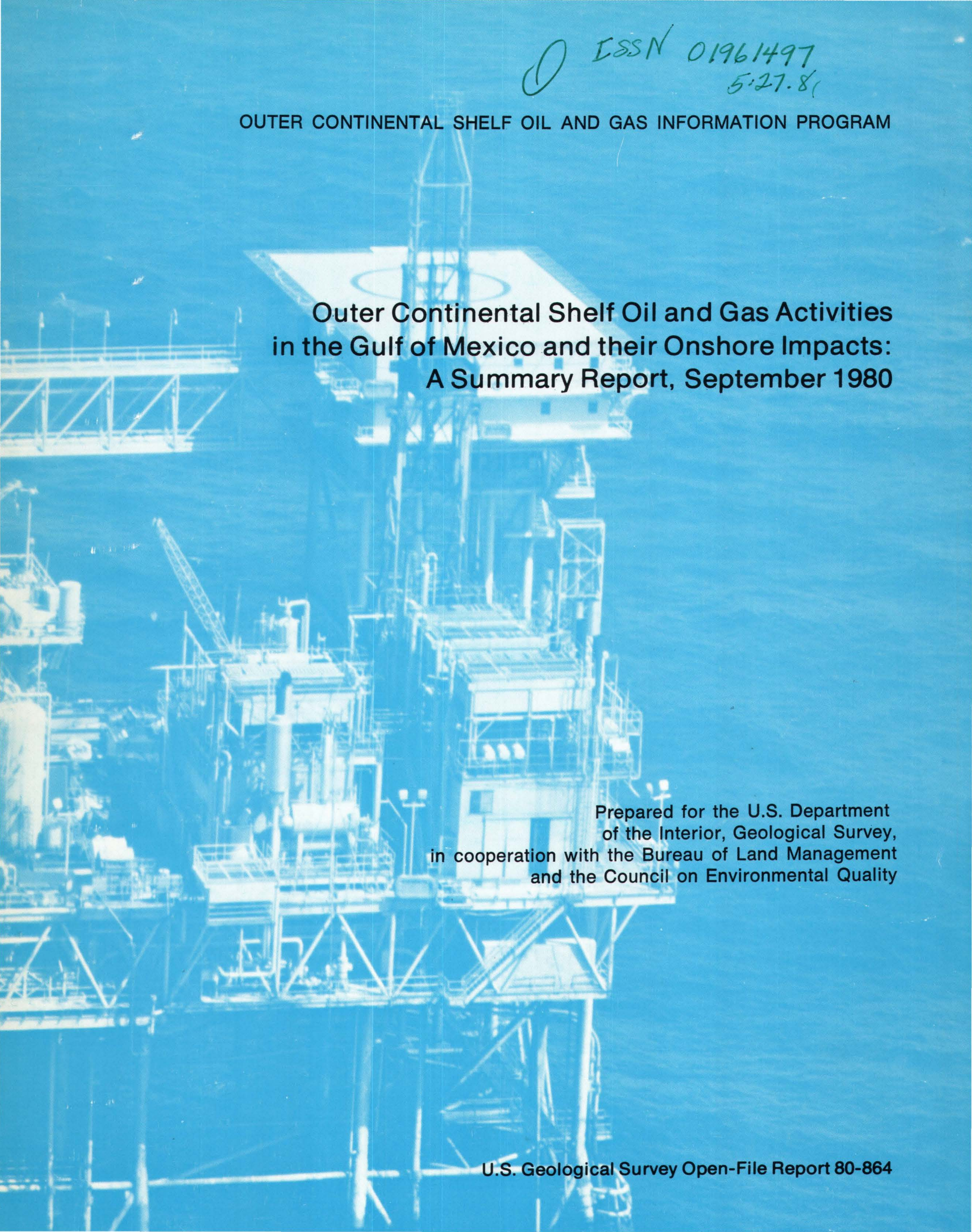

OUTER CONTINENTAL SHELF OIL AND GAS INFORMATION PROGRAM

Outer Continental Shelf Oil and Gas Activities in the Gulf of Mexico and their Onshore Impacts: A Summary Report, September 1980

Prepared for the U.S. Department
of the Interior, Geological Survey,
in cooperation with the Bureau of Land Management
and the Council on Environmental Quality

U.S. Geological Survey Open-File Report 80-864

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To receive Gulf of Mexico Summary Report revisions, return the postcard attached to the back cover, or write to the above address.

COVER.—Main platform of Exxon's West Delta Block 73 field (photograph by Karen M. Collins, 1980).

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DEPARTMENT of the INTERIOR

news release

GEOLOGICAL SURVEY

Bob Johns (703) 860-7444

For release: March 30, 1981

OCS SUMMARY REPORT PUBLISHED FOR THE GULF OF MEXICO

The fifth in a series of reports that provide affected states with current planning information on Outer Continental Shelf (OCS) oil and gas activities and their onshore impacts has been prepared for the U.S. Geological Survey, Department of the Interior, and focuses on the Gulf of Mexico.

The latest report, which was prepared for the USGS under contract by the consulting firm of Rogers, Golden, and Halpern, Inc., focuses on the Gulf of Mexico and follows similar summary reports on the Mid-Atlantic, Pacific, South Atlantic, and Gulf of Alaska. Each report provides summary information regarding oil and gas resources, magnitude and timing of OCS activity, oil and gas transportation strategies, and nearshore and onshore activity resulting from offshore activity. Other summary reports required by section 26 of the OCS Lands Act Amendments are being written or planned for the North Atlantic and Beaufort Sea.

Cumulative production from the Gulf of Mexico OCS, the report said, was about 4.76 billion barrels of oil and condensate and 39 trillion cubic feet of gas as of January 1, 1979. Remaining recoverable reserves are estimated to be about 2.76 billion barrels of oil and 37.2 trillion cubic feet of gas. The undiscovered recoverable resource estimates for the Gulf of Mexico are about 6.5 billion barrels of oil and 71.9 trillion cubic feet of gas. Most of the known hydrocarbon deposits in this area are off the coasts of Texas and Louisiana.

Exploration and development activity is continuing in the area, the report said, with 109 offshore mobile drilling units currently active. In addition, hundreds of exploration plans and development and production plans are submitted each year. There are 2,432 production platforms in the Gulf of Mexico OCS.

Some highlights from the USGS report include:

* Oil production from the OCS in the Gulf of Mexico increased steadily from 1953 to 1972. Since 1972, oil production has declined each year. Virtually all OCS oil production in the United States comes from the Gulf of Mexico (96 percent in 1979).

* The Gulf currently produces 274 million barrels of oil annually, or about 750,000 barrels per day.

(more)

* Gas production from the Gulf OCS rose slowly until 1965, before it increased more steeply through 1974. After a slight decline in 1975, it has continued to climb to the present and it is expected to peak in 1981.

Copies of the 100-page report, "Outer Continental Shelf Oil and Gas Activities in the Gulf of Mexico and their Onshore Impacts: A Summary Report, September 1980," published as USGS Open-File Report 80-864, may be obtained free upon request from the Office of OCS Information, U.S. Geological Survey, 640 National Center, Reston, Va. 22092.

The report includes six plate-size maps of the Gulf of Mexico describing the leased tracts, current federal lease status, pipeline systems, onshore facilities and other features related to petroleum production and planning. A glossary of scientific and industrial terms and six appendices in the report provide basic primer information on such topics as how petroleum occurs and accumulates, geology of the Gulf of Mexico, methods of estimating resources, and procedures for lease processing.

# # # #

(Note to editors: Review copies of the report are available from the Office of Public Affairs, phone (703) 860-7444. Technical questions regarding the report may be directed to Louis G. Hecht, Jr., acting chief, Office of OCS Information, phone (703) 860-7166.)

OUTER CONTINENTAL SHELF OIL AND GAS INFORMATION PROGRAM

Outer Continental Shelf Oil and Gas Activities in the Gulf of Mexico and their Onshore Impacts: A Summary Report, September 1980

by Kenneth J. Havran and Karen M. Collins

Prepared for the U.S. Department of the Interior, Geological Survey,
in cooperation with the Bureau of Land Management
and the Council on Environmental Quality
under Contract No. EQ9AC006, by

ROGERS, GOLDEN & HALPERN, INC.
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U.S. Geological Survey Open-File Report 80-864

METRIC CONVERSIONS

(The following table gives the factors used to convert metric units to English units and explains nautical miles and marine leagues.)

Multiply metric units	by	to obtain English units
meters	3.281	feet
kilometers	0.621	miles
hectares	2.471	acres

1 nautical mile = 1.152 statute miles = 6,080 feet
3 marine leagues = 9 nautical miles = 10,368 statute miles

ACRONYMS AND ABBREVIATIONS

APD - Application for Permit to Drill
API - American Petroleum Institute
bbl - barrel(s)
BLM - Bureau of Land Management, U.S. Department of the Interior
bpd - barrels per day
Btu - British thermal unit
CEIP - Coastal Energy Impact Program, administered by the Office of Coastal Zone Management of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce
cfd - cubic feet per day
COST - Continental Offshore Stratigraphic Test
CZM - Coastal Zone Management
DEIS - Draft Environmental Impact Statement
DES - Draft Environmental Statement
DOT(OPS) - Department of Transportation, Office of Pipeline Safety
dwt - dead weight ton
EA - Environmental Assessment
EIS - Environmental Impact Statement
ER - Environmental Report
FERC - Federal Energy Regulatory Commission
FY - Fiscal year
ICC - Interstate Commerce Commission
GS - U.S. Geological Survey, Department of Interior
IMCO - Intergovernmental Maritime Consultative Organization
IPP - Intergovernmental Planning Program for OCS Oil and Gas Leasing, Transportation, and Related Facilities, BLM
LOOP - Louisiana Offshore Oil Port
MAFLA - The area composed of coastal Mississippi, Alabama, and Florida
MAR - Maximum Attainable Rate of Production
mcfd - million cubic feet per day
m.y. - million years
OCS - Outer Continental Shelf
OCSI - Office of OCS Information, USGS
POD/P - Plan of Development and Production
POE - Plan of Exploration
RAG - Resource Appraisal Group (USGS)
RTMP - Regional Transportation Management Plan
RTWG - Regional Technical Working Group, BLM
SALM - Single anchor leg mooring
SPM - Single-point mooring
TBtu - Trillion Btu
ULCC - Ultra-large crude carrier
USGS - U.S. Geological Survey, Department of the Interior
VLCC - Very large crude carrier

Acknowledgments

Many people have provided information and insights to the authors for the preparation of this report. All deserve our expression of gratitude. Among those who were especially generous with their time and knowledge were Mary Bartz, Syd Verinder, and Alice Laforet of the Bureau of Land Management's New Orleans OCS Office; Floyd Bryan, Gene Marsh, Don Solanas, Frank Pons, Alex Alvarado, and Frank Torres of the USGS Office in Metairie, Louisiana; and Troy Davey of Exxon Company, U.S.A.

The Field Draft Review Committee recommended changes that improved upon early drafts. Members of the committee were David Nystrom, Louis G. Hecht, Jr., Mary Davis, Lucille C. Tamm, Don Solanas, Floyd Bryan, Courtney Reed, Ray Martin, and John Ward, of the U.S. Geological Survey; and Yvonne Morehouse and Syd Verinder, from the Bureau of Land Management. David Nystrom provided overall guidance and direction of the project for the Survey; Louis G. Hecht, Jr., provided day-to-day counsel. Ray Martin of the Survey provided direction for the sections dealing with marine geology. Special thanks are extended to him. Valuable suggestions for the improvement of the geology discussions in chapter 1 and appendix A were also made by Lucille C. Tamm, Ozzie Girard, and Terry Edgar of the Survey. Mary Davis served as the USGS editorial coordinator.

At Rogers, Golden & Halpern, Fritts Golden provided overall project direction. Sandy Dechert designed and edited the report and supervised its production. Mark Yankoski directed graphics production and, with Margaret Judd and Kim Tomlinson, executed the graphics. Deborah Gould served as assistant editor and also worked on graphics. Bruni Haydl, Angela Gandy, Sue McGuire, Valerie Smith, and Pam Staubus provided editorial, graphics, and technical support.

Abstract

The Gulf of Mexico Outer Continental Shelf (OCS) is an important oil- and gas-producing region with a long history. Its volume of production is greater than that of any other offshore region in the world. Most of the known hydrocarbon deposits in the area are situated off the coasts of Texas and Louisiana, where geologic structures associated with salt tectonism are responsible for oil and gas entrapment. Cumulative production from these fields to January 1, 1979, has yielded 4.76 billion barrels of oil and condensate and 39 trillion cubic feet of gas. Remaining recoverable reserves are 2.76 billion barrels of oil and 37.2 trillion cubic feet of gas, distributed among 385 known fields. Undiscovered recoverable resource estimates for the Gulf of Mexico are 6.5 billion barrels of oil and 71.9 trillion cubic feet of gas.

Offshore production began on lands under State jurisdiction in the Gulf of Mexico in 1938, 15 years before enactment of the Outer Continental Shelf Lands Act. That legislation, together with the Outer Continental Shelf Lands Act Amendments of 1978, governs the leasing of offshore tracts for exploration, development, and production of subsea mineral resources. Since 1953, 39 lease sales have been held on the Gulf OCS. Offshore operations have expanded throughout the central and western portions of the Northern Gulf of Mexico. Leasing in the Eastern Gulf has not been as extensive, nor has exploration there resulted in any commercially attractive discoveries. Exploration and development activity in the Gulf is continuing, with 109 offshore mobile drilling units currently active. Production platforms, which presently number 2,432, generally produce sweet, light crude oil and gas. Hundreds of exploration plans and development and production plans are submitted each year.

Gulf of Mexico OCS production platforms are linked to shore by an extensive network of pipelines that transport daily production of 750,000 barrels of oil and 13.1 billion cubic feet of gas to nearby coastal locations. To offset the decline in Gulf OCS production, offshore operators are engaging in techniques to enhance recovery.

Transportation of oil and gas is a concern in areas of offshore production. For reasons of safety and economics, pipelines are the preferred transportation mode. However, small quantities of OCS oil are moved by tanker and barge. One deepwater port designed to accommodate supertankers is also under construction in the Gulf.

Onshore and offshore oil and gas production along the Gulf Coast has resulted in the growth of an impressive industrial complex. The economic base of the Gulf Coast States is closely tied to the global oil and gas industry. Cities and towns of the Region act both as support bases for offshore operations and as processing and distribution points for offshore resources.

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Introduction

The United States is currently engaged in an effort to develop the oil and gas resources of the Outer Continental Shelf (OCS). Offshore activities must be supplied and supported from land, and the onshore activities required may have significant effects on the communities in which they occur. For example, oil and gas production might involve the expansion of existing transportation and processing facilities and the construction of new ones. The effects of these facilities could influence employment patterns, regional income, demand on public services, tax revenues, and air and water quality.

The need for planning to accommodate the onshore impacts of offshore oil and gas development and production has long been recognized. State and local governments need current information about offshore resources and related onshore activity to make these plans. In response to needs expressed by State and local governments for current information about offshore resources and related onshore activity, section 26 of the Outer Continental Shelf Lands Act Amendments of 1978 (43 U.S.C. 1352) created an Outer Continental Shelf Oil and Gas Information Program (OCSIP), which is now managed by the Office of Outer Continental Shelf Information (OCSI), U.S. Geological Survey, Conservation Division. Authorities and operating procedures for the OCSIP are detailed in the Code of Federal Regulations (30 CFR 252), published in the Federal Register of August 7, 1979. Under this program, the Director of the U.S. Geological Survey (USGS), in conjunction with the Director of the Bureau of Land Management (BLM) (43 CFR 3300), has prepared indexes of information used by the Federal Government in its OCS decisionmaking process. The Pacific, Atlantic, Gulf of Mexico, and Alaska Indexes have already been made available to the public. The Information Program also requires the Director of the USGS to make available to affected States a Summary Report of data and information designed to assist them in planning for the onshore impacts of potential OCS oil and gas development and production.

> The OCS, which is under Federal jurisdiction, comprises the submerged lands of the Continental Shelf seaward of State boundaries. In Texas and the west coast of Florida, State jurisdiction extends 3 marine leagues (approximately 17 km, or 10.4 mi) from the coastline; in Louisiana, Mississippi, Alabama, and the east coast of Florida, jurisdiction extends 3 geographical (statute) miles (4.8 km) from the coastline.
>
> The Bureau of Land Management frequently uses the designations Western Gulf, Central Gulf, and Eastern Gulf to refer to broad areas of leasing interest or activity in the Gulf of Mexico. These terms, as well as such phrases as "off the coast of Texas" or "off Mississippi" appear in this Summary Report. When an area is described as off a Gulf Coast State, the designation is used for the sake of specificity of description. It does not imply legal boundaries between areas.

This report, the Gulf of Mexico Summary Report, covers the Gulf of Mexico Region, the area defined for purposes of the report as extending from the United States-Mexico border, near Brownsville, Texas, to the Florida Keys. The Gulf of Mexico is the fifth in the series of regional Summary Reports. The Mid-Atlantic, Pacific (Southern California), South Atlantic, and Gulf of Alaska Summary Reports have already been completed; others are currently under way for the Beaufort Sea and the North Atlantic.

The Summary Report is designed to assist State and local communities in their planning by describing the OCS-related activity that has occurred to date and by projecting activity in the near term, for approximately 6 months. It complements the environmental impact statement (EIS) process by providing additional information and reporting on events that have taken place since the publication of EIS's.

Each of the Summary Reports begins by presenting the most recent OCS oil and gas resource and reserve estimates. The magnitude and timing of OCS activity are discussed in chapter 2 of the report. The third chapter presents information on offshore oil and gas transportation strategies, including those that are developed as part of the BLM's ongoing Intergovernmental Planning Program (IPP). Chapter 4 describes the nearshore and onshore activities that are occurring and/or probably will occur as a result of current and projected offshore activity. Appendixes provide further detail, and a glossary presents definitions of geologic, industry-specific, and other special terms used in the report. In the pocket on the inside back cover of the Gulf of Mexico Summary Report is a series of plates that supplement the text, showing OCS activities in the Region.

Resource and reserve estimates presented in the Summary Reports reflect the most recent Federal Government information. The Gulf of Mexico Summary Report is based in part on data collected by Federal agencies in the course of leasing and managing the Gulf of Mexico OCS and on studies and reports of OCS activities that have been prepared outside the Federal Government. Representatives of the OCSI have also discussed oil and gas activities with Federal, State, and local officials, oil industry representatives, and other interested persons. The OCSI convened public meetings in Houston, Texas, and in Tallahassee, Florida, on January 16 and 17, 1979, and February 13 and 14, 1979, respectively. Both meetings were attended by representatives of Federal, State, and local government, industry, and public interest groups. Followup meetings concerning the scope and content of this report were held early in 1980 in each of the States in the Gulf of Mexico Region. The concerns voiced by participants at these meetings and in subsequent interviews and research resulted in the identification of issues addressed in this Summary Report.

State and local officials and other representatives in the Gulf of Mexico Region are primarily concerned with maintaining the economic base of the Region over the long term, as oil and gas production from the OCS declines. They are also concerned about systematically dismantling the production infrastructure in the future without drastically affecting enterprises that have developed an interdependence with the oil and gas industry, for example, the recreation and commercial fishing industries.

The Gulf of Mexico Region is the hub of the U.S. oil and gas industry, and it is an integral part of a worldwide network of services, supplies, and engineering and technical expertise. The Region is the core of an intensely developed domestic onshore and offshore exploration, development, and production capability. Its ports and terminals receive a large and ever-increasing volume of imported oil to supplement declining U.S. production. Furthermore, the Region serves as a comprehensive supply and service base for the dispersed activities of the major oil companies: many of the oil companies, if not headquartered in the Region, have offices there. The high level of industry development and the huge capital investment in personnel and equipment assure that oil and gas will be a continuing feature of the Gulf Coast economy for the foreseeable future.

It should thus be recognized that the development of the resources of the Gulf of Mexico OCS is only one facet, albeit an important one, of a complex, global, multi-industry supply and distribution network. In chapter 4, onshore oil- and gas-related facilities are identified. To single out individual places, facilities, or services in the Region as having significance solely with respect to oil and gas from the Gulf of Mexico OCS would be misleading. Most service and supply centers cater to an international market of onshore and offshore operators. Most processing plants, while serving an essentially domestic market, depend, more or less, on some combination of resources from a worldwide network of suppliers.

State agencies may consult with the OCSI if they require additional information or clarification on items in this report. Limited technical assistance on a case-by-case basis is available from OCSI to assist States in improving their abilities to plan for the effects

TABLE 1.—Current 5-year leasing schedule for the Gulf of Mexico

PROPOSED SALE AREA	PROPOSED DATE	1980												1981												1982											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
A62	9/80		F			P	S/C	R	N	S																											
62	11/80		F				P		S/C	R	N	S																									
A66	7/81							E		H			F		P		S/C	R	N	S																	
66	10/81							E		H			F					P		S/C	R	N	S														
67	3/82	C		D		T										E		H			F		P		S/C	R	N	S									
69	8/82	C		D		T										E		H			F							P		S/C	R	N	S				
72	3/83													C		D		T										E		H			F		P		S/C
74	9/83													C		D		T										E		H			F				
79	3/84																									C		D		T							
81	7/84																									C		D		T							
84	1/85																																			C	

PROPOSED SALE AREA	PROPOSED DATE	1983												1984												1985											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
A62	9/80																																				
62	11/80																																				
A66	7/81																																				
66	10/81																																				
67	3/82																																				
69	8/82																																				
72	3/83	R	N	S																																	
74	9/83				P		S/C	R	N	S																											
79	3/84			E		H			F		P		S/C	R	N	S																					
81	7/84			E		H			F						P		S/C	R	N	S																	
84	1/85	D		T										E		H			F		P		S/C	R	N	S											

C - Call for Nominations
D - Nominations Due
T - Tentative Tract Selection
E - Draft Environmental Statement
H - Public Hearing
F - Final Environmental Statement
P - Proposed Notice of Sale
S/C - State Comments Due
R - Energy Review
N - Notice of Sale
S - Sale

SOURCE: U.S. Department of the Interior, 1980.

of onshore development related to OCS oil and gas activity. The current 5-year OCS oil and gas leasing schedule calls for approximately two sales per year through 1985 in the Gulf of Mexico Region (U.S. Department of the Interior, June 1980). Table 1 shows the leasing schedule for the Gulf of Mexico. Based on the number of lease sales projected in the current schedule, the OCSI will revise this Summary Report annually. To receive Summary Report revisions, return the postcard attached to the back cover.

1. Offshore Oil and Gas Resources of the Gulf of Mexico Region

This chapter summarizes the geology of the Outer Continental Shelf in the Gulf of Mexico Region, an area defined for purposes of this Summary Report as extending from the United States-Mexico border, on the Gulf of Mexico, to the Florida Keys. Plate 1 shows the extent of the Region. Because the Federal Government must prepare resource estimates for a variety of purposes and the estimation techniques used often differ, various estimation methods and their applicability to onshore planning are also discussed here. The most recent information available on the oil and gas resources of the Gulf of Mexico OCS is presented at the end of the chapter.

GEOLOGIC ASPECTS OF THE GULF OF MEXICO REGION

The Outer Continental Shelf of the Gulf of Mexico has long been a major oil- and gas-producing region for the United States, and extensive exploration continues in the area. There has been a natural progression from onshore to offshore development. As drilling technology has improved, exploration has focused on the seaward portions of the Continental Shelf, the upper portion of the Continental Slope, and other deepwater areas not previously explored. A generalized cross section of the Continental Margin (fig. 1) shows the relationship of these features.

In the Gulf of Mexico basin, the Continental Shelf is an extensive plain with a gentle slope generally less than 1 degree. However, the gradient of the entire shelf is not uniform, and its surface is irregular. Piercement salt domes and ridges result in a hummocky topography, especially at the shelf-slope break. The shelf varies in width from a minimum of 19 km (12 mi) off the Mississippi River Delta to a maximum of 225 km (140 mi) off Crystal River, Florida. Figure 2 shows the principal subsea features of the Gulf. The major hydrocarbon-producing area lies largely south of Louisiana and East Texas, on the Texas-Louisiana Shelf. The shelf contains a series of Pleistocene wave-cut terraces, the lowest of which are at a water depth of about 130 m (426 ft).

The Continental Slope is a relatively steep geologic feature that lies between the shelf and the abyssal ocean floor (fig. 1). The Gulf of Mexico Continental Slope extends from the shelf edge (the shelf-slope break) to the base of the Sigsbee Escarpment in the Central and Western Gulf, and to the base of the Florida Escarpment in the Eastern Gulf.

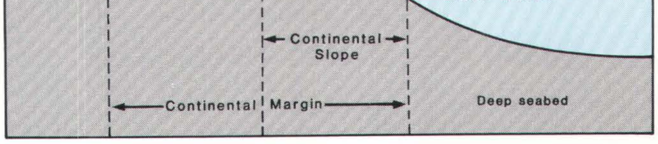


FIGURE 1.--Generalized cross section of the Continental Margin (adapted from Macpherson and Bookman, 1979, p. 7, by Rogers, Golden & Halpern, 1980).

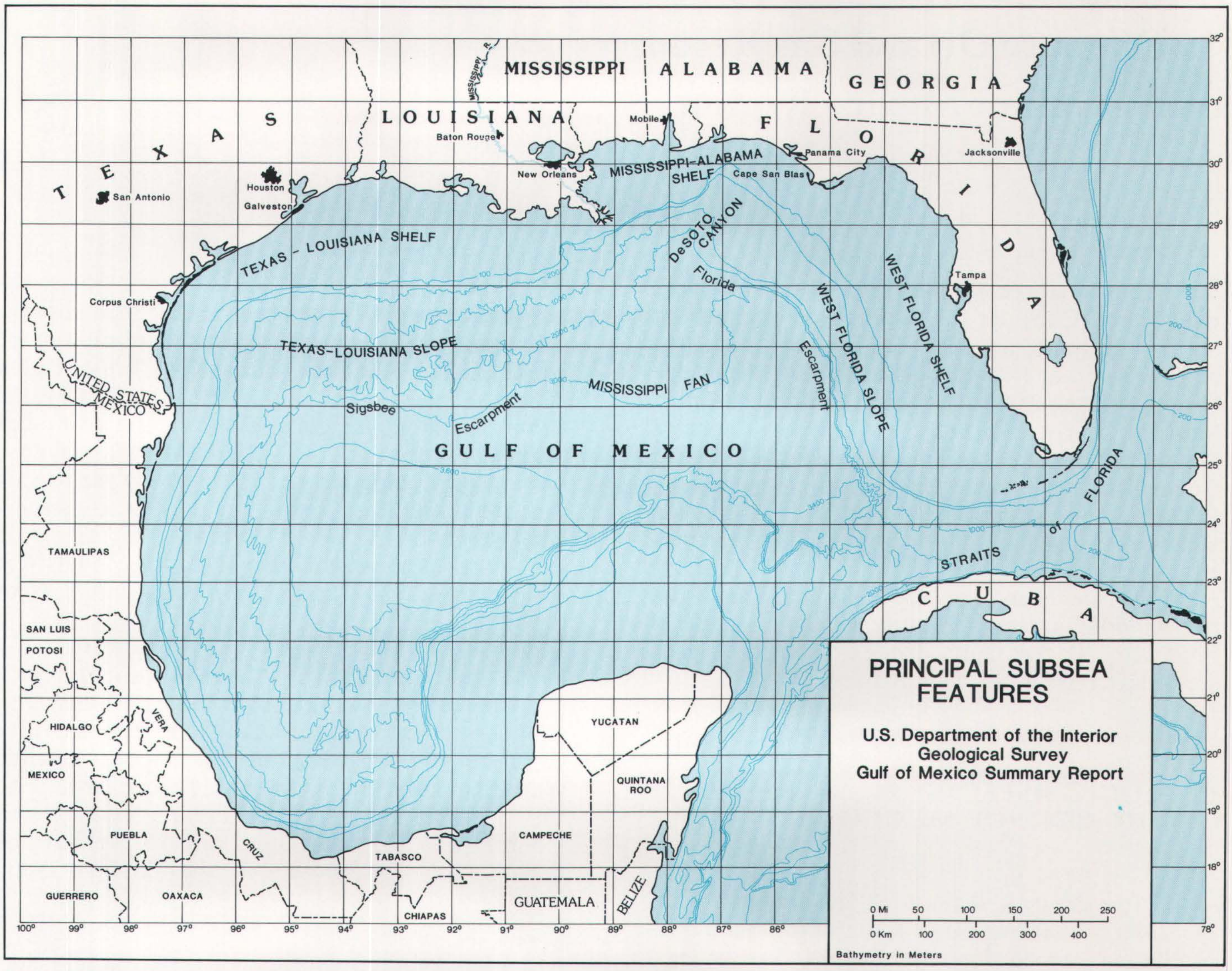


FIGURE 2.--Principal subsea features of the Gulf of Mexico (Pequegnat, Bela, Bouma, Bryant, and Fredericks, 1972, p. 71; base from Sorensen and others, 1975).

Both the Sigsbee Escarpment and the Florida Escarpment drop abruptly to the abyssal ocean floor. The Continental Slope has a gradient that ranges from 2 degrees in the vicinity of the De Soto Canyon to more than 45 degrees in limited areas of the reef-formed Florida Escarpment.

The Gulf of Mexico OCS can be divided into six distinct physiographic provinces. These six provinces are the Texas-Louisiana Shelf; the Texas-Louisiana Slope; the Mississippi-Alabama Shelf; the Mississippi Fan; the West Florida Shelf and Slope; and the Straits of Florida. To date, OCS oil and gas exploration and production have occurred primarily in the Texas-Louisiana Shelf and Slope provinces in the Northern Gulf of Mexico, where sedimentary deposits approach a maximum thickness of 18,300 m (60,000 ft).

The basinward migration of the Continental Margin during the post-Cretaceous development of the Gulf of Mexico has governed the subsidence of the Gulf Coast basin. This has occurred as offlapping wedge after wedge of land-derived Tertiary and Quaternary sediments accumulated in the basin.

The thickest accumulations of sediments in the basin occur along the present coastline from southernmost Texas to the Mississippi River Delta. The landward limit of the basin lies approximately 325 km (200 mi) north of the present shoreline, and the southern limit of the basin is generally considered to be located above the base of the slope. Further discussion of the geologic structure of the Gulf of Mexico is in appendix A.

Along the coast of Louisiana and Texas and on the Continental Shelf, masses of salt have pierced upward through thick beds of sediment to form **salt domes.** The salt was deposited as a sedimentary evaporite in Jurassic time and was subsequently buried beneath other marine sediments of Cretaceous and Tertiary age. Under the weight of the overlying beds, the salt, being less dense, became plastic and was squeezed or intruded upwards, piercing the sedimentary beds and arching the uppermost beds into domes. The domes are typically topped by sediments known as **caprock,** usually composed of lime, sulfur, anhydrite, or gypsum. Oil and gas accumulate along the flanks of salt domes or in overlying upwarped sediments. Figure 3 is an idealized cross section of a salt dome.

OIL AND GAS RESOURCES IN THE GULF OF MEXICO

The U.S. Geological Survey is responsible for estimating oil and gas resources. For this purpose it conducts various geologic and geophysical investigations and analyzes the results. In addition to conducting its own geophysical studies, the USGS has access to privately owned information that oil and gas companies have gathered under either pre-lease exploratory permits or as a result of exploration and development activities conducted on leases obtained from the Government. Pre-lease permit data include geophysical survey, shallow core, and deep stratigraphic test data. Data acquired under lease agreements include information from exploration and development wells and additional geophysical survey data. Analysis of this public and proprietary information has enabled the USGS to develop a picture of the petroleum geology of the Gulf of Mexico OCS.

Hydrocarbon-bearing formations in the Gulf of Mexico are primarily associated with vertical salt movement, which has resulted in the formation of salt domes. This process, known as salt tectonism, frequently results in the formation of structural and stratigraphic traps where oil and gas can be found, if other favorable conditions for their accumulation are also present. Hydrocarbons in the Gulf are

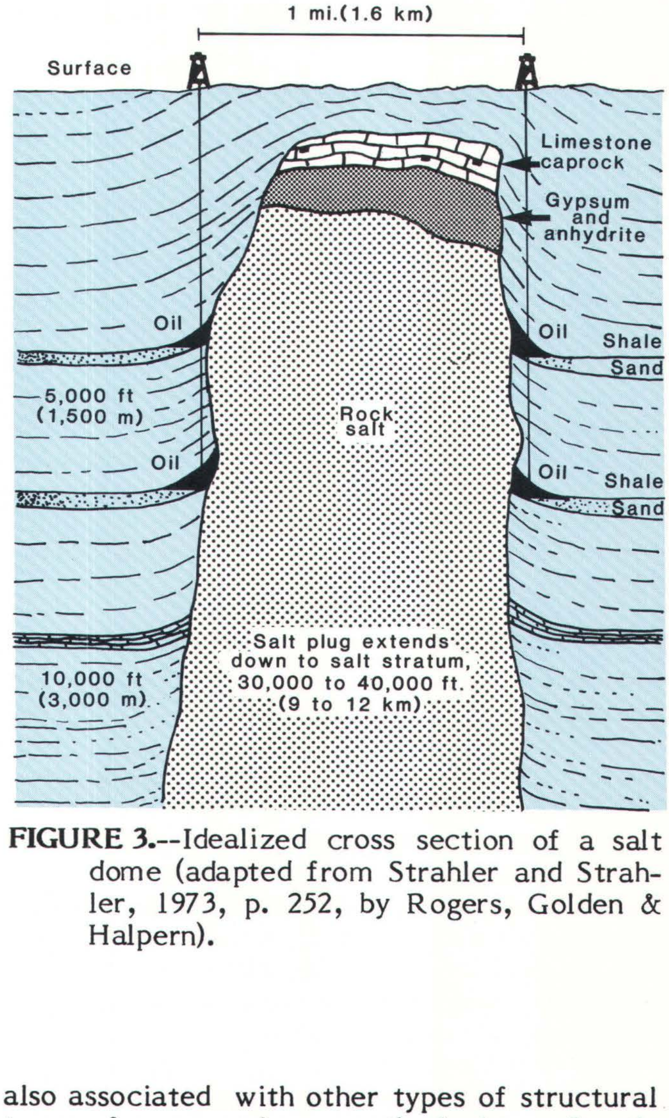


FIGURE 3.--Idealized cross section of a salt dome (adapted from Strahler and Strahler, 1973, p. 252, by Rogers, Golden & Halpern).

also associated with other types of structural traps, for example, growth faults. Stratigraphic traps, which frequently form in areas characterized by salt tectonism, provide additional environments for hydrocarbon entrapment.

Oil and gas reservoirs have formed around the various salt dome structures that are abundant on the Texas-Louisiana Shelf off East Texas and Louisiana. For reasons not well understood, this same type of dome structure is quite rare off the coast of South Texas, suggesting less potential there for the discovery of many reservoirs of oil and gas.

The Texas-Louisiana Slope, an area of irregular or hummocky topography caused by salt intrusion, contains numerous diapiric salt structures offering further potential for hydrocarbon discovery. They extend from nearshore to the Sigsbee Escarpment. Production in the Flower Garden Banks area, offshore southeast of Galveston, comes from sandstone along the flanks of piercement salt domes.

There is reason for optimism concerning the potential for additional hydrocarbon discoveries on the Mississippi-Alabama Shelf as well. Despite the fact that wells have been drilled and were found to be dry in the Destin Dome, a number of piercement domes lie at the head of the De Soto Canyon. These diapirs are the kinds of structures that generally provide conditions favorable for the accumulation of oil and gas, and continued exploration there is probable.

In the course of exploring for, developing, and producing offshore oil and gas, certain geologic features and conditions may jeopardize offshore platforms and pipelines. Failure to identify, avoid, or take proper engineering precautions against geologic hazards could result in the failure of a platform or pipeline.

Geohazards in the Gulf of Mexico OCS are of several kinds. Active faults, fault blocks, and large down-to-basin faults associated with salt tectonism are prevalent in the Northern Gulf. Large faults are frequently of regional extent. Mass slumping, sediment creep, and submarine landslides are examples of geologic hazards found along the slopes and in the upper Mississippi Fan. The least stable sediments are in the region just off the Mississippi River Delta. Other serious concerns are shallow gas deposits and deeper high-pressure zones, because they increase the possibility of a blowout during drilling operations. In addition, highly unconsolidated gas-saturated alluvial deposits can cause voids and differential compaction.

Existing standard design and engineering technology can be used to minimize some of these problems, especially such features and conditions as local thickening and thinning of clastic deposits, differential compaction of sediments, and bottom objects and debris. In areas where other conditions have been identified, special engineering procedures may be required, or planned well locations may have to be changed, or tracts may have to be deleted from a sale.

Before OCS tracts are leased, explored, and developed, the USGS and the petroleum industry conduct geophysical studies to identify potential geohazards. As a result of this evaluation, the Secretary of the Interior may delete tracts from a sale or may impose stipulations on the development that can take place on a tract. When an Application for Permit to Drill (APD) is submitted, the applicant is thus aware of any known geohazards in the proposed area of operations and must submit an operational plan that outlines procedures to deal with these hazards. All applications are reviewed by the USGS before a permit to drill is issued.

ESTIMATING HYDROCARBON POTENTIAL

To appreciate the complexities and uncertainties of estimating hydrocarbon potential, one must understand the process by which petroleum resources are discovered and developed. It is extremely difficult to estimate how much oil and gas are in the ground in any given area until that area has been extensively explored by drilling.

For areas of the Gulf of Mexico OCS that have not been extensively drilled, especially the frontier areas off the coasts of Mississippi, Alabama, and Florida (MAFLA), it

> In estimating resources, assumptions are often made in order to account for uncertainties. For example, a resource estimate conditioned by the word **recoverable** takes into account the fact that physical and technological constraints dictate that only a portion of resources or reserves can be brought to the surface. An estimate of **economically** recoverable resources takes into account the costs of exploration, development, transportation, and the market prices of oil and gas. A third uncertainty stems from the probability that resources are, or are not, present in a given area. A **risked** resource estimate is one that has been modified according to the estimator's confidence in the estimate (i.e., "risked" to account for the probability that economically recoverable resources will actually be encountered within the area of interest).

is only possible to estimate the Region's resources in terms of **undiscovered resources:** quantities of oil and gas that have been estimated to exist outside known fields. Undiscovered resource estimates are made by identifying areas of resource potential on the basis of broad geologic knowledge and theory. Until a well has been drilled, investigators derive all their knowledge of subsurface geology indirectly, from geologic and geophysical data collected at the surface. Using available data as a basis for further investigations, petroleum geologists then conduct a variety of geologic assessments of the Region. The geologists' data base may include physical confirmation of the presence of resources by exploratory drilling, which can provide valuable information for appraising resource potential. The porosity and permeability of rock samples extracted from an exploratory or stratigraphic test well can be analyzed in the laboratory, and any oil and/or gas found can be sampled and examined. Although improvements in the geologic and geophysical data base enable estimates to be refined, estimates of undiscovered resources are always matters of subjective, albeit expert, interpretation.

After a discovery is made and the commercial potential of a reservoir has been established, it is possible to calculate **reserves.** Reserve estimates are estimates of the portion of the identified resource that can be economically extracted. A preliminary estimate of reserves might be based on information obtained from several wells, or conceivably from a single well, and maps of the subsurface geology.

For additional information on the process of resource estimation, see appendix B, which explains in greater detail how resource and reserve estimates are derived, what they mean, what they should be used for, and how the process of estimating resources relates to the process of exploring for oil and gas.

RESOURCE AND RESERVE ESTIMATES

The most recent oil and gas resource and reserve estimates issued by the U.S. Geological Survey for the Gulf of Mexico Region appear in table 2. These are risked estimates of undiscovered recoverable resources (as of October 1980) and estimates of remaining recoverable reserves (as of January 1979).

Original recoverable reserves are those that existed before any hydrocarbon exploration, development, and production took place: they represent the total production that can ever be expected from a field before it is abandoned. Remaining recoverable reserves are those that have not yet been recovered. Estimates of original recoverable reserves are periodically revised in retrospect to reflect new information. The original recoverable reserves from the identified fields in the Gulf of Mexico OCS are currently estimated to have been 7.52 billion barrels of oil and 76.2 trillion cubic feet of gas. More than 3 decades of production have resulted in a cumulative yield of 4.76 billion barrels of oil and 39 trillion cubic feet of gas, leaving remaining recoverable reserves of 2.76 billion barrels of oil and 37.2 trillion cubic feet of gas (U.S. Department of the Interior, Office of the Secretary, 1979). The most recent undiscovered recoverable resource estimates for the Gulf of Mexico are 6.5 billion barrels of oil and 71.9 trillion cubic feet of gas.

Of the 416 oil and gas fields in the Gulf of Mexico OCS, 31 fields have not been mapped, nor is there an estimate of remaining recoverable reserves for them; 15 previously active fields are now depleted and abandoned; and 370 are still active. The original recoverable resource estimates given above are for the latter 385 fields; the number given for

TABLE 2.—Gulf of Mexico OCS oil and gas resource and reserve estimates

	Oil (billion bbl)	Gas (trillion cu ft)
Undiscovered recoverable resource estimates (Mean estimates)		
Western Gulf of Mexico (Main Pass Area (see plates) and west) 0-2,500 m water depth	5.2	69.0
Eastern Gulf of Mexico (east of Main Pass Area) 0-2,500 m water depth	1.3	2.9
Reserves	2.8	37.2

SOURCES: USGS, Geologic Division (resource estimates), October 1980; USGS, Conservation Division (reserve estimates), January 1979.

remaining recoverable reserves is the amount left in the 370 active fields. For the 385 fields where reserves have been estimated, estimates exist for individual reservoirs in 289 fields and on a field-wide basis for the remaining 96 fields (Bryan and others, 1979, p. 1). Table 3 outlines the distribution of those reserves by field area. Plate 2 is a map showing the distribution of blocks now producing oil and gas.

