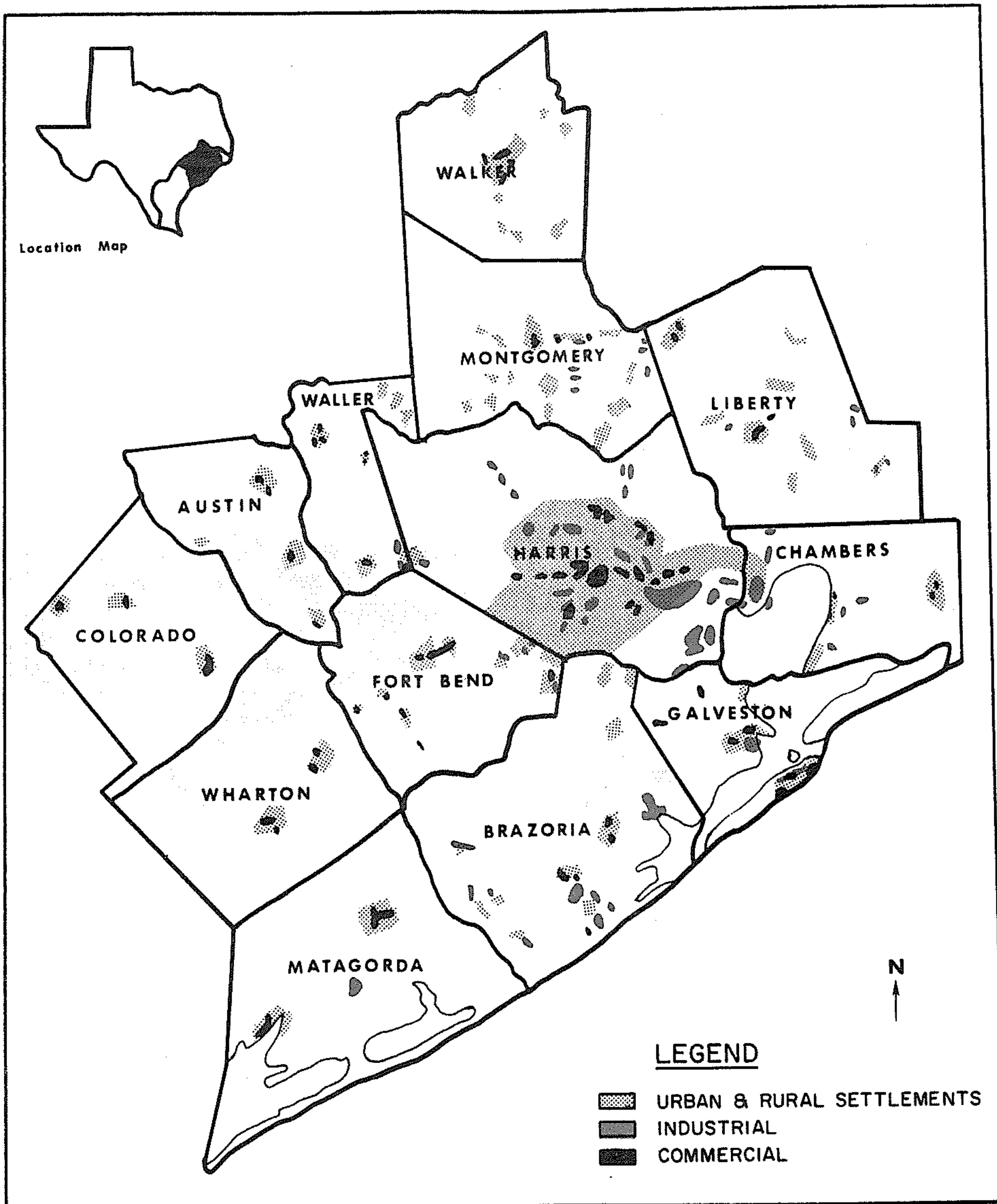
1970 POPULATION DISTRIBUTION IN THE GOLDEN CRESCENT REGION

