OCS Study
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History of the Offshore Oil and Gas Industry in Southern Louisiana

Interim Report

Volume I: Papers on the Evolving Offshore Industry

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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1. Introduction and Background

The evolution of the oil and gas industry and its movement to the offshore has been one of the fundamental forces shaping Louisiana's culture, geography, society and economy during the twentieth century. In the late 1920's and into the '30's, the lakes, marshes and bayous of southern Louisiana began to rival the famous Spindletop salt dome in neighboring Texas in the production of fossil fuels. Workers flocked in from northern Louisiana, Arkansas, Oklahoma, Texas – all of them "Texians" to the local shrimpers, trappers, and farmers. The locals, for the most part, accommodated the outsiders. And many soon found jobs as roustabouts, roughnecks, and drillers with the big operators - the Texas Company, the California Company, Humble, and Shell. Others put their invaluable knowledge of the waters and the marshes to good advantage. The Texians needed these skills to explore the foreign geography of the coast.

A consortium of companies led by Kerr-McGee and Phillips Petroleum completed the first out-of-sight-of-land well in 1947 off Morgan City, marking a new phase in the evolution of Louisiana's oil and gas industry. Hamlets and towns would be transformed to support the offshore industry, which now is producing oil and gas in water depths of 8,000 feet, 200 miles off the coastlines of Alabama, Mississippi, Louisiana, and Texas.

As a collection of structures, the more than 4,000 offshore platforms represent a significant part of the nation's stock of productive physical capital. As habitat for fish and other sea life, these structures are some of the largest additions to a natural ecosystem ever made as a consequence of human activity. The repercussions on labor markets and local economies of the movement offshore changed communities, institutions and businesses all along the coast of the Gulf of Mexico in fundamental and defining ways. New Orleans, linked to Harvey on the opposite bank of the Mississippi River, became a regional hub of operations for offshore activities, second only to Houston. Morgan City and Houma grew as fabrication centers and staging bases for the offshore rigs and platforms. Humble Oil Company built its headquarters on the barrier island at Grand Isle, as did Freeport at its company town of Port Sulphur along the lower Mississippi River. Lafayette aggressively led as a regional administrative oil center. In the often indeterminate edge between land and water, ports were built to access the Gulf. The envy of these now is Port Fourchon at the end of Highway 1 along Bayou Lafourche, supplying and servicing the newest expanse of deepwater exploration and production.

The history of the offshore oil and gas industry in Louisiana is also a story of national and international diffusion and influence. Corporations and businesses that were born in the Gulf grew and expanded to distant corners of the world. In addition to the oil and gas companies that made their home in the Gulf, regional entrepreneurs found a fertile ground for developing businesses to provide specialty services and supplies to the offshore oil and gas industry. Both the oil and gas companies and the myriad service and supply companies depended on ever-expanding technologies that were imported from, and later exported to, places outside the region.

Yet the story of how this came about -- how the offshore oil and gas industry progressed from humble beginnings to an information-intensive force whose ability to perform in hostile environments is often compared to the manned space program--is not well known or understood.

Even less well documented are the effects that the evolution of the offshore oil and gas industry has had on coastal communities and institutions.

1.1. Project Objectives

The purpose of this project is to study, document and explain this evolution in an objective and comprehensive way. A critical element of the history of the offshore industry resides in the memories of the "old timers." They were there. They remember how things were and how they have changed. Unfortunately, many of the people responsible for this phenomenal growth are passing away and their stories are being lost. There is a long list of innovators and pioneers from fabricators, port officials, helicopter pilots and catering crews, to divers, truckers, suppliers, boat captains and able-bodied seamen. They are all part of the growth and development of the industry. There are also civic leaders, business owners, spouses and family members who felt firsthand the impacts of this industry. The oral history record that has been built through this study has depended on the active participation of a diverse cross section of people with direct experience with the oil and gas industry and its effects.

1.2. Rationale

The Minerals Management Service (MMS) has sponsored and organized this study, and its motivation is in part internal. Both legally and operationally, the agency is required to evaluate and document how its activities and policies affect the communities and economies within which it functions. A comprehensive and accessible history of the evolution of the industry, and its effects on the people and institutions of the coastal economy, will assist those who are responsible for planning and managing the development of the offshore oil and gas reserves and understanding the consequences of such development on coastal institutions and the economy.

However, the project has value that extends beyond its use to the MMS. It fills a gap in the existing literature by addressing the growth and development of the petroleum industry and the related service industries in Louisiana that took exploration and development into the coastal zone and, then, into deeper and deeper offshore waters. In addition to its published reports and documents, this project is creating an organized archive of materials that can be used efficiently by other scholars and researchers. State agencies and local communities will also be able to use the materials to better understand the historical context of issues and problems of interest to them.

When the project initially was proposed, the Social Science Subcommittee of the Scientific Committee, several MMS Headquarters and GOM staff, members of the business and academic communities, and local civic leaders and educators argued that the project was timely and supported its funding. Reasons they gave included:

1) The offshore industry and its associated support industries are little known or understood and their dynamic role in the U.S. economy is virtually invisible. Research that gives this industry a "human face" would be a contribution to the OCS program, Louisiana, and the country.

2) The National Environmental Policy Act (NEPA) charges MMS with documenting the social and economic effects of the industry. The National Research Council's (NRC) assessment of the studies program noted that the fifty-year history of offshore oil provides a natural laboratory for studying its effects. To "calibrate" this laboratory, the changing dynamics of the industry (such as its technological evolution, changes in business practices, changes in financing) must be documented and analyzed.

3) MMS is charged by NEPA with assessing the cumulative effects of the industry. This history will provide what in many respects will be the most comprehensive and accessible source for discussing such cumulative effects. The study will help provide MMS a "baseline" for future analysis.

4) Associated with the baseline issue, MMS has been requested by its Science Committee and others to synthesize its research findings about the socioeconomic effects of the program. This study brings together a range of experts knowledgeable about the Gulf to begin synthesizing this material.

5) The project will help distinguish the effects of onshore oil production from offshore oil production, and offshore oil production from the OCS. Currently, the agency does this by dividing effects according to the number of barrels produced. However, onshore barrels have different effects than offshore barrels and this study may help document these differences over time.

6) While MMS must study the social and economic effects of the offshore industry, these effects are often defined abstractly. This study builds on methodologies used in prior studies (e.g., *Social and Economic Impacts of Outer Continental Shelf Activities on Individuals and Families* [USDOI, MMS, 2002]) which demonstrated that social and economic effects of the industry could be described and assessed in ways helpful to both industry and the affected communities.

7) This study is designed to serve as a "scoping" vehicle. Affected parties will define the salient social and economic issues in a non-adversarial milieu. Related to this process, the study has been organized to provide the agency with effective outreach to other federal and state institutions as well as communities.

8) Finally, the study could be considered as "mitigation." Knowledge about the industry and its origins are of value to the people of the State of Louisiana. This knowledge will be lost as industry pioneers pass away.

1.3. Methods

The project has used published works, documents, oral histories, and life stories to explore the complex mosaic of Louisiana's history in oil and gas. Within this mixed methodological approach, much of the effort has focused on the collection and analysis of oral histories and life stories. This reflects the study's goal of telling the story from the perspective of those who made the industry, who lived within its midst, and who now look back at the trials and accomplishments from a new century's circumstances and expectations.

Information collected in this project is being synthesized and summarized in a series of project reports. In addition, all of the primary information collected is being organized and cataloged in archives that will be available to scholars, industry analysts, community officials, local historians, and others interested in the industry or region. An interim archive for all materials collected for the project will be established in the Library of the Center for Energy Studies at LSU. A permanent special collection at the T. Harry Williams Center for Oral History will be established if the necessary funding can be secured. Other libraries and universities may establish archives in other localities in the region.

1.4. Organization of the Project

The project has been financed through a cooperative agreement between MMS and Louisiana State University (LSU). The Center for Energy Studies at LSU, under Allan Pulsipher, oversees the administration of the study and is responsible for the final deliverables. Harry Luton at MMS oversees the project and is the agency liaison.

The execution of the project, however, is decentralized with subcontractors supported via the cooperative agreement responsible for most of the research. The principal subcontractors are:

1) University of Houston/History International. Joseph Pratt and Tyler Priest are experienced historians who have specialized in the Gulf of Mexico oil and gas industry, producing several industry histories (the latest on Brown and Root) as well as more general studies. They are conducting interviews with corporate leaders, providing analysis and synthesis for the project and serving as liaisons to the Offshore Energy Center in Galveston, Texas.

2) University of Arizona, Bureau of Applied Research in Anthropology. Diane Austin and Thomas McGuire are experienced applied anthropologists who are experts in community-level studies. They conducted the MMS study of social and economic impacts (USDOI, MMS, 2002) and are responsible for collecting, cataloguing, summarizing, and synthesizing hundreds of interviews within the communities of southern Louisiana.

3) University of Louisiana at Lafayette, Public History Program and Department of Sociology. Robert Carriker directs the Public History Program and Robert Grambling, a sociologist, has long experience researching the social impacts of the Louisiana offshore petroleum industry. Their research efforts are focused in and around Lafayette.

In addition to administering the study, LSU researchers from the Center for Energy Studies, which has a history of successful research on Louisiana onshore and offshore oil and gas industry, are helping to gather and synthesize data. The Center maintains specialized databases and information on Louisiana energy industries. Also involved, as an initiator and participant, is Don Davis, a geographer who was studied Louisiana's coastal landscape and culture. He also directs the Louisiana Oil Spill Research and Development Program (OSRADP) and serves as a liaison with the State of Louisiana agencies, and the oil and gas industry.

1.5. Organization of the Interim Report

Because of the extensive amount of material included, the final report will be organized as a series of separate volumes. The interim report follows this format.

The first volume includes the introduction and four analytical papers. Each deals with an important aspect of the evolution of the offshore oil and gas industry. Although each paper is still subject to revision and extension, the papers exemplify the type of information the project will produce and the style in which it will be presented.

In the first paper, Joseph Pratt investigates the relationship between hurricanes and the development of industry culture, attitudes and practices. Next, Tyler Priest examines the history of federal leasing from a two-man operation to the creation of a full-blown federal agency. In the third paper, he analyzes the development of technologies and strategies for petroleum exploration in the offshore. The fourth analytical paper is Diane Austin's history of commercial oilfield diving and its relationship to the people and communities in which it developed and grew. Also included with these three papers are a description of the work plan and additional products that Pratt and Priest plan to include in the final report.

The second volume of the report is Thomas McGuire's *Bayou Lafourche: An Oral History of the Development of the Oil and Gas Industry*. It uses extended excerpts from oral history interviews for a broad look at the impact of the industry on a single geographic region. Monograph length, it provides an alternate format for presenting the rich data being collected in this study.

The third volume of the interim report, produced at the University of Arizona, illustrates how the information gathered during the interviews is being organized. It begins with a sample of the photos that were shared during some of the interviews and excerpts from interviews conducted with the individuals who contributed the photos. Together, these photos and descriptions provide a unique visual dimension to the history. The photos and excerpts are followed by samples drawn from the full database of interviews. Within that database, which includes background details and summaries of all the interviews, information about the interviewees and what they discussed is distilled for researchers and others interested in using the collected materials.

The final project report will be completed by the end of 2004.

2. The Brave and the Foolhardy: Hurricanes and the Early Offshore Oil Industry

When the oil industry moved offshore into the Gulf of Mexico after World War II, it plunged into an ocean of ignorance. Little was known about conditions in the Gulf. As the industry sought to adapt technologies developed onshore to the challenges of operations in the open sea, it also had to collect basic data about wind, waves, and soil offshore. Every-day operations offshore required engineering adjustments in the design of drilling rigs, pipelines, and construction equipment. And out there beyond the horizon loomed an engineer's nightmare, the extreme, unpredictable conditions generated by hurricanes (Veldman and Lagers 1997; Pratt et al., 1997).

Those seeking to develop a technological system capable of finding and retrieving oil and natural gas from underneath the ocean faced formidable challenges in defining basic design criteria. Traditional engineering calculations could estimate the environmental forces that would come to bear on the equipment and structures needed to produce oil, but such calculations could be made only after the collection of data about these forces of nature. How strong would the winds blow? How high could hurricane-driven waves be expected to crest? How solid was the foundation provided by the soft, sandy bottom of the Gulf of Mexico, and how would this soil be affected by hurricanes? Underlying these questions was another, more practical one: How much were oil companies willing to spend in order to develop safe, durable offshore structures?

It was at yet unclear if offshore oil could be developed in a way that made it competitive in price with oil produced onshore in the United States and with growing imports from Venezuela and the Middle East. Numerous companies stood ready to explore the risks and rewards of offshore operations in the late 1940s, in part because of the scarcity of good leases onshore, where large oil companies had locked up giant acreage at low costs in the depressed 1930s. Seismic surveys in the 1930s had revealed numerous large salt domes in the Gulf of Mexico. It made good geological sense that the excellent oil fields discovered in the early twentieth century along the Texas-Louisiana coasts did not stop at the water's edge.

At war's end, several major oil companies eagerly extended their on-going quest for large oil fields out into the Gulf. A handful of smaller companies looked out in the same direction seeking "break-through" discoveries that could vault them up the ranks of the independent oil producers. These companies faced an uphill battle offshore. If they could not develop a technological system capable of getting offshore oil to markets onshore at a price competitive with other sources, they could not sustain operations in the Gulf of Mexico.

History was kind to the pioneers of the offshore industry in the Gulf of Mexico. They arrived at the right shore at the right time. The Gulf sloped very gently out, stretching for a hundred miles in places along the continental slope before reaching water depths of 300 feet. Companies thus could walk gradually, step-by-step into deeper waters as they developed new technologies. As they moved out, they could draw on the workforces and expertise of clusters of oil-related manufacturers and service companies that had grown previously to meet the needs of a booming onshore industry in the region. Best of all, significant discoveries in the Gulf quickly rewarded their initial efforts, encouraging them to make larger investments.

In developing new, the offshore industry could draw on previous experiences gained near the shore in California and in a variety of inland waters around the world. Before the 1930s, oil had been developed off the southern California coast near Summerland using a system of trestles that reached out into the edge of the Pacific Ocean to tap oilfields that extended from known onshore deposits. But this region lacked the threat of the extreme weather produced by hurricanes. Extensive development of oil in the protected waters of Caddo Lake in Louisiana, Venezuela's Lake Maracaibo, and the Caspian Sea generated knowledge useful in every-day operations offshore. Finally, work in the marshy areas of "inshore" Louisiana in the 1930s helped prepare the way for operations in nearby areas offshore. None of these previous projects, however, had to be designed to stand up to hurricanes in the open sea (Veldman and Lagers 1997).

Griff Lee, a design engineer for Humble Oil and then for offshore construction giant McDermott, aptly summarized the situation facing the industry in 1945: "There had been no construction of open frame structures in open water before." Designers could look at data on the wave and wind forces exerted on seawalls or on ships at sea, but such data could not predict the forces that would come to bear during a hurricane on structures permanently fixed to the ocean's floor (Lee, personal communication, 1996). Given this void of knowledge about conditions offshore, those eager to explore for oil in the Gulf of Mexico would have to take calculated risks while they learned by doing.

This was not unusual in the oil industry or, indeed, in any innovative industry in America in this era. Oilmen lived by the oft-repeated adage: "Fortune favors the brave." With great confidence born of past technical successes and fed by the profits promised to first movers into the Gulf, the oil industry used very rough "best estimates" of wind and wave forces in the initial design of offshore facilities. When problems arose, engineers and construction specialists within the individual oil companies joined forces with their counterparts in offshore construction and service companies to solve them "on the run." Meanwhile research went forward by all involved--including consultants and academics-- to generate the data needed to improve the best estimates. This "entrepreneurial" approach was possible in a largely unregulated environment in which the companies enjoyed great freedom to make their own choices (Pratt et al., 1997).[1]

If fortune favored the brave in the formative years of offshore development, unusually good weather favored the foolhardy. Until 1964, no major hurricanes swept through areas with high concentrations of offshore operations. Thus for almost twenty years, the offshore industry amassed the data and the experience needed to improve the design of its equipment in the relative calm before major storms returned to the region in the mid-1960s. Three major storms, Hilda (1964), Betsy (1965), and Camille (1969) severely tested the technical system that had evolved in the Gulf of Mexico (Tait 1995). The industry received a gentleman's "C" on these tests. The brave and the foolhardy had demonstrated admirable ability to make engineering adjustments on the run, but they had gravely underestimated the risks presented by major hurricanes.

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[1] Government regulation of offshore activity before the 1970s came from a variety of agencies, none of which exercised strong control. Both the state and federal government had authority to lease offshore lands. The Army Corps of Engineers held the power to issue construction permits for projects in navigable waters, and it required offshore companies to clearly mark their platforms and to dismantle them once they were no longer in use. The Coast Guard had authority over safety and limited powers over oil pollution.

The oil industry first stuck its toe into the Gulf of Mexico to test the waters before World War II, and the results of these early forays identified several key problems presented by storms. In the late 1930s, Humble Oil (then a Houston-based, majority-owned subsidiary of Standard Oil of New Jersey) constructed one of the first drilling sites in the Gulf at McFadden Beach, south of the giant refineries at Port Arthur, Texas. Borrowing from the approach that had proved successful in southern California, the company extended a trestle more than a mile out from shore, with drilling rigs at the end of the line supported by men and materials brought out on a train track over the trestles. The drillers struck no commercial deposits of oil, and after a small hurricane in August of 1938 ripped apart the entire facility, Humble abandoned this venture. The industry subsequently ratified Humble's decision: trestles could not be built high enough or strong enough to withstand hurricane-driven waves in the Gulf (Larson and Porter 1959, pages 422 and 433; *Oil and Gas Journal* 1938, page 113).

The first real test of offshore construction came up the coast about 50 miles near Cameron, Louisiana. In 1937 and 1938, Pure Oil and Superior Oil together built a large wooden platform about a mile offshore in approximately 14 feet of water. This Creole field became the first producing property in the Gulf. It proved that profits could be made offshore while also revealing the severe challenges posed by hurricanes and the limitations of applying onshore technology in an offshore environment.

The companies constructed a giant platform measuring 320 feet by 180 feet from which to drill the exploratory well and then to produce any oil found. The primary task was to drive some 300 treated yellow pine piles 14 feet into the sandy bottom using pile drivers mounted on barges. This "stick-building" approach sought safety and strength through the clustering of many wooden piles; it sought stability against wave forces by driving the piles as far as possible into the sand. It sought protection from hurricane winds by using design criteria developed for onshore buildings to construct a structure that could survive winds of up to 150 miles per hour (Alcorn 1938a, pages 33-37).

Hurricane-generated waves were another thing entirely. With no available data on wave heights or wave forces, I. W. Alcorn, the designing engineer from Pure Oil, chose to build the deck 15 feet out of the water. He figured that such height would provide sufficient protection from normal high waves. He could not calculate the strength and height needed to survive a major hurricane; nor did he have the capacity to build such a structure with existing tools. So he struck upon a reasonable compromise. He designed the deck so that it would be swept off the piles by very high waves, thus limiting the damage done by a severe hurricane to the extensive system of piles. The wooden deck could then be replaced after the storm (Alcorn 1938b).

The Creole platform completed the first successful well in the Gulf on March 18, 1938.[2] Once production began, the problems of transportation and communication became more pronounced, foreshadowing similar problems in the post-World War II offshore industry. Workers lived in houseboats at Cameron, the closest town. But the platform itself was some ten miles along the

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[2] March 18, 1938 was a momentous day in oil history. As the first offshore well came in, the Mexican government was proclaiming the expropriation of U.S. and British oil properties in Mexico. Half way around the world, the discovery well for the first oil found in Saudi Arabia also came in on March 18, 1938.

coast from Cameron, meaning that all men and supplies came to the platform via a long and often rough ride out in shrimp boats leased for this purpose. A one-way ride might take up to an hour and a half. Without communication between the supply point, the boats, and the platforms, the shrimp boats often arrived at the platform only to find seas at the site too rough to allow workers to transfer from the boat to the platform. Rope ladders hanging from the platform could be lowered down to the deck of the shrimp boats in relatively calm waters, but not in rough seas. In the thick fog that often hovered over the platform, boat captains would at times simply cut their engines and listen for noise from the platform in order to find this man-made island. From the start, it was understood that in the event of a major storm, the men would be evacuated after the equipment on the deck had been secured.

The Creole platform proved quite successful in finding and producing oil. Using directional drilling to tap the field at several surrounding locations, it produced over four million barrels of oil over the next thirty years, during which time it was constantly upgraded as the offshore industry became more experienced at construction. Alcorn proved farsighted on one key point. In 1940 a small hurricane moved through the region, sweeping the deck into the ocean and badly damaging the piles. Crews drove some new piles, quickly rebuilt the deck, and the platform returned to production, the first offshore structure in the Gulf to survive a hurricane (*Offshore* 1963, pages 17-19).

World War II halted development in the Gulf. Workers on several small platforms being built offshore in 1942 remember scanning the horizon nervously in search of the periscopes of German submarines. But the war set in motion several processes that proved quite helpful to the offshore industry when peace returned. First and foremost was the work of the U.S. Army's oceanography and weather service, which created a corps of well-trained specialists who forecast wind, wave, and soil conditions for use in the amphibious landings in northern Africa, Normandy, and the Pacific. These "weather officers" accumulated data on the behavior of waves and soils in different storm conditions. From such information they sought to predict whether conditions at a specified place and time might be appropriate for an amphibious landing. Several of the weather officers led the industry's post-war efforts to collect and interpret better data on winds, waves, and soil in the Gulf of Mexico. Their methodology—using observations of past conditions to help forecast current and future conditions—evolved into much more sophisticated methods of "hindcasting" hurricanes as a way to more fully understand and predict the probabilities for severe weather at a given location out in the Gulf.[3]

The war paved the way for post-war developments in many other ways. Much improved communications at sea could be adapted for use offshore. War-surplus vessels produced in great numbers to support amphibious landings could be purchased and converted for offshore uses at bargain basement prices after the war. Perhaps the most important impact of the war, however, was on attitudes, not equipment. Veterans who had postponed their lives for four or five years

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[3] For profiles of several of these weather officers, see Offshore Energy Center (OEC), Offshore Pioneers: A Tribute (Houston: Gulf Publishing, 1998). This booklet was published as a part of the induction of individuals into the OEC Offshore Hall of Fame. In conjunction with this event, the inductees are interviewed and the interviews are transcribed and placed on file at the OEC in Houston. See, for example, Interview of Robert Reid by Malcolm Sharples, Houston, October 17, 1998; Interview of Curtis Cooke by Tyler Priest, Houston, October 6, 2001; Interview of John A. Focht by Tyler Priest, Houston, October 6, 2001; Interview of Bramlette McClelland by Tyler Priest, Houston, October 6, 2001.

returned eager to get back to normal work and family lives. They came back with a sense of urgency and a sense of adventure, two characteristics required of those who leaped out into the Gulf in search of oil after World War II.

The race offshore was on in the late 1940s. Despite uncertainties between coastal states and the federal government over the ownership of offshore lands, despite economic uncertainties, despite technical uncertainties, numerous oil companies headed out into the Gulf in search of big, virgin fields. Economics shaped their technical choices. One young Shell engineer, C.H. Siebenhausen, recalls asking an old hand at Brown & Root (one of the two dominant offshore construction companies in these early years): "In just how deep of water do you think Brown & Root could build an offshore platform?" The simple answer was: "First, young man, you will have to tell me how much money Shell is prepared to spend on such a platform" (Siebenhausen 2000). The economics of offshore construction included considerations of severe weather in the design and construction of new facilities.

In these formative years, two basic approaches to offshore exploration and production emerged. The first was the Creole approach writ large. Humble, Superior (a large independent), and Magnolia (a Dallas-based majority-owned subsidiary of Standard of New York) chose to build permanent platforms to find and develop oil in the Gulf. These platforms could hold crews of up to 50 workers, as well as all needed equipment and supplies. They were sturdy enough to last the life of the field and to survive harsh weather. They were also expensive to build and fixed in place once constructed, attributes that greatly magnified the risk of building them for use in drilling wildcat wells (McGee 1949, pages 50-53 and 117-120; *World Petroleum* 1947, pages 60-61; *The Humble Way* 1948a, pages 15-17).

A smaller company, Kerr-McGee, developed a less expensive approach, using refurbished war-surplus LSTs to house men and supplies and a small platform to support the drilling rig needed to find and produce oil. The LSTs were more than 300 feet long; once most of their insides, including their engines, had been removed, they could be converted into a sort of giant floating storage bin. This small platform with tender approach had obvious economic attractions, at least while war-surplus vessels remained plentiful and inexpensive. In the event of a dry hole, the tender--unlike the large fixed platforms--could be towed to a new location and at least a portion of the cost of the small platform could be salvaged (Pratt et al., 1997, pages 21-30; *The Humble Way* 1948b, pages 6-7).

Severe weather had implications for both systems. Large platforms could be designed and built to withstand hurricane level storms much more easily than the small platforms with tenders. High decks--at least in the context of the prevailing wisdom at that time--and safe procedures for transferring workers could be incorporated in their designs. The first generation of fixed platforms constructed from 1946-1948 placed decks from 20 feet to 40 feet above the mean level of the Gulf, reflecting the broad range of opinion on what was the most likely wave height in a severe hurricane (*Shell News* 1949, pages 4-9).

In contrast, the tenders posed serious problems in high wind and waves. These vessels were not self-propelled, and they could become heavy floating sledgehammers in rough seas. After the success of the Kerr-McGee's small platform with tender, Humble invested millions of dollars in buying surplus LSTs and converting them for use as tenders. It developed a mooring system using chain two inches in diameter to hold these large vessels alongside small platforms. Company engineers designed the ship's anchoring system to withstand 100 mile per hour winds. To accommodate the height of the tender, decks on the small platforms were as high as 34 to 44 feet above the ocean. Men and equipment moved from the tender to the platform over a bridge that could be raised from the vessel to the deck. So difficult was passage over this bridge in rough seas that workers came to call it "the widow maker." If a hurricane seemed likely to affect a tender operation, the company would move the tender away from the platform so that it could ride out the storm at anchor while posing less danger of pulling off of its moorings and smashing into the platform. Humble maintained large vessels near its offshore locations to evacuate workers in the event of severe weather (*The Humble Way* 1948b; Kolodzey 1954).

Problems with the tenders in rough weather did not, however, outweigh the economic advantages the small platform with tender had over the large fixed platforms. The huge downside of permanent platforms remained: a dry hole meant that literally "sunk costs" could not be recovered. Until the development of dependable, cost-effective mobile drilling rigs that could stand up to rough conditions in the open sea, the "semi-mobile" small platform with tender remained the dominant approach to offshore exploration and production.

Oil companies active in the Gulf went forward using both approaches until the late 1940s, when the "tidelands" controversy temporarily halted leasing while the federal government and state governments turned to Congress and the courts to resolve questions of ownership of offshore lands. This controversy became quite heated, particularly in the 1952 presidential campaign. But the pause in leasing gave the industry a short breathing space in which to reexamine assumptions about design criteria for offshore structures and to begin a generation of basic research about waves and soil conditions in the Gulf.

This research proceeded on a number of loosely coordinated fronts. The major oil companies created their own research groups, which worked closely with leading research institutes such as Scripps and the University of California-Berkeley. Consultants also provided much input into the studies of basic conditions. In the 1950s, the American Petroleum Institute (API), the industry's primary trade association, became more active in the collection of improved data about waves and soil, and the API gradually emerged as the focal point of much of the industry's interpretation of the data collected from research.

One key area of concern was the composition and load-bearing capacity of the soft soil in the Gulf. The leading authorities on soil conditions were the founders of McClelland Engineers, a consulting firm based in New Orleans that extended the work of the weather officers into the Gulf of Mexico. Bramlette McClelland, John Focht, and Robert Perkins pioneered the applications of soil mechanics to the problems of the offshore industry. To do this, they had to have data on conditions in the Gulf. With industry funding and cooperation, in 1947 they began boring soil samples offshore, building a data base for use in offshore construction. At times they worked just ahead of the contractors busy designing and installing structures; at other times, they investigated general conditions in areas likely to be explored in the future. Their analysis of the results of oil company-sponsored tests also led the way in applied research on the load-bearing capacity of the piles used to support offshore platforms (Offshore Energy Center, n.d., pages 34-36).

The API took the lead in the collection of other sorts of data on the soil in and along the Gulf. In 1951 the Institute launched what came to be known as Project 51, which spent four years undertaking basic work on conditions in the Gulf, using core drillings, serial mapping, and seismic surveys. This work, as well as that of McClelland Engineers, provided fundamental information vital to the safe construction of offshore structures. It did not, however, directly address a question that was later revealed as important: what would be the reaction of soil in various parts of the Gulf to the extreme conditions generated by severe hurricanes.

Other research studied the force of waves on offshore structures, both in normal times and in times of extreme weather. Here the oceanography department at Texas A & M University led the way. C.L. Bretschneider and Robert Reid, two more former weather officers, cooperated with several major oil companies to conduct field measurements to determine the wave forces exerted on vertical cylinders placed in the ocean. J. R. Morison later added considerations of inertial components to this work (Reid, personal communication, 1998).

Other primary research was much more directly tied to hurricanes. From 1947 into the 1970s, extreme wave heights remained a critical question on the minds of offshore engineers. This question was attacked from two directions. The first sought to develop better means to track storms and to predict where they would hit; the second sought better information about the maximum height of waves that could be expected in different parts of the Gulf. Weather forecasting in general had advanced steadily over the decades before World War II, but the offshore industry needed more detailed and more frequent forecasts than the U.S. Weather Service could make available to them. To meet this demand, A.H.Glenn, a former weather officer with graduate training at the Scripps Institute of Oceanography and U.C.L.A., mustered out of the U.S. Air Force and created Glenn and Associates, a New Orleans-based weather forecasting agency designed to meet the special needs of operators of offshore facilities. Glenn and others made great strides in using historical data about past hurricanes to "hindcast" the path and the intensity of future hurricanes. By analyzing all available information about past hurricanes with sophisticated theoretical models of the behavior of winds and waves, Glenn and a growing group of hindcasters gave platform designers a much-improved understanding of potential wave forces while beginning the process of categorizing hurricanes according to their intensity (Ward, personal communication, 1998).[4]

But forecasting storms was not quite the same as forecasting maximum wave heights; the particular organization, timing, and location of a hurricane could influence wave heights in localized areas near the eye wall. How could a designer improve his estimate of the maximum wave height and wave force that might challenge the structural integrity of a platform over its life in a specific place in the ocean? With no trustworthy measured data on extreme wave heights, different companies placed their bets using the best guesses of dueling consultants, many with connections to prestigious universities or research institutes. Highly publicized reports by two such consultants, retired naval officers F.R.Harris and H.G. Knox, stated authoritatively that "in 100 feet of water waves will probably seldom, if ever, exceed 20 feet in height." Decks thus should be placed "20 feet above the still water line" (Harris and Knox 1947, page 131).