Field sizes on the basis of original reserves are shown as histograms in figures 4 and 5 (p. 12). Figure 4 is the distribution of 90 oil fields, and figure 5 is the distribution of 304 gas fields. Nine fields appear in both histograms because they contain significant reserves of both oil and gas. The amount of reserves in a gas field of mean (weighted average) field size is 207 billion cubic feet; for oil fields, it is 65 million barrels. The average for oil fields is strongly influenced by 18 fields (20 percent of the total number) that contain 66 percent of the total reserves. These "giant fields" have at least 100 million barrels of original reserves.

Among the major hydrocarbon-bearing fields, there are 70 that the USGS considers "significant fields," those that are developed or developing, in which production over the most recent 6-month period has averaged at least 5,000 barrels of oil per day or 100,000 million cubic feet of gas per day, or those that are capable of such amounts. Of the currently active and developing fields identified here, 38 oil fields and 32 gas fields in the Gulf of Mexico OCS are classified as significant.

TABLE 3.—Estimated demonstrated oil and gas reserves for 385 fields, Gulf of Mexico Outer Continental Shelf and Slope, January 1, 1979

(Demonstrated reserves: the sum of measured and indicated reserves. Liquids expressed in million barrels, gas in billion cubic feet. "Liquids" include crude oil, condensate, and gas-plant products sold; "gas" includes both associated and nonassociated dry gas.)

Area	Fields[1] (total 385)	Original recoverable reserves		Cumulative production		Remaining recoverable reserves	
		Liquids	Gas	Liquids	Gas	Liquids	Gas
Mustang Island[2]	5	1.8	230	0	0	1.8	230
Brazos	7	7.8	670	3.8	220	4.0	450
Galveston	5	34	780	25	630	9	150
East Breaks	2	18	310	0	0	18	310
High Island	59	103	5,800	6	700	97	5,100
West Cameron	49	191	12,400	81	5,500	110	6,900
East Cameron	34	132	6,200	78	3,600	54	2,600
Vermilion	46	315	8,600	162	5,400	153	3,200
South Marsh Island	31	530	8,400	210	4,100	320	4,300
Eugene Island	40	1,050	10,000	650	5,600	400	4,400
Ship Shoal	31	870	7,700	570	4,500	300	3,200
South Timbalier[3]	18	1,030	3,560	800	2,150	230	1,410
South Pelto	4	70	186	39	81	31	105
Grand Isle	10	740	2,900	640	1,920	100	980
West Delta	14	1,080	3,470	770	2,330	310	1,140
South Pass	8	610	1,660	410	930	200	730
Main Pass[4]	19	610	2,500	320	1300	290	1,200
Mississippi Canyon	3	130	800	0	0	130	800
Total	385	7,522.6	76,166	4,764.8	38,961	2,757.8	37,205

[1]Represents 370 of the 401 active (September 1979) fields and 15 formerly productive, now abandoned fields.

[2]And Matagorda Island Area.

[3]And Bay Marchand Area.

[4]And Breton Sound Area.

SOURCE: U.S. Department of the Interior, Office of the Secretary, 1979, Letter to President of the Senate.

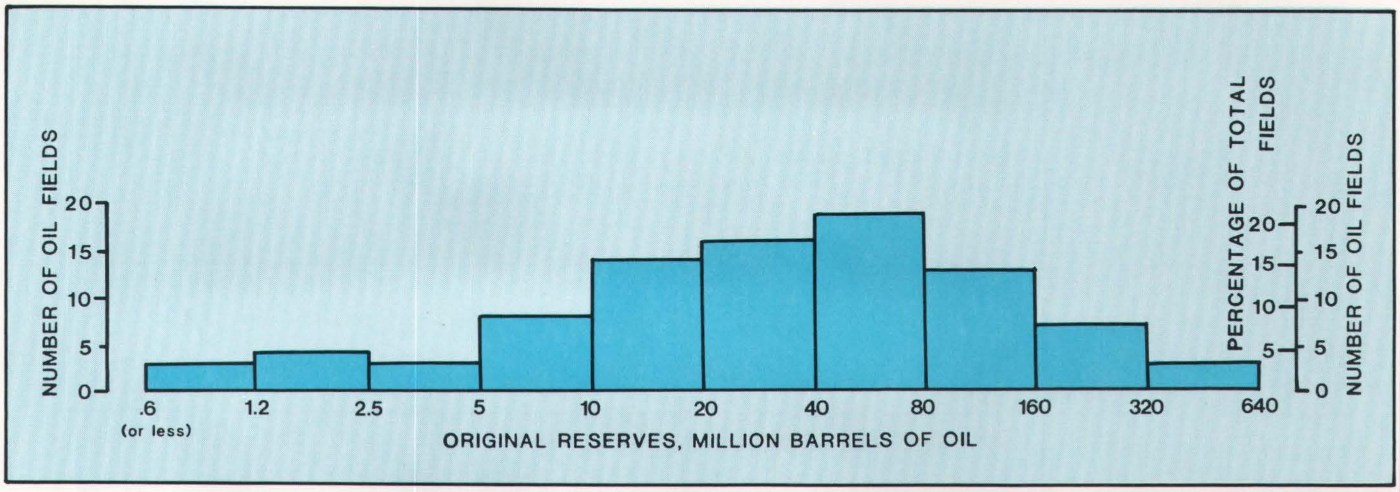


FIGURE 4.--Oil field-size distribution (modified from Bryan, Knipmeyer, and Schluntz, 1980, by Rogers, Golden & Halpern).

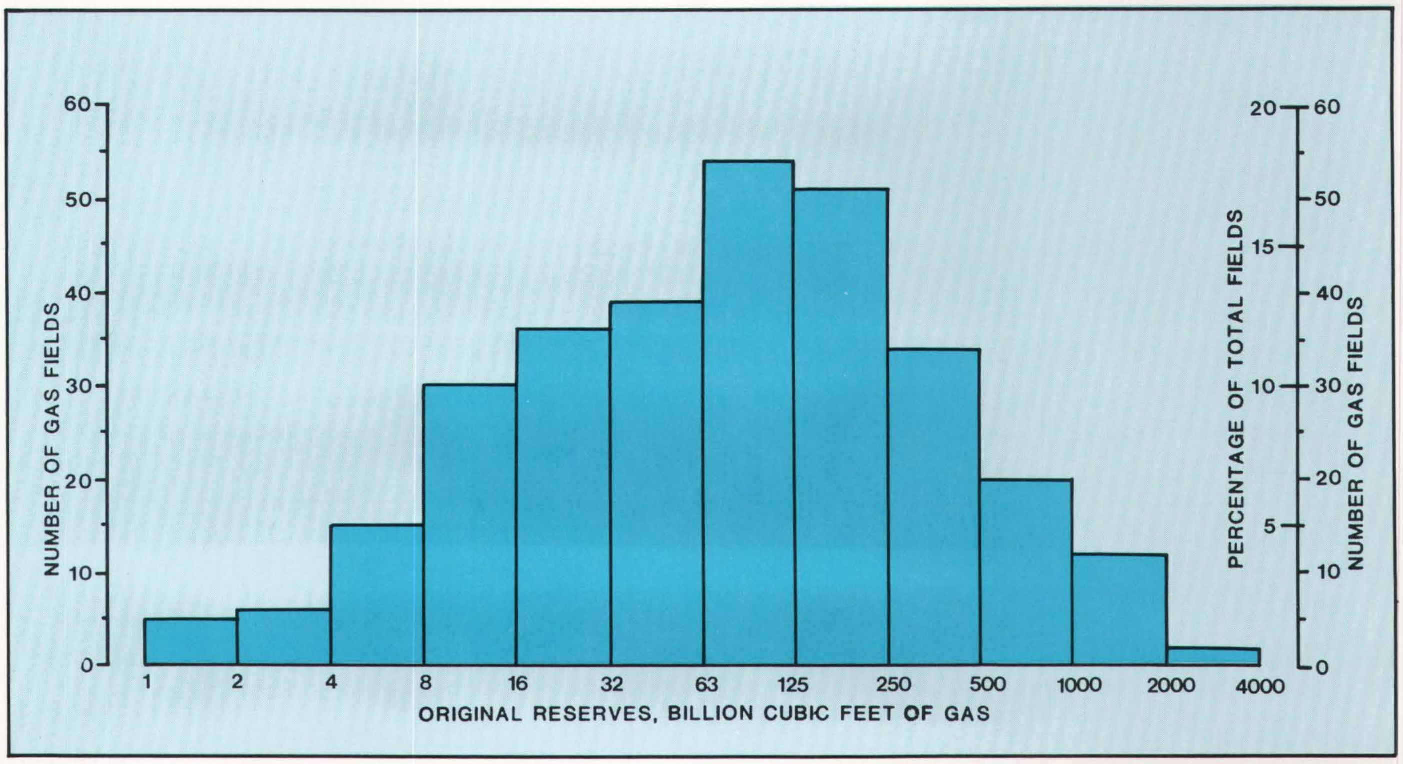


FIGURE 5.--Gas field-size distribution (modified from Bryan, Knipmeyer, and Schluntz, 1980, by Rogers, Golden & Halpern).

2. Magnitude and Timing of OCS Development

The Gulf of Mexico is the world's most intensively developed offshore oil- and gas-producing area, largely because the Region has a geologic structure and history favorable to hydrocarbon formation and entrapment. Other significant factors contributing to the intensity of the Gulf of Mexico development are the proximity of offshore resource areas to the onshore oil- and gas-producing areas of Louisiana and East Texas and the presence of nearby onshore production and support facilities that have fostered the technology necessary to develop offshore resources.

This chapter begins by briefly presenting background information on the history of offshore activities in the Gulf. Past lease sales in the Gulf are then described. The final section of the chapter provides information on OCS exploration, development, and production.

HISTORY OF OFFSHORE OIL AND GAS ACTIVITIES: 1933 TO THE PRESENT

The history of offshore activity in the Gulf of Mexico began in 1933 with the first attempt to drill an offshore well. In October 1937, the first well to produce hydrocarbons from the Gulf was drilled at a site 1,830 m (6,000 ft) offshore in the Creole Field off Louisiana by the Pure Oil Company and the Superior Oil Company. It was drilled from a small 30.5x91-m (100x300-ft) wooden platform on pilings in 4 m (13 ft) of water. Production began in 1938.

The Kerr-McGee Oil Company, operating under State lease no. 754 in the Ship Shoal Area off Terrebonne Parish, Louisiana, is recognized as discovering the Gulf's first commercial offshore oil completely out of sight of land. Kerr-McGee's well, completed on November 11, 1947, produced 600 barrels of oil per day. The installation consisted of a fixed platform for the rig plus basic machinery. Equipment, supplies, and crew quarters were provided by a small fleet of barges that moved between the platform and a support base at Berwick, Louisiana, 83 km (52 mi) away. Following this success, the use of offshore platforms and onshore support bases became the universal method of operation in offshore development.

By 1955, oil companies had extended the offshore frontier in the Gulf of Mexico to 80 km (50 mi), and there were more than 40 offshore platforms in operation. Problems associated with subsurface geology, platform design, and distance from supply and support bases caused costs to rise, but oil production from offshore wells increased through 1972. It has been declining since then. Gas production, however, continues to increase annually in small increments and is likely to level off in 1981 (USGS, December 1979, unpublished documents).

Summary of Legal History

Prior to 1953, individual States, particularly Louisiana, took the initiative to lease offshore tracts for oil and gas exploration. Louisiana held its first offshore lease sale a few months after the end of World War II. Leases sold by the States prior to passage of the Outer Continental Shelf Lands Act were later validated as Federal leases under section 6 of the Act. These leases, many of which are still producing, became known as "section 6" leases. The active section 6 leases are shown on plate 3.

A series of events established Federal jurisdiction over submerged lands of the Outer Continental Shelf. In 1945, President Truman issued a proclamation declaring the natural resources of the subsoil and seabed of the Outer Continental Shelf to be a territory owned by the Nation. By Executive Order No. 9633, the President placed certain resources of the Outer Continental Shelf under the jurisdiction of the Secretary of the Interior. On June 5, 1950, in a case involving Louisiana and Texas, the Supreme Court held that the United States is entitled to submerged lands in the area extending seaward from the coastline for 43 km (27 mi) from State waters. Louisiana had formerly claimed a 27-mile limit, and in Texas, the same ruling denied claims to all Outer Continental Shelf lands. On August 7, 1953, Congress passed the Outer Continental Shelf Lands Act, establishing Federal jurisdiction over all lands of the Outer Continental Shelf beyond State jurisdiction and assigning jurisdiction for these Federal lands to the Secretary of the Interior. The current authority for the leasing of OCS lands comes from this Act, as amended in 1978.

The U.S. Supreme Court established the boundaries between State and Federal jurisdictions in 1954. For Texas and the western coast of Florida, the boundary is the 3-marine-league line (17 km, or 10.4 mi); for Louisiana, Alabama, Mississippi, and the eastern coast of Florida, it is the 3-geographical (statute)-mile (4.8 km) line.

OCS LEASE SALES

Since the enactment of the Outer Continental Shelf Lands Act in 1953, the Bureau of Land Management has conducted 39 oil and gas lease sales in the Gulf of Mexico. Table 4 presents a summary of past lease sales and proposed sales for the Gulf.

Three types of oil and gas sales have been conducted in the Region: general lease sales, drainage lease sales, and government motion lease sales. **General lease sales** involve tracts to be leased as a result of the usual nomination and selection procedure. **Drainage lease sales** differ from general sales in one respect. Drainage tracts involve oil and gas reservoirs that drain from the unleased acreage of the Federal OCS into blocks being produced under either Federal or State leases. **Government motion lease sales,** which were once authorized under Department of the Interior regulations, were considered necessary for timely and orderly development, particularly in well-established and highly developed OCS leasing areas of the Gulf of Mexico. A government motion sale was one in which the Director of the BLM, with the recommendation of the Director of the USGS, selected drainage, development, and other special tracts to be considered for sale without first calling for nominations or comments. Current Federal regulations preclude any additional government motion sales.

In the Gulf of Mexico OCS, there have been 27 general lease sales, 11 drainage lease sales, and 1 government motion lease sale (Sale 45, in 1978). The frequency of sales in the Gulf shows considerable variation. Nearly 75 percent have occurred in the last 10 years. Although the first general oil and gas lease sale took place on October 13, 1954, there were only 10 such sales from that date through 1970. The pace of leasing increased to two sales each in 1972 and 1973. In response to the Arab oil embargo in 1973-74, lease sales further increased to seven in the period from 1974 to 1975. The rate returned to approximately two sales per year in 1976, and the current 5-year OCS oil and gas leasing schedule, published in June 1980, projects two sales per year through 1985 (U.S. Department of the Interior, June 1980, p. 3).

The Bureau of Land Management has offered 6,183 tracts (approximately 29 million acres) for lease in the Gulf of Mexico since 1953. Over 3,300 (53 percent) of those tracts were bid on, and those bids resulted in 2,936 tracts being leased. That is a lease rate of 89 percent of tracts upon which bids were received, and of 47 percent of the tracts offered.

TABLE 4.—Summary of Gulf of Mexico OCS lease sales and proposed sales through 1985

					Tracts offered		Tracts bid on		Tracts leased	
Year	Sale[1]	Sale date	Sale[2] type	Region[3]	Number	Acres[4]	Number	Acres[4]	Number	Acres[4]
1954	1	10/13	G	C	199	748,819	90	394,721	90	394,721
	2	11/09	G	W	38	111,788	19	67,148	19	67,148
1955	3	7/12	G	C&W	210	674,095	121	402,566	121	402,566
1956		No sales								
1957		No sales								
1958		No sales								
1959	5	5/26	G	E	80	458,000	23	132,480	23	132,480
	6	8/11	D	C	38	81,812	28	62,967	19	38,819
1960	7	2/24	G	C&W	385	1,610,254	173	813,663	147	704,526
1961		No sales								
1962	9	3/13	G	C	401	1,808,275	212	918,407	206	956,407
	10	3/16	G	C&W	410	1,875,984	210	977,092	205	956,592
	11	10/09	D	C	19	38,854	14	24,857	9	16,177
1963		No sales								
1964	12	4/28	D	C	28	34,027	23	32,671	23	32,671
1965		No sales								
1966	14	3/29	D	C	18	35,993	18	35,993	17	35,055
	15	10/18	D	C	52	227,898	32	134,717	24	104,717
1967	16	6/13	G	C	206	971,488	172	812,202	158	744,456
1968	18	5/21	G	W	169	728,550	141	666,630	110	541,304
	19	11/19	D	C	26	46,824	21	40,261	16	29,679
1969	19A	1/14	D	C	38	96,388	26	61,628	20	48,504
	19B	12/16	D	C	27	93,763	16	60,153	16	60,153
1970	21	7/21	D	C	34	73,359	21	50,889	19	44,642
	22	12/15	G	C	127	593,485	127	593,485	119	553,897
1971	23	11/04	D	C	18	55,872	13	42,222	11	37,222
1972	24	9/12	G	C	78	366,681	74	346,692	62	290,320
	25	12/19	G	C	132	604,029	119	548,374	116	535,874
1973	26	6/19	G	C&W	129	697,643	104	566,573	100	547,173
	32	12/20	G	E	147	817,297	89	496,916	87	485,396
1974	33	3/28	G	C	206	930,918	114	522,396	91	421,218
	34	5/29	G	W	245	1,355,678	123	680,335	102	565,112
	S1	7/30	G	C&W	258	1,298,738	49	249,703	19	100,240
	36	10/16	G	C	297	1,421,545	157	733,926	144	675,586
1975	37	2/04	G	W	515	2,870,344	143	796,366	113	626,585
	38	5/28	G	C&W	283	1,346,431	102	486,327	86	406,941
	38A	7/29	G	C&W	345	1,772,958	80	408,008	66	336,300
1976	41	2/18	G	C,W&E	132	687,603	41	191,717	34	161,285
	44	11/16	D	C&W	61	254,488	48	201,825	43	178,127
1977	47	6/23	G	C&W	223	1,074,535	152	739,326	124	605,426

See footnotes on next page.

TABLE 4.--Summary of Gulf of Mexico OCS lease sales and proposed sales through 1985--Continued

					Tracts offered		Tracts bid on		Tracts leased	
Year	Sale[1]	Sale date	Sale[2] type	Region[3]	Number	Acres[4]	Number	Acres[4]	Number	Acres[4]
1978	45	4/25		C&W	145	709,726	101	490,751	90	438,756
	65	10/31	G	E	89	511,709	35	201,294	35	201,294
	51	12/19	G	C&W	128	643,986	88	449,690	81	412,416
1979	58	7/31	G	C&W	123	577,516	88	424,029	81	391,182
	58A	11/27	G	C&W	124	588,600	96	450,913	90	421,519
1980	A62	9/30	G	C	192	909,207	147	706,042	116	551,643
	62	November			81	456,720	--	--	--	--
1981	A66	July			176[5]	897,877	--	--	--	--
	66	October			209[5]	1,081,114	--	--	--	--
1982	67	March			223[5]	1,160,964	--	--	--	--
	69	August			247[5]	1,287,850	--	--	--	--
1983	72	March								
	74	September								
1984	79	March								
	81	July								
1985	84	January								

[1]Prior to OCS Sale 33, designators (numbered designations) were not preassigned to OCS lease sales. For ease of reference, however, a designator has been assigned to each sale. OCS Sale 4, a planned Gulf of Mexico sale, was cancelled in 1956.

[2]G indicates general oil and gas lease sale; D indicates drainage oil and gas lease sale; GM indicates government motion oil and gas lease sale.

[3]C=Central; E=Eastern; W=Western.

[4]OCS lease sales are traditionally made in terms of acres. To obtain the metric equivalent (hectares), divide the acreages by 2.47.

[5]Tentative Tract Offerings.

SOURCE: Bureau of Land Management, 1979b.

Geographic Pattern of Leases

The diffusion of leasing and exploration throughout the Gulf of Mexico has been characterized by two phases of expansion. First, the leading edge of the frontier has extended seaward from the coast into the deepwater areas of the Outer Continental Shelf as technology has developed. The second phase is both a westward expansion of exploration along the South Texas coast and an eastward expansion into the MAFLA region (Sales 5, 32, 41, and 65). Plate 3 shows geographic distribution of current and expired leases in the Gulf of Mexico.

Several factors have influenced the spatial distribution of leases in the Gulf of Mexico over the last 3 decades. Three significant factors have governed the overall expansion of exploration, development, and production: (1) technological development, (2) increased geophysical and geological knowledge, and (3) the economics of incremental expansion of offshore production and pipeline facilities and onshore support and processing facilities.

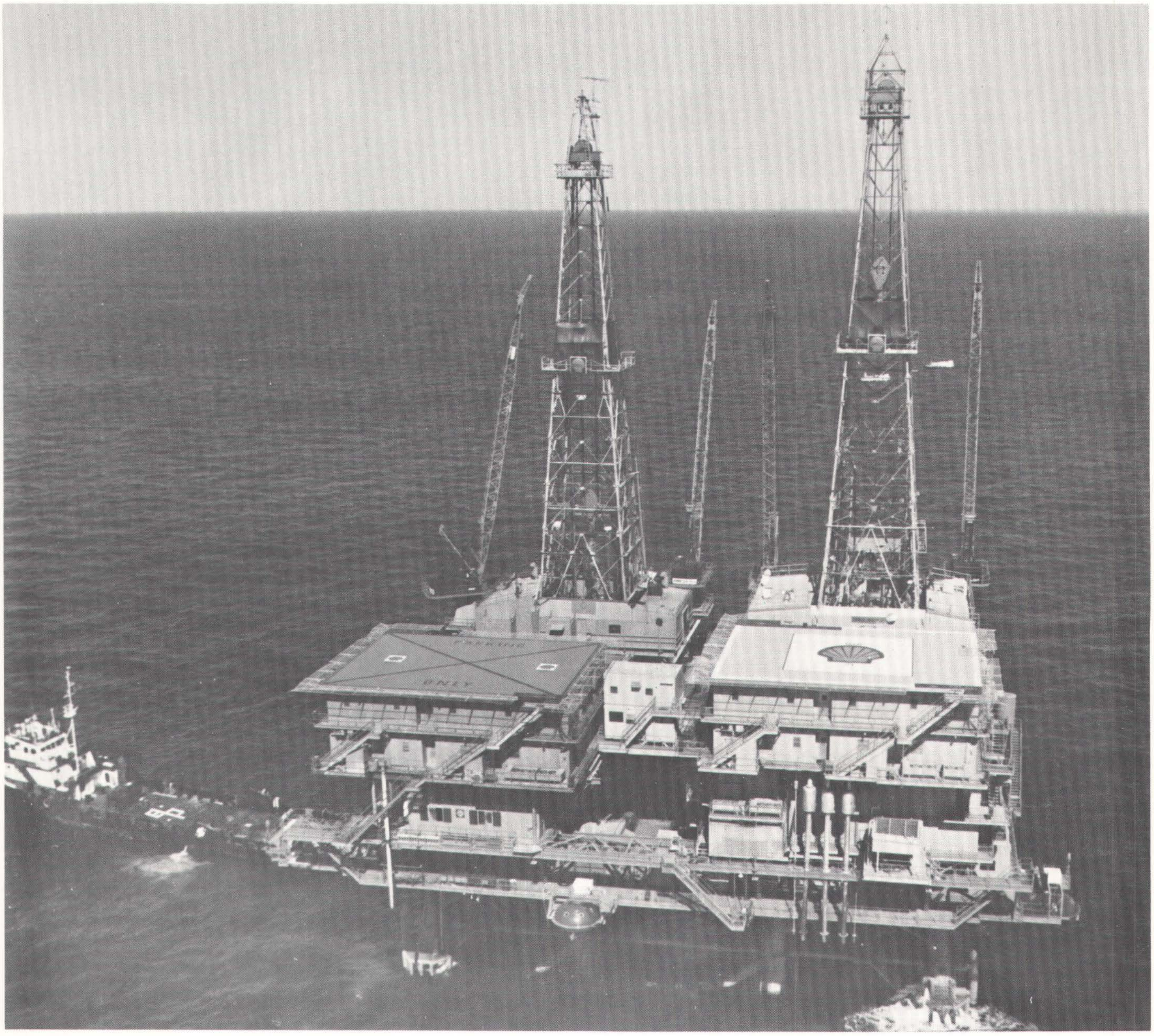


FIGURE 6.--Cognac Platform (photograph by Shell Oil Company).

The development of new technology for operations in deep water has paralleled, and in some cases caused expansion of, the OCS frontier in the Gulf of Mexico. Technological achievements include subsea well completions, the successful laying of deepwater pipelines, and improved resource recovery methods. Shell Oil Company's Cognac Platform is an example of the latest advances in deepwater technology (fig. 6). It stands in 312 m (1,025 ft) of water just 24 km (15 mi) south of the mouth of the Mississippi River. Cognac is the world's deepest-water offshore platform (Dunn, 1980, p. 25). Deepwater production platforms like Cognac usually require deepwater pipelines to transport oil and gas to onshore locations: a small-diameter pipeline was installed from Cognac to Plaquemines Parish, Louisiana, originating at the platform in 305 m (1,000 ft) of water (Lochridge, 1980, p. 123).

Exploration has hitherto been limited by the inability to locate hydrocarbons without drilling. In recent years, sophisticated instrumentation and refinements in computer methods have enhanced geologists' ability to gather and interpret data gleaned through geological and geophysical surveys, and previously bypassed tracts have become more attractive prospects for oil companies. This has resulted in the diffusion of exploration into previously unleased areas.

Tracts Leased and Royalty Revenue Received

The number of tracts offered and leased in the Gulf of Mexico has fluctuated widely by sale and by year. Many factors contribute to the relative attractiveness to the petroleum industry of individual tracts in a given sale. On occasion, a lease sale may include tracts that are generally unattractive to industry. A comparison made between the number of tracts offered, the number of tracts bid on, and the number of tracts leased provides some understanding of the yearly change (fig. 7).

It is obvious that fewer tracts are actually leased than the number offered or bid on in a given sale. There are years, however, when the number of tracts offered in the Gulf has greatly exceeded both the number of tracts bid on and the number of tracts actually leased. This occurred frequently in the period before 1976, when the tract nomination and selection process was initiated and the first 5-year oil and gas lease sale schedule was established.

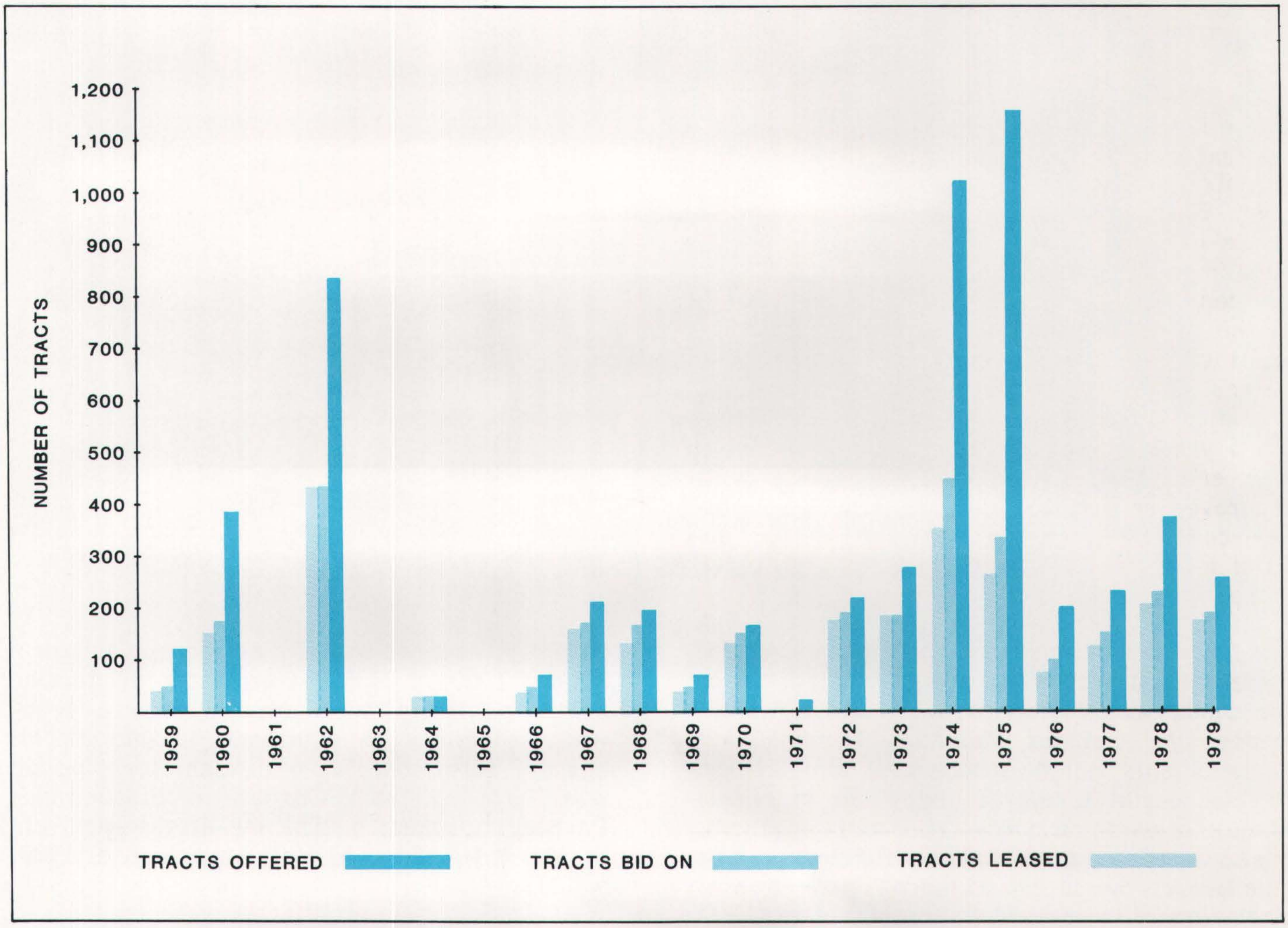


FIGURE 7.—Yearly summary of tracts offered, bid on, and leased, 1959-1979 (BLM, 1979b).

In 1974 and 1975, a large number of tracts were offered in an effort to increase exploration in the Gulf of Mexico. Not only did the number of tracts per sale offered in 1974 and 1975 increase, but the number of lease sales also increased. Seven lease sales were conducted in the 17-month period from March 1974 to July 1975. Many of the tracts offered for lease in Sales S1 and 37, however, were not attractive to bidders. (Sale S1 consisted of tracts previously offered in Sales 33 and 34.) Bids for Lease Sales S1 and 37 were few and the average per-acre bonus (a measure of the potential yield) accepted by the Government was low.

A similar phenomenon occurred in Lease Sales 7, 9, and 10, held in 1960 and 1962. However, the disparity between the number of leases offered and the number of leases bid on and accepted seems to be attributable to a more complex, less easily explainable, set of circumstances (Sieverding, 1980, oral commun.).

Three types of revenue are generated from leases in the Federal OCS: **cash bonuses, annual lease rentals,** and **royalty revenue.** Appendix C describes the bidding system in detail. Briefly, tracts are typically leased on the basis of a cash bonus bid system. In this system, bids are submitted accompanied by 20 percent of the winning bid, or cash bonus. When tracts are leased, the remaining 80 percent of the bonus is collected and the first year's lease rentals are paid annually while the lease is active, generally for a primary term of 5 years. If production commences before the end of the initial 5-year period, or if approved drilling or well reworking operations are conducted, the lease remains active. Annual lease rental is calculated at a fixed rate based on acreage. Recent lease rentals in the Gulf of Mexico OCS have been $3.00 per acre or fraction of an acre per year. Normally, blocks off Louisiana comprise 2,024 hectares, or 5,000 acres; blocks off the other Gulf States are 2,304 hectares, or 5,760 acres.

In addition to the cash bonus and the annual lease rental, lease holders typically pay fixed royalties on the value of production from the block. While the statutory requirement is that royalty rates not be set lower than 12-1/2

The words "lease," "tract," and "block" have discrete definitions and applications. **Lease** is used to mean a contract authorizing exploration for and development and production of minerals, or the land covered by such a contract. A **tract** is the geographic and legal extent of a single lease area. It is a convenient way of numbering blocks offered for sale so that they can be sequentially numbered in the process of offering. Once an operator signs the lease, the area is referred to as a **block;** that is, the geographical area as portrayed in official BLM protraction diagrams or leasing maps. A block generally contains approximately 9 square miles (2,024 hectares, or 5,000 acres, off Louisiana and 2,304 hectares, or 5,760 acres, elsewhere in the Gulf of Mexico).

percent, the usual rate for blocks in the Gulf of Mexico is 16-2/3 percent. Figure 8 shows royalty revenue by year in the Region. Virtually all royalty revenue generated from Gulf of Mexico oil and gas operations (97 percent in 1979) results from production off Louisiana. Three percent comes from the Texas OCS. No royalty revenue is generated off Alabama, Mississippi, or Florida. Table 5 is a summary of royalty revenue.

OCS EXPLORATION, DEVELOPMENT, AND PRODUCTION

Since the 1947 completion of the first well on a platform out of sight of land, exploration, development, and production activities in the Gulf of Mexico have proceeded at a

FIGURE 8.--Federal royalty revenues by year in the Gulf of Mexico (drafted from USGS, June 1979, by Rogers, Golden & Halpern).

TABLE 5.—Federal royalty revenue from Gulf of Mexico OCS oil and gas operations

Year	Louisiana	Texas	Total
1953	$ 967,892	--	$ 967,892
1954	2,748,977	--	2,748,977
1955	5,139,027	$ 979	5,140,006
1956	7,622,708	6,675	7,629,383
1957	11,387,865	3,380	11,391,245
1958	17,423,878	--	17,423,878
1959	26,539,836	141	26,539,977
1960	36,807,678	47	36,807,725
1961	46,733,742	--	46,733,742
1962	65,253,373	1,837	65,255,210
1963	75,347,238	26,627	75,373,865
1964	86,532,857	2,449	86,535,306
1965	99,654,618	1,666	99,656,284
1966	131,253,307	1,596,615	132,849,922
1967	149,096,032	4,336,351	153,432,383
1968	190,907,982	4,676,977	195,584,959
1969	226,504,238	4,999,819	231,504,057
1970	262,709,833	4,940,860	267,650,693
1971	324,815,819	4,648,136	329,463,955
1972	342,476,302	5,490,243	347,966,545
1973	380,509,177	6,087,415	386,596,592
1974	535,836,029	7,334,827	543,170,856
1975	593,359,397	7,643,604	601,003,001
1976	682,922,971	7,113,687	690,036,658
1977	899,016,863	10,640,022	909,656,885
1978	1,086,512,776	51,813,251	1,138,326,027
1979	1,344,995,442	157,025,060	1,502,020,502

NOTE: No royalty revenue has been generated from OCS production offshore Alabama, Florida, and Mississippi.

SOURCE: Adapted from USGS, June 1980.

great pace. More than 17,000 offshore wells, most of which are south of Louisiana and the Mississippi River Delta, have been drilled in the Gulf of Mexico OCS (USGS, June 1980, p. 32). Exploration, development, and production currently occur on 1,777 leased blocks (USGS Monthly Report, February 1980, p. 23).

Exploration

EXPLORATORY ACTIVITY. The initial phase of offshore oil and gas operations is exploration. Exploratory operations are carried on so that geological formations with hydrocarbon potential can be located.

Once a block is leased, and prior to exploratory drilling on it, an operator must submit a Plan of Exploration (POE) to the Deputy Conservation Manager of the U.S. Geological Survey. The USGS receives hundreds of Plans of Exploration annually. In FY 1978, 465 Plans of Exploration were received; 371 such plans were received in FY 1979. Between December 13, 1979, when the revised requirements for the filing of Plans of Exploration and Plans of Development and Production were implemented (30 CFR 250.34), and July 24, 1980, 255 POE's (including Initial, Supplemental, and Revised Plans) were filed. Approvals were granted for 220 of these plans. The number of Plans of Exploration is one indicator of the general level of exploration activity. In FY 1978, 369 exploratory wells were drilled in the Gulf of Mexico OCS; in FY 1979, 314 exploratory wells were drilled.

When exploration begins, operators select one of several types of mobile drilling rigs (barge, drill ship, jack-up, or semisubmersible) to match water depth and bottom conditions. The offshore exploration activity is supported by onshore bases from which supplies are transported by boat to the drilling rigs. Apart from these supply bases, little onshore development takes place during the exploration phase, unless the drilling rigs themselves are fabricated in communities adjacent to the area of offshore exploration.

As of February 1980, there were 109 offshore mobile drilling units operating in the Gulf of Mexico: 11 submersible rigs, 68 jack-ups, 23 semisubmersibles, and 4 mobile drill ships that are working; and 2 jack-up rigs and 1 mobile drill ship that are under repair (USGS Monthly Report, February 1980, p. 26). Figure 9 shows activity on a drill ship, the Glomar Grand Banks.

UNITIZATION OF LEASES. Frequently, during both the exploration and development phases, a single reservoir may underlie leases held by two or more companies. In such cases a strong motivation exists for each company to explore for and produce as much oil and gas as possible from its own lease to prevent drainage of oil and gas to adjoining leases. In the past, this practice has led to needless and costly drilling and large-scale waste of oil and gas. Unitization is one means of curbing such wasteful practices.

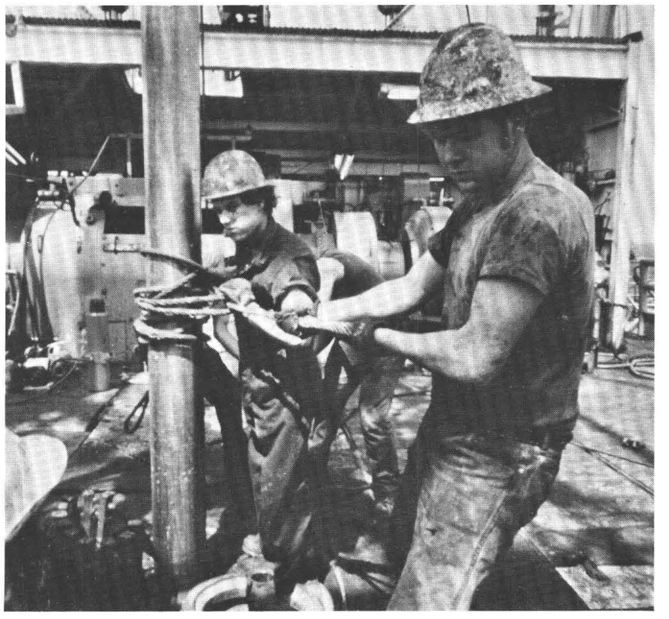


FIGURE 9.--Activity on the drill ship Glomar Grand Banks (photograph by American Petroleum Institute).

Unitization is the practice of pooling all interest, ownership, and control in a producing field or part of a field. A "unit agreement" provides for a single operator or company to develop and operate several leases as if they were one. The purpose of the agreement is to maximize oil and gas recovery from reservoirs with multiple owners, while eliminating the drilling of unnecessary wells, reducing development and production costs, and assuring the orderly development of petroleum resources.

As part of its supervisory role in the OCS production process, the USGS encourages voluntary unitization. When operators fail to enter into unit agreements voluntarily, the USGS initiates the formation of units where it is deemed necessary for conservation and protection of public resources. The USGS administers operations in approved unitized areas.

There are currently 123 units in effect in the Gulf of Mexico OCS. Eighty-seven are reservoir units, with a total of 58 leases; and 36 are fieldwide or exploratory units, with a total of 200 leases. Unitization is usually required for the effective use of most secondary and tertiary recovery operations where the petroleum reservoir involves more than one lease. Of 354 secondary recovery projects in effect in the Gulf, 130 of them are within unitized areas (USGS Monthly Report, February 1980, p. 14).

Discoveries and Development

DISCOVERIES. Exploration may lead to discoveries of oil and gas. Although the number of exploratory wells (and discoveries) may vary from year to year, the general level of activity in the Region remains relatively constant. In FY 1978, 28 discoveries were made: 21 were classified as gas and 7 as oil. There were 43 discoveries in FY 1979.

DEVELOPMENT ACTIVITY. The development phase encompasses the activities necessary to bring a discovered field to the point of commercial production. This is a period of intense activity. When significant (commercially producible) quantities of hydrocarbons are discovered, development follows. Delineation, or expendable, wells are drilled to determine the field's configuration and capacity.

Most of the critical decisions concerning the location and construction of onshore and offshore facilities are made during the development phase, and it is the period of the greatest employment and the most significant environmental impacts. However, in the Gulf of Mexico Region, the infrastructure necessary for development (permanent service and support bases, pipelines, marine terminals, processing plants) already exists; therefore the requirements for each additional field add a relatively small increase to the Region's workload. At the end of 1979 there were 2,420 platforms in the Gulf of Mexico, a net increase of 95 platforms over the end of 1978. By March 1980 the number of platforms had increased to 2,432. Because many platforms are automated, not all are manned at all times. Only 490 of the current number are manned 24 hours a day (USGS, 1979-1980 monthly reports). Figure 6 (p. 17) is a photograph of Shell Oil Company's Cognac Platform.

Completion is the term used to encompass the various activities necessary to convert a development well or an exploratory well into a producer of oil and/or gas. Completion may involve setting and cementing casing; perforating the casing to permit oil and gas to flow into the well hole; fracturing (introducing chemicals, applying pressure, or using explosives to increase formation permeability); acidizing (using acid to enlarge holes in the formation); consolidating sand (to keep sand from filling the well bore); setting tubing (conduit for routing oil and gas to the surface); and installing downhole safety devices (valves installed to prevent blowouts during production) (Kash and others, 1973, p. 21). These completion procedures are closely supervised and regulated by the USGS in OCS Orders 5 and 6.