FIGURE 32



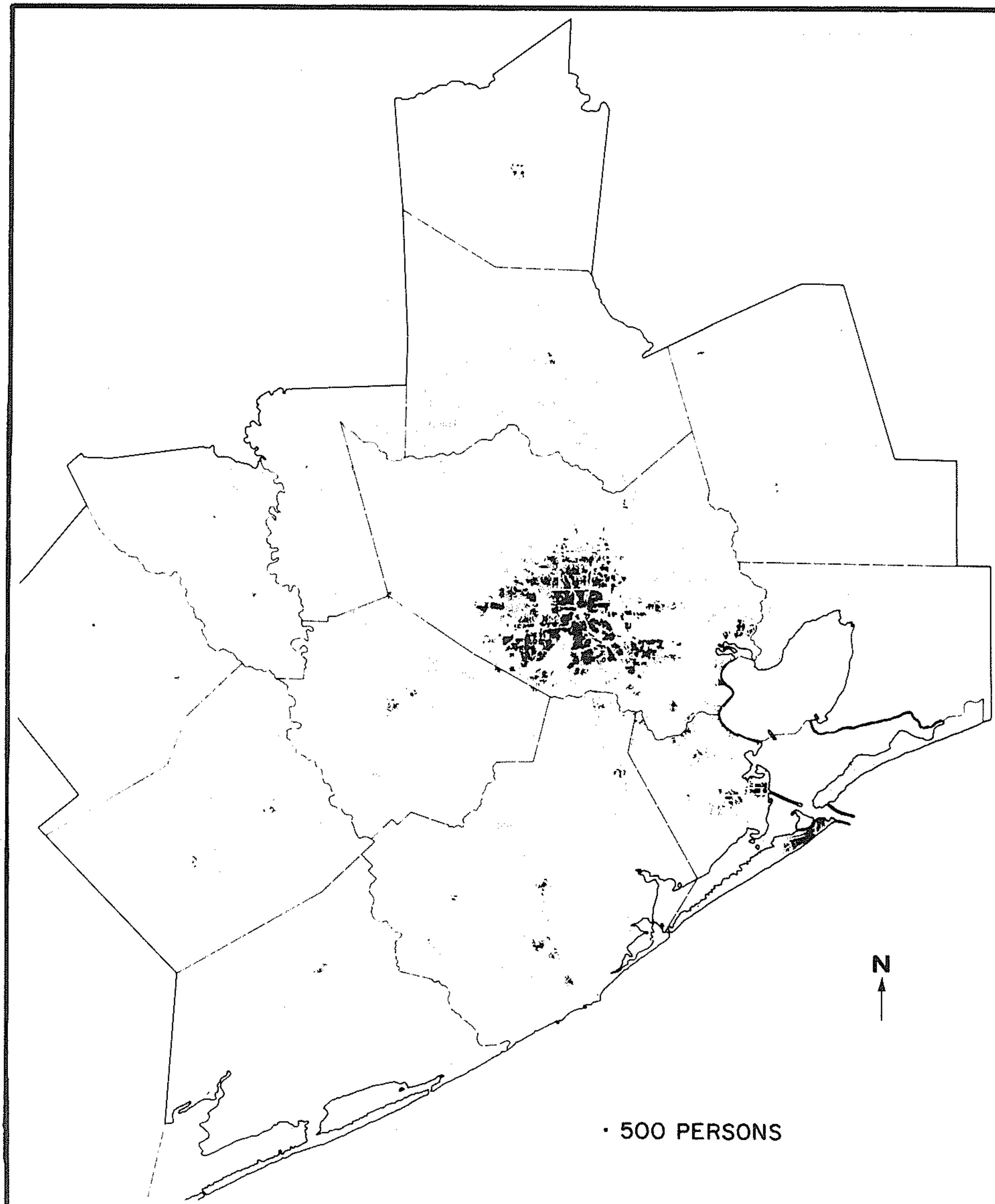
LAND USE IN THE GULF COAST REGION

FIGURE 33