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[4] A.H. Glenn folder, OEC Archives, n.d.

The king of the wave consultants in this era was W. H. Munk, a former weather officer who had forecast weather conditions for the Normandy invasion. After analyzing existing data with theoretical models of wave formation and behavior, Munk settled on a maximum wave height of about 25 feet and a recommended deck height of 32 feet above the water. With a wide range of "expert" opinions from which to choose, companies designed their platforms based on their willingness to take risks and their sense of the odds against a 25-year storm hitting their particular location during the life of their particular field. The safe consensus in these early years hovered around a maximum wave height of about 29 feet in the shallow waters of the Gulf, with a frequency of perhaps once every 40 to 50 years.

A series of relatively weak, small hurricanes in 1947-1952 quickly called this consensus into question. A small but intense hurricane offshore Freeport, Texas, in October 1949 severely damaged a platform; the post-mortem suggested waves as high as 40 feet had buffeted the platform. The observed wave damage to several platforms in these years led to estimates of waves in the 22-29 foot range in each case. Once every 50 years, indeed. Observations also showed more clearly than had been previously understood that the key problem was to keep these mammoth waves from cresting on the deck. During the Freeport storm, a platform with a deck 26 feet above the ocean suffered damages that cost its owner more than $200,000 in losses while a nearby platform with a 33-foot deck showed no damage (Farley 1950, pages 85-92; Willey 1953, pages B-38-47). The owner of the damaged platform came away convinced that a relatively small investment to build a slightly higher deck would have been justified to avoid the very high costs of cleaning up a damaged platform and the loss of production and revenues from shut-down time when oil could not be produced.

The California Company (Calco, a subsidiary of Standard Oil of California) had a particularly dangerous encounter with the first hurricane of this era, and its leaders responded by greatly improving safety standards. In early September 1948, a hurricane rose quickly offshore Louisiana, without sufficient warning for the evacuation of all offshore workers. The hurricane hit Calco's operations off Grand Isle, Louisiana, placing more than 50 men in harm's way. 25 of them huddled aboard a converted LST tender placed undertow to try to reach safe harbor. Unable to make much headway, the captain of the tug towing the LST decided to cut his lines, leave the LST adrift, and take his tug to safety. Meanwhile a derrick barge with 30 men aboard also bounced about in the rough seas after a rescue boat sent for it ran aground. Hours later tugs finally managed to control both vessels and bring them to safety, with the men aboard "wet, but unhurt." Those involved in this incident came away determined to make changes to avoid risks to workers and to minimize the damages that the hurricane had done to Calco's platforms (Besse interview by Offshore Energy Center, 2000; *The Calco News* 1948, page 1).

With such concerns in mind, Calco went back to the drawing board, applying significantly higher estimates of maximum wave heights and forces in its designs. In the words of Paul Besse, one of the engineers at Calco who took the lead in redesigning its offshore facilities, "That certainly elevated every platform that Chevron put in from that day forward." The company also elevated the decks of two platforms already installed in the Gulf, staking claim to leadership in the offshore industry in moving decks up higher to avoid wave damage in severe storms. Seeking better information with which to design platforms, Besse found little, since "there had never been a time when anyone was crazy enough to try to build a platform in the open ocean and place men and equipment on it…We had to go on theory, and the hurricane…caused Chevron to start thinking about placing wave measuring equipment on a platform offshore" (Besse interview by Offshore Energy Center, 2000).

Others agreed that it was time to obtain better measurements of wave heights. After Chevron installed three separate pilings in the Gulf with devices to measure wave heights in 1954, Humble Oil helped analyze the data obtained. The companies then calculated new design criteria for severe hurricanes in Texas and Louisiana. A.H.Glenn used these calculations along with wind and wave measurements from onshore and from ships to generate for the industry a new estimate of projected hundred-year storm conditions in the Gulf and other locations around the world. Calco and Humble, later joined by Shell, became the offshore industry's leading advocates for using such data to adopt higher, safer standards for platform construction and deck placement. Humble's leading offshore engineer, Arthur Guy, expressed the philosophy behind this new attitude with a simple sentence: "Error is cheap." These large companies took the view that the costs of potential for damage far outweighed the relatively small costs of building safer platforms. Better safe than sorry—and less expensive in the long run (Dunn interview by Joseph Pratt, 1996).

The election of Dwight Eisenhower and the end of the stalemate in offshore leasing in 1953 unleashed a burst of activity in the Gulf. At that time, there were already approximately 70 separate platforms in waters up to 70 feet in the Gulf (Toler 1953). Both numbers increased dramatically from 1953 until the economic downturn in the Gulf in the late 1950s. In this building boom, the offshore industry created a fully developed "Gulf of Mexico system" for exploring and producing oil.

At the heart of this approach was the development of mobile drilling rigs that could explore for oil in different locations, leaving production of oil for permanent platforms. The mobile drilling industry evolved quickly and in several competing directions at once, as entrepreneurs created companies to develop and exploit various technologies for drilling at sea. Submersible rigs, jack-up rigs, drilling ships, and semi-submersible drilling rigs evolved side-by-side in the 1950s and 1960s. Each type rig had characteristics that made it attractive for certain water depths and locations, and all were used to find oil in the Gulf and in other regions from the 1950s forward. These drilling rigs had one common characteristic that made them vulnerable to severe storms: they were designed to drill oil wells, not to move gracefully through the ocean. Most proved awkward to control and use in the open sea, and numerous accidents resulted (Veldman and Lagers 1997, pages 49-58).

Such accidents highlighted a key problem facing offshore operators in these early years, uncertainty over insurance. Hedging risks with insurance made good business sense, but underwriters shied away given the "perils beyond their (the offshore operators) reasonable control and not heretofore encountered in their land operations." Yet after deciding that risky offshore work might not yet be insurable, insurance companies examined more closely their existing policies and found that they were already liable for hundred of millions of dollars under policies covering such things as damage to vessels, explosions, and injuries to workers. The lull in activity during the tidelands controversy afforded these companies the opportunity to begin to sort out the key questions facing them? Were mobile drilling rigs vessels or drilling rigs? Should their workers be considered seamen or drillers? Was a blow-out of an oil well in the ocean the same as an explosion at sea? Providing legally binding answers to such questions was the first step in providing adequate coverage for offshore operations (Pike 1949, pages 49 and 108-109).

In comparison to the mobile drilling rigs, underwriters had less trouble in insuring the permanent platforms most companies built to provide a safe, sturdy foundation for long-term development. By the mid-1950s, these platforms were much-improved versions of those first built by Magnolia, Superior, and Humble in the late 1940s. The Gulf of Mexico system of this era came to be dominated by "piled jackets," large metal structures constructed in specialized fabrication yards onshore, transported by purpose-built barges, installed using specialized equipment, and then pinned to the ocean floor by piles driven down through the jacket into the ocean floor. Once the piles had been driven, prefabricated decks could be welded onto the jacket. Fabrication onshore produced a stronger, more uniformly built frame; the time spent on construction in the rough, unpredictable conditions out in the open sea could be minimized. The completed structure was self-contained, including quarters for work crews (Willey 1953, pages B-43-47).

Transportation and communication improvements allowed these platforms to be supplied more easily, while also assuring that the crews could be evacuated in the event of a storm. Fleets of purpose-built supply boats owned and operated by emerging firms such as ODECO quickly replaced the shrimp boats and war-surplus boats that had provided much offshore transportation in the earliest years in the Gulf. These boats were faster, stronger, and more comfortable, and they were equipped with modern communications. But they still required long hours in the water to ferry men and supplies back and forth from platform to shore (LaBorde, personal communication, 1998).

For safety and convenience, it was only a matter of time before local entrepreneurs developed helicopter service out to the rigs. By the early 1950s, Humble had contracted with a local company to lease helicopter service to platforms far out in the Gulf. The first entrant into this new business was PHI (Petroleum Helicopters Incorporated), which grew quickly in the 1950s and operated a fleet of 33 helicopters as on 1958. Once oil companies made the investment in helicopter landing pads out on the platforms and drilling rigs, the industry had a greatly improved capacity to respond to emergency. When a hurricane threatened, the skies filled with helicopters ferrying men to safety onshore (Persinos 1999, page 39; *The Humble Way* 1957a, pages 14-21; *Petroleum Week* 1960). Such transportation improvements became the offshore industry's first line of defense against hurricanes. If loss of life could be avoided, then the industry could learn to live with property damage as it gained a greater understanding of how to protect its facilities from major storms.

Effective evacuations, however, required more accurate and more up-to-date weather forecasting. To monitor the path of hurricanes, many companies subscribed to a well-developed forecasting service that kept in touch with their offshore facilities via advanced communications equipment. The U.S. Weather Service simply could not deliver the quality of forecast information available through New Orleans-based Glenn and Associates, which provided frequent detailed reports on wind, weather, and waves in areas of the Gulf containing offshore operations. This private weather service supplemented government data with its own long-range radar system and with the four daily observations submitted from the rigs of subscriber companies. The companies could have personal consultations with meteorologists if in doubt about storms. In this era before satellite observations, the offshore industry had far superior information about storms than was available to others; its special needs gradually led to the improvement of forecasting in general (*The Calco News* 1949, pages 3-4).

An overview of the response of this system of operations when faced with a hurricane comes from an article in the *Humble Way*, the employee magazine of Humble Oil. In this case, the weather forecasting service warned the company of a gathering storm that might ultimately pass over one of its major facilities. Careful monitoring of the storm convinced management to prepare for the worst. Workers then cleared the decks of the small platform in use at the site, storing some materials in the tender vessel, which was then battened down and moved away from the platform using winches on the mooring system. After anchoring the tender, workers evacuated in ships. Once the storm had passed with little damage, the workers returned and the platform was back in production the next day (*The Humble News* 1956, pages 18-21).

Humble was, of course, a major company with well-built platforms and well-developed safety procedures. The storm that threatened its facility was relatively small and did not score a direct hit. In 1956 and 1957, Humble and the rest of the companies in the Gulf had a more demanding test, as two fairly large hurricanes passed through areas with numerous offshore platforms.

The first was Hurricane Flossie, which moved through clusters of facilities offshore near the western edge of Louisiana in September of 1956. Labeled the “first real hurricane test” for offshore operators since drilling activity began in 1947, Flossie unleashed 110 mile per hour winds and 15 to 20-foot waves that caused the shutdown of several hundred offshore producing wells and many drilling rigs for two to three days. Although costs from downtime exceeded actual damages, this minimal hurricane did teach operators several valuable lessons.

The first lesson reflected the attitudes produced by a decade of relatively mild weather. Again, as in 1948, nearly 50 men “rode out” the storm on tenders and other vessels. After a Calco tender vessel had been torn from its anchor, 25 crewmen fighting to survive in the high seas floated serenely in the eye of the storm for a while before 100 mile per hour winds returned from the opposite direction and their struggle began anew. The companies and the men involved took a calculated risk that they would be safe. After noting that Flossie was only half as forceful as hurricanes that could hit the area, one trade journal, *World Oil*, echoed the arguments of operators who “say more attention should be given to complete evacuation, doing away entirely with the calculated risk.” The industry took justifiable pride in its lack of fatalities in hurricanes, a record not exactly guaranteed by asking workers to ride out storms in clumsy converted LSTs (*The Calco News* 1956, page 3; Lambert 1956, pages 73-75).

Numerous tenders broke their mooring chains or moved off their anchors during Flossie. One of Humble’s tenders suffered breaks in six of eight mooring chains and swung around into the adjoining platform, causing some $200,000 in damage. Other companies reported problems with damaged risers, the conduits for the pipe from the platform to the ocean bottom. Yet despite such problems, all in all, the reports on Flossie stressed the effectiveness of existing designs and safety procedures, with the oft-repeated caveat that this was not a major storm. One respected trade magazine writer gave an optimistic interpretation of the lesson of Flossie: “The greatest fears of the offshore oil operators have been dispelled by the arrival of Hurricane Flossie.” This “full-blown hurricane” had shown conclusively that the industry’s “engineering estimates were correct” (Bailey 1958; Calvert 1957b, pages 48-51).

Nine months later, Hurricane Audrey, the first major hurricane to skirt Louisiana’s “offshore alley,” inflicted expensive damage, reminding the industry that it still had not experienced the effects of the direct hit of a major storm. In June of 1957, this storm arose quickly in the Bay of Campeche, took a straight path up toward the Texas-Louisiana state line, and slammed ashore at Cameron killing 400 to 500 people. It is remembered in the region as the deadliest hurricane since the Galveston storm of 1900, and it remains the sixth deadliest hurricane in U.S. history. Yet damage offshore was relatively minor. One mobile drilling rig sank in the storm and four tenders suffered damage when they pulled loose from their moorings and ran aground. Estimated damage to all offshore facilities reached about $16 million (*Offshore Drilling* 1957; *Offshore* 1957).

What registered most clearly in the harsh aftermath of the storm was that the offshore industry had fared dramatically better than the communities along the coast. After helping clean up the carnage in Cameron, the industry reflected that “forethought minimized hurricane damage to offshore installations.” On the key issue, the industry’s record remained spotless: not a single life was lost offshore in Audrey. Two offshore workers reportedly died, but only after they had been evacuated from a platform to an interior location and then chose to return to Cameron to try to protect their homes. In its overview of the “scars” left by Audrey, one of the major offshore trade journals concluded that the “the industry has scored an overwhelming though costly victory” (*Offshore Drilling* 1957, page 25; *The Humble Way* 1957b, pages 8-9).

The industry could not be quite so optimistic concerning the performance of mobile drilling rigs. In quick succession in 1956 and 1957, five mobile rigs capsized--four in the Gulf of Mexico and one off Qatar in the Middle East. Some were in rough waters; one was at dock being readied for sea. These five disasters caused more than $7 million in damages, with 13 fatalities in the four accidents in the Gulf of Mexico. The first imperative of mobile drilling rig design was the effective drilling of oil wells once on locations, but all had to be seaworthy enough to be towed in calm conditions. Although these “ungainly monsters of the sea” had been designed “to float within a reasonable degree of safety,” they continued to experience difficulties from rough seas and high winds (Calvert 1957b, pages 30-33).

In September of 1957 still another hurricane, Bertha, moved up the Gulf and inland near Cameron, sinking one drilling tender and driving another aground. The industry had been put on notice by nature, not once, but three times in a single year. It responded by raising new questions about the origins and properties of hurricanes. The focal point of investigations was a newly formed API committee, the Advisory Committee on Fundamental Research on Weather Forecasting. Staffed by industry experts who had the resources to fund research by academics and consultants, this new committee tackled fundamental issues that had long eluded explanation. What caused hurricanes to form and could their paths and intensity be forecast with greater certainty?

To address such issues, the API committee engaged the services of Herbert Riehl, a professor of meteorology at the University of Chicago, to prepare a "think piece" on what was known about hurricanes and what sorts of research were needed to advance knowledge. In the years from 1956 through 1962, the committee explored these issues with the best available theoretical ideas about hurricane formation and motion and the creative use of data supplied by A.H. Glenn on past hurricanes and potential hurricanes that did not develop. The committee, like the oil industry as a whole in these years, made use of rudimentary computers. Computer analysis helped the committee improve the art and science of hindcasting, giving the designers of offshore equipment useful information on which to base design criteria. In 1962 the API decided to sponsor no more research on hurricanes and the committee went out of existence. Its last publication reminded the reader of the great economic value of research that could predict the path of hurricanes, but apparently those who funded the work of the API could not see concrete results coming from the work of this advisory committee (Riehl 1957, pages 65-69; Parks and Riehl 1963).

The offshore industry had its hands full with many other things. The push out to produce oil in the deeper waters of the Gulf reached the 100 foot mark in 1957 and then quickly moved on out to 225 feet in 1965 and more than 300 feet in 1969. More than a thousand platforms had been built in the Gulf by the mid-1960s. The technology of exploration and production, as well as that of deep water pipelines, moved forward by leaps and bounds, enabling the industry to increase offshore production in the Gulf of Mexico to more than 2 million barrels a day by the late 1960s. At the same time, the Gulf of Mexico system was being improved to operate effectively in deeper water in the Gulf, it was also being adapted for work offshore in the Middle East, in earthquake-prone California, and the in the powerful ice floes of the Cook Inlet in Alaska (Pratt et al. 1997, pages 95-179). As the offshore industry tackled this array of challenging technical problems, there was a sense that the hurricane problem had been contained, if not solved, by research, measurements, and experience. In these heady years, the stakes grew higher for those working offshore, since the costs of development tended sharply upward as water depths increased. Yet despite this growing economic incentive to build sturdier platforms, many companies refused to depart from traditional practices. Despite a growing consensus on the basic oceanographic issues--wave, wind, and soil mechanics—the "design criteria used by various major oil companies differed by more than 200 percent for the same wave height considerations" (Lee 1963, page 384). On the key issue of deck height, common practices ranged from the use of the 1950s standard of 28-32 feet above mean Gulf level all the way up past the 50-foot range by safety-conscious companies such as Calco. Higher meant safer and more expensive, and each company placed a bet on the right combination of safety and cost for the particular location and water depth of each particular project.

In 1964 through 1969, a series of devastating hurricanes called these bets. Hilda (October 1964) and Betsy (1965) both measured as "100-year" storms; then four years later in August 1969, Hurricane Camille, labeled a "four-hundred year storm," roared through the western Gulf. These three major storms in rapid succession showed conclusively that hindcasters had underestimated the potential frequency and power of severe hurricanes.

Hilda was not the largest hurricane to hit the Gulf of Mexico in the post-war years, but it did more damage to the offshore industry than any previous storm. In late September of 1964 Hilda spun into the Gulf and grew into a very scary storm, with winds estimated as high as 150 miles per hour. As it moved over cooler waters toward landfall in central Louisiana, the storm lost force while slowly moving through offshore facilities valued at more than $350 million. In the words of one executive from a company that suffered severe damage, “Instead of spreading out over a big area…, she seemed to gather her energy into one tight mass and moved in and really tore things up.”[5] When the sun came out after the storm, clean-up crews returning to the evacuated platforms found stunning devastation. Losses reached more than $100 million, with 13 platforms destroyed and 5 more damaged beyond repair. Hilda had delivered a jolt of reality to an industry grown complacent about the power of major hurricanes (*Offshore* 1965, pages 26-28).

One response was a meeting of concerned offshore operators at the Roosevelt Hotel in New Orleans in November of 1964. 64 people attended, including representatives of most of the major oil companies active in the Gulf, the major contractors, gas transmission companies with pipelines in the Gulf, oceanographic consultants, and several university researchers. No organization called the conference; it came about because Hilda scared individuals into action. Those who had previously been satisfied to go it alone in designing offshore platforms now looked about for help in understanding what had happened and what needed to be done to avoid future catastrophes. Griff Lee, who had been active in offshore design and construction with a major oil company (Humble) and a major contractor (McDermott) since World War II, described the meeting as “a turning point for the industry. Before then, it had almost been every man for himself. This put together a cooperative spirit.”[6] In some ways, the meeting resembled an old-fashioned Southern Baptist revival meeting, with admissions of sin followed by a call to accept a higher calling—and higher decks.

The meeting began with a somewhat apologetic speech by A.H. Glenn, the leading weather forecaster and hindcaster employed by the offshore industry. After reviewing the history of Hilda’s development, Glenn addressed a question on everyone’s mind: what was the practical meaning of the phrase “25-year storm?” Hilda, labeled a 100-year storm, differed from previous post-war hurricanes more because of its path and its slow lateral speed than because of the force of its winds or waves. As Glenn lectured the audience about the problems of defining a 25-year or a 100-year wave and the distinctions between a 100-year storm and a 100-year wave, many in the room must have wondered why they had paid so much for so long for forecasts and hindcasts and why they had ever been so confident that hurricane conditions could be accurately predicted.[7]

When Glenn sat down, the group confessional began. Representatives of individual companies summarized the amount of damage they had suffered and then described in great engineering detail how the damage had affected the various parts of their platforms. These reports had a somber tone, as those who had ordered platforms and those who had built them traded notes about how Hilda had mangled their handiwork.

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[5] Transcript of Hurricane Hilda Damage Conference, New Orleans, November 23-24, 1964, pages 3-4. Copy provided by Griff Lee.

[6] Hilda Transcript, pages 75-78; Transcript Hurricane Andrew Structural Performance Information Exchange, API Meeting, October 29, 1992, pages 5-7. Copy provided by Griff Lee.

[7] Hilda Transcript, pages 5-8.

Near the end of the meeting Griff Lee took the floor to review "the complete failure" of a major platform that his company, McDermott, had recently built for Union Oil. Lee included a pointed reminder that McDermott had used A.H. Glenn's predictions of the forces generated by a 25-year storm in designing the platform. An examination of the wreckage made it clear that Glenn's estimates had been much too low. Working from severely flawed design data, the company had produced a severely flawed design with a lower deck that, at least in retrospect, had no realistic chance of surviving the fury of Hilda's waves.

The analysis of the problems with the design of this destroyed platform had a hard practical edge, since its twin had been loaded on a barge awaiting installation at a nearby site when Hilda hit. Lee gave the audience a classic account of engineering on the run, relating how McDermott had carefully studied the destroyed platform to make "some reasonable modifications of the (twin) structure," which it then installed. This was the ultimate wave tank test, using a real hurricane in the real Gulf of Mexico to test design assumptions. With strengthening near the ocean floor, stronger deck legs, and a higher deck, the one-time twin took its place as an only child out in the Gulf, near where the destroyed platform had once stood.[8]

After summarizing the overall destruction of Hilda, Lee concluded with a call for those gathered to admit their sins and change their ways. He noted that all but one of the platforms destroyed by Hilda had been designed to meet the projected forces of a 25-year storm. This meant, in effect, that they had been "designed with the owner accepting a risk." The prevailing attitude was "that the 25-year storm was only going to occur once in the whole Gulf of Mexico every 25 years, and if I'm lucky it will be over by your platform, not by mine."[9] In a speech subsequently repeated many times at industry gatherings, he admonished the group to cut through the uncertainty about wind and wave forces by moving toward design criteria based on the forces generated by a 100-year storm. This meant strengthening platforms, with emphasis on raising the decks, since Hilda had provided striking evidence of the dangers to platforms when crashing waves "get into the decks." Two practical incentives pushed those present to heed Lee's call for action. The first was economic; the costs of clean-ups and repairs were quite high compared to the incremental costs of building stronger platforms. The second was a matter of engineering pride; good engineers did not like waste and inefficiency, and the images of platforms crumpled over into the Gulf were not ones they cared to see again.[10]

Unfortunately, they saw many more less than a year later in September of 1965, when Hurricane Betsy emerged in the Atlantic, crossed Florida, and moved through the eastern coast of Louisiana in an area with more than $2 billion in offshore investments. The storm destroyed eight more platforms and damaged others. In the massive damage caused by Betsy, one event came to symbolize the dangers of hurricanes. "Maverick," a state-of-the art jack-up drilling rig owned by George H.W. Bush's Zapata Corporation and at work on a project for Calco when Betsy struck, simply disappeared. So did a platform previously installed by Shell in the waters off the mouth of the Mississippi River. The future president received a check for $5.7 million from a New Orleans underwriter who had placed the insurance for the rig with Lloyd's of London. The

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[8] Hilda Transcript, page 75.
[9] Andrew Transcript, page 6.
[10] Hilda Transcript, page 76.

offshore industry as a whole received another unmistakable warning that it had not correctly understood the risks posed by major hurricanes (*Drilling* 1965, pages 46-48).

Insurance could ease the financial pain only if insurers continued to accept the extreme risks of providing coverage for moble drilling rigs. “Maverick’s” destruction was only the latest in a line of accidents involving such rigs, and underwriters had begun to revisit the question of whether this segment of the offshore industry might be uninsurable. A representative of John L. Wortham & Son, a major Houston-based insurance company, acknowledged that the “tremendous risks” required “extra efforts” from insurers. Others in the underwriting business continued to debate the basic issue of whether a mobile drilling rig should be insured as a vessel or as a drilling rig, its workers as “landlubbers or seamen.” The compromise gradually struck was to take greater care for making the rigs safer as they were towed to the drilling site by having inspections of them by experienced naval architects while they were under construction and then having qualified naval engineers aboard while they were under tow. This compromise satisfied Lloyd’s and others, and an insurance crisis was avoided (Kuhlmann 1956, pages 74-75; *Drilling* 1957; Griffin 1959, pages 57 and 131).

Insurance covered some of the losses from accidents, but better design and construction that prevented accidents was obviously cheaper and more efficient. The devastation of Hilda and Betsy finally convinced the offshore industry to reevaluate its traditional approach to the threats posed by hurricanes. Greater cooperation was needed to define better design standards. The conference after Hurricane Hilda was followed by another conference after Hurricane Betsy, which had dramatically reinforced the calls of Griff Lee and others for change. At Houston’s Rice Hotel in November of 1966, representatives of the offshore industry met to create what became the API’s Offshore Committee. Under the auspices of the industry’s major trade association, this committee gradually became a permanent focal point of efforts to define uniform standards that would limit future damage from hurricanes (Lee, personal communication 1996, pages 27-29).

Basic research and measurement of wind, waves, and soil continued, at times in cooperative efforts and at times within individual companies. Shell Oil led the way in the gathering of data on wave heights with a project that placed sophisticated measuring devices on a string of large platforms in the Gulf. These devices could provide real measures to confirm the theoretical models of maximum wave heights during severe storms.

Or, as it happened, they could show finally and conclusively that the maximum waves from hurricanes had been consistently and grossly underestimated. During Hurricane Camille in August of 1969 Shell measured waves 70 to 75-feet high. These figures stunned offshore veterans who remembered early predictions by “experts” that waves in the Gulf would “seldom if ever, exceed 20 feet.” Of course, twenty years of experience and the movement into deeper water had replaced such early guesses with higher and higher figures. But 70 feet made a mockery of the common wisdom about wave heights.

Before Camille ripped apart the region around Biloxi, Mississippi, this monstrous Category 5 hurricane passed through a heavily developed offshore region south of New Orleans. Initial estimates of $100 million in property damages raised questions about what the toll might have been had the storm taken a track 100 miles to the west through the heart of offshore alley. But the “quality,” as well as the quantity, of damage drew as much attention as the astonishing reality of a 70-foot wave in the Gulf. Included in the platforms destroyed were three modern ones installed by Shell, the generally acknowledged leader in offshore design. One of these was only five months old and was at the time the world’s record deepwater platform (*Offshore* 1969).

Suddenly, more than thirty years after the first successful offshore venture in the Gulf of Mexico, Camille had washed up a new design problem. The giant new platform lost by Shell had been designed to withstand 100-year waves, but a mudslide caused by the storm, not wave forces alone, had toppled the structure, which had come to rest on its side some 100 feet away from its original site. Before 1969, shifting ocean sediments caused by earthquakes had been known to break telephone cables on the ocean floor, and as early as 1950, oceanographic consultants had studied the possibility that unburied offshore pipelines might move during hurricanes. But before Camille, platform designers had not appreciated that, under certain conditions, mudslides might pose catastrophic threats to platforms. The soil analysis routinely conducted for platform construction simply had not examined this possibility (Reid 1951, pages 1-6; Bea 1971, pages 88-91; Focht, personal communication, 2001, pages 10-11).

Shell’s failed platform was in 300 feet of water in “South Block 70,” located offshore from the mouth of the Mississippi River. In retrospect, it was not surprising that the ocean bottom in a region covered by sediments deposited by a large river would be soft and relatively unsettled. Under extreme hurricane conditions—Camille had 200 mile per hour winds to go with its 70-foot waves—such sands could behave almost like a liquid. Shell’s studies of the failed platform’s site revealed a phenomenon not previously observed by the offshore industry. Camille had dramatically altered the contours of the Gulf of Mexico in South Block 70, lowering the ocean floor and, in effect, placing standing platforms into deeper water. While this was perhaps the most cost efficient way imaginable to establish a new world’s record for platform water depth, it was not easily absorbed into the design criteria for new platforms (Bea 1971, page 89).

The process for finding ways to design platforms to withstand mudslides now began, taking a somewhat accelerated form of the process previously used to try to design for maximum wave forces without a full understanding of the maximum height of waves. First came the careful post-mortem of the platform that had been swept away in Camille and another one nearby that had been displaced. The information from these studies was placed in the context of the scant existing scientific literature on the frequency and intensity of mudslides. From this starting point, research was undertaken to fill in the wide gaps in information about mudslides. As this research moved forward, preliminary engineering analysis of the forces exerted by mudslides could begin. Design criteria gradually emerged from this analysis, as did the realization that in extreme hurricanes some areas of the Gulf simply might not support platforms built with existing technology.

By 1970 the process of adaptation to hurricanes had reached a turning point. The offshore industry had pushed ahead for a quarter of a century, solving engineering problems on the run when necessary by using the best available estimates of hurricane-generated forces and then adapting these standards after they were called into question by additional research or by damage caused by hurricanes. Three major hurricanes in the 1960s removed much of the uncertainty about the power of severe storms in the Gulf, and the offshore industry responded by taking a hard, collective look at its traditional assumptions.