Occasionally, development wells are brought into production by means of subsea completions. These are wells in which the major assembly of piping, valves, and related equipment used to produce oil and gas are located at or near the sea bottom. The wellhead is placed on the sea floor rather than on platforms, and the produced liquids or gases are transferred from the wellhead either to a nearby platform or directly to a shore facility by pipeline for processing. At the present time there are 25 subsea completions in the Gulf of Mexico (Courtney, 1980, oral commun.).

In the Gulf of Mexico OCS, development is a continuous activity. Plans of Development and Production (POD/P's) are received by the USGS in a continuous flow numbering in the hundreds per year. During FY 1978, 567 POD/P's were submitted to the USGS; 271 such plans were submitted in FY 1979. Between December 13, 1979, when the revised requirements for the filing of POE's and POD/P's were implemented (30 CFR 250.34), and July 24, 1980, 159 POD/P's (including Initial, Supplemental, and Revised Plans) were filed. Eighty-seven of those plans were approved. The number of POD/P's is indicative of the magnitude, timing, and complexity of Gulf of Mexico OCS operations. Moreover, a complete review of recently submitted POD/P's reveals an intense regionwide scope of development and production.

Gulf of Mexico Outer Continental Shelf Orders Governing Oil and Gas Lease Operations, issued by the U.S. Geological Survey, regulate exploration, development, and production on the Gulf of Mexico OCS. The orders, numbered as follows, establish operating requirements in 14 critical categories: (1) identification of wells, platforms, structures, mobile drilling units, and subsea objects; (2) drilling operations; (3) plugging and abandonment of wells; (4) determination of well producibility; (5) production safety standards; (6) completion of oil and gas wells; (7) pollution prevention and control; (8) platforms and structures; (9) oil and gas pipelines; (10) sulfur drilling procedures; (11) oil and gas production rates, prevention of waste, and protection of correlative rights; (12) public inspection of records; (13) production measurement and commingling; and (14) approval of suspensions of production.

Drilling activity on the Gulf OCS, reflected by the number of POE's and POD/P's submitted to the USGS, is displayed in figure 10, which is a summary of wells started, wells completed, and dry holes, failures, and abandoned wells in the Gulf of Mexico OCS. At the end of FY 1979 there were 3,382 producing gas wells and 3,576 producing oil wells on the Gulf OCS (USGS, unpublished documents, 1979, p. 2).

Production

PRODUCTION ACTIVITY. In the production phase, oil or gas or both begin to be produced from offshore wells. Hydrocarbons are then transported to shore in the pipelines laid during the development phase. When a new field cannot be economically linked to the existing pipeline network, oil and gas is transported by tankers or barges.

Production has the longest duration of all phases of offshore operations: it may last for 20 years or longer. Characteristically, employment offshore drops sharply from that of the development stage as production becomes a routine procedure. Automated platforms may require only daily inspections and regular maintenance. In the case of subsea completions, longer service intervals are possible.

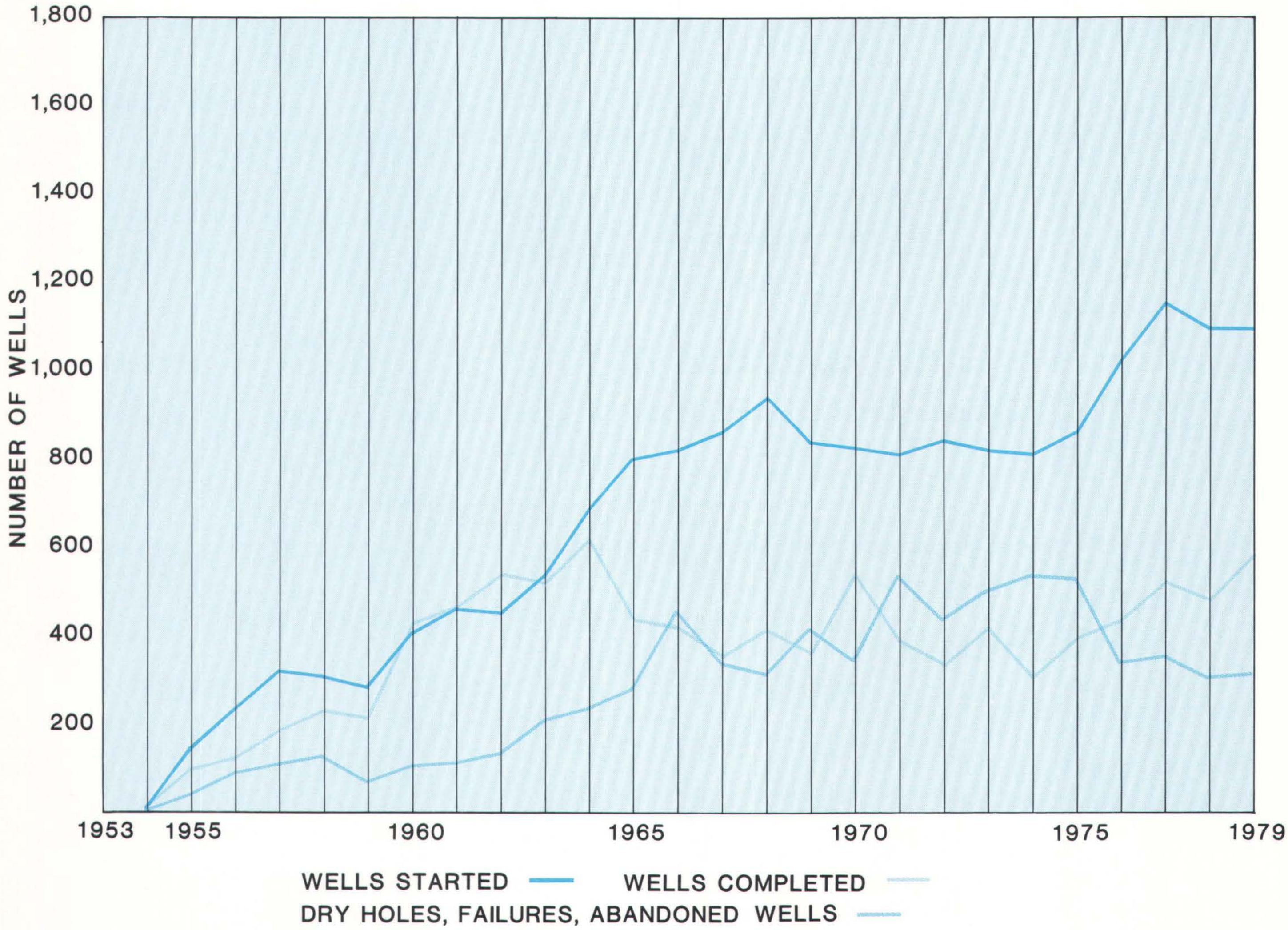


FIGURE 10.--Summary of oil and gas well activity in the Gulf of Mexico OCS (drafted from USGS, June 1979, by Rogers, Golden & Halpern).

Production may take place on one platform or on a series of offshore structures consisting of one or two main platforms and several outlying structures. Exxon Company, operating on West Delta Block 73 Field, about 32 km (20 mi) southeast of Grand Isle, Louisiana, has this type of production complex. There are two linked platforms with crew quarters and production and related facilities. Five satellite structures are located nearby. The main structure, located in 49 m (160 ft) of water, has been producing since 1962 (fig. 11). Approximately 12,000 barrels of oil and 40 million cubic feet of gas are produced daily from eight directionally drilled wells. Oil and gas are transported to shore in separate 12-inch pipelines (Davey, 1980, oral commun.).

Although offshore manpower requirements usually decline during production, as the focus of activity shifts to onshore locations, the process of bringing new fields into full production requires additional drilling and labor. Exploration and development drilling in the form of delineation wells continues until each new field is defined. When production declines, wells are periodically worked over to boost output.

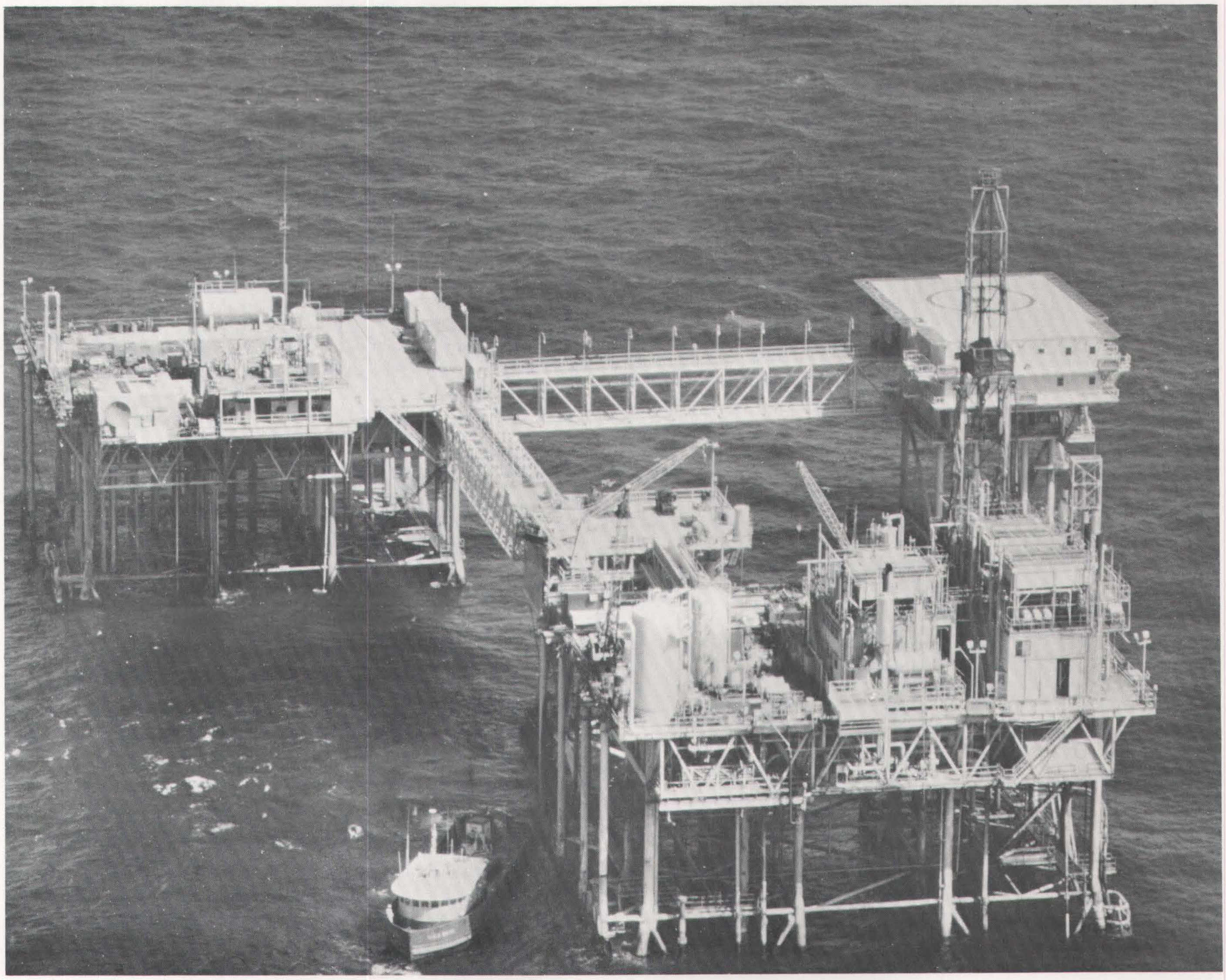


FIGURE 11.--Main platform of Exxon's West Delta Block 73 field (photograph by Karen M. Collins, 1980).

PAST AND PRESENT PRODUCTION. Oil production from the OCS in the Gulf of Mexico increased steadily from 1953 to 1972. Since 1972, oil production has declined each year. Virtually all OCS oil production in the United States comes from the Gulf of Mexico (96 percent in 1979). In 1971, just before it peaked, production in the Gulf accounted for 93 percent of U.S. OCS oil, and that was the lowest proportion of OCS production ever to come from the Gulf of Mexico. Although OCS production from the Gulf comes from areas off Louisiana and Texas, 99 percent is currently produced from the Louisiana OCS. The Gulf currently produces 274 million barrels of oil annually, or about 750,000 barrels per day. Figure 12 shows Gulf of Mexico OCS oil production.

Gas production from the Gulf OCS rose slowly until 1965, before it increased more steeply through 1974. After a slight decline in 1975, it has continued to climb to the present and it is expected to peak in 1981. Unlike the State oil production levels, gas production from Texas accounted for 12.2 percent of the Gulf total in 1979. New field discoveries in recent years have added more gas than oil to known reserves.

Figure 13 shows gas production from the Gulf of Mexico OCS. Current gas production from the Gulf is over 4-1/2 trillion cubic feet annually, or about 13.1 billion cubic feet per day on the average.

An assessment of the characteristics of Gulf of Mexico oil and gas indicates that both are generally of high quality in terms of specific gravity and relative freedom from impurities like sulfur and its compounds.

Production capabilities of some significant oil and gas fields are quite high. For example, South Marsh Island Block 66, a major oil-producing field, yielded 272,659 barrels during August 1979, but the field had a projected fourth quarter 1979 Maximum Attainable Rate of production of 372,900 barrels. Vermilion Block 39, a major gas-producing field, yielded 552,707,000 cubic feet of gas during August 1979.

Oil produced on the U.S. OCS is about 9.3 percent of all domestic crude oil and condensate production (USGS, June 1979, p. 100). Gas production from the nation's OCS accounts for approximately 22.4 percent of all domestic gas production (USGS, June 1979, p. 100).

FIGURE 12.--Annual oil production from the Gulf of Mexico OCS (drafted from USGS, June 1979, by Rogers, Golden & Halpern).

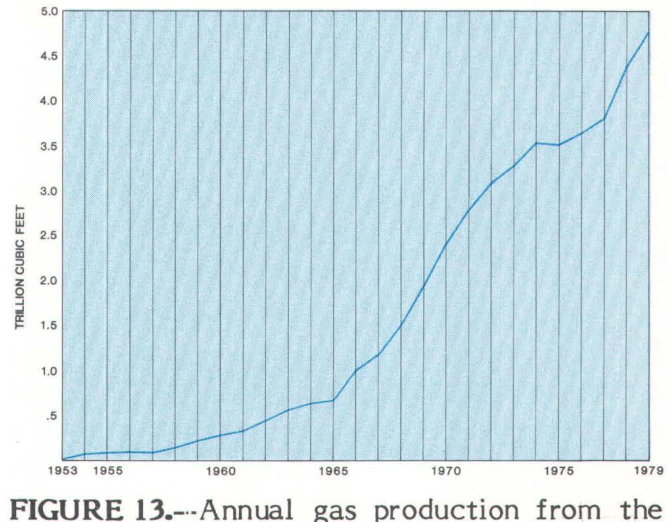


FIGURE 13.--Annual gas production from the Gulf of Mexico OCS (drafted from USGS, June 1979, by Rogers, Golden & Halpern).

The specific gravity of a liquid is the ratio of its density to the density of water at specified temperature and pressure. The gravity of oil, which is usually lighter than water, is normally specified not as a fraction of water density but in terms of degrees on the API gravity scale, which allows finer distinctions to be made among oils than measurements in terms of specific gravity. On the API scale, oil with the least specific gravity has the highest API gravity. Other things being equal, the higher the API gravity, the lighter (less viscous) the oil, and the less complex the refining process. Most crude oils range from 27 degrees to 35 degrees API gravity (Williams and Meyers, 1976, p. 25).

The specific gravity of Gulf of Mexico crude oil ranges between 25 degrees API and 45 degrees API, with most of it falling between 25 degrees and 37 degrees API. Gulf of Mexico crude oil is considered to be light oil. Density is also an indicator of end use. The heaviest oils are used to make products like asphalt, while the lightest oils may be used for aircraft fuel or gasoline. Crude oil in the midrange is used to manufacture many products such as home heating oil, fertilizers, pharmaceuticals, synthetic fabrics, and plastics.

Crude oil, natural gas, and gas condensate (liquid hydrocarbons produced with natural gas) from the Gulf OCS are generally classified as "sweet." This means that Gulf crude oil contains very little sulfur and that the gas and gas condensate are free of significant amounts of hydrogen sulfide, sulfur compounds, or other chemical impurities. Sweet oil and gas are cheaper to refine or process, capable of a wide range of end uses, and more marketable.

The viscosity of a crude oil is a measure of its ability to flow. The more viscous an oil, the less readily it will flow; the lower the viscosity, the faster the oil will flow. To arrive at the viscosity of a crude oil, a measured quantity (usually 60 cc) of oil is permitted to flow through a standard gauge at a specified temperature. The number of seconds required for it to flow through is the oil's viscosity.

Viscosity of Gulf crude oil ranges between 1 and 1-1/2 centipoise. This is a low viscosity, and the oil can be easily pumped from wells and transported to shore in pipelines. The low viscosity also permits the use of traditional enhanced recovery techniques when well workover becomes necessary.

DECLINING PRODUCTION AND ENHANCED RECOVERY. Production from oil and gas wells reaches a peak and then begins a long, slow decline. Although the periodic working over of wells boosts declining output, it can prolong the useful life of a well only until reserves are depleted or production is no longer economically justified. With changing market conditions and the availability of new technology, declining production may be forestalled by using various techniques for **enhanced recovery.**

Enhanced recovery techniques promote further production from wells where production is declining. In one-third of the oil fields in the Gulf, conventional water flooding is used to maintain pressure. In another third, some combination of water and steam or gas injection is employed (Schluntz, March 1980, oral commun.). More sophisticated recovery methods for crude oil are steam drive, polymer injection, CO_2 injection, steam soaking, caustic flooding, and in situ combustion.

Enhanced recovery of crude oil in the Gulf is currently limited to the smaller types of gas and/or water injection projects because of economics and the characteristics of the oil and the reservoirs. Some fields require the application of one of the above methods even for initial recovery of crude oil. However, large-scale enhanced recovery has not been necessary in the past because recovery through primary flow is reasonably high in the Gulf.

There are several reasons for the anticipated decline in oil production from the developed area of the Gulf of Mexico OCS.

- Oil and gas resources of the Gulf OCS are found in association with salt domes and a highly faulted geological structure. This tends to limit reservoir and field sizes. The major domes with the largest associated reservoirs and fields have probably already been discovered. Smaller and less important structures remain.

- The larger established oil fields have been producing for a long time. They are aging fields and depletion can be expected. Exploration westward, toward Texas, is resulting in discovery of more gas than oil.

Although the decline in gas production from the Gulf is not so imminent, the long-term future is not much brighter than that for oil, unless the possibility of discoveries in deepwater areas is realized. By and large, the reasons for the long-term decline in gas production are the same as those for oil.

Of the 70 significant oil and gas fields discussed earlier in this chapter, yields from the 38 oil fields and the 32 gas fields are expected to decline by 16.6 and 14.9 percent, respectively, over the 2-year period ending January 1, 1982. This decline will occur despite continued drilling on some leases. However, enhanced recovery is likely to support production to some degree (USGS, December 1979, unpublished document, p. 2).

PRODUCTION SHUTDOWN. The shutdown phase occurs when reserves are depleted and production ceases. When production is no longer economically justified, wells are capped and fields are gradually abandoned. Onshore facilities are closed or put to other uses. Planning considerations are directed toward mitigating impacts, adjusting to the loss of revenues, and maintaining the economic base.

When a field is depleted and abandonment is necessary, the operator must plug the wells in accordance with USGS OCS Order No. 3. The USGS monitors and enforces abandonment regulations. All oil and gas zones must be isolated, and freshwater zones must be protected by installing cement plugs 4.5 m (15 ft) below the ocean floor to ensure a permanent seal. All pipe casings are cut off below the ocean floor and the well location is cleared.

In the past, platform removal and field depletion have not generated serious concern, but production from the Gulf of Mexico is in decline and planners must consider mitigating the effects of these changes. While platform installations now exceed platform removals by a wide margin, future years will bring a reversal of this trend. The average annual platform removal rate is currently around 40 (Reggio, 1980, oral commun.). Concern over removal of these structures is expressed by recreational planners because platforms, many of which have been in the Gulf for a period of years, form artificial reefs that provide good sport fishing, a major recreational activity among Gulf Coast residents and tourists.

Planning considerations also shift to onshore locations when decisions are made concerning platform removal. Leases require that abandoned platforms be dismantled and removed no later than 1 year after the lease expires. To date, abandoned platforms have been hauled to onshore locations, but as the pace of field depletion increases, this may become an unattractive and inadequate solution.

As oil and gas production decline more rapidly in the future, a question arises: where will future supplies come from? According to an analysis made by the Central Intelligence Agency in 1979, total U.S. oil production for 1979 was about 10.2 million bpd. This is expected to drop to 9.9 million in 1980 and 9.2 million in 1982 (OGJ, September 3, 1979, p. 50). The result of declining domestic reserves and production has been a steady increase in oil and gas imports. In 1978, over 46 percent of petroleum consumed in the United States was imported, while almost 5 percent of natural gas consumption was supplied by foreign sources (Bookman, 1980, p. 3).

Future Exploration, Development, and Production

LEASE SALES SCHEDULED THROUGH 1985. According to the current 5-year OCS oil and gas leasing schedule (June 1980), two lease sales are scheduled each year for the next 5 years in the Gulf of Mexico, except for 1985, when only one sale is scheduled. On the basis of the Tentative Tract Selections that have occurred for 6 of the 11 proposed sales in the Gulf, it is likely that tracts included in future sales will be distributed through the Gulf OCS. Table 4 (p. 15-16) gives dates of proposed Gulf of Mexico sales.

FUTURE PACE OF EXPLORATION, DEVELOPMENT AND PRODUCTION. Exploration and development on the Gulf of Mexico OCS will continue at their present levels in the short term, but both are likely to increase over the long term. Oil production, however, is expected to continue its gradual decline for the foreseeable future. Gas production is expected to increase and then begin a gradual decline. Additional reserves from future discoveries and development will likely not be enough to offset the decline in reserves from future production.

Future exploration and development will almost certainly involve deepwater and geographically remote areas (South Texas, MAFLA, and far offshore). Any discovered fields in these areas will have to be larger than fields in shallower waters in order to meet minimum economic requirements for development. In areas closer to shore, newly discovered, smaller fields could be economically attractive because the technology and infrastructure already exist to produce from them. The stimulus of price decontrol and the use of new, more cost-effective technology will allow the development of these marginal fields.

Implementation of enhanced recovery techniques may also make it possible to extract a larger proportion of oil and gas from both the newly discovered fields and the already developed mature fields, depending on the physical nature of the reservoirs and on the economics of production. However, unless more and larger discoveries result from future exploration efforts (a prospect which is not likely), ultimate depletion of Gulf of Mexico OCS reserves is probable sometime after the year 2000, given current production rates. For discussion of the long-term oil and gas production forecast and the implications of the future decline in OCS-generated supply, see appendix D.

The Gulf of Mexico is a mature oil- and gas-producing region with a fully developed network of onshore and nearshore support facilities. Although production is projected to decline, onshore facilities will continue to provide a high level of support for offshore operations. As production declines, more exploration is likely to occur as operators seek to maintain production levels. This greater exploration effort will require an increased level of support in the form of services and equipment.

Although the long-range outlook is for an increased pace of exploration and development, a short-term increase in exploration and development is constrained by a relatively fixed stock of drilling equipment and sites to construct such equipment like drill ships, rigs, and platforms. The pace of exploration and development activity will increase as additional drilling rigs and equipment become available. The demand for additional drilling machinery for both Gulf of Mexico operations as wells as the worldwide offshore industry should result in more onshore activity in selected Gulf Coast centers, especially where platform fabrication, pipe coating, and related activities occur. Transportation and onshore facility aspects of future exploration, development, and production are discussed in chapters 3 and 4.

3. OCS Oil and Gas Transportation Strategies

Oil and gas produced offshore may undergo preliminary separation and treatment at the platform, but they must be transported to shore for additional processing and refining. Ninety-eight percent of the oil produced in the Gulf is transported to shore by pipeline; the balance is carried on barges or tankers (Overstreet, 1980, oral commun.). With the implementation of the Intergovernmental Planning Program, State and local officials now have the opportunity, through Regional Technical Working Groups, to participate in the transportation planning process.

EXISTING AND PROPOSED TRANSPORTATION NETWORK

Pipeline Transportation

Pipelines serve two functions on the OCS: gathering hydrocarbons from scattered fields and carrying them to a central point for storage, measurement, and preliminary treatment; and moving the oil and gas ashore. Before pipelines can be installed, operators must file applications for pipeline permits and approval must be granted. Pipeline permit applications are reviewed by a number of agencies, depending on the purpose of the pipeline, the mineral resource being transported, the method of transport, and the onshore facilities required. As of March, 1980, there were 18,160 km (11,285 mi) of approved pipelines in the Gulf of Mexico. Over half (10,610 km or 6,593 mi) of those pipelines were approved by the BLM; the remainder were approved by the USGS.

The portion of a pipeline between a platform and a collection point is called a **gathering line.** The portion of a pipeline between a collection point and the shore is called a **transmission line.** Transmission lines may carry oil or gas (and sometimes both) and are classified, for purposes of regulation, as either single-custody or common-carrier lines. Single-custody lines carry the output of only one operator; common-carrier pipelines transport the resources of several operators. These transportation activities are regulated by a number of government agencies (table 6).

The use of pipelines as the predominant method of transporting OCS oil and gas is a result of safety and economic considerations. Pipelines benefit from economies of scale: the larger the pipeline, the lower the unit transportation cost. The link between pipeline size and economy is illustrated by the fact that a line 36 inches in diameter can carry 17 times more oil or gas than a 12-inch line. For each barrel or cubic foot of capacity, construction and operating costs for the larger line are smaller than for the smaller line. As long as the total volume, or throughput, is sufficient to keep the pipeline essentially filled, considerable economies are possible (API, 1979, p. 5). Since the probability of spillage increases with the amount of handling, the fact that the oil and/or gas enters the pipeline at the platform and goes straight to the onshore processing facility reduces exposure to transfer-type accidents. Spills or leaks from pipelines generally result from exterior physical damage to the pipe, overpressurization, lack of seal integrity, or interior or exterior corrosion. Barge and tanker operations, unlike pipeline transport, have the additional disadvantage of being subject to changes in the

TABLE 6.—Government agencies responsible for regulating oil and gas transportation activities

	Jurisdiction		Regulation and Administration		
Agency	Material	Type	Purpose	Inspection function	General role
BLM	Oil and gas or other minerals	Common-carrier and single-custody lines[1]	Administration	None	Issues right-of-way permits, collects right-of-way rental fees
USGS	Oil and gas	Field gathering and flow lines[2]	Safety, administration	Field inspection	Approves platforms, easements, sets safety standards, measures flow and value, and commingling, checks inspection and maintenance records, collects royalty
DOT (OPS)	Oil and gas	Common-carrier lines	Safety: enforces regulations for transport of crude oil by pipeline	Field inspection	Reviews accident reports, contracts engineering studies
FERC	Gas	Common-carrier lines	Rate regulation	None	Issues "certificates of public convenience and necessity" required for line construction, facilitates acquisition, regulates gas prices, purchases and sales
ICC	Oil	Common-carrier lines (onshore)	Rate regulation	None	Oversees profit structure of oil line companies

[1]Lines not located in their entirety within the boundaries of a single lease, unitized leases or contiguous leases of the same owner or operator.

[2]Lines located in their entirety within the boundaries of a single lease, unitized leases, or contiguous leases of the same owner or operator.

SOURCE: Kash, 1973; and Kaufman, 1980.

weather. They are also subject to constraints in channel depths and harbor laws. It was a common practice in the past for well operators to barge their oil ashore while a pipeline connecting the platform with the shore was being built, or when the quantities produced were too small for economical pipeline transport. This practice is not as common now; generally, the new production well is capped until the connecting pipeline has been completed (Overstreet, 1980, oral commun.).

At present, 56 major pipeline systems bring Gulf of Mexico oil and gas ashore. Current pipeline construction consists mainly of linking newly productive fields with existing networks. Marine pipelines are set into the seabed by a team of vessels known in the industry as a **lay barge spread** or **work spread.** This spread consists of a lay barge, one to three tugboats, and several pipe supply vessels. Figure 14 shows a lay barge spread at work in the Gulf of Mexico.

Because of the high cost of pipeline construction, the economically optimal location for a landfall is the shortest distance from the platform(s) supplying the crude. Plate 4 shows major pipeline routes and known proposed pipelines and extensions. Also shown are landfall sites of the major existing Gulf of Mexico oil and gas pipeline systems. Once the general location for a landfall has been chosen, the final siting decision depends on the physical characteristics of the shore, the company's production plans, and agreement among the company, the public jurisdiction, and private landowners.

Additional facilities may be required at or near the landfall site, depending on the substance transported and its ultimate destination. Gas processing plants may be sited along the overland pipeline between the landfall site and the nearest commercial gas transmission line. Pumping stations and oil storage facilities may also be located near the landfall site if the oil is to be transported some distance away from the shore point. If the oil will be shipped to refineries in distant areas, marine terminals and their associated storage tanks may be established in the general vicinity of the landfall.

Pipelines do not require large parcels of land. At the shore line, they need a minimum

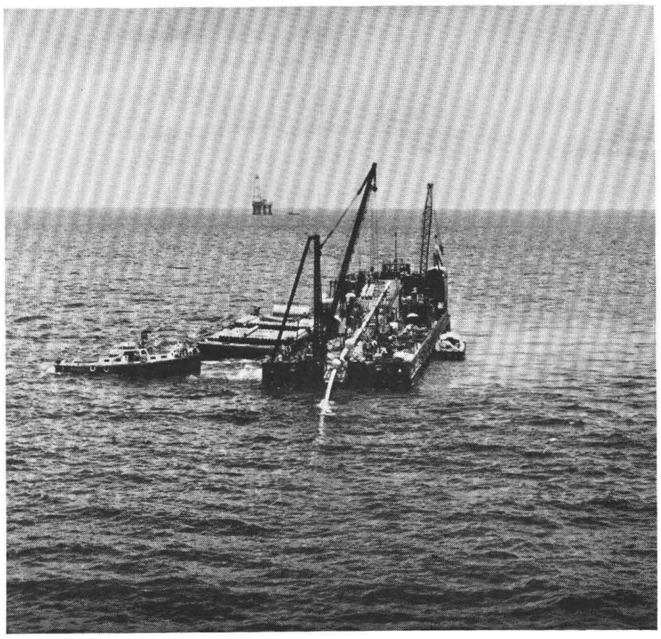


FIGURE 14.--Lay barge spread at work in the Grand Isle area off Louisiana (photograph by Conoco, Inc.).

right-of-way of between 15 and 30 m (50 and 100 ft). Pipeline companies generally purchase some of this land outright and acquire easements for the rest to allow use of it during construction and maintenance operations. If pumping stations are sited at or near the landfall, approximately 16 more hectares (40 acres) are required for storage tanks, the pump station, and office space. If a tanker/barge terminal were to be located at the landfall, another 24 hectares (60 acres) would be acquired.

Vessel Transportation

Two percent of the oil produced on the Gulf OCS is brought to shore by barges and tankers. Because of the greater possibility of collisions and groundings, use of these vessels for transporting hydrocarbons is not as attractive as pipeline transport.

Another method by which crude oil is transported to shore is called **lightering.** This method, usually used for imported oil, involves offloading large tankers at sea or outside ports to smaller vessels, which then travel to a discharge point. Tankers can lighter their entire cargo, or, when enough oil has been lightered to allow a tanker to draw less water, the ship can proceed to a refinery terminal to discharge the remaining cargo. Lightering is a common practice at entrances of Gulf ports that are too shallow to handle deep-draft vessels. This offloading activity can take place without docking or mooring the tankers. Lightering activities are regulated by the U.S. Coast Guard Captains of Ports, who have the authority to grant lightering permits.

Deepwater Ports

Deepwater ports are designed to accommodate supertankers, the huge vessels that are used to carry large quantities of crude oil over long distances. The draft requirements of these vessels call for water depths of up to 30 m (100 ft). Most conventional ports are limited in depth and thus cannot accommodate supertankers. Deepwater ports are usually sited some distance offshore and consist of either a fixed island pier or some type of floating mooring system.

Tankers offloading at a deepwater ports transfer crude oil to storage tanks, from which it is pumped to onshore points. It is subsequently distributed to other storage tanks or refineries.

In the past 10 years, there have been a number of proposals for deepwater ports in the Gulf of Mexico--facilities capable of offloading huge quantities of crude oil from supertankers at locations relatively far outside major ports. The following proposals were considered: Ameriport, off Mobile, Alabama; Harbor Island, north of Corpus Christi, Texas; Seadock, off Freeport, Texas; and Louisiana Offshore Oil Port (LOOP), south of Lafourche Parish, Louisiana.

Seadock and LOOP were the most promising proposals. Seadock, begun as a private industry venture, was taken over by the Texas Deepwater Port Authority (TDPA). TDPA is presently pursuing the project, but Seadock has encountered a number of organizational and permitting difficulties, as well as problems securing a commitment of sufficient future business to make the project economical.

LOOP, Inc. is a consortium of five companies: Ashland Oil; Marathon Pipe Line Company; Murphy Oil Corporation; Shell Oil Company; and Texaco, Inc. The first phase of the project is scheduled to begin operating in the first quarter of 1981. This phase will have an estimated 1.4-million-bpd throughput, half of which will be transported to Louisiana refineries. The rest will be transported through the Capline pipeline system to refineries in the Midwest.

Phase II of the LOOP project is planned to provide a 2.4-million-bpd throughput, additional storage capacity at the Clovelly Salt Dome, near Galliano, Louisiana, and additional pumping capacity at all Phase I pump stations.

Phase III of LOOP involves plans to increase throughput to 3.4 million bpd and add storage capacity at the Clovelly Salt Dome and pumping capacity at all pump stations. Time schedules for Phases II and III are not yet firm.

The LOOP marine terminal and platform complex is located about 31 km (19 mi) off Louisiana, in Grand Isle Blocks 52 and 59, in 30 m (110 ft) of water. The terminal/platform complex will be operated as a common-carrier system and will consist of a pump platform, a control platform and three single-anchor-leg mooring (SALM) buoys. Figure 15 illustrates the LOOP offloading system. LOOP will also require onshore storage for crude in the caverns at the Clovelly Salt Dome. A shore-based operations center for the system will be located at Galliano as well.

In addition to these plans for new deepwater port development, Galveston Wharves, a city-owned Texas port, has signed a contract to have its port deepened. Thirty-five km (22 mi) of the channel seaward from the Galveston Seabuoy would be 183 m (600 ft) wide and about 17 m (56 ft) deep. Another section would be dredged inside the jetty to a depth of 16 m (54 ft) and width of 244 m (800 ft). In

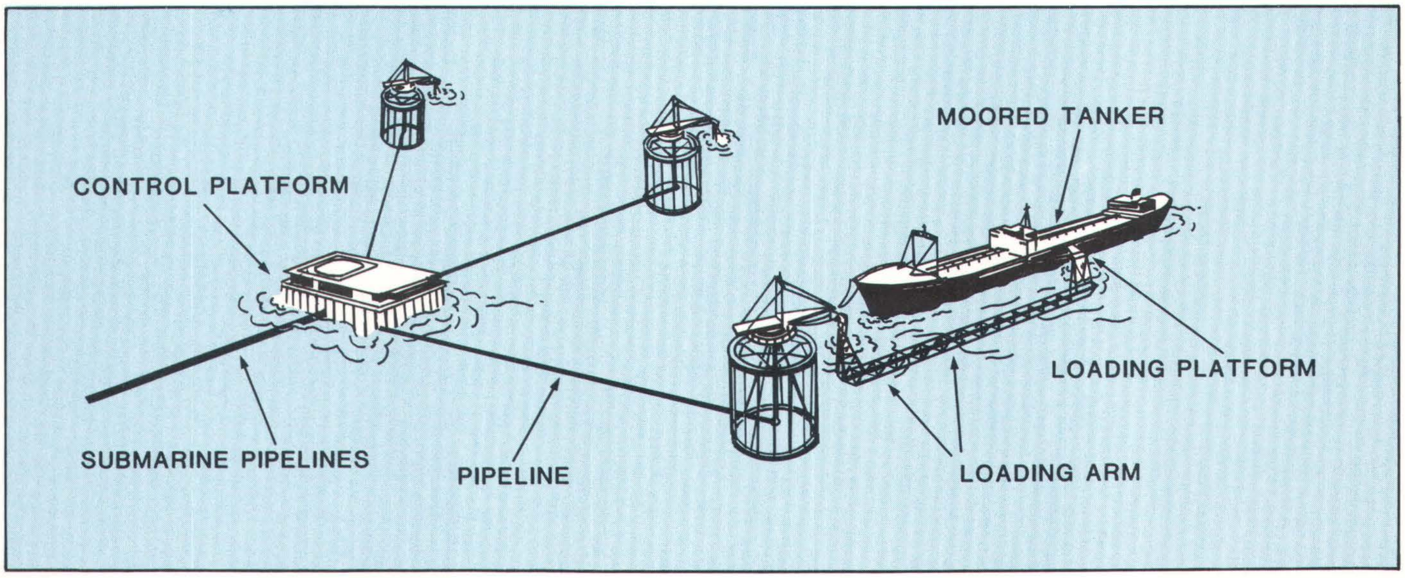


FIGURE 15.--LOOP offloading system (adapted from Oceanus, 1975, p. 54, by Rogers, Golden & Halpern).

addition, two 91-cm (36-in) crude lines would connect Galveston's dockside facilities to a 12-million-bbl tank farm at Texas City. From there, further lines would run to the Beaumont-Port Arthur, Freeport, and Houston-Baytown areas. As presently planned, the Pelican Island project will take 2-1/2 to 3 years for dredging, beginning in the spring of 1981.

The 1974 Deepwater Port Act gave the Department of Transportation responsibility for administering deepwater ports. The U.S. Coast Guard published rules for the design, construction, and operation of deepwater ports in the Federal Register (May 7, 1975) and also plays an important role in deepwater port activities.

Fairways

Fairways or Shipping Safety Fairways have been internationally defined by the Intergovernmental Maritime Consultative Organization (IMCO) as a means of "ensuring that the exploitation of seabed resources does not seriously obstruct sea approaches and shipping routes...." Shipping safety fairways are established by the Army Corps of Engineers (COE)" to control the erection of structures therein to provide safe approaches through oil fields in the Gulf of Mexico to entrances to the major ports along the Gulf Coast..." (33 CFR 209.135). In 43 USC 1333(f) Congress extended this authority of the Corps to artificial islands and fixed structures on the Continental Shelf.

The designation of fairways is a dynamic process. Oil and gas operators, most of whom are represented by the Offshore Operators Committee, have an input into the process of locating fairways. Operators must obtain a Corps of Engineers navigation permit prior to exploratory drilling and must also file for a permit certifying that proposed platforms and pipelines will not obstruct navigation. Through the authority granted by the Ports and Waterways Safety Act, the U.S. Coast Guard may advise the Corps of Engineers of COE permit violations. Plate 5 shows current fairways in the Gulf of Mexico.

Although established fairways are charted to assure unobstructed lanes for navigators, vessels in the Gulf are free to travel outside the shipping lanes.

Marine Terminals

Marine terminals are used for receiving waterborne shipments of crude oil or products (fig. 16). The main components of a marine terminal are berthing space for vessels, loading and offloading equipment, storage tanks, terminal control and safety equipment, and navigation facilities.

Marine terminals may serve one or more of these functions:

- loading crude oil piped from offshore production platforms onto tankers, which then deliver the crude to refineries;

- receiving crude oil from tankers and transporting it through pipelines to nearby refineries; and

- receiving refined petroleum products from tankers and storing them prior to delivery to final markets.

There are three basic types of marine terminals: (1) crude oil pipeline/tanker terminals, (2) crude oil receiving terminals, and (3) product terminals. Each type has its own characteristics and is discussed in detail in the following sections.

The decision to site a marine terminal to serve offshore development activities is made at the same time OCS transportation and production strategies are being planned. The use of tankers and barges offloading OCS crude oil at marine terminals is limited to cases where vessels are more economical than pipelines for transporting the petroleum to shore. As stated earlier, tankering and barging represents a very small portion (about 2 percent) of the overall shipment of OCS hydrocarbons out of the Gulf. Marine terminals mainly offload imported crude.

Shoreside marine terminals require sheltered deep water and may be located in an existing port or harbor, if depths are adequate for the anticipated tanker traffic. When shore conditions in a harbor are not suitable, terminal piers are located offshore, in deeper water; sites offering some shelter from adverse weather are usually sought.

Tank farms storing crude oil received at marine terminals are located as close as possible to the terminals. The use of a common terminal/tank farm site eliminates the need to construct duplicate site offices and safety equipment. A single site requires less land and less construction of overland pipelines, and it may be easier to transport materials used in tank farm construction to a site near the terminal by sea rather than overland.

Most of the land required for siting a marine terminal is used for storage tanks, the size and number of which will be determined by types of material stored, terminal throughput, the size and frequency of tankers offloading, and the pipeline throughput capacity.

Plate 5 shows the locations of marine terminals in the Gulf of Mexico.

CRUDE OIL PIPELINE/TANKER TERMINALS. Crude oil arrives at pipeline/tanker terminals via pipelines. From this point, the crude is pumped onto tankers, which then travel to refineries. Since the crude oil is piped directly from production platforms, associated gas, water, and impurities may need to be separated at the terminal, if no partial processing was done at the platform. Partial processing at the terminal reduces transportation costs.