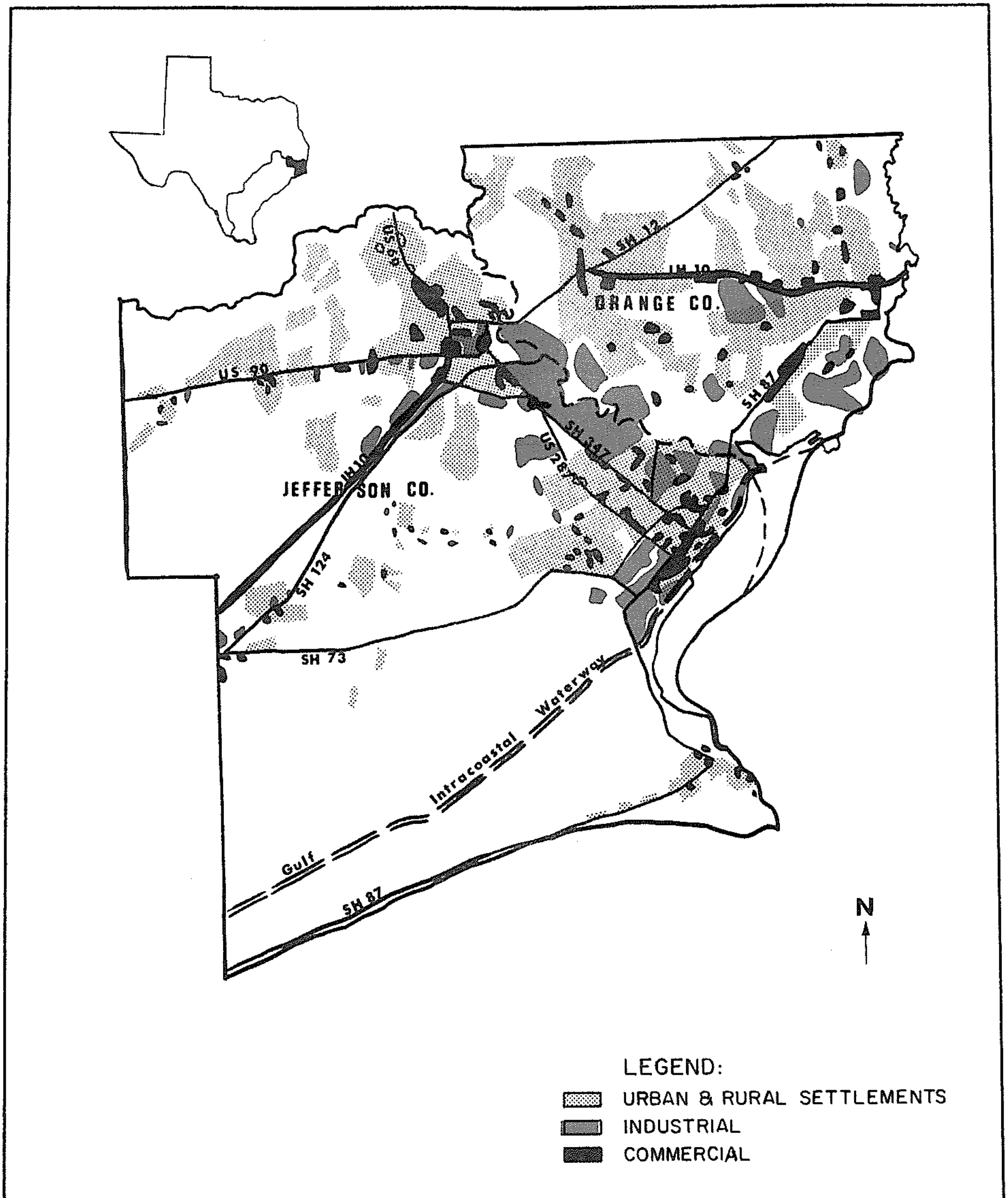


LAND USE IN THE GULF COAST REGION

FIGURE 33 (Cont'd)