They did so within two important new venues for cooperation among oil companies, construction companies, and consultants. After its establishment in 1966, the API's Offshore Committee quickly grew into an effective instrument for defining, publicizing, and modifying the best possible standards for offshore operations. The definition of industry standards had been an important part of the work of the API, which was ideally suited to bring together experts from various areas of the industry to share information about best practices. The Offshore Committee simply extended this tradition to matters concerning standards of safety and design offshore. The sharing of basic research on various aspects of offshore operations went forward after 1969 at the Offshore Technology Conference (OTC), an annual meeting where industry specialists gathered to present papers about their research. Both researchers and standard-setters could take advantage of the growing power and availability of better computers.

Peter Marshall, a Shell engineer who entered the offshore industry in 1962, summarized the difference between the early days and the years after the coming of computer-assisted design: "Intuitive design and an entrepreneurial spirit gave way to computers and an era of no surprises." Marshall summarized the key change in attitude with the simple declaration that "we were less afraid of failure then." He lamented the passing of the days when offshore engineers had been given greater latitude to do their jobs more creatively while accepting more risk.

Marshall was even able to joke about his own strange experience with failure. He designed a platform installed in 1965 in 283 feet of water, earning the record for water depth. Two days after its installation, almost before he could brag about his efforts, the platform suffered severe damage during Hurricane Betsy. Examination of the platform revealed pieces of the "Bluewater 1." When built by Shell in the early 1960s, this semi-submersible had been an epoch-defining technological break-through in offshore drilling. Hurricane Flossie had capsized the vessel in 1964. As a new owner readied it to return to work the next year, Hurricane Betsy displayed a stormy sense of irony by sending it careening into its former company's record-holding platform (Marshall, personal communication, 2002).

Such events make good stories, at least after the passage of a few decades. But do they also illustrate the folly of "entrepreneurial engineering"? Looking back at the formative years in the Gulf of Mexico, several things stand out. Fortunately, the emphasis on good forecasting and early evacuation meant that few people died or were seriously injured offshore in hurricanes.[11] The scanty accounts that exist suggest pollution from storm-related damage was not extreme. With risks managed through insurance and improvements in designs, property damages were not high enough to stop the movement into deeper waters. All in all, taking "calculated risks" and then fixing mistakes exposed by hurricanes on the run allowed the offshore industry to push through its ignorance and develop much needed domestic oil and natural gas reserves.

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[11] Overall, the offshore industry had more serious safety problems in such areas as the development of deep water diving and blow-outs of offshore wells, especially in the early years, when mobile drilling rigs also presented problems in rough seas.

Looking back on this process from the perspective of fifty years of work on offshore structures, Griff Lee offers a sobering appraisal that suggests how little the industry knew as it plunged into the Gulf of Mexico: "In light of today's data, the early load estimates were off (too low) by a factor of ten." A factor of ten would seem to be well past the threshold where the brave become the foolhardy. But in the American offshore oil industry of the post-World War II era, this distinction was blurred by a combination of unusually good weather, extraordinary technical innovations, and the systematic efforts of good engineers and work forces to recognize and fix problems exposed by one of the strongest, most unpredictable forces in nature, the hurricane.

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3. History of U.S. Oil and Gas Leasing on the Outer Continental Shelf

3.1. Introduction

The ocean is the last earth-bound frontier. For all of human history, it has beguiled those who ventured across or beneath it, from Christopher Columbus to Chester Nimitz, from Captain Ahab to Captain Nemo. Traditional discourses on the ocean focus on its mysteries, its alien allure. These discourses see the open sea as undeveloped and lawless. It yields bounty and resources, but remains distinctly outside the realm of state territory or human institutions. It is a space *across* which trade is conducted and power is projected, void of social processes and antithetical to terrestrial land-space. The ocean, in the words of Philip Steinberg (2001, page 35), lies "outside the rational organization of the world, an external space to be feared, used, crossed, or conquered, but not a space *of* society."

Just as historians of the American West have challenged Frederick Jackson Turner's conception of the landed "frontier" as an empty place existing outside of society, geographers such as Steinberg have begun to revise our understanding of the ocean frontier, demonstrating that the dynamic processes of the global political economy have historically and socially constructed ocean space. The development of offshore oil and gas provides a prime example of how human political/legal institutions have incorporated marine territory adjacent to littoral states. Oil and gas development involves large fixed investments, which require strong territorial regimes capable of guaranteeing the security of those investments. To enable oil companies to extract hydrocarbons from beneath the seafloor in a rational manner, ocean-space and submerged lands had to be defined, claimed, governed, and managed. They had to be made part of society.

Bringing ocean space and submerged lands into society was a difficult and contentious process, in the first place because legal jurisdiction was not clear-cut. Did states own or merely assert territorial rights to submerged lands of the continental margin? How far did ownership or rights extend? In the case of the United States, divided sovereignty between the central government and individual states further complicated the territorial definition of the sea. For many years, from the mid-1930s to the mid-1950s, the legal showdown between the states and the federal government in the United States over control of submerged lands adjacent to the states dominated all questions about leasing offshore lands for the exploitation of oil and gas. This long-standing "Tidelands Controversy" was gradually settled by a series of Supreme Court decisions from 1947 to 1960 that granted federal control beyond three miles from the coastline. In the meantime, the states and the federal government established a working administrative framework for leasing.

Sorting out jurisdiction was a first step toward bringing ocean space and its hydrocarbon resources into society, but their integration still required ongoing negotiation and trade-offs. The policy of the United States governed both by law and practical politics was to maintain a balance between the demands of various segments of industry, which generally desired greater and more open access to offshore lands, and those of environmentalists, states, coastal communities, fishermen, and even competing oil interests who for one reason or another desired to limit or constrain access to submerged lands for oil and gas development. From the inception of federal leasing, officials in the Bureau of Land Management and the USGS Conservation Division (whose leasing and regulatory functions merged in 1982 with the creation of the Minerals Management Service) faced the challenge of managing the trade-offs over leasing submerged lands with much less information, personnel, and financial resources than the interest groups with an economic and political stake in the outcome of policy and leasing decisions, especially the oil and gas companies. Neither oppressors of the oil business nor its captive instruments, federal regulators weathered many controversies, managing to give the industry enough access to make offshore development viable while attempting with varying degrees of success to protect the interests of many other groups.

In the ideal world of oil companies, all federal lands would be open for lease. Access to land or property is the single most important factor to survival and profitability in the business, and it is the arena in which the companies compete most fiercely. Oilmen are like-minded and have common interests, but contrary to myth of the oil industry as one big trust setup or conspiratorial club, oil exploration is fiercely competitive. The key to success is figuring out where the oil is and getting to it before your competitors. Offshore exploration is a game of high risks as well as high rewards, spectacular failures and enviable triumphs. Overall, the federal Outer Continental Shelf leasing program has created a vibrant marketplace and shepherded into being a profitable segment of the industry. From 1953 through 2000, the leasing of federal lands in the U.S. Outer Continental Shelf, primarily in the Gulf of Mexico, led to a total commercial production of 13.1 billion barrels of oil and 140.5 billion Mcf of natural gas. The program has also been a major source of revenue for the United States, the second largest behind taxes. From 1954 to 2002, the federal government collected a total of $49.5 billion in cash bonuses and $67.3 billion in royalties – not adjusted for inflation – from offshore oil and gas leases (Minerals Management Service, 2003). In constant dollars, according to a former Interior official, the U.S. offshore program has been the largest non-financial auction in the world (West, personal communication, 2002).

3.2. Claiming the Coastal Sea: From the Tideland’s Controversy to the Landmark 1962 Sale

3.2.1. “Tidelands” Controversy

The United States was the first nation to begin constructing the ocean, legally and politically, for the exploitation of petroleum. The first well drilled “offshore” in ocean waters was from a wooden platform off Santa Barbara County, California in 1896. After 1921, California offered leases to operate in “state-owned” tide and submerged lands, spawning a boom marked by the development of an extensive pier system to tap the portion of the onshore Summerland field that extended out under the ocean. In 1938, a year after North Dakota Senator Gerald P. Nye introduced the first congressional resolution to declare lands under the marginal seas of all the coastal states to be part of the national public domain, the Pure Oil and Superior Oil companies produced the first oil in open waters of the Gulf of Mexico on a lease obtained from the State of Louisiana. That discovery, in the Creole field, was made in 26 feet of water a mile and half from the city of Cameron. In November 1947, Kerr-McGee drilled the first well “out-of-sight-of-land” from a tender-supported platform about 12 miles off the coast of Louisiana. Earlier that year, in June, the U.S. Supreme Court handed down a decision in the case of *The United States v. California*, ruling that the federal government had “paramount rights” in the marginal sea and dominion over submerged lands and its resources. Similar decisions in the cases of *The United States v. Texas* and *The United States v. Louisiana*, both issued three years later on June 5, 1950, set the stage for a dramatic political battle between the states and the federal government over control of the "tidelands" (Bartley 1953; Steinberg 2002, pages 89-99).

Neither side in the Tidelands Controversy could rest their case on unambiguous legal precedent. The territorial concept of the marginal sea – the submerged part of the continental margin or continental shelf – was not well developed. The early Romans viewed the sea as open to all people (*res communes*) and therefore owned or controlled by nobody (*res nullius*). Engaged in long-distance trade and colonization, the maritime nations of medieval Europe eventually claimed unequaled rights to the sea. The most famous of these claims was the 1494 Treaty of Tordesillas in which Spain and Portugal divided the oceans and territories of the New World into spheres of influence between them. England and Holland challenged such division, continuing to trade with Asia and using naval power to render the Iberian decrees unenforceable. In 1608, Dutch legal philosopher Hugo Grotius formulated the doctrine of *mare liberum*, or "freedom of the seas," by asserting the existence of a community of sovereign, territorial states and declaring that the space between these states was *res extra commercium* and thus should be open to universal access and free transit. Yet, at the same time Holland's ally England championed freedom of the seas across much of the globe, the English declared dominion over the seas adjacent their coast. Self-defense required an exclusive zone of protection, argued the English legal scholar John Selden in 1635. Nations could effectively possess a portion of the ocean. By the eighteenth century, many scholars of international law accepted that a nation's control over the coastal sea extended to three miles, which was believed to be the maximum range of a smooth bore cannon (Bartley 1953, pages 7-10).

Nevertheless, questions still remained about the three-mile marginal sea. Did a littoral state "own" these submerged lands or did it merely have certain rights, privileges, and jurisdiction in the area? British common law after 1776 adapted the concept of the three-mile limit into a doctrine of Crown ownership, granting public rights of navigation and fishing. Although largely recognized in international law, it was not universally accepted. The federal division of power in the United States added another wrinkle. Given acceptance of the British territorial theory, who assumed the rights of the Crown after independence, the central government or the states? Evidence and early legal precedent seems to indicate that each of the thirteen states was a sovereign entity and therefore succeeded to the rights or title of the Crown at the time of the Revolution. These rights or title would also be assumed by states admitted later to the Union through the Constitutional provision that they enter on an "equal footing" with the original states. Gulf Coast states even asserted title that went beyond the three-mile zone. Texas, a truly independent republic before joining the Union, claimed that its boundary, based on Spanish claims and title, extended three leagues, or approximately 10½ miles, into the Gulf of Mexico. In 1938, Louisiana declared the three-mile limit to be outmoded, because of the greater range of modern artillery, and passed legislation, Act No. 55, fixing a new boundary twenty-seven miles into the Gulf, which the state claimed was coextensive with U.S. territorial waters under international law (Bartley 1953, pages 27-57 and 79-94).

A conflicting line of argument regarded sovereignty over the marginal sea as an aspect of international law, and the rights and powers attached to it belonged to the national government through the theory of "implied powers." At least until 1938, however, congressional and executive policy assumed that littoral states held title out to three miles. In October 1934, Secretary of Interior Harold Ickes even rejected an application for a mineral prospecting permit off Huntington Beach, California from Joseph Cunningham, holding that the states retained title as laid down by common law and the Supreme Court and that any challenge to such title should be tried in the federal courts. During the next several years, Ickes reversed his earlier opinion, as he stepped up his campaign to assert greater national control over the oil industry. It is not clear when exactly Ickes changed his mind, but it is clear that he became increasingly possessed by his mission to bring order to the American petroleum market through controlling production, or "conservation," and that such control could best be achieved by the national government. "It is no coincidence," writes Juan Carlos Boué, "that, by the time Ickes *volte face* came about, Congress had passed the Connally Hot Oil Act, the Interstate Oil Compact has been ratified and the Texas Railroad Commission had to a considerable extent succeeded in imposing its will on producers in that state, especially the mavericks in the East Texas field" (Boué and Boué 2002, page 130). Indeed, between 1934 and 1936, a significant shift took place in the U.S. political economy, as the depression deepened, labor and political unrest rose, and the sputtering, corporatist initiatives of the early New Deal gave way to reforms leading to the creation of an incipient regulatory state. Giving states free reign to lease submerged lands off their coasts for development, Ickes grew to believe, would be inimical to his drive to restructure the industry.

In 1937, Ickes initiated a shift in executive policy by encouraging Senator Nye to introduce his resolution proclaiming national dominion over the marginal sea. In congressional hearings over the resolution, Representative Sam Hobbs of Alabama, who supported it, advanced a novel theory of "nonownership" over the bed of the ocean. He argued that neither the federal government nor the states could claim title to submerged lands. Rather, it belonged to the family of nations and was subject only to the right of the United States to take and use it in the exercise of its constitutional powers. The resolution failed, but Ickes continued to push for federal control, encouraging the filing of suits to test the validity of state claims (Bartley 1953, pages 95-143). In May 1943, Ickes formally reversed the Department's position in the Cunningham case and influenced President Harry Truman to issue the September 28, 1945 proclamation, which claimed "the natural resources of the subsoil and sea bed of the continental shelf beneath the high seas but contiguous to the coasts of the United States as appertaining to the United States, subject to its jurisdiction and control." The same day, Truman signed Executive Order 9633 reserving and placing certain resources of the continental shelf under management of the Secretary of the Interior.[12]

At least by the end of World War II, Ickes enjoyed growing support from various parts of the federal government for his campaign. Federal officials concluded from prior experience in leasing other minerals, as well as private leasing of oil lands, that coastal states would not manage offshore oil with conservationist goals in mind, but instead would accelerate leasing in order to increase their fiscal revenues. Furthermore, Truman anticipated worldwide interest in ocean resources, and thus national security considerations underscored his determination to designate and reclaim the coastal sea under federal jurisdiction. The Navy Department, urging the conservation of petroleum reserves for national defense, strongly supported Ickes' position.

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[12] Harry S. Truman, Presidential Proclamation No. 2667 (*Federal Register* 12303: 1945); Harry S. Truman, Executive Order No. 9633 (*Federal Register* 8835: 1945).

Everette DeGolyer, the famous oil geologist and geophysicist who as assistant deputy petroleum administrator during the second World War helped draft much of the federal legislation claiming the tidelands, championed the idea of holding offshore lands as an undeveloped reserve or as a federally regulated province in order to make room for large imports of Middle Eastern oil, which he believed were essential to long-term national security. DeGolyer feared reckless leasing by the states and declared that he "preferred federal development of the tidelands if that meant a more gradual development" (Kreidler 1997).

Almost immediately after Truman's proclamation and executive order, U.S. Attorney General Tom Clark filed an original action against the State of California in the U.S. Supreme Court, challenging the state's right and title in submerged lands below the low-water mark. In 1947, the court rendered its decision, whose majority opinion was written by Justice Hugo Black, sidestepping the question of who had the best legal claim to title in the submerged lands, California or the federal government. The court majority focused on the question of rights and jurisdiction, rather than ownership. Using Hobbs's theory of nonownership as a foundation, Black argued that the federal government had "paramount rights" in and over the submerged lands below the low water mark, out to and beyond the three-mile belt, off the coast of California. Similar decisions in the cases of *United States v. Louisiana* and *United States v. Texas* set off a raging political controversy that lasted six years. On December 11, 1950, the Supreme Court issued a supplemental decree prohibiting further offshore operations without the authority of the United States. The decree prompted the Department of the Interior to ban new explorations but permit wells being drilled to continue to completion. As rental payments and royalties from offshore leases were impounded awaiting final disposition, and as offshore development came to a virtual standstill, advocates of state ownership and control attempted to legislate a return, or "quitclaim," of the submerged lands to the status they held prior to the decisions.

The so-called "tidelands" controversy was a misnomer, because nobody disputed the state's claim to lands lying between low and high water. The issue was control over the marginal sea below the low-water mark. If federal control were upheld, it involved the added complexity of determining where the low-water mark was and sorting out state leases that already had been issued. At first, the sympathies of most oil companies lay with the states. The independents and smaller integrated companies explicitly opposed a federal role in the tidelands. Many majors already held offshore leases issued by California, Texas, and Louisiana, the latter two having leased almost 5 million acres of offshore lands, with 300 leases more than three miles offshore, most in Louisiana's deltaic plain. Oil companies, mainly the major integrated ones, had made some astounding oil finds on those leases, discovering an average of nearly 38 million barrels for every wildcat well, far above the discovery rate for onshore fields in the United States (Attanasi and Attanasi 1984, page 438). Giant oil fields had been discovered on Shell Oil's leases on South Pass Blocks 24 and 27 and Eugene Island 18, The California Company's (Socal) Bay Marchand 2 and Main Pass 69 leases, and Humble Oil's (Jersey Standard) Grand Isle 18 lease. All except Eugene Island 18 straddled or lay beyond the three-mile line. Attorney General Tom Clark's announcement in early 1949 that the Truman administration would recognize prior state leases somewhat allayed these concerns, to the point where the *Austin Report* observed in July 1949 that the "oil companies have long since abandoned the States' side in this fight" (quoted in Kreidler 1997). Supporters of quitclaim enjoyed majorities in both houses of Congress, and a bill was passed in April 1952, only to be vetoed by President Truman (Bartley 1953, pages 195-246).

After the parties and candidates in the 1952 presidential election postured around the issue – Republican Dwight Eisenhower favoring quitclaim and Democrat Adlai Stevenson supporting Truman's position – a compromise was finally reached. On May 22, 1953, Congress passed, and President Eisenhower signed, the Submerged Lands Act. While the act did not recognize the states' claims, it nevertheless quitclaimed to the states all lands permanently covered by tidal waters seaward three geographical miles from the coast line of each state as this boundary existed when the state became a member of the Union. The act preserved federal rights and control over the submerged lands lying seaward of the belt granted the coast states, but invited each of the states bordering the Gulf of Mexico the opportunity to prove entitlement in judicial proceedings to a larger grant up to three marine leagues (approximately 10 ½ geographical miles) by showing it had a boundary extending more than three miles when it joined the Union or that such a boundary previously had been approved by Congress. The Submerged Lands Act essentially divided the continental shelf into two areas, one belonging to the coastal states and the remaining area set aside for the United States. On August 7, 1953, Eisenhower signed the Outer Continental Shelf Lands Act (OCSLA), authorizing the Secretary of the Interior to grant mineral leases on the "outer continental shelf," the name given to the U.S. area, and to prescribe regulations that might be necessary to carry out the provisions of the act. The official U.S. foreign policy position on these acts was that the United States did not claim vis-à-vis other nations that its territorial sovereignty extended beyond three miles, but that the United States did declare its right to lease and manage the resources of the seabed to the outer edge of the continental shelf without exercising territorial sovereignty in the area (Orn 1954, page 81).

These landmark pieces of legislation established a new foundation for offshore oil and gas leasing, but they by no means ended the controversy. Over the years, state-federal conflict over offshore leasing has taken place on two basic issues: developmental impact and territorial jurisdiction. On the development impact issue, the submerged lands legislation granted broad discretionary authority to the federal government for leasing beyond the designated boundaries and made no provision for sharing the revenues collected from leasing between the federal government and coastal states. Apparently, nobody at the time could foresee the tremendous revenues that the federal leasing program would take in over the years and the widespread array of petroleum activities leasing would stimulate. The risks and costs of such development would be borne solely by the states and coastal communities, yet they would receive no compensation in return. In the 1980s, the inequity of this arrangement would erupt in what one observer has called "The Seaweed Rebellion" (Fitzgerald 2001).

Although it took decades for the development impact issue to flare, the territorial jurisdiction issue exploded immediately and burned brightly for many years. The submerged lands legislation left questions about historical boundary claims and the exact location of the coastline open to interpretation. Many millions of dollars were at stake in revenues from existing or future leases to be divided between the federal government and the states depending on where these lines were drawn. Congress did not explicitly set the boundary between state and federal waters, three miles from the coastline, other than to define the "coastline" under Section 2 (c) of the Submerged Lands Act as "the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters." Where the coast was in direct contact with the open sea, the coastline would follow the line of low tide. But where the coast was interrupted by rivers, bays, estuaries, inlets – most notably in Louisiana – determining the location of the base line separating inland waters from the open sea would be the subject of difficult legal and engineering problems (Orn 1954, page 81).

The Department of Interior used the "Chapman Line," named after Secretary of the Interior Oscar Chapman (1942-1953), as a baseline for demarcating federal from state waters along the coasts of Texas and Louisiana. Developed in the summer of 1950 for the Department of Justice for use in the Submerged Lands case before the Supreme Court, the Chapman Line was drawn along the "natural shoreline," or line of low tide, on coast charts issued by the U.S. Coast Guard and Geodetic Survey. State waters were then determined to be inside a line drawn three miles from the Chapman Line into the sea. To determine the point of contact between inland waters and the open sea where the shoreline was interrupted, the survey employed the so-called "Boggs Theory," which essentially marked a straight line across headlands entrances no more than ten miles wide or across a span nearest the entrance which did not exceed ten miles.[13] The department awarded exclusive jurisdiction to the State of Louisiana on leases lying inside the three miles line, and section 6 of the OCSLA provided for the federal recognition and validation of leases issued by states outside the line. In 1954, Interior received 404 applications for continuance or validation of leases under section 6, and close to 270 were continued or validated, consisting of approximately 1 million acres (many of the leases, approximately 50 of the 300 leases off Louisiana for example, straddled the three miles line and thus the portion on the OCS side had to be given a separate and distinct lease). So when the federal leasing program began in 1954, it had an instant inventory of leases.[14] "Interesting to note that 204 of these leases are still producing," observed John Rankin, former regional director of the BLM OCS office in New Orleans, in 1986. "Would that success ratio be maintained!" (Rankin, personal communication, 2000).

3.2.2. Early Federal OCS Leasing and the "Interim Agreement"

Suddenly, after Congress passed the Submerged Lands and Outer Continental Shelf Land Acts and applications for lease validations started pouring in, the Department of the Interior had to create from scratch a federal offshore leasing and regulatory program. Its mandate from Congress, as stated in the policy declaration Section 3 of the OCSLA, was broad: "the Outer Continental Shelf is a vital national resource reserve held by the Federal Government for the republic, which should be made available for expeditious and orderly development, subject to environmental safeguards, in a manner which is consistent with the maintenance of competition and other national needs." In view of the dire warnings from Gulf states politicians and oilmen during the Tidelands political drama about the menace of big government to offshore operations, it is surprising how ill-prepared the federal government actually was to assume the large responsibilities of managing offshore oil and gas exploration and development. It had no

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[13] Donald Clemens, Assistant Chief, Division of Cadastral Engineering, Bureau of Land Management, Memorandum for the record, June 23, 1954, Box 513, Office of the Secretary of the Interior, Central Classified Files (CCF), 1954-1958, Record Group (RG) 48, Records of the Secretary of the Interior, National Archives and Records Administration, College Park, MD.

[14] John Rankin, Acting Solicitor, Memorandum to Director, BLM, February 18, 1955, Box 513, CCF, 1954-1958, RG 48.

specialized bureaucracy, regulations, or models to follow, other than what the states and companies were already doing offshore.

The first order of business called for establishing the regulations to govern leasing. The Bureau of Land Management and the Conservation Division of the U.S. Geological Survey were the two federal agencies responsible for conducting minerals leasing on federal lands in the Department of the Interior.[15] The BLM handled the issuance of leases and pipeline rights of way, as well as all title matters relating to such leases, and prepared the official leasing maps. The Conservation Division managed all operational matters, collecting rentals and royalties and policing the operations. With the passage of the OCSLA, the two agencies extended their jurisdiction to mineral leasing offshore. In the spring of 1954, the directors of the BLM, Edward Woozley, and USGS, Dr. W.E. Wrather, conducted extensive conversations with industry and held a series of government meetings and conferences to draw up the regulations. The BLM and USGS adopted most of the industry's suggestions, according to the directors, "in whole or in substance, since to a great degree they are based on a knowledge of conditions which we do not have..."[16] In fact, it is believed that George Schoenberg, an attorney in New Orleans for Shell Oil, one of the most active companies in the Gulf, did much of the preliminary work (Rankin 1986, pages 21-22).

Section 8 of the OCSLA stipulated that tracts be auctioned by competitive, sealed bidding. "I came to the OCS with a background in oral auctions on federal lands," remembered John Rankin, "and when I think about the difficulty of executing bids, I shudder to think of how long it might have taken to auction one offshore tract." (Rankin 1986, page 24) Section 8 also stipulated the issuance of leases based on a "cash bonus" bid (simply a price to obtain the lease) with a fixed royalty on oil and gas production paid to the government of not less than 12 ½ percent per annum, or a royalty bid of not less than 12 ½ percent with a fixed cash bonus. The early leases issued by the State of Louisiana were obtained by cash bonus/fixed royalty bids, which were overwhelmingly favored by the industry. Cash bonuses/fixed royalties thus became the bidding practice for federal leases as well. The lease areas offered could not exceed 5,760 acres and would last for a period of not less than five years for oil and gas (ten years for sulfur) or as long as oil and gas was being commercially produced or drilling operations were underway as approved by the secretary of the Interior. Before the auction, the department would conduct a resource evaluation of a broad area and then invite industry to "nominate" tracts within that area. The nominations would be published in the *Federal Register* and the department would then select tracts for auction based on the indication of interest by industry in the nomination process and the resource assessment conducted by the USGS. On June 14, 1954, the department put out to industry a call for the nomination of tracts for bidding on the first federal lease sale set for October 13 offshore Louisiana and for a second one November 9 offshore Texas. On July 1, in preparation for the sales, the Conservation Division of the USGS opened a new regional Oil and Gas Leasing Branch office in New Orleans, at 1503 Masonic Temple Building, with a staff numbering 10 people. Not until the next year, however, did the BLM open its own regional OCS office in New Orleans.[17]

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[15] For background on the relationship between the BLM and USGS Conservation Division in minerals leasing, see Marion Clawson, *The Bureau of Land Management* (New York: Praeger Publishers, 1971), pages 139-141.

[16] Directors, BLM and USGS, to Secretary of the Interior, April 27, 1954, Box 513, CCF, 1954-1958, RG 48.

[17] USGS, Conservation Division, Oil and Gas Leasing Branch, Gulf Coast Region, Monthly Engineering Report, December 1954, A-1, RG 57 (hereafter, GCR, MEP, followed by month and year).

OCS conference meetings in July and August, 1954, presided over by Assistant Secretary for Mineral Resources, Felix Wormser, and Assistant Secretary for Public Land Management, Orme Lewis, decided specific procedures and issues for that first sale which would become the norm in the federal leasing program. Conferees agreed that the first leases would offer a 16 2/3 percent royalty rate and a $3/acre annual rental fee. After years of offering leases based on this rate and fee, officials in the program later lost track of how they had been initially established. It appears that the 16 2/3 percent royalty was the sum of the mandated 12 ½ percent royalty plus an amount equal to the severance tax that had been levied by the State of Louisiana. "Never have I known where the $3 per acre came from," confessed John Rankin. Early Louisiana leases charged a rental fee of one-half of the cash bonus. Many of these bids went for around $7,500 per block, which meant a $3,750 annual rental or less than $1/acre for a 5,000 acre block. Texas, meanwhile, charged a $2/acre rental fee. A figure of $3-5/acre was suggested in the early meetings in Interior, and $3/acre was agreed on because $5/acre simply seemed "too high" for leases that had a shut-in gas well. Another figure arrived at somewhat arbitrarily, at least for the first sale, was that of the "minimum bid." Although Interior had the discretionary authority to reject any and all bids, some department officials expressed concern that unnecessary administrative time would be spent rejecting "token" or low-ball bids. At a July meeting of the assistant secretaries and directors, the figure of $15/acre was proposed and accepted as "unobjectionable"(Rankin 1986, page 29).[18]

The other major issues for the first sale were the size of the blocks and the number and location of acres to be opened for leasing. The first OCS leasing maps were extensions of the leasing maps of Texas and Louisiana as authorized by the OCSLA. These states had adopted the Lambert Grid Coordinate System, developed by a Frenchman in the late 18th century for artillery firing. A regular block offshore Louisiana consisted of 5,000 acres and those offshore Texas were sized at 5,760 acres, the maximum allowed by the OCSLA. After drawing the maps, which blocked off acreage extending out to 120 feet water depths, questions arose as to where should the department accept nominations. Should it accept nominations or put up blocks for lease in the "twilight zone," the area between three miles and three leagues that was still disputed by Louisiana and Texas? More specifically, should it focus on areas adjacent to existing production or merely on areas adjacent to state-owned leases? The department received nominations from 14 companies and decided to offer most of the acreage nominated beyond the three leagues or 10 ½ mile line (many companies in fact notified the department that they would not bid inside the line because of the uncertainty as to the claims of the State of Louisiana). This acreage ranged out as far as 50 miles. On August 10, Assistant Secretary Orme Lewis approved the offering of 748,000 acres (and 520,000 acres for sulfur leases), consisting of 199 tracts ranging in area from 1,250 acres (partial blocks) to 5,000 acres (full blocks) (*World Petroleum* 1954, page 86).[19]

Just as the list of tracts to be offered was announced on August 18, the dispute between the state and federal government over jurisdiction entered into a new phase, as the State of Louisiana enacted a statute redefining Louisiana's seaward boundary even further beyond its earlier claim

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[18] Director, USGS, to Assistant Secretary Lewis and Assistant Secretary Wormser, Memo, May 24, 1954, Box 513, CCF, 1954-1959, RG 48; Minutes, OCS Conference, July 20-21, 1954, Box 513, CCF 1954-1958, RG 48.

[19] Director, USGS, to Assistant Secretary Lewis and Assistant Secretary Wormser, May 24, 1954; and Harry J. Donohue, Special Assistant to Assistant Secretary Lewis, August 16, 1954, Box 513, CCF, 1954-1958, RG 48.