If large quantities of natural gas are associated with the crude, it may be processed and sold locally or used for fuel for terminal facilities and equipment. The partially processed crude is stored in tanks at the terminal prior to tanker loading.

Because tankers arriving at the terminal carry ballast water, the terminal has ballast handling facilities: a ballast storage tank, oil and water separators, and equipment to reduce oil concentrations in the ballast water to acceptable levels.

CRUDE OIL RECEIVING TERMINALS. Tankers offload crude oil to storage tanks

FIGURE 16.--Ships offloading at a marine terminal (photograph from Rogers, Golden & Halpern files).

located at receiving terminals. From these points, the crude is transshipped through pipelines to nearby refineries.

Crude oil receiving terminals do not require ballast treatment facilities, as the tankers berthing at the terminal discharge crude and take on ballast water. Bunker fuel, the heavy residual fuel oil used in the boilers and heating/generating plants of tankers, is supplied to the terminal's tank farm by refineries and pumped aboard the tankers.

A crude oil receiving terminal may also have partial processing facilities to remove impurities and water in the oil.

PRODUCT TERMINALS. Product terminals receive waterborne shipments of different types of refined oil. These products are then transferred to rail cars, tank trucks, or small coastal vessels, which carry them to market areas. Products can be shipped in smaller vessels than those used to transport crude, so terminal draft requirements are less for these ships. However, the multitude of individual refined products requires separate storage facilities for each type, and the land area allotted to storage may be more extensive than land used for storage of crude oil, which can be kept in larger tanks.

BERTHING AND STORAGE FACILITIES. There are three types of berthing facilities at marine terminals: shoreside fixed piers, offshore fixed piers, and offshore floating moorings.

Shoreside fixed piers are usually found inside harbors, either parallel or perpendicular to the shoreline depending on harbor traffic patterns and wind and wave conditions. These piers generally serve tankers in the 40,000- to 70,000-dwt range.

Offshore fixed piers are structures that must also be located optimally in terms of wind and water movement. Mooring space is available on both sides of the pier, and offloaded crude is carried in submarine pipelines from the piers to onshore storage and distribution points. These piers typically serve tankers in the midrange of 70,000 to 150,000 dwt.

Offshore floating moorings, found at deepwater ports, consist of an anchored floating buoy, floating hoses connecting the tanker to the buoy, and undersea hoses connecting the buoy to submarine pipelines. The buoy is designed to allow the moored tanker to rotate in response to variable wind and wave movements.

Storage facilities used by offshore terminals are either floating, bottom-standing, or above-water tanks.

OCS TRANSPORTATION PLANNING

Intergovernmental Planning Program

The U.S. Bureau of Land Management plays a prominent role in the transportation planning process through its Intergovernmental Planning Program for OCS Oil and Gas Leasing, Transportation and Related Facilities. Two other elements of the OCS oil and gas leasing program are also addressed by the IPP--Pre-Lease Sale Activities and the Environmental Studies Program (also referred to as the Regional Studies Program). Further discussion of Pre-Lease Sale Activities and the Studies Program may be found in appendix E.

IPP transportation planning has four phases, each tied to steps in the OCS leasing, exploration, and development sequence. Each planning phase is more detailed and site-specific than the previous one, and the third and fourth phases are begun only in the event of a discovery of oil and/or gas in commercially producible quantities. The result of IPP planning is a set of detailed transportation management plans for each leasing region.

The IPP was officially chartered on September 20, 1979, when the final selection was made for the Regional Technical Working Group (RTWG) Committees. These committees, which implement the IPP, are composed of Federal and State officials, petroleum industry representatives, and representatives of other special and private interests. The members of the Gulf of Mexico Regional Technical Working Group Committee are listed in table 7.

The movement of oil and/or gas from the Outer Continental Shelf to processing points and markets is an important part of the overall RTWG planning function. The principal end product of this planning effort is a Regional Transportation Management Plan (RTMP). Its purpose is to identify acceptable corridors in each leasing region for transporting OCS oil and gas.

To effectively prepare the RTMP's, a planning system was designed to accommodate

TABLE 7.—Gulf of Mexico Regional Technical Working Group Committee

Member	Affiliation
Mr. Tom Joiner	State of Alabama (Co-chair)
Mr. John Rankin	Bureau of Land Management (Co-chair)
Capt. Ralph Hill	U.S. Coast Guard
Dr. James Kirkwood	U.S. Fish and Wildlife Service
Mr. Douglas McIntosh	U.S. Geological Survey
Mr. Don Moore	National Oceanographic and Atmospheric Administration
Mr. Clinton Spotts	Environmental Protection Agency
Dr. Charles Groat	State of Louisiana
Mr. Walter Kolb	State of Florida
Dr. Richard Leard	State of Mississippi
Dr. E.G. Wermund	State of Texas
Mr. Rick Anderson	Interstate Natural Gas Association of America
Mr. Charles Bedell	International Association of Drilling Contractors
Mr. Walter Fondren, III	Private Sector
Mr. J. Duane Orr	Private Consultant
Ms. Doris Falkenheiner	Public Law Utilities Group
Mr. J.E. Thomas	Private Sector
Mr. John Wolfe, Jr.	American Petroleum Institute

NOTE: For additional information, contact Syd Verinder, Regional IPP Coordinator, at (504) 589-6541.

wide regional differences in OCS oil and gas activities. The system is based on three levels of working plans, differing in degrees of detail in relation to specific OCS actions. Each State member will be responsible for completing the plan(s) in a given time frame, using any State expertise needed. The BLM will prepare the portion of the plan applicable to the Federal jurisdiction. As a plan is completed, it is subjected to review by other RTWG members in the Region.

At a minimum, the final RTMP will include the following information and recommendations:

- analysis and recommendations for definite transportation corridors and alternatives, including all routes to onshore facilities or to offshore terminals serving as collection points for more than one production area;
- identification of environmentally sound alternative areas for the location of onshore facilities;
- alternatives regarding surface vessel transportation, in accordance with appropriate regulatory agencies;
- plans for monitoring construction and operations and any required followup studies; and
- any stipulations and use restrictions identified as applicable to transportation rights-of-way.

In April 1980, the members of the Gulf of Mexico RTWG were instructed to begin work on the Region's Transportation Management Plan. All members of the RTWG's have

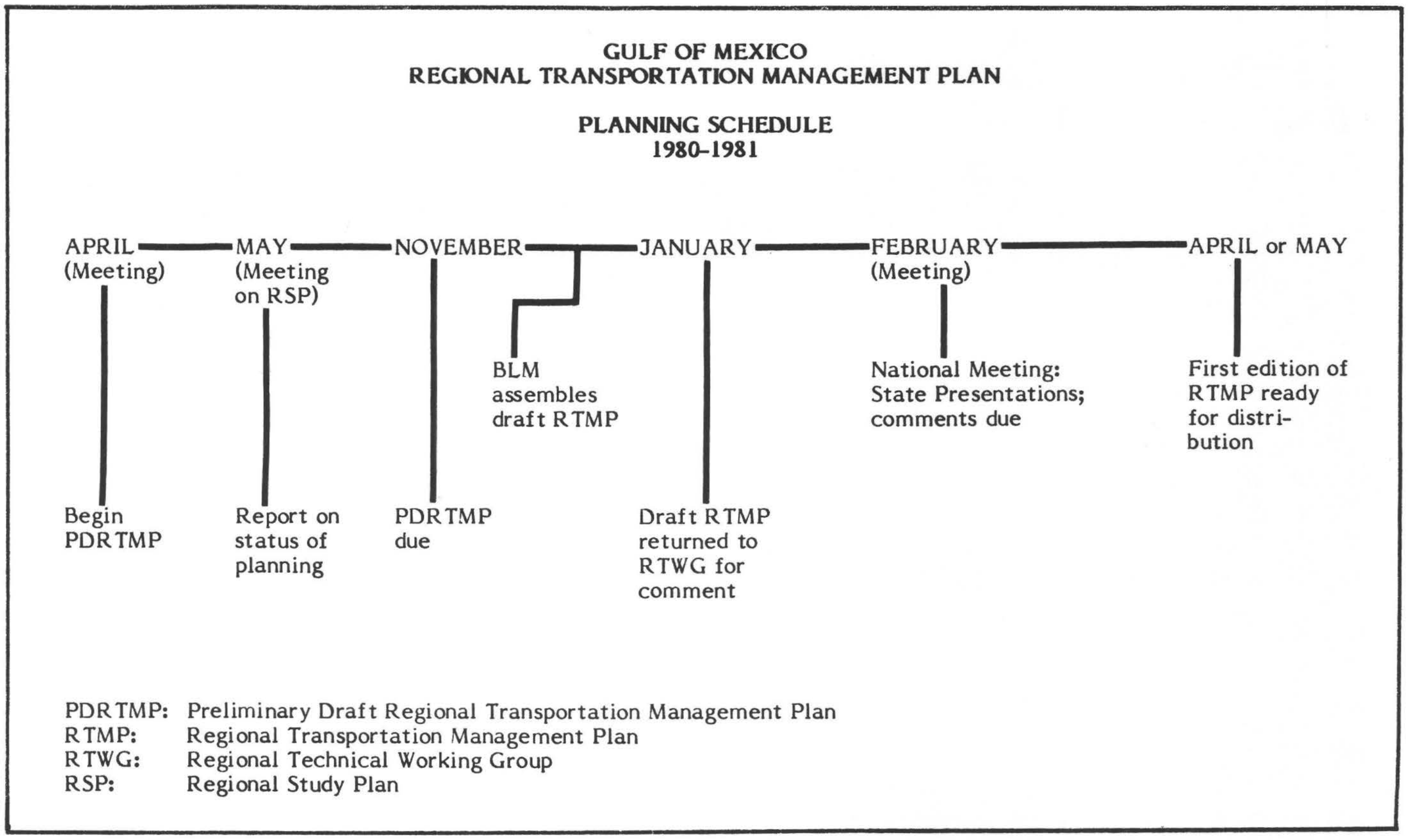


FIGURE 17.--RTMP planning schedule for 1980-1981 (drafted from BLM, May 1980, unpublished documents, and Verinder, 1980, oral commun., by Rogers, Golden & Halpern).

been invited to attend the February 1981 plenary session of the OCS Advisory Board, to be held in Charleston, South Carolina. At this meeting they will submit their respective plan components. This will be the first time all members and BLM officials review and comment on the complete Preliminary Draft RTMP. Once comments are evaluated and incorporated into the draft plan, the first edition of a Gulf RTMP will be made available. Tentative date for distribution is spring 1981 (Verinder, 1980, oral commun.).

Figure 17 shows the 1980 RTMP planning schedule.

4. Nature and Location of Nearshore and Onshore Facilities

Offshore oil and gas operations in the Gulf of Mexico have steadily intensified since the 1947 Kerr-McGee discovery in the Ship Shoal area off Louisiana. This well produced 600 barrels of oil per day and was the first commercial discovery in the Gulf of Mexico. Many nearshore and onshore pipelines, support centers, refineries, storage tanks, and platform fabrication yards have been in use for close to 3 decades. The developed areas of the Gulf coastline--especially the central area--are characterized by concentrations of these and other petroleum-related industries.

In view of the facts that Gulf of Mexico crude oil production has been declining since 1972 and that Gulf gas, now considered to be near its production peak, will also see a decline in the near future, it is likely that present and future OCS oil and gas production will be supported mainly by existing facilities. Construction of **grassroots** refineries, those built from the ground up, has been rare in the last few years. Future exploration off the coast of Texas for natural gas will probably result in new onshore facility siting in that State.

The onshore and offshore oil and gas industry is so widespread on the Gulf Coast that virtually every urban area in coastal Texas and Louisiana owes part of its economic base to it. The interdependence of firms that provide "front-end" support for offshore operations encourages them to locate near each other. This has resulted in the emergence of a hierarchy of service and support centers since the beginning of offshore drilling in the Gulf of Mexico over 3 decades ago.

The Gulf Coast of the United States is a complex and dynamic oil- and gas-producing region. Individual facilities situated in the coastal area form the connecting links in an intricate network of resource supply and distribution. Virtually all oil and gas, including both onshore and offshore production and increasing amounts of imported oil and gas, are commingled, usually at onshore storage locations, before processing and final distribution. Because of this process of blending many resources into a common stock, very few onshore facilities in the "post-production" phase can be linked directly to OCS production. Conversely, OCS production does not usually influence the decision to site additional plants in the adjacent coastal area, independent of other resource supply considerations.

Specific support services owe their existence almost entirely to OCS production. These include platform fabrication yards, diving service companies, helicopter companies, and boatbuilders, plus a variety of other vendors of services to the offshore industry. Offshore operators usually contract for the services of the vendors, and while there is a core of permanent service companies, many others form a footloose type of enterprise that appears and disappears from the landscape as the level of demand for their services changes and as the geographic focus of offshore activity shifts. Frequently, offshore support services appear on the landscape without prior planning, except for the necessary permit applications from State and local governments, or from the U.S. Army Corps of Engineers in cases where wetlands and waterways will be disturbed.

The discussion of the nature and location of nearshore and onshore OCS-related facilities is oriented toward establishing a current (1980) inventory and base for analyzing future changes. The large volume of Plans of Exploration and Plans of Development and Production submitted since the enactment of the OCS Lands Act Amendments of 1978 has only allowed a complete review of the most recently submitted plans, in effect establishing 1980 as the base year for this discussion. The New Orleans Office of the BLM compiles an inventory of OCS-related facilities in the coastal zone for purposes of preparing EIS's. This inventory has formed the basis for the maps of current facilities in this Summary Report. Forecasting for additional onshore facilities or expansions to existing facilities is made difficult for a number of reasons:

- the number and complexity of interrelated Gulf Coast oil and gas facilities developed to process onshore, offshore, and imported products make it extremely difficult to single out any one facility as OCS-related;
- Environmental Reports, which the OCSIP has found very useful in identifying planned OCS-related facility additions and expansions in the coastal zone in other OCS Regions of the country, are not mandatory in the Gulf of Mexico Region, except for activities off the coast of Florida or when drilling affects a State with a Federally approved Coastal Zone Management Program (30 CFR 250.34; Federal Register, January 17, 1979, p. 3513-4527);
- no Federal program has monitored onshore facilities construction that results specifically from OCS oil and gas operations; and
- the identification and tracking of new OCS-related facilities construction is complicated because permitting agencies have discrete areas of responsibility with no formal interagency communication mechanisms.

The following discussion of nearshore and onshore facilities in the Gulf of Mexico Region is based on information that characterizes the Region at present. Future Summary Reports will strive to build on this established base in an attempt to monitor the nature and location of onshore facilities that relate specifically to Gulf of Mexico OCS oil and gas operations.

ONSHORE ACTIVITY

Generally, the nature and location of nearshore and onshore facilities is closely tied to the stages of offshore operations: exploration, development, production, or decline of production.

Onshore activity in the exploration stages is generally minimal. Operations onshore during this phase are limited to the port-centered servicing requirements for exploration vessels. Harbor activity revolves around loading ships with drilling equipment, pipe, chemicals, drilling muds, food supplies, and the like. Transfer of these materials to and from the rigs goes on more or less constantly.

Once a commercial hydrocarbon discovery is made, the pace of onshore activity increases. If the field discovered is large, a platform fabrication yard may be sited in a shoreline area accessible to the field. From the fabrication yard, the platforms can be barged or towed to the field.

At the same time, refineries are constructed if none already exist, or if those already in operation cannot handle production from the discovery. Refineries may be located either at the shoreline or inland, closer to distribution centers and markets, and may be supplied with crude oil by either vessel or pipelines. Gas processing plants may also be built near the coast during this phase.

Pipeline construction, both onshore and offshore, is also a major activity during the development phase. Pipe fabrication and coating yards are established, and operations for offshore pipe laying are begun. Large supply depots are required for storage of drill pipe cement, drilling muds, and drilling equipment.

Harbors and channels may need to be dredged and wharves constructed or expanded to accommodate the additional ship traffic. Facilities for repair of supply boats and drilling rigs may also be built. Land transportation routes--highways and railroads--may need to be improved to provide movement of personnel, equipment, and supplies.

During the development phase, the influx of specialized labor into the coastal areas requires expanded public services such as housing, schools, hospitals, and new or upgraded utilities--sewer, water, and electricity.

In the transition period between the development and production phases, heavy construction declines and operations related to supply and maintenance increase. Other industries, such as petrochemical plants, manufacturers, and commercial/retail establishments, move into the coastal regions. Supply boats, generally about two per platform, continue to use harbor facilities for transfer of personnel and supplies to platforms. This transfer may be augmented by helicopter traffic from nearby airfields.

Socioeconomic impacts of oil- and gas-related activities vary directly with the type and extent of development already in an area. Obviously, the most severe impacts are felt in frontier areas. The greater the extent of previous development and the diversity of the existing economy, the less the impacts of new or increased oil and gas operations will be felt. In already developed areas, additional oil- and gas-related industry, with its attendant secondary and tertiary industries, are more easily accommodated. The Gulf Coast, except for the central area (offshore Texas and Louisiana), is heterogeneous in this respect. Some parts of the Mississippi, Alabama, and Florida coastline are comparatively undeveloped; any major hydrocarbon discovery adjacent to these areas would alter some local economic and settlement patterns. Texas and Louisiana, on the other hand, have a well-developed oil and gas industry. While the economies of these two States (at least in the coastal regions) are not diversified, they can more easily accommodate additional petroleum-related activities, as basic industries and services--pipelines, refineries, transmission lines, transportation arteries, ports, petrochemical plants, and support facilities--are already in place.

LEADING CENTERS OF ONSHORE FACILITIES

Throughout the Gulf of Mexico Region, a number of areas exist where activities associated with the offshore oil and gas industry have agglomerated. These are shown on plate 6. They include the large metropolitan areas of Houston and New Orleans; although these cities are diversified centers, oil and gas contribute significantly to their economic bases, especially to that of Houston. Smaller centers also exist whose local economies are dominated by oil- and gas-related activity: Morgan City, Lafayette, Harvey, Baton Rouge, Houma, and Lake Charles, Louisiana; and Corpus Christi and Beaumont, Texas. In addition to these important oil- and gas-related centers, there are many locations, both small and large, where offshore oil- and gas-related functions are apparent but may not be dominant. These include such places as Cameron, Lake Arthur, and Geismar, Louisiana; Galveston, Freeport, and Port Arthur, Texas; and Pascagoula, Mississippi.

Houston is the leading metropolis associated with the oil and gas industry. Its close proximity to onshore fields in East Texas and its access to offshore fields in the Gulf of Mexico via the Houston Ship Channel make Houston's location strategic for supplying and servicing both onshore and offshore operators and receiving oil and gas by pipeline or vessel. These geographic relationships contribute to Houston's position as the nation's largest center for petroleum refining, petrochemical manufacturing, and manufacturing and distribution of petroleum equipment and transmission pipelines.

New Orleans, unlike Houston, specifically serves the needs of the offshore operators. New Orleans is situated closer to the major offshore producing area. Oil companies having major offshore operations in the Gulf of Mexico maintain corporate offices in New Orleans, as do major offshore equipment suppliers and fabricators. Federal Government field operations that relate to offshore resources (for example, the U.S. Geological Survey and the Bureau of Land Management) are also in New Orleans. Essentially, New

Orleans serves as a business, administrative, and financial center for the offshore oil and gas industry.

Smaller centers act either as supply and service bases or as receiving and processing centers for offshore resources. Morgan City, Lafayette, Harvey, and Houma, Louisiana, primarily provide support activities like platform fabrication, pipelaying, transportation services, boat building, and engineering. Refining, processing, and petrochemical manufacturing are found in Corpus Christi and Beaumont, Texas, and Lake Charles and Baton Rouge, Louisiana.

SUPPORT FACILITIES

In addition to the major industries associated with hydrocarbon exploration, development, and production, myriad secondary industries are involved in the oil and gas business. Plate 6 shows these prominent industries. The location and time of establishment of these businesses follows the pace of oil and gas operations.

In offshore operations, time is costly. It is imperative that the offshore operator or drilling contractor have quick and easy access to the supplies and services essential at each phase of operations. The earliest service bases were run by chemical suppliers for the drilling companies. They often were little more than dockside service stations, supplying drilling muds and cements. Soon other services were added, and the comprehensive service base evolved, providing storage space, docks for supply and crew boats, fuel, water, and equipment for lifting materials onto supply boats and barges. Onshore service bases are generally established when OCS exploration begins.

Drilling mud and cement companies are also among the first to move into the coastal area, as the materials they supply are also essential for exploratory drilling. At the same time, companies providing drilling tools and wellhead equipment establish facilities, perhaps on a temporary basis, to support exploration.

As exploration increases and more drill rigs are operating, demand for helicopters to carry personnel and supplies to the rigs increases. Catering companies are also retained to provide food and housekeeping services for the drill rig crews.

Diving service companies (new to the area or already in business in locations close to the exploration site) may be contracted to serve on an as-needed basis for subsea installations and repairs, and local machine tool, fabrication, welding, and repair shops may expand to accommodate new or increased offshore operations.

If a commercial hydrocarbon discovery is made, ancillary industries become much busier. New personnel are hired, either from the local labor market or from a pool of new workers moving into the area.

Service Bases

Onshore service bases are established to provide major transshipment points for the support necessary for offshore drilling and production activities. A service base functions as an essential link to offshore operations. The range and extent of services offered at such a base may vary depending on the stage of the offshore enterprise, but the base itself will be in use from the exploratory period until production ceases and offshore structures are dismantled and removed.

The primary locational factors in establishing a service base are the distance from offshore activity and the proximity to deepwater channels and land transportation routes. Service bases require rail and highway access so that materials fabricated and packaged elsewhere can be expeditiously delivered. Materials from a variety of scattered locations may be transported across the base docks en route to offshore structures. Because many of the services offered require specialized labor, engineering offices, welding and machine shops, diving services and caterers also locate in the vicinity of service bases.

Although a specially developed service base or series of service bases might offer many of the supplies and services for offshore operations, many of these functions are also provided by major ports established prior to offshore exploration, development, and production. In the Gulf of Mexico, ports such as New Orleans, Corpus Christi, and Galveston merely increased their already extensive port facilities to accommodate the offshore industry. Smaller ports like Freeport, Texas, and Morgan City, Louisiana, developed largely in response to oil and gas discoveries in the Gulf. Plate 6 shows major service bases in the Gulf of Mexico Region.

Service bases may be either temporary or permanent. If a commercial discovery is made, the temporary facilities may establish permanent locations. Companies occasionally place options on land in port areas adjacent to the offshore areas of highest industry interest as early as the bidding stage in the lease sale sequence. Temporary bases may be quite small: for example, a recent study examining four supply bases developed to serve oil and gas exploration off the coast of Florida found the average area of these bases to be about 1.5 hectares (3.6 acres). A fully developed onshore base supporting offshore production averages 8 to 10 hectares (20 to 25 acres) (Wales and others, 1976, p. 228). Figure 18 shows which services are required during each successive stage of offshore operations.

A service base offers a diverse array of equipment, supplies, and professional expertise--an array too comprehensive for even the largest of the integrated oil companies to provide without subcontracting much of the work. Although exploration, development, and production are indeed financed by vertically integrated oil companies, most of the actual work is delegated to specialized companies within the industry. Other services and ancillary facilities (treated in detail in later sections) are run by divisions of large corporations not directly involved in the oil and gas industry.

Depending on the site chosen for a service base, impacts of development may vary. If a base is located at an existing port, facilities already in place may need only be altered or enlarged, involving only minimal effects. However, when a previously undeveloped site is selected, major site alteration impacts can be expected. Examples of such impacts are changes in drainage and groundwater, effects on wildlife and vegetation nearby, and possible air and noise pollution.

Wherever possible, oil companies site temporary service bases where communication and transportation facilities already exist. Permanent supply bases require the full range of social services, including housing, schools, and hospitals.

At a temporary base, there are about 45 jobs for each rig drilling on the OCS. About three-fourths of these jobs can be filled by local laborers. In the case of a permanent supply base, 50 to 60 workers would be needed for each offshore drilling platform in operation.

The socioeconomic effects of establishing a supply base are much greater than the environmental effects. These centers are labor-intensive, and much of the labor is located in the general vicinity. The offshore-industry-related companies are mutually supportive, each drawing on personnel and services provided by the others. Secondary commerce--retail trade and personal services--depends heavily on this mix of industries. Local real estate speculation and investment are also significant. The high level of petroleum-related industry in these areas can provide the community with a solid tax base as well.

Service bases in a period of declining production will support increasing exploratory and development activity, as operators attempt to find new hydrocarbon-bearing fields and to bring smaller fields, previously consi-

SERVICES and FACILITIES ▷ / Individual Categories ▷ / OPERATIONS arranged in sequence of development ▽	Accommodation and Catering			Ports			Transportation							Communications			Supply Handling and Storage				Engineering/Industrial Supplies and Services									
	Housing	Work Camps and other temporary Accommodations	Contract Catering, Laundry Services, etc.	All-weather Harbors —medium draft	All-weather Harbors —deep draft	Very deep water Harbors close inshore	Service Vessels and Tugs	Cargo Vessels, Coastal Tankers and Barges	Large Tankers	Rail Transport	Heavy Road Transport	Scheduled and Chartered Air Services	Helicopter Services	Standby Safety Vessels	Navigational Aids	Telecommunication	Open Storage	Warehousing	Specialized Storage (silos, tanks, etc.)	Freight Handling, Customs, etc.	Dredging	Land Reclamation	Machinery Repairs and Servicing	Steel Fabrication	Equipment Rental (compressors, welding, drilling equipment, etc.)	Engineering and Scientific Consultancy	Industrial Gases	Muds and Mineral Fluids	Diving Services	Specialized Drilling Services
1. Geophysical and Oceanographic Exploration	○	○	○	●	○	○	○	○	○	○	○	●	○	○	●	●	○	●	○	●	○	○	○	○	○	●	○	○	●	●
2. Construction of Service Bases and Ports	○	●	●	○	○	○	○	●	○	○	○	●	○	○	○	○	●	○	●	●	●	●	●	●	●	●	○	●	○	●
3. Service Base Operation	●	○	●	●	○	○	●	●	○	◐	◐	●	●	○	●	●	●	●	●	●	◐	○	●	●	●	●	●	●	●	●
4. Oil Rig Operation	●	○	●	●	○	○	●	○	○	◐	◐	●	●	●	●	●	●	●	●	●	○	○	●	●	●	●	●	●	●	●
5a. Production Platform Construction	●	●	●	○	○	●	○	●	○	◐	◐	●	○	●	○	○	●	○	●	○	●	●	●	●	●	●	○	●	○	●
5b. Module Construction	●	○	●	○	○	○	○	●	○	◐	●	○	○	○	○	○	●	●	○	●	○	○	●	●	●	●	○	○	○	●
6. Collection Station Construction	○	●	●	●	○	○	○	●	○	◐	◐	●	○	○	○	○	●	●	●	●	○	○	●	●	●	●	○	○	○	●
7. Tanker Terminal Construction	○	●	●	○	●	○	○	●	○	◐	◐	●	○	○	○	○	●	○	●	●	●	●	●	●	●	●	○	●	○	●
8a. Pipe-Laying and Burying — Sea	○	○	●	●	○	○	●	●	○	◐	◐	●	●	○	●	●	●	●	●	●	●	○	●	○	○	●	○	●	○	●
Land	○	●	●	○	○	○	○	○	○	◐	◐	●	●	○	○	●	●	○	○	●	○	○	●	○	●	●	○	○	○	●
8b. Production Platform Installation	○	○	●	●	○	○	●	●	○	●	●	●	●	○	●	●	○	○	○	●	○	○	●	○	●	●	○	●	○	●
9. Production Platform Drilling	●	○	●	●	○	○	●	○	○	◐	◐	●	●	●	●	●	●	●	●	●	○	○	●	●	●	●	●	●	●	●
10a. Production Platform Operation and Workover	●	○	●	●	●	○	●	○	◐	◐	◐	●	●	●	●	●	●	●	●	●	○	○	●	●	●	●	●	●	●	●
10b. Collection Station Operation	●	○	○	○	○	○	○	●	○	●	●	●	○	○	○	●	○	○	●	○	○	○	●	○	○	○	○	○	○	●
10c. Tanker Terminal Operation	●	○	○	○	●	○	●	●	●	●	●	●	○	○	●	●	○	○	●	●	◐	○	●	○	○	○	○	◐	○	●
Management of Exploration and Production	●	○	○	○	○	○	○	○	○	○	○	●	●	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	●	●

KEY

● Required

◐ Possibly required

○ Not required

NOTE: Other existing local services which have to be greatly expanded to serve the oil industry include: hotels, bars, restaurants, car rental and taxi services, travel agencies, banking and insurance, secretarial services, lawyers, real estate agents and employment agencies.

Building and construction trades are particularly heavily employed, with labor shortages quickly developing.

FIGURE 18.—OCS oil and gas operations and requirements (modified from Alaska Consultants, 1976, p. 2, by Rogers, Golden & Halpern).

dered uncommercial, into production. In short, the current level of activity at Gulf Coast service bases will probably be maintained over the next 2 decades.

The eventual role of service bases and the fate of their surrounding communities is of concern to the coastal States. If a significant decline in OCS oil and gas activities occurs, many of these bases could continue in use as centers for marine transportation, commercial and sport fishing, fish processing, and wood processing, or as industrial parks (Wales and others, 1976, p. 7).

New requirements of companies providing support services and supplies are closely associated with maintenance of the onshore service bases. In view of the diversity of these industries, from drilling mud companies to catering services, the anticipated impacts of these activities have been stated in general terms in the following description. For a detailed treatment of effects of these ancillary industries on the communities in which they locate, the reader is directed to the New England River Basins Commission's **Factbook,** cited in the references chapter.

Drilling Mud Companies

Drilling mud companies supply essential drilling fluids to contractors. "Mud" is actually a complex substance, with ingredients that can be varied in order to perform a variety of downhole drilling functions. The formulation of drilling muds requires considerable chemical expertise--specialized knowledge provided by chemists and mud engineers.

Facilities required by a drilling mud company generally include a central office with sales, clerical, and bookkeeping personnel, in addition to the engineers, chemists, and technicians. Distribution points are also located to store muds and service the rigs. There is often a small office and laboratory adjoining the distribution facility.

A distribution point for a major drilling mud company may require from 1.21 to 4.04 hectares (3 to 10 acres), but 1 hectare may be sufficient for a small supplier. A large supplier may find rail delivery service the most economical means for bringing supplies to the distribution center. If a site does not include a rail siding, trucks are used. Thus, good highway access may be necessary.

Four to 15 people may be employed at a mud company's distribution base, and most of these companies have a policy of hiring local labor whenever possible.

Cement Companies

Cement companies provide highly specialized services, supplying the offshore operators with the bulk cement, additives, and heavy machinery used for mixing the cement and pumping it downhole during the well casing process. In addition to cementing, these companies generally provide well stimulation services such as acidizing and fracturing during well workover operations.

Like the mud companies, cement contractors provide services of highly trained specialists who work out of centrally located offices and dockside distribution bases from which supplies can be transported to the offshore rigs.

The size of a cement distribution base varies in proportion to the volume of business handled through the facility and the amount of land available in the chosen area. Half a hectare to 4 hectares (about 1 to 10 acres) may be leased for a site. A cement distribution company requires waterfront access. Generally, there should be dock space for at least three boats, and minimum dockside depth of 4.3 m (14 ft) is also needed.

The number of people on a cement company payroll may vary widely, depending on the number of offshore rigs being serviced at any given time. As few as 5 or as many as 165 workers may be employed, both offshore and onshore.

Drilling Tools and Equipment Companies

Drilling tools and equipment companies manufacture and market the equipment used in the drilling process. A handful of large tool companies sell this equipment from branch sales offices and warehouses located in coastal areas adjacent to drilling operations. Engineers and service technicians are employed by these companies to recommend the best available drilling technology for the conditions encountered in a given geologic formation.

Drilling tools and equipment companies generally locate their branch offices near other ancillary industries. Although they do not require waterfront siting, they do need to be relatively close to the docks used to supply the rigs.

In the Gulf Coast area, the equipment needs of permanent sales and service facilities are served by regional warehouses; therefore, storage space requirements are minimal. Gulf Coast facilities of drilling tools and equipment companies are usually sited on 1,000 to 2,000 sq m (1/4 to 1/2 acre).

A permanent facility may employ one or two warehouse/office personnel and six or seven service technicians.

Wellhead Equipment Companies

Wellhead equipment companies manufacture, install, and maintain surface equipment (such as blowout preventer stacks, drilling safety valves and manifold systems and casing heads and hangers, and marine riser systems) that controls the flow of oil and gas at the wellhead during the drilling and production phases. These companies also offer the services of trained technicians to supervise wellhead control operations.

Companies that sell wellhead equipment have large, centrally located manufacturing and supply facilities. Sales and service branches and storage warehouses are established in coastal areas to supply exploratory drilling rigs and development and production platforms.

Wellhead equipment companies do not require extensive acreage. For example, one wellhead equipment company in Lafayette, Louisiana, occupies a site of half a hectare (1.5 acres) and has office and repair shop space in a 15x79-m (50x260-ft) building.

A site with dock facilities is the preferred location for a wellhead equipment company, as it facilitates the transfer of equipment to service boats. However, if a dockside location is not available, a location near a dock facility, and probably near the service base of the wellhead equipment company's major customer, is adequate. Since a wellhead equipment company is not likely to establish a machine shop, a location near such a shop might be selected.

Employment at a permanent wellhead equipment facility ranges from 10 to 100 people, depending on the extent of offshore drilling activity.

Helicopter Companies

Helicopters are used to transport crews and supplies to offshore rigs and platforms. They also provide emergency services. Helicopter companies own and operate all their aircraft and employ pilots and repair and maintenance personnel. Generally, the oil company, drilling contractor, or service company contracts with one helicopter company to perform offshore functions.

The type of helicopter most frequently used is powered by turbines. These jet-powered helicopters are able to travel longer distances in shorter periods of time than the conventional engine types. Skilled pilots and service technicians, proficient with turbine engines, are employed by the companies. Less specialized repair and maintenance personnel may be recruited from the local labor force.

A heliport consists of a helicopter landing area, a radio and/or control tower, a hangar for repairs, storage tanks for turbine and aviation fuel, an office/communications facility with a waiting room, and parking facilities for employees and customers.

The amount of land required by a helicopter facility may range from 2 to 20 hectares (5 to 50 acres), depending on a number of factors. Each landing pad at a base takes 333 to 1,000 sq m (1/12 to 1/4 acre) of land; at a large or permanent heliport, a maintenance hangar of 1,300 sq m (14,000 sq ft) would be sufficient for the indoor servicing of 10 to 12 aircraft. The amount of land necessary to ensure a clear flight path free of obstructions, such as tall trees and power lines, ultimately dictates the amount of land required.

A small group of helicopter companies serves the Gulf of Mexico from a number of onshore airfields.

Employment rolls at a helicopter base depend on the number of helicopters at the facility. Total employment at a single helicopter base may range from 20 to 140 people. This includes pilots, mechanics, and administrative personnel.

Catering Services

Catering services provide food and housekeeping to offshore drilling rigs, development and production platforms, and derrick barges. The caterer usually provides all the necessary personnel--cooks, bakers, assistants, and cleaning help--and the linens used by the customer. The oil company has the responsibility for transporting catering personnel and supplies offshore, either by helicopter or boat.

Approximately 10 to 12 catering companies currently operate in the Gulf of Mexico region. These services are generally supplied by local food purveyors, employing local labor. One important requirement for this type of operation is the availability of local laborers skilled in food preparation. The catering business is estimated to be an $80-100 million business, thus a catering company can be a major employer in a Gulf Coast area.

A caterer typically operates from one central onshore facility, consisting of office, kitchen, and warehouse/refrigeration space. Food can either be prepared at this onshore facility and transported to a remote location, or it can be prepared on the platform or derrick barge, using the galley equipment provided by the catering service customer.

Onshore catering facilities often require less land than do many other types of offshore-related businesses. For example, Oceanic Butler, a catering service in Morgan City, Louisiana, occupies a 1.6-hectare (4-acre) site. This includes an office, a kitchen, a butcher shop and training facility, and warehouse and parking space.

Because most of the labor in a catering service will come from local markets, the availability of local workers skilled in food preparation is an important factor in siting a catering facility. The number of persons employed at such an operation ranges from 1 to 10 per rig, depending on the number of persons served and the extent of service provided offshore.

Diving Service Companies

Diving service companies provide equipment and divers for subsea construction, installation, inspection, repair, and maintenance required by offshore operations. In general, there are two types of diving companies: large major diving companies that are often associated with a major construction contractor and small independent diving companies. Divers install production platform risers, survey and assist in trenching pipelines, complete pipeline tie-ins, set offshore tanker moorings, and inspect and maintain subsurface structures and equipment.

Diving service companies often exist in coastal areas prior to oil and gas exploration, having been formed to subcontract on projects such as river and harbor construction. When offshore oil and gas activities commence, local diving service companies may expand their business to serve the oil operators. Smaller companies tend to specialize in underwater inspection, although such services as welding may also be offered.

In addition to local diving companies, there are a few large firms (offshore contractors) that may offer diving services. The large businesses offer a full range of diving services, but many of them specialize in subsea heavy construction. Other marine-related services such as drilling vessel support, engineering and hydrographic studies, and development of new technology for offshore operations may be offered.

Diving service companies require dockside locations and access to marine loadout facilities, as well as adequate highway access for employees, equipment, and materials brought to the site by truck. It is also optimal for a diving service company to have access to a heliport, in order to facilitate transport of divers between the land base and the offshore operation. A representative small diving service located in Morgan City, Louisiana, has a 1-hectare (2-acre) dockside site. A 1,463-square-meter (4,800-square-foot) permanent building provides office space, storage space, and shops for repairing and maintaining equipment.

PLATFORM FABRICATION YARDS

Platform fabrication yards are large industrial facilities where the platforms and related structures used to drill for and produce hydrocarbons are built (fig. 19). These yards are generally established once a commercial hydrocarbon-bearing field has been discovered. Platforms used offshore are made from either of two basic materials: steel or concrete. The type of platform employed depends on such factors as the conditions encountered in the field under development, the mix of oil and gas produced, climatic and sea conditions, ocean bottom characteristics, and the number of wells drilled from the platform. In addition, the decision to store quantities of crude oil at the platform may necessitate the choice of a concrete platform.

In terms of general siting and labor requirements, the differences between steel and concrete platform fabrication are minimal. Both types require large expanses of firm, cleared land next to a deep channel, access to the waterway, and proximity to land transportation routes. Cement platforms are built in large, deeply dredged drydock basins separated by a cofferdam from the very deep adjacent channel.

Most of the platforms currently in use in the Gulf of Mexico are fabricated of steel. Land requirements for steel platform fabrication yards vary widely with the size and complexity of the structures built. A small yard (8 to 16 hectares, or 20 to 40 acres) can produce platforms of simple design. The deck sections for these platforms may be constructed at other locations. Larger yards (averaging from 162 to 324 hectares or 400 to 800 acres) are capable of producing large platform jackets, as well as the deck sections, catwalks, and helipads. Table 8 shows the locations and lists the operators of the major platform fabrication yards in the Gulf of Mexico Region.

Yards must be sited adjacent to deep channels, usually from 5 to 9 m (15 to 30 ft) deep, through which the fabricated platform jackets and deck modules can be barged or towed by tugs to the offshore installation site. In addition to deepwater channels, platforms require unobstructed air space (64 to 107 m or 210 to 350 ft, horizontal and vertical) in the transport path from the wharf to the open Gulf.

Of the variety of materials used in platform fabrication, the most important are special types of steel. The petroleum industry uses approximately 6 percent of the U.S. domestic steel output (National Petroleum Council, 1974, p. 20). Accordingly, the availability

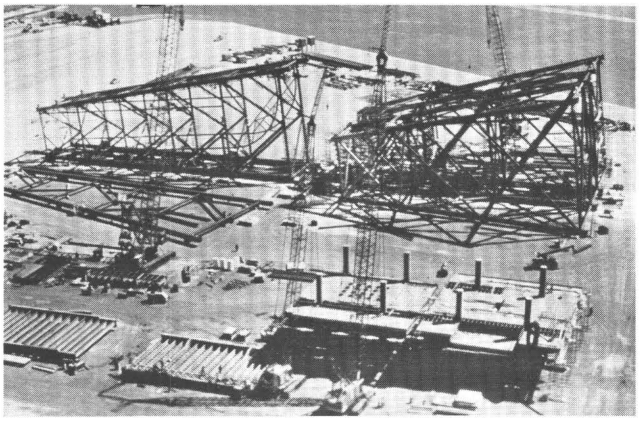


FIGURE 19.--Platform fabrication yard at High Island, Texas (photograph by American Petroleum Institute).

TABLE 8.—Platform fabrication facilities

Company	Location
Texas	
Baker Marine	Beaumont
Bethlehem Steel	Ingleside
Brown and Root	Houston
Brown and Root	Harbor Island
Gulfco	Freeport
Levingston Shipbuilding	Orange
Marathon-LeTourneau	Brownsville
Louisiana	
Avondale Shipyards, Inc.	Morgan City
Brown and Root	Morgan City
McDermott Incorporated	Morgan City
DuPont Fabricators	Amelia
Avondale Shipyards, Inc.	New Orleans
Williams-McWilliams Company, Inc.	New Orleans
Avondale Shipyards, Inc.	Harvey
Brown and Root	Harvey
McDermott Incorporated	Harvey
Williams-McWilliams Company, Inc.	Harvey
Benoit Machine	Houma
Delta Fabrication	Houma
Teledyne Movible Offshore, Inc.	Lafayette

SOURCE: BLM OCS Office, New Orleans, 1980, unpublished documents.

and cost of domestic steel will have a bearing on the scale of future platform fabrication activities.