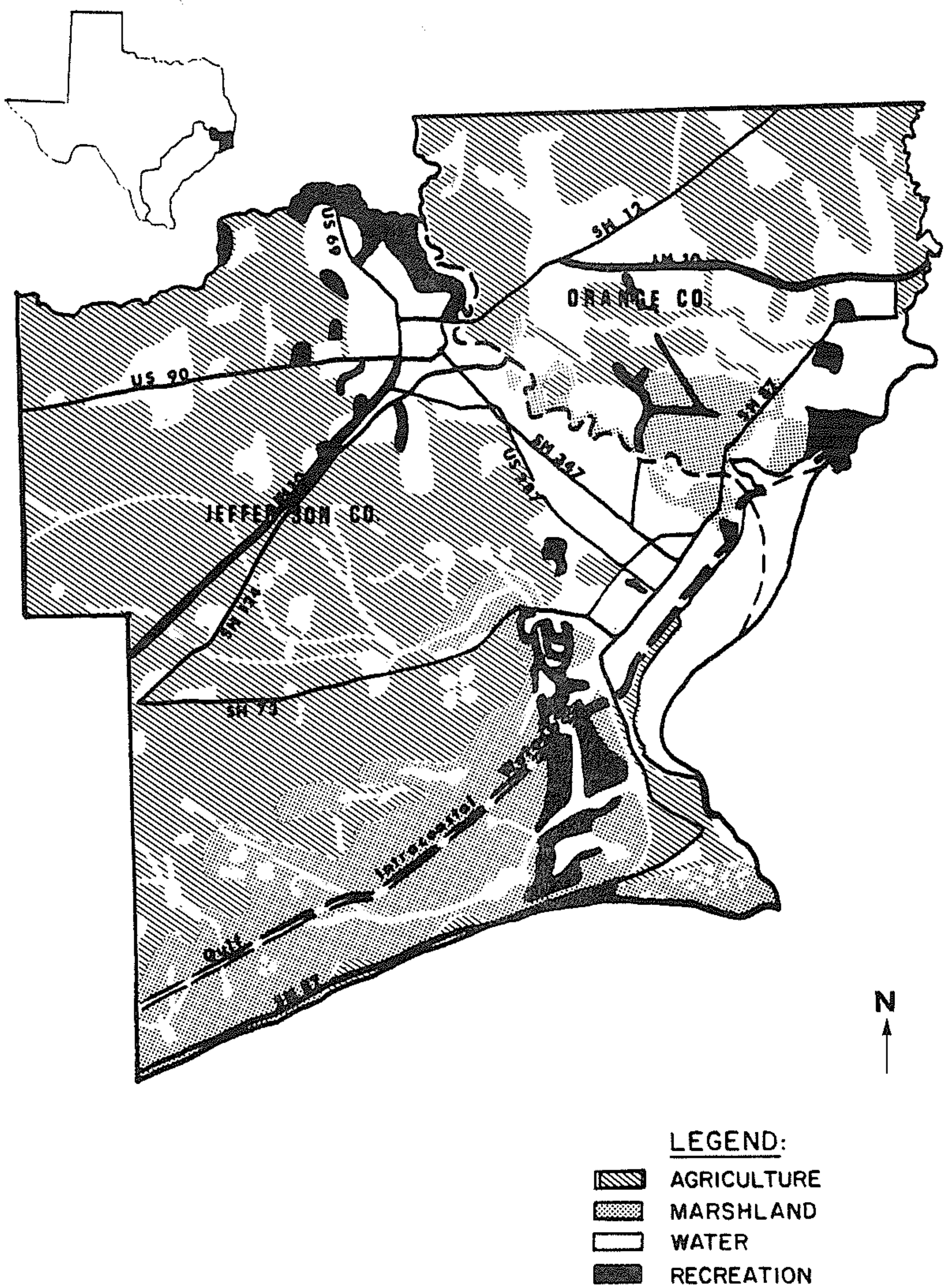


1970 POPULATION DISTRIBUTION
IN THE GULF COAST REGION