(see below). The Interior department briefly lost its nerve. It withdrew the offshore Louisiana offering just a few hours after announcing it, explaining that Louisiana's claim to an extended boundary deserved further study. Then, in early September, department heads changed their minds and reissued the offering, exactly the same as before including the tracts inside Louisiana's newly claimed border. Withdrawing the tracts would have implicitly conceded that the state had a valid claim, which upon closer examination seemed dubious, before the courts or Congress ruled on the question (Linz 1954).

The first federal OCS sale, held as planned at the BLM in Washington on October 13, 1954, surpassed Interior's expectations and gave exceptional promise to the new federal offshore leasing program. The BLM collected $129.5 million on bids submitted by 23 companies for 417,221 of the 748,000 acres offered for oil and gas. Although unimpressive compared to later sales in the 1970s where that much could be laid out for a *single* tract, this represented a significant new source of revenue for the federal government. The Forest Oil Company of San Antonio, Texas made the highest cash bid – $6.1 million or $1,220 per acre for a tract in the Eugene Island area. Gulf Refining ($35.7 million for 22 tracts) and Shell Oil ($18.7 million for 13 tracts) offered the highest total winning bids. Phillips Petroleum, Kerr-McGee and Humble Oil rounded out the list of the top five successful bidders. The money exposed by the companies, at an average high bonus of $310 per acre, signaled that they were serious about the prospects of offshore oil and gas in the Gulf (*World Petroleum* 1954, page 86).

Kerr-McGee, however, did not stay in the top five for long. As the winning bids were read at the auction, the company's exploration managers sitting in the audience realized with horror that they had submitted bids on the wrong tracts. Leases were offered by tract number, which was not the same as the block number. For example, where the sale notice read "LA-41, Block 92, Vermillion Area, 5000 acres," with LA-1 designating the tract number, Kerr-McGee bid on tract LA-92, mistakenly substituting the block number. They had no competition on nine tracts in which they bid this way. Kerr-McGee's attorney, Clark Clifford, wrote in a petition to the director of the BLM immediately after the sale that the company's written bids "did not in truth and in fact express the intention of Kerr-McGee to be tracts desired by them, but instead constituted bids on tracts in which Kerr-McGee had no geological information or interest whatsoever." This being the first federal sale, and considering that the acceptance of the bids under the circumstances would not have constituted a binding contract, the U.S. Comptroller General forgave Kerr-McGee, disregarded the bids, and returned the company's deposits. The incident nevertheless caused a bit of a commotion for several weeks. As the Gulf Coast Region of the Conservation Division reported to the USGS in Washington: "The New Orleans office received numerous inquiries for information whether the money submitted with the bids would be retained or refunded and some very positive opinions as to what should be done."[20]

The next two federal lease sales further demonstrated oil operators resolve to push forward with offshore exploration. On November 9, 1954, the Washington office of the BLM opened the bids for leases off the coast of Texas. Only four companies had nominated tracts, as most were preoccupied with action off of Louisiana. Nevertheless, the department took in high bids of $23.4 million on 19 of the 38 tracts offered, all outside the three league line. The Magnolia

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[20] Clark Gifford to Director, BLM, October 14, 1954, Box 513, CCF, 1954-1958, RG 48 and GCR, MEP, November 1954, A-1 – A-2.

Petroleum Company paid $3.18 million for a single tract, or $2,209 per acre, the highest per acre price paid for a state or federal lease in the Gulf of Mexico up to that point. The third sale, offering lands offshore both Louisiana and Texas, took place for the first time in New Orleans, in the Main Post Office Building on July 12, 1955. By this time, the BLM had opened a regional OCS office in New Orleans managed by Sidney Groom as basically a one person operation. The 1955 sale collected total high bids of $100 million on 94 tracts off Louisiana and $8.4 million for 27 tracts off Texas. Combined, the first three sales of OCS lands held by Interior brought the Federal Treasury more than $252 million in bonuses and first-year rentals on oil, gas, and sulfur leases (Wahl 1955, page 986).[21]

Even before the third OCS sale, the conflict between the federal government and the states over offshore jurisdiction was becoming intractable. On May 18, 1955, the State of Louisiana held a lease sale in which 9 of the 22 tracts offered lay over three miles seaward of the Chapman line. Despite official protest from Secretary of the Interior Douglas McKay in a telegram to the State Mineral Board, three of the blocks were leased. The State Mineral Board retaliated by protesting Interior's July offering, in the form of a Resolution dated May 19, demanding that the United States rescind and abandon its call for bids and warning prospective bidders that the state would take legal action to protect its "property rights" in the contested area of submerged lands.[22]

The year before, in August 1954, Louisiana's state legislature had asserted those rights by passing a statute, Act No. 33, which redefined the state's seaward boundary as a minimum of three leagues beyond the coastline, as described in the act of admission of Louisiana to statehood and union. The novel aspect of the legislation was the definition of the coastline, which the state argued was the dividing line between inland waters and the open sea as determined by the Coast Guard and authorized by acts of Congress in 1807 and 1895. The Coast Guard fixed lighthouses and buoys along this line, as the U.S. Department of Justice pointed out, for navigational purposes, to determine where ships changed from rules for the open sea and to rules for inland waters. Act 33, however, tenuously claimed this boundary as the state's historical coastline and asserted Louisiana rights to submerged lands three leagues beyond it. Because of the many sandbars and islands in these coastal waters, this line in some places reached 37 miles into the Gulf from the Chapman Line (Rankin 1986, page 27; *Offshore Drilling* 1957).[23]

The Act 33 Line came to be known as the "Perez Line" or the "Leander Meander," after Leander Perez, the district attorney for St. Bernard and Plaquemine Parishes. A segregationist candidate for governor in 1951 and infamous political boss of southern Louisiana, Perez had been the driving force behind the legislation. Perez's commandeering of Louisiana's tideland's fight began in the late 1940s when Governor Earl Long appointed him to the post of unpaid special assistant attorney general to help prepare the state's legal arguments before the Supreme Court. Dedicating himself to the cause with unflagging zeal, Perez became the state's unofficial spokesman on the Tideland's question, for years even after he broke with Long in 1950 and lost his special position. As his biographer writes: "He rummaged through dusty Washington bookshops for contemporary works on colonial America, reread Benjamin Franklin's

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[21] GCR, MEP, July 1955, A-2; GCR, MEP, May 1955, A-4.
[22] GCR, MEP, November 1954, A-2.
[23] Leander H. Perez to Judge Simon Sobeloff, Solicitor General of the United States, September 2, 1954, Box 513, CCF, 1954-1958, RG 48.

autobiography, carefully examined the proceedings of the Constitutional Convention, and purchased from the Library of Congress a copy of every Louisiana coastal chart in their files" (Jeansonne 1977, page 166).

Perez resisted the assertion of federal jurisdiction with the same kind of fervor that he pressed the cause of racial segregation. His ideological commitment to "states' rights" was as strong as his economic motivations in claiming for Louisiana the lion's share of the offshore bounty. However, his unyielding stance ultimately proved counterproductive and detrimental to Louisiana's long-term interests. In 1949, the state nearly reached a compromise with the federal government when federal negotiators proposed granting to Louisiana all royalties and bonuses from fields within three miles from shore and, crucially, 37.5 percent of revenues from wells beyond that point. Louisiana's negotiators were preparing to accept the offer when Perez blocked the settlement, refusing to forfeit the state's claim to the disputed area. As it turned out, he ended up forfeiting billions of dollars of revenue for the state as the industry expanded into progressively deeper water in subsequent decades, though at the time he could hardly have foreseen the magnitude of his miscalculation. The developmental impact issue of later years would have been greatly muted for Louisiana had the state accepted the Fed's settlement. Like Joseph McCarthy's numbers for communists in the federal government, Perez's claims for the extent of Louisiana's jurisdiction in the Gulf varied widely. He once asserted that it lay sixty or seventy miles offshore. Meanwhile, he ridiculed the Chapman Line, arguing that it lay so far inland that Russian submarines could navigate miles up the Mississippi River and still be in international waters. "The Chapman goes to Shreveport and the Perez Line goes to Venezuela," one observer wryly commented (Jeansonne 1977, pages 166-167).

Louisiana's challenge to federal jurisdiction on the continental shelf set off a new round of legal wrangling. In May 1955, just before the Louisiana state sale, the U.S. Attorney General Herbert Brownell, Jr., filed a motion in the U.S. Supreme Court asking for a modification of the court's December 11, 1950 decree (see above) to state whether Louisiana's seaward boundary extended three miles or three leagues from the coastline. In October, the Supreme Court denied the motion, casting a pall over offshore operations in the Gulf. Many offshore operators had hoped the court would intervene to fix the boundary and relieve them of the burden of making dual royalty payments and complying with two sets of regulations. Others, who had accepted only federal ownership outside the three-mile line and were not paying royalties to the state, pessimistically interpreted the court's denial of the motion as a reluctance to limit the state's claims. In December, Attorney General Brownell responded by filing an original complaint requesting that the Supreme Court determine the right of ownership in the submerged lands and resources lying more than three miles seaward from the ordinary low water mark along the coast of Louisiana. The table was set for another big, legal showdown.[24]

This came in the run up to the fourth OCS sale planned for June 1956 in which large new acreage – the West Addition to the West Cameron area and the East Addition to the High Island area – had been plotted on the leasing maps. A month before the sale, the State of Louisiana followed through with its legal threat from a year earlier and filed a petition in the State District Court and the Parish of Calcasieu successfully seeking a temporary restraining order preventing the BLM and 25 oil companies from "disturbing the plaintiff's possession, enjoyment, use and

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[24] GCR, MEP, October 1955, A-4; GCR, MEP, December 1955, A-4.

administration of the submerged lands and natural resources or from slandering the plaintiff's title and from offering for lease or accepting or receiving or awarding bids for leases, and from bidding or offering to bid on mineral leases on the land described in the petition which is the Act 33 boundary." The U.S. attorney in Shreveport removed the case from the State to the Federal District Court, which released the corporate defendants from the temporary restraining order but held all other aspects of the order in effect. Upon appeal, the U.S. Supreme Court enjoined the State of Louisiana and the federal government from leasing and operations until the court had made a final determination in the case of the United States' original complaint and the Louisiana coastline or until the parties had reached a working agreement (Rankin 1986, pages 26-27).[25]

Strong economic pressures forced the two sides together. During 1954-1956, the offshore industry had come alive again in southern Louisiana, in both state and federal waters. Oil and gas companies discovered 34 new fields in 1954, 57 fields in 1955, and 72 fields in 1956. The success rate for wildcat exploratory wells was exceptionally high (34 percent in 1956), much higher than onshore. New-fangled drilling and construction vessels were being designed and launched to support exploration and production. Construction yards were ramping up the assembly of steel jacket platforms and beginning to lay marine pipelines. All kinds of new companies, from helicopter services to geophysical contractors to offshore caterers, were emerging as part of this rapidly expanding industry. Both the federal government and the state had a pressing interest in setting aside their differences to keep from nipping offshore development in the bud (Meier and Meier 1955, page 988; Waters and Waters 1956, page 1,253; Waters and Waters 1957, page 1,190).

On October 12, 1956, after months of feverish negotiations, the two parties constructed an "Interim Agreement" enabling the resumption of operations and leasing in the contested area pending final resolution of the controversy. The agreement created four zones. Zone 1 comprised the area out to three geographical miles seaward of the Chapman Line. Zone 2 embraced the area between Zone 1 and a line three leagues seaward of the Chapman Line. Zone 3 spanned the area seaward from the outer edge of Zone 2 up to the juridical boundary claimed by the State of Louisiana, that is, up to the Perez Line or Leander Meander three leagues seaward of the so-called Coast Guard Line. And Zone 4 covered all submerged lands seaward of Zone 3 to the limits of the Outer Continental Shelf. The Interim Agreement awarded the State of Louisiana exclusive jurisdiction over Zone 1, designated Zones 2 and 3 as disputed areas to be administered jointly, and defined Zone 4 as an area of exclusive federal jurisdiction (Rankin 1986, pages 45-48).

In the jointly administered zones, the parties erected a cumbersome but workable framework for holding leases and collecting revenues. In Zone 2, sales would be held under federal jurisdiction, lease forms, and regulations, but only if the tracts proposed for leasing were being "drained" by an adjoining tract. In other words, only if the hydrocarbons under the tract were being siphoned off by a nearby producing lease could that tract be put up for lease. The State of Louisiana was given the right to agree that the proposed tract for offering was indeed being drained. The state also had to agree, after the sale, that the cash bonus received for a tract was adequate. To consider the matter of drainage, officials from the BLM and the state would meet in an ad hoc

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[25] J. Reuel Armstrong, Solicitor, Department of the Interior, memorandum for the files, May 17, 1956, Box 514, CCF, 1954-1958, RG 48.

session. But to determine the adequacy of bids, the Interim Agreement established a procedure whereby the director of the BLM presented to a six person committee, composed of three representatives from the federal government and three from the state, a report on the bids he proposed to accept or reject. The committee's majority vote would be the last word. In the case of a three-to-three tie, the federal position would prevail. In Zone 3, the federal government did not need to justify drainage or obtain the state's agreement to hold a lease sale, but the same procedures as in Zone 2 governed the consideration of cash bonus bids. The revenues derived from leases, rentals, and royalties in Zones 2 and 3 would go into a special account that would be held in escrow until the federal-state boundary question was settled (Rankin 1986, pages 47-48).

The Interim Agreement offered a temporary spatial reconciliation between the State of Louisiana and the federal government over offshore leasing in the Gulf of Mexico. Offshore oil and gas development, which was strongly desired by both parties, could not go forward without at least a provisional territorial regime to guarantee the security of the massive fixed investments that such development would require. Although the "Tidelands Controversy" was by no means over – in fact, it would endure another thirty years before it was finally resolved – the Interim Agreement advanced the political and legal process to a point where conflicting claims to submerged lands would no longer limit the pace and scope of offshore leasing.

3.3. Sales that Revived the Gulf

Just when the Interim Agreement appeared to break the impasse, the industry's enthusiasm for leases evaporated. During 1957-1958, economic recession, an oversupply of crude, a series of hurricanes, and declining oil finds in deeper waters forced a slowdown in offshore exploration. Both dry holes and capital costs were increasing in water depths beyond 60 feet. The percentage of available drilling rigs working dropped from 100 percent in 1957 to 37 percent in 1958 (Frederick 1959, pages 55-56). "The rapid rise and correspondingly rapid decline in offshore drilling operations in the Gulf of Mexico," wrote the president of the American Association of Oil well Drilling Contractors in 1959, "is one of the most surprising phenomena which has occurred in the oil business in many years" (Zeppa 1959, page 59).

Oil companies definitely had not given up on the Gulf, however. They just needed time to reassess the situation. Waiting for the return of better market conditions, managers focused on bringing in production from their many offshore discoveries and improving their exploration technologies. By 1959, the industry was ready to get moving again. The U.S. economy was back in a growth mode. The high success rate of those offshore drilling operations that continued during the recession gave cause for new optimism. In March 1959, President Eisenhower imposed mandatory quotas on oil imported into the United States, expanding the market for domestic oil. And innovations in seismic prospecting – especially the introduction of magnetic tape for recording and the improvements in data processing it afforded – stimulated renewed offshore exploration. Even though the federal-state dispute over the submerged lands still awaited a Supreme Court decision, both Louisiana and the federal government were also ready and willing to implement the Interim Agreement.

In May 1959, the BLM held a small sale offshore Florida (23 tracts leased for $1.7 million), but the big action came on an August 11th drainage sale held for Zone 2 offshore Louisiana. John

Rankin, who had taken over as regional manager of the BLM's New Orleans OCS office in January 1959, remembered the sale very well. "First, it was held on my birthday," he said. "Second, and probably first, my youngest daughter was born the night before. And third, to my consternation, I opened a bid from Shell Oil Company and didn't know whether I could handle such a figure." Shell Oil had bid $26 million for a single, half-block tract adjoining the company's producing leases in the South Pass area. "I gulped twice and read that historic bid which was the record high price per acre bid [$10,442] for many a year [until 1964]."(Rankin 1986, page 48) In all, the BLM leased 19 tracts (39,000 acres) for $88 million. The average bid per acre, $2,267, shattered previous average bids. Combined with the $141 million paid by operators for Zone 1 leases in three sales held by the State of Louisiana in 1959, the August 1959 drainage sale sent a clear message that the offshore play was on again.

Immediately after the sale, oil companies indicated that the time was right for a general lease sale with nominations in Zones 3 and 4. This would be the first general sale since 1955. Some government officials, however, did not appreciate just *how* eager the companies were to expand the offshore horizon. The director of the USGS cautioned against offering too much acreage, especially in the deeper waters of Zone 4. Operators were not ready to drill much beyond 100-foot depths, he insisted, and thus bonus bids for deeper acreage would be reduced. "Any leases acquired at this time in water depths exceeding 100 feet will probably be for speculative reasons."[26] But as the nominations came in for an announced February 1960 sale, John Rankin compared the tracts nominated in the ill-fated 1956 lease sale with those nominated for the proposed sale. He found that there was very little overlap, which demonstrated to him how much the industry had learned in the intervening three years. The move into deeper waters might not be so speculative after all (Rankin 1986, page 50).

Indeed, Shell Oil, which was emerging as the undisputed leader in the Gulf of Mexico, had secretly designed a floating drilling vessel that could take exploratory drilling into 300-feet plus water depths. Upon publication of the initial Call for Nominations for the 1960 sale, the company's representatives convinced the Department of the Interior to withdraw the call and issue a new set of leasing maps with deeper acreage beyond the 300-foot depth contour. With Shell's assistance, the BLM redrew the maps with "south additions" to all the old original blocks off Louisiana and issued a new Call for Nominations. On February 26, 1960, the BLM offered 1.17 million acres offshore Louisiana and 437,000 acres offshore Texas. Once again, offshore operators spent big – $285 million in high bids ($249 million for the tracts off Louisiana) – more than double the amount spent in any previous sale. Shell Oil leased a number of tracts in the Grand Isle Area South Addition, which the company eventually drilled, starting in January 1962, with its revolutionary *Bluewater 1* semi-submersible drilling vessel. The 1960 sale truly opened what many people referred to at the time as "deepwater" (Rankin 1986, page 53; *Offshore* 1960).

The 1960 sale also marked the beginning of a more systematic approach taken by the federal government to offshore oil and gas leasing. The BLM invited all bidders at the 1960 sale to visit the OCS office while they were in New Orleans to discuss future lease sales, and then followed up those meetings with a more formal solicitation of industry's views on OCS leasing procedures. BLM officials asked company representatives a series of questions: How often

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[26] Director, USGS, to Director, BLM, September 18, 1959, folder: Oil and Gas Rates, 1959-1962, 3-1, Box 211, CCF, 1953-1968, RG 57, Records of the USGS.

should lease sales be held? How large should lease offering be (should blocks be offered in less than 5,000 acres)? Should minimum bids be eliminated? Should bids be taken on a sliding royalty rather than on a bonus, or a combination of both? Should bonus bids be financed through installment payments? Should the government waive its inherent right to reject any or all bids? (Rankin 1986, pages 50-51).[27]

"Certainly, we got diverse answers," remembered Rankin (Rankin, personal communication, 2000). The only real consensus was that the BLM should establish a regular schedule for lease sales and forget about installment plans or royalty bidding. The apathy for royalty bidding by the smaller companies was surprising, considering the arguments advanced in some trade journals that cash bonuses created a barrier to entry in offshore leasing. Beyond the issues of agreement, the recommendations for the frequency of sales ranged from once a month to once a year. Opinions on the size of tracts split between offering whole blocks of 5,000 acres and half blocks of 2,500 acres. Seismic information, the companies agreed, was still not accurate enough to allow them to bid large bonuses on unproved areas in smaller tracts of 1,250 acres. Recommendations as to size of sales ranged from specific acreage amounts to offering the whole Gulf of Mexico at each lease sale. "I wanted to offer all unleased blocks in a particular and different map area on a month-by-month basis," said Rankin, who had just come from a program where there was as sale every week. "Fortunately no one listened to me"(Rankin 1986, page 52).[28] For the most part, the discussions with industry convinced the BLM to maintain its leasing procedures but eventually to move the sales onto a more regular schedule.

One of the most controversial issues was the rejection of bids, which had happened for the first time in the 1959 drainage sale. Then in the 1960 sale, the BLM-State of Louisiana committee rejected 10 bids in Zone 3 and the BLM rejected 16 bids in Zone 4, all of which met the minimum bid requirement. However, as explained above, the minimum bid figure was quite arbitrary and was not an accurate estimation of prospective value for any given tract. The rejections created sore feelings and many companies appealed the decisions. Upon reviewing the appeals, as George Abbott, the departmental solicitor, pointed out, some people in the department realized that the BLM "does not have – and perhaps cannot have – precise yardsticks for determining adequacy of bids."[29] But the BLM had a duty to try to insure that the government received fair value for its leases. The OCS office had better information on resources and structures in Zones 2 and 3 than in Zone 4. The federal-state committee that considered the recommendations of the director in Zones 2 and 3 used information furnished by Louisiana's state geologist. Louisiana had been leasing submerged lands for many years and possessed well logs and geologic data which greatly aided the evaluation of bids. For the deeper areas of Zone 3 and for all of Zone 4, however, the government had very little information. The number of people in the Department of Interior with OCS responsibilities, both in Washington and New Orleans, only totaled about 35. The entire regional BLM office in New Orleans consisted of John Rankin, his assistant regional director, Bill Grant, and two support staff. As

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[27] Under Secretary Elmer Bennett to Assistant Secretary Ernst and Assistant Secretary Hardy, April 22, 1960, Box 283, CCF, 1959-1963, RG 48; Assistant Director, BLM, to Under Secretary Bennett, July 28, 1960, Box 283, CCF, 1959-1963.

[28] Assistant Director, BLM, to Under Secretary Bennett.

[29] George Abbott, Departmental Solicitor, to Secretary of the Interior, April 7, 1960, Box 283, CCF, 1959-1963, RG 48; USGS Oil and Gas Supervisor, Gulf Coast Region, to Chief, Conservation Division, April 21, 1961, Box 284, CCF, 1959-1963, RG 48.

Abbott implied, the government simply did not have the manpower, resources, and information to analyze the bids rigorously and scientifically (Rankin 1986, pages 101-102).

So the deeper tracts were subjected to the scrutiny of what came to be known as the "Bierne Eyeball" method. Jim Bierne, the assistant director for administration in the BLM, at the time had responsibility for the BLM's share of OCS administration. Bierne used a simple association method to rule on the adequacy of bids. "Eyeballing" the leasing map, he rejected bids that were unusually low when compared to bids offered for offsetting tracts or that were in close proximity to proven acreage. For example, hypothetically, if a tract brought a high bid per acre of $100, and all surrounding tracts, both adjacent and cornering, brought high bids of $1,000 or more, the $100 per acre bid would be rejected. On the other hand, relatively low bids would sometimes be accepted in very deep, rank wildcat areas. The flaws in the Bierne Eyeball method were obvious to the government geologists involved in OCS work. A particular tract covering the crest of a salt dome, where oil and gas was unlikely to be found, would invite much lower bids than for nearby or adjoining tracts on the flanks of the same salt dome, where the probability of a discovery was much higher. Even for those tracts on the flanks, bonus bids could vary greatly between bidders who all had staffs using sophisticated seismic and geological data unavailable to the Department of the Interior. In reviewing the 1960 sale, E.W. Henderson, oil and gas supervisor for the USGS Gulf Coast region, observed that "It would be difficult for Departmental representatives to determine with any degree of accuracy a reasonable minimum bid for each offshore tract offered for leasing since most of the tracts are considerably removed from developed areas and on salt domes proximity is not a dependable indication of prospective value."[30]

The Bierne Eyeball method nevertheless prevailed until the Conservation Division acquired a larger staff and developed analytical methods for pre-sale tract evaluation in the late 1960s (see Part II). The Secretary of the Interior denied all appeals of rejected bids from the 1960 sale, respecting the collective sense of department OCS officials that the BLM could not waive its right to reject bids and that they did not have enough information on which to base an acceptance of the appeals. In reviewing leasing procedures, it was proposed at one point that the BLM solicit geophysical data from the companies in support of their appeals on rejected bids. Very protective of this data, the industry strongly opposed the idea. By and large, industry representatives accepted the BLM's right to reject bids, but worried about the basis for exercising this right. George Schoenburg, the Shell Oil attorney in New Orleans, remarked to John Rankin, "I would not deprive the Secretary of the discretion to either issue or not issue a lease, but I would not want acceptance or rejection to be made upon a like or a dislike of the color of my hair" (Rankin 1986, page 52).

Despite tensions between government and industry caused by the rejection of bids, the 1960 sale was by most accounts a tremendous success. Further encouraging news for the federal OCS program came on May 31, when the U.S. Supreme Court ruled that Louisiana, as well as Mississippi and Alabama, could claim jurisdiction only over submerged lands out to three geographical miles from the coastline. The Court also validated the three-league boundary claimed by Texas when it entered the Union as well as the extension of Florida's Gulf Coast boundary to three leagues by virtue of Congressional approval of a boundary asserted in

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[30] E.W. Henderson to Chief, Conservation Division, April 21, 1961, Box 284, CCF, 1959-1963, RG 48.

Florida's constitution upon its readmission to the Union after the Civil War. These decisions, however, did not determine the location of the coastline along these states, and Zones 2 and 3 offshore Louisiana continued to be administered under the Interim Agreement. Although final determination of Louisiana's coastline would consume many more years of litigation, the state was forced to drop its liberal territorial claims, placing the federal leasing program on firmer legal footing. Encouraged by the outcome of the 1960 sale, the response from industry to its queries, and the 1960 Supreme Court decision, the BLM prepared for another general sale in the Gulf.

That sale would be held in March 1962. The sale would actually take place on two separate days, two days apart. The response from industry to the call for nominations in October 1961 was so overwhelming that there was no way the New Orleans OCS office could handle a sale large enough to accommodate the demand for leases in one day. Some 20 operators nominated 3.67 million acres, most of which was off the coast of Louisiana (some 30 tracts were nominated off Texas) in Zone 4 and in water depths beyond 100 feet. Path breaking advances in drilling and exploration technology had primed oil companies to explore in ever deeper waters and whetted their appetite for offshore leases. Shell Oil was preparing to test its revolutionary *Bluewater 1* "semi-submersible" drilling vessel in 300 feet of water. Between 1960 and 1962, the most technologically advanced companies in the industry had adopted the seismic exploration technique known as common-depth-point (CDP) data stacking, invented by Harry Mayne of Petty-Ray Geophysical in the late 1950s. CDP stacking greatly enhanced seismic signals by filtering out unwanted "noise," revolutionizing the processing and interpretation of geophysical data. Conoco's development of the "Vibroseis," which substituted manmade vibrations or waves for those caused by dynamite-generated explosions in seismic prospecting, made feasible the multiplicity of source points necessary for CDP stacking without the associated increase in cost if dynamite were the only energy source. On top of these developments, digital seismic recording and processing neared the point of commercial application. The 1960-1962 interval, therefore, was truly a watershed in the technological development of offshore oil and gas exploration, which was reflected in the surging interest in offshore leases for the March 1962 sale.

Aware of the increasingly pent-up demand for leases, the BLM believed it was time to give the companies a chance to really prove what they could do. Leasing officials decided to open up the sale and auction everything that industry nominated. This was a bit of a tough sell to Secretary of the Interior Stewart Udall. It also generated protests from some smaller independents, who felt they could not compete offshore and who feared increased production in an industry they claimed already had an excess or "shut-down" capacity of 3 to 4.5 million barrels a day. John Rankin remembered writing pages of "justifications" for such a large sale. With decreasing oil finds onshore in the United States, combined with rising foreign production, he argued it was increasingly imperative that U.S. companies develop the technology required to explore, drill, and produce oil from the deeper waters of the Outer Continental Shelf. Unless the government provided some incentive in the form of acreage held under lease, it was doubtful that the oil companies could continue with the research and expense necessary to perfect the technology. Rankin made a strong enough case for the big sale. In fact, he anticipated more opposition than what actually materialized. At a meeting in Washington to discuss the upcoming sale, Rankin and E.W. Henderson, the oil and gas supervisor the USGS Gulf Coast region, unrolled a large map with all the nominated tracts shaded in bold colors. Expecting an argument about the offering, they were surprised to find that the only comments from their superiors were: “boy, that sure is a pretty map!” The meeting room was soon vacated, and Rankin and Henderson were left to draw up the sale as they had planned (Rankin 1986, page 8).[31]

The March 13 and March 16, 1962 lease sales became legendary in the industry. Everyone from that era remembers the “the sale so large it took two days to read the bids.” It was in reality one large sale split over two days. On the first day, the BLM offered 401 tracts, of which 212 received bids and 206 were leased. Cash bonuses for the tracts leased totaled over $177 million. On the second day, 410 tracts were offered, 210 received bids, and 195 were leased for cash bonuses of $269 million. Looking at the difference in the average per acre bids – $186 on the first day and $281 on the second – many analysts claimed that bidders took the money exposed in their unsuccessful bids on the first day and upped their bids for the second day. Although this theory was never proved, a study conducted by Rankin in 1984 showed that the difference in production of both oil and gas from the tracts leased on different days was negligible, fueling arguments for sequential or split sale as a way to increase government revenue, which in the end was never put into practice.[32]

Many stories about the March 1962 sale, imagined or real, evolved from this theory of how companies approached the split sale. Oilmen were so secretive about their bids and their methods of attaching dollar figures to tracts that nobody will ever really know what their strategies were. A penny could theoretically decide who won or lost a particular tract. The fewer people involved in making the final decision, the fewer chances for leaks. On the morning of March 16, just before the second day’s sale, a land man took John Rankin into a conference room rented in the old Roosevelt Hotel in New Orleans for a bidding meeting for the second day, and Rankin recalled seeing cover pages of a magazine entitled *Hush* taped over each vent in the room to prevent whispers of the strategy meeting from escaping. Joe Foster, a drilling engineer who was responsible for computing reserve estimates and economic calculations for Tennessee Gas (Tenneco) at the time, remembered keeping the company’s deposit checks, which were to be submitted with the bids, under his mattress the night before the sale. “The land man did not want to keep them in his room because he was afraid somebody might break in and discover the value of our bids on those checks,” said Foster. “That is how paranoid we were!”(Rankin 1986, page 57; Foster, personal communication, 2002)

The March 1962 sale was a landmark in the history of offshore development in the Gulf of Mexico, for several reasons. First, it reopened the Gulf of Mexico to a broader range of players. Forty companies or combinations of companies bid successfully in the sale. Although independents like Kerr-McGee, Pure Oil, and Magnolia Oil had been early pioneers in the Gulf, the majors integrated companies, especially Shell Oil and The California Company, had quickly overtaken them as the dominant players. During the 1951-1960 period, the majors drilled over 90 percent of the wildcat wells in federal waters (beyond three miles) and over 75 percent of the

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[31] U.S. Representative Jim Wright to Stewart Udall, March 2, 1962, Box 284, CCF, 1959-1963m RG 48; John Kelly, Assistant Secretary of the Interior, to Representative Jim Wright, March 9, 1962, Box 284, CCF, 1959-1963, RG 48; Ibid., 55-56.