Labor requirements also vary with complexity of platform design. Skilled labor such as welders, mechanics, and pipefitters (who may comprise 40 percent of the fabricator's payroll) may be trained in company-run programs, while less-skilled workers may be drawn from local labor pools. Some fabricators, such as McDermott Incorporated (formerly J. Ray McDermott of Louisiana), have a policy of training and employing local laborers when possible. Construction of one steel platform may require several hundred workers, many of whom are drawn from local markets.

Physical impacts on the area in which a platform fabrication yard is located will depend on the nature of the chosen site. If the yard is sited in a previously undeveloped place and requires channel dredging, the environs will be disturbed, and dredge spoil may have detrimental effects on the area's marine life. If the site chosen is in an existing industrial area, and water adjacent to the site is between 4.6 and 9 m (15 and 30 ft) deep, dredging will be unnecessary, and there will be minimum additional disturbance of the biota.

In terms of economic effects on the community, a platform fabrication yard employs large numbers of skilled laborers, as well as supervisory, administrative, and engineering personnel. If skilled labor is available, as much as 85 to 90 percent of a yard's workers may be hired locally. Inasmuch as fabrication yards are permanent facilities, these workers will reside in the adjacent region and thus demand social services provided by an established community.

It should also be noted that the platform fabrication yards of the Gulf Coast furnish structures for the world oil industry. For example, McDermott Incorporated, maintains offices in the United States and in the North Sea area, the Middle East, West Africa, Southeast Asia, and Central and South America. It can be expected that the scale of platform fabrication activities in the Region will be either maintained or increased in the next few years.

PIPE COATING YARDS

Pipe used for offshore oil and gas transmission must be coated for corrosion-proofing and, in some instances, to prevent floating. From scheduling to loadout (onto supply barges) the coating process involves several intermediary stages and can take as long as 8 months (New England River Basins Commission, p. 9.5).

Raw pipe lengths and joints are shipped from steel mills via either barge or rail car, depending on transport economics. Sand, cement, and ore aggregates are also transported to the coating yard. Once in the yard, pipe lengths undergo a series of treatments before coatings can be applied. Pipe interiors and exteriors must be cleaned of rust and dirt and then shotblasted. Shotblasting produces a textured surface to which the coatings can be more firmly bonded. After shotblasting, the pipe is primed with a thin coat of asphalt and petroleum thinner. Then it is ready for coating with anti-corrosion mastic, a substance that forms a dense, seamless sleeve around the pipe--protecting it from corrosion and electrolytic deterioration. In addition to the mastic, other coatings such as polyurethane foam may be applied as insulation. Once these coatings have been applied, the pipe lengths cool in the yard. The cooled pipe then undergoes careful inspection.

Concrete of very high density is mixed and applied at the coating yard to pipe that must be prevented from floating. This cement-coating process is also closely supervised; every length is checked for uniformity and compliance with coating specifications.

Pipe lengths are inspected and reinspected on land and on the lay barge to assure integrity of pipe and seals. Preventive inspection is more easily and economically accomplished than repairing a leak in a pipe once it has been set into the sea floor.

The final operation in the coating process is loading the finished pipe onto supply barges, which ferry it to lay barges at sea. Since the yard may be supplying pipe for several simultaneous laying operations, it must have enough wharf space to accommodate several supply barges at one time.

The decision to establish a new pipe coating yard generally occurs after pipeline design and preliminary route surveying are completed by the pipeline operator. Early in the lease sale process, however, the coating yard owner may be looking at land in the coastal area adjacent to the offshore tracts of highest industry interest.

There are two types of pipe coating operations: temporary ("railhead") and permanent. The temporary coating firm may move into an area after a contract to supply coated pipe has been signed. It may coat and furnish pipe for one pipeline contractor for the duration of a season, or until that particular pipeline is completed. All this operation requires is firm, cleared ground, proximity to overland transportation (generally a railroad), and access to the waterfront. If the company sees the possibility for continuing business, it may make the operation permanent.

A permanent pipe coating facility is established when the owner receives a long-term contract or sees the possibility for continuing, large-scale business. Once the yard is established, the owner expands it as orders resulting from new offshore discoveries are received. Table 9 shows major permanent pipe coating yards in the Gulf of Mexico Region.

In terms of location, it is optimal for a pipe coating facility to be sited close to other oil-related businesses such as the service base and the pipelaying company's base of operations. A permanent pipe coating facility requires between 40 and 60 hectares (100 and 150 acres) of land. Temporary plants can operate on as little as 12 hectares (30 acres), provided access to water and rail routes is also present. Existing yards in the Region range from 30 to 40 hectares (75 to 100 acres), approximately 95 percent of which are used for pipe storage. The remaining 5 percent of the land houses coating, office, and loadout operations.

Labor at pipe coating yards comes primarily from local communities. Few specialized workers are employed in these yards.

TABLE 9.—Pipe coating and fabrication facilities

Company	Location
Texas	
Morrison-Knudsen Co., Inc.	Houston
Nippon Kokan K.K.	Houston
Raymond International	Houston
Panama-Williams, Inc.	Houston
NOVA Pressure Services	Houston
Northwest Constructors, Inc.	Houston
H.H. Null, Inc.	Houston
Netherlands Offshore Co.	Houston
Natural Gas Construction Co.	Houston
Mid-Valley, Inc.	Houston
Marathon Paving and Utility Construction	Houston
McDermott Incorporated	Houston
Brown & Root	Port O'Connor
U.S. Steel	Baytown
Louisiana	
McDermott Incorporated	Lafayette
Brown & Root	Morgan City
Brown & Root	Harvey
McDermott Incorporated	Gibson
Williams-McWilliams Co., Inc.	New Orleans
McDermott Incorporated	Venice
Brown & Root	Belle Chasse
Brown & Root	Intracoastal City
McDermott Incorporated	New Iberia

SOURCE: BLM OCS Office, New Orleans, 1980, unpublished documents.

The socioeconomic effects resulting from pipe coating yards are much the same as those from supply bases: additional housing, food purveyors, social and health services, and some upgrading of roads, schools, and utilities such as sewer, water, and electricity are required.

As noted in chapter 2 of this report, a high level of exploration and development for oil and gas is likely to continue even as production from the Gulf of Mexico OCS declines. Permanent pipe coating yards on the Gulf Coast will respond to the continuing demand for pipelines for the entire U.S. offshore oil and gas industry. These same pipe coating facilities may also supply the growing offshore industry in other parts of the world.

ONSHORE PIPELINE SYSTEMS

Hydrocarbons produced on the Gulf OCS, as well as onshore and imported petroleum, find their way to domestic users through a widespread network of crude oil and products pipelines, a network that is continually expanding. The offshore pipeline network was discussed in chapter 3. Onshore, products pipelines in the United States increased from 33,604 km (20,881 mi) in 1949 to 103,846 km (64,529 mi) in 1968 alone (Mississippi Marine Resources Council, 1976, p. 181).

Movement of products from refiners to consumers is carried on in two stages: (1) shipment from refineries to terminals (referred to as **primary transport**) and (2) shipment from terminals to users (referred to as **secondary transport**).

The most economical, safe, and reliable means of accomplishing both primary and secondary transport of petroleum is through pipelines. Although the fabrication and laying of pipeline systems is capital-intensive, the operation and maintenance costs of pipelines are relatively small compared to those of other modes of transportation.

Products pipelines on the Gulf Coast fall into two categories: (1) those that distribute products within the Region, and (2) those that transport products to areas of demand elsewhere in the Nation. Because of the multitude of refineries and petrochemical plants situated in the Gulf Coast States, there is extensive pipeline movement of such products as natural gasoline and liquefied petroleum gases. Figure 20 shows major Gulf Coast products pipeline systems. Figure 21 shows destinations of these products.

Pipeline construction requires the acquisition of rights-of-way for the pipeline, large amounts of heavy construction equipment, many kilometers of specialized pipe, and a great number of skilled workers. These requirements are the same for both crude and products pipeline construction.

FIGURE 20.--Gulf Coast products pipeline systems (adapted from National Petroleum Council, 1967, p. 101-102, as modified by American Petroleum Institute Products Pipe Line Map of the United States and Southern Canada, 1979, by Rogers, Golden & Halpern).

Acquisition of land for the pipeline, by purchase in fee or purchase of permanent easements, is a major financial constraint in pipeline construction, as well as a very time-consuming activity. The right-of-way necessary varies according to legal dictates and the size of pipe to be installed. Generally, a minimum of 6 m (20 ft), plus the pipe diameter, is needed for the permanent easement, with a minimum of 12 m (40 ft) required for the construction easement (the surrounding strip temporarily used during pipeline construction) (Wales and others, 1976, p. 187).

A variety of heavy equipment is used in pipeline construction. Machines clear and fence land to facilitate access by construction equipment. Pipe lengths are arranged in a line adjacent to the pipeline right-of-way. A machine is used to bend the pipe so that it can accommodate gentle curves in the land. Equipment is also used to dig trenches at least deep enough to provide a meter's (3-ft) cover of earth, and wide enough to allow at least 1/3 m (1 ft) on each side of the pipe. Other types of heavy equipment are used to bury the pipe.

Welding equipment is necessary for pipefitting, and radiographic equipment is used to test the integrity of joints and tie-ins. If the pipe lengths have not been precoated, equipment will be used to coat the completed sections of pipe on-site. Other heavy equipment is used to lower pipe into the trench and backfill over it.

Pipeline construction activities typically have short-term impacts on Gulf Coast communities. A relatively labor-intensive operation, pipelaying requires large numbers of specialized workers such as civil engineers, surveyors, welders, pipefitters, and heavy equip-

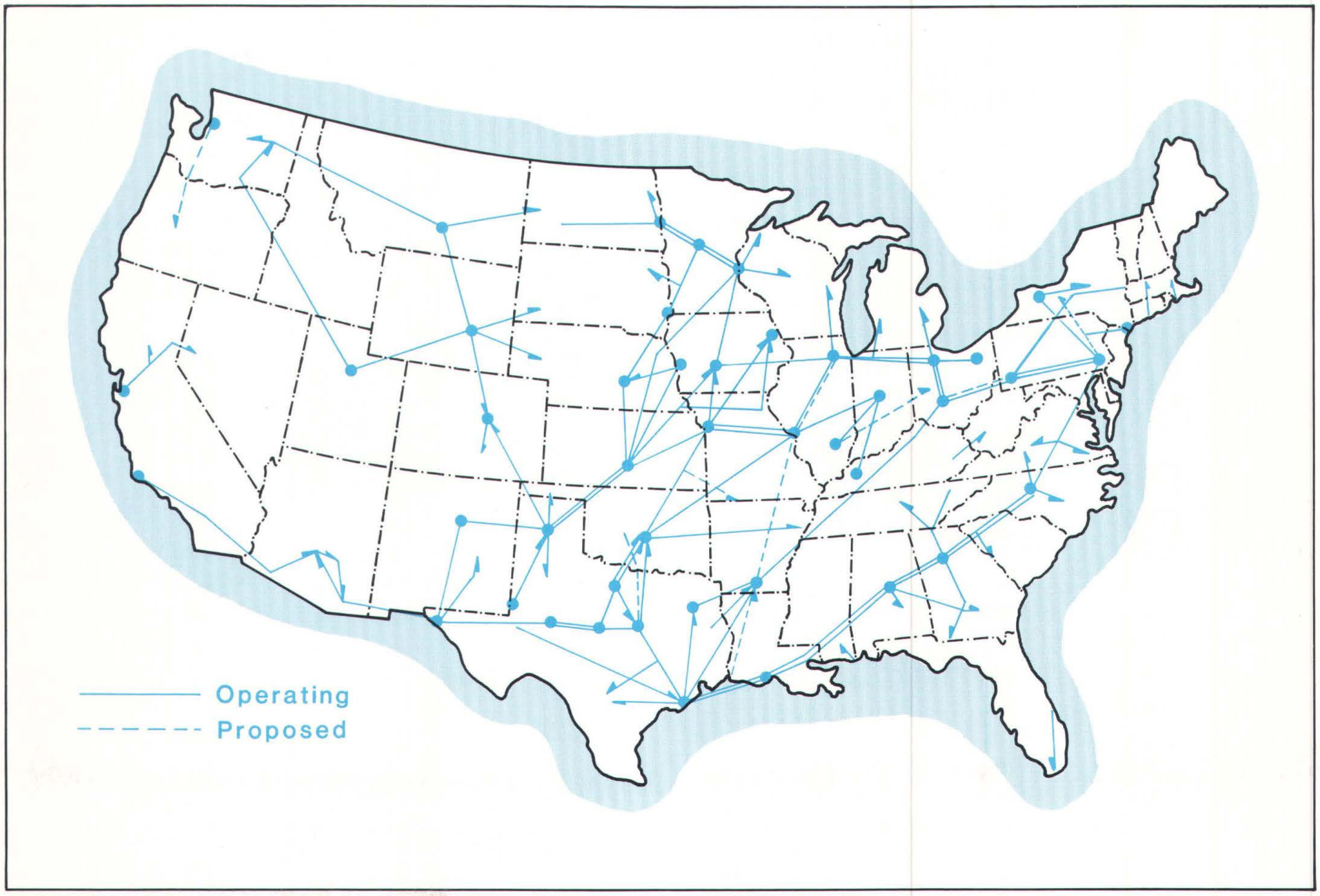


FIGURE 21.—National products pipeline network (adapted from National Petroleum Council, 1967, p. 71-72, as modified by American Petroleum Institute Products Pipe Line Map of the United States and Southern Canada, 1979, by Rogers, Golden & Halpern).

ment operators. Depending on availability, some of these workers may be drawn from the community. Once the pipeline is in place and operating, however, few persons (mostly inspectors) will be needed, and the specialized laborers will likely move out of the area to new construction sites. At the peak of construction, the area may thus experience a temporary influx of laborers and a need for additional housing and health and social services for them.

Planning for onshore pipeline construction in the Gulf requires a complete analysis of product mix and movement. Few, if any, onshore pipelines move products from a single origin to a single destination. Imported, onshore, and offshore petroleum are commingled (frequently before processing occurs) and distributed through the network of primary and secondary transport pipelines. Because of the industry practice of commingling of petroleum, onshore pipeline construction for OCS oil and gas is not planned independently of the total resource supply and distribution pattern.

PARTIAL PROCESSING FACILITIES

Partial processing is the first step in the treatment of liquid and gaseous hydrocarbons as they flow from well to consumer. Partial processing facilities separate oil, gas, water, and dissolved or suspended materials from the petroleum mixture produced from the well. The partial processing facility is like a small refinery, but its role is that of separation rather than refining.

Frequently, partial processing facilities are located on the offshore platform, especially if the platform is a major one or if the distance to shore is great. Otherwise, partial processing facilities are located onshore, usually close to storage facilities or gas processing and treatment plants. The location strategy is fixed at the same time as platform and other transportation decisions are made. The decision whether to locate partial processing operations onshore or offshore is made on the basis of economics and physical properties of the resource.

Although the locations of partial processing facilities are not confined to onshore sites, the impacts discussed here are characteristic of onshore plants.

Partial processing facilities sited onshore require approximately 6 hectares (15 acres) of land per 100,000 barrels of oil and associated gas to be produced. This area requirement assumes collocation of gas processing facilities. If gas processing is done elsewhere, less land area is required (New England River Basins Commission, 1976, p. 4.23).

Raw gas is usually delivered to the plant by pipeline. Commingling with other gas supplies, from both onshore and offshore wells, is common. Because hydrocarbons are blended, the source of the raw gas is a less important siting consideration than the amount of gas and the assurance of a continuing supply.

Processing facilities are best located near the pipeline landfall site in order to minimize pipeline construction and operating costs. If the processed crude is brought to the partial processing facility via tanker or barge, the proximity of the plant to a port with sufficient depth and a turning basin becomes an important consideration.

Partial processing facilities do not require large volumes of water. Requirements for electricity and natural gas vary widely, depending on the size of the facility and the method of processing used.

During construction of a partial processing facility, about 150 field workers may be employed. Once the plant is completed, operation continues 24 hours per day, with only two or three full-time workers per shift (New England River Basins Commission, 1976, p. 4.28).

The siting of additional processing plants is closely related to the projected levels of gas production from the Gulf of Mexico OCS, which do not suggest the need for additional processing plant capacity. However, planning for future plant siting is likely to respond to the changing hydrocarbon mix and field locations in the Region. As noted in chapter 2, more recent discoveries have been gas fields than oil fields, and these discoveries have occurred frequently off the Texas coast. Over a period of time, expanded processing plant capacity will therefore be needed in Texas.

REFINERIES

Modern refineries are highly automated facilities designed to produce a range of petroleum products through physical or chemical alteration of crude oil. Refinery complexity depends on the type of crude oil being refined and the number and kinds of end products. A typical refinery consists of processing units, storage tanks, water treatment facilities, offices, an electrical substation, a fire house, a pumping station, truck loading areas, pipelines, a rail spur, parking areas, and a buffer zone. Figure 22 shows an aerial view of the Baytown refinery in Baytown, Texas.

Refineries, even those having small capacities, are capital-, land-, and water-intensive. Construction costs for new refineries may run to several hundred million dollars. Because of these huge capital costs, refineries are sited at locations where a long-term supply of crude oil is assured. Increased refining capacity is frequently attained by expansions of existing plants rather than construction of new ones.

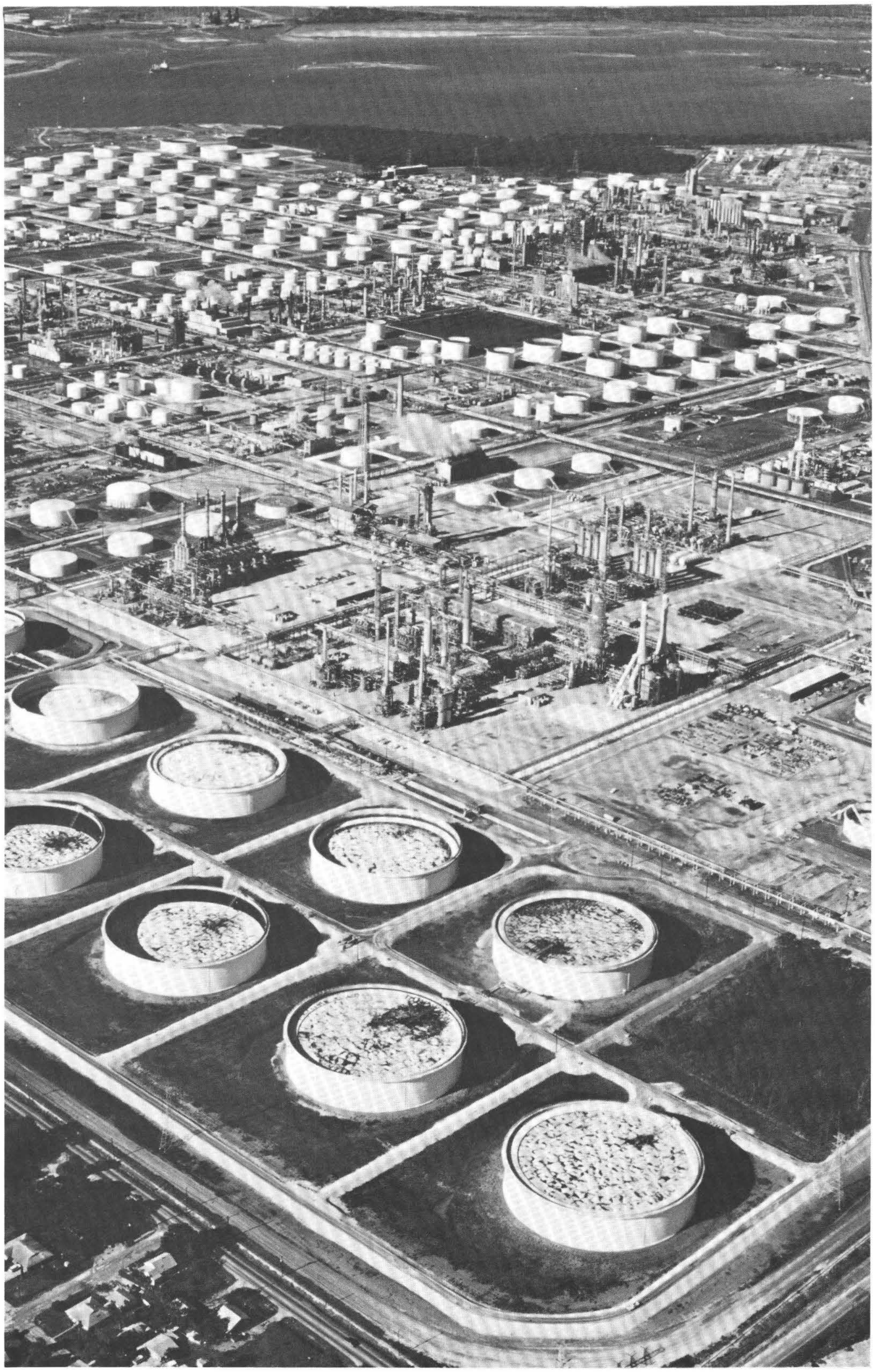


FIGURE 22.--Aerial view of the Baytown Refinery in Baytown, Texas (photograph by Exxon Company, U.S.A., 1977).

Refineries require considerable acreage, but only a small percentage of the total area is used intensively. Large parcels of land, frequently 405 hectares (1,000 acres) or more, are used. This allows for future expansion and provides a buffer between the refinery and its neighbors. Oil refineries are among the most controversial facilities associated with OCS oil and gas development because of their adverse impacts on air and water quality. Refinery sites are chosen to avoid areas where public opinion is likely to oppose such development.

Abundant water supplies at refinery sites are required for two reasons: much fresh water is used for processing and cooling, and nearby deep water is necessary to permit the use of deep-draft vessels when feedstocks are waterborne.

Locations of hydrocarbon resources and markets affect the choice of refinery locations. **Market refineries** are built to serve the needs of consumers within their localities. **Resource refineries** are located on or near major oil fields. **Swing refineries** are built at some intermediate or less specific location to balance the supply or demand for particular refined products when the major consumption centers are geographically dispersed.

For economic reasons, industry prefers to build market refineries. It is cheaper to transport a homogeneous commodity like crude oil in bulk over a distance than to distribute a variety of specialized products to many markets over the same distance. In the absence of a concentrated market like that of the large urban areas of the U.S. Northeast, refiners build resource-oriented plants.

In the early 1900's, when the East Texas oil fields were discovered, large markets were distant. Resource refineries built near these large fields expanded to accommodate increasing production. Few, if any, refineries have been built solely to handle OCS oil. Most were originally built for proximity to the oil fields in the Region, and they acquire feedstocks from a combination of offshore, onshore, and imported crude oil. Tracing the movements of OCS oil (as well as gas) is complicated by an industry practice called **swapping.** Companies "swap" or exchange crude oil when one company's production is closer to the refinery of another, or vice versa. This practice lowers transportation costs and eliminates the need for redundant refining capacity.

There are 47 refineries operating in the coastal counties and parishes of the Gulf of Mexico Region. They have a refining capacity of approximately 6 million barrels per day. More than half the plants and nearly two-thirds (64.1 percent) of the total capacity are in Texas. Together, Texas and Louisiana account for 96.5 percent of the refining capability along the Gulf Coast. The MAFLA States have five refineries and 3.5 percent of the coastal region's refining capability. Table 10 shows refining capacity by State for the Gulf Coast.

Many refining centers have more than one or two refineries. These centers include Corpus Christi, Houston, Texas City, and Port Arthur, in Texas, and Lake Charles, Louisiana. Plate 6 shows existing and proposed refineries.

Additions to refinery capacity have been proposed in Texas, Louisiana, and Alabama. These facilities are in various stages of development. A 150,000-bpd petroleum refinery on 810 hectares (2,000 acres) in Brownsville, Texas, is in the design and construction stage. It is being built by the Barbour Energy Co., Inc., of Houston at an estimated cost of $400 to $600 million.

In Louisiana, three projects to increase refinery capacity are contemplated. Feasibility studies for expansion of an oil refinery are being conducted by Tenneco, Inc., at its Chalmette, Louisiana, facility. A refinery at Baton Rouge, Louisiana, is planned by United Energy Resources at a projected cost of $30 million. Tiber Petroleum of Houston has a crude oil refinery in the design and construction phase at Harvey, Louisiana.

Refinery capacity in Alabama will be expanded. J.E. Sirrine Co. of Houston plans an oil refinery expansion at Theodore at an estimated cost of $10 million (Engineering News Record, 1979, p. 158).

TABLE 10.—
Refining capacity of Gulf coastal counties and parishes by State

State	Number of refineries	Crude oil capacity (bpcd)
Alabama	2	57,500
Florida	1	13,000
Louisiana	17	1,931,200
Mississippi	2	135,800
Texas	25	3,816,750

SOURCE: BLM OCS office, New Orleans, 1980, unpublished documents; and Oil and Gas Journal, March 24, 1980, p. 143-156.

As indicated earlier, the types of refineries and their scale of operations can vary widely, and with them, the impacts they cause. The following section addresses general effects characteristic of a refinery with a 250,000-bpd capacity.

A grassroots refinery in the 250,000-bpd range requires 405 to 607 hectares (1,000 to 1,500 acres) of cleared, flat, industrially zoned land. Of the total land required, about 81 hectares (200 acres) is needed for processing units, 162 hectares (400 acres) for buildings and storage, and the balance employed for buffer.

Three years are generally required for the construction of a refinery. During this time, environmental impacts may be minimal or significant, depending on the location chosen. If a coastal site is selected, construction activities primarily affect marine and estuarine ecosystems, as jetties, piers, and crude oil and product transshipment facilities are built. Should an inland site be chosen, temporary alterations in the land result from clearing and cutting a 15 to 30 m (50 to 100 ft) pipeline right-of-way from the coastal terminal to the refinery.

It is preferable, although not essential, that a refinery be sited close to a major urban area. Access to railways, port facilities, major highways, and crude and product pipelines is required. A location near related industries such as machine shops, valve manufacturers, warehouses, and contract maintenance companies is also desirable.

Refineries are water-intensive. The community in which a refinery is located has to provide as much as 11 barrels of fresh water per barrel of crude oil refined per day (Wales and others, 1976, p. 159).

Electricity purchased locally provides about 80 percent of a refinery's power. Power needed to run a 250,000-bpd refinery could be as much as 100,000 kilowatt-hours per day (New England River Basins Commission, 1976, p. 6.14).

Total direct labor for a 250,000-bpd refinery may vary from 400 to 900 people. Many of these workers are recruited from local labor markets. Of the total payroll, about 70 percent are operations and maintenance personnel, while 20 percent fill administrative positions. The remaining 10 percent are safety, security, clerical, and laboratory workers (New England River Basins Commission, 1976, p. 6.15). Since most of the workers in an established refinery are local residents, additional housing and social services may not be needed. However, during the construction phase, there may be more job openings than can be filled locally. As many as 70 percent of the workers may be brought in from other areas, and housing and social services will need to be provided for the influx of workers and their families.

The presence of an extensive refinery capacity along the Gulf Coast is likely to lead to the expansion of existing facilities and the construction of additional installations to the Region over the long run. The oil and gas industry's heavy investment in Texas and Louisiana, coupled with the economies that can be achieved by the continued development of the industrial base of these States, suggest a long-term presence in the Region. The dispersed nature of the resource supply (onshore, offshore, and foreign imports) and the industry practices of swapping and commingling complicate the process of identifying specific sites where OCS oil and gas are likely to necessitate refinery expansion or construction.

GAS PROCESSING AND TREATMENT PLANTS

Gas processing and treatment plants are similar to refineries, but smaller. They are designed to strip both impurities and valuable liquefiable hydrocarbons such as ethane, butane, and propane from raw gas before it enters commercial gas transmission pipelines. Plant sizes and designs may vary considerably, as these facilities are custom-built to accommodate a particular gas stream. Capacities may range from 2 million to 2 billion cfd.

Gas processing and treatment plants are constructed soon after the size and characteristics of the natural gas supply are known. Several factors influence the siting of a plant:

- the size of the supply;
- the anticipated rate of production;
- the location of transportation and partial processing facilities;
- the liquid hydrocarbon content and composition of the gas;
- the sulfur content of the gas; and
- the market for liquid hydrocarbons.

The development of gas processing and treatment facilities, like that of oil refineries, depends on an assured supply of resources. When gas is discovered in sufficient quantity to justify the costs of producing, transporting, and processing it, construction of a gas plant is virtually certain.

While coastal sites are preferred, land availability is the primary factor influencing the location of gas processing and treatment plants. The plants are usually located between a gas pipeline landfall and a nearby commercial gas transmission line. Gas processing and treatment plants may provide feedstock for petrochemical plants, but the presence of one does not always indicate the presence of the other.

Gas processing and treatment plants on the Gulf Coast are heavily concentrated in Texas and Louisiana. Few existing plants are found in the MAFLA portion of the Region. Out of a total of 176 gas processing and treatment plants, 101 are in Louisiana and 71 are in Texas. There are two plants each in Alabama and Florida and none in Mississippi. Plate 6 shows the distribution of those gas processing and treatment plants.

Because gas production from the Gulf of Mexico is nearing its peak, it is unlikely that new facilities for gas processing will be sited in the coastal zone. Unless massive new discoveries of gas are made, existing facilities should serve present production.

If new or expanded gas processing plants are proposed, planning for them will probably focus on Texas. As already noted, new gas discoveries in the Gulf of Mexico are most likely to occur off the Texas coast; however, the largest concentration of existing processing plants is in Louisiana. New or expanded facilities are likely to be considered on the basis of the following:

- the relationship between new, expanded, or existing plants and current regional transportation strategies;
- the proximity of new wells or gas fields to shore; and
- well stream and reservoir characteristics.

PETROCHEMICAL COMPLEXES

The petrochemical industry in the Gulf of Mexico is a highly developed, mature activity that produces a wide range of products. These products are distributed both in national and international markets. Petrochemical plants, like oil refineries, have existed in the Gulf of Mexico Region for a long time and are supplied by varying combinations of onshore, offshore, and imported oil and gas supplies. Since there are over 200 petrochemical plants in the Gulf of Mexico Region, complete discussion of them is not possible in this report.

This section briefly describes the characteristics of petrochemical complexes, their usual locations, geographical distribution of existing facilities, and proposed expansions and additions to current capacity.

Petrochemicals are chemicals, not fuels, that are derived from hydrocarbons. Petrochemical processing occurs in several stages. First, mixtures of hydrocarbons from either gas processing plants or oil refineries are converted into primary petrochemicals. These are the basis for all other petrochemical production. Major primary petrochemicals in clude ethylene, propylene, butylene, benzene, toluene, and mixed xylenes.

Primary petrochemicals are then converted into intermediate petrochemicals, including ethylene oxide, ethylene glycol, propylene oxide, phenol, styrene, and vinyl chloride.

Intermediate petrochemicals are then converted to final petrochemicals. Final petrochemicals, while undergoing no further chemical processing, may be physically transformed or fabricated into end products such as plastics, synthetic fibers, synthetic rubbers, paints, industrial solvents, pharmaceuticals, explosives, fertilizers, and pesticides.

Petrochemical plants are similar to oil refineries. They are relatively land- and capital-intensive. The most important criterion for the location of a petrochemical plant is the availability of a sufficient amount of feedstock. Most primary petrochemical production currently comes from natural gas liquids. As natural gas production declines, sources of feedstocks are likely to shift away from the light natural gas liquids to heavier feedstocks.

The need for proximity to a source of raw materials frequently leads to the establishment of refinery/petrochemical complexes. Several oil refineries may be needed to supply a series of petrochemical plants with differing feedstocks. The large volume of raw materials necessary to supply a petrochemical plant encourages clustering of facilities to minimize transportation costs.

The nature of the market also constrains the location of petrochemical facilities. Frequently, the output of one plant is the input to another plant; thus, petrochemical plants form a series of linkages in a network of both producers and consumers. Proximity to market, rather than to raw material, becomes more important with each succeeding stage of production. These relationships have resulted in an intricate network of petrochemical complexes throughout the Region, based on a steady supply of raw materials over a long period.

Petrochemical plants in the Gulf of Mexico Region are heavily concentrated in both Texas and Louisiana. Half (100) of all these facilities are located in Texas. Louisiana contains another 70 plants. There are 4 plants in Mississippi, 4 in Alabama, 13 in Florida, and 9 petrochemical plants in the planning and construction stage in the Region. These projects include both new plants and expansions of existing facilities. Table 11 identifies the proposed plants.

Because of the complexity of the petrochemical industry and the variety of products and processing techniques, sizes and requirements of these plants vary widely. Impacts of these plants and complexes should be evaluated on a site-by-site basis. However, certain effects on a community in which a petrochemical plant is located are common to all sizes.

As noted earlier, the most important element in siting a petrochemical plant is access to feedstocks. It is therefore likely that a new petrochemical plant would be sited close to or within a complex containing an oil refinery or gas processing plant. Because feedstocks are usually derived from oil and gas originating at onshore, offshore, and foreign locations, proximity to Gulf of Mexico OCS crude oil supplies is not a major criterion for site selection. Land required for a primary petrochemical plant could range from 81 to 162 hectares (200 to 400 acres) (New England River Basins Commission, 1976, p. 7.24).

The volume of fresh water required also varies according to the size and complexity of the plant and the types of equipment used. All types of plants are water-intensive, and they also require large amounts of electricity and fuel. A primary petrochemical plant may use

TABLE 11.—Proposed petrochemical facilities, Gulf of Mexico

Location	Operator	Product	Additional Comments
		Texas	
Bayport	ICI Americas	Ethylene oxide/ ethylene glycol	ICI Americas is a subsidiary of Imperial Chemicals, Ltd., London, England.
Green Lake	Vistron Corp.	Acrylonitrile	Plant to be constructed on a 930-hectare (2,300-acre) site. Vistron Ltd. is a subsidiary of Standard Oil Co. of Ohio; project cost in excess of $100M; completion scheduled for fall-winter 1981.
Channelview	ARCO Chemical Co.	Methyl ethyl ketone	ARCO Chemical is a division of Atlantic Richfield Co.; the planned facility is part of the Lyondell Chemical Complex at Channelview; completion scheduled for mid-1982.
Deer Park	Soltex Polymer	High density polyethylene	Plant capacity planned for 150 million lbs/yr; completion scheduled for 1980.
Cedar Bayou	Gulf Oil Chemicals	Normal alpha-olefins	Completion scheduled for end of 1981.
		Louisiana	
Baton Rouge	Allied Chemical	High density polyethylene	Estimated cost $52M; completion scheduled for 1981.
Geismar	Borden, Inc.	Plastics	Plant construction planned for the Petrochemical Complex in Geismar, La.; estimated cost $60M; completion scheduled for 1982.
		Mississippi	
Port Bienville	Borg-Warner Corp.	Plastics polymerization and compounding facility	Estimated cost $50M; completion scheduled for 1982.
		Alabama	
Mobile	Shell Chemical	Pyridin insecticide	Shell Chemical Co. is a unit of Shell Oil Co.; completion scheduled for 1981.

SOURCE: Engineering News Record, January 1978 - May 1980.

as much as 450 million kilowatt-hours per year (New England River Basins Commission, 1976, p. 7.28).

During construction of a primary petrochemical plant, the work force averages 2,000 workers. Once the plant is in operation, the need for full-time workers decreases sharply; as few as 400 employees may be needed to run it (New England River Basins Commission, 1976, p. 7.30). In general, the labor intensity is directly proportional to the stage of processing--the more highly refined the product, the larger the plant's payroll.

CONCLUSION

Chapters 1 through 4 of this initial Gulf of Mexico Summary Report provide the States of Texas, Louisiana, Mississippi, Alabama, and Florida, and other interested parties, with up-to-date information on Gulf of Mexico OCS oil and gas operations and their onshore impacts. The Outer Continental Shelf Oil and Gas Information Program (OCSIP) concludes that, due to the maturity of the Gulf as a hydrocarbon-producing region and the vast onshore infrastructure that supports this industry, exploration, development, and production activities anticipated in the next 6 to 12 months will have little additional aggregate effect on coastal communities. The coastal communities of the Gulf Region contribute to a global oil and gas exploration, development, and production effort. Against that worldwide effort, the short-term regional dynamics have little impact on the overall economy of Gulf Coast communities.

Chapters 2 through 4 portray a picture of continuous exploration, development, and production. Although oil production is declining, and gas production is projected to begin declining soon, Gulf Coast oil and gas operations will remain very active in the near term. Most, if not all, hydrocarbon-bearing fields will ultimately be exploited, as changing economics and technology make it feasible to extract more resources from the Gulf. The overall level of OCS-related onshore activity is also expected to remain about the same for the foreseeable future.

The principal planning issues that have arisen during consultations with State and local planners are as follows:

- More gas fields will be found off Texas; thus, new or expanded/modernized gas processing plants will likely be sited in the coastal counties of Texas.

- Thus far, exploration in the MAFLA region has failed to identify commercially producible hydrocarbons. Onshore facilities that supported past exploration are probably adequate for any additional near-term exploration.

- Texas and Louisiana depend heavily on the oil and gas industry for State revenues. Declining Gulf of Mexico production will have a gradual negative effect on the revenues of these two States in particular. The economic ramifications of this trend will have to be considered by planners.

In July 1980, the Bureau of Land Management published a Draft Environmental Impact Statement for proposed Lease Sales A66 and 66, expected to be held in July 1981 and October 1981, respectively. Certain assumptions regarding onshore effects of these sales have been made. The following are summaries of the anticipated impacts.

- OCS activity occuring off Texas and Louisiana will most likely be supported by existing service bases and support and processing facilities, with only a small amount of expansion expected.

- Offshore production could significantly contribute to the need for one new pipeline landfall in Texas and one in Louisiana. (More specific siting information is not available at this time.)

- Very little OCS activity will be supported from Florida Gulf Coast locations because very limited oil and gas infrastructure exists in the MAFLA region. Existing or expanded service bases at Port Manatee near Tampa, Florida, are expected to be adequate for exploration, development, and protion support activities. Future discoveries in the OCS off Florida may justify a pipeline landfall in Charlotte County, Manatee County, or Hillsborough County, Florida.

- General requirements for land and water are expected to increase only minimally. Air emissions, wastewater contaminants, and solid waste from OCS-related activities are also expected to be minimal.

Analysis of the expected new resident population growth and its average annual rate of increase indicates that it would be highly unlikely that any affected coastal community will be subjected to rise in demand for housing and social services beyond its capacity to provide these services and facilities.

For a more detailed treatment of the impacts expected from Lease Sales A66 and 66 in the Gulf of Mexico, the reader is referred to the EIS for these sales, as well as to later editions of the Gulf of Mexico Summary Report.

In light of the gradual decline in petroleum production in the Gulf of Mexico (discussed in preceding chapters), the State representatives from Texas and Louisiana evinced a concern at the May 1980 IPP meeting as to the future of coastal communities when Gulf production significantly decreases. These representatives suggested that studies addressing this eventuality be undertaken.

The current 5-year OCS oil and gas leasing schedule (June 1980) projects two lease sales per year through 1985 for the Gulf of Mexico. In order to provide continuing up-to-date information, the OCS Oil and Gas Information Program will produce a new Gulf of Mexico Summary Report annually.

For States seeking additional help in planning for coastal effects associated with OCS oil and gas development, limited technical assistance is available. Requests for technical assistance will be evaluated and approved on a case-by-case basis and inquiries should be directed to the Office of Outer Continental Shelf Information at the address shown in the front of this publication.

References

Alaska Consultants, Inc., 1976, Marine service bases for offshore oil development: Anchorage, prepared for the Division of Community Planning, Department of Community and Regional Affairs, State of Alaska, 87 p.

American Petroleum Institute, 1971, Facts and figures: Washington, D.C.

------ 1979, Annual report: Washington, D.C.

Antoine, John W., 1972, Structure of the Gulf of Mexico, in Rezak, Richard, and Henry, Vernon J., eds., Contributions on the geological and geophysical oceanography of the Gulf of Mexico: Houston, Gulf Publishing Co.

Aronson, Ellen, 1979, IPP briefing package: Los Angeles, Calif., BLM Pacific OCS Office.

Bergantino, Robert N., 1971, Submarine regional geomorphology of the Gulf of Mexico, in Geological Society of America Bulletin, v. 82, no. 3.

Bird, Cyril, 1980, Estimated oil and gas reserves, Southern California Outer Continental Shelf, January 1, 1979: Draft U.S. Geological Survey Open-File Report.

Bookman, Charles A., 1980, The contribution of OCS oil and gas to the U.S. energy supply: prepared for the Marine Board Safety Study, working paper no. 4.

Bryan, Floyd, Petroleum Geologist, USGS, Conservation Division, oral communications, 1980.

Bryan, Floyd T., Knipmeyer, John H., and Schluntz, E. Kenneth, 1980, Estimated oil and gas reserves, Gulf of Mexico Outer Continental Shelf, January 1, 1979: U.S. Geological Survey Open-File Report No. 80-644, 10 p.

Courtney, Lawrence, Technical Writer, USGS Conservation Division, oral communication, May 23, 1980.

Dam, Kenneth W., 1976, Oil resources: who gets what how: Chicago, Ill., University of Chicago Press.

Davey, Troy, Production supervisor, Exxon Company, U.S.A., oral communication, March 13, 1980.

Drew, Larry, Reservoir Engineer, USGS, Geologic Division, oral communication, April 17, 1980.

Dunn, F.P., 1980, Deepwater drilling and production platforms in non-Arctic areas, in Outer Continental Shelf frontier technology: proceedings of a symposium: Washington, D.C., National Academy of Sciences.

Engineering News Record, January-May 1980.

Federal Register, January 17, 1979, p. 3513-4527; February 12, 1980, p. 9536-9540.