FIGURE 34



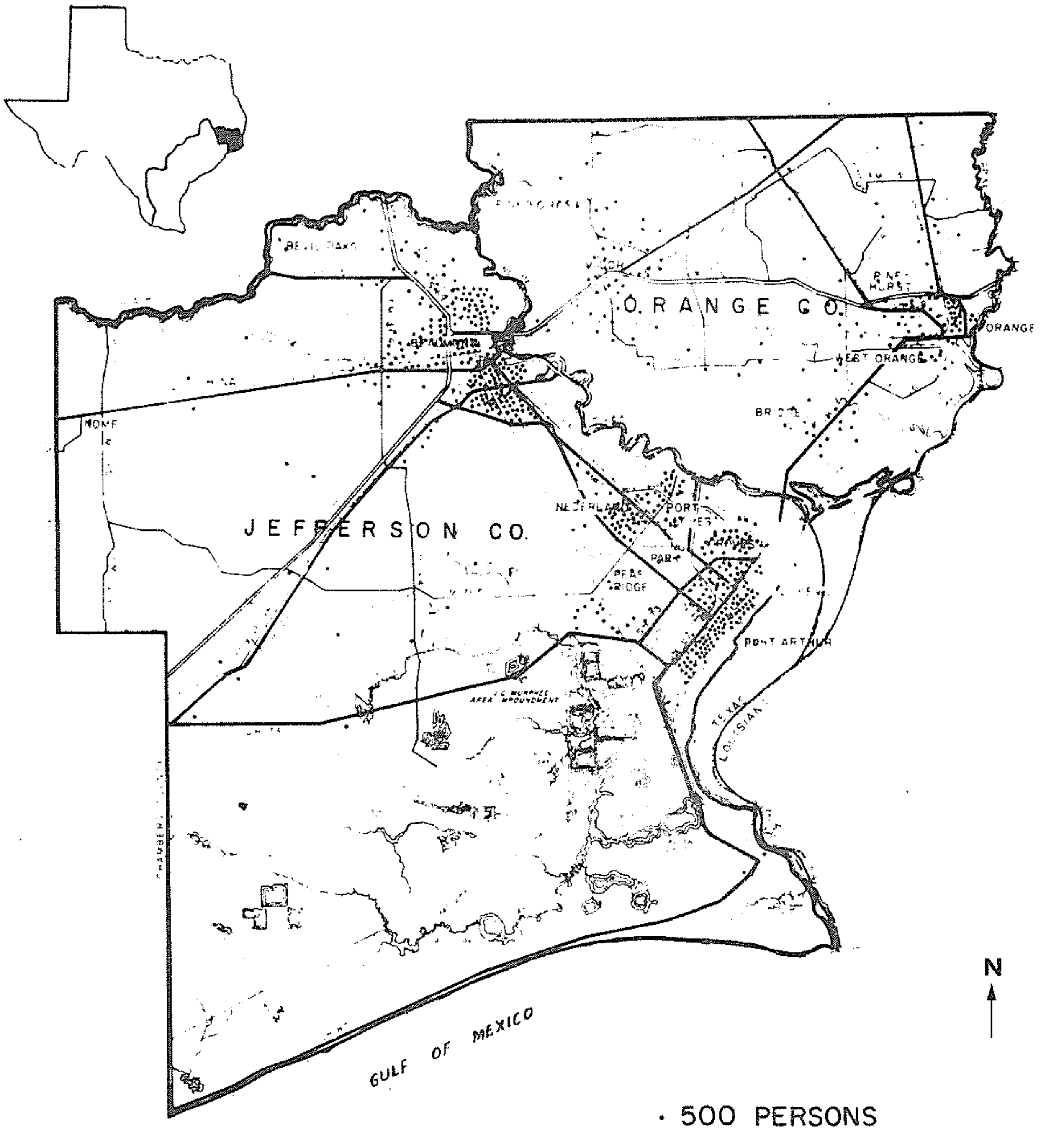
LAND USE IN THE SOUTH EAST TEXAS REGION

FIGURE 35