[32] GCR, MEP, March 1962, A-1; U.S. Department of the Interior, “Petroleum and Sulfur on the U.S. Continental Shelf,” Internal Study, August 1969, Box 134, CCF, 1969-1972, RG 48.

wells in state waters. The majors also accounted for nearly 100 percent of the discoveries in federal waters and over 80 percent in state waters. By the late 1960s, however, non-majors were drilling nearly 30 percent of wildcat wells in federal waters with a corresponding rise in their share of discoveries. Putting so much acreage up for sale, first in 1960 and then really opening up in 1962, not only provided more leases for a larger number of companies to choose from, but it also drove down the price of cash bonuses, allowing smaller companies to acquire a piece of the action (Attanasi and Attanasi 1984, page 440).

Still, the majors retained a commanding lead in exploration, especially in the deeper waters. The big spenders on cash bonuses in the sale were Humble ($63.1 million), Gulf ($46.6 million), and Shell ($45.5 million). Not far behind was Tennessee Gas ($43.3 million), a very well-managed gas company that was betting heavily on the Gulf for future gas supplies. Although the California Company only spent $17.8 million in bonuses, it acquired 50 tracts, second only to Shell's 57. What separated some of the majors from all the rest was not only capital, but science and technology. Humble, Gulf, Shell, and Chevron had the most sophisticated exploration and production research organizations in the industry. In the 1962 sale, it appears they all began to develop their bids, for the first time really, with rigorous and quantitative studies of reserve estimates, risk discounting, rates of return, and bidding tendencies of competitors. In previous sales, a lot of guesswork and hunches had gone into formulating "back-of-the-elbow" bids. But by 1962, the more advanced companies began to arrive at bids that contained more concrete numbers.[33]

In 1959-1960, for example, Shell Oil geologists undertook a major quantitative study of all the known salt dome fields of southern and offshore Louisiana and tried to discover why some were better than others. According to Shell geologist Jerry O'Brien, "the idea was how can we look at a huge sample and arrive at some sort of a value which is not based on hysterics, or whim, or some old theory that someone had?" They discovered that the better fields had certain characteristics in common, such as a good balance between sand and shale in the section, a minimum area of uplift, and certain kinds of geologic closure and quality of objectives. Then they plotted out correlations on a chart to help them evaluate the huge number of prospects that were going to be put up for sale in 1962. Shell also had paleontologists estimating the age and environment of deposition in order to help predict the kind of sand-shale section in the prospects. Once all the geological work was done and advanced geophysical data collected and processed, the next step was determining how much oil and gas from a prospective field would be in a particular block, which was very tricky. Gene Bankston, who was with Shell Oil's E&P economics department at the time, explained: "a typical block would have some part of a potential oil field underlying it, and we would have to look at the probability of certain amounts of oil or gas, or both; and then, we had to provide a development scheme that showed how they would be developed and produced, and based on this calculate a value we could afford to bid, with the proper discounting for risk." The other major players were developing similar quantitative approaches to bidding, allowing them to put their money where their mouth was in the sale. They were able to risk such large sums of money, not simply because they could afford it, but because they could back it up (O'Brien, personal communication, 2000, pages 10-14; Bankston, personal communication, 1999, page 9).

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[33] GCR, MEP, March 1962, A-2.

From the oil industry's perspective, the 1962 sale turned the Gulf of Mexico into the major focus of oil and gas exploration in the United States. "One could speculate," wrote Shell Oil's production manager in New Orleans in 1963, "that perhaps this area or province offers the best place to find large oil and gas reserves in this country, and maybe one of the last places" (Pittman 1963, page 9). Oil companies acquired almost 2 million acres of new leases, much of them in unprecedented water depths (the average water depth of leases in the 1962 sale was 125 feet, compared to 67 feet in 1954-1955 and 89 feet in 1960). The sale also opened up larger areas in the Western part of the central Gulf – Eugene Island, South Marsh Island, Ship Shoal areas – in addition to the delta regions which had been the scene of the most activity until then. This inventory of leases would keep the industry busy for the next five years. Indeed, the BLM did not hold another general sale until 1967. Meanwhile, all phases of exploration and development offshore Louisiana enjoyed boom times. Oil companies wasted no time drilling their leases. By September 1963, there were nearly 90 drilling operations in progress. According to one estimate, the industry was spending $1 million per day on drilling alone (Pittman 1963).

The risks and expenditures laid out by the industry were amply rewarded. Although the success rate of exploratory drilling offshore Louisiana in the immediate years after 1962 could not match the extraordinary record of the late 1950s, overall drilling success in the Gulf approached the U.S. average of 60 percent. The real impressive numbers were in the drilling success on federal leases issued in 1962 compared to earlier sales, and the reserve finding rate per exploratory well. Out of 420 leases issued in the1962 sale, 252 or 60 percent were productive as of 1969, compared to 178 productive leases out of 410 for the four previous federal sales. Most significant was the number of exploratory wells per giant field (100 million barrels) discovery: 155 for offshore Louisiana versus 3,773 for the United States as a whole. As of 1968, 14 of the 62 giant fields discovered in the United States were offshore Louisiana, and 11 of those 14 lay either wholly or partially within federally administered areas. Total offshore production from the Gulf of Mexico rose from 127.6 million barrels in 1962 (4.8 percent of total U.S. production) to 334.6 million barrels in 1968 (8.6 percent of the U.S. total), all but about 30 million barrels of this increase coming from federal areas, and most of it from acreage leased in 1960 and especially 1962.[34]

The 1962 sale had another important, long-range effect on the offshore industry. It fostered greater technological cooperation among firms and the standardization of practices. With only five years to establish oil and gas production on 420 leases, companies in the industry had to work together to find ways to operate safely and economically in increasingly precarious depths. Shell Oil set things in motion in January-February 1963 when the company held its famous and unprecedented three-week "school" on offshore technology for representatives from industry and government. Paying "tuition" of $100,000, seven companies along with the USGS signed up for a series of courses on all aspects of Shell's innovative deepwater drilling and production program, from floating drilling to sub-sea well completions. Shell offered its technology to the industry, explained Ron Geer, a top engineer in the deepwater program, because in the 1962 sale the BLM had not honored some of the company's bids on the deepest tracts in 300 feet of water where Shell was the only bidder. Senior management concluded that there had to be greater competition, both to enable Shell to continue acquiring deepwater acreage and to stimulate the

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[34] Department of the Interior, "Petroleum and Sulfur on the U.S. Continental Shelf."

commercialization of the technology. The costs and risks were so high that no one company could venture alone into deepwater. Other oil companies, as well as suppliers, manufacturers, and construction firms could only progress deeper together. "We realized that the only way we could ever have access to those frontier areas was to share our knowledge with the rest of the industry, to give them a base of technology from which they could expand," said Geer (Abbott 1984, page 10). The 1962 sale, in other words, sparked the diffusion of drilling and production technology and created a greater sense of technological purpose that eventually culminated in 1969 with the organization of the Offshore Technology Conference (OTC).

Finally, the 1962 sale had major implications for federal offshore leasing. The $445 million collected in bonus bids opened people's eyes to the importance of the program. Government analysts, particularly in Interior, were awakened to the fact that this program, with only about 30 people total, part of whom did not even devote full time to it, took in more money in a single sale (and in later years a single tract) than all the timber sales in Oregon and California and onshore mineral leasing for the year *combined*. "My office began receiving daily attention rather than only on sale day," said John Rankin. The 1962 sale, of course, was an anomaly. It brought an end to lease sales where most tracts nominated, with a few exceptions, were offered. In future sales, the BLM and the USGS Conservation Division, like industry, would become more rigorous and scientific in its approach to evaluating and leasing tracts. Offshore leasing was now big business, and the federal government had large and expanding responsibilities for regulating it.

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4. Technology and Strategy of Petroleum Exploration in Coastal and Offshore Gulf of Mexico

> It takes luck to find oil. Prospecting is like gin rummy. Luck enough will win but not skill alone. Best of all are luck and skill in proper proportion, but don't ask what the proportion should be. In case of doubt, weigh mine with luck (Everette DeGolyer, quoted in Knowles 1978, page 300).
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> It is the genius of a people that determines how much oil shall be reduced to possession; the presence of oil in the earth is not enough. Gold is where you find it, according to an old adage, but judging from the record of our experience, oil must be sought first of all in our minds (Wallace Pratt, quoted in Pratt 1943, page 1).
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> We usually find oil in new places with new ideas. When we go to a new area we can find oil with an old idea. Sometimes also we find oil in an old place with a new idea, but we seldom find much oil in an old place with an old idea (Parke Dickey, 1958, quoted in Dickey 2002, page 36).
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>> My own view is that it's easy to find oil. It's hell to make money
>> (Marlan Downey, 1991, quoted in Steinmetz 1992, back cover).

4.1. Introduction

The quotes from DeGolyer, Pratt, Dickey, and Downey capture the essence and historical evolution of the search for petroleum. They each reveal the preoccupations with risk, failure, innovation and fortune that have always characterized exploration. Taken from different points in time, these observations also demonstrate how exploration has changed from a crapshoot informed by hunches and rewarded largely by luck, to a sophisticated endeavor requiring vision and invention, to a modern science that has nearly become a victim of its own success in finding commercial prospects. With modern industry and indeed whole economies dependent on it, oil is still the greatest prize and exploration still the greatest game.

For decades, the Gulf of Mexico has been one of the most lively and captivating exploration frontiers in the world. The history of the petroleum industry from its early days on the Texas-Louisiana coast to its recent conquests in the "deepwater" Gulf exemplifies, better than anywhere in the world, the transformation of the oil exploration from an unsophisticated prospecting endeavor to a high-tech business. The Gulf Coast was the first area of the world to employ geophysical technology rigorously in a successful hunt for oil. The introduction of the torsion balance and the refraction seismograph in the 1920s enabled the successful search for buried salt domes in the region. In the 1930s, the reflection seismograph transformed the business of petroleum exploration in nearly every oil region in the United States, but its greatest economic impact was on the Texas-Louisiana Gulf Coast, where it refined the search for salt domes and effected changes in exploration strategy.

Combined with developments in drilling and well logging, geophysical technology pushed the industry from onshore marine environments into offshore waters of the Gulf of Mexico. In the 1940s and 1950s, the move from onshore leasing from various private and public landowners to offshore leasing by competitive bid from state and federal governments placed an even greater premium on geologic and geophysical capabilities, as incentives for speculative leasing were fewer offshore. Oil firms and their companion service companies faced unprecedented challenges and made rapid strides in learning how to drill and produce hydrocarbons from increasing water depths offshore, but not without steep rises in the costs of development, which mandated greater accuracy and effectiveness in exploration.

While recognizing the amazing accomplishments and steep learning curves of production engineers, construction and shipbuilding companies, and all the mechanics and tinkerers along the Gulf Coast who helped make offshore a going proposition, it must be understood that the primary challenge was not figuring out how to build and service offshore platforms, but figuring out *where exactly to build* them and *how much to pay* for them. Often, when production engineers were asked the question, "how deep can you build a platform," their typical reply was, "tell us how much you are willing to pay for a platform, and we'll tell you how deep we can build it." So a key historical question in understanding the evolution of this industry, it seems, is "how did oil companies determine how much money they were willing to pay for a platform?"

The answer to this question, of course, depended on the costs of finding new reserves, which in turn depended on two things: 1) the terms of access; and 2) the costs and accuracy of exploration. Finding commercial quantities of oil in a risky, high-cost environment was the name of the game. Yet the story of offshore Gulf of Mexico has really not been told from the perspective of the managers, geoscientists, and surveyors who pioneered path-breaking exploration technologies, took the risks, found the oil, and made the play. The drillers and platform builders, so far, have stolen the limelight.[35] The narrative needs to be placed in the context of evolving geophysical technology, with attention to how such technology shaped exploration strategy, and how the economics of leasing and exploration, in turn, drove technological innovation. It needs to include the contributions of local residents and entrepreneurs in helping oil companies get into the swamps, marshes, and open waters, as well as the disappearance of this local support niche as operations and sources of technological innovation became more sophisticated and distant from onshore support centers. Most importantly, it needs to include the role of geophysical contractors in pioneering a string of innovations in seismic surveying and the associated changes in research and development at the major oil companies to keep up with and accommodate the growing importance of geophysics.

While exploration geophysicists and geologists have studiously documented the history of geophysics, they have underemphasized the Gulf Coast origins of commercial geophysical surveying and the close relationship between technological innovation in this field and the

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[35] See, for example, Joseph A. Pratt, Tyler Priest, and Christopher J. Castaneda, *Offshore Pioneers: Brown & Root and the History of Offshore Oil and Gas* (Houston: Gulf Publishing Company, 1997); Clyde W. Burleson, *Deep Challenge! The True Epic Story of Our Quest for Energy Beneath the Sea* (Houston: Gulf Publishing Company, 1999); Robert Gramling, *Oil on the Edge: Offshore Development, Conflict, Gridlock* (Albany, NY: State University of New York Press, 1996); and Tai Deckler Kreidler, *The Offshore Petroleum Industry: The Formative Years, 1945-1962* (Ph.D. Dissertation, Texas Tech University, 1997).

particular characteristics of the region's geology and stratigraphy.[36] The deep-seated salt domes and sedimentary strata along the coast and on the continental shelf in the Gulf of Mexico hold vast amounts of petroleum, but they are geologically complex, with massive salt sheets and extrusions, steep-dipping and highly faulted beds, and numerous but thin and often indistinguishable sands in which hydrocarbons are difficult to pinpoint. Early on, exploration in this region came to depend on continuous improvements in geophysical techniques. The development of marine geophysical operations in the 1950s enabled leaders in the industry to realize economies of scale in gathering seismic information. The introduction of magnetic tape recording and "common-depth-point" shooting in the late 1950s, closely followed by digital processing and recording in the early 1960s, provided for a quantum leap in the amount of data that could be handled and manipulated. This led to an almost continuous innovation in seismic processing and interpretation, with the "deconvolution" of signals caused by reverberations in water in the early 1960s, the direct detection ("bright spots") of hydrocarbons in the late 1960s, three-dimensional seismic in the late 1970s, and 4-D or "time-lapse" seismic today. All of these innovations saw their greatest application offshore and especially in the Gulf of Mexico. Advances in digital seismic technology in the 1980s and 1990s initiated a shift in continental shelf/deepwater plays, as majors upgraded to deepwater tracts and sold off shelf tracts to smaller independents who used the technology to extend the life of older fields.

From the standpoint of exploration, there is greater continuity in the story of the oil industry's move from inland south Louisiana to offshore Gulf of Mexico than is revealed in traditional offshore narratives, which emphasize a fundamental discontinuity in engineering practices. The offshore environment certainly presented unique and daunting challenges, but we must piece together the threads of continuity to appreciate the industry's willingness and ability to confront great uncertainty and risk in the open Gulf.

4.2. Salt Domes and Salt Water: Gulf Coast Exploration Technology to 1945

4.2.1. Grand Entrance of Geophysics

The discovery of the giant oil field on the Spindletop salt dome in January 1901 ushered in the modern age of oil exploration. It vaulted the Gulf Coast of the United States to prominence in the world petroleum industry. This region also became the first big oil province not dominated by the Standard Oil colossus. The soon-to-be majors Gulf Oil Corporation and The Texas Company among other firms would establish a strong foothold there. At Spindletop, one well produced 100,000 barrels/day (b/d), capable of producing one-fourth of the entire world's annual production at the time. Spindletop also created the legend of the wildcatter, whose swashbuckling spirit and penchant for risk-taking would define the image and stereotype of the Southwestern oilman.

As legendary geologist Michel Halbouty has explained, science played no role in this discovery. Humans did not even begin scientifically to study the earth until the eighteenth century. By the end of the nineteenth century, the science of geology was still in its infancy, and the few

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[36] See, for example, George Elliott Sweet, *The History of Geophysical Prospecting* (Los Angeles: The Science Press, 1966); and L.C. Lawyer, Charles C. Bates and Robert B. Rice, *Geophysics in the Affairs of Mankind: A Personalized History of Exploration Geophysics* (Tulsa, OK: Society of Exploration Geophysicists, 2001).

geologists at work in the United States were most concerned with the origin and age of the earth, the mechanics of mountain formation, or the classification of rocks. Prospectors employed doodlebugs, divining rods, or other instruments of metaphysical prognostication in the search for oil, and they often adhered to superstitions which held that drilling sites be kept close to cemeteries or on the right-hand forks of creeks. Leading geoscientists of the day believed that the unconsolidated sands underlying the Gulf Coast area could not contain oil and that drilling anywhere in the region was a waste of time. Beaumont trader Patillo Higgins, who persevered in drilling at Spindletop, "had the faith and the determination to pursue his belief in face of lay and scientific criticism, and he proved to all, especially those geologists who called him "fool," that the so-called "oil experts" were not looking ahead, much less keeping up with current developments" (Halbouty 1957, page 19). Or, as oil historian Edgar Wesley Owen writes, "the story is of astute geological hunches by nonprofessionals and lack of intuition on the part of more expert scientists" (Owen 1975, page 195).

Higgins had read enough geology to believe that the prominent hill seeping gas a few miles from Beaumont might be a favorable structure for the presence of petroleum. His partner, Captain Anthony Lucas, had witnessed oil showings from salt drilling operations at Avery Island and Jefferson Island, Louisiana. But they were still operating on a hunch. In 1871, Rumanian geologist Franz Pošepný had observed that petroleum in Rumanian Moldavia was associated with salt domes, but his contribution and other European literature on salt were largely unknown in the United States, even thirty years later when oilmen and geologists observed that the gushing Spindletop hill was similar to mounds bearing salt, sulfur, and shows of oil at many locations in Louisiana and Texas. After Higgins and Lucas struck "black gold," leasing and exploration soon commenced in a feverish pace east and west of Spindletop on every low groundswell that seemed to indicate the existence of a salt dome.

The entire Gulf Coast was pocked by these features, a vast field of oil reservoirs in the imagination of many oil men. New oil fields indeed were proven by the end of 1901, at Jennings, Louisiana, most notably, and elsewhere. They were discovered mainly on the basis of simple surface observations of oil or gas seeps ("paraffin dirt"), sulfur-water springs, asphalt beds, and distinct topographic features. Yet, despite the stunning success of early drilling, the notion that every salt dome sat atop a huge pool of oil proved to be fanciful. Not all salt domes yielded oil, and some not until after several years of development, as major reserves tended to be restricted to a single flank or segment of the structure. Drillers were handicapped by the lack of subsurface knowledge and crude rotary drilling methods. By 1911, oil companies had verified the existence of 36 salt domes; 22 of them were discovered before the end of 1901. Almost all the 36 domes eventually produced oil, especially after 1913 when drilling moved off the tops of the structures to explore the flanks, where the sands turned out to be much more productive. Many drilling failures, however, accompanied each discovery. Only 12 more domes were discovered before 1924, when geophysical methods of prospecting were introduced in the region. Meanwhile, Gulf Coast geologists focused on developing theories to explain the origins of salt domes, correlating surface indicators with well data (Owen 1975, pages 191-203).

The northern Gulf of Mexico, geologists later pieced together, is a great geosyncline, a giant downwarp of the earth's crust filled with tens of thousands of feet of ancient river sediment deposited over 100 million years. Except for the extensive carbonate parts of the Florida and

Yucatan shelf platforms, deposition during the Tertiary period (2 to 65 million years ago), which represents the largest sedimentary section, was predominantly clastic, composed of non-marine sands and shales. The landward extent of the Gulf Coast geosyncline is the outcropping Cretaceous and basal Tertiary sediments approximately 200 miles north of the shoreline. The southern extent is located beyond 400 miles into the deepest water (12,000 feet) of the Gulf near the Sigsbee Scarp. Drill down 20,000 feet under the shallow seafloor off Louisiana and one is still in the Miocene epoch sands deposited 5 to 24 million years ago. Some places contain more than 60,000 feet of sediment above the Upper Cretaceous. The crust can only take about 40,000 feet of sediment, however, before heaving it upward. Ancient subsidence and heaving created complex fold and fault systems in the northern Gulf. At great depths, the sediment was heated and melted, releasing water, oil, and gas from the rock, which eventually found their way into the structural traps created by folding and faulting (Atwater 1959, pages 131-32; Antoine and Gilmore 1970, pages 37-38).

Sodium chloride, or rock salt, also migrated up through the strata. The shrinking of ancient oceans once stranded bays that gradually dried up and left plains of salt which were later buried deep under layers of sediment deposited by returning waters. The action of salt under these extensive layers is eloquently described by essayist John McPhee:

> Salt has a low specific gravity and is very plastic. Pile eight thousand feet of sediment on it and it starts to move. Slowly, blobularly, it collects itself and moves. It shoves apart layers of rock. It mounds upon itself, and, breaking its way upward, rises in mushroom shape – a salt dome. Still rising into more shales and sandstones, it bends them into graceful arches and then bursts through them like a bullet shooting upward through a splintering floor. The shape becomes a reverse teardrop. Generally, after the breakthrough, there will be some big layers of sandstone leaning on the salt dome like boards leaning up against a wall. The sandstone is permeable and probably has a layer of shale above it, which is not permeable. Any fluid in the sandstone will not only be trapped under the shale but will also be trapped by the impermeable salt. Enter the strange companionship between oil and salt (McPhee 1981, pages 75-76).

Geologists eventually classified three different kinds of salt domes: "piercement-type" domes, in which the salt remained near the surface throughout their history, piercing sediments shortly after their deposition; "deep-seated" domes buried beneath thousands of feet of sediment; and "intermediate-type" domes falling in between. By the 1960s, more than 400 salt domes had been identified in the Gulf Coast province through drilling alone, and thousands more indicated by geophysical measurements (Antoine and Gilmore 1970, page 37; Halbouty 1967).

In the 1920s, knowledge of the "strange companionship" between oil and salt was still in its infancy, although it had begun to move out of the realm of divination and into the realm of science. Prior hypotheses about the origin of salt domes claimed that they were a by-product of volcanic action or a result of the expansive force of growing salt crystals. Everette Lee DeGolyer, a founder of the American Association of Petroleum Geologists and the man many people regard as the founder of modern geophysics (see below), was the first American to recognize and develop the idea of "plastic flow." "De," as he was affectionately known among friends and colleagues, published dozens of geological and geophysical papers during his career, but in the early years he was most interested in the origin of salt domes. After extensive reading about the concept in European geology, DeGolyer wrote influential articles beginning in 1918 that changed the thinking of American geologists about how salt domes developed. Still, geologists had few tools for understanding the subsurface. Outcrops could not be found in the region, and drillers' logs were unreliable. According to Halbouty: "the only real tools that were available for scientific study were the bit, the few honest drillers' logs and micropaleontology" (Halbouty 1957, page 19). Furthermore, the discovery of the huge Caddo Lake field in 1904 shifted the attention of geologists in this region to northern Louisiana. By the early 1920s, no important new fields were being developed in southern Louisiana, and low crude prices tempered the enthusiasm of oil operators to hunt for more (Steinmayer 1957).

The introduction of new geophysical techniques rejuvenated exploration for buried Gulf Coast salt domes. In fact, geophysical exploration with the torsion balance and refraction seismograph achieved its first notable success on the Gulf Coast in the mid-1920s, after previously demonstrating the capability to map subsurface structures in Europe. The first geophysical contracting firm in the United States actually appeared in 1921, when four talented scientists who had studied reflected blast waves to detect the location of enemy artillery for the U.S. Bureau of Standards during World War I – William P. Haseman, John C. Karcher, E.A. Eckhardt, and Burton McCollum – organized the Geophysical Engineering Company (GEC). GEC did experimental work, underwritten by Marland Oil Company, employing reflection seismology (see below) to search for petroleum in Oklahoma. However, their results were inconclusive, and geophysical prospecting in the United States soon turned to the Gulf Coast and to other equipment and methods, though the principals in GEC would go on to shape the evolution of geophysical technology in profound ways. In July 1924, Amerada Petroleum Corporation and its affiliate, Rycade Oil Corporation, used the Eötvös torsion balance, named after Baron Roland Eötvös, a professor of experimental physics at the University of Budapest, to locate the Nash dome in Brazoria County, Texas. This is generally acknowledged as the first discovery of oil using geophysical instruments.

The Eötvös torsion balance essentially measured changes in the earth's gravity field at different points over a given area by light metal beams suspended from a hair-like torsion wire. Everette DeGolyer, who in 1919 became vice president and general manager of the newly created Amerada and who had been diligently searching for a practical geophysical instrument, sought out and obtained the first device for the United States. "If DeGolyer was spending a goodly portion of his time writing and thinking about how salt domes were formed," writes George Elliott Sweet, "you can be sure that he was also thinking long and hard about how best to find those buried domes that had no surface expression or surface seepage indication" (Sweet 1966, page 99). The new instrument proved more precise than pendulum devices, which had been used to measure gravity since the 18th century, although improved pendulums were applied with some success along the Gulf Coast in the early 1930s. Royal Dutch-Shell and the Gulf Production Company (an affiliate of the Pittsburgh-based Gulf Oil) began experimenting with the torsion balance about the same time as Amerada-Rycade, and each had success locating salt domes. Unfortunately, many of the domes showed little or no oil and the torsion balance fell into disrepute until 1929, when the discoveries of deeper domes confirmed the theory behind early torsion-balance surveys and the seismograph refined discredited prospects. More efficient and lightweight gravity meters or "gravimeters" soon replaced the torsion balance and eventually found widespread use in the search for salt domes in marine areas (Owen 1975, pages 755-757).

Gravity instruments were most effective in structural reconnaissance work. Also at this time, magnetometers, which measured changes in the vertical component of the earth's magnetic field, demonstrated capabilities for reconnaissance, especially where crystalline basement rocks were part of large local uplifts. For detailed prospecting and mapping, on the other hand, the seismograph was the answer. Whereas gravity and magnetic methods showed only average properties of all subsurface rocks, the seismic method distinguished rocks of different properties at particular depths. Scientists for years had suggested using seismology – the measurement of acoustic wave velocities through elastic layers in the earth's crust – for determining geologic structure, and the Germans had adapted the technology for locating enemy artillery during World War I. Only after the war, however, did companies deploy the seismograph in the hunt for oil.[37] In 1923, Royal Dutch-Shell made the first large-scale seismograph trial in Mexico. Soon after, Marland Oil Company introduced it into the United States, first in Oklahoma and then later in East Texas and the Gulf Coast. Both oil companies contracted with a German firm, Seismos Gesellschaft, founded by Dr. Ludger Mintrop, to conduct the seismic surveying.[38]

Mintrop had obtained a German patent on a seismic technique that came to be known as refraction. In a refraction survey, a charge of dynamite set off near the surface created a shock wave which traveled through the earth and was picked up by a series of seismometers or "geophones." Connected by wires to a central recording point, these devices detected the first of the acoustic waves and thus allowed for an accurate determination of the travel time from the point of explosion. These waves traveled through soft formations, such as sand and shale, in underground arcs at a known velocity. A hard or more compact formation, such as a salt dome, would transmit the waves at a much faster rate, in effect refracting them like a prism. Refracted waves would arrive at the geophone abnormally fast, often indicating the presence of salt.

The early tests turned in disappointing results, mainly because they were performed in areas with no shallow salt domes, and amplification of the sound signals on the Seismos mechanical seismographs was too low to detect deeper structures. But in June 1924, a Seismos crew working for Gulf made the first ever seismic discovery of a buried salt dome – the Orchard dome in coastal Texas – which contained commercial amounts of oil. During the next year, this crew mapped three more Texas domes by seismic refraction. The success of the new method truly marked a breakthrough in the art and science of petroleum exploration. News traveled fast, and by the end of 1926, refraction crews had combed large parts of coastal southeast Texas and southwest Louisiana for shallow salt domes (Beaton 1957, page 203; Owen 1975, pages 504-505). "The years 1924 to 1927 saw the wildest competition between oil companies in the history of the Gulf Coast," remembered O. Scott Petty, who in 1925 co-founded Petty Geophysical. "Suddenly, almost overnight, there appeared a way to find shallow domes fast and with certainty" (Petty 1976, page 21).

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[37] For comprehensive histories of seismology and geophysical forebears, see Sweet 1966; and Lawyer et al. 2001, pages 1-12.

[38] For more on Mintrop, see Sweet 1966, pages 89-92.

Seismos supplied the instruments and outfitted most of the crews for this burst of exploration, and improvements to the method allowed for more rapid surveying. One weakness of the early work by Seismos was that the profiles taken by shooting along a straight line yielded inconclusive observations unless that line happened to cross a shallow salt plug directly. Velocity contrasts were not distinct enough in some places to be recognized by the instruments. L.P. Garrett, Gulf Oil's chief geologist, suggested placing several geophones in a fan-shaped pattern radiating from a single shot point, which would allow for a more detectable "time lead" on any line whose waves were refracted through a salt mass. In addition, a smaller number of shots would be required to search for domes over a large area. Although it provided better and cheaper coverage than profile shooting, fan-shooting could still miss salt domes. And despite the acceptance of the revolutionary new technology and the improvements made by fan-shooting, Seismos had only proven that it could find shallow domes. Slow to refine its instruments and field techniques, the German company soon lost ground to more aggressive innovators and in 1930 discontinued operations in the United States (Sweet 1966, page 92; Owen 1975, page 505).