Kash, Don E., White, Irvin L., Bergey, Karl H., Chartock, Michael A., Devine, Michael D., and Leonard, R. Leon, 1973, Energy under the oceans: a technology assessment of Outer Continental Shelf oil and gas operations: Norman, Oklahoma, University of Oklahoma Press, 378 p.

Kaufman, Herbert, Environmental Specialist, BLM, 1980, oral communication.

Larson, D.K., Davis, D., Detro, R., Dumond, P., Liebow, E., Motschall, R., Sorensen, D., and Guidroe, W., 1979, A socioeconomic characterization of the Mississippi Deltaic Plain Region (draft): prepared by Willdan Associates for the U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-79/05, 3 vols.

Lochridge, J.C., 1980, Deepwater pipelines, in Outer Continental Shelf frontier technology: proceedings of a symposium: Washington, D.C., National Academy of Sciences.

Macpherson, George S., and Bookman, Charles A., 1979, Outer Continental Shelf oil and gas activities in the Mid-Atlantic and their onshore impacts: a summary report, November 1979: prepared by Rogers, Golden & Halpern for the U.S. Geological Survey, Open-File Report 80-17, 63 p.

Martin, Ray G., 1980, Distribution of salt structures in the Gulf of Mexico: maps and descriptive text: U.S. Geological Survey, Misc. Field Studies map, MF-1213, scale 1:2,500,000.

Miller, Betty M., and others, 1975, Geological estimates of undiscovered recoverable oil and gas resources in the United States: U.S. Geological Survey Circular 725, 78 p.

National Petroleum Council, 1967, U.S. petroleum and gas transportation capacities: Washington, D.C.

------ 1974, Availability of materials, manpower and equipment for the exploration, drilling, and production of oil--1974-1976: Washington, D.C., National Petroleum Council.

New England River Basins Commission, 1976, Factbook: onshore facilities related to offshore oil and gas development: prepared for the Resource and Land Investigations Program, U.S. Geological Survey, Boston, Mass., 588 p. and appendixes.

Oceanus, Fall 1975, v. 19, no. 1, p. 54.

Office of Technology Assessment, U.S. Congress, 1976, Coastal effects of offshore energy systems: Washington, D.C., Government Printing Office, 288 p.

Office of Technology Assessment, U.S. Congress, 1977, Federal role in OCS oil and gas development: Washington, D.C., Oceans Program.

Oil and Gas Journal (OGJ), September 3, 1979; January 1, 1980; January 14, 1980; March 24, 1980.

Overstreet, Bill, Cartographer, BLM, oral communication, April 1980.

Pequegnat, Willis E., Bela, M.J., Bouma, Arnold H., Bryant, William R., Fredericks, Allen D., 1972, Photographic study of deep sea environments of the Gulf of Mexico, in Rezak, Richard, and Henry, Vernon, J., eds., Contributions on the geological and geophysical oceanography of the Gulf of Mexico: Houston, Gulf Publishing Co.

Reggio, Villere C., Recreation Planner, BLM New Orleans OCS office, oral communication, 1980.

Rioux, Robert L., Deputy Division Chief, Offshore Minerals Regulation, USGS, Conservation Division, Memorandum to Conservation Manager, Gulf of Mexico Region, January 25, 1980.

Rodgers, Bert, 1979, IPP briefing package: Washington, D.C., BLM Division of Offshore Resources, IPP Program.

Schluntz, Ken, Reservoir Engineer, USGS Conservation Division, oral communication, March 12, 1980.

Sheldon, Richard P., 1978, Estimates of undiscovered petroleum resources--a perspective: reprinted from USGS Annual Report, Fiscal Year 1975, Washington, D.C., U.S. Government Printing Office.

Sieverding, Harold P., Assistant Manager, BLM New Orleans OCS office, oral communication, 1980.

Sorensen, R.H., Snodgrass, L.W., Rebman, J.H., Murchison, R.R., Jones, C.R., and Martin, R.G., 1975, Preliminary bathymetric map of Gulf of Mexico region: U.S. Geological Survey Open-File Report 75-140, scale 1:2,500,000.

Strahler, Arthur N., and Strahler, Alan, 1973, Environmental geoscience: interaction between natural systems and man: Santa Barbara, Calif., Hamilton Publishing Co.

U.S. Department of the Interior, 1980, Five-year OCS leasing schedule approved: Washington, D.C., news release, June 18, 5 p.

U.S. Department of the Interior, Bureau of Land Management, 1979a, Draft environmental impact statement for the proposed 1980 OCS oil and gas lease sales A-66 and 66.

------ 1979b, Brief outer continental shelf statistical information package: New Orleans, La., New Orleans OCS Office.

U.S. Department of the Interior, Geological Survey, Conservation Division, June 1979, Outer Continental Shelf statistics: OCS no. 10.

------ October 1979, Annual field name master list revision.

------ June 1980, Outer Continental Shelf statistics: OCS no. 11.

U.S. Department of the Interior, Geological Survey, Conservation Division, Gulf of Mexico OCS Region, Monthly Reports.

U.S. Department of the Interior, Geological Survey, Geologic Division, October 1980, Undiscovered recoverable OCS oil and gas resources, Washington, D.C., unpublished information.

U.S. Department of the Interior, Office of the Secretary, 1979, Letter to the President of the Senate, Honorable Walter F. Mondale, and four enclosures: Washington, D.C., December 18.

Verinder, Sydney, Environmental Specialist, BLM OCS Office, oral communication, 1980.

Wales, Robert W., Gladden, James W., Jr., and Roberts, William M., 1976, Social, economic, and environmental requirements and impacts associated with the development of oil and gas resources in the Outer Continental Shelf of the Gulf of Mexico: University of Southern Mississippi, Department of Geography and Area Development, Miss., prepared for the Mississippi Marine Resources Council.

Williams, Howard R., and Meyers, Charles, J., 1976, Oil and gas terms: annotated manual of legal, engineering tax words and phrases (4th ed.): New York, Matthew Bender and Co.

Appendix A. The Geologic Setting

PETROLEUM GEOLOGY

There is general agreement that petroleum is derived from accumulations of organic matter within the upper portion of the earth's crust transformed by the action of heat, pressure, and time into various mixtures of crude oil and natural gas. The environment in which the conversion occurs and the time required are not precisely known. Optimal conditions must prevail for the generation, migration, entrapment, and preservation of hydrocarbons, and the time involved is believed to be on the order of millions of years.

The occurrence of hydrocarbon accumulation depends on many factors: (1) an adequate thickness of sedimentary rocks; (2) the presence of source beds (rocks containing large amounts of organic matter); (3) a suitable environment for maturation of the organic matter into oil and/or gas; (4) the presence of porous and permeable reservoir rocks; (5) hydrodynamic conditions permitting the migration of hydrocarbons and their ultimate entrapment in reservoir rocks; (6) a regional thermal history favorable for the generation and preservation of hydrocarbons; (7) formation of adequate geologic traps for accumulation of the hydrocarbons; and (8) suitable timing of petroleum generation and migration to ensure the entrapment and preservation of the hydrocarbons (Miller and others, 1975, p. 17).

In areas where the geologic formations suggest the presence of hydrocarbons, geologists look for structural or stratigraphic traps where oil and gas can accumulate. Structural traps are formed by salt and other dome-like intrusions, by anticlinal uplift and folding, and by faulting. Stratigraphic traps result from differences in the porosity or permeability within the rocks. Reefs and pinchouts of porous rock are two examples of potential stratigraphic traps. Frequently, entrapment results from a combination of structural and stratigraphic factors.

Hydrocarbons trapped within the pore spaces of a rock such as a sandstone float on the water that is also found in the reservoir. An impervious layer of rock must be present to seal the trap from above. Reservoirs typically vary from 3 to 305 m (10 to 1,000 ft) in thickness.

Petroleum is not a homogeneous compound; it is a complex mixture of hydrocarbons and oxygen, nitrogen, and sulfur derivatives of hydrocarbons or asphaltic components. Hydrogen and carbon are the essential elements, accounting for 10 to 15 percent and 80 to 89 percent of crude oil by weight, respectively. Oil occurs mixed with natural gas, condensate, and salt water within pore spaces of sedimentary rock.

As oil accumulates in a trap or reservoir, gravity separates it from any free gas and from any unattached water. A gas cap forms if the amount of gas is greater than the volume of gas that is soluble in the reservoir's liquids. A water column is always found in the Gulf of Mexico OCS reservoirs because the formations contain an excess of salt water over the amounts clinging to the individual rock grains.

The temperature and pressure of the hydrocarbons are reduced as they flow to the surface, causing some of the physical properties of the oil and gas to change. The properties of the fluids remaining in the reservoir may also be changed as the pressure is reduced.

GEOLOGY OF THE GULF OF MEXICO OCS

The Gulf of Mexico OCS consists of two principal geologic provinces. To the west of the De Soto Canyon, the Continental Margin is composed of a thick accumulation of land-derived clastic sediments that accumulated during Tertiary and Quaternary time in the subsiding Gulf Coast basin (fig. 2, p. 6). Southeast of the canyon the margin consists of a massive accumulation of carbonate sediments deposited in a slowly subsiding platform environment. All hydrocarbon production to date on the OCS has come from strata in the Gulf Coast basin off Texas and Louisiana.

The Gulf Coast basin is composed of an extremely thick sequence of regressive and transgressive clastic sediments of Cenozoic age that accumulated on a Mesozoic foundation of platform carbonate and deep-marine ooze deposits. Crustal subsidence in this region initially resulted from extension and rifting in Mesozoic time. Continued subsidence of the northern Gulf of Mexico was in response mainly to crustal loading by Cenozoic sediment accumulation. Sediment accumulation generally exceeded crustal subsidence during the Cenozoic, thus causing the face of the margin to prograde more than 400 km (248 mi) into the Gulf Coast basin. The thickest sediment accumulations lie beneath the inner shelf, generally parallel to the present coastline. Strata dip and thicken basinward (seaward) and are modified by faults, diapirs and flexures (paleo-shelf-edges where stratigraphic dips and thicknesses increase abruptly). Most syndepositional faults of regional extent (Gulf Coast growth faults) are associated with shelf-edge flexures; each flexure is generally located seaward of the preceding older one, indicating a progressive basinward migration of the Continental Margin during the Cenozoic. Superimposed on the basinward progradation of the margin is a progressive migration of the centers of Cenozoic sediment accumulation in response to a shift of sediment supply from the ancestral Rio Grande-Nueces River system in south Texas to Mississippi River distributaries in Louisiana. Thickest accumulations of lower Tertiary strata are located along the present coastline from northeastern Mexico to western Louisiana, Miocene strata across southern Louisiana and the adjacent Continental Shelf, Pliocene deposits beneath the central shelf, and Pleistocene sediments along the present shelf-edge from off eastern Texas to the Mississippi River Delta.

The eastern Gulf of Mexico Continental Margin, affected by lesser rates of crustal subsidence and terrigenous clastic influx, is characterized in Cenozoic time by the continuation of constructional carbonate accumulation that prevailed throughout the Gulf-Caribbean region during the Mesozoic. Mesozoic and Cenozoic strata generally consist of cyclic accumulations of limestone, dolomite, and anhydrite deposited in a slowly subsiding shelf environment. Strata dip and thicken basinward. Lower Cretaceous strata outcrop along the face of the Florida Escarpment, which forms the western edge of the platform. Overlying Cretaceous and younger strata thin drastically to a pinchout on the Continental Slope above the escarpment. Major structural features present in the eastern Gulf include salt diapirs and uplifts in the northwesternmost area of the shelf and slope near the De Soto Canyon, and minor structural warpings and faults distributed at random throughout the province.

The potential for major petroleum accumulation is closely related to the depositional environment and structural history of the basin in which hydrocarbons were generated, migrated, and were ultimately trapped. Basins must contain an appropriate combination of source rock, such as marine shale, and reservoir rock, such as sandstone. Basins must also have adequate trapping mechanisms established or forming at the time when migration of hydrocarbons occurs. The necessary conditions existed and provided an optimal environment for the successful formation, accumulation, and entrapment of oil and gas on the Outer Continental Shelf and the upper Continental Slope of the Gulf Coast basin.

Organic material deposited with fine-grained silts and clays is preserved in the outer shelf-upper slope environment. Organic material, if deposited in shallow, more turbulent water, usually oxidizes. Multiple transgressions and regressions of the seas across the region of the present outer shelf during the late Cenozoic created a condition of interfingering between the inner- and middle-shelf sands and the organic-rich marine shales. Deposition of material in the outer shelf and deepwater environments provided a very favorable ratio of sandstone to shale. This very favorable ratio diminishes both seaward and landward of the outer shelf-upper slope environment. Seaward environments contain progressively less sand that could act as reservoirs, and landward environments contain progressively less organic material. As the northern Gulf margin prograded, the outer shelf-upper slope depositional regime advanced seaward, forming a series of progressively younger bands of sediments parallel to the present shoreline.

Hydrocarbons occurring in structural traps in the Gulf Coast Basin are associated with salt diapirism or growth faulting; those trapped stratigraphically are associated with inner- and middle-shelf zones of the sandstone shale depositional environment. Oil is found primarily landward of major flexures, at subsea depths less than 3,030 m (10,000 ft), on salt domes, in the inner- and middle-shelf depositional environment, and in shallow continental depositional environments. Greatest oil production is from the Miocene and Pliocene trends on the eastern and central Louisiana OCS. Gas more commonly occurs seaward of flexures, at subsea depths greater than 3,030 m (10,000 ft) in traps related to growth faulting, in outer-shelf sandstone depositional environments in association with outer-shelf shales. Gas production comes primarily from the Miocene trend in the western Louisiana and eastern Texas OCS, the Pliocene trend off central Louisiana, and the Pleistocene trend along the outer shelf off western Louisiana and eastern Texas.

Significant factors that make the northern Gulf of Mexico Continental Margin one of the world's richest offshore petroleum provinces include the following:

- the accumulation of thick interfingering sequences of transgressive and regressive porous sands and impervious shales during Quaternary and Tertiary times due to local and regional fluctuations of sea level, sediment supplies, and crustal subsidence;
- the generally rapid burial of thick sections of fine-grained sediment rich in organic matter;
- the presence of a regional geothermal environment favorable for optimal thermal maturation of hydrocarbons;
- an optimal scheme of timing relative to the generation and migration of hydrocarbons and structural growth for entrapment; and
- the presence of a thick, extensive layer of middle to upper Jurassic salt that has pierced, uplifted, and faulted overlying strata of Mesozoic and Cenozoic age to produce a wide variety of structural traps and to influence the development of numerous stratigraphic traps.

Hydrocarbon generation, migration, and accumulation in the eastern Gulf carbonate environment has been generally more complicated than in the clastic sedimentary provinces off Texas and Louisiana. Although Mesozoic strata in the eastern Gulf are rich in organic matter, slow rates of burial, insufficient geothermal regimes, and infrequency of large structures for entrapment have been inhibiting factors to hydrocarbon generation and accumulation. Additionally, because most hydrocarbon accumulations probably occur in subtle stratigraphic traps in this region, detection by even the most sophisticated geophysical exploration techniques is inhibited.

PHYSIOGRAPHIC PROVINCES

The Texas-Louisiana Shelf and Slope

The Texas-Louisiana Shelf has a width of about 100 km (62 mi) off the mouth of the Rio Grande in Texas, but it widens to more than

200 km (124 mi) at the Texas-Louisiana boundary. To the east it narrows to only a few kilometers because the present Mississippi River Delta has prograded across almost the entire shelf southeast of New Orleans.

The greatest influence on the structural character of the northwestern Gulf is the presence of vast thicknesses of salt near the base of the sedimentary section. This has led to a high degree of tectonic mobility. Deep salt has intruded the Tertiary and Quaternary formations to form domal and anticlinal features throughout the shelf. The salt has flowed both vertically and laterally to displace and rearrange the thick clastic deposits by processes of faulting, slumping, and local thickening and thinning of beds. Along the outer edge of the shelf a series of banks marks the crests of shallow salt domes.

The Texas-Louisiana Slope has nearly the same dimensions as those of the adjacent shelf. its greatest width is about 240 km (150 mi) at a point south of Marsh Island, Louisiana; it narrows to 110 km (68 mi) seaward of the Rio Grande. The Sigsbee Escarpment, formed by salt uplift along the base of the Continental Slope, marks the apparent southern limit of salt structures in the northern Gulf of Mexico margin.

Widespread salt deposits have provided the necessary structural mobility to foster favorable conditions for hydrocarbon entrapment. Over 400 salt domes are known from drilling activity, while hundreds more are indicated from geophysical surveys. These salt structures occur throughout the margin from nearshore to the Sigsbee Escarpment in the region off Texas and Louisiana. On the Continental Shelf the structures are usually buried, but on the Continental Slope they appear as surface features, where they form an irregular or hummocky surface (Antoine, 1972, p. 27). Figure 23 shows the offshore distribution of buried salt in the Gulf of Mexico.

Small knolls, which most investigators consider to be the surface expressions of salt domes, are common on the upper Texas-Louisiana Slope. The western portion of the upper slope contains few surface irregularities. Knolls are most pronounced near the northern edge of the slope. The largest knolls have a relief of 365 to 460 m (1,200 to 1,500 ft), with diameters of 5 to 13 km (3 to 8 mi). Their average relief decreases southward. Large featureless areas on the slope have probably resulted because evaporites have flowed laterally, to form the Sigsbee Escarpment, rather than vertically, to form knolls (Bergantino, 1971, p. 746-47).

The Mississippi-Alabama Shelf

The Mississippi-Alabama Shelf occupies the northeastern Gulf east of the Mississippi River Delta to the vicinity of the De Soto Canyon. Tertiary strata represent the eastern margin of the Northern Gulf terrigenous clastic embankment. These strata onlap and cover Mesozoic carbonate bank deposits that outcrop to the south along the Florida Escarpment.

The shelf and slope of the northeastern Gulf comprise a transition in the physiography of the region at the juncture of western clastic deposition and the eastern carbonate embankment (Antoine, 1972, p.6). The northwest flank of the De Soto Canyon forms the face of the gulfward-prograding clastic embankment, and it is composed of a great thickness of mostly unconsolidated sediments of Tertiary and Quaternary age. From a structural point of view, the northeastern Gulf is composed of a carbonate bank which has been subsiding since Cretaceous time. The Mesozoic salt structures characteristic of the northern Gulf margin thin toward the east in this region. There is a subtle change from the predominantly land-derived clastic Tertiary section near the northern edge of the West Florida Shelf to a carbonate sequence south of Cape San Blas.

The De Soto Canyon marks the approximate eastern limit of the shallow piercement domes that are prevalent to the west. Within the canyon itself, there are numerous salt diapirs. Figure 24 indicates the location of piercement structures in the De Soto Canyon area.

Although salt domes are the dominant structural features in the vicinity of the De Soto Canyon, the general decrease in their

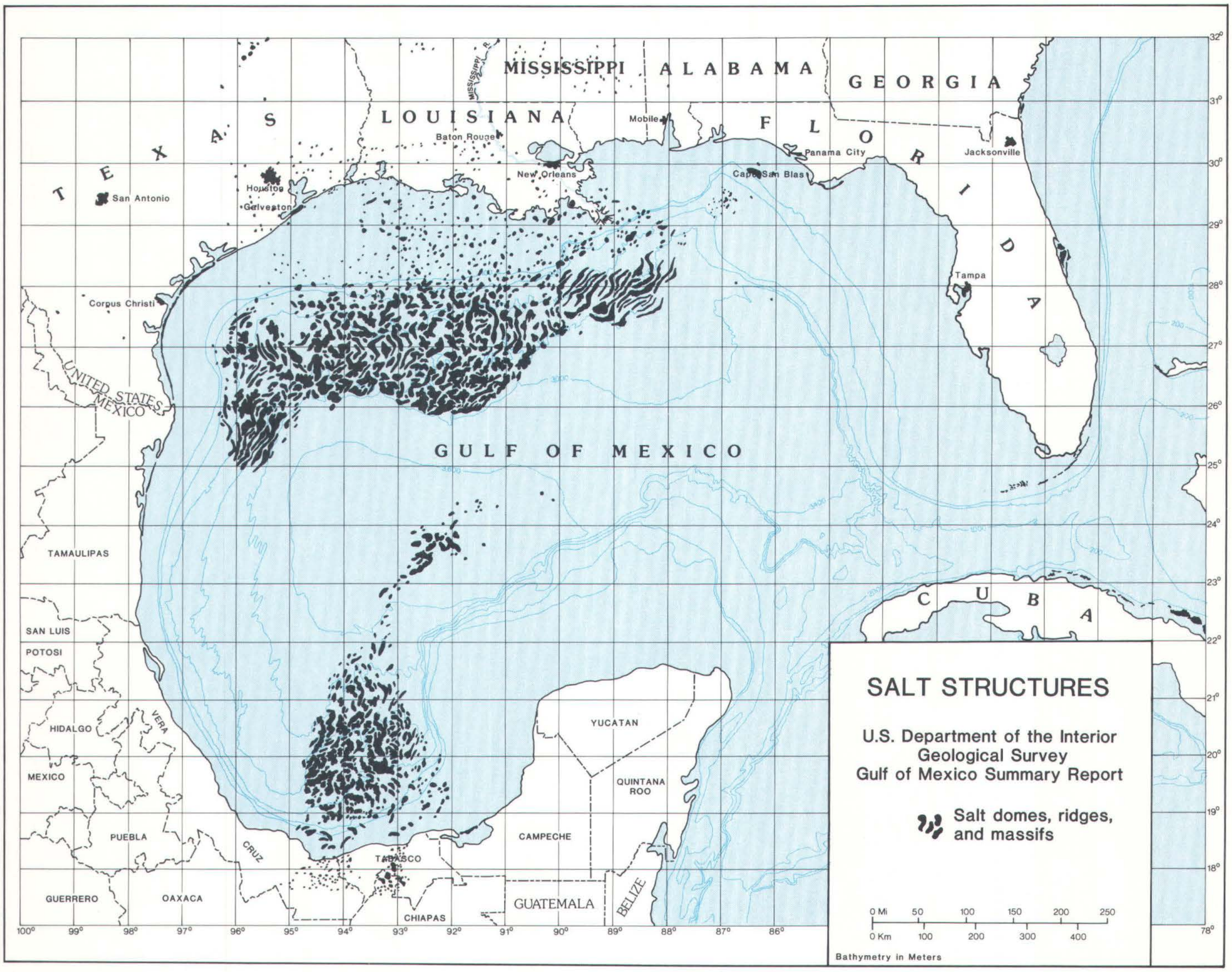


FIGURE 23.--Offshore distribution of buried salt deposits in the Gulf of Mexico (modified from Martin, 1980, by Rogers, Golden & Halpern).

occurrence to the east suggests that the eastern limits of the middle to upper Jurassic salt deposits are located beneath the carbonate platform of the Northeastern Gulf.

Landward of the Canyon, toward Panama City, Florida, is the Destin Dome (fig. 23), where intensive oil and gas exploration has occurred in recent years. The Destin Dome is a 32x80-km (20x50-mi) structure that arches Jurassic and Cretaceous strata. The long axis of the anticline is oriented east-west and is located about 64 km (40 mi) from the coast. With nearly 915 m (3,000 ft) of closure, the Dome rivals in size some of the great petroleum-producing structures of the Middle East, but drilling results to date have not been encouraging.

The Mississippi Fan

The Mississippi Fan has been created by the accumulation of sediment deposited seaward of the Mississippi River Delta. The fan itself contains topographic irregularities due to diapirism, differential compaction of sediments, slumps, and downslope creep. Diapirs

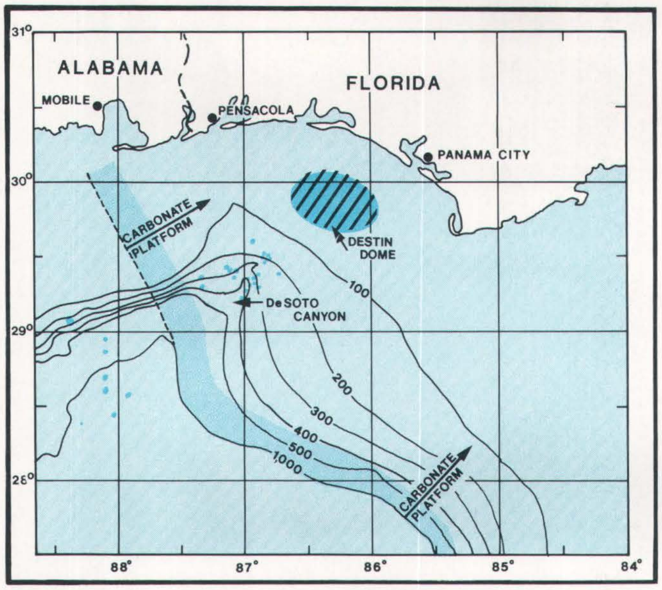


FIGURE 24.—Distribution of piercement structures in DeSoto Canyon area and Destin Dome (modified from Antoine, 1972, p. 6, by Rogers, Golden & Halpern).

underlie the thicker sediments closest to the delta. The diapirs, although less common in this area, are continuous with those to the west and are possibly favorable sites for hydrocarbon entrapment.

The West Florida Shelf and Slope

The West Florida Shelf and Slope forms the Continental Margin in the eastern Gulf of Mexico, extending from the De Soto Canyon to the Straits of Florida. Geologically, it is the submerged extension of peninsular Florida. The shelf is the surface of a carbonate platform composed of a thick accumulation of shallow-to-deep-sea carbonate and evaporite deposits of Mesozoic and Cenozoic age.

Although salt structures are associated with hydrocarbon production in the Gulf Coast basin, they are not the dominant exploration objectives in the West Florida carbonate platform. Salt anticlines and domes were exploration targets only in the Destin Dome OCS area. Porosity traps formed by buried bioherms, reef complexes, and other bodies of detrital carbonates are the principal hopes for hydrocarbon production in this area. The lack of magnificent structures such as salt domes seemingly diminishes the likelihood of numerous significant discoveries in this region, but productive reef structures elsewhere in the world suggest a relative equality in terms of potential entrapment of significant hydrocarbon resources.

Appendix B. Estimating Oil and Gas Resources

Before exploratory drilling, both the Federal Government and industry undertake analyses of geological basins to determine their oil and gas potential. The Government uses different methods of analysis depending on the purpose of the estimate and the availability and level of detail of the data. The data base for resource estimation is regularly updated with new geologic and geophysical information, and as more data for a given area are gathered, processed, analyzed, and interpreted, the resource estimate is updated to reflect them.

Prior to a lease sale, the process of estimating the amount of oil and gas in a potential reservoir or a lease sale area involves a high degree of uncertainty. The USGS makes these pre-sale estimates for a variety of purposes. Regionwide estimates are used to aid in the preparation of proposed lease sale schedules. More specific resource estimates are made for the lands tentatively selected to be offered for lease. Later estimates are made on a tract-by-tract basis to establish a dollar value for each tract offered. However, it should be reemphasized that estimates of undiscovered resources are extremely uncertain. The existence of resources cannot be confirmed until an area has been thoroughly explored by drilling.

REGIONWIDE RESOURCE ESTIMATES

In the early stages of exploration, when only gross interpretations of regional geology are possible, it is necessary to use expert judgment based on these minimal amounts of data to make resource estimates. As more data become available, the resource estimates and the methods used are refined. When data are abundant and detailed, the choice of method used depends on the availability of the estimator's time and the purpose of the resource estimate. The quality of the estimate, however, depends on the quality of the geologic and geophysical data and other studies on which it is based.

A number of estimation techniques are available for making regionwide or basin resource estimates. For an area that has not been extensively drilled, the most useful techniques are the **volumetric-yield methods.** In these methods, the volume of potentially hydrocarbon-producing rocks is calculated, and a yield of oil and/or gas based on known yields from geologically analogous basins or regions is derived. Other methods, more useful in regions that have experienced extensive exploratory drilling, are **performance** or **behavioristic extrapolation methods.** In these, various indexes of past performance such as discovery rates, cumulative production, and productive capacity are fitted by various mathematical derivations into logistic or growth curves that are then projected into the future. In addition to these, more sophisticated methods involving geological, engineering, and statistical models may be used (Miller and others, 1975, p. 18).

TRACT-SPECIFIC RESOURCE ESTIMATES

Each tract selected for leasing for exploration and development of oil and gas resources must be evaluated prior to the lease sale. After the lease sale, resource estimates are periodically updated.

Resource evaluations of tracts consist of three parts: a geophysical and geological evaluation of potentially recoverable resources in possible hydrocarbon-bearing structures and stratigraphic traps underlying the tract; an assessment of the risk that, for whatever reason, hydrocarbons are not present in the quantities foreseen by the geologic evaluation; and an engineering and economic evaluation of the monetary value of those resources, taking the assessed risk into account.

Data used for resource estimation are seismic records, well data, other geologic data, and production histories from wells and fields in or near the sale area. In the case of frontier areas, the drilling and production histories of geologically analogous petroleum-producing basins and fields are substituted. Once an area has been leased and exploratory drilling has commenced, the results of drilling may allow updating of resource estimates. Changes in exploratory drilling and production techniques and costs may also necessitate re-evaluation.

The tract-specific resource estimates are derived by using a **Monte Carlo discounted cash flow computer program.** In this program, geologic, engineering, and economic information is used to calculate recoverable resources and an economic value of the resources for each tract. Some parameters, such as tract size, are entered as fixed values. Others, such as pay thickness and production rates, are given a range of values. Each variable is assigned a range of possible values. The program then randomly selects values for each variable and combines them with the fixed parameters to calculate a resource estimate and economic value. The process is run many times, and eventually a mean resource estimate and economic value are determined.

A **risk factor** is used to discount the mean resource estimate. The risk factor represents the probability that a particular trap will not contain hydrocarbons in the quantities predicted by the geologic evaluation. The risk factor is a subjective appraisal by a geologist, geophysicist, and engineer based on the data available to them. It is determined through a knowledge of an area's (or an analogous area's) exploration history, together with an assessment of how strongly the data indicate the presence of a trap, of source rocks, and of other elements that make a good prospect.

RESERVE ESTIMATES

Reserves are the portion of identified resources that can be economically extracted (Miller and others, 1975, p.8). The techniques available for estimating reserves are similar to those used in making resource estimates, only in the case of reserves, they are more refined and are based on more information.

In **volumetric estimation** of reserves, the bulk volume of a reservoir can be calculated from interpretation of seismic data and information gained by drilling. Porosity of the rock and the relative amounts of oil, gas, and water in its pore spaces can be interpreted from borehole logs and analyses of cores.

For reservoirs in which some production has taken place, the **decline-curve method** may also be used. In this method, future production is estimated by extrapolating plots of actual production rates and fluid percentages into the future. By adding past production to predicted future production, an estimate of original reserves can be obtained (Bird, 1980, p. 3-4).

Appendix C. Bidding Systems for OCS Oil and Gas Leasing

On the OCS, competitive bidding is mandatory under section 8 of the 1953 Outer Continental Shelf Lands Act. This is currently accomplished by a system of auction wherein Outer Continental Shelf tracts are offered for lease by competitive sealed bidding, and leases are issued to the highest responsible qualified bidder upon determination by the Secretary of the Interior that the high bid reflects the fair market value of a tract. When a lease is awarded, the lessee acquires the right to extract and sell hydrocarbons from the tract for which the lease is held.

The system of auction most frequently used in the Federal offshore leasing program has been the **bonus bid system,** so called because a cash bonus is paid at the outset for the lease. The typical lease is awarded on the basis of the highest cash bonus bid, 20 percent of which must accompany the sealed bid. After production begins, the lessee also pays a fixed royalty on the value of production, usually 16-2/3 percent, but not less than 12-1/2 percent.

The use of alternative bidding systems is specifically authorized by section 205 of the Outer Continental Shelf Lands Act Amendments of 1978. Current U.S. Department of Energy (DOE) regulations (10 CFR 375 and 376, March 13, 1980, and 10 CFR 379, May 30, 1980) have established four bidding systems for OCS oil and gas lease sales: (1) the **cash bonus bid** with a **fixed royalty,** (2) the **royalty bid** with a **fixed cash bonus,** (3) the **cash bonus bid** with a **sliding-scale royalty,** and (4) the **fixed net profit share.** Each of these systems also includes a fixed lease rental component.

The system or systems to be employed in each OCS lease sale are chosen from among the four bidding alternatives established by the DOE regulations. Bids are made in conformance with the bidding system that is applicable to a particular tract, as specified in the notice of lease sale. In the **cash bonus bid system,** bidders competing for a Federal tract submit bids in the form of cash bonuses. Bidders governed by the **royalty bid system** submit bids in the form of fixed royalty rates, paid in cash, based on a percentage of the value of production. In the **cash bonus bid with a sliding scale royalty system,** as in the cash bonus bid with a fixed royalty system, bidders compete for tracts by submitting bids in the form of cash bonuses. The royalty rates in the sliding scale royalty system are based upon a sliding, or changing, percentage of the value of production, with the percentage increasing or decreasing during the course of production. The **fixed net profit share** uses cash bonus as the bid variable and, in lieu of royalty based on a value of production, requires net profit share payments at a rate that is constant for the duration of the lease.

Although the petroleum industry prefers the exclusive use of the traditional cash bonus bid with a fixed royalty system for the sale of tracts on the OCS, future leasing activity is certain to employ alternative bidding systems. Sale A62 (September 1980) used the fixed net profit share bidding system for the first time in an OCS lease sale. The Outer Continental Shelf Lands Act Amendments of 1978 reflect the commitment of Congress to pursue the use of alternative bidding systems. The legislation explicitly authorizes the use of 10 alternative systems and allows for the development of others.

The purpose of exploring the use of alternative bidding systems is to foster competition in the leasing process. The goal has been to strike a proper balance between securing a fair market return to the Federal Government for the lease of its lands, increasing competition for the use of its resources, and providing the incentive of a fair profit to the oil companies, which must risk their investment capital. The system of bidding employed in a particular lease sale or for particular tracts in a lease sale is likely to have as its objective the achievement of this goal (Federal Register, February 12, 1980, p. 9536-9540).

Appendix D. Oil and Gas Production Forecast

The long-term forecast for oil and gas production from the Gulf of Mexico OCS is for protracted decline, with ultimate depletion occurring sometime after the year 2000. Although the course of decline is not likely to be reversed or significantly changed, production levels are not independent of technology, economics, and market forces. For example, a technological advancement in enhanced recovery could, through reassessment, cause an increase in the estimates of remaining recoverable reserves from existing fields. A breakthrough in knowledge about platform design that would enable smaller, cheaper units to be employed might bring small, currently uneconomical fields and reservoirs into production. These are only a few examples of how production levels might change. The technological and economic possibilities for extracting marginal resources are extensive, and each incremental achievement provides the opportunity to alter the slope of the production curve, thus delaying the time when depletion occurs.

The Resource Appraisal Group (RAG) of the USGS in Denver, Colorado, assesses undiscovered recoverable oil and gas resources. This is accomplished through various geological analog techniques and computer-assisted analysis. In order to make estimates, the RAG analyzes a multiplicity of variables that bear a relationship to the volume of resources and reserves. Estimates are reviewed periodically to reflect changes in resource assessment. The estimating process must consider such parameters as producton rates, field discovery rates, market conditions and the changing price of oil and gas, and expectations of technological improvement.

Using resource and reserve estimates, as well as other data, the USGS formulates the curves that project future rates of oil and gas production. Figures 25 and 26 show recent production forecasts to the year 2000 for oil and gas production from the Gulf of Mexico OCS.

Many factors govern the shape of the production curve. Professional engineers, geologists, and economists, among others, are constantly engaged in an effort to alter the curve by extending the productive life of the resource base. This is done by increasing the supply of oil and gas through new field discoveries, enhanced recovery from existing fields, or technological gain. Another means of extending the productive life of a field is by decreasing demand, which can be achieved largely through conservation measures. Efforts to achieve a balance between supply and demand involve increasing the rate of production until a peak is reached and then sustaining those levels of production and reducing the rate of decline.

The USGS engages in research to fulfill its responsibility of continuing to improve resource estimates. The RAG and the Office of Resource Analysis are developing the computerized analytical techniques required for two types of modeling: occurrence and search. **Occurrence modeling** involves the development of field size distributions in the petroleum provinces of the country and the application of mature geologic basin analogs to each of the frontier basins and the partially explored basins. **Search modeling** involves generating field size distributions, by basin, of petroleum discoverable and recoverable under alternative economic and technological conditions as well as present conditions.

A third technique, **production modeling,** is used to generate long-range supply curves. Since occurrence and search modeling form

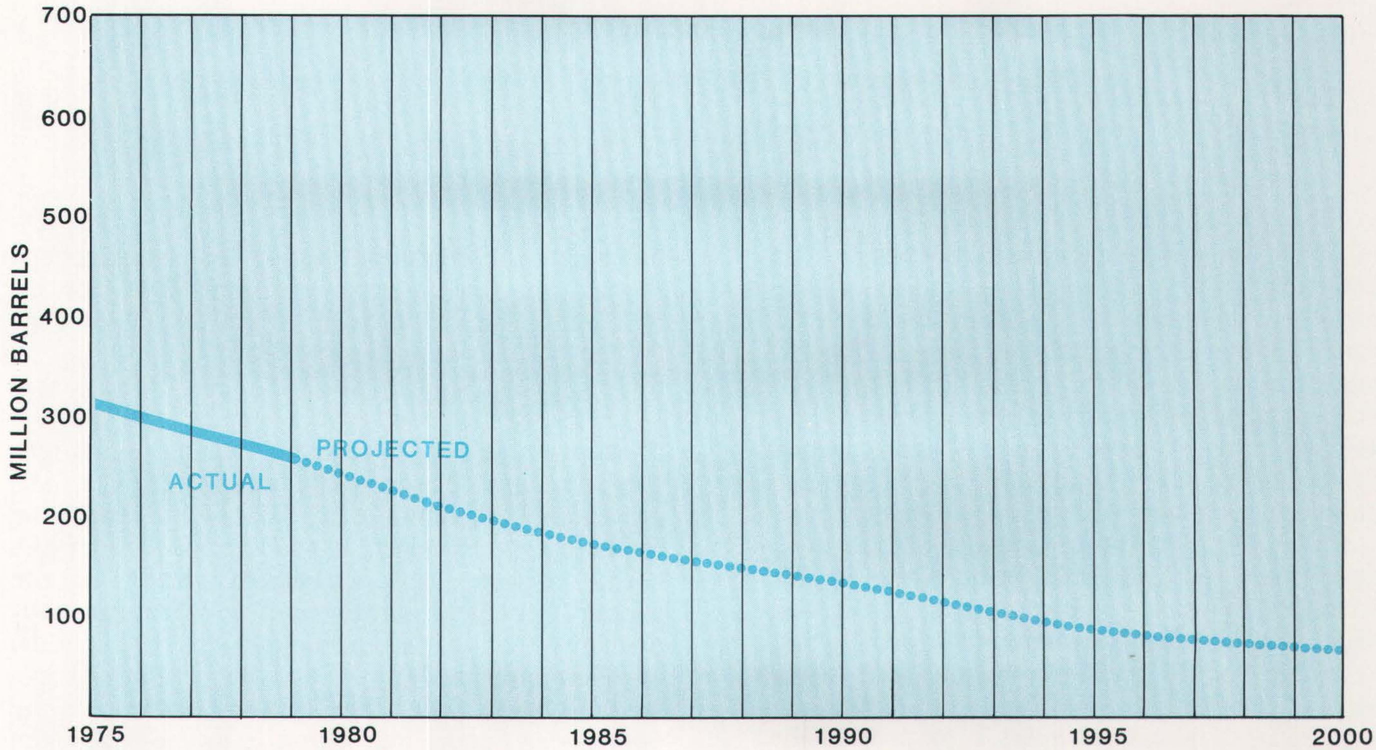


FIGURE 25.—Oil production curve to the year 2000 (drafted from USGS, June 1979, by Rogers, Golden & Halpern).

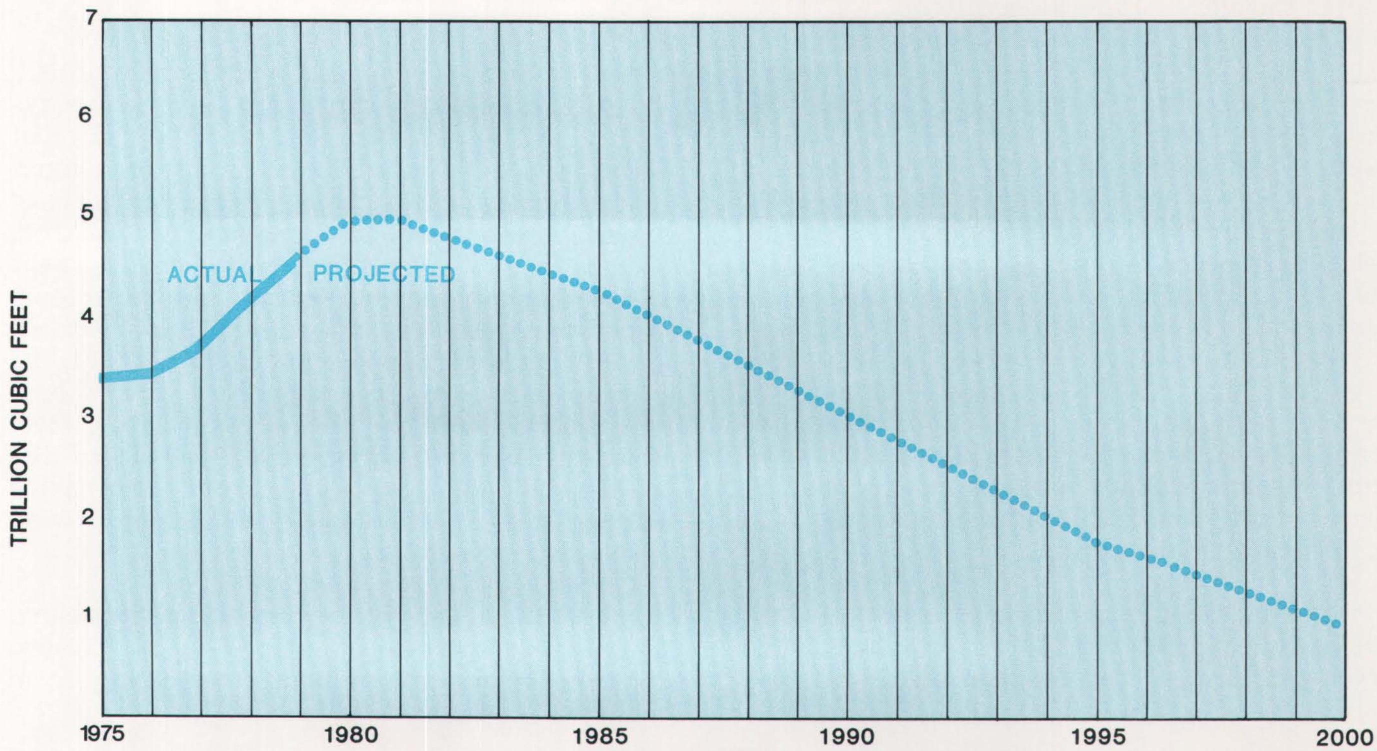


FIGURE 26.—Gas production curve to the year 2000 (drafted from USGS, June 1979, by Rogers, Golden & Halpern).

the input to production modeling, the USGS is conducting ongoing research to integrate occurrence and search modeling with production modeling, thus producing a dynamic model of the petroleum supply system (Sheldon, 1978, p. 20-22).