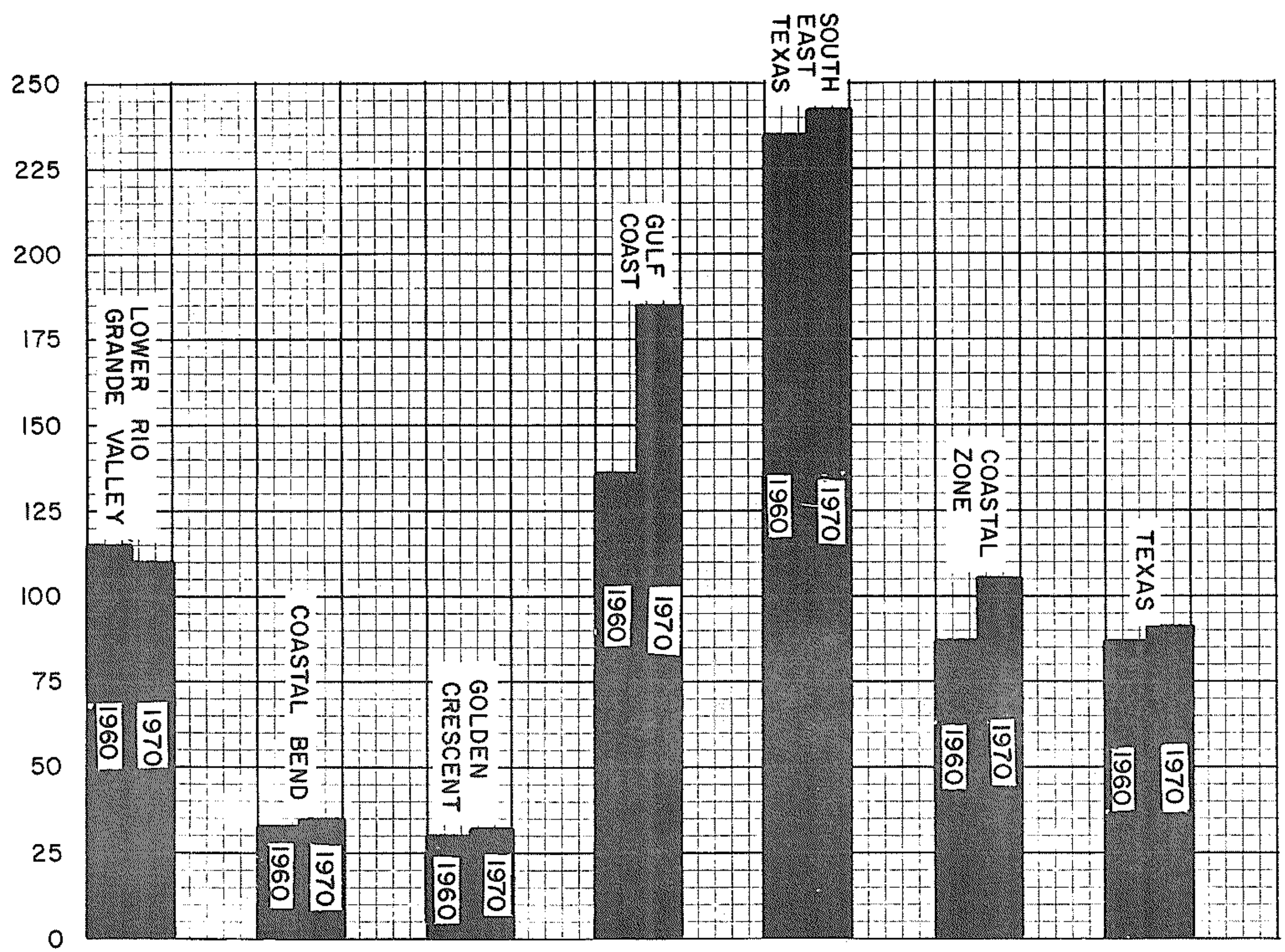
LAND USE IN THE SOUTH EAST TEXAS REGION

FIGURE 35 (Cont'd)