The strongest competition came from the Tulsa-based Geophysical Research Corporation (GRC), an Amerada Petroleum affiliate established in 1925 by Everette DeGolyer. Under the direction of John C. Karcher, who had done pioneering work on seismic technology at the Bureau of Standards, GRC acquired a patent held by Reginald Fessenden (chief physicist for the Submarine Signaling Company of Boston) for recording both refraction and reflection waves in search of "ore bodies" and quickly made vital enhancements to refraction seismology. DeGolyer and Karcher realized that shallow salt domes were not that hard to find in a region which abounded with similar structures and producing domes. They wanted to see if exploration technology could be improved to allow for greater accuracy as well as insight into more deeply buried structures. Working under contract with Gulf Oil in the spring of 1926, GRC introduced newly designed electrical seismometers and a vacuum tube amplifier that made its seismograph much more sensitive than the German mechanical seismographs. The unit also contained a single trace recording camera modified from an old hand-cranked 35-mm movie camera. By shining a light through slits attached to the prongs of a large tuning fork, timing lines could be projected onto the 35-mm film. Radio signals from shot point to detector point communicated the instant of explosion, whereas Seismos had estimated this instant from the arrival time of the air wave and the surveyed distance (Owen 1975, pages 505-506 and 760; Lawyer et al. 2001, pages 15-17).

The system greatly increased the speed and accuracy of shooting, and all at a reduced cost. Distances between shot point and recorder could also be lengthened to about 5 miles (and later to 9 miles) allowing for the detection of more deeply buried salt domes. In June 1926, GRC discovered two salt domes for Gulf at Moss Bluff, Texas and Port Barre, Louisiana. During the next three years, another GRC crew found ten domes for Gulf in Mississippi River delta region of southern Louisiana. Trudging equipment through the hot, fetid, and mucky swamps was no picnic for the crew led by Eugene McDermott. They had to contend with aggressive cottonmouth moccasins, leeches, and alligators. But the work of GRC party No. 2 revealed the hitherto virgin territory of Plaquemines, LaFourche, and St. Charles Parishes to be fertile hunting ground for seismograph operations. Gulf promptly drilled some of these prospects, many of which became major fields aggregating over 1.5 billion barrels of oil, but major development on most of them was postponed until after the depression (Owen 1975, page 760).

Expanding rapidly and spreading its crews far and wide, Amerada's GRC firmly established itself as *the* seismic contractor in the United States, and especially on the Gulf Coast. In addition to its work for Gulf, GRC made its mark with another "water job" for the Louisiana Land and Exploration Company (LLE). This company was created in 1927 when Colonel E.F. Simms, a shrewd, independent oilman from Houston who had purchased from the State of Louisiana oil and gas leases on over 1 million acres of the coastal plain, joined forces with H.H. Timken, who controlled some 700,000 acres of fee land foreclosed from failed agricultural ventures. Shortly after its formation, LLE hired GRC for a seismograph survey of its vast holdings. Everette DeGolyer and Alfred Jacobson of Amerada joined the LLE board, making the interlocking directorates of Amerada, GRC, and LLE, in the words of oil historian Edgar Wesley Owen, "an effective managerial mechanism for the venture" (Owen 1975, page 761).

It was an ambitious venture, undertaken across swamps, lakes, and open bays. For the first time in the history of seismic exploration, surveying was conducted almost entirely from boats, with equipment adapted for underwater work. GRC crews mounted the recording apparatus in fishing luggers and at each of three recording boat locations pushed a single geophone into the soft mud with a pole. The explosive charge was lowered to the water bottom on similar boats or buried in a hole on shore. The results were astoundingly successful. Two GRC crews, surveying as much as 15,000 acres a day, discovered 9 salt domes (seven in Terrebonne Parish) in 16 months for LLE, culminating with the giant Caillou Island dome in April 1928. This feat was unequaled, before or since, in the history of geophysical prospecting in the United States (Sweet 1966, pages 135-138; Dobrin 1952, page 125).

LLE eagerly followed up its seismic exploration with drilling. But dry holes in Calcasieu Lake, Vermillion Bay, and East Hackberry placed the company in financial straits and left it unable to complete its planned drilling program. LLE board member Alfred Jacobson came to the rescue by negotiating a deal – the famous "28 Contract" – whereby the Texas Company subleased about 1.5 million acres of LLE holdings in return for cash, royalties, a percentage of future profits, and a promise to drill 4 wells on each of the 9 geophysical structures. The Texas Company proceeded to fulfill its drilling commitment, with moderate success in 1929-1930, especially at East Hackberry. It took at least another decade, however, after improved drilling and exploration technologies helped locate reserves, for the Texas Company and LLE to realize the vast amount of oil underlaying their leases. By the mid-1960s, the four most productive fields discovered in the deal – Caillou Island, Lake Barre, Bay Ste. Elaine, and Lake Pelto – had a combined cumulative production and remaining reserves of more than 1 billion barrels, "a rich return from 16 months of work by a few men trying out novel methods with rather crude equipment" (Owen 1975, page 762).

After 1929, the technology and strategy of geophysical exploration in the Gulf Coast salt dome region moved into a new phase. The industry began to search for and discover more deep-seated salt domes, beyond 2,000 feet and ranging to 10,000 feet. Beginning in 1927, almost the entire Gulf Coast salt dome region was reshot with the torsion balance and refraction seismograph, but the drill did not achieve high rates of success until 1929, after Humble Oil and Refining Company's discovery of the Sugarland Field in Fort Bend County, Texas, which confirmed the importance of both exploration tools for mapping at depths around 3,500 feet. More new oil and gas fields were opened in 1929 than in any previous year, and the industry was even contemplating the use of geophysics to search for oil and gas bearing structures other than salt domes.

Geophysics as both a science and commercial enterprise was beginning to come into its own. In the mid- to late-1920s, several major oil companies established geophysical departments. Marland Oil had the strongest organization, led by William Haseman and E.A. Eckhardt, who had left the Geophysical Engineering Company. This, however, did not guarantee financial rewards for Marland, which was taken over by Continental Oil Company in 1928. Eckhardt then moved on to head a new geophysical division at Gulf Refining, another early adopter of geophysical technology. The other notable geophysical group to emerge at this time was at Humble Oil. Organized in 1924 by the company's chief geologist and legendary oil finder, Wallace Pratt, Humble's group was unique in developing its own instruments and techniques rather than relying on outside contractors. This delayed Humble's progress but eventually made the company a major force in seismic exploration. In 1926, the Colorado School of Mines, with help from some oil companies, established the first department of geophysics to provide research and training for a new generation of petroleum explorationists (Owen 1975, pages 506-510).

The new phase of geophysical exploration on the Gulf Coast was characterized, most significantly, by the commercialization of reflection seismology. After the war, the Geophysical Engineering Company had experimented with this technology in Oklahoma. GEC's founders – Haseman, Eckhardt, Karcher, and McCollum – along with their associates continued to build on this work in the 1920s. Developing a reflection technique was a main objective of the Geophysical Research Corporation, directed by Karcher, when it was created by Amerada in 1925. The reflection method offered much more seductive possibilities than refraction. Whereas refraction measured the differences in the velocity of energy waves through different rock strata, reflection measured the time it took for a wave to travel from the sound source at the surface to a hard underground layer and back to the surface again. An acoustic wave would be reflected or bounced back toward the surface, much like an echo, from any place where there was a change in the elastic properties of the medium through which the wave traveled. It was harder to interpret data from the refraction method because refraction waves travel in three distinct paths, in contrast to reflection waves which travel in only two paths. Moreover, the angle of refraction is governed by the relative velocity of sound at the interface of two different kinds of rocks, whereas the angle of reflection is geometrically determined. Using a series of recordings and a knowledge of wave velocities through various formations, the reflection method made it possible to plot the contour and depth of reflecting layers (Klotz 1952, page 20).

Early reflection seismology had its flaws. Verifying reflections required correlating events from two or more seismic traces on separate paper records, cranked at different speeds. Equipment was too primitive to allow for easy discrimination between the desired reflections and undesired ones. When dynamite was exploded in a shot hole, the waves recorded by the geophones traveled along a variety of paths, the undesired ones creating what geophysicists called "noise." Acoustic waves were created by dynamite detonated in shallow holes dug by hand, and thus the effectiveness of the shot depended on near-surface soil conditions. Nevertheless, in the summer of 1928, GRC crews working for Amerada began obtaining strong reflections in the Seminole area of Oklahoma. As work continued into 1929, GRC rapidly improved its techniques, introducing better geophones, a new amplifier that rejected low frequencies, including surface waves or “ground roll,” and drilling machines that dug shot holes to the water table. A second galvanometer on each camera simplified interpretation by providing for two traces on each record; later cameras recorded multiple traces. In 1930, Amerada discovered three substantial oil fields in the Seminole area based on structures mapped from GRC’s reflection surveys (Owen 1975, pages 510-511).

The reflection method had so proved its worth that Amerada’s president, Alfred Jacobsen, wanted to limit GRC’s reflection parties for the exclusive benefit of Amerada. The company’s chairman, Everette DeGolyer, strongly disagreed, arguing that GRC could not hope to keep this powerful technology from competitors for long and that the best way for GRC to maintain its virtual monopoly on the seismograph business was to offer reflection crews to other firms, thus continuing to bring in substantial revenues for the parent company. This policy would prevent, at least in the short term, rivals to GRC, which employed approximately 70 percent of all seismic exploration scientists in the world. Jacobsen prevailed, and GRC placed its seismic crews exclusively at the service of Amerada. This provoked DeGolyer’s eventual resignation from the company, but not before he secretly financed the creation of a new independent contracting company, Geophysical Service, Inc. (GSI), headed by Karcher and McDermott, both of whom resigned from GRC in early 1930. Many other GRC men joined GSI, which became an instant player in seismic exploration. On the eve of World War II, GSI fielded 28 crews working on several continents. By the 1950s, GSI had become the largest geophysical company in the world and the leading innovator in seismic technology. In addition, the company’s research into transistors and electronics spawned the renowned technology giant, Texas Instruments, Inc., which would grow to overshadow and become the parent of GSI (Sweet 1966, pages 122-125; Lawyer et al. 2001, pages 17-18).

Still other GRC employees left to start new geophysical companies. During the 1930s, more than thirty U.S. seismic contracting firms appeared, many of which could trace their lineage to GRC or GSI. In 1933, Henry Salvatori left GSI to form Western Geophysical Company, which would become GSI’s chief competitor and even eclipse it in size by the 1970s. The main exceptions to the GRC-GSI ancestry included United Geophysical Company, GSI’s largest competitor in the 1930s and headed by Herbert Hoover, Jr., and the San Antonio-based Petty Geophysical Engineering Company. Established in 1925 by Dabney Petty, associate state geologist for the Texas Bureau of Economic Geology, and his brother, Olive Scott, Petty Geophysical developed its own seismic instruments and became a technical innovator in the industry.

Reflection seismic transformed the business of petroleum exploration in nearly every oil region in the United States. Its greatest economic impact, however, was on the Texas-Louisiana Gulf Coast, especially after the development of “dip-shooting.”[39] First carried out by a GRC crew on the Darrow field in 1928, dip shooting involved placing geophones in opposite directions of the shot point and measuring the differences in arrival times. The presence of steep dips in

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[39] In the 1930s, the courts sorted out the question of patent rights to the reflection seismograph. In 1933, the Texas Company, having purchased the McCollum and Mintrop patents, invited all users of seismic technology to pay royalties and a year later sued the Sun Oil Company for infringement. Litigation was settled out of court in 1937 and cross-licensing agreements involving other patents helped further commercialize the technology.

sedimentary beds thus could be detected. "A new vista of the petroleum potentialities of the Gulf Coast petroleum province of Texas and Louisiana has been opened by the developments of the past few years," wrote Donald C. Barton, in a 1930 appraisal for the American Association of Petroleum Geologists. A pioneer in Gulf Coast geology and geophysics with Amerada and Humble before striking out on his own as a consultant, Barton described the expansion of the salt-dome and Tertiary producing area southward and eastward, venturing a radical upward revision of recoverable reserves from only two years earlier when he had estimated them to be 2.3 billion barrels. "The ultimate production of oil in the area," he now wrote, "surely will be at least 3.5 billion barrels; probably at least 5.5 billion barrels; and possibly at least 10 billion barrels." This proved to be a discerning guess. Although for some years Barton appeared to have placed too much faith in the impact of geophysical technology, by 1965 cumulative production plus proved reserves along the upper Gulf Coast, excluding offshore, was 15 billion barrels (Barton 1930, page 1,380).

In the early 1930s, reflection surveying slowly but steadily demonstrated its effectiveness in detailing deep Gulf Coast prospects which the refraction seismograph and torsion balance had indicated with less precision, such as the Iowa field in Louisiana (Vacuum, Shell) and the Tomball (Magnolia-Vacuum, Humble) and Anahuac (Humble) fields in Texas. On the heels of these discoveries, oil companies set out to reevaluate one dome after another with reflection seismic. Even during the great depression, with the price of oil plummeting, reflecting crews and leasing agents were busy throughout the region. Detailed mapping with the reflection seismograph required much closer spacing of shots and detectors. But improvements to equipment and technique – most notably "continuous profiling," which recorded a continuous set of reflection points along a profile line, as opposed to "correlation shooting" or "spot shooting" – increased the speed and decreased the cost of surveying, making the reflection method economical for wider-ranging reconnaissance. California inventor and geophysicist Frank Rieber developed the "sonograph," based on the technology used in early talking motion pictures, which recorded the seismic traces as reproducible sound tracks and subsequently reproduced them in phased combinations and through filters that reduced interference noises. Along with the discovery of the great East Texas field, reflection seismic work in south Texas and Louisiana turned the decade of the 1930s into the most prolific period for oil discoveries in U.S. history. In 1940, GSI geophysicist E. Eugene Rosaire estimated that the reflection seismograph had found 131 fields on the Gulf Coast, many of them major ones, at an average geophysical cost of $164,000 per discovery (Owen 1975, pages 511-514 and 794-797; Lawyer et al. 2001, pages 21-24).

The technology was not foolproof. It yielded many dry holes, and success rates in some places were no better than other methods of prospecting. Some geologic areas simply did not lend themselves easily to reflection. Soft, unconsolidated sands in many places on the Gulf Coast did not generally provide strong reflections. Most crucially, early reflection techniques had problems detecting faults, which became a serious concern as evidence by the late 1930s was showing that fault blocks were more productive than salt domes. However, ongoing innovation and refinements to the technology, especially in continuous profiling, which enabled more accurate mapping of faulted horizons, would ultimately give the reflection seismic method much broader range along the Gulf Coast and into the Gulf of Mexico.

The revolution in technology brought about by the reflection seismograph also effected a striking change in exploration strategy along the Gulf Coast. New capabilities for detailed geophysical prospecting accelerated the pace of wildcat leasing. Rival companies who could not afford or obtain seismic crews, which were limited in number, deployed large numbers of scouts to monitor the crews working for the companies who could – namely, Gulf, Humble, Shell, Pure, and LLE/Texaco. "Seis scouts" looked for any signs of unusual activity that might suggest the existence of a dome. Remembered O. Scott Petty: “If, for example, a crew should shoot a cross fan at an angle to one they had already made, that was fatal. The first scout to learn that would phone his company and within hours they might have lease men trying to lease the area where the fans crossed.” Crews tried various kinds of evasive maneuvers to shake the scouts, such as changing their working hours, making decoy shots, and spreading false rumors. “Of course there was lots of bribery going on too,” added Petty. “Sometimes the company that found the dome got less acreage then their competitors. So – anything went in those days. You had just better be smart enough to outwit the other fellow” (Petty 1976, page 21).

To prevent cherry-picking by watchful competitors, larger companies increasingly found that they needed a lease on the land instead of a mere permit before they began a survey. In 1927, Humble Oil adopted a new policy of leasing large blocks of land as a strategy of conservation and as a remedy to the problem of competitive drilling. With fast-improving seismic technology and the growing influence of geologists in its organization, the company extended this policy during the depression and broadened its leasing. It obtained large semi-proven and wildcat leases all along the Gulf Coast. In 1933, most notably, Humble took a 20-year lease on the million-acre King ranch in south Texas. “A ranch of over a million acres was bound to contain at least a few oilfields,” explained John Bonner to fellow Humble Oil directors who were skeptical about the deal. It contained more than a few. During the next several decades, the world’s most famous cattle ranch also yielded an abundance of oil and gas fields. Humble Oil’s aggressive leasing strategy, combined with the company’s increasing sophistication in reflection seismology, allowed it to reach, in the words of Everette DeGolyer, a “paramount position as a holder of domestic oil reserves.” Humble’s record of acquisitions and discoveries along the Gulf Coast during the 1930s remains one of the most impressive achievements in the history of American oil exploration (Sweet 1966, pages 174-175).

As the reflection seismograph revealed the great oil and gas potential of the Gulf Coast, the race to acquire geophysical information and leases intensified, even as economic conditions in the nation worsened. The center of gravity in Louisiana’s oil industry shifted decisively to the southern region of the state. By the early 1930s, southern Louisiana’s prorationing allotment (a limit on aggregate production established by an interstate compact in 1933) was double that of northern Louisiana. (More often produced - “hot oil” schemes of Long machine) As one newspaper account described the scene, “trucks rumble through the streets, restaurants are crowded, hotels are filled and business houses are busy. Out in the network of navigable streams, barges and boats of all descriptions are traveling to and from the marshland fields and seaplanes dot the skies” (quoted in Franks and Lambert 1982, page 184).

Oil companies were not the only ones who aimed to profit from this oil potential. The most brazen bid was made by “Judge” Leander Perez, long-time district attorney and ruthless political boss of the deep-delta Louisiana parish of Plaquemines, which embraces the mouth of the

Mississippi River. “A stubby, 125-mile-long thumb of lushly green, creamy delta earth, Plaquemines pokes out into the Gulf of Mexico, spurting out the Mississippi as from the nozzle of a hose,” wrote a *Collier’s* feature in 1949. “Plaquemines contains fabulous riches of oil, sulphur and natural gas, much of it on public lands. But most important for Plaquemines’ fame: it is the bailiwick of Leander H. Perez” (Velie 1949, page 10). In 1929, shortly after oil had been discovered in Plaquemines by GRC Party No. 2 for Gulf Oil, Perez helped Governor Huey Long defeat an impeachment attempt in Baton Rouge by devising a filibuster strategy and arranging “rewards” to local legislators. In return, Long assisted Perez’s attempt to seize the potential oil wealth of Plaquemines Parish.

This required complex legal and financial machinations. The public lands in question had been deeded by the state in the late nineteenth century to levee boards organized into statewide districts. The levee boards, somewhat of an anachronism since the Army Corps of Engineers had taken over levee work elsewhere, used revenues from leasing and taxing the deeded land to finance the construction of levees. The problem for Perez was that the Governor’s office controlled the levee boards through appointments. Huey Long was understanding, however, and helped Perez push through a harmless seeming piece of legislation at the state house in Baton Rouge which amended Louisiana’s constitution to permit local police juries to assume the bonded indebtedness, and consequently the assets, of levee districts within the parish. This amendment opened the way for Perez, who controlled the police juries. As oil companies came calling for permission to lease and drill on levee board lands and as financial control of those lands passed to police juries, Perez frantically organized numerous land corporations, technically owned by friends, family members, and cronies. All chartered out-of-state, thus making them difficult to trace, with anonymous officers and stockholders, these dummy corporations developed a remarkable knack for obtaining leases from the local boards for nominal fees. Perez acted as legal advisor to the boards and also earned “legal fees” from representing the land corporations, which would then sublease the land to oil companies for a price much higher than the original lease plus an overriding royalty of typically 1/16 or 1/32 of all production if oil were discovered. And it was discovered. By the late 1940s, Plaquemines was producing ten percent more oil than any other parish in Louisiana (Smith 1958, page 152; Sherrill 1968, pages 12-13; Jeansonne 1977, pages 74-77; Velie 1949, page 11).

Thus did Perez, nicknamed the “Swampland Caesar” or “Delta Dictator,” amass his legendary fortune and expand his political power. The judge would subsequently wield his power not only locally over almost every aspect of life in the so-called “rotten boroughs” of Plaquemines and neighboring St. Bernard parishes, but statewide and nationally on behalf of segregationist organizations such as the Dixiecrats and White Citizens’ Councils. After World War II, he would lead the fight against federal control over submerged lands offshore. Beginning in the early 1930s, all oil companies operating in the deep delta, including prominently Shell, Texas, Humble, Gulf, and the California Company, became beholden to Perez. They “handled him like a demijohn of nitroglycerin,” wrote *Fortune* magazine in 1958. “If they want to lay a pipeline or put up a terminal in Plaquemines, Perez has the power to block them. If their leaseholds are being challenged, as consistently a hazard of life in Plaquemines as the cottonmouth moccasin, then Perez may be behind it – and what they can save of their holdings lies substantially in his hands” (Smith 1958, page 144).

Rather than discouraging the hunt for oil, the proliferation of leases along the Gulf Coast held by the more aggressive and deep-pocketed oil companies or by opportunistic, if not boldly corrupt, political barons like Leander Perez, provided new inspiration to enterprising companies and wildcatters who were either lease poor or aggressive explorers. In the mid-1930s, some paused and cast their sights over the unexplored and unclaimed waters of the Gulf of Mexico. After all, no evidence suggested that the subsurface offshore would be radically different than onshore; fields producing in the delta were further out on the continental shelf than a good part of the marine area. In 1927, David White of the U.S. Geological Survey predicted that exploration of the salt domes underlying the continental shelf would yield large oil fields. Drilling was already underway in bays, swamps, and lakes, and the shelf sloped so gradually in the Gulf that a person could wade out as far as the eye could see and still keep a head above water. In 1937, F.P. Shepard delivered a paper to the Geological Society of America, calling attention to 26 topographical features that protruded prominently on the ocean floor of the shelf. It did not take a large leap in imagination to see them as salt domes.

“A lot of people were thinking about it in the 1930s,” remembered Tom Barrow, a pioneer in offshore exploration for Humble and Exxon. “My father was head of Humble's exploration group, and I can remember trips down along the coast from Galveston to Beaumont, and his talking about the fact that you could see some of the effect of the salt domes onshore. And he made the comment that the present shoreline is a temporary phenomenon . . . He said, ‘There have to be salt domes out there’” (Shepard 1937; Barrow, personal communication, 2001, pages 10-11).

4.2.2. Pirogues, “Pack Mules,” and Marsh Buggies

In truth, oilmen began addressing the challenges of marine environments long before they began to think seriously about drilling offshore in the Gulf of Mexico. Exploring such environments tended to be a gradual and incremental process, involving the adaptation of land-based equipment and technologies to particular locations. As early as 1896, companies had drilled in ocean waters from piers extending off the beach at Summerland, California. In 1911, Gulf Oil drilled the world’s first oil well in inland waters at Caddo Lake, Louisiana -- the first truly "offshore" well, detached from the shore -- and subsequently built numerous structures on wood pilings there using a fleet of tugboats, barges, and floating pile-drivers. Following on these precedents in the late 1920s, the Soviet Union constructed extensive trestle systems offshore from Baku for drilling in the Caspian Sea, and oil firms found a solution to Venezuela’s teredo-infested Lake Maracaibo by installing platforms on reinforced concrete pilings (Lankford 1971).

Southern Louisiana added another level of difficulty for even the most intrepid oilmen. Swamps, marshes, and shallow open water, all difficult to classify strictly as land or water in many places, posed frustrating transportation and operating problems. In his survey of the history of marine drilling, Raymond Lankford explains the problem:

> There were no roads in the marshes, no bridges over the bayous, no bases from which to move out into the bays. That whole expanse from Calcasieu Lake to Breton Sound was a sort of nature’s no-man’s land, neither land nor sea. A steamboat ran from Lake Charles to Cameron; the road would not be built until

> the mid-1930s. . . . Even the largest oil companies regarded the cost of building roads and bridges prohibitive. Transportation of personnel by boat and barge was difficult (Lankford 1971).

Even if exploration and drilling crews could survey, test and get to a location, the costs of moving in equipment, rigging up, and tearing down was so high that in the 1920s southern Louisiana discouraged all but a few companies.

Two in particular, Texas and Gulf, braved the challenges. But they and the companies that followed them into the region had to make fundamental adjustments not demanded of previous marine work. To a greater extent than elsewhere, they had to tap into local knowledge of the confusing and forbidding terrain. And they had to develop new and innovative means of transportation to enable surveying and drilling in wetlands where it was too hard or too expensive to establish fixed foundations.

Geophysical explorations did much of the advance work in defining the problems. Although a few salt domes had been discovered and developed prior to the 1920s, serious and sustained exploration of the wetlands surrounding those and other domes did not get under way until the geophysical campaign of 1925-1930 initiated by GRC crews for Gulf Oil and LLE/Texaco (see above). A crew would typically rent boats and hire laborers and guides in the small Cajun communities where people traditionally made their living variously by fishing, shrimping, crabbing, frog hunting, muskrat trapping, salt mining, or harvesting sugar, rice, tobacco, moss, or oysters. A typical Shell Oil seismic crew in the 1930s included ten specially trained seismologists and technicians and 6 to 30 helpers or laborers hired from the community. Typically, crews would live on quarter boats for 10 days while they were on a job and then have four days off. Residents of these insular communities initially looked with understandable suspicion upon the outsiders hauling strange geophysical equipment and large magazines of explosives into their midst. But party chiefs offered relatively good money, which was difficult for available hands to pass up as hardship hit rural economies such as southern Louisiana beginning in the late 1920s.

Where waters were deep and open enough, the outsiders rented boats and mud scows to transport their equipment to desired locations. But in the wooded swamps and thick marsh of the Bayou country, geophysical crews turned to methods and equipment used by muskrat trappers. The trappers relied on flat-bottomed *pirogues* (pronouned pea-rogue) to navigate *trainasses* (French, meaning “to drag”), tiny canals often carved out of the swamps and marshes by hand with the aid of a pirogue paddle. A French adaptation of the canoe, a pirogue was constructed by scooping out a tree log, 6 to 20 feet long, which yielded a boat light enough to ride “on a heavy dew.” They were generally propelled by men standing in the stern and bow pushing against the bottom with long poles. Equipment was loaded onto the pirogues and pushed or towed along the trainasses and winding, narrow water courses maintained by trappers. “You know, we benefitted from the trappers,” remembered Pete Rogers, a long-time Shell hand who joined the company in 1935 (Rogers, personal communication, 2002, page 9). Often, however, thick vegetation prohibited boat traffic, and everything had to be carried by foot after parking the boats in a nearby inlet. With their pant legs tied tightly to protect against snakes and leeches, laborers would trudge along waist-deep in swamp water dodging cypress roots and saw-toothed palmetto leaves. "Instruments, explosives, pumps and pipe for drilling, cables, and all the other paraphernalia of the seismologist's art must be carried distances often of miles, and at a rate rarely exceeding one mile per hour," wrote a *Shell News* feature from 1939. "These are the longest miles in the U.S.A.! The number of helpers in a crew is generally measured by the difficulties to be overcome in local transportation" (*Shell News* 1939, page 15).

This was suffocating, back-breaking, and dangerous work, especially as exploration techniques changed from the torsion balance to the seismograph and all the heavy instrumentation and equipment it entailed. "In the mountains, they used these pack mules; well, that's what we were in the swamps," recalled Nelson Constant, who worked on survey and geophysical crews for several companies. "We had motors and pipes that we had to carry on our backs. We had all these instruments" (Constant, personal communication, 2001, page 6). Not to mention cases and cases of dynamite. When they reached a location, still submerged up to their armpits, a crew would set out the geophones, or the "jugs," very sensitive equipment that had to be handled with great care. "Every 200 feet we'd put a yellow flag, and that is where we'd put one of these jugs," said Constant. "Then we'd go 1,200 feet and we'd put out a red flag and that would be a shot point" (Constant, personal communication, 2001, page 5).

With the jugs planted and cables rolled out at the recording locations, the next job was to wrench a heavy section of casing into the muddy floor at the shot location and pump water at high pressure into the casing to make a shot hole for the dynamite. Then, anywhere from 5 to 50 pounds of dynamite were set and detonated in the hole, the explosion creating a tall geyser of water, mud, and plant particles. "No job would be complete without its own peculiar assets and liabilities," wrote *Shell News*. "'Dynamite's' job has in its favor a lack of monotony and a constantly changing scene; but ask anyone who has contracted a dynamite headache through breathing too freely the fumes of an explosion and he will have no difficulty in naming at least one liability"(*Shell News* 1939, page 15). Dynamite posed ever-present risks for the hearty crews, and not just from being too close to an immediate blast. Explosions could leave large craters in the mud floor, often 30 to 50 feet wide in diameter. "If you didn't know about it, and you walked across it, you'd go right on down," explained Constant. "And if you had a load on your back, it was pretty doggone hard to get up again out of the water" (Constant, personal communication, 2001, page 25).

The rewards of this work outweighed the risks for many young men in the Bayou communities. It offered decent pay and opportunities for advancement and the acquisition of new technical skills. When asked why he did not immediately return to easier work at his father's store, Nelson Constant replied: "Once I got in there, I liked it. I really did. Maybe after a year, I don't believe they could have kicked me out if they wanted to" (Constant, personal communication, 2001, page 6). Men like Constant developed a new sense of self-worth, as this dynamic enterprise of geophysical exploration drew on their knowledge and talents. The companies hired them as surveyors and permit men as well as "pack mules." They applied their familiarity of the local terrain and people to determine lease lines and help the companies acquire permits to explore outside the leases. Constant had experience cutting property lines in the swamps and he spoke Cajun French. So when he went to work for a Humble crew, he was soon assigned as a guide and translator to the company surveyor/permit man, and quickly succeeded to this position. Obtaining permits to survey from local landowners was much easier from a fellow rural, Frenchspeaking Cajun than it was from an English-speaking company man from Texas. "In some cases," Constant recalled, "contract companies had come out and busted up their roads and fences and one thing or another." Other residents were worried about protecting their oyster beds. "Some guys would say, 'I'm not going to let you have it [the permit].' So I just stayed and talked with them and just kept talking and let them get it all out. First thing you know, they almost asked you to go ahead and do it" (Constant, personal communication, 2001, page 3). Constant's facility with the land and people was such that within a year or two he had acquired wide-ranging responsibilities, which included hiring local laborers, arranging locations for boat landings, and drafting maps of bayous, property lines, and oyster leases.