One application of this research is being developed as a sophisticated model of the dynamics of the complete petroleum supply system--the Clark-Drew Model. The model uses the three basic techniques described above to arrive at (1) the field size distribution of total resources, (2) the field size distribution of deposits discoverable at different levels of cost and technology, and (3) the production curves over time, using various socioeconomic assumptions (Sheldon, 1978, p. 8).

The Clark-Drew Model suggests that there are over 1,000 fields and/or reservoirs remaining to be discovered in the Gulf of Mexico. About half of them are likely to be very small, perhaps containing fewer than 1 million barrels of recoverable oil each. With the appropriate market conditions and technology, these currently marginal fields and other probably existing fields could be brought into production. Hydrocarbons produced from them would not result in any significant increase in the rate of oil and gas production, but it could extend the date of ultimate depletion.

Appendix E. Intergovernmental Planning Program

The Intergovernmental Planning Program for OCS Oil and Gas Leasing, Transportation and Related Facilities was implemented to provide a formal coordination and planning mechanism for three major OCS program elements administered by the Bureau of Land Management. These elements are Pre-Lease Sale Activities, the Environmental Studies Program, and Transportation Planning. The Transportation Planning element was discussed in chapter 3. The other two elements will be addressed in this appendix.

In each of the six OCS leasing regions, a Regional Technical Working Group (RTWG) Committee is established and, if a commercial discovery of oil or gas is made, a State Technical Working Group subcommittee is formed. One of three types of committees comprising the National OCS Advisory Board, the RTWG Committees are the nucleus of the IPP.

The National OCS Advisory Board provides advice to the Secretary of the Interior and to other offices in the Department of the Interior in the performance of discretionary functions of the OCS Lands Act, as amended (43 USC 1331 et. seq.), including all aspects of leasing, exploration, development, and production of the resources of the Outer Continental Shelf. The organization of the National OCS Advisory Board and its reporting structure are presented in figure 27.

Through the accumulation and evaluation of information, the Regional Technical Working Group provides guidance to the BLM and information to other bureaus within the Department of the Interior. Each RTWG is composed of representatives of the participating states, the BLM, the Fish and Wildlife Service, the Coast Guard, the Geological Survey, the Environmental Protection Agency, the National Oceanographic and Atmospheric Administration, the petroleum industry, and other special and private interests within a leasing region. Every RTWG is co-chaired by a State representative, who is elected by all the State representatives of the group, and by the BLM representative. The State representative's term of service is determined by all the State representatives of the group.

The Gulf of Mexico Regional Technical Working Group first met on October 30, 1979, in New Orleans. This meeting was called principally to formally establish the RTWG and also to familiarize the members with the organizational structures of the Department of the Interior, the Bureau of Land Management, its Outer Continental Shelf Office, the BLM oil and gas leasing program, and the organization and functions of the National OCS Advisory Board and its component committees. Copies of the FY 1981 Regional Studies Plan (Preliminary Draft) were disseminated to the RTWG members for their comments.

The second meeting of the Gulf of Mexico RTWG took place at the national meeting held in Norfolk, Virginia, on December 5, 6, and 7, 1979. The National OCS Advisory Board met in full session at this meeting. The Gulf session requested comments from RTWG members on the Draft Studies Plan for FY 1981, outlined the oil and gas leasing schedule for the Gulf, and discussed the responsibilities of the IPP members in the leasing process. At this meeting, the group elected Tom Joiner of Alabama as the State Co-Chairman.

On April 1 and 2 and April 15 and 16, 1980, the group met again in New Orleans to discuss tract selection for proposed Gulf of Mexico Lease Sales 67 and 69. The Call for

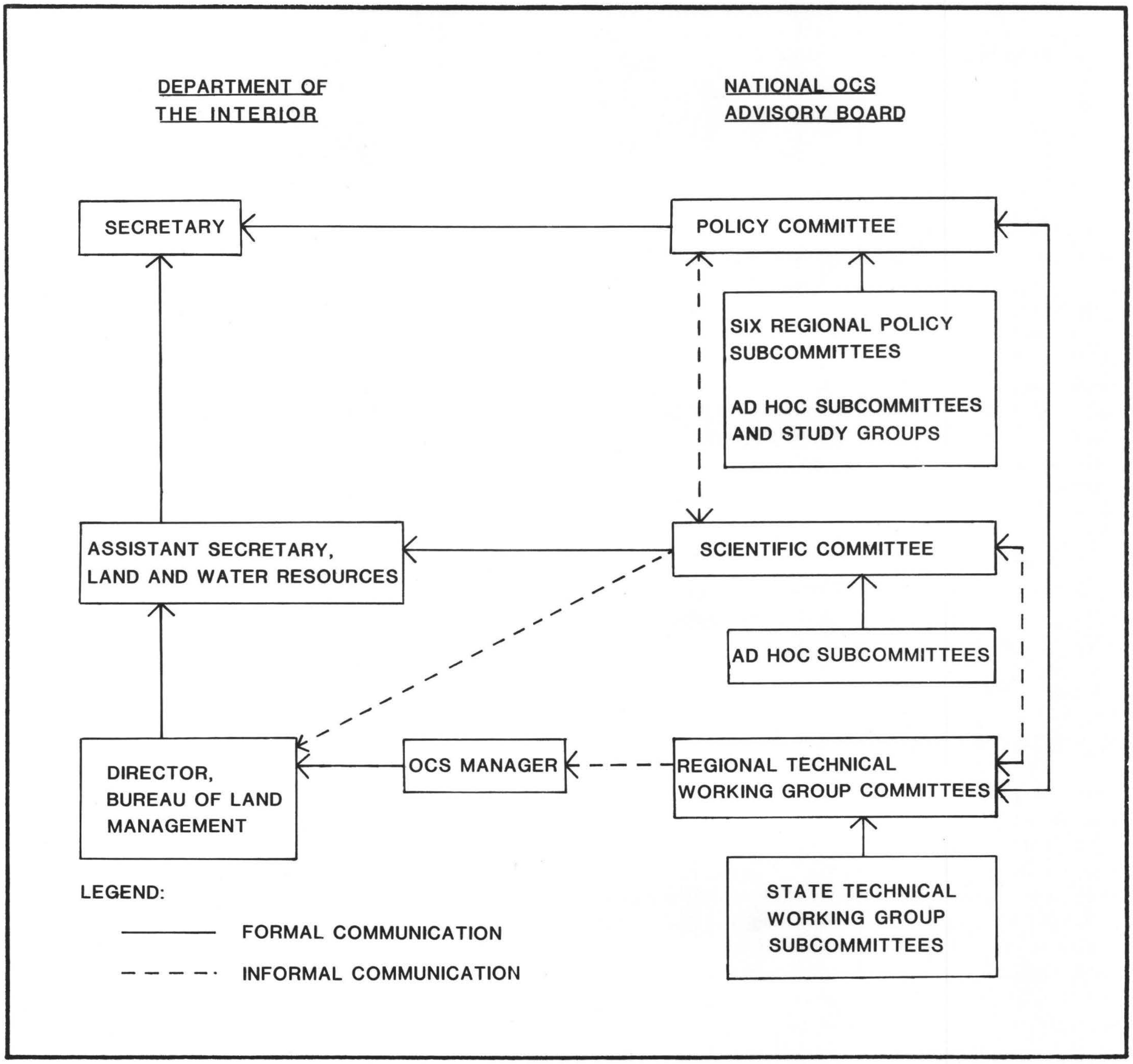


FIGURE 27.—Organization of National OCS Advisory Board and reporting structure (modified from Aronson, 1979, by Rogers, Golden & Halpern).

Nominations was discussed, and environmental briefings regarding the tracts were presented. RTWG members also participated in the Stipulations Meeting for proposed Lease Sales A66 and 66. A detailed history and procedures of the Regional Studies Plan were given, and the responsibilities of the RTWG members in the Regional Studies Plan were discussed. Also addressed were details of the Regional Transportation Management Planning process.

The group met again on May 14-16, 1980. This meeting, held in New Orleans, was convened for the purpose of review and critique of the Preliminary Draft FY 1981 Regional Studies Plan. As a result of these sessions, the

New Orleans OCS Office will now prepare the Draft Regional Studies Plan, which should be available sometime in July of 1980.

THE OCS LEASING PROCESS

The leasing of OCS lands sets in motion a process that can affect interests at local, State, regional, and national levels. Many decisions are made in this process that determine the manner in which development will take place. The IPP has been divided into four phases, discussed below and shown in figure 28.

Phase I

The objective of Phase I of the IPP is to assist in coordinating all activities leading up to a lease sale decision. This phase begins prior to the Call for Nominations and terminates with the Sale Decision. Most activities in Phase I concern the exchange and assessment of information. Inventory and analysis of information related to the later preparation of Regional Studies Plans and Transportation Management Plans are also a part of this Phase.

Phase I can last about 2 years. It is completed by the time of a Sale Decision.

Phase II

Phase II of the IPP is formally implemented with the publication of the Proposed Notice of Sale in the Federal Register. During this phase, each RTWG recommends site-specific and generic studies that should be included in a Regional Studies Plan to be drawn up during Phase III. Other Federal, State, or local agencies may also identify and fund OCS-related studies independent of the IPP leasing process.

Phase II should be completed by the time a commercial discovery of oil and/or gas is made.

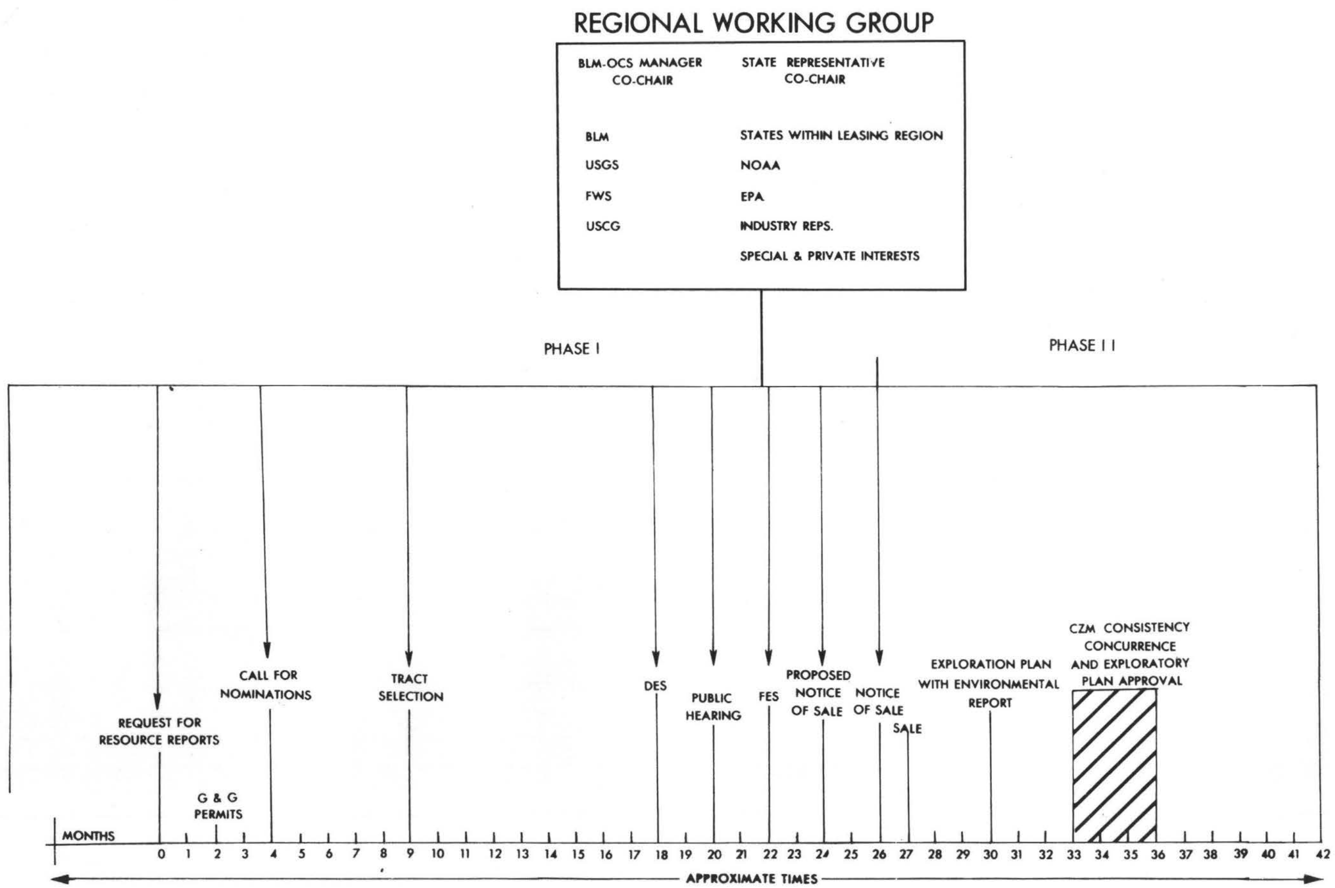
Phase III

Phase III of the IPP begins with the announcement of a discovery of hydrocarbons in marketable quantities in the Region. At this time, a State Technical Working Group is formed to refine potential transportation corridors. The State Technical Working Group includes all Federal and private members of the RTWG as well as the State representatives of the affected States.

Phase IV

During Phase IV of the IPP, a Regional Technical Management Plan is developed. Phase IV begins as soon as transportation studies are complete and should either precede or coincide with the first Development Plan.

The IPP is a long-range planning effort. While its actual timing varies from region to region, the estimated minimum time for completion of the four phases of the process is approximately 4-1/2 to 5 years. However, the process could conceivably take as long as 9 years.


REGIONAL WORKING GROUP
BLM-OCS MANAGER CO-CHAIR
STATE REPRESENTATIVE CO-CHAIR
BLM
USGS
FWS
USCG
STATES WITHIN LEASING REGION
NOAA
EPA
INDUSTRY REPS.
SPECIAL & PRIVATE INTERESTS
PHASE I
PHASE II
REQUEST FOR RESOURCE REPORTS
G & G PERMITS
CALL FOR NOMINATIONS
TRACT SELECTION
DES
PUBLIC HEARING
FES
PROPOSED NOTICE OF SALE
NOTICE OF SALE
SALE
EXPLORATION PLAN WITH ENVIRONMENTAL REPORT
CZM CONSISTENCY CONCURRENCE AND EXPLORATORY PLAN APPROVAL
MONTHS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
APPROXIMATE TIMES

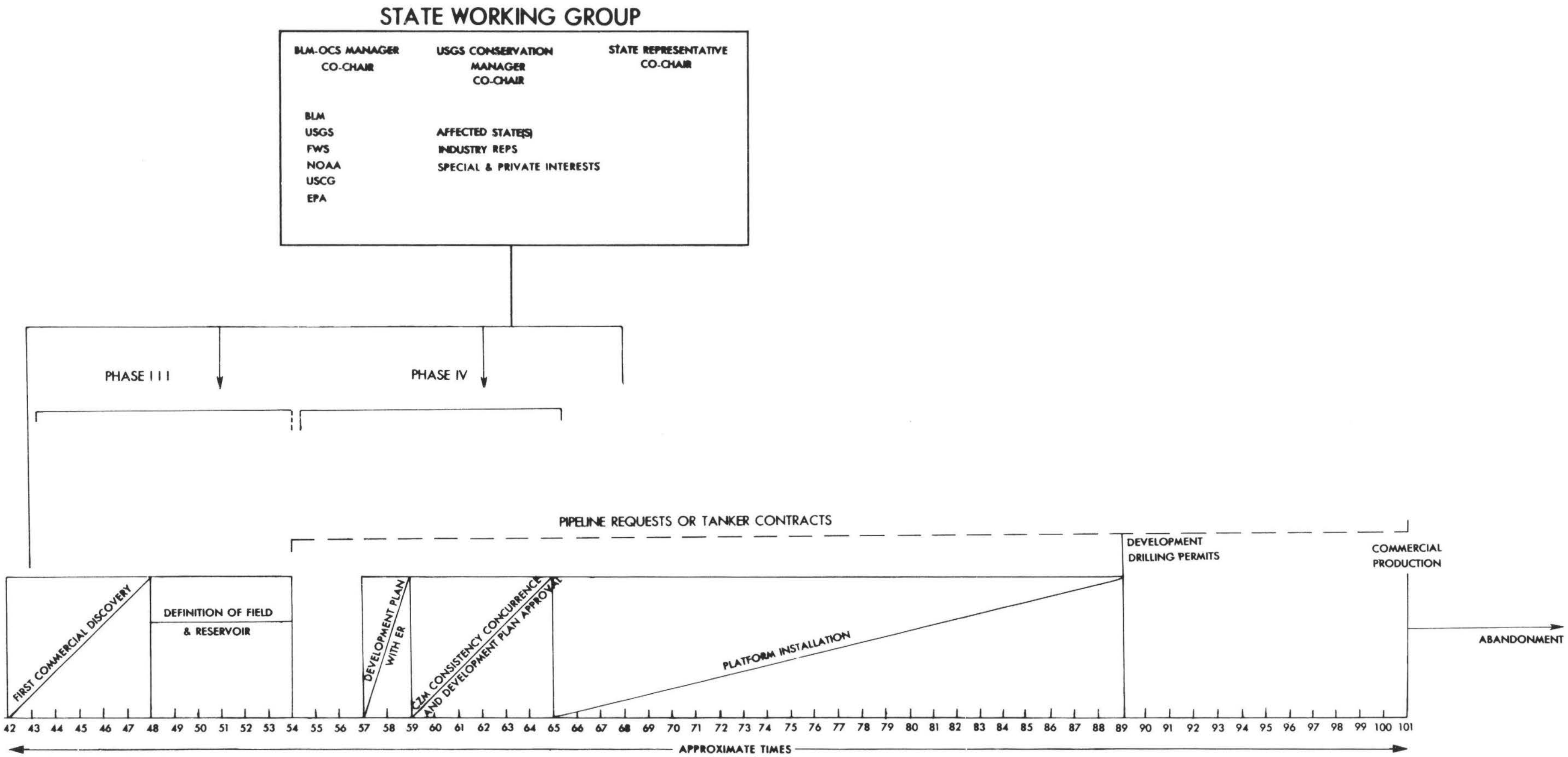


FIGURE 28.—Relationship of the OCS oil and gas leasing process to the IPP (Rodgers, 1979).

Appendix F. General OCS-Related Studies

Over the years, a great number of studies have been done regarding the Gulf of Mexico's geology, biology, mineral resources, and the like. It is not within the scope of this Summary Report to present a complete bibliography of Gulf of Mexico studies. The following section focuses on recent and current studies primarily dealing with the onshore and nearshore impacts of OCS oil and gas operations in the Gulf.

FEDERAL STUDIES

U.S. Department of the Interior

Fish and Wildlife Service

Gosselink, J.G., Cordes, C.L., and Parsons, J.W., 1979, An ecological characterization study of the Chenier Plain coastal ecosystem of Louisiana and Texas: Slidell, La., 3 vols. Available from Information Transfer Specialist, National Coastal Ecosystem Team, U.S. Fish and Wildlife Service, 1010 Gause Blvd., Slidell, LA 70458.

An ecological characterization is a description of the important components and processes that make up an ecosystem, stressing functional relationships and synthesizing existing information from the biological, physical, and social sciences. The Chenier Plain ecosystem was selected for study because of its biological diversity, valuable fish and wildlife resources, and proximity to actual and proposed oil and gas production activities. This study comprises three volumes, including a narrative text, a data source appendix, and an atlas.

Shanks, Larry R., 1978, Coastal systems and management options relation to OCS development: Washington, D.C., 20 p. Limited number of copies available from the National Technical Information Service (NTIS), 2585 Port Royal Road, Springfield, VA 22161 (PB-297 635/5ST).

Methods are suggested to reduce the impacts of construction activities in the coastal zone. Oil and gas developments in the Outer Continental Shelf can affect offshore and onshore habitats of fish and wildlife. Five basic activities of concern in this report are dredging, pipeline construction, site preparation, construction in wetlands, and shoreline alterations. Management options are outlined for each type of activity.

Other Federal Studies

Pierce, H.F., 1969, Impact of petroleum development in the Gulf of Mexico: Washington, D.C., Information Circular No. 8408, 62 p. Available from the U.S. Bureau of Mines, Washington, DC.

Shoeph, Richard W., 1976, Offshore exploration and development: Washington, D.C. 1976. Limited number of copies available from the U.S. Department of the Interior Natural Resources Library, 18 and C Sts., Washington, DC 20009.

This is a guide to bibliographical sources covering the broad subject area of offshore exploration and development. Included under this broad heading are the scientific exploration of the offshore areas and their makeup, engineering aspects associated with drilling for oil and

gas and construction of the accompanying marine structures, mining operations in the seabed and on the OCS, and management and leasing functions, as well as ecological studies to determine the effects of such development activity.

Perrault, Armand L., and Cartier, Allen, 1977, A study on the economic impact of two planned offshore oil ports in the Gulf of Mexico: Washington, D.C., four vols. Available from the NTIS, 2585 Port Royal Road, Springfield, VA 22161, v. I (PB-278 862/8ST), v. II (PB-278 863/8ST), v. III (PB-278 864/8ST), v. IV (PB-278 863/8ST).

Volume 1: This report analyzes the circumstances that induced two groups of oil companies to plan the building of two deepwater ports, LOOP and Seadock, in the Gulf of Mexico. It explores the possibility for enhancing the economic growth and development of the production and economics of large-scale transportation associated with the use of supertankers.

Volume 2: This volume deals with problems generated by progress in planning superports. Among these problems are the increased demand for public services as well as environmental degradation. The study inventories the obvious economic impacts in relation to offshore activity and presents the acquired data as a resource tool for planners.

Volume 3 and Volume 4: These two volumes complement research on economic impacts discussed in the previous volumes.

STATE STUDIES

Louisiana

Gagliano, S.M., Culley, P., Earle, D.W., Latiolais, C., Light, P., Roques, N., Rowland, A., Shlemon, R., and van Beek, J.L., 1972, Proposed multiuse management plan for the Louisiana coastal zone: Baton Rouge, La., 30 p. Available from Center for Wetland Resources, Louisiana State University, Advisory Committee on Coastal Marine Resources, Baton Rouge, LA 70804.

------ Culley, P., Earle, D.W., Light, P., Rowland, A., Schlemon, R., and van Beek, J.L., 1973, Environmental atlas and multiuse management plan for South-Central Louisiana: Baton Rouge, La., Report No. 18, v. 2, 22 p. Available from Center for Wetland Resources, Louisiana State University, Baton Rouge, LA 70804.

Mumphrey, A.J., Thayer Jr., R.E., Wagner, F.W., Brooks, J.S., Fromherz, C.B., Miller, J.C., Wildgen, J.K., Young, A.H., Carlucci, G.D., Landry, M.J., and Whalen, T.F., 1977, OCS development in coastal Louisiana: a socio-economic impact assessment: New Orleans, La. Prepared for the Louisiana Department of Transportation and Development. Limited number of copies available from Coastal Management Section, Department of Transportation and Development, State of Louisiana, Baton Rouge, LA 70804.

Texas

Milton, J., 1974, Environmental analyses for development planning in Chambers County, Texas: a proposed incremental change system for Texas: Houston, Tex.

This report includes service of regulations, legislation, and opinion concerning natural resources, principally land and water use. The review is used as a basis for designing a viable incremental change system developed with a scenario for developing the change program. The report includes specific proposals pursuant to the enactment of the system of growth.

Research and Planning Consultants, Inc., 1977, Offshore oil: its impact on Texas communities: Austin, Tex., four vols., 900 p. Limited number of copies available from Texas General Land Office, 1700 North Congress, Austin, TX 78701.

This study: (1) presents a tested methodology for estimating the impacts of future OCS development on Texas cities and counties; (2) provides OCS development scenarios to acquaint public and private decisionmakers with the potential onshore impacts of OCS activities on their areas of responsibility; and (3) provides an analysis of current Federal programs to compensate State and local governments for the fiscal deficits OCS development will cause in Texas.

Manners, Ian R., Dietrich, Wyatt, and Keen, Teri, 1980, Energy development and coastal zone management in Texas: Austin, Tex.

This article discusses OCS development and the Texas coastal zone; policy issues involved; and the impact of offshore development. Also covered is the Coastal Energy Impact Program and its implementation in Texas.

(For a more detailed version of this article, see Ian R. Manners, Implementation of the Coastal Energy Impact Program in Texas, Research Report Series. Austin: Bureau of Business Research, forthcoming.)

Other OCS Related State Studies

Adams, R.D., Banas, P.J., Baumann, R.H., Blackmon, J.H., and McIntire, W.G., 1978, Shoreline erosion in coastal Louisiana: inventory and assessment; 139 p. Submitted to Paul R. Templet, Coastal Zone Management Coordinator, Louisiana Department of Transportation and Development, Baton Rouge.

Adkins, G., and Bowman, P., 1976, A study of the fauna of dredged cannals of coastal Louisiana: La. Wildlife and Fisheries Commission Technical Bulletin 27, 77 p.

Atherton, R. W., Finnemore, E.J., Gillam, M.L., DeGance, A.E., Grimsrud, G.P., and Schainker, R.G., 1976, The analysis of subsidence associated with geothermal development: Palo Alto, Calif., Systems Control, Inc. 3 vols.

Baker, J. M., 1971, Seasonal effects of oil pollution on salt marsh vegetation: Oikos 22:106-110.

*------ 1973, The effects of a single oil spillage, **in** Cowell, E.B., ed., Ecological effects of oil pollution on littoral communities: The Institute of Petroleum, Great Britain, p. 16-20.*

*------ 1973, Successive spillages, **in** Cowell, E.B., ed., Ecological effects of oil pollution on littoral communities: The Institute of Petroleum, Great Britain, p. 21-32.*

*------ 1973, Refinery effluent, **in** Cowell, E.B., ed., Ecological effects of oil pollution on littoral communities: The Institute of Petroleum, Great Britain, p. 33-43.*

*------ 1973, Growth stimulation following oil pollution. **in** Cowell, E.B., ed., Ecological effects of oil pollution on littoral communities: The Institute of Petroleum, Great Britain, p. 72-77.*

*------ 1973, The effects of oils on plant physiology, **in** Cowell, E.B., ed., Ecological effects of oil pollution on littoral communities: The Institute of Petroleum, Great Britain, p. 88-98.*

Battelle Corporation, 1975, A study of selected coastal zone ecosystems in the Gulf of Mexico in relation to gas pipelining activities: Columbus, Ohio, Battelle Columbus Laboratories.

Beek, J.H. van, Smith, W.G., Smith, J.W., Light, P., 1977, Plans and concepts for multiuse management of the Atchafalaya Basin: Las Vegas, prepared by Ecological Research Services, for the U.S. Environmental Protection Agency, Report EPA-600/3-77-062, 204 p.

*Bryan, C., and Sabins, D., 1979, Management implications in water quality and fish standing stock information in the Atchafalaya Basin, Louisiana, **in** Day, J.W., Jr., ed., Proceedings 3rd Coastal Marsh and Estuary Management Symposium,* *1978: Baton Rouge, Louisiana State University, p. 293-316.*

Bybee, R, 1973, Compatability of petroleum exploration with marsh and estuarine ecosystems in Louisiana, **in** *Chabreck, R., ed., Proceedings 2nd Coastal Marsh and Estuary Management Symposium, 1972: Baton Rouge, Louisiana State University.*

Chapman, C., 1968, Channelization and spoiling in Gulf coast and south Alantic estuaries, **in** *Newsom, J.D.,ed., Proceedings Marsh and Estuary Management Symposium, July 19-20, 1967: Baton Rouge, Louisiana State University, p. 93-106.*

Coastal Environments, Inc., 1974, Environmental planning base, Terrebonne parish, Louisiana: an environmental baseline assessment and management approach. Submitted to the Terrebonne Parish Police Jury, Houma, Louisiana.

Conner, W.H., Stone, J.H., Bahr, L.M., Jr., Bennett, V.R., Day, J.W., Jr., and Turner, R.E., 1976, Oil and gas use characterization impacts and guidelines: Baton Rouge, Center for Wetland Resources, Louisiana State University.

Cowell, E. B., 1969, The effects of oil pollution on salt marsh communities in Pembrokeshire and Cornwall: Journal of Applied Ecology 6:133-142.

------ and Baker, J.M., 1969, Recovery of a salt marsh in Pembrokeshire, South-west Wales, from pollution by crude oil: Biological Conservation 1(4):291-295.

Craig, N., Turner, R.E., and Day, J.W., Jr., 1979, Land loss in coastal Louisiana, **in** *Day, J.W., Jr., et al., eds., Proceedings 3rd Coastal Marsh and Estuary Management Symposium, 1978: Baton Rouge, Louisiana State University.*

Crow, S.A., Jr., Bavor, H.J., Jr., and Hood, M.A., 1976, Toxicity of crude oil on marsh plants: Baton Rouge, Center for Wetland Resources, Louisiana State University.

Crow, S.A., Jr., Meyers, S.P., Ahearn, D.G., 1974, Microbiological aspects of petroleum degradation in the aquatic environment: Baton Rouge, Center for Wetland Resources, Louisiana State University.

Davis, D. W., 1973, Louisiana canals and their influence on wetland development (Ph. D. dissertation): Baton Rouge, Louisiana State University, 199 p.

Day, J. W., Jr., Craig, N.J., and Turner, R.E., 1976, Cumulative impact studies in Louisiana coastal zone: land loss: Baton Rouge, Louisiana State Planning Office.

----- Smith, W., Wagner, P., and Stowe, W., 1973, Community structure and carbon budget of a salt marsh and shallow bay estuarine system in Louisiana: Baton Rouge Center for Wetland Resources, Louisiana State University, Publication LSU-SG-72-04, 79 p.

Earle, D. W., 1975, Land subsidence and maintenance costs to homeowners in east New Orleans, Louisiana (Ph.D. dissertation): Baton Rouge, Louisiana State University.

Emmer, R. E., 1978, Environmental considerations and the geothermal energy resources in Louisiana, **in** *Proceedings American Nuclear Society Conference on Environmental Aspects of Non-Conventional Energy Resources-II, September 26-29, 1978: Denver, Colo., p. 40-1 to 40-27.*

Farber, S., and Johnson, D.B., 1976, The impact of oil and gas exploration: development and production on the Outer Continental Shelf of Louisiana: background and methodology; Baton Rouge, Louisiana State Planning Office.

Fucik, K. W., 1974, The effect of petroleum operations on the phytoplankton ecology of the Louisiana coastal waters (M.S. thesis): College Station, Tex., Texas A & M University.

Gagliano, S.M., 1971, Petroleum-industry dredging in the Louisiana coastal zone:

Part C of hydrologic and geologic studies of the coastal Louisiana: New Orleans, U.S. Army Corps of Engineers, 27 p.

------ *1973, Canals, dredging, and land reclamation in the Louisiana coastal zone: Baton Rouge, Center for Wetland Resources, Louisiana State University, Hydrological and Geological Studies of Coastal Louisiana report 14, 98 p.*

Gagliano, S.M., and van Beek, J.L., 1970, Geologic and geomorphic aspects of deltaic processes, Mississippi Delta system: Baton Rouge, Center for Wetland Resources, Coastal Resources Unit, Louisi ana State University, Hydrologic and Geologic Studies of Coastal Louisiana Report 1.

Gebhart, J.L., 1973, The effects of varying levels of crude oil on plans of the Louisiana coastal marshes (M.S. thesis): Baton Rouge, Louisiana State University, 77 p.

------ *and Chabreck, R.H., 1975, Effects of various levels of crude oil on Olney bullrush (Scirpus olneyi) and marshhay cordgrass (Spartina patens). Proceedings of the Annual Conference of the Southest Association, Game Fish Commission, v. 29, p. 567-577.*

Gosselink, J.G.,Miller, R., Hood, M., and Bahr, L.M., Jr., 1976, Louisiana offshore oil port: environmental baseline study: New Orleans, LOOP, Inc., 4 vols. (Also included in LOOP report sections: Benthos, Microbiota, Nekton, Insects, Reptiles and amphibians, Mammals, Avifauna studies).

Gulf Universities Research Consortium, 1974, The offshore ecology investigation: Houston, Tex.

Gunter, G., 1967, Some relationships of estuaries to fisheries of the Gulf of Mexico, **in** *G. Lauff, ed., Estuaries: American Association for the Advancement of Science, publication 83, p. 621-638.*

Happ, G., Bennett, V.R., Burke, W.H., Conner, W.H., Craig, J.N., Hinchee, R.E., Stone, J.H., and Bahr, L.M., Jr., 1976, Impacts of Outer Continental Shelf activities: Lafourche Parish: Baton Rouge Center for Wetland Resources, Louisiana State University.

Lytle, J. S., 1975, Fate and effects of crude oil on an estuarine pond, **in** *American Petroleum Institute, 1975 Conference on Prevention and Control of Oil Pollution: San Francisco, Calif., p. 595-600.*

McGinnis, J. T., R. A. Ewing, C. A. Willingham, S. E. Rogers, D. H. Douglas, and D. L. Morrison, 1973, Final report on evironmental aspects of gas pipeline operations in the Louisiana coastal marshes: 95 p. Submitted to the Battelle Memorial Institute, Offshore Pipeline Committee, Columbus, Ohio, 95 p.

McHugh, G. F., 1976, Development of a hydrodynamic numerical model for use in a shallow well-mixed estuary: Baton Rouge, Center for Wetland Resources, Louisiana State University, Sea Grant Publication LSU-T-76-008.

Mackin, J. G., 1961, Canal dredging and silting in Louisiana bays: Institute of Marine Sciences, University of Texas 7, 314 p.

------ *and A. Sparks, 1961, A study of the effect on oysters of crude oil loss from a wild well: Institute of Marine Sciences, University of Texas 7, p. 230-261.*

Mayuga, M. N., and D. R. Allen, n.d., Subsidence in the Wilmington Oil Field, Long Beach, California: AIHS-UNESCO Land Subsidence Publication 88(I), p. 6.

Milan, C.S., 1978, Accumulation of petroleum hydrocarbons in a salt marsh ecosystem exposed to steady state oil input. (M.S. Thesis): Baton Rouge, Louisiana State University, 155 p.

------ *and Whelan, T., III, 1979, Accumulation of petroleum hydrocarbons in a salt marsh ecosystem exposed to steady state oil input,* **in** *Day, J.W., et al., eds., Proceedings 3rd Coastal Marsh and Estuary Management Symposium: Baton Rouge, La., p. 65-87.*

Monte, J., 1978, The impact of petroleum on Louisiana's coastal landscape: a plant biogeographical analysis and resource assessment of spoil bank habitats in the Bayou Lafourche Delta: (Ph.D. dissertation): Baton Rouge, Louisiana State University, 334 p.

Morgan, J., 1973, Impact of subsidence and erosion on Louisiana coastal marshes and estuaries, in Chabreck, R., ed., Proceedings 2nd Coastal Marsh and Estuary Management Symposium, 1972: Baton Rouge, Louisiana State University, p. 217-233.

Mumphrey, A. J., Jr., Durabb, E.J., and McDronklin, W.B., 1975, Louisiana metropolitan welands: a planning perspective: University of New Orleans, Urban Institute.

----- and Carlucci, G.D., Jr., 1978, Environmental planning for offshore oil and gas: vol. 5: Regional status report: part 3: Gulf coast region: U.S. Fish and Wildlife Service, Biological Services Program, FWSOBS-77/16.3, The Conservation Foundation, Washington, D.C., 158 p.

----- Wagner, F.W., Carlucci, G.D., Jr., Landry, M.J., and Miller, J.C., Jr., 1976, The impacts of Outer Continental Shelf development on Lafourche parish: Urban Studies Institute, University of New Orleans, prepared for Louisiana State Planning Office, Baton Rouge, La.

Pequegnat, W., 1975, Some effects of platforms on the biology of the continental shelf: Proceedings Estuarine Resources Federation, Outer Continental Shelf Conference and Workshop, Texas A & M University, College of Geosciences Contribution 64, p. 455-466.

Portnoy, J. W., 1977, Nesting colonies of seabirds and wading birds--coastal Louisiana, Mississippi, and Alabama: U.S. Fish and Wildlife Service, Biological Services Program, FWS/OBS-77/07, 126 p.

St. Amant, L. S., 1971, Impacts of oil on the Gulf coast: Transcript 36th North American Wildlife Confederation Natural Resources Conference, 36, p. 206-219.

------ 1972, The petroleum industry as it affects marine and estuarine ecology: Journal of Petroleum Technology 4, p. 385-392.

Stone, J.H., 1975, The environmental impact of a superport in the Gulf of Mexico: Baton Rouge, Center for Wetland Resources, Louisiana State University.

----- 1976, An evaluation of Louisiana superport studies and implications for coastal zone management: Baton Rouge, Center for Wetland Resources, Louisiana State University.

----- Byrne, P., and Fannaly, M., 1976, Selected environmental impacts of proposed Louisiana Oil Fort Project, chapter 5: New Orleans, LOOP, Inc.

----- Byrne, P., and Fannaly, M., 1976, Unavoidable and adverse environmental effects of LOOP Project, chapter 6: New Orleans, LOOP, Inc.

----- Byrne, P., and Fannaly, M., 1976, Irreversible and irretrievable commitments of resources by LOOP Project, chapter 7: New Orleans, LOOP, Inc.

----- Byrne, P., and Fannaly, M., 1976, Relationships between local short-term uses of man's environment (LOOP Project) and the maintenance and enhancement of long-term production and uses (National Functions) of coastal Louisiana, chapter 8: New Orleans, LOOP, Inc.

----- Byrne, P., and Fannaly, M., 1976, Measures to enhance the environment or to avoid or mitigate adverse environmental effects of the LOOP Project, chapter 9: New Orleans, LOOP, Inc.

----- *1977, The petroleum industry in coastal Louisiana: environmental impacts and lessons: Baton Rouge, Center for Wetland Resources, Louisiana State University.*

----- *1977, Environmental impacts of crude oil storage in the Clovelly Oil Storage for Louisiana offshore oil port--LOOP: Baton Rouge, Center for Wetland Resources, Louisiana State University.*

Glossary

Definitions presented in the Glossary describe terms as they have been used in this Summary Report. The Glossary is intended for general reference only: for detailed descriptions of technical or specialized terms, the reader should seek a reference in the field of particular interest. Abbreviations and acronyms are presented in tabular form on p. ii.

Sources used in compiling this glossary were the Gulf of Mexico Summary Report itself; the Mid-Atlantic, South Atlantic, Pacific, and Gulf of Alaska Summary Reports; the OCSIP Atlantic, Pacific, Gulf of Mexico, and Alaska Indexes; the NERBC-RALI Factbook; Webster's Third New International Dictionary; the American Geological Institute's Dictionary of Geological Terms; Langenkamp's Handbook of Oil Industry Terms and Phrases (2d ed.); the U.S. Department of the Interior, Fish and Wildlife Service's Steam Electric Power Plant Review Manual and Hydroelectric Power Plant Review Manual; and the Encyclopedic Dictionary of Exploration Geophysics.

Acidizing - A technique for increasing the flow of oil from a well. Hydrochloric acid is pumped into the well under high pressure to reopen and enlarge the pores in oil-bearing limestone formations.

Anticline - An upfold or arch of stratified rock in which the beds or layers bend downward in opposite directions from the crest or axis of the fold.

API gravity - Gravity (weight per unit of volume) of crude oil or other liquid hydrocarbon measured by a system recommended by the American Petroleum Institute.

Ballast treatment - Treatment of a tanker's ballast water, which is contaminated by residuals of the original tanker cargo.

Basin - A depression of the earth in which sedimentary materials accumulate or have accumulated, usually characterized by continuous deposition over a long period of time; a broad area of the earth beneath which the strata dip, usually from the sides toward the center.

Block - A geographical area, as portrayed on an official BLM protraction diagram or leasing map, that contains approximately 9 square miles (2,304 hectares or 5,760 acres).

Blowout - An uncontrolled flow of gas, oil, and other fluids from a well to the atmosphere. A well blows out when formation pressure exceeds pressure applied to the well by the column of drilling fluid.