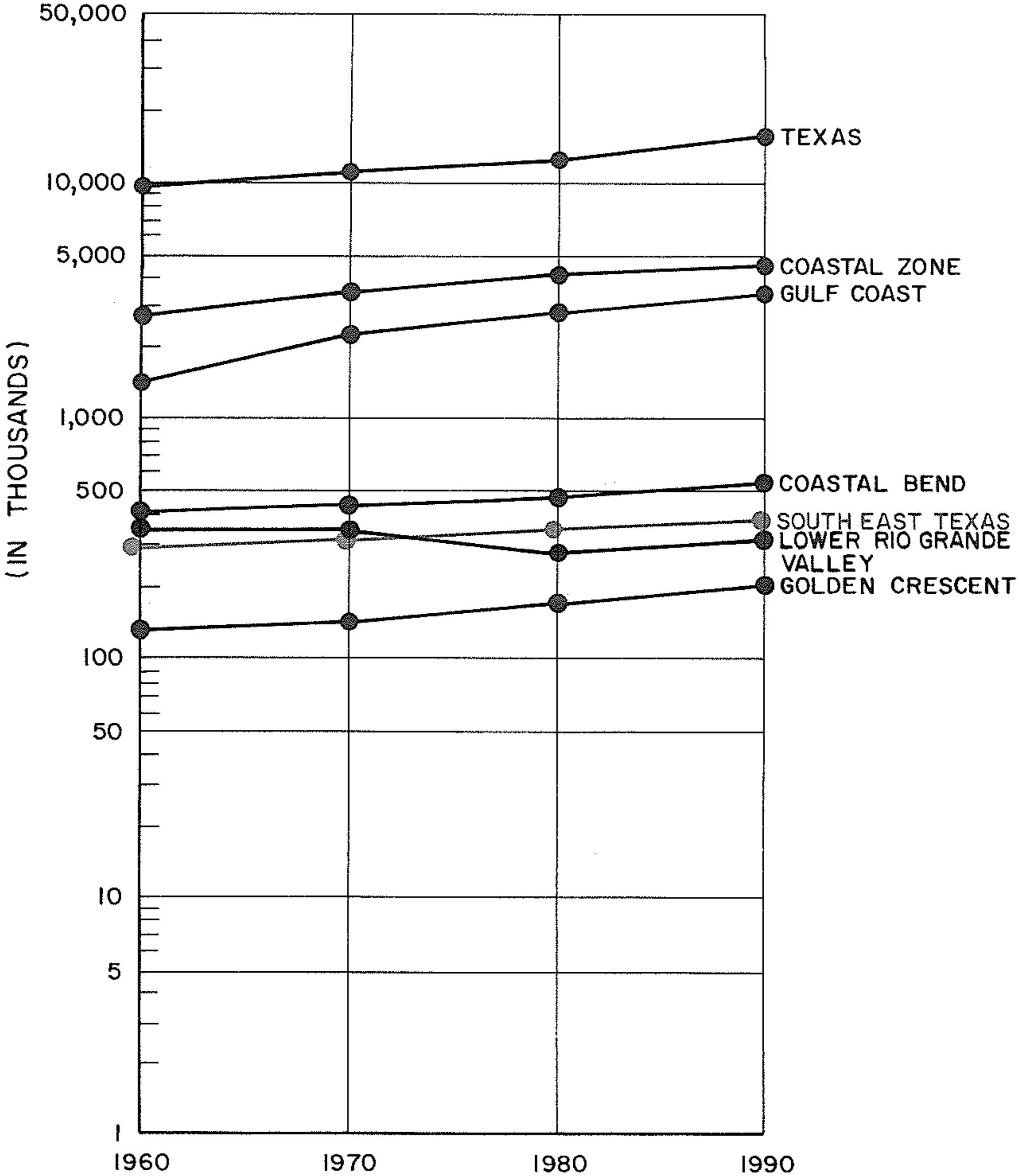


1970 POPULATION DISTRIBUTION IN THE SOUTH EAST TEXAS REGION

FIGURE 36

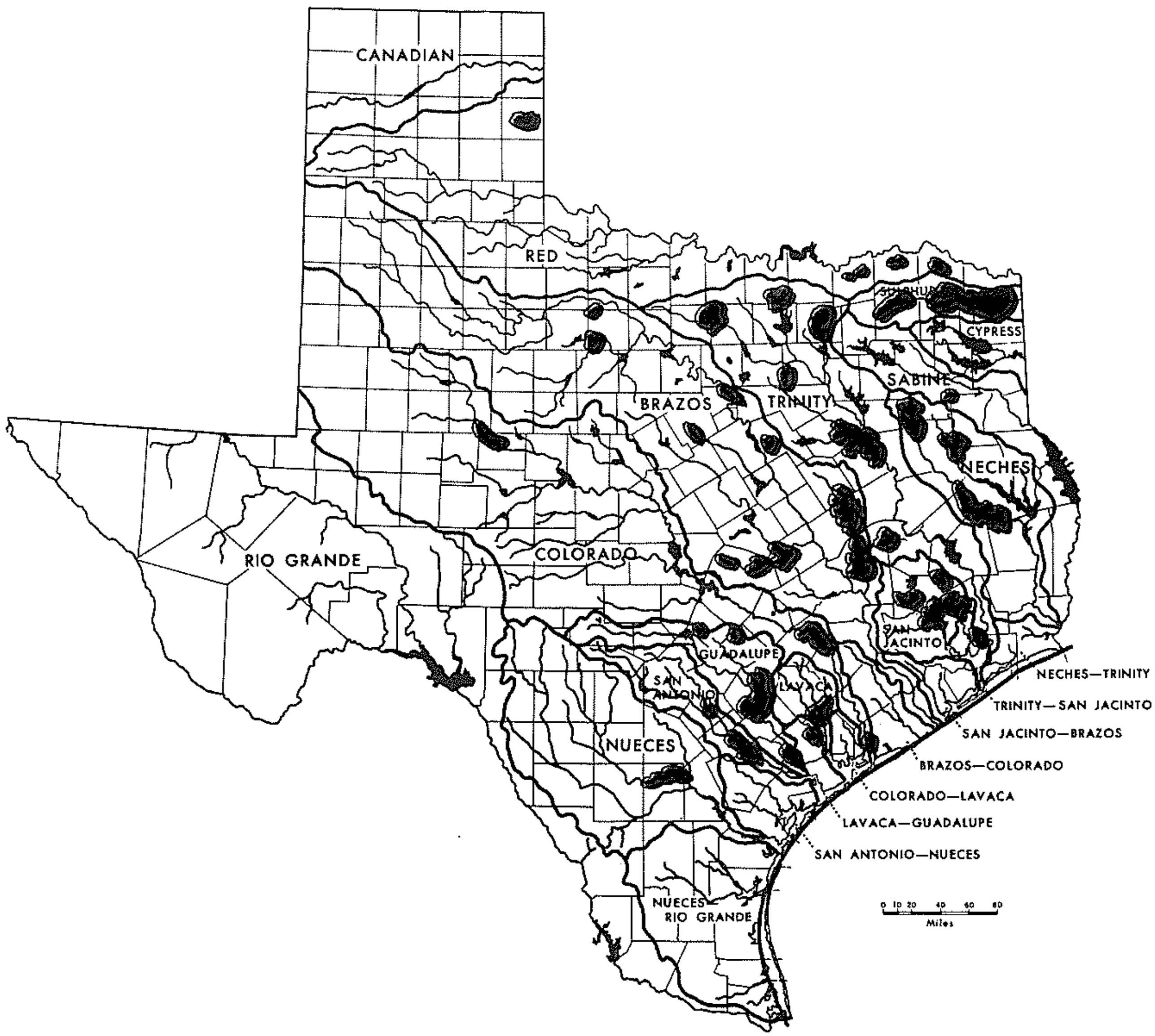


POPULATION DENSITY, 1960-1970
REGIONS, COASTAL ZONE, TEXAS
FIGURE 37



POPULATION GROWTH BY REGIONS, COASTAL ZONE, AND TEXAS

FIGURE 38



LEGEND

N

BASIN BOUNDARIES
EXISTING RESERVOIRS
PROPOSED RESERVOIRS (to 2020)
GULF-INTRACOASTAL WATERWAY

Source: Texas Water Development Board, Water for Texas: A Plan for the Future, 1966 (Preliminary).

RIVER AND COASTAL BASINS WITH MAJOR RESERVOIRS

FIGURE 39

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BIBLIOGRAPHY

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