The average cost of operating a seismograph party in the Louisiana low country was substantially higher than on dry land. In 1939, Shell Oil estimated the difference to be $350/day versus $250/day. Moreover, the acquisition of data was much slower in the swamps and marshes. Increased mobility, therefore, was the key to cheaper and more efficient operations. As was often the case in oil and gas operations in coastal and offshore Louisiana, homegrown innovation offered the needed solution. One of the most notable contributions made by Southern Louisianans to increasing the mobility of petroleum exploration in the wetlands was the "marsh buggy." Although it is not clear who originated the idea, in the 1930s, trappers in the Mermentau Basin first deployed a motorized, large-wheeled contraption, called a "slat-whell buggy" (the name marsh buggy was applied later), to travel over Chenier Plain marshes dominated by heavy grass cover. A lightweight Model A Ford truck with extended axles and wagon wheels fitted with four- to five-feet wide wooden slats, the first buggies functioned well in mashing a trail across marsh grass, but lost traction and bogged down in wetter and muckier areas. "They sure saved us a lot of leg work," remembered Pete Rogers. But they "could go underwater and we'd have to dig them out" (Detro 1978, page 8; Rogers, personal communication, 2002, page 8).

It did not take long, however, for enterprising souls to find modifications that provided buoyancy and expanded the use of marsh buggies into the Deltaic Plain. In the mid-1930s, Gulf Oil designed a model with rubber tires 10 feet in diameter and 3 feet thick, known as the "Gulf Marsh Buggy" or "balloon buggy-boat." Used mainly by geophysical crews, the Gulf buggy achieved widespread notoriety for its ability to function in a variety of wetland environments. Gulf chose not to manufacture and offer the vehicle commercially, but other pioneers continued the process of innovation. During World War II, Higgins Shipyards in New Orleans developed three different models and the McCollum Exploration Company in Houston produced a propeller-driven version. Oil and gas companies, such as Shell Oil, Stanolind Gas, and United Gas, all designed their own buggies. One of the most successful designs was by Andrew Cheramie, who after World War II patented a marsh buggy design which consisted of a tractor mounted on giant pontoon wheels. With ribbed and troughed treads, these wheels propelled the buggy as fast as 10 mph in marsh and water and up to 30 mph on land. Others introduced models with caterpillar track revolving around flotation pontoons. "Within a few years," writes Randall Detro, "the coastal wetlands were being crisscrossed regularly by seismograph crews on marsh buggies, towing their equipment on sledges" (Detro 1978, page 97).

Marsh buggies facilitated the penetration of geophysical crews, and behind them drilling and pipeline operations, into the marshes of southern Louisiana. This advance force of the oil and gas industry managed to conquer some of the forbidding elements of the wetlands, but not without environmental consequences. Trappers complained that buggy wheels damaged habitat and destroyed “sets” (traps). The marsh was resilient and often grew back. “We once went back to these areas that we had torn up,” recalled Willy “Dub” Noble, a longtime Humble seismograph crewman, “and it was in 3-4 times better condition than the surrounding marsh because we had stirred up this floating marsh stuff. When it grew back, it was a beautiful pad. You could walk all over that” (Noble, personal communication, 2001). Still, trails that received repeated use left deep and lasting incisions. Over time, as tracks, canals, and pipelines spread throughout the marsh, open water areas expanded, breaking up natural barriers and leading to tidal scouring and increased water salinity. The transition to less-destructive track-type buggies by 1960 helped minimize some of the damage from exploration. Still, marsh buggies, drilling rigs, and pipelines were there to stay, and the development of oil and gas on a large scale in this region permanently altered the environment of southern Louisiana, contributing to the increasing submergence and disappearance of vast areas of marshland which greatly threatens the survival of Cajun communities today (Detro 1978, pages 97-98; Tidwell 2003).

4.2.3. Exploratory Drilling from Wetlands to Open Water

Geologists and geophysicists were responsible for finding structures and potential oil-bearing formations, but, as the old adage goes, the driller was the one who found the oil and gas. And the environment of southern Louisiana was no more inviting or yielding to the driller than it was to the geoscientist. “It is natural to assume that oil men chiefly know oil, but the type of worker engaged on the water locations of The Texas Company in Southern Louisiana is guilty of no such limitations,” wrote the *Texaco Star* in 1930. “He not only has to know oil, but he must be reasonably conversant with the higher forms of construction engineering and have a workable appreciation of what it means to be a sailor”(*Texaco Star* 1930b, page 27).

In the late 1920s, drillers faced a host of new challenges as they tried to move rigs from dry land to marshes and bays. Soft, mucky silt in these areas could not tolerate the same kinds of loads that hard-ground soils could. “In these coastal marshes,” wrote F.C. Embshoff of the *Shell News*, “where the land is scarcely more than a series of floating dirt rafts insecurely anchored by vegetation, there is nothing solid upon which to build a derrick” (Embshoff 1938, page 4). Compounding this problem was the fact that drilling objectives in southern Louisiana were located at greater depths, thus requiring more drilling pipe, casing, and heavier equipment. In the marsh, drillers resorted to constructing huge “mats” made out of timber upon which to place derricks, tanks, and boilers. In the open waters of bays and lakes, drawing on experience from places like Lake Caddo and Lake Maracaibo, drillers placed their equipment on planks supported by a foundation of numerous piles driven deep into the silt bottom. At Dog Lake, where in 1929 Texaco brought in the first commercial production from its 28 Contract sublease and the first production in Terrebonne Parish for the industry, the company built a foundation of 52 cypress piles, each sixty feet long, to support the drilling of its first well (*Texaco Star* 1930a, page 5). Large expenditures of time and money were required to prepare the location and foundation, construct heavy board roads, move in, rig up and tear down the derricks and associated equipment, and then haul them to a new location. For all but a few companies, these expenditures were prohibitive for exploratory drilling.

After a couple years of drilling prospects in this costly manner, G.I. McBride, an engineer in Texaco's Shreveport division, envisioned the possibility of achieving mobility in wetland drilling using a barge, equipped with a derrick and drilling equipment, that could be floated and submerged as a stable drilling base, thus eliminating the time and expense of fixed foundations. In pursuing this concept, Texaco discovered with amazement that it had been patented four years earlier by Louis Giliasso, a native of Italy and captain in the merchant marine. Giliasso conceived of a "practical apparatus for drilling oil wells in lake bottoms and other submerged lands" after having observed the difficulties encountered by oil companies in establishing foundations for drilling operations in Lake Maracaibo, Venezuela. A months-long search eventually found Giliasso operating a saloon in Colon, Panama. In 1933, Texaco coaxed Giliasso back to the United States and obtained an agreement whereby the company acquired an exclusive license to use the submersible barge and the right to license it to other companies. Soon, a barge christened the *Giliasso* was floated from a shipyard at Leesdale, Pennsylvania, down the Ohio and Mississippi Rivers to Lake Pelto in Terrebonne Parish, Louisiana (Lankford 1971).

The *Giliasso* was constructed by fastening together the twin steel hulls of two standard transportation barges, leaving space in the middle for drilling. Concerned about the risk attendant upon use of the first unit, Texaco decided to use two barges which could be salvaged in case of failure, rather than design an odd-shaped barge for this single purpose. Towed to location, the lower compartments of the hulls were flooded, sinking the barge to the bottom. The upper compartments remained above the water and provided a platform to hold the drilling structures, equipment, and power plant. The *Giliasso* demonstrated its drilling capabilities immediately in Lake Pelto, reducing by 20 percent the time spent on a well not related to drilling or completing, and afterward proved its ease of mobility in being towed to Lake Barre. By 1935, Texaco had built and deployed a fleet of seven such barges along the Louisiana coast, each drilling 6 wells per year. G.I. McBride estimated that the barges provided an annual total saving over ordinary pile-supported structures of $600,000 (McBride 1935).

Other companies followed Texaco's pioneering example, and by the late 1930s dozens of "floating derricks" could be seen moving through the bayous and newly constructed canals of south Louisiana. By 1938, the industry had drilled 3,300 wells in parishes adjacent to the Gulf, 700 of which were surrounded by water. The most active areas were in the Lake Barre, Terrebonne Bay, Pelto Bay, and Timbalier Bay areas of Terrebonne Parish (Flood 1939, page 98). Success with mobile drilling led oilmen to ponder cautiously the utility of submersible barges in the open waters of the Gulf. "The present design is adequate for territory inside and in water up to 10 feet deep out in the Gulf," claimed McBride in 1935. "We feel that, for drilling a well beyond the last sand bars, drilling barges offer the only satisfactory protection to equipment exposed to Coastal storms. We prefer for the present, at least, not to try to predict the size and shape of barges which might venture well out into the Gulf" (McBride 1935, page 45).

Nobody as yet, however, was willing to tempt fate in the Gulf by trying to drill from a barge. But in the late-1930s companies did begin to experiment with drilling in open water using "land operations." In 1932, the Indian Oil Company, drilling off Rincon, California, became the first company to drill in the ocean from an independent platform supported on pilings. A few years later, a joint operation by Pure Oil and Superior Oil placed a similar structure in the Louisiana

Gulf. The project began in 1934 when geologists from the Pure Oil Company discovered evidence of salt domes west of the little town of Creole, Louisiana. Further surveying with reflection seismic along the shore suggested that the prospect extended out into the Gulf. In 1936, Pure and Superior persuaded the State of Louisiana to lease the combine 7,000 acres on land and 33,000 acres offshore. In 1937, the companies hired Brown & Root, an engineering and construction firm out of Houston, to construct a relatively massive (180 feet by 300 feet) wooden platform for the Creole field in about 15 feet of water -- one mile from shore, thirteen miles from nearest supply point at Cameron (Lankford 1971; *Offshore* 1963, pages 17-19).

As an exercise in "stickbuilding" – that is, using work barges to piece together a wooden structure out in the ocean, this project was only a distant cousin to the metal structures of later eras, but it helped oil men identify the key problems that would have to be overcome to operate in the Gulf. The most obvious of these was the impact of hurricanes. Lacking any reliable data on wave heights in the Gulf, the designer of the Creole platform settled for an interesting compromise made possible by the fact that the work force commuted daily to the platform and did not live there. He simply placed the deck at fifteen feet above water and sought to design it so that high waves would wash it away while leaving the remainder of the structure in tact. In March 1938, the Superior-Pure State No. 1 well brought in the first oil from "offshore" Gulf of Mexico. For an initial investment of $150,000, the Creole platform produced more than 4 million barrels of oil over the next 30 years. Money could be made offshore despite the many difficulties to be confronted (Alcorn 1938).

In view of the difficulties in loading and unloading crews at a free-standing platform, Humble Oil in 1938 constructed a pier more than a thousand feet out into the Gulf off High Island's McFadden Beach on the upper Texas Gulf Coast and drilled wells from separate platforms built off the end of the pier**.** Such piers, however, had a limited range and proved inadequate in the soft sands of the Gulf. So companies continued to experiment with free-standing platforms. In 1938, Standard Oil Company of Texas (a subsidiary of Socal) completed Texas' first offshore well a mile off Cedar Point in Galveston Bay. Three years later, British American Oil Company discovered oil two miles offshore near Sabine Pass in 17 feet of water. The same year, Texaco had a gas blowout off Coon Point, Terrebonne Parish, Louisiana. All these ventures were extremely tentative moves "offshore." They emerged from the exploration of coastal prospects and retained close operational ties to land. Only the Pure-Superior's Creole platform achieved production. Despite the costly failures of the other wells and resulting leeriness about offshore endeavors among some operators, others in the industry began to contemplate jumping in with both feet and extending their exploration activities into the open water horizon.

Progress in drilling technology and in developing inland fields in Southern Louisiana increased the allure of the ocean. In the late 1930s, the industry made revolutionary strides in improving rotary-drilling technologies, which allowed for the drilling of deeper wells with savings of cost and time. Improvements came cascading in all facets of drilling, including balanced rigs, internal-combustion-engine power, straight-hole drilling, drilling-rig instruments, mud control, retarded cements, electric logs, radioactive logs, side-wall coring, gun perforating, and drillstem testing. Electric logging was especially important to revealing subsurface details unobtainable by any other method. Developed in France in the late 1920s and introduced in the Gulf Coast in 1933, electric well logging tools lowered into a well hole measured the difference in electrical conductivity of oil, gas and water. Since oil and gas have different conductivity properties than water, this method was useful in locating hydrocarbons. Electric logs were also used to determine the permeability and porosity of formations. “Perhaps in no other region were they so indispensable as here [the Gulf Coast],” writes Owen, “distinguishing the otherwise indistinguishable sands, measuring the displacement of otherwise unsuspected faults, defining structural attitude, and pointing out local facies variations and regional environments of deposition” (Owen 1975, page 798).

Electric logs were crucial in providing the stratigraphic details and correlations of cross sections in the upper Miocene sands of coastal Louisiana. In the late 1930s, these sands yielded prolific oil production in the lower Mississippi delta region. Later called “one of the great deltaic accumulations in the world,” these sands, thousands of feet thick, grew thicker toward the Gulf. Electric-log correlations and paleontologic and lithographic markers in the Miocene also improved as exploration moved Gulfward (Limes and Stipe 1959). Technical advances in drilling and logging helped make 70 new discoveries during 1936-1940 in southern Louisiana. However, the new finds did not add to the region's reserves as much as extensions and new producing sands in known major fields. Discoveries of large new structures slowed and drilling costs rose as a growing percentage of wells (36.5 percent by 1946) were drilled in water locations. The convergence of all these factors pointed in one direction – into the open waters of the Gulf.

In early 1941, consulting geologist O.L. Brace wrote: “It may be tentatively assumed that the Gulf of Mexico is a potential source of salt-dome oil . . . Whether or not it will ever be economically feasible to explore these waters for the domes that must exist is a question for the future to answer” (Brace 1941, page 1,007). The future was not long off. Even though World War II and federal restrictions on new reservoir development, before the war was over oil companies would start sending seismic crews offshore in shrimp boats.

4.3. References

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5. Work Plan: Tyler Priest and Joe Pratt, History International

Based on the oral histories and archival research conducted for this project, History International is drafting a series of "working papers" on three thematic areas relating to the history of the offshore oil and gas industry in southern Louisiana: 1) the history of exploration technology and strategy in the Gulf of Mexico; 2) the history of state and federal leasing in southern and offshore Louisiana; and 3) the history of hurricanes and environmental issues in the development of offshore platform technology. Detailed below is a prospectus outlining the drafts completed and projected work for inclusion in the final report.

5.1. Technology and Strategy of Petroleum Exploration in Coastal and Offshore Gulf of Mexico

5.1.1. "Salt Domes and Salt Water: Gulf Coast Exploration Technology to 1945"

This chapter addresses the oil industry's exploration for oil on the Gulf Coast, beginning with the discovery of Spindletop in 1901. Profiling the leading oil companies and the emergence of the geophysical contractors, it examines the science and technology of exploration for oil reservoirs associated with salt domes, from the torsion balance to the refraction seismograph to the revolution brought about by the reflection seismograph. By the late 1920s, geophysics as both a science and a commercial enterprise had come into its own. Geologists and paleontologists also made valuable contributions to understanding the stratigraphy and sedimentary sequence. The chapter also describes the early methods of exploration in coastal marine environments using pirogues, marsh buggies, and submersible drilling vessels. Other developments in the 1930s such as electric well logging and rotary drilling were crucial to finding new sands in known major fields. The effects of changing technology had a dramatic effect on the strategy of exploration and the development of leasing, pushing it into the open waters of the Gulf of Mexico.

5.1.2. "The Pursuit of Data: New Methods of Seismic Exploration and Prospect Evaluation, 1945-1962"

This chapter details the rapid changes in geophysical technology after World War II and the increasing sophistication of offshore exploration. At the end of World War II, the industry began making its first offshore seismic surveys in shrimp boats and using radar positioning technologies developed during the war. Multi-boat operations soon brought down the costs of data collection, and by the end of the 1950s, Western Geophysical had introduced group surveys. Meanwhile, several developments during the decade greatly enhanced the acquisition and processing of reflection seismic data: continuous velocity well logs (sonic logs), magnetic tape recording and playback, "common-depth-point" stacking (which filtered out unwanted seismic reflections, or "noise"), the replacement of dynamite charges with air guns, analog processing computers, and analog-to-digital converters. By the late 1950s, the increasingly sophisticated scientific means of collecting and processing seismic data was accompanied by advances in Gulf Coast geology as well as new methods of analyzing prospects and developing bidding strategies for offshore lease sales. The development of the semi-submersible drilling vessel in the early

1960s allowed companies to focus on geology rather than water depths in extending the offshore play further out into the Gulf.

5.1.3. "Seeing the Subsurface: The Digital Revolution and Its Impact on Exploration in the Gulf of Mexico, 1962-1988"

In 1962, Geophysical Services Inc., the undisputed leader in geophysical innovation by this time (it spun off computer research into a separated company called Texas Instruments), performed the first digital recording on a two-year proprietary contract for Mobil and Texaco, and by 1965 most oil companies were working with digital field recordings. Digital computers enabled a quantum leap in the amount of data that could be handled and manipulated, leading to an almost continuous innovation in seismic processing and interpretation, with the "deconvolution" of signals caused by reverberations in water in the early 1960s, the "direct detection" of hyrdocarbons ("bright spots") in the late 1960s, and three-dimensional seismic in the mid-1970s. Brights spots, though not foolproof, radically improved the accuracy of exploration and contributed as much as the spike in oil prices to soaring bonuses paid for offshore leases in the 1970s. To compete offshore by the mid-1970s, oil companies had to be proficient with digital seismic technology and advanced geophysics. Although the first truly 3-D seismic survey was conducted in 1973, the high costs of the technology delayed its widespread implementation until the mid-1980s, when commercial development of interactive workstations cut interpretation time from months to weeks.

5.1.4. "Beyond the Shelf: Taking Geologic and Economic Risks in Deepwater, 1974-2000"

In 1974 in the Gulf of Mexico, oil companies acquired the first deepwater leases – in the modern sense of the term deepwater – in 1,000 ft of water, extending from the upper continental slope to the abyssal plain. The key to the industry's move into deepwater was a combination of shrewd geological investigations, advances in deepwater production technology, and a willingness by managers to take risks that would be hard to imagine in the tough, quarterly profit-oriented business of today. Probe studies of deepwater turbidite geology, beginning in the 1960s, by a number of universities and oil companies, led by Shell Oil, had confirmed the potential for an exploration play. Several factors came together in the early 1980s to spur interest in the play, including the discovery of several significant turbidite fields on the shelf margin and upper slope, the recognition of great reservoir potential in deeper waters, and a rosy outlook for prices. Leasing activity was subdued until 1983, when the move to the area-wide system sparked a flurry of deepwater leasing, again led by Shell Oil, who, more than any other company was willing to take on the large risk of exploring in deepwater. Progressive improvements in drilling and production technology, especially the tension-leg platform, allowed Shell to develop its leases, with stunning well production rates coming from Auger in 1994. Thereafter, the deepwater rush was on, abetted by royalty relief in 1995 and continuing improvements in production technologies (subsea tie-backs and directional drilling) and 3-D seismic capabilities.

5.2. History of State and Federal Leasing in Southern and Offshore Louisiana

5.2.1. “The Harvest from the Hayride: Louisiana’s Leasing of Petroleum Lands, 1908-1945"

This chapter surveys the leasing of public lands for petroleum development by the State of Louisiana from the first lease in 1908 by the Caddo Parish Levee Board, to the President Harry Truman’s 1945 proclamation challenging the State’s jurisdiction offshore. It focuses on the centralization and almost total discretionary authority over leasing in the Governor’s office and the abuse of that authority in the late 1920s and early 1930s when huge swaths of land in South Louisiana, where significant oil reserves had been discovered, were leased in corrupt and complex deals to members of the Long machine who then transferred those leases, with overriding royalties, to oil companies. Texaco acquired the largest acreage, including one giant lease in the Ship Shoal area, State Lease 340, which extended three leagues into the Gulf of Mexico and whose validity would become the subject of legal wrangling for years. Meanwhile, in Plaquemines Parish, the ruthless political boss Leander Perez used complex legal and financial machinations to amass wealth from the leasing of public lands by levee boards. In 1936, after Long’s assassination, the state finally reformed the leasing program through the creation of the State Mineral Board. The upshot of all these deals was the rapid extension of lease claims over much of the land in South Louisiana by a few companies and interests, forcing the rest of the industry to look offshore by the late 1930s to expand the play.

5.2.2. “Claiming the Coastal Sea: From the Tideland’s Controversy to the Landmark 1962 Sale”

This chapter analyses the emergence and development of federal jurisdiction and leasing over the outer continental shelf in the Gulf of Mexico. It details the political and legal battle between the State of Louisiana and the federal government over the “tidelands.” In 1937 North Dakota Senator Gerald P. Nye introduced the first congressional resolution to declare lands under the marginal seas of all the coastal states to be part of the national public domain, and in 1945 President Truman issued a proclamation officially asserting it. The chapter chronicles the Supreme Court decisions validating these claims and the passage of the Tidelands Act and Outer Continental Submerged Lands Act (OCSLA) enabling federal leasing and regulation offshore beyond the three-mile limit of state jurisdiction, as well as Louisiana’s challenges to the state-federal boundary line in the 1950s. Leasing and regulatory functions were established in the Department of the Interior’s Bureau of Land Management and U.S. Geological Survey, respectively. The federal government first offered OCS leases in 1954, but Louisiana obtained an injunction against further leases in 1956. An “Interim Agreement” advanced the political and legal process to a point where conflicting claims to submerged lands would no longer limit the pace and scope of offshore leasing. In 1960, the Supreme Court upheld the three-mile limit to Louisiana’s jurisdiction over submerged lands, but state-federal conflict would continue for years over the location of the three-mile line and the division of escrowed revenues. In 1960 and 1962 sales, the federal government leased a tremendous amount of OCS acreage, firmly establishing offshore oil as a new major area of federal regulation in the oil industry.

5.2.3. “Searching for ‘Fair Market Value’: The Tract Selection System, 1962-1978"

This chapter discusses the “second phase” of the federal offshore leasing system, which began after the 1962 sale. The next sale was not held until five years later in 1967, and in the intervening years, the Department of the Interior developed a new system referred to as “tract selection,” in which DOI officials imposed acreage limitations on sales to increase cash bonuses. The government recognized offshore leasing as a significant source of revenue, and as the costs of the Vietnam War escalated, the DOI was pressured to increase its take from bonuses and search for a more scientific estimation of “fair market value” for the public lands being offered. The primary criterion for the acceptance or rejection of bids was the DOI’s independent estimate of the value of each tract, and not the magnitude of the highest bid, though the DOI’s fair market value estimates tended to be quite lower than winning high bids, especially as bullish projections of oil prices and bright spot technology drove bonus bids to ridiculously high levels in the mid- to late-1970s. National Environmental Policy Act (NEPA) regulations following the Santa Barbara blowout in 1969 complicated the work of leasing officials, but leasing in the Gulf continued. The industry often cried foul at the “checkerboarding” of blocks offered under the tract selection system, and fair market value proved to be an elusive concept, but the system brought in substantial revenue for the government and kept demand for offshore leases high. However, by the late-1970s, it became clear that the system was creating an artificial shortage of exploration opportunities, especially as the environmental concerns severely restricted leasing off the Atlantic and Pacific coasts.

5.2.4. “Reviving the ‘Dead Sea’: The Origins and Development of the Area Wide Leasing System, 1978-2000"

This chapter analyzes the “third phase” in the federal offshore leasing program -- the “area-wide leasing” system. In the late 1970s, the second oil shock had hit and there was growing concern about declining U.S. production, as well as mounting concern for environmental protection of coastlines. Resistance by some coastal states to OCS leasing forced Congress to pass in 1978 the Outer Continental Shelf Lands Act Amendments (OCSLAA), which opened the decision-making process to a wider audience and authorized the DOI to experiment with alternative bidding systems, and mandated a five-year plan to govern the pace of leasing. In 1981, controversial Secretary of the Interior James Watt carried out further reforms, instituting the “area-wide leasing” system, which opened the leasing process to entire planning areas (e.g., the central Gulf of Mexico) and consolidated all the leasing, regulation, and study functions in a single DOI agency, the Minerals Management Service. Beginning in 1983, major offshore acreage was leased in the Gulf of Mexico planning areas at sharply reduced bonus prices. Shell Oil acquired a large majority of these leases and in 1994 brought production in at Auger, which led to a steep increase in deepwater leasing. Despite early criticism of area-wide leasing, the new system, along with the Royalty Relief initiative passed in 1995, helped open up deepwater exploration in the Gulf of Mexico, which has led to some spectacular developments in recent years. On the other hand, one can argue that the political controversies over AWL led to the closing off of vast areas of the U.S. OCS and that the AWL system has reduced competition between oil companies for offshore acreage, or at least over control of deepwater development. One objective of this chapter will be to assess the costs/benefits of AWL by looking at its effect on government revenues and its role in stimulating the deepwater boom.

6. History and Evolution of the Offshore Oil and Gas Industry in Southern Louisiana: A Brief Look at Commercial Diving and the Role of People, Technology, and the Organization of Work

6.1. Brief Overview

The offshore oil and gas industry is an extension of the vast U.S. petroleum industry, and it has been and is influenced by the operational, technological, economic, political, and moral issues that characterize that industry (see Yergin 1993; Olien and Olien 2000). Still, the move offshore produced its own unique contests (see Freudenberg and Gramling 1994; Gramling 1996).

The oil and gas industry benefited from national and international demand for its products – it, in turn, has provided sufficient economic, social, and political support for the development of specialized sectors such as commercial oilfield diving. Capturing the history of the offshore industry presents special challenges; development and production do not occur in factories where the artifacts can be catalogued and the activities of workers and managers are regulated and can be readily investigated. Instead, the industry is a vast configuration of individuals and organizations working in numerous sectors responsible for exploration, drilling, fabrication, transportation, and production. It comprises small, specialized companies and large, integrated corporations. As the industry has moved from solid land to encounter swamp, lake, marsh, shallow waters over the outer continental shelf, and now depths greater than two miles, the companies and sectors have evolved and changed. Consequently, the industry provides an excellent case for examining the interplay of technology and work organization.

6.2. Construction Diving

Underwater construction played an important role in the early industrialization of Europe, and divers borrowed equipment and techniques from sponge and salvage divers who had been practicing their craft for hundreds and even thousands of years on several continents. By the late 1800's, large commercial diving projects, such as deepening shipping lanes and constructing bridges and ports, were undertaken, and divers were hired to place concrete, cut and weld metals, and lay pipelines. The first wooden piers built to support oil drilling operations over seawater were constructed by pile driving crews in 1896 off the coast of California.

Within the early years of the 20th century, the U.S. oil economy developed, and by WWII oil was recognized as being so important to national security that young men who worked on the seismic and drilling crews active in the swamps and shallow waters of southern Louisiana were kept home to continue their work. When the war ended, vast numbers of people and new technologies were poised for action. Many men returned to the communities from which they had joined the service to find that jobs were scarce. Their wartime knowledge and experiences made them particularly well suited to the oilfield. They brought with them technologies for transporting goods, fabricating large metal structures, and working underwater. And they had become accustomed to working in harsh, dangerous environments. The rapid development of the offshore industry off the coast of Louisiana meant that the Gulf of Mexico soon became the "place divers went to earn their stripes" (Austin et al. 2002). For many companies and workers, offshore oil and gas work came to occupy the vast majority of their time, attention, and resources.

6.2.1. Diving as a Factor in Offshore Oil and Gas Development

The first diving operations in the Gulf of Mexico were little more than topside jobs completed underwater. Men recall jumping off of boats, barges, and platforms to retrieve dropped objects, install clamps, or check for oyster beds. They did not have, nor perceive a need for, any formal training as divers.

However, the progress into deeper water was rapid, and keeping the rigs, platforms, pipelines, and vessels operating called for modification and innovation. Underwater jobs required longer than the time a man could hold his breath and expanded to include inspection, installation of anodes for protection against corrosion, and salvage. Those already working in the industry began to look outward for new technologies developed elsewhere, and those with the interest and training in underwater work saw the industry as a new opportunity.

Working from within the industry, local workers used the air compressors available on boats and acquired war surplus equipment to create systems that would allow them to breathe while underwater. The early jobs were in depths under 100 feet, and divers could stay down as long as they wanted without suffering ill effects, so there were ample opportunities for them to learn how to manipulate tools and perform tasks underwater. Through magazines and trade publications individuals acquired information and ideas. Each diver had to come to the job with his own mask, hose, and compressor, and anyone who acquired the equipment was likely to form his own company. Technological diffusion was rapid, facilitated by the loose organization of diving companies and their propensity to join together when more than one or two divers were needed on a job.

SCUBA (self-contained underwater breathing apparatus) was developed in 1947 but was not readily adapted for offshore work. Specialized tanks and compressors were not available in New Orleans until the mid-1950’s, and even then they were rare. Roy Smith, a diver who introduced SCUBA gear to the offshore industry in the Gulf described the early days:

> In the early ‘50’s, around ’53 or ’54, work was slow, so my friend and I said, “Why don’t we go to Grand Isle?”… I was in the U.S. Coast Guard during the war, so I went and got my operator’s license and started working on boats. After awhile, the platforms grew in number, and I got more interested in diving. I wanted to dive. There was no SCUBA diving at that time. Since I was the captain of a boat, I got me a gas mask and a hose and would dive around the boat. A friend of mine and I had heard about them diving with SCUBA gear in Florida, so we said, “Let’s go see it.” … Rowland’s Sporting and Army Goods Store in New Orleans ordered an aqualung. They didn’t know what to do with it, so they called me. We threw it overboard and all took a dive with the tank. I bought the aqualung from him. They found a surplus compressor from a submarine and put it in their store and started filling tanks (Smith, personal communication, 2002).