Blowout preventer - A stack or an assembly of heavy-duty valves attached to the top of the casing to control well pressure.

Bonus - Money paid by the lessee for the execution of an oil and gas lease.

Bunker fuel - Heavy residual fuel oil used in ships' boilers and in large heating and generating plants.

Caprock - A disklike plate over all or part of the top of most salt domes in the Gulf Coast States, composed of anhydrite, gypsum, limestone, and occasionally sulfur. Caprock may also be the comparatively impervious stratum immediately overlying an oil- or gas-bearing rock in an anticline.

Casing - Steel pipe used in oil wells to seal off fluids in the rocks from the bore hole and to prevent the walls of the hole from sloughing off or caving.

Centipoise - A unit of viscosity, equal to one hundredth of a poise (one dyne-second per square centimeter).

Clastic - Consisting of fragments of rocks or organic structures that have been moved individually from their places of origin.

Cofferdam - A temporary watertight enclosure from which the water is pumped to expose the bottom of a body of water and permit construction (as of foundations or piers).

Commingling - Bringing together the production from wells, leases, pools, and fields with production of other operators.

Completion - Conversion of a development well or an exploratory well into a producer of oil and/or gas.

Condensate - Liquid hydrocarbons produced with natural gas that are separated from the gas by cooling and various other means. Condensate generally has an API gravity of 50 to 120 degrees and is water-white, straw, or bluish in color.

Continental Margin - A zone separating the emergent continents from the deep sea bottom.

Continental Shelf - A broad, gently sloping, shallow feature extending from the shore to the Continental Slope.

Continental Slope - A relatively steep, narrow feature paralleling the Continental Shelf; the region in which the steepest descent to the ocean bottom occurs.

Contingency plan - A plan for possible offshore emergencies prepared and submitted by the oil or gas operator as part of the Plan of Development and Production.

Delineation well - An exploratory well drilled to define the areal extent of a field. Also referred to as an "expendable well."

Depocenter - An area or site of maximum deposition.

Development - Activities that take place following exploration for, discovery of, and delineation of minerals in commercially attractive quantities, including but not limited to geophysical activity, drilling, platform construction, and operation of all directly related onshore support facilities; and that are for the purpose of ultimately producing the minerals discovered.

Diapir - A piercing fold; an anticlinal fold in which a mobile core, such as salt, has broken through the more brittle overlying rocks.

Differential compaction - The relative change in thickness of mud and sand (or limestone) after burial due to reduction in pore space.

Discovery - The initial find of significant quantities of fluid hydrocarbons on a given field on a given lease.

Dome - A roughly symmetrical upfold, the beds dipping in all directions, more or less equally, from a point; any structural deformation characterized by local uplift approximately circular in outline, for example, the salt domes of Louisiana and Texas.

Drill pipe - Heavy, thick-walled steel pipe used in rotary drilling to turn the drill bit and to provide a conduit for the drilling mud.

Drill ship - A self-propelled, self-contained vessel equipped with a derrick amidships for drilling wells in deep water.

Drilling mud - A special mixture of clay, water, or refined oil, and chemical additives pumped downhole through the drill pipe and drill bit. The mud cools the rapidly rotating bit; lubricates the drill pipe as it turns in the well bore; carries rock cuttings to the surface; serves as a plaster to prevent the wall of the bore hole from crumbling or collapsing; and provides the weight or hydrostatic head to prevent extraneous fluids from entering the well bore and to control downhole pressures that may be encountered.

Drydock - A dock, from which the water can be emptied, that is used for building or repairing ships.

Economically recoverable resource estimate - An assessment of hydrocarbon potential that takes into account (1) physical and technological constraints on production and (2) the influence of costs of exploration and development and market price on industry investment in OCS exploration and production.

Enhanced recovery techniques - Recovery methods for crude oil that include water flooding, steam and gas injection, micellular-surfactant, steam drive, polymer, miscible hydrocarbon, CO_2, and steam soak methods. Enhanced recovery techniques are not restricted to secondary or even tertiary projects: some fields require the application of one of the above methods even for initial recovery of crude oil.

Environmental impact statement - A statement required by the National Environmental Policy Act of 1969 (NEPA) or similar State law in relation to any action significantly affecting the environment.

Exploration - The process of searching for minerals. Exploration activities include (1) geophysical surveys where magnetic, gravity, seismic, or other systems are used to detect or infer the geologic conditions conducive to the accumulation of such minerals and (2) any drilling, except development drilling, whether on or off known geological structures. Exploration also includes the drilling of a well in which a discovery of oil or natural gas in paying quantities is made and the drilling, after such a discovery, of any additional well that is needed to delineate a reservoir and to enable the lessee to determine whether to proceed with development and production.

Fan - An accumulation of sediment transported downward in a relatively high-energy, constricted environment and debouching (discharging) onto a low-energy, unconstricted surface, forming a widespread deposit of low relief.

Fault - A fracture in the earth's crust accompanied by a displacement of one side of the fracture with respect to the other.

Feedstock - Crude oil or other hydrocarbons that are the basic materials for a refining or manufacturing process.

Field - An area within which hydrocarbons have been concentrated and trapped in economically producible quantities in one or more structural or stratigraphically related reservoirs.

Field gathering lines - Pipelines that move oil or gas from the well to a header system or storage tank.

Flexure - A broad domical structure.

Flowlines - Pipelines that move oil from a header system, tank platform, or other facility to a point of final metering, processing, and/or sale.

Fracturing (hydraulic fracturing) - A method of stimulating production from a formation of low permeability by inducing fractures and fissures into the formation through application of very high fluid pressure to the face of the formation, forcing the strata apart.

Gathering lines - Pipelines used to bring oil from production leases by separate lines to a central point, that is, a tank farm or a trunk pipeline.

Geochemical - Of or relating to the science dealing with the chemical composition of and the actual or possible chemical changes in the crust of the earth.

Geologic hazard - A feature or condition that, if unmitigated, may seriously jeopardize offshore oil and gas exploration and development activities. Mitigation may necessitate special engineering procedures or relocation of a well.

Geologic trap - An arrangement of rock strata, involving their structural relations or varied lithology and texture, that favors the accumulation of oil and gas.

Geomorphic - Of or pertaining to surface landforms.

Geomorphology - The science of surface landforms and their interpretation on the basis of geology and climate.

Geophysical - Of or relating to the physics of the earth, especially the measurement and interpretation of geophysical properties of the rocks in an area.

Geophysical survey - The exploration of an area, during which geophysical properties and relationships unique to the area are measured by one or more geophysical methods.

Geosyncline - Large, generally linear trough that subsided deeply throughout a long period of time, causing a thick succession of stratified sediments to accumulate.

Grassroots - Pertaining to a refinery or other installation built from the ground up, as contrasted to a plant merely enlarged or modernized.

Header - A large-diameter pipe into which a number of smaller pipes are perpendicularly welded or screwed; a collection point for oil or gas gathering lines.

Hydrocarbon - Any of a large class of organic compounds containing primarily carbon and hydrogen, comprising paraffins, olefins, members of the acetylene series, alicyclic hydrocarbons, and aromatic hydrocarbons, and occurring in many cases in petroleum, natural gas, coal, and bitumens.

Intrusion - A body of igneous rock resulting from solidification of the intruding magma; the plastic injection of masses of salt or shale into overlying rocks; magma, shale, or salt injected into overlying rocks.

Jack-up rig - A bargelike, floating platform with legs at each corner that can be lowered to the sea bottom to raise the platform above the water.

Landfall - The site at which a marine pipeline comes to shore.

Land use - The function for which people employ an area of land.

Lay barge - A shallow-draft, bargelike vessel used in the construction and laying of underwater pipelines.

Lease - A contract authorizing exploration for and development and production of minerals; the land covered by such a contract.

Lease sale - The public opening of sealed bids made after competitive auction for leases granting companies or individuals the right to explore for and develop certain minerals within a defined period of time.

Lease term - For oil and gas leases, a period of either 5 years or up to and exceeding 10 years (when a longer period is necessary to encourage exploration and development in areas because of unusually deep water or other adverse conditions (see **primary term**)).

Lighter - A barge or small tanker used to move cargo from a large ship to port; also, to transport by lighter.

Massif - A block of the earth's crust bounded by faults or flexures and displaced as a unit without internal change.

Mass movement - Unit movement of a portion of the land surface. Mass movement, or slumping, can occur where unconsolidated sediments are distributed over a steep gradient.

Offshore monobuoy - A buoy system at which a tanker may anchor, discharge, or load petroleum products.

Organic matter - Material derived from living plant or animal organisms.

Orogenic - Characterized by the process of forming mountains, particularly by folding and thrusting of the earth's crust.

Outer Continental Shelf (OCS) - All submerged lands that comprise the Continental Margin adjacent to the U.S. and seaward of State offshore lands. The OCS has been subject to Federal jurisdiction and control since enactment of the Submerged Lands Act (43 USC 1301 and 1302).

Permeability - The ability to transmit fluids.

Permeable - Capable of transmitting fluids.

Petroleum - An oily, flammable bituminous liquid that occurs in many places in the upper strata of the earth, either in seepages or in reservoirs; essentially a complex mixture of hydrocarbons of different types with small amounts of other substances; any of various substances (as natural gas or shale oil) similar in composition to petroleum.

Pinchout - A phenomenon occurring when a stratum becomes thinner and thinner as it is traced in any direction, until it finally disappears and its place is taken by another stratum.

Plan of Development and Production - A plan describing the specific work to be performed, including all development and production activities that the lessee(s) propose(s) to undertake during the time period covered by the plan and all actions to be undertaken up to and including the commencement of sustained production. The plan also includes descriptions of facilities and operations to be used; well locations; current geological and geophysical information; environmental safeguards; safety standards and features; time schedules; and other relevant information. Under 30 CFR 250.34-2, all lease operators are required to formulate and obtain approval of such plans by the Director of the U.S. Geological Survey before development and production activities may commence.

Plan of Exploration - A plan based on all available relevant information about a leased area that identifies, to the maximum extent possible, all the potential hydrocarbon accumulations and wells that the lessee(s) propose(s) to drill to evaluate the accumulations within the entire area of the lease(s) covered by the plan. Under 30 CFR 250.34-1, all lease operators are required to formulate and obtain approval of such plans by the Director of the U.S. Geological Survey before exploration activities may commence.

Platform - A steel or concrete structure from which offshore wells are drilled.

Platform jacket - A supporting structure for an offshore platform consisting of large-diameter pipe welded together with pipe braces to form a four-legged stoollike structure. The jacket is secured to the ocean floor by pilings driven through the legs. The four-legged platform is then fitted into the jacket and secured.

Porosity - The capability to contain fluids within void spaces in rock.

Porous - Containing void spaces that may be occupied by fluids.

Primary term - The initial period of oil and gas leases, normally 5 years (see **lease term**).

Production - Activities that take place after the successful completion of any means for the removal of minerals, including such removal, field operations, transfer of minerals to shore, operation monitoring, maintenance, and work overdrilling.

Production curve - A curve plotted to show the relation between quantities produced during definite consecutive time intervals.

Province - An area throughout which geological conditions have been similar or that is characterized by particular structural, petrographic, or physiographic features.

Recoverable resource estimate - An assessment of oil and gas resources that takes into account the fact that physical and technological constraints dictate that only a portion of resources or reserves can be brought to the surface.

Refining - Fractional distillation, usually followed by other processing (for example, cracking).

Relief - The elevations or inequalities of a land surface.

Reserve estimate - An assessment of the portion of the identified oil or gas resource that can be economically extracted.

Reserves - Portion of the identified oil or gas resource that can be economically extracted.

Reservoir - An accumulation of hydrocarbons that is separated from any other such accumulation.

Resource - Concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust.

Rig - Equipment used for drilling an oil or gas well.

Right-of-way - A legal right of passage over another person's land; the strip of land for which permission has been granted to build a pipeline and for normal maintenance thereafter.

Riser - Platform deck.

Risked resource estimate - An assessment of oil or gas resources that has been modified to take into account the uncertainty of the estimate and to account for the possibility that economically recoverable resources may not be found within the area of interest.

Risked, economically recoverable resource estimate - An assessment of oil or gas resources that has been modified in the following ways: to take into account (1) physical and technological constraints on production, (2) the influence of the costs of exploration and development and market price on industry investment in OCS exploration and production, and (3) the uncertainty of the estimate; and to account for the possibility that economically recoverable resources may not be found within the area of interest.

Sediment - Material deposited (as by water, wind, or glaciers) or a mass of deposited material.

Sedimentary rocks - Rock formed of mechanical, chemical, or organic sediment.

Seismic - Pertaining to, characteristic of, or produced by earthquakes or earth vibration; having to do with elastic waves in the earth.

Single-anchor-leg mooring (SALM) - A semi-rigid anchored mooring used to connect vessels to storage tanks or production platforms.

Slumping - (See **mass movement**).

Source bed - Rocks containing relatively large amounts of organic matter that is transformed into hydrocarbons.

Single point mooring (SPM) - Offshore anchoring and loading or unloading point connected to shore by an undersea pipeline. Used in areas where existing harbors are not deep enough for laden tankers.

Stratigraphic trap - A geologic feature that includes a reservoir, capable of holding oil or gas, that is formed from a change in the character of the reservoir rock. Such a trap is harder to locate than a structural trap because it is not dependent on structural closure and is thus not readily revealed by geological or geophysical surveys.

Stratum (pl., strata) - A tabular mass or thin sheet of sedimentary rock formed by natural causes and made up usually of a series of layers lying between beds of other kinds.

Structural trap - A geologic feature that includes a reservoir, capable of holding oil or gas, that is formed from crustal movements in the earth that fold or fracture rock strata in such a manner that oil or gas accumulating in the strata are sealed off and cannot escape. In some cases "structure" may be synonymous with structural trap.

Subsea completion - A self-contained unit to carry men from a tender to the ocean bottom and enable them to install, repair, or adjust wellhead connections in a dry, normal atmosphere.

Subsidence - Movement in which there is no free side and surface material is displaced vertically downward with little or no horizontal component; a sinking of a large part of the earth's crust.

Subsurface geology - The study of structure, thickness, facies, and correlation of rock formations beneath land or seafloor surfaces by means of drilling for oil or water, core drilling, and geophysical prospecting.

Summary Report - A document prepared by the Department of the Interior pursuant to 30 CFR 252.4 that is intended to inform affected State and local governments as to current OCS reserve estimates, projections of magnitude and timing of development, transportation planning, and general location and nature of nearshore and onshore facilities.

Supply boat - A vessel that ferries food, water, fuel, and drilling supplies and equipment to a rig and returns to land with refuse that cannot be disposed of at sea.

Swapping - Exchange of crude oil among companies to facilitate refining when one company's production is closer to the other's refinery, or vice versa.

Sweet crude - Crude oil containing very little sulfur or sulfur compounds.

Sweet gas - Natural gas free of significant amounts of hydrogen sulfide (H_2S) when produced.

Tectonic - Of or pertaining to the rock structure and external forms resulting from the deformation of the earth's crust.

Tract - The geographic and legal extent of an area offered as a single lease; a convenient way of numbering blocks offered for sale so that they can be sequentially numbered in the process of offering.

Transmission lines - Pipelines that move oil and/or gas after final USGS metering, processing, and/or sale.

Trap - A geologic feature that permits the accumulation and prevents the escape of accumulated fluids (hydrocarbons) from the reservoir.

Truncated - Terminated abruptly as if cut or broken off.

Ultra-large crude carrier (ULCC) (sometimes called a supertanker) - A tanker in excess of 300,000 dwt.

Undiscovered resources - Quantities of oil and gas estimated to exist outside known fields.

Unit - Administrative consolidation of OCS leases held by two or more companies but explored, developed, and/or produced by one operator for purposes of conservation, eliminating duplication of operations, and/or maximizing resources recovered.

Unitization - A process by which two or more lease holders allow one company to serve as the operator for exploration, development, and/or production of the affected leases.

Very large crude carrier (VLCC) - A crude oil tanker of 160,000 dwt or larger, capable of carrying one million barrels or more.

Well stream - Continuous flow of oil from a well.

Workover - Operations on a producing well to restore or increase production. Tubing is pulled and the casing at the bottom of the well is pumped or washed free of sand that may have accumulated.

GULF OF MEXICO SUMMARY REPORT PLATES

Plates accompanying this Summary Report are found in the pocket opposite.

PLATE 1.—Gulf of Mexico Region

Modified from a New Orleans BLM OCS Office base map and the USGS Conservation Division Gulf of Mexico OCS Operations Office map entitled "States of Tex., La., Miss., Ala. & Fla., Outer Continental Shelf" (revised 2/80, scale 1":80,000'), this plate shows the general extent of the Gulf of Mexico OCS Region. It contains principal offshore administrative areas, the Federal-State jurisdictional boundary, coastal counties and parishes, and significant urban centers where OCS-related activities are found. Plate 1 is the base map for all other plates in this series.

PLATE 2.—Hydrocarbon-bearing leased tracts

Plate 2 shows the distribution of hydrocarbon-bearing leased tracts in the Gulf of Mexico. It is compiled primarily from the World Oil-Ocean Industry-Pipe Line Industry, Offshore Texas and Louisiana map (Gulf Publishing Company, 1977, P.O. Box 2608, Houston, Tex.), a map depicting major oil and gas fields off the coasts of Louisiana and Texas. Additional data were from the USGS Conservation Division's Annual Field Names Master List Revision, October 9, 1979, and from photographs of the facilities map at the New Orleans BLM OCS Office. The base map is modified from BLM.

PLATE 3.—Current Federal lease status in the Gulf of Mexico OCS

Plate 3 is compiled from raw data from the U.S. Geological Survey and base data from plate 1. It shows the distribution of expired Federal leases, active section 6 leases, and active section 8 leases. Raw data for the map was provided by the U.S. Geological Survey, Division of Offshore Resources. The base map is modified from BLM.

PLATE 4.—Pipeline systems

Information on pipeline systems, blocks producing oil, gas, or both, and pipe sizes and locations of landfalls came from the World Oil-Ocean Industry-Pipe Line Industry, Offshore Texas and Louisiana map (Gulf Publishing Company, 1977, P.O. Box 2608, Houston, Tex.) Information on proposed pipelines came from magazine articles in **Offshore** (July 1979) and **Pipeline & Gas Journal** (January 1980). Data on substances produced on leased blocks in the Gulf of Mexico came from the U.S. Geological Survey, Conservation Division, Gulf of Mexico Field Office. Information was added by Conservation Division to the Field Names Master List Revision, October 9, 1979, to indicate which blocks produced oil, gas, or both. The base map is modified from BLM.

PLATE 5.—Current fairways

Locations of fairways were taken from the visuals in the Draft Environmental Impact Statement produced by the New Orleans BLM OCS Office for Lease Sales A62 and 62. Information on marine terminals came from the U.S. Army Corps of Engineers Port Series documents. The base map is modified from BLM.

PLATE 6.—Onshore facilities

Plate 6 illustrates the distribution of OCS-related onshore facilities, including refineries, gas processing plants, platform fabrication yards, pipe coating yards, and other support industries. It is compiled principally from information obtained from the New Orleans BLM OCS office. Additional information came from **Social, Economic, and Environmental Requirements and Impacts Associated with the Development of Oil and Gas Resources in the Outer Continental Shelf of the Gulf of Mexico** (Mississippi Marine Resources Council, 1976, Long Beach, Miss.). The base map is modified from a standard BLM base map of the Gulf of Mexico OCS.

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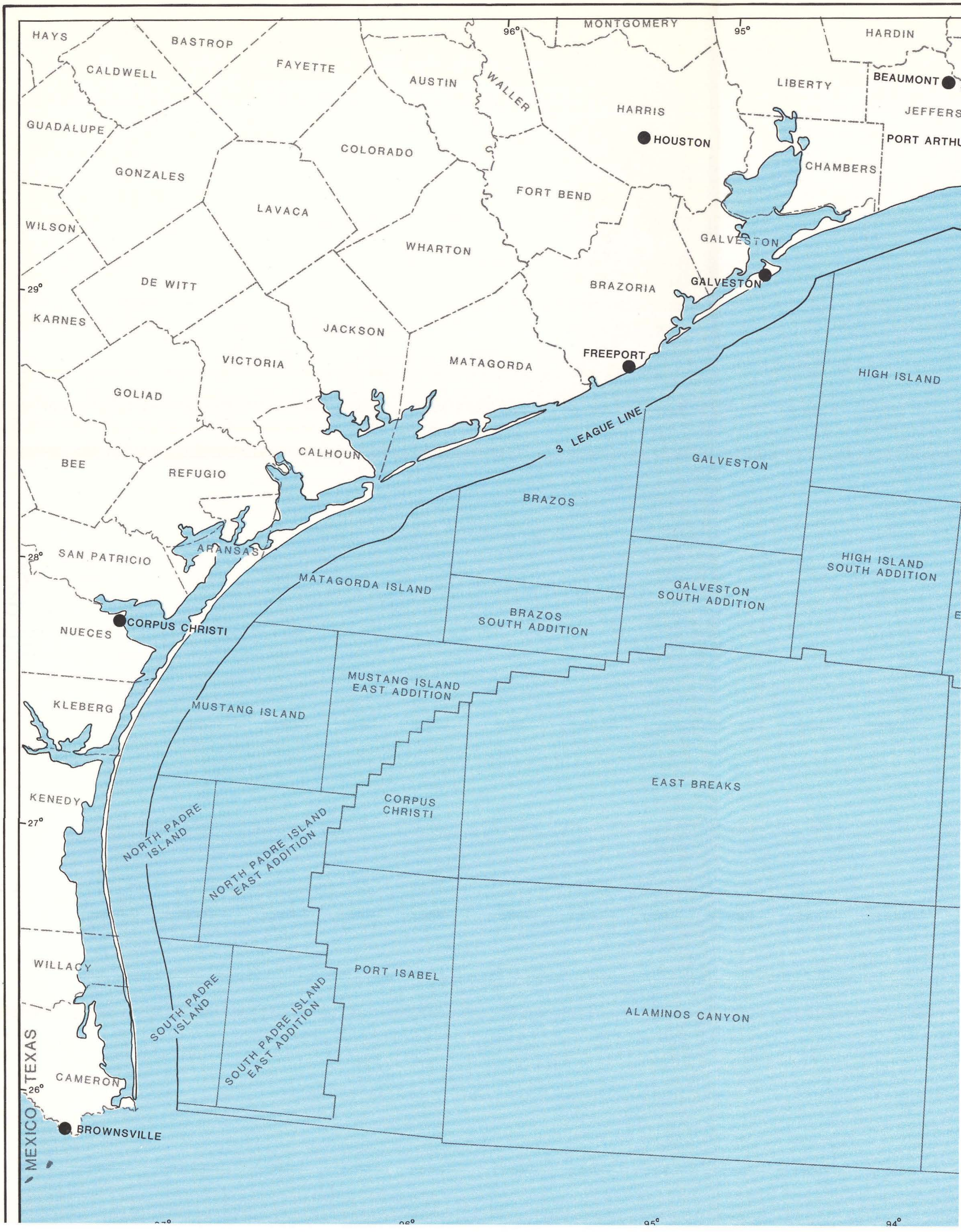

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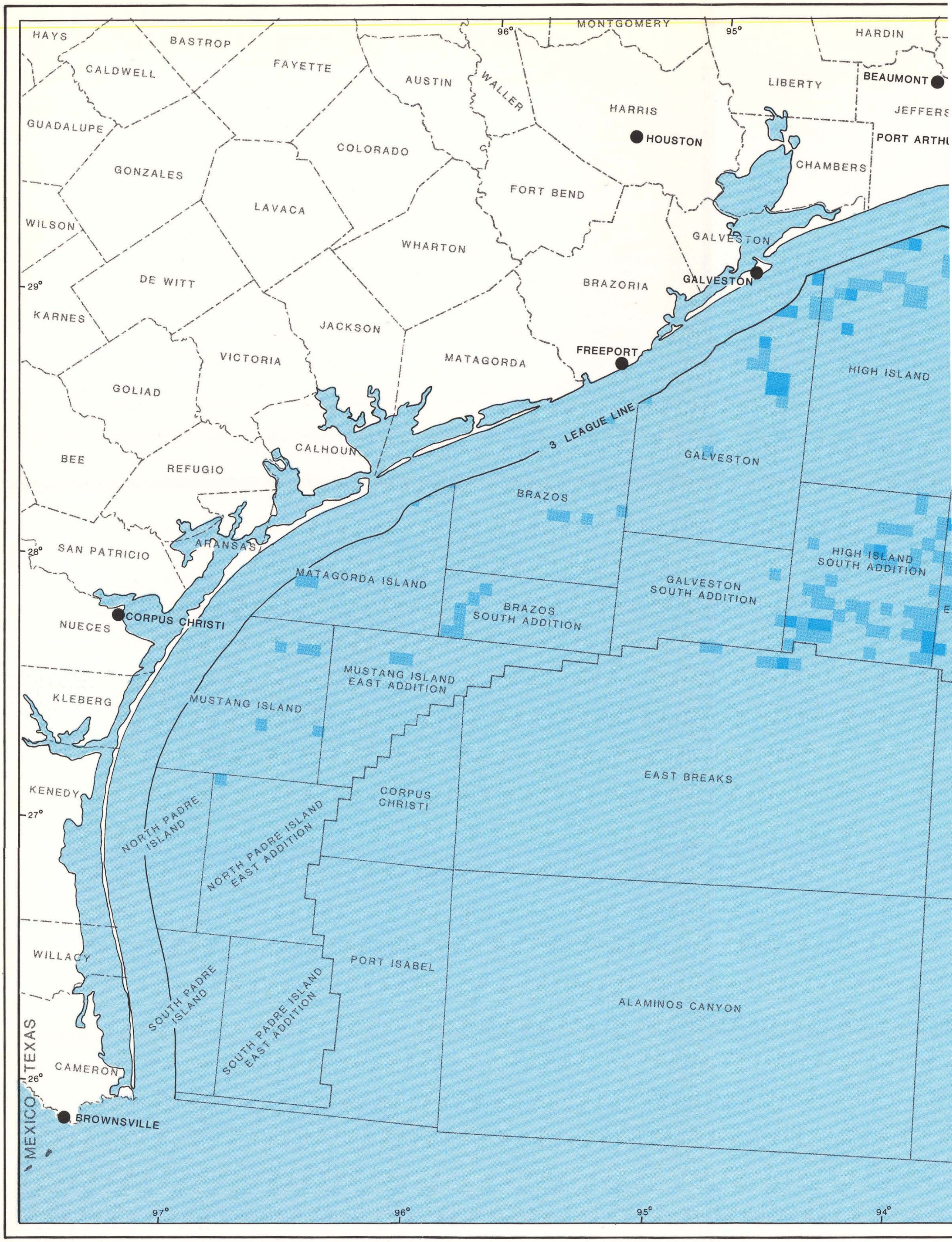

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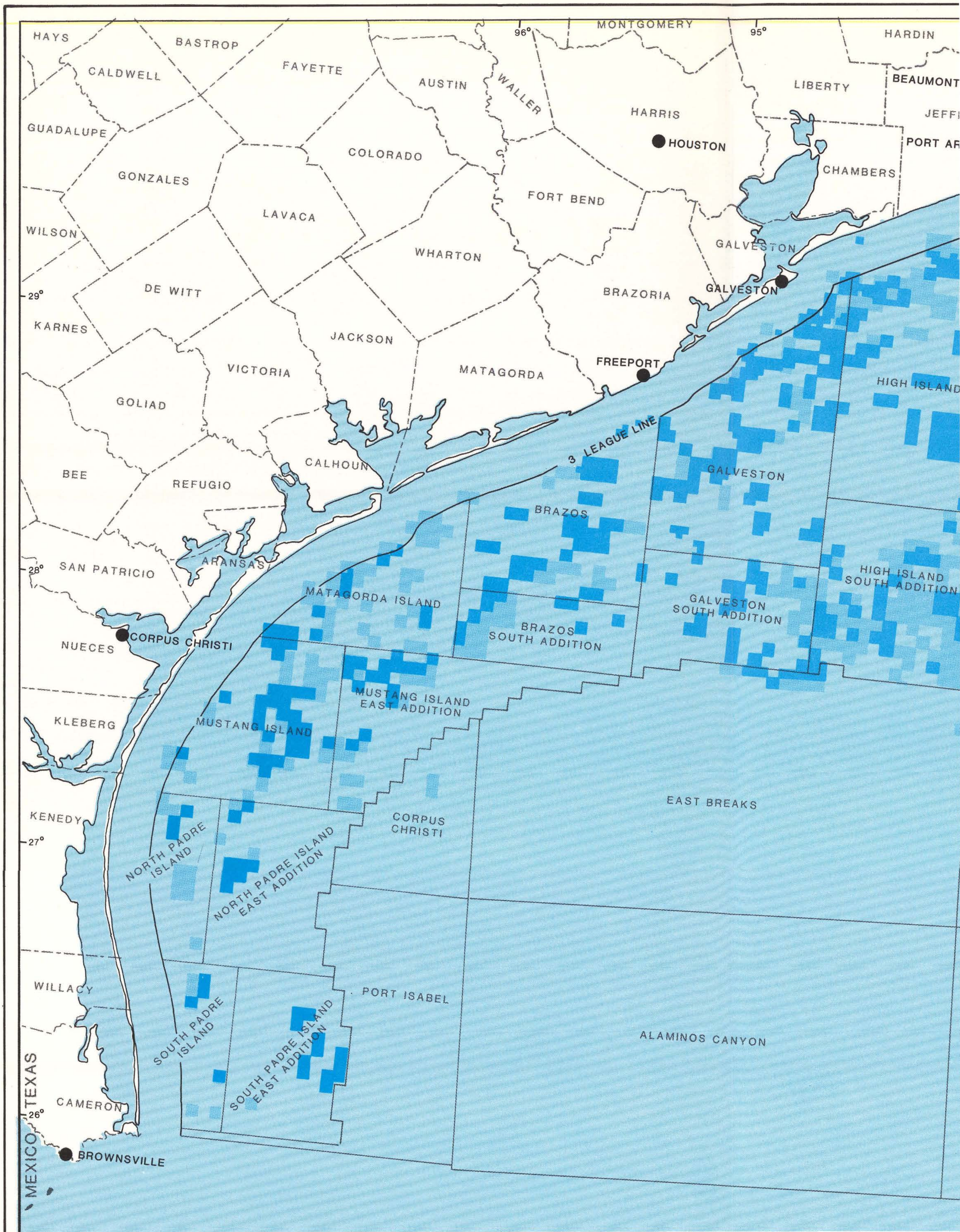
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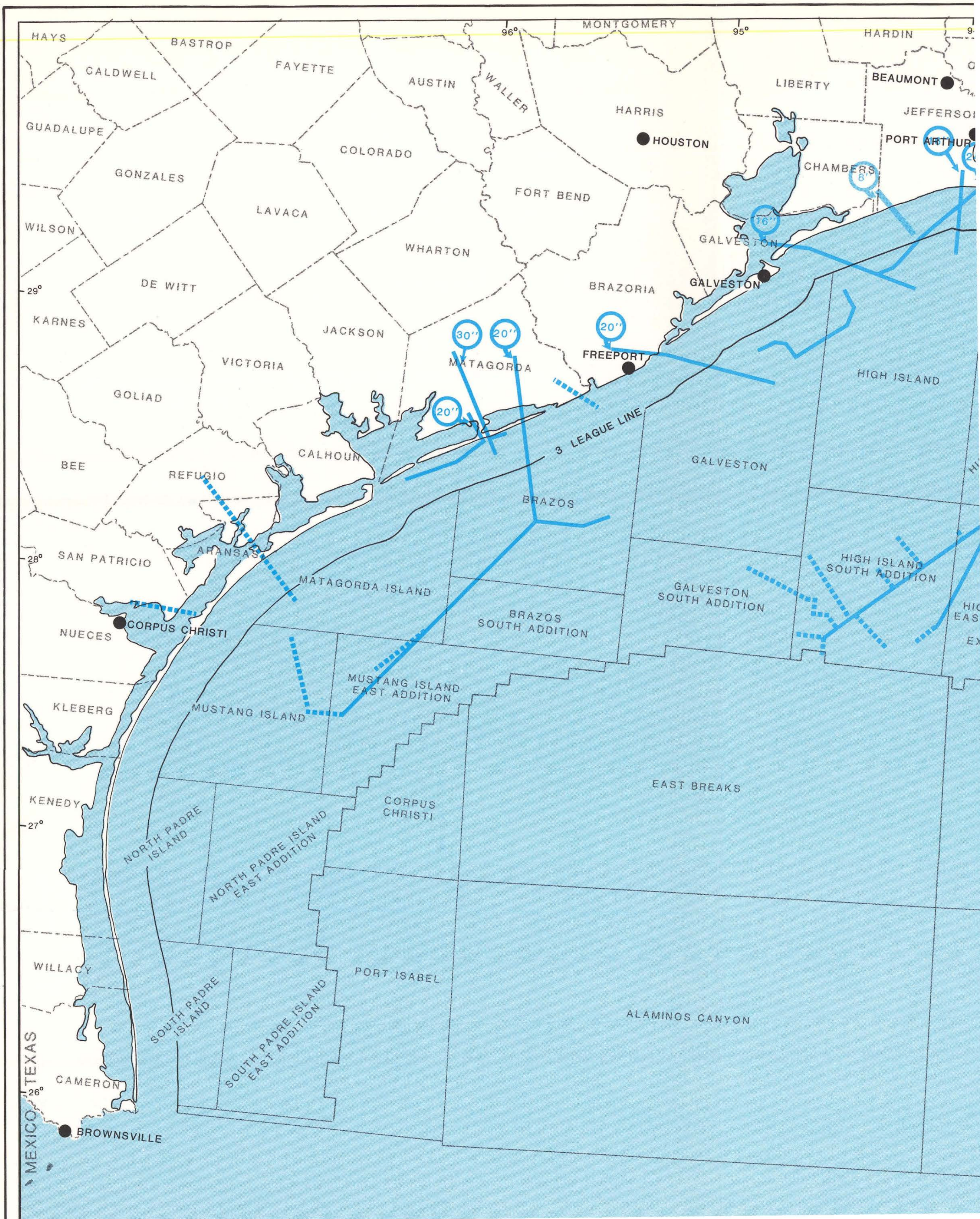

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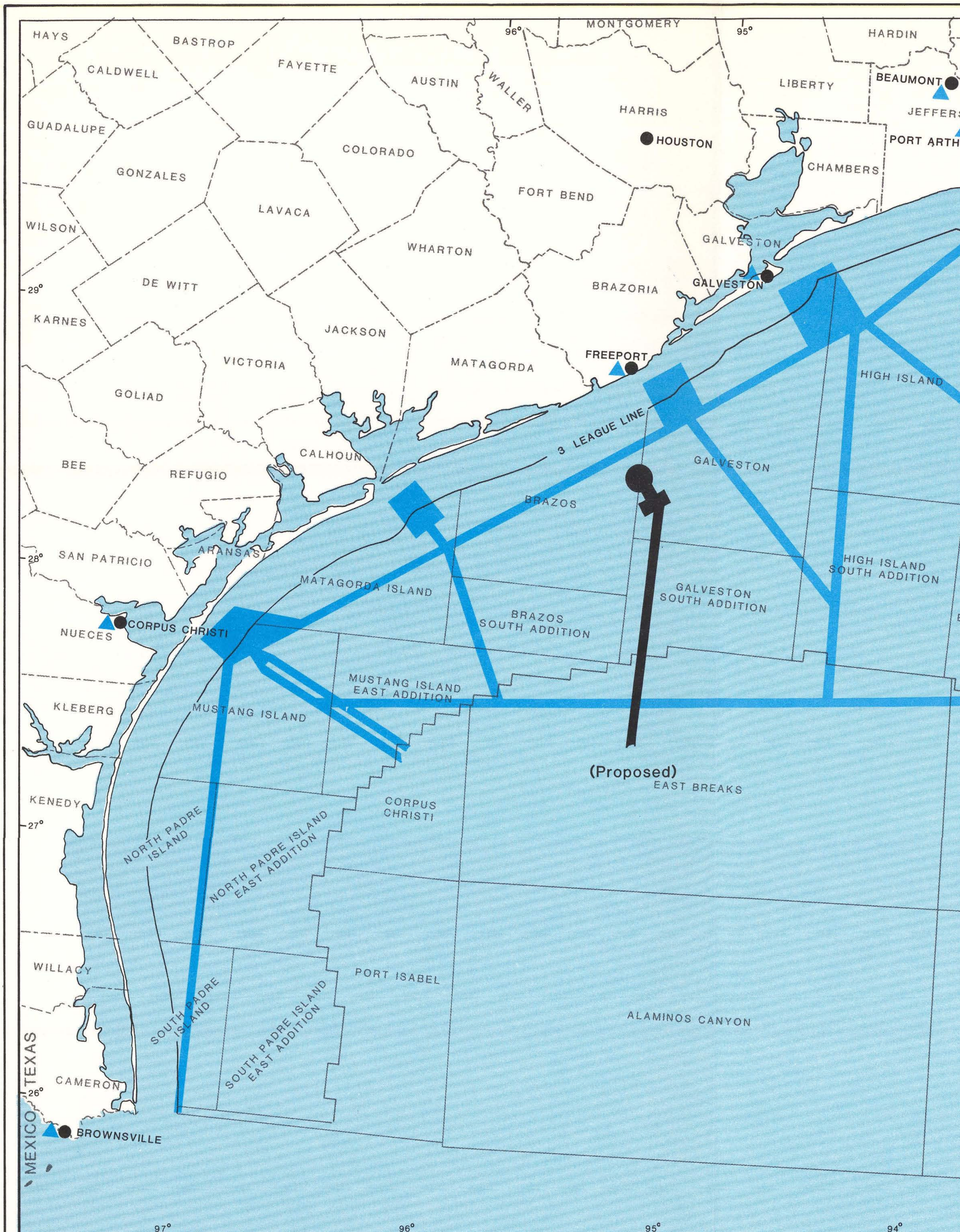
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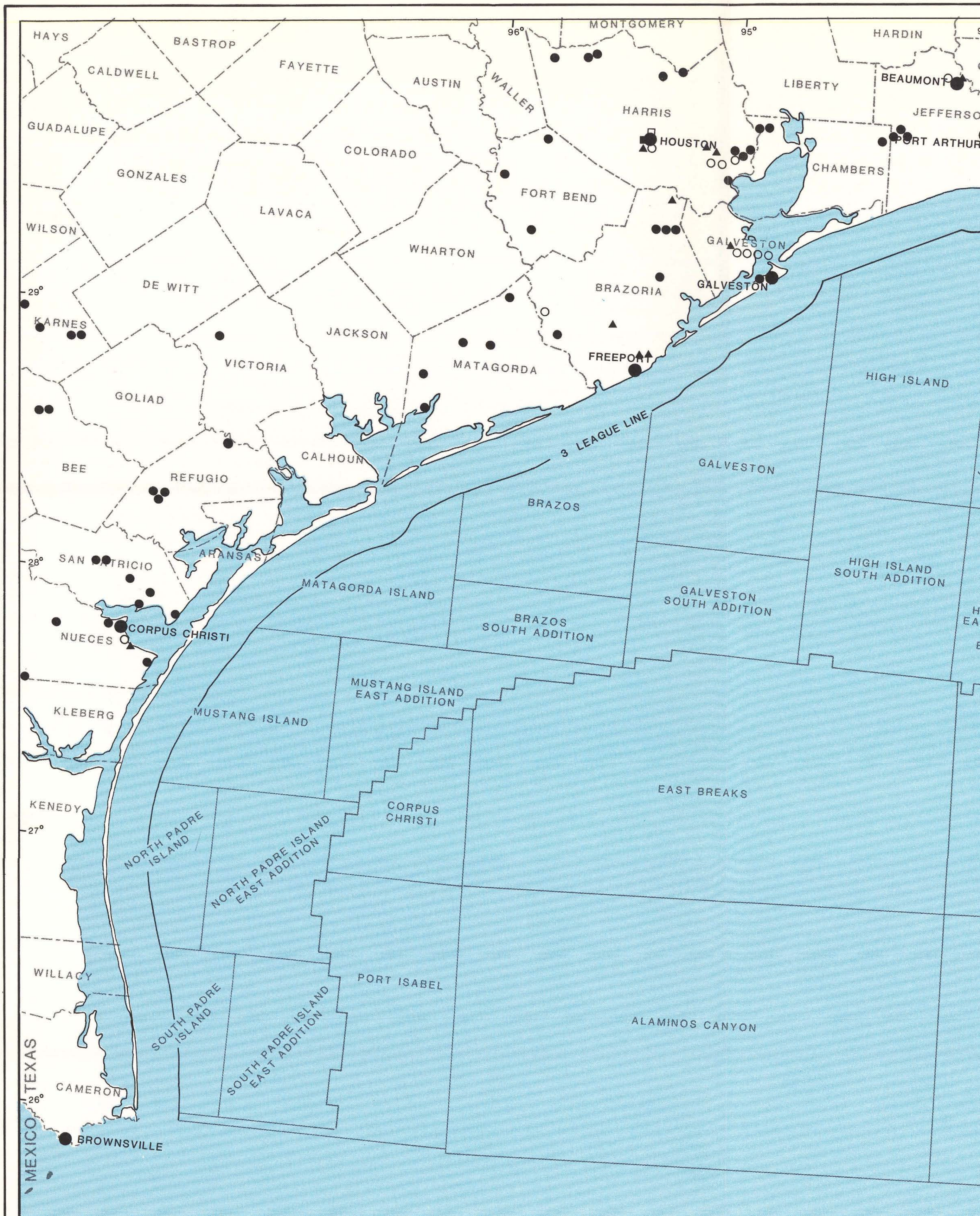

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