A few years later, in 1957, Ronald and Walter Daspit, natives of Lafayette, Louisiana, developed a “bailout bottle” that could be worn on a diver’s belt and provide a short-term, emergency air supply for a diver whose surface air supply had been cut off.

Outside the industry, the U.S. Navy was the principal source of technology and personnel. As early as the 1930's, the Navy began experimenting with gas mixtures that would allow divers to go deeper and stay underwater longer. Diving was an important responsibility of the Navy in WWII, and divers conducted salvage operations, helped construct ships, cleared ship channels, and performed numerous other tasks. During the war, new techniques of underwater welding, burning, and the use of explosives were advanced, and new tools and equipment were developed for undersea construction and other work. Though Navy divers started several Gulf Coast diving companies during the 1950's, the attitudes, tasks, technologies, and forms of work organization in the oilfield were markedly different from those of the Navy. The transition was difficult for some divers. The following two career divers describe the same situation from two different points of view:

> After the war was over… life got boring. For some reason or other I decided it would become more interesting if I would become a Navy diver. … I graduated from the Navy Deep Sea Diving School…in 1946. I went on from there and was a Navy Deep Sea Diver up until the time I retired from the Navy … in 1960… Then, immediately, if I had never tasted boredom before, I got a hell of a taste of it after retiring. I was not finding myself being very well adapted to most civilian occupations so I quickly found myself down at the Gulf Coast - New Orleans - and became a commercial, professional diver in the offshore oil fields… Most divers on the Gulf Coast were not highly trained or highly experienced, either one. They were just people who knew how to put on the diving gear and make an effort. Yet, the Navy training had value because I knew a lot about decompression and treating the bends that others did not know. On the other hand… even though I was highly experienced, 15 years in the Navy, I began immediately a heavy-duty learning curve figuring out how to do things in lightweight gear. The thing that sticks in my mind as heavy duty is how hairy it was. As compared to Navy diving where you always have a chamber setting topside, here you are doing it with nothing. You got your tender, you got a little old compressor, your face mask, your wet suit, your gear, and you are pretty much on your own. If you have a diving accident then it is shame on you, especially if it requires decompression because no chambers. Even if there were, nobody who knows how in the hell to use it….Once I saw that I could do it, it was a horrendously nightmarish thing psychologically. … But it was the hardest part, just getting used to the danger. It was such a relief when I finally got to the west coast where decompression tables and chambers were the norm (Taylor, G., personal communication, 2002).

> I used to do a lot of experimental diving for the Navy, checking out different equipment, showing them how it can work. The Navy divers wouldn't do some things, so we'd do it. …The Navy master divers would come out and see what we were doing, shake their heads, and say, "No way we'd do this in the Navy." That's what you had to do to get the job done. There were some innovations, like the frying pan shaped O ring to use in the flange groove and help keep divers from losing fingers. We got new wrenches. I was concerned about safety, but in commercial diving if you are going to think about safety you are not going to get

> anything done. Offshore, everything around you is dangerous; you've got to take your chances there (Schouest, J., personal communication, 2002).

When the U.S. Merchant Marine began to decline (Gibson and Donovan 2000), some mariners turned to the offshore oil and gas industry for work. The wages paid to offshore mariners were far below those to which seamen had become accustomed, so some took up commercial diving because it required many of the skills they had developed on ships and offered more lucrative financial opportunities than work on oilfield vessels. Though some of the early divers enrolled in commercial diving schools, formal training was not considered a necessity and some even argued they could better prepare divers themselves. Walt Daspit, a career diver, describes his path through the Merchant Marine:

> I graduated from high school in '45 and I joined the merchant marine when I was 17. In 1946, there was a general seaman's strike. All seamen went out on strike… When the seaman's strike was over after about three or four months, I went back to sea again. Somewhere around 1950, I was about to get drafted during the Korean War so I joined the Air Force. Right before getting discharged I came across a magazine that had schools for higher occupations and one was Spalding School of Deep Sea Diving. It showed a picture of a diver wearing heavy gear and it said that divers make as much as $200 a day. I said, "Well, that is for me." After I got out of the service about '52, I went back to sea and got enough money to go to diving school. I began diving school in the fall of '53 and got out in January of '54 (Daspit, personal communication, 2002).

Communication problems between divers and those on the surface were significant. In most early underwater jobs, especially those performed under conditions of no or low visibility, a single diver worked alone. Many early divers argue that more than one diver would have increased the danger because divers would then have had to worry about one another. Divers communicated with the surface via hand signals on a rope, and they and their tenders worked out complicated systems known only to themselves. Communication was necessary when a diver required tools, wanted the people on the barge to raise or lower cables and equipment, and needed to inform the tender that he was trapped or could not breathe. Loss of communication required aborting the dive.

Though radios were customary within the Navy by WWII, they were large and bulky, and commercial divers did not commonly use them. Diving helmets were equipped with telephones, but hearing was often disrupted by the noise of breathing gas entering and exiting the helmet. Fixing communication devices to masks proved a significant challenge. Divers experimented with earphones, transceivers, and devices they could purchase at electronics stores, but they did not forego the use of ropes and hand signals. William Brown began diving for his uncle in California at age 16 during WWII when older divers were scarce:

> We had what they called sound powered phones at that time [1945]. You didn't have any magnification or anything. It had two sticks and you wore a skull cap and you put these things on each ear and you would tape it up. It was very uncomfortable. [The diver] had a bull horn on his chest that you could talk into.

> It was sound powered. We worked with hand signals most of the time (Brown, personal communication, 2002).

While maintaining communication with the surface was vital to a diver, controlling that communication was a key point at which the diver could assert his autonomy, control the work setting, and enhance his status. In the early days, everyone depended on the diver to report conditions at the bottom, the time the job would require, and the progress he was making. To regain some of the control, companies began hiring inspection divers to assess initial damage and report on work completed. By the mid-1950's, underwater photography was recognized as a valuable means of augmenting a diver's description of the situation, but it was rare in the Gulf of Mexico. Its widespread use in the 1960's was another feature that marked the maturation of the oilfield diving industry.

Though technologies were borrowed and adapted from commercial diving operations elsewhere, rigid forms of work organization were actively resisted. In the early days, a diver needed only his equipment and a trustworthy "tender," someone who would stand at the surface to monitor his hose and compressor and pass him tools. Numerous small companies, comprised of one or two divers and their tenders, formed in southern Louisiana and east Texas. A particularly successful job gave the company a boost. Each successive achievement maintained a diver's reputation; a single failure could damage it. Maintaining relationships with those who hired divers sometimes required being willing to do things other than dive.

Commercial diving schools on the west coast provided a tenuous link between Gulf Coast divers and others, but though the interaction led to sharing of technology, it had little impact on ideas about and approaches to work organization. Staunch individualists, a fervent anti-union mentality, and an industry structure within which oil companies contracted simultaneously to drilling companies, fabricators, and boat companies and established an environment within which time meant money – huge sums of it – all contributed to the highly competitive and dispersed nature of the workforce. As the industry moved into deeper waters new challenges emerged and had to be overcome. Divers were rewarded for taking increased risks with a pay structure that included a baseline daily rate and depth pay.

In addition, a nation enamored with individualists and innovation and already lamenting the tedium accompanying factory and office work was captivated by the freedom and excitement associated with nontraditional careers such as diving. In general, underwater achievements were trendy topics for periodicals such as *Popular Mechanics* and *Popular Science* (Heyn 1972), and, in the Gulf region, newspaper coverage was frequent.

Throughout the early period, to the end of the 1950's, commercial diving and underwater construction were necessary for the construction and maintenance of harbors, ports, piers, and power plants throughout the United States. During those years, diving companies were still working to demonstrate their value to the offshore industry (e.g., *Offshore Drilling* 1957; Taylor 1958). Soon, though, diving became an integral part of offshore operations, and the oil and gas industry, due to its size and financial strength, eclipsed other applications. Both technology and ideas about work began to flow outward from the Gulf.

6.3. Innovation and Adaptation

As both the depths and the level of offshore activity increased, the largely informal and small-scale diving sector matured. From the perspective of the companies paying the bills, the primary goal was to increase the time divers could stay on the bottom and minimize the time spent in decompression. Numerous changes and innovations made it possible for a person to advance from jumping into ten feet of water for a few minutes to staying at depths greater than one thousand feet for several weeks to complete a job. Gas mixtures allowed divers to achieve greater depths but also withdrew the heat from their bodies and made their speech unintelligible; their use required new masks and the development of hot water suits and new communication devices fitted with unscramblers. Pneumofathometers and decompression chambers and tables removed some of the uncertainty from the return to the surface and reduced injury and death so that underwater operations could continue and saturation diving could develop.

6.3.1. Getting Divers and Keeping Them at Work

To meet the goal of increased bottom time and more rapid ascent, both mechanical and biochemical problems had to be overcome. Under pressure, the density of air increases and impairs breathing by reducing the mechanical efficiency of the lungs. Divers' bodies absorb more air under pressure than at the surface. Atmospheric pressure doubles with each 33 feet of depth, and with each doubling the volume of gas is reduced by half. The longer the diver is down, the more compressed air circulates through his system. When the pressure decreases upon ascent, the gas expands. The diver must rise in stages to allow the blood to circulate and air escape slowly in a process known as decompression. Rapid decompression leads to the dangerous condition known as the "bends." Decompression tables established safe rates of ascent. Then, decompression chambers allowed divers to be brought up quickly, repressurized, and decompressed slowly while at the surface. Other divers could continue the job during the process. Consequently, the ability to function in confined quarters became an important requirement for divers.

The fundamental physiological concern was to provide divers' bodies with levels of oxygen that would sustain life while reducing gases whose volume underwent significant changes with changes in air pressure. By altering the gas mixtures divers breathed, both depth and bottom time could be increased, so various gas mixtures were tried. Oxygen is toxic at high levels and results in convulsions and death; as the pressure of the gas goes up the percentage of oxygen must decrease. Divers with high oxygen tolerance have a distinct advantage. Carbon dioxide is also toxic, and materials to absorb the excess gas were inserted in helmets. Nitrogen has a narcotic effect at depths beyond 100 feet, so a replacement carrier for oxygen was sought. Helium tempers the taste buds, causes dehydration of the sinus cavities, and, because its thermal conductivity is greater than that of air, carries heat away from the diver's body. It also comes out of the system more slowly than nitrogen and affects the vocal cords resulting in the "Donald Duck effect." Nevertheless, the problems associated with helium proved to be the most amenable to solutions, and helium-oxygen mixtures that had been developed by the Navy decades earlier were widely used in oilfield diving by the late 1960's. The high cost of helium led to efforts in the 1970's to develop rebreathers that would recycle the gas and to efforts to replace helium with nitrogen.

Divers worked in confined spaces at high pressure, lived for up to several weeks at a time in close quarters, and took risks relying only on the word of supervisors and company doctors that new methods were safe. Every new invention required additional human capacities and experimentation on divers, and many innovations were motivated by injuries and deaths. Still, as each new innovation came along, divers could be found to try it out. Macho pride, the desire to be the first, prospects for higher pay, and a love of diving all played a role:

> I like the gas work. I quit doing anything above 150 feet of water. Greed overcame my fear. You could go down and work an hour or two and you would get paid more than you spent working a week in some waters (Daspit, personal communication, 2002).
>
> [Being in diving] a long time starts to define who you are almost (Taylor, G., personal communication, 2002).

Problems with heat were addressed through the use of suits that were heated either by surface-supplied hot water or electric wire. Hot water suits were preferred even though they initially scalded the divers; divers reported that they would leave the front of their suits open to allow cold water to mix with the heated water coming from the surface.

The introduction of new gas mixtures meant new mechanisms for generating and then delivering those gases to the divers; standard air compressors were no longer adequate and gas mixtures had to be purchased from elsewhere. Significant invention and innovation accompanied the development of diving masks and helmets. One of the first Navy artifacts to be modified for oilfield work was the Mark V helmet, which had been developed prior to WWI and remained in use until the 1980's. The helmet and full diving suit with which it was used weighed as much as 200 pounds. Working in the Gulf of Mexico around rigs and platforms, divers needed flexibility and the ability to climb up and down, in and out among platform legs and tangled pipes. In addition, divers were frequently given a small area on the barge from which to work; in this space they had to cram their air compressor, tanks, radio, and everything else they brought along. Masks that were originally designed for SCUBA were adapted for use with hoses and compressors because they were smaller and used less air; however, the lack of any head protection was a disadvantage in construction work. Beginning with the end of WWII, Gulf Coast divers acquired access to Japanese helmets, and these became popular among some divers.

By the 1960's, several Gulf coast divers had designed and built their own hats. Walt Daspit, who was motivated by Joe Savoie to design and construct his own hat, describes why:

> The first guy that came out with a lightweight diving helmet was Joe Savoie. We were working on one of McDermott's barges with Chuck Gage and we saw Joe. Joe was explaining to us what he was going to build. He was going to use an aqualung, which was a sterile diving dress that was used at the time. It was a front entry and you would wrap up tight and you would stay dry. Joe was going to put a neck ring on it… He wanted to build a helmet out of a race car crash helmet. Then he was going to the faceplate visor and a neck ring and tie it. He was explaining that to us and drawing it. I said, "Joe, you can't do that because

> having that half opening of the dress, when you lean over air is going to go to the highest point. It is going to flip you upside down and you are going to come floating up to the surface upside down." That was one of the things about diving with heavy gear. You had to be careful. If you leaned over too far, the air went to your feet. You were out of control then. You couldn't exhaust it… I am trying to explain this to Joe who has never had any formal diving training. When you argued with Joe, all he did was talk louder. Once he gets something in his head that is where it stayed. He was a hard-headed coonass and I was a hard-headed coonass. I tried explaining to him that he couldn't do that. He said that he was going to put valves on the feet and relieve the air through the feet. I told him he couldn't do that because it wasn't going to work. You have to have a seal around the neck. Joe just kept getting louder. Joe eventually found out that I was right so he made a neck ring for his hats. He made a very good helmet but it took him a while to evolve it into something. What he first had in mind just wasn't going to work (Daspit, personal communication, 2002).

Though Joe sold a dozen helmets and Walt and a couple of other local divers sold a few more, Kirby Morgan of California achieved the greatest success. He visited Gulf Coast divers and convinced some of them to try his helmets. Soon Kirby Morgan hats were in widespread use.

Introduction of new gas mixtures required changes to communication devices. Though divers and their tenders learned to understand each other even with the distortions caused by breathing helium, barge superintendents and others at the surface did not. Unscramblers were employed to facilitate communication.

As jobs began to require many divers, supervisors were hired to manage both the work and the divers. Some supervisors managed all communication with the divers, both to maintain control over the job and to ensure diver safety. During the development of new procedures, the highly competitive environment of offshore construction and the huge profits to be made from substantial breakthroughs made secrecy paramount. One supervisor recalls a time he wrote down instructions for a welder inside the chamber:

> I have always been of the opinion that you like to keep information confidential, but in order to gain information you've got to tell the welder what he's doing, why he's doing it, and what you're looking for. So I had written down for a welder and he was in the tank welding. And [the CEO's] got a stool pigeon works for him, that found my note, and he took it to [him]. And [the CEO] called me in his office, and [the CEO] was setting holding his head like this and he goes to screaming at me about confidential information.

Gas mixtures and helmets continued to be developed and modified, and so did the search for efficiency and ways to keep divers underwater for longer periods of time and maintain continuous operation. Throughout the 1960's as the industry matured, diving companies showed uneven rates of adoption of new technologies and forms of work. Even after diving bells, chambers within which divers can descend to depths of thousands of feet, and decompression chambers were common in the Gulf, divers reported being on jobs where either no chamber was present or no one knew how to use the chamber correctly.

The diving bell provides physical protection for the diver and a more comfortable environment within which to undergo decompression. However, though it enables the diver to descend to deeper depths and facilitates the return to the surface, it does not significantly alter the time on the bottom. The major breakthrough in that area came in 1957 when the director of the Navy’s Submarine Medical Center demonstrated that the body’s tissues would become completely saturated with inert gas within 24 hours so that the period required for decompression for any dive of that duration or longer would be the same (Zinkowski 1976). In the 1960’s when the concept was applied widely, the limits of both depth and time expanded exponentially. Military, scientific, and commercial interests converged in a period of rapid research and development of equipment, gas mixtures, and forms of work organization. According to the general superintendent of one of the industry leaders at the time, “No industry today can boast of more rapid technological development than commercial diving” (Morrissey 1966, page 88).

Saturation diving systems are themselves complex environments, and their development required parallel development of analyzers to read partial pressure of oxygen (systems were developed to include both galvanic and polarographic types of analyzers); controllers to maintain oxygen levels; and analyzers for carbon dioxide (infrared); carbon monoxide (infrared); helium (thermal conductivity); nitrogen (computation of difference); and relative humidity (electric hygrometric) (UST 1968, page 41). Within the diving bell, scrubbers kept the moist atmosphere ventilated; rack operators monitored readouts to safeguard against carbon dioxide and oxygen poisoning; and emergency gas bottles were installed to offer a few minutes of air in an emergency (Seib 1976).

These technological achievements introduced a host of changes in work organization and the social environment within which diving took place. The expense of constructing, operating, and maintaining saturation systems increased the capital needed to remain at the forefront of the industry. Small companies were either absorbed by larger ones or had to restrict their work to shallow environments. They had a hard time attracting divers when the innovation and record-setting was occurring elsewhere.

Companies gained greater control over the divers and their pay. Prior to saturation diving, with decompression time tied to depth and time spent under pressure, deep work was done via bounce dives wherein divers stayed on the bottom only a short period of time. Pay was tied to depth, so divers could make huge sums of money in relatively little time. Both physiological and financial factors limited the depths to which divers could go and the time they would remain there. Saturation diving removed many of the constraints and set up new dynamics between divers and their employers. “With saturation diving and almost unlimited working time at depth, diving performance is now being judged on how long a period of time divers are in the water – that is, 20 hours a day in the water is somehow ‘better’ than 16 hours a day, even when less actual work has been performed…(O)perators of lockout submersibles welcome a more accurate, qualitative evaluation of work performed, and they are motivated to provide the performance that this approach demands” (Duggar and Majendie 1979, pages 92 and 94).

Saturation diving also changed the nature of the relationships among divers and between divers and their supervisors. Instead of one diver working alone, as many as six divers and a tender would work from a diving bell. Communication was managed via unscramblers on the radio and took place between the divers and the topside supervisor and not with tenders in the bell. Tenders were excluded from decisions about the work to discourage them from taking charge of the operations; if the tender entered the water to aid the diver no one would be tending and two could be lost (Seib 1976).

Despite, and perhaps because of, the continued experimentation and ongoing danger of the early years, divers continued to dive. Long hours in a diving bell could be excruciatingly dull, so divers sought distraction. Some divers became avid readers while others worked longer than their allotted time to avoid getting back into the deck chamber.

The continued advance of exploration and drilling toward deeper waters provided the stimulus for invention, innovation, and dissemination in commercial diving. These technological advances that made it possible for humans to work at great depths below the water's surface also made way for new technologies associated with the construction, maintenance, and operation of oil and gas platforms and pipelines. In the following section, a brief overview of the history and development of underwater welding illustrates the links.

6.4. Underwater Welding: An Example of Technological Change in the Offshore Oilfields

The development of underwater welding was preceded by several alternative approaches to the construction and repair of offshore structures and pipelines. When wooden derricks and platforms gave way to steel ones, installation, repair, and removal required men to work with metal. Platforms were fabricated onshore and transported offshore via barges. Pipelines were joined on the decks of barges and then lowered to the seafloor; repairs were initially made by hauling the lines to the surface. Then, successful divers demonstrated the advantages of performing the work on the bottom, installing clamps and mechanical devices where needed. Soon, cutting, burning, patching, cementing, pipelaying, welding, and inspecting were all done underwater. Both the tasks to be done and the people to do them had to be modified for this new environment.

Even prior to WWII, underwater welding had proven an effective temporary means of joining pieces of metal, but the inferiority of wet welds to those performed at the surface limited its use. By the mid-to-late 1960's, however, the idea of welding underwater had captured the attention of a number of key construction companies and personnel. Saturation diving provided the context within which underwater welding could develop. Though not the only source of need, the offshore oil and gas industry was by far the largest and had the most capital. Research and development moved in two directions: creating dry environments within which welding could occur and developing wet welding techniques. In 1967, Taylor Diving and Salvage began developing an underwater welding habitat and alignment frame to facilitate welding underwater in a dry environment; it was used successfully on the St. Lawrence River in 1968. In 1969, under the direction of C.E. "Whitey" Grubbs, Chicago Bridge and Iron began an underwater welding research program focused primarily on wet welding.

Dry habitat welding progressed through several stages, beginning with the gas tungsten arc. This process was considered too slow, so alternatives were tried until the shielded manual arc became the accepted standard. Under pressure, the welding arc becomes constricted. In addition, weld metal chemistry, weld notch toughness, and hardness all are affected by pressure. Different gas mixtures were tried. At increased pressure, hydrogen's solubility increases and leads to cracking. Helium's conductivity is six times that of air, and rapid heat loss from the weld area increased hardness and the risk of cracking. Nitrogen leads to nitrides in the weld deposit and destroys the properties of the weld because molten metal will preferentially absorb nitrogen and form nitrides. To complicate matters, as the welding process was evolving to respond to increased depth, so, too, was the type of metal being used in pipes and structures.

At each stage, both weld procedures and diver/welders had to be qualified to perform to specific standards under specific conditions. The use of x-ray technologies to inspect welds required that some divers be qualified as radiographers. Anthony Gaudiano, who worked as an engineer for Taylor Diving and Salvage from the late 1960's until 1984, describes the environment of the time:

> And you have to understand that when all this was going on, and people were working like 11-12 hours a day, we didn't have meetings where we sat down and made presentations. We didn't do all of that planning and all of that critical path charts, none of that stuff. You just did it. You got it done… People did some very impressive things, really very impressive things. Innovative things. And I would think that the habitat welding was one of those innovative things (Gaudiano, personal communication, 1996).

The OPEC increase in oil and gas prices spurred U.S. interest in developing offshore oil and gas fields and increased interest in underwater welding (Cotton 1977). The 1970's were a period of new development and innovation. Though the first remotely operated vehicles (ROVs) were constructed and used by the Navy in the early 1970's, it was several years before they were available commercially.

6.5. Work Organization and Labor Issues

As the processes and techniques associated with underwater construction evolved, a very specialized labor force was required. Though some jobs, such as pipeline installation and platform removal, had fairly standard procedures, no two jobs were ever the same. Accidents, hurricanes, and general wear and tear presented unfamiliar circumstances for even experienced divers. Pride and the fear that one diver would outdo another and win over a customer kept divers attempting new feats:

> When [the barge] capsized, they had about a 130 foot derrick standing. It capsized and the derrick bent out to the middle of the river. They couldn't do anything. They couldn't move it because the derrick had the barge anchored. It was upside down and you had this derrick bent out towards the middle of the river. I went down and burnt and cut it loose to where it dropped. That was kind

> of scary and I don't know if I would do that today. The other divers flat out refused to do it. I said that I would do it (Daspit, personal communication, 2002).

Maryann Galletti, wife of John Galletti and co-owner of J&J Diving, describes how the company evolved:

> We started working out of a garage with two sets of diving equipment and no vehicle. We gradually acquired equipment, property, a building. Within a span of ten years, we had also bought a tractor trailer truck. John informed me he was going to buy this tractor trailer truck for $12,000 and I liked to have a heart attack. He had the sights to see the work that was out there and all I could see was more money, more money. It was like you would pay for one thing before you moved onto another (Galletti, personal communication, 2002).

The era of the small companies was short lived. The rapid advance to deeper waters required specialized equipment and knowledge to enable divers to work safely at ever-increasing depths. Thus, during the 1950's and early 1960's the diving companies went through the process of getting organized (Batteau 2001). A steady increase in offshore activity during the 1960's drove up demand for divers and meant that existing companies expanded and new ones formed. "The explosive growth of offshore oil exploration and development brought round-the-clock overtime and deep diving premiums. There was a lot of money being made by the younger divers, though it was often at great risk" (Parker 1997, page 115). Divers were put into the water with little, if any, training, and the greater depths substantially increased the risks associated with inexperience.

In addition, divers were under tremendous pressure to perform. The hierarchical nature of the industry and separation of those with the ultimate authority over decisions from those on the barges, rigs, platforms, and vessels led to circumstances within which divers were pushed to dive even when conditions would dictate otherwise. Both when divers were called out in an emergency and when they performed routine tasks such as laying pipelines, the work of people at the surface was halted until the diver was out of the water. Entire crews were held captive on barges and platforms while divers completed their work. Though the situation gave divers a certain amount of autonomy, it also resulted in significant peer pressure to get the job done quickly. Walt Daspit captures the sentiments expressed by most of the early divers:

> [The barge captain] can't say [to a diving company] you have to put this man in the water. But, the next time they call for divers, he can say that he doesn't want whoever out here. So, you have to keep the barge captain happy. The main thing in keeping the barge captain happy is getting the job accomplished….The barge was surging. It was going up and down. The water was picking up. They wanted me to go down and cut the pulling head loose. When I went down, the barge surged down and I had my hand on the top of the handrail. A huge block, about 7 or 8 feet tall, came down and side-swiped my hand. My hand just went numb. I unshackled the block and I was going back up to the surface….When I got to the surface, I pulled the glove off and my finger was just hanging by a string (Daspit, personal communication, 2002).

Nevertheless, diving was attractive to many young males looking for an exciting career, and would-be divers were not hard to find. Andre Galerne, a company owner and early member of the Association for Diving Contractors, commented on the problems associated with low diver pay and benefits in the Gulf of Mexico:

> The price we were paying the divers was in my book much too low, and if a guy can make the same amount of money by selling hamburgers to Big Mac, than to be a diver, I think it's exploiting the fact that the guy likes diving. [If we advertised this as something other than diving], then the people will not be doing that for the pleasure, so they will demand money. Diving is a different thing. The guy is ready to dive at any price, because they want to dive (Galerne, personal communication, 2001).

Joe Schouest (personal communication, 2002) confirmed this, "I love diving. I'd dive for nothing. Sometimes I've done it. I like the challenge."

Though divers and welders were easy to find, engineers were not. Several companies struggled to find people to enter the industry. According to Anthony Gaudiano,

> Of course, you have to understand in those days, nobody wanted to be associated with us. We were kind of wild outlaws and anybody who had any smarts would look at this little two by four organization and say, 'I can go to work for General Motors. Why should I be associated with this little bitty place?' There were a few who saw the potential but not very many. We didn't get the experts until quite a number of years later when the revenue and the reputation were worldwide (Gaudiano, personal communication, 1996).

Due to the high costs of specialized equipment such as decompression chambers and a pool of divers who would work under almost any conditions, the organizational culture of diving was at first slow to change.

Many companies continued to operate at the margins of safety, but injuries, deaths, and expanding liability caught the attention of the oil companies. In the early 1960's, Joe and Tom Sanford came to Louisiana as outsiders and were able to establish a clientele and obtain work because at that time they were one of the only diving companies working in the oilfield with insurance. Soon the largest companies were requiring proof of insurance, and by the mid-1970's the substantial extension of depth limits proved to be too expensive to be undertaken by individual companies and required a joint industry financial program (Jones 1977, page 70). Rapidly rising insurance costs and fear of government intervention and of unionization among the divers led companies to organize the Association for Diving Contractors to develop industry standards and address safety concerns.

The move from land to water affected the organization, or lack thereof, of the labor force. Divers were engaged in underwater survey work beginning in 1929, about the same time that the first efforts to organize divers began on the east coast (Parker 1997). Near shore, divers worked alongside unionized construction crews but remained independent until pile drivers unions successfully claimed submarine divers among their numbers. The unions are credited with establishing better working conditions for divers on the west and east coasts. However, the move offshore undermined union activity and influence over the offshore oil industry because oil companies and drilling contractors operating drilling vessels were not signatory to pile driving and diving union agreements. “Other than establishing the fledgling oil divers with standards of safe work rules and pay scales precedent, the union had little influence over the offshore oil diving industry” (Parker 1997, page 115). Despite significant efforts in the 1970’s, the unions were never able to organize the labor force working in the Gulf of Mexico.

The push into deeper water drove technological development, and the larger companies responded by establishing research divisions. J&J Marine Services, one of the few early Texas companies that also worked out of south Louisiana, was among the few small companies that invested substantially in research. The company owners hired an independent scientist in the early 1960’s to help develop decompression tables. At that time, the company employed only a few divers, but the owners recognized the critical role that science and technology would play in the diving industry.

6.6. Discussion and Conclusions

Divers and companies in oilfield diving and underwater construction began by adapting technologies and patterns of work developed elsewhere and have continued to maintain links to the U.S. Navy and to commercial diving and construction interests operating outside the oil and gas industry. The steady march from shallow to deep water supported a continual process of innovation and change in both the equipment and methods required to put and keep divers underwater and those required for constructing, installing, repairing, and salvaging offshore structures. Within this regular evolution several events, such as the adoption of mixed gas breathing mixtures and of saturation diving, marked discontinuities that led to periods of rapid research, development, and change. The particular nature of the offshore industry – distributed networks of innovation and implementation, the continued reworking of nearshore fields in the Gulf of Mexico, and expansion worldwide – nevertheless made it possible for companies to continue using old technologies as they developed new ones.

Technological challenges – welding and burning underwater, for example – matched challenges of getting workers to the work site and keeping them there. The challenges of transporting and maintaining workers hundreds of feet below the surface proved to be both physical and psychological. The industry was able to play into key tenets of American culture and society – freedom, individualism, and competition – to attract and hold divers. Divers and the companies they formed fought hard to maintain a significant level of autonomy and defy both larger companies and unions who sought to organize them. Yet, through time, in the face of economic pressures to manage liability, the oilfield diving enterprise became organized. By the 1970’s, the technological and social milieu and forms of work organization of oilfield diving were substantially different from those which marked its beginning. Small companies of one or two divers and their tenders had given way to large enterprises. Though several unionization attempts ultimately failed, the organizing drives provide another sign of maturation within the industry. The late 1970’s and beyond would bring further changes.